Refugio Beach Oil Spill

Final Damage Assessment and Restoration Plan/Environmental Assessment

Prepared by:
California Department of Fish and Wildlife
California State Lands Commission
California Department of Parks and Recreation
University of California
The Department of Interior, U.S. Fish and Wildlife Service
National Oceanic and Atmospheric Administration

Refugio Beach Oil Spill

FINAL

Damage Assessment and Restoration Plan/Environmental Assessment

June 2021

On the Cover:
Oiled Beach by U.S. Coast Guard
Oiled octopus and invertebrates by Natural Resource Damage Assessment Trustees
Dolphins by Natural Resource Damage Assessment Trustees
Pelicans by Natural Resource Damage Assessment Trustees
Harbor seal by Santa Barbara Channelkeeper

Suggested Citation:
Refugio Beach Oil Spill Trustees. 2021. *Refugio Beach Oil Spill Final Damage Assessment and Restoration Plan/Environmental Assessment.* Prepared by the California Department of Fish and Wildlife, California State Lands Commission, California Department of Parks and Recreation, Regents of the University of California, U.S. Department of the Interior, U.S. Fish and Wildlife Service, and National Oceanic and Atmospheric Administration.

Refugio Beach Oil Spill Natural Resource Damage Assessment Summary:

Shoreline Habitats

$5.5 million

Injury: Approximately 1,500 acres of shoreline habitat were impacted including sandy beach and rocky intertidal habitats.

Restoration: Remove Ellwood seawall, enhance black abalone populations, and restore degraded sand dune habitats.

Subtidal and Fish Habitats

$6.1 million

Injury: Approximately 2,200 acres of benthic subtidal habitat were impacted.

Restoration: Restore abalone populations in Marine Protected Areas, restore eelgrass beds in Refugio cove, remove Ellwood seawall, restore sand dwelling kelp offshore of Goleta Beach.

Birds

$2.2 million

Injury: 558 birds were estimated killed, representing over 28 different species.

Restoration: Remove invasive plants from brown pelican nesting colonies on Anacapa Island, reduce seabird injuries from recreational fishing, and implement conservation actions for western snowy plovers.

Marine Mammals

$2.3 million

Injury: 156 pinnipeds and 76 cetaceans were estimated injured or killed.

Restoration: Increase the capability to recover and rehabilitate marine mammals in distress in Santa Barbra and Ventura County, and Increase the capability to respond to instances of cetacean entanglement in the Santa Barbara Channel.

Human Uses

$3.9 million

Injury: The Trustees estimate over 140,000 lost recreational user days in Santa Barbara and Ventura Counties; six days of beach closures in Los Angeles County; and lost research, education, and outreach opportunities at the University of California, Santa Barbara Coal Oil Point Natural Reserve. Affected recreational activities included camping, sunbathing, beach combing, exercising, swimming, wildlife viewing, fishing, diving, boating and surfing.

Restoration:

Restoration funds (53%) will be administered by State Parks for use on projects benefiting camping and shore-based recreation from Gaviota State Park to El Capitan State Beach.

Restoration funds (46%) will be administered by State Trustees for use on projects benefiting coastal recreation in Ventura County, Los Angeles County, and Santa Barbara County downcoast of El Capitan State Beach.

Restoration funds (approximately 1%) will be administered by the University of California for use on projects benefiting research, education, or outreach at the Coal Oil Point Reserve.

Restoration Planning, Implementation, and Oversight

$2 million

Public Input

Full Document: https://go.usa.gov/xvWEg

Administrative Record: https://go.usa.gov/xvWEc

Submit Questions: RefugioRestoration@fws.gov

Executive Summary

On May 19, 2015 a 24-inch diameter on-shore pipeline (Line 901) that extends approximately 10.7 miles along the Santa Barbara County coastline in California ruptured resulting in the release of approximately 2,934 barrels (123,228 gallons) of heavy crude oil (U.S. DOT 2016, hereafter referred to as "the spill"). Line 901 is a buried, insulated pipeline that transported heated crude oil from Exxon Mobil's storage tanks in Las Flores Canyon westward to Plains' Gaviota Pumping Station. The pipeline is owned and operated by Plains All American Pipeline, L.P., and Plains Pipeline, L.P. (jointly, Plains). The Pipeline and Hazardous Materials Safety Administration (PHMSA) determined that the cause of the Line 901 failure was external corrosion under insulation that thinned the pipe wall to a level where it ruptured suddenly and released heavy crude oil. Crude oil from the buried pipeline saturated the soil and flowed into a culvert that crosses under Highway 101 and railroad tracks, and ultimately discharged into the Pacific Ocean at Refugio State Beach.

The crude oil that entered the ocean posed a significant risk to and injured marine plants and wildlife, including seagrasses, kelp, invertebrates, fish, birds, and mammals. In addition to direct natural resource impacts, the closure of beaches and fisheries occurred just days before the Memorial Day weekend, resulting in losses for local businesses and lost opportunities for the public to visit and enjoy the shore and offshore areas. Tar balls attributable to the Line 901 release were carried by southerly ocean currents and eventually reached some beaches in Los Angeles County (California Department of Fish and Wildlife 2016).

The response (cleanup) to this significant spill brought together a number of federal, state, local agencies, and Native American tribes operating under a Unified Command. For the spill response, Incident Commanders consisted of representatives of the United States Coast Guard (USCG), California Department of Fish and Wildlife, Office of Spill Prevention and Response (CDFW-OSPR), Santa Barbara County, and Plains[1]. The Refugio Beach oil spill cleanup effort completed Phase I "active cleanup and gross oil removal" on August 31, 2015, and completed Phase II "refined oil cleanup endpoints for shorelines targeting maximum net environmental benefit" on January 22, 2016 (U.S. Coast Guard, 2016). Phase III monitoring activities were largely concluded on May 26, 2016 and the Unified Command disestablished on March 10, 2017 (U.S. Coast Guard 2017).

In parallel with the response and cleanup effort, the natural resources trustee agencies (Trustees) conducted a Natural Resource Damage Assessment (NRDA) to quantify the injuries to natural resources from the spill and assess natural resource damages. In this case, the Trustees for the natural resources injured by the spill include the United States Department of Commerce represented by the National Oceanic and Atmospheric Administration (NOAA); the United States Department of the Interior represented by the United States Fish and Wildlife Service

[1] The National Contingency Plan calls for the Responsible Party to be a member of the Unified Command; ref. 40 CFR 300.135(d)

(USFWS), National Park Service (NPS) and Bureau of Land Management (BLM); the CDFW-OSPR; the California Department of Parks and Recreation (CDPR); the California State Lands Commission (CSLC); and the Regents of the University of California (the Trustees). As a designated Trustee, each of these agencies is authorized to act on behalf of the public under state and/or federal laws to assess and recover natural resource damages and to plan and implement actions to restore, rehabilitate, replace, or acquire the equivalent of the affected natural resources injured as a result of a discharge of oil.

In accordance with the Oil Pollution Act (OPA) NRDA regulations (33 U.S.C. 2706(e)), the Trustees have cooperatively gathered information and prepared this Final Damage Assessment and Restoration Plan (DARP)/Environmental Assessment (EA). This document describes the injuries resulting from the spill and the restoration projects selected to compensate the public for those injuries. This document is also an Environmental Assessment intended to satisfy the Federal Trustees' requirement to evaluate the environmental impacts of the proposed restoration projects under the National Environmental Policy Act (NEPA) and is therefore called a DARP/EA. Prior to releasing this Final DARP/EA, the Trustees released a Draft DARP/EA for public review and comment. After considering the public comments received, the Trustees prepared this Final DARP/EA. A full environmental review would be premature for some of the selected projects in this Final DARP/EA, as well as projects that were deemed "second tier" or of lower priority. The need for additional NEPA review will be determined once detailed engineering design work or operational plans are developed for selected projects. Additional review may also be required if any second tier projects are implemented.

This document describes the restoration projects selected by the Trustees to address the various resources impacted by the spill, as well as a process to identify appropriate human use projects for funding. All of the selected projects are designed to restore, replace, or acquire the equivalent of the lost resources and/or their services through restorative on-the-ground actions. Furthermore, several of the projects address multiple resources. The projects were selected based upon the biological needs of the injured species and the feasibility of restoring the resources.

Under OPA, the responsible party is liable for the cost of implementing restoration projects, as well as the costs incurred by the Trustees to undertake this damage assessment. The Trustees settled their claim for natural resource damages with Plains. A summary of the injury to each resource category, the approximate allocation of damages and selected restoration projects are shown below. Web links to data used in the injury assessment can be found in Appendix B of the DARP/EA.

SHORELINE HABITATS $5.5 million

Injury: Trustees estimate that approximately 1,500 acres of shoreline habitat were impacted including sandy beach and rocky intertidal habitats.

Restoration: Remove Ellwood seawall, enhance black abalone populations, and restore degraded sand dune habitats.

SUBTIDAL AND FISH HABITATS $6.1 million

Injury: Trustees estimate that approximately 2,200 acres of benthic subtidal and fish habitat were impacted.

Restoration: Restore abalone populations in Marine Protected Areas, restore eelgrass beds in Refugio cove, restore sand-dwelling kelp offshore of Goleta Beach, and remove Ellwood seawall.

BIRDS $2.2 million

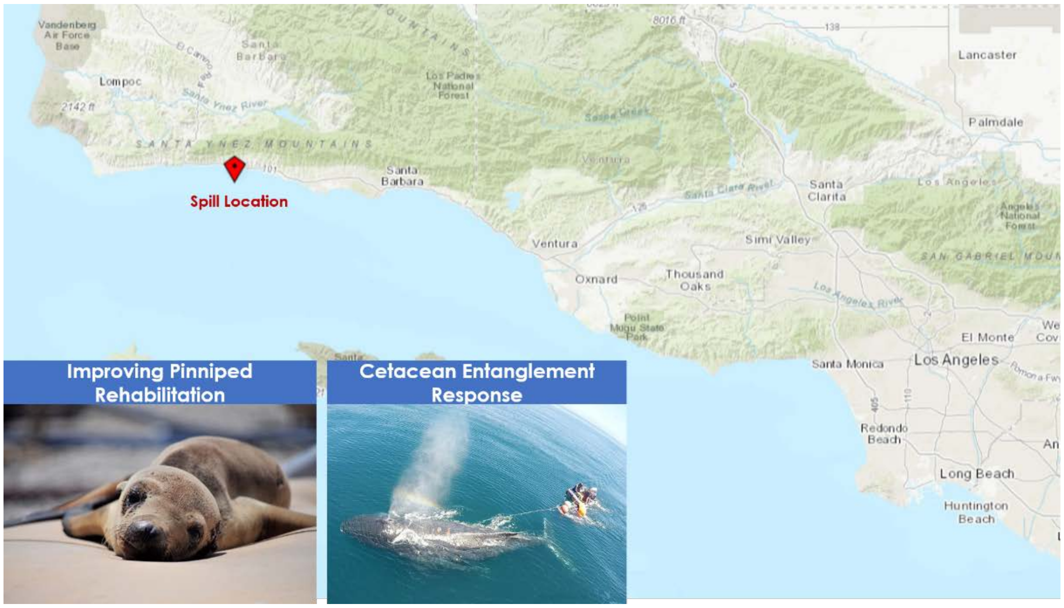
Injury: Trustees estimate 558 birds were killed, representing approximately 28 different species.

Restoration: Remove invasive plants from brown pelican nesting colonies on Anacapa Island, reduce seabird injuries from recreational fishing, and implement conservation actions for western snowy plovers.

MARINE MAMMALS $2.3 million

Injury: Trustees estimate 156 pinnipeds and 76 cetaceans were injured or killed.

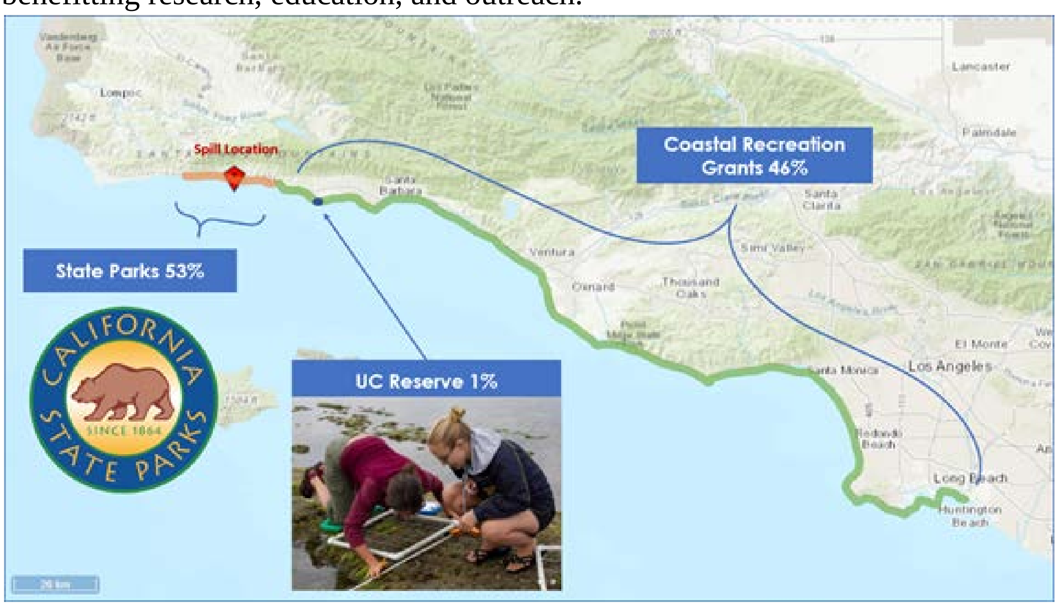
Restoration: Increase the capability to recover and rehabilitate marine mammals in distress in Santa Barbara and Ventura Counties, and increase the capability to respond to instances of cetacean entanglement in the Santa Barbara Channel.



HUMAN USE $3.9 million

Injury: Trustees estimate over 140,000 recreational user days were lost.

Restoration: Various projects to improve human recreation, to be administrated as follows - 53% to State Parks for projects benefitting camping or shore-based recreation including and upcoast of El Capitan State Beach; 46% for a grants program for projects downcoast of El Capitan State Beach, on non-State Parks lands benefitting coastal recreation as well as boating and off-shore recreation in Santa Barbara, Ventura, and Los Angeles Counties; and approximately 1% to Coal Oil Point Reserve for projects benefitting research, education, and outreach.



RESTORATION PLANNING, IMPLEMENTATION, AND OVERSIGHT $2.0 million

The Trustees have prepared this Final DARP/EA to inform the public about the natural resource damage assessment (NRDA) and restoration planning efforts that have been conducted following the spill. This document is also an Environmental Assessment (EA) intended to satisfy the Federal Trustees' requirement to evaluate the environmental impacts of the selected restoration projects, and the alternatives considered, under NEPA. As environmental review would be premature for some of the projects in the document, additional review may be required in some instances. This will be determined once recreational use projects are identified and/or when more detailed engineering design work or operational plans for the selected projects are available. To coordinate and oversee implementation of this DARP/EA, the Trustees have formed a Trustee Council comprised of representatives from each of the Trustee agencies. To submit questions or contact the Trustee Council, please use the following contact information:

Electronic Mail:

RefugioRestoration@fws.gov

U.S. Mail:

Refugio Beach Oil Spill Natural Resource Trustees
C/O Ventura Fish and Wildlife Office
2493 Portola Road, Suite B
Ventura, California 93003

Attn:
Michael Anderson, California Department of Fish and Wildlife
Jennifer Boyce, National Oceanic and Atmospheric Administration
Colleen Grant, U.S. Fish and Wildlife Service

Abbreviations

BLM	Bureau of Land Management
CDFW	California Department of Fish and Wildlife
CESA	California Endangered Species Act
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CSLC	California State Lands Commission
CSSC	California Species of Special Concern
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DARP	Damage Assessment and Restoration Plan
DOC	United States Department of Commerce
DOI	United States Department of the Interior
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FLAT	Federal Lead Administrative Trustee
FONSI	Finding of No Significant Impact
FWCA	Fish and Wildlife Coordination Act
GNOME	General NOAA Operation Modeling Environment
HEA	Habitat Equivalency Analysis
IBA	Important Bird Area
IEc	Industrial Economics, Inc.
LAT	Lead Administrative Trustee
MBTA	Migratory Bird Treaty Act
MMPA	Marine Mammal Protection Act
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NMSA	National Marine Sanctuaries Act
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollution Discharge Elimination System
NPFC	National Pollution Funds Center
NPS	National Park Service
NRDA	Natural Resource Damage Assessment
NWR	National Wildlife Refuge
ONMS	Office of National Marine Sanctuaries
OPA	Oil Pollution Act of 1990
OSPR	Office of Spill Prevention and Response
PAHs	Polycyclic aromatic hydrocarbons
REA	Resource Equivalency Analysis
RFP	Request for Proposals
RP	Responsible Party
SCAT	Shoreline Cleanup and Assessment Team
USFWS	United States Fish and Wildlife Service
UV	Ultraviolet light

Common and Scientific Names

Mammals and Other Vertebrates
Blue whale (*Balaenoptera musculus*)
California red-legged frog (*Rana draytonii*)
California sea lion (*Zalophus californianus*)
Common bottlenose dolphin (*Tursiops truncatus*)
Fin whale (*Balaenoptera physalus*)
Gray whale (*Eschrichtius robustus*)
Green turtle (*Chelonia mydas*)
Guadalupe fur seal (*Arctocephalus townsendi*)
Hawksbill turtle (*Eretmochelys imbricate*)
Humpback whale (*Megaptera novaeangliae*)
Leatherback turtle (*Dermochelys coriacea*)
Loggerhead turtle (*Dermochelys coriacea*)
Long-beaked common dolphin (*Delphinus capensis*)
Northern elephant seal (*Mirounga angustirostris*)
Northern fur seal (*Callorhinus ursinus*)
Pacific harbor seal (*Phoca vitulina*)
Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)
Short-beaked common dolphin (*Delphinus delphis*)
Southern sea otter (*Enhydra lutris nereis*)
Steller sea lion (*Eumetopias jubatus*)

Birds
American pipit (*Anthus rubescens*)
Ashy storm-petrel (*Oceanodroma homochroa*)
Belding's savannah sparrow (*Passerculus sandwichensis beldingi*)
Black-bellied plover (*Pluvialis squatarola*)
Black-crowned night heron (*Nycticorax nycticorax*)
Black phoebe (*Sayornis nigricans*)
Brandt's cormorant (*Phalacrocorax penicillatus*)
Brown pelican (*Pelecanus occidentalis*)
California gull (*Larus californicus*)
California least tern (*Sterna antillarum browni*)
Common loon (*Gavia immer*)
Ducks (Anatidae)
Forster's tern (*Sterna forsteri*)
Glaucous-winged gull (*Larus glaucescens*)
Horned grebe (*Podiceps auritus*)
Horned lark (*Eremophila alpestris*)
Light-footed Ridgeway's rail (*Rallus obsoletus levipes*)
Long-billed curlew (*Numenius americanus*)
Long-billed dowitcher (*Limnodromus scolopaceus*)
Marbled godwit (*Limosa fedoa*)
Mew gull (*Larus brachyrynchus*)
Red-throated loon (*Gavia stellata*)
Ring-billed gull (*Larus delawarensis*)
Royal tern (Thalasseus maximus)
Sanderling (*Calidris alba*)
Say's phoebe (*Sayornis saya*)
Scripp's murrelet (*Synthliboramphus scrippsi*)
Short-billed dowitcher (*Limnodromus griseus*)
Surf scoter (*Melanitta perspicillata*)
Western grebe (*Aechmorphorus occidentalis*)
Western gull (*Larus occidentalis*)
Western snowy plover (*Charadrius nivosus nivosus*)
Whimbrel (*Numenius phaeopus*)
White-winged scoter (*Melanitta fusca*)
Willet (*Tringa semipalmata*)
Yellow-rumped warbler (*Setophaga coronate*)

Fish
Anchovy (Engraulidae)
Barred surfperch (*Amphistichus argenteus*)
Blenny (*Blennioidei*)
Broomtail grouper (*Mycteroperca xenarcha*)
Cabezon (*Scorpaenichthys marmoratus*)
California corbina (*Menticirrhus undulates*)
California grunion (*Leuresthes tenuis*)
California sheephead (*Semicossyphus pulcher*)
Chinook "King" salmon (*Oncorhynchus tshawytscha*)
Coho "Silver" salmon (*Oncorhynchus kisutch*)
Croaker (Sciaenidae)
Garibaldi (Hypsypops rubicundus)
Giant "Black" sea bass (*Stereolepis gigas*)
Giant kelpfish (Heterostichus rostratus)
Gopher rockfish (*Sebastes carnatus*)
Grass rockfish (*Sebastes rastrelliger*)
Guitarfish (Rhinobatidae)
Halfmoon fish (*Medialuna californiensis*)
Kelp bass (*Paralabrax clathratus*)
Kelp rockfish (*Sebastes atrovirens*)
Leopard shark (*Triakis semifasciata*)
Northern anchovy (*Engraulis mordax*)
Opaleye (*Girella nigricans*)
Pacific halibut (*Hippoglossus stenolepis*)
Painted greenling (*Oxylebius pictus*)
Plainfin midshipman (*Porichthys notatus*)
Ray (Batoidea)
Sandab (*Citharichthys* spp.)
Scorpion fish (Scorpaenidae)
Señorita (*Oxyjulis californica*)
Silverside (Atherinidae)
Skate (Rajidae)
Smooth-hound shark (*Mustelus* spp.)

Sole (Soleidae)
Starry flounder (*Platichthys stellatus*)
Steelhead trout (*Oncorhynchus mykiss*)
Surfperch (Embiotocidae)
Tidepool sculpin (*Oligocottus maculosus*)
Tidewater goby (*Eucyclogobius newberryi*)
Topsmelt (*Atherinops affinis*)
Walleye surfperch (*Hyperprosopon argentuem*)
White seabass (*Atractoscion nobilis*)
White shark (*Carcharodon carcharias*)

Invertebrates
Acorn barnacle (*Balanus* spp.)
Bat star (Patiria miniata)
Beach hopper (*Megalorchestia* spp.)
Bean clam (*Donax gouldii*)
Black abalone (*Haliotis cracherodii*)
Bloodworm (*Thoracophelia mucronata*)
Bryozoan (Bryozoa)
California mussel (*Mytilus californianus*)
California spiny lobster (*Panulirus interruptus*)
Chiton (Polyplacophora)
Clam (Bivalvia)
Cup coral (*Balanophyllia elegans*)
Decorator crab (Majoidea)
Feather duster worm (Sabellidae)
Gastropod (Gastropoda)
Globose dune beetle (*Coelus globosus*)
Gooseneck barnacle (*Pollicipes polymerus*)
Hermit crab (Paguroidea)
Inshore “Market” squid (*Loligo opalescens*)
Isopod (Alloniscus perconvexus and Tylos punctatus)
Kelp fly (Diptera)
Keyhole limpet (Fissurellidae)
Limpet (Gastropoda)
Lined shore crab (*Pachygrapsus crassipes*)
Mole crab (*Emerita* spp.)
Nemertean worm (Nemertea)
Nudibranch (Nudibranchia)
Ochre sea star (*Pisaster ochraceus*)
Octopus (Cephalopoda)
Olive snail (*Olivella biplicata*)
Opheliid polychaete worm (Ophelia)
Pacific purple sea urchin (*Strongylocentrotus purpuratus*)
Periwinkle snail (*Littorina littorea*)
Pismo clam (Tivela stultorum)
Polychaete worm (Polychaeta)
Red abalone (*Haliotis rufescens*)
Red sea urchin (*Mesocentrotus franciscanus*)
Rock crab (*Cancer productus*)
Rove beetle (Staphylinidae)
Salp (Salpidae)
Sand castle “Honeycomb” worm (*Phragmatopoma californica*)
Sand crab (*Emerita analoga*)
Sand dollar (Echinodermata)
Sea anemone (Actiniaria)
Sea cucumber (Holothuroidea)
Sea hare (Anaspidea)
Sheep crab (*Loxorhynchus grandis*)
Shrimp (Dendrobranchiata and Caridea)
Sponge (Porifera)
Talitrid amphipod (*Megalorchestia* spp.)
Top snail (Trochidae)
Tunicate (Tunicata)
Turban snail (*Tegula funebralis*)
Whelk (Gastropoda)
White abalone (*Haliotis sorenseni*)
Plants and algae
Bladder chain kelp (*Stephanocystis osmundacea*)
Bladder kelp (*Sargassum muticum*)
Cape ivy (*Delairea odorata*)
Coast live oak (*Quercus agrifolia*)
Coralline algae (Corallina/Bossiella/Calliarthron spp.)
Cordgrass (*Spartina alterniflora* and *Spartina densiflora*)
Eelgrass (*Zostera pacifica*)
Feather boa kelp (*Egregia menziesii*)
Gaviota tarplant (*Deinandra increscens ssp. villosa*)
Giant kelp (*Macrocystis pyrifera*)
Grapestone seaweed (*Mastocarpus papillatus*)
Nailbrush seaweed (*Endocladia muricata*)
Palm tree (Arecaceae)
Red algae (*Prionitis* spp. and *Porphyra* spp.)
Rockweed (*Fucus distichus* and *Silvetia compressa*)
Sea lettuce (*Ulva lactuca*)
Surfgrass (*Phyllospadix* spp.)
Turkish-towel seaweed (*Chondracanthus* spp.)
Western sycamore (*Platanus racemose*)

Table of Contents

List of Appendices

1.0 Introduction and Purpose

The purpose of this Final Damage Assessment and Restoration Plan (DARP)/Environmental Assessment (EA) is to provide information to the public about the results of the Natural Resource Damage Assessment (NRDA) that was conducted to assess injuries to natural resources that were caused by the Refugio Beach Oil Spill. This document further describes the selected restoration projects to restore habitats and natural resources affected by the spill and compensate for interim losses of natural resources and their services from the date of the incident until recovery. A list of second tier restoration projects are also identified, should any selected restoration projects become infeasible or funded by other entities. The document incorporates feedback provided through the public comment process. A full summary of public comments received on the Draft DARP/EA and the Trustees’ responses to those comments can be found in Appendix O. The document also serves as an Environmental Assessment under the National Environmental Policy Act (NEPA) evaluating the potential effects to the environment from implementing the selected restoration projects.

1.1 Overview of the Incident

On May 19, 2015, a 24-inch diameter buried pipeline known as Line 901, owned and operated by Plains All American Pipeline, L.P., and Plains Pipeline, L.P. (jointly, Plains), ruptured in Santa Barbara County, California, in the vicinity of Refugio State Beach. Line 901 transported heated crude oil extracted from deep subsea formations at several offshore platforms. As a result of the rupture, an estimated 2,934 barrels (123,228 gallons) of heavy crude oil were released from the pipeline (U.S. DOT 2016). A significant portion of the oil reached the Pacific Ocean at Refugio State Beach after flowing through culverts and across several upland areas (Figure 1). The incident is referred to throughout this document as the Refugio Beach Oil Spill or the “spill.”

Plains initially estimated that approximately 2,400 barrels (100,800 gallons), of crude oil were spilled and that 500 barrels (21,000 gallons) reached the ocean (U.S. DOT 2016). The total volume released from the pipeline was later revised to 2,934 barrels (123,228 gallons) (U.S. DOT 2016). Subsequently, consultants for Plains increased the estimate of oil reaching the ocean to 598 barrels (25,116 gallons). An analysis on behalf of the Trustees concluded that as much as 1,262 barrels (53,000 gallons) of oil reached the ocean (Baker 2018).

Within hours of the spill, based on recommendations from the California Office of Environmental Health Hazard Assessment (OEHHA), the California Department of Fish and Wildlife (CDFW) initiated a fishery closure in the vicinity of the spill. The following day, Governor Edmund G. Brown, Jr., declared a state of emergency for Santa Barbara County. Several beaches in Santa Barbara County were closed to the public, including Refugio and El Capitan State Beaches (described further in Section 5.5). On May 21, 2015, the fishery closure was expanded along the shore and offshore out to 6 miles, encompassing a total area of 138 square miles, based on aerial observations and National Oceanic and Atmospheric

Administration (NOAA) oil spill trajectory models of where the oil was likely to move (OEHHA 2015). The fishery closure ended on June 29, 2015 (OEHHA 2015).

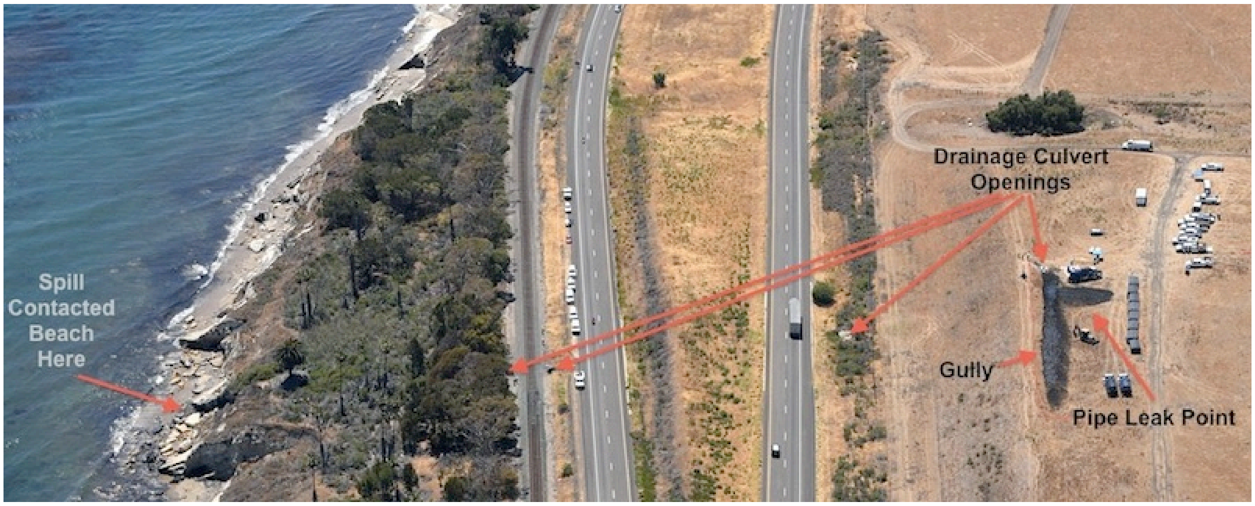


Figure 1. Flow path of the Line 901 pipeline rupture into culverts under Highway 101 and railroad tracks and ultimately into the Pacific Ocean at Refugio State Beach. Credit: John Wiley (http://flickr.com/jw4pix)

The crude oil smothered and soaked into terrestrial areas along the pathway from the pipeline rupture to the site where the oil entered the ocean, a short distance west of Refugio Cove (Figure 1). The shorelines from the release point, within Refugio State Beach to El Capitan State Beach, received the heaviest coastal oiling. Shorelines downcoast as far as Long Beach were intermittently oiled with tarballs and subject to beach closures, with the level of oiling generally decreasing farther away from the release point. Subtidal habitats in the vicinity of the release point also experienced oil exposure.

In the days after the spill, ocean surface currents and strong afternoon winds carried oil mostly downcoast, although some oil was deposited on beaches upcoast of the release site.

Marine organisms, including plants, invertebrates, fish, birds, and mammals, were exposed to oil. In addition to direct natural resource impacts, the closure of beaches and fisheries occurred just days before the Memorial Day weekend resulting in lost opportunities for the public to visit and enjoy the shore and offshore areas after the spill. Floating oil attributed to Line 901 was identified 17 km southwest of the release site, and more than 8 miles offshore (Valentine 2017). Tarballs attributed to the Line 901 release were identified as far south as Los Angeles County, more than 100 miles from the release site, where there were additional beach closures.

1.1.1 Cleanup Operations

The spill brought together many federal, state, and local agencies for cleanup operating under a Unified Command. For the spill response, the Incident Commanders consisted of representatives of the USCG, CDFW-OSPR, Santa Barbara County, and Plains[2]. Throughout the response, the incident received high interest from news media, legislators, non-governmental organizations, members of the public, and other stakeholders.

The Unified Command conducted a phased approach to oil spill cleanup, in accordance with the National Oceanic and Atmospheric Administration's Shoreline Assessment Manual that provides for defined cleanup processes and goals for each cleanup phase. The cleanup effort completed Phase I "active cleanup and gross oil removal" on August 31, 2015, and completed Phase II "refined oil cleanup endpoints for shorelines targeting maximum net environmental benefit" on January 22, 2016 (U.S. Coast Guard 2016). Phase III monitoring activities were largely concluded on May 26, 2016, and the Unified Command was disestablished on March 10, 2017 (U.S. Coast Guard 2017).

The majority of the response effort was focused on minimizing environmental and cultural site damage and maximizing the recovery of discharged oil. Oil spill response operations were divided into three areas including an Inland Branch, Shoreline Branch, and On-water Branch.

The Inland Branch included the discharge site and pathway of oil to the Pacific Ocean. Inland branch response operations included oil recovery and removal, pipeline excavation, contaminated soil removal, contaminated vegetation removal, community and responder air monitoring, and oil sampling from the source of discharge.

The Shoreline Branch addressed oil in the path of discharge from the top of a cliff down to the beach and along 96 miles of affected shoreline. Response teams applied manual and mechanical recovery methods, primarily removal and disposal of oiled sand, wrack, and marine organisms. Removal of oil from rock was accomplished with scrapers or wire brushes. In some areas, dry ice was also used in conjunction with compressed air to freeze oil on rocks, allowing it to flake off more easily. In other areas, oiled cobble was placed in the surf zone to be scrubbed clean by wave action and tumbling amongst other cobble. Other operations included community and responder air monitoring, oil sampling, and wildlife recovery, rehabilitation, and release.

The On-water Branch addressed recoverable oil in offshore waters affected by the spill. On-water response operations included the use of oil containment and protection boom, skimmers, and oil recovery vessels. Local private vessels were also enlisted to assist with removal of oil from the marine environment.

[2] The National Contingency Plan calls for the Responsible Party, in this case Plains, to be a member of the Unified Command; ref. 40 CFR 300.135(d).

Staff responsible for conducting reconnaissance, recovery, and rehabilitation for wildlife exposed to Line 901 oil throughout the response area were organized and deployed through a Wildlife Branch that operated throughout the spill-affected area.

1.1.2 Transport and Fate of the spilled Oil

Line 901 oil coated shores predominantly downcoast for several miles from the release site within hours of the spill, primarily due to along-shore transport of the oil by currents, surge and surf action. While there are known active natural off-shore oil seeps in the spill vicinity, virtually all oil observed in the area from the release point to El Capitan in the days immediately after the spill, was from the Refugio Beach Oil Spill. Oil was also transported offshore by currents, surge action and wind drift and was observed during Unified Command overflights between May 20 and June 3 (Figure 3). Over time, oil from the spill spread farther offshore and downcoast, and in the days and weeks after the spill, light to moderate shoreline oiling, largely in the form of tarballs, occurred much farther away from the spill site. By May 28 unusually heavy tar ball stranding was reported in Ventura County near Oxnard. Soon after, unusually heavy depositions of tar balls were reported at several beaches near Redondo and Manhattan Beaches in Los Angeles County. The presence of stranded oil along some Los Angeles County beaches was heavy enough that several beach closures were declared by County officials, and a separate Unified Command was established in Los Angeles to respond to the oiling.

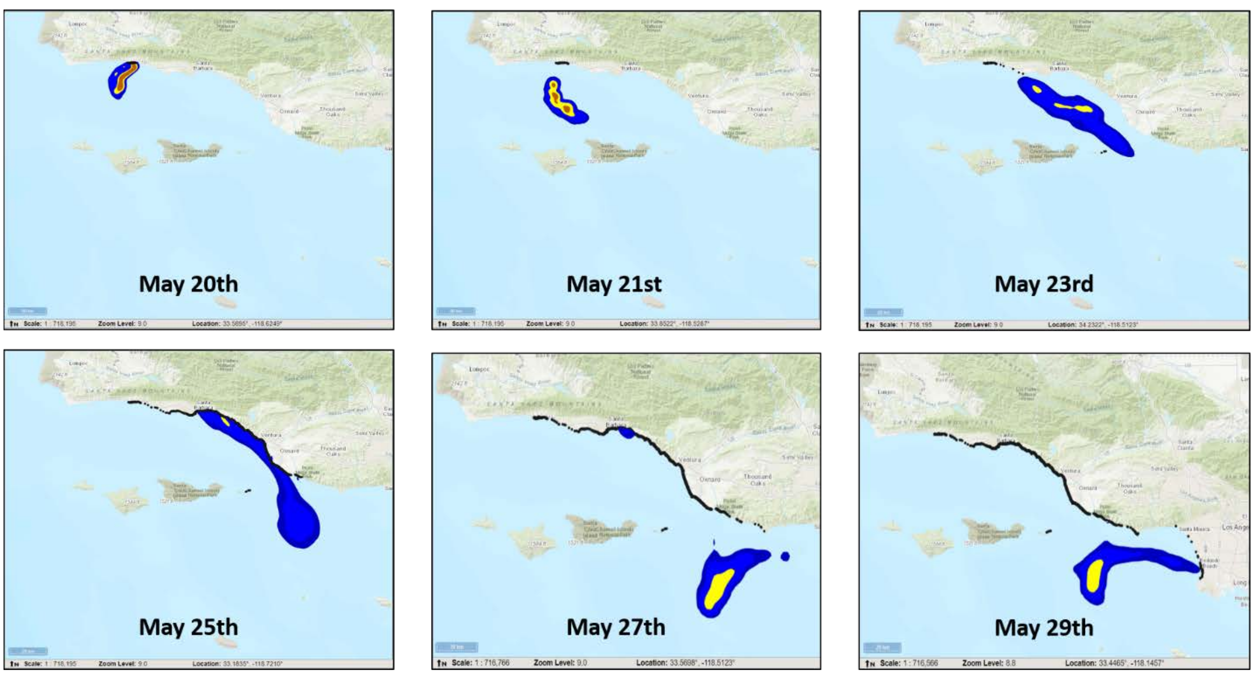


Figure 2. Results of hindcast modeling that shows the simulated oil transport trajectory based on the spill origin, winds, and currents that occurred between May 19, 2015 and May 29, 2015. The colors represent particle density, with red/orange being the highest density, yellow moderate density, and blue low density. See Appendix B for data associated with this figure.

To further understand and illustrate the transport and fate of spilled Line 901 oil, NOAA performed hindcast modeling using the General NOAA Operation Modeling Environment (GNOME). GNOME is an oil spill trajectory model in which the surface oil is divided into a large number of small particles of equal mass that move under the influence of surface ocean currents, wind drift, and horizontal mixing from the time of the spill. GNOME also includes algorithms that simulate surface oil weathering, e.g., evaporation and dispersion. GNOME modeling snapshots (Figure 2) show Line 901 oil moving into the Santa Barbara Channel May 20, 2015 and May 21, 2015, transiting the waters of the Channel Islands National Marine Sanctuary, but no particles reached the Channel Island shores. Rather, the particles move east, making landfall on the Ventura coast about May 25, 2015 with subsequent deposition by May 29, 2015 in Los Angeles County. More information on the GNOME modeling can be found in Appendix A.

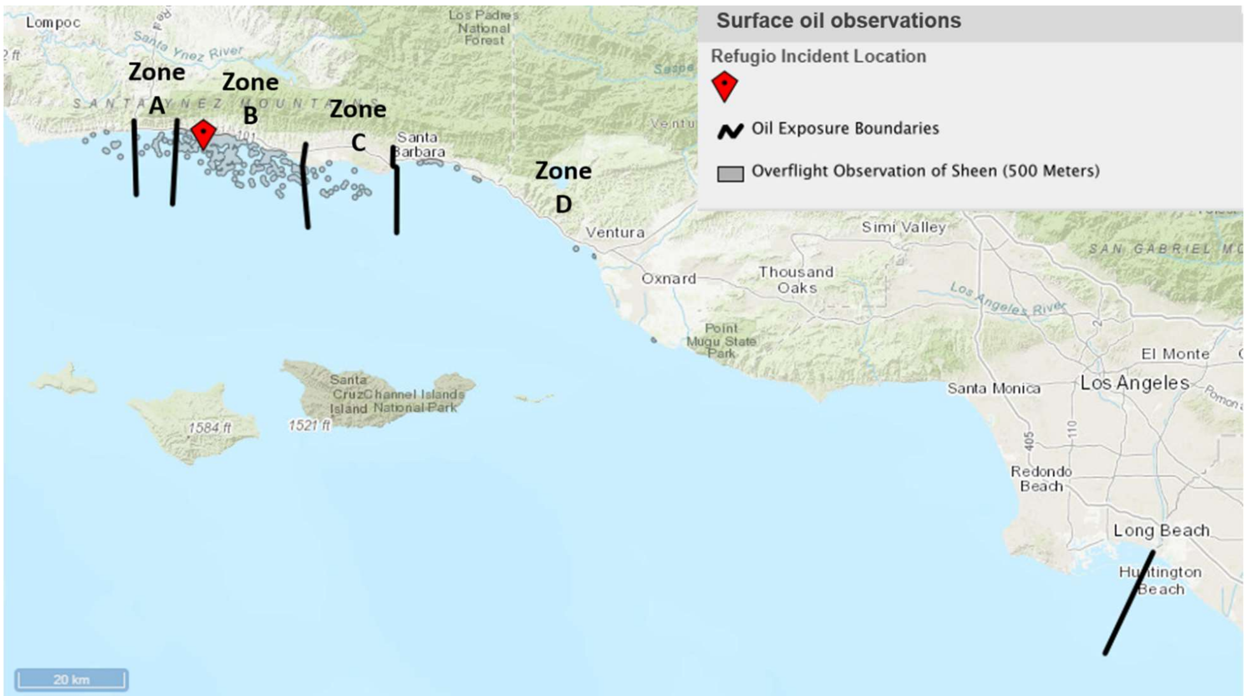


Figure 3. Map showing total U.S. Coast Guard overflight observations of surface oil over a 14 day period between May 21, 2015 and June 3, 2015. Note that the representations of sheen in this graphic are cumulative, i.e., oil was not in all of these locations at any given time. See Appendix B for data associated with this figure.

Line 901 oil was also transported downward through the water column due to mixing in the nearshore environment and the surf zone. Submerged oil was observed at several locations between May 22, 2015 and June 2, 2015 by UCSB and other entities. Of the oil observed, seven samples were collected and analyzed forensically, five of the samples matched Line 901 oil (Valentine 2019). The Unified Command undertook a submerged oil survey on May 29, 2015 through May 30, 2015 and reported no recoverable submerged oil. Oil may have been mixed with sediment through the surf action and was subsequently redistributed along the bottom and surface through sinking, tidal action, and surf transport. Based on general oceanographic conditions in the area vertical mixing of oil droplets and dissolved oils is estimated to occur to a depth of approximately 14 meters (Appendix A).

1.1.3 Forensic Identification of Line 901 Oil in the Environment

There are active, well-studied natural oil seeps in the region where the Refugio Beach Oil Spill occurred (Lorenson et al. 2009; Lorenson et al. 2011). These seafloor seeps release oil and gas that float to the ocean surface and periodically strand on regional shorelines, generally in the form of tar balls. Thus, not all of the oil evident in the region in the aftermath of the initial spill came from the Line 901 pipeline.

Spilled Line 901 oil can be distinguished from natural seep oil by using specialized chemical fingerprinting techniques[3]. In the days after the spill, hundreds of oil samples were collected from Santa Barbara, Ventura, Los Angeles, and Orange Counties. Selected samples were analyzed and forensically interpreted by experts working on behalf of the Natural Resource Trustees (Trustees), as well as by several other laboratories and experts engaged by the Unified Command and independently by Plains (Valentine 2015; Jeffrey 2016; Stout 2016; Stout et al. 2018). Oil samples collected from the ocean surface and from beaches were determined in some cases to be from Line 901, in other cases to be from known natural seeps, and in some cases to have characteristics of both, implying they were mixtures of natural seep and spilled oil.

After careful investigation, the Trustees concluded that oil from the Refugio Beach Oil Spill was deposited intermittently on shores from Gaviota State Park in Santa Barbara County to Los Angeles County (Figure 4). For purposes of the NRDA, the furthest southern extent of the spill was determined to be Long Beach based on beach closures.

Figure 4. Geographic extent of Line 901 oil. This Figure shows oil samples collected and analyzed on behalf of the Trustees through June 2, 2015 when the Trustees' trajectory modeling suggests that oil would have moved through the impacted area. This does not include samples collected by the response and analyzed for the criminal investigation. In People of the State of California v Plains All American Pipeline, L.P., Sup. Court of State of California, County of Santa Barbara, Case No. 1495091, People's Trial Exhibit 078.0001 oil was documented as far south as Seal Beach in Orange County. See Appendix B for data associated with this figure.

[3] Plains does not agree.

1.2 NRDA Overview

There are typically four types of claims that are made against responsible parties in an oil spill such as this one:

1. reimbursement for cleanup costs;
2. natural resource damages (including the costs of assessment);
3. fines and penalties under various laws; and
4. third-party claims (e.g. from non-government parties, such as commercial fisheries and affected businesses).

This document is only concerned with the second item, natural resource damages. This Damage Assessment and Restoration Plan and Environmental Assessment (DARP/EA) has been prepared by state and federal natural resource Trustee agencies responsible for restoring natural resources[4] and resource services[5] injured by the release of oil from the May 19, 2015, Refugio Beach Oil Spill. This document provides details regarding:

- Environment affected by the spill (Section 2);
- Coordination and compliance among the government agencies and responsible party (Section 3);
- Injury quantification and restoration planning methods (Section 4);
- Nature and scope of injuries and the quantification of those injuries (Section 5);
- Selected restoration projects to address the injuries (Section 5); and
- NEPA alternatives analysis (Section 6).

Consistent with the Oil Pollution Act (OPA) and the National Environmental Policy Act (NEPA), 42 U.S.C. § 4321, et seq., the purpose of restoration planning is to identify and evaluate restoration alternatives and to provide the public with an opportunity for review and comment on the proposed restoration alternatives. Restoration planning provides the link between injury and restoration. The purpose of restoration, as stated in this DARP/EA, is to make the environment and the public whole for injuries resulting from the spill by implementing restoration actions that return injured natural resources and services to baseline conditions and compensate for interim losses.

United States Department of Commerce represented by the National Oceanic and Atmospheric Administration (NOAA); the United States Department of the Interior represented by the U.S. Fish and Wildlife Service (USFWS), National Park Service (NPS), and Bureau of Land

[4] Natural resources are defined under the Oil Pollution Act as "land, fish, wildlife, biota, air, water, groundwater, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States, any State or local government or Indian tribe, or any foreign government." 33 U.S.C. §2701(20).

[5] Services (or natural resources services) means the functions performed by a natural resource for the benefit of another natural resource and/or the public.

Management (BLM); the CDFW-OSPR; the California Department of Parks and Recreation (CDPR); the California State Lands Commission (CSLC); and the Regents of the University of California are the Trustees who are addressing the natural resources injured by the spill. As a designated Trustee, each agency is authorized to act on behalf of the public under state and/or federal law to assess and recover natural resource damages and to plan and implement actions to restore, rehabilitate, replace, or acquire the equivalent of the affected natural resources injured by a discharge of oil. For purposes of coordination and compliance with OPA and NEPA, NOAA is designated as the lead federal Trustee.

The Trustees have prepared this DARP/EA to inform the public about the NRDA and restoration planning efforts that have been conducted following the spill. This document is also an EA intended to satisfy the Federal Trustees' requirement to evaluate the environmental impacts of the selected restoration projects under NEPA. As full environmental review would be premature for some of the selected projects in the document pending development of sufficient project-level detail. This will be determined once detailed engineering design work or operational plans are developed for those projects.

1.3 Summary of Natural Resource Injuries

The injuries from the oil spill can be divided into the following categories: shoreline habitats, subtidal and fish habitats, birds, marine mammals, and human uses. The injuries to each category are summarized here (Figure 5) and presented in greater detail in Section 5.

- **Shoreline Habitats**: The Trustees estimate approximately 1,500 acres of shoreline habitat were impacted including sandy beach and rocky intertidal habitats.
- **Subtidal and Fish Habitats**: The Trustees estimate approximately 2,200 acres of benthic subtidal habitat were impacted.
- **Birds:** The Trustees estimate 558 birds were killed, representing over 28 different species. The primary species impacted were brown pelicans, representing 57% of the total estimated mortality. Western snowy plovers were also impacted through effects to reproduction the year after the spill, following oil exposure.
- **Marine Mammals**: The Trustees estimate that 156 pinnipeds (94% California sea lions, 5% northern elephant seals and 1% Pacific harbor seals) and 76 cetaceans (95% long-beaked common dolphins and 5% common bottlenose dolphins) were injured or killed by the spill.
- **Human Uses**: The Trustees estimate over 140,000 lost recreational user days in Santa Barbara and Ventura Counties; six days of beach closures in Los Angeles County; and lost research, education, and outreach opportunities at the University of California, Santa Barbara Coal Oil Point Natural Reserve. Affected recreational activities included camping, sunbathing, beach combing, exercising, swimming, wildlife viewing, fishing, diving, boating and surfing.

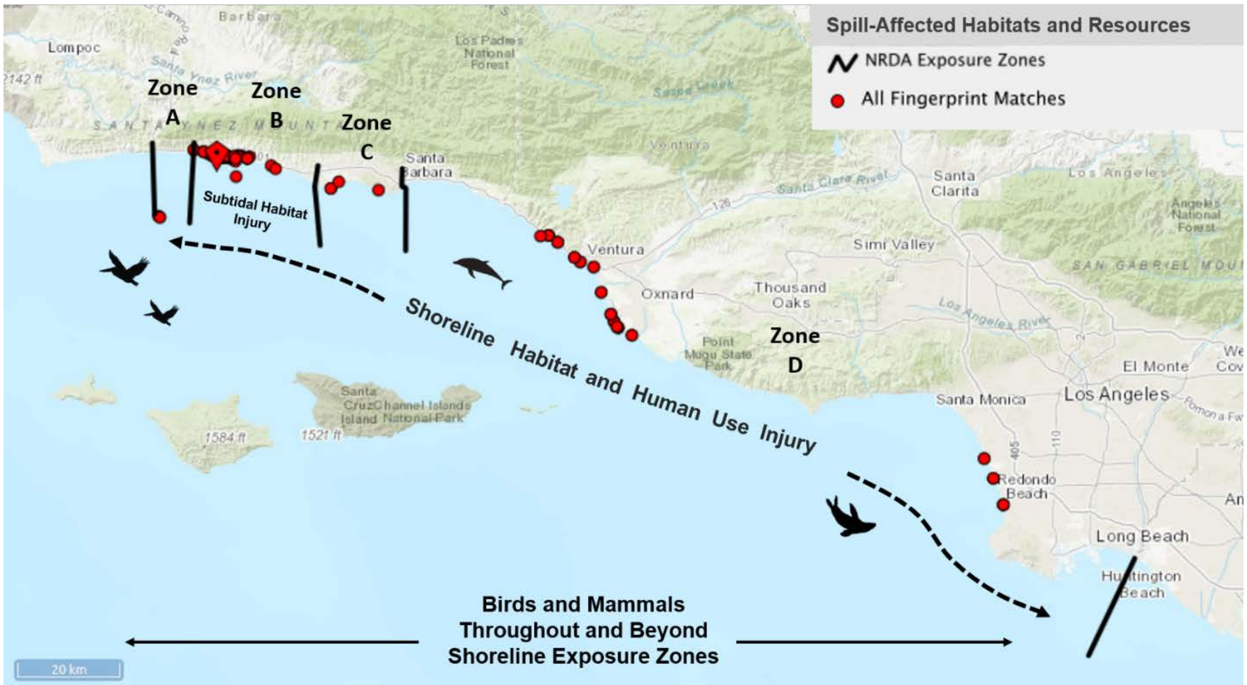


Figure 5. Refugio Beach Oil Spill fingerprint matches (red circles) along with the habitats and resources that were injured by the spill. See Appendix B for data associated with this figure.

1.4 Summary of Selected Restoration Projects

The Trustees' mandate under OPA (see 33 U.S.C. 2706(b)) is to make the environment and the public whole for injuries to natural resources and natural resource services resulting from the discharge of oil. This requirement must be achieved through the restoration, rehabilitation, replacement, or acquisition of equivalent natural resources and/or services. Thus, for a project to be considered there must be a connection, or nexus, between the natural resource injuries and the proposed restoration actions.

Compensatory restoration is any action taken to compensate for interim losses of natural resources and services pending recovery to baseline conditions. The scale, or amount, of the required compensatory restoration will depend on the extent and severity of the initial resource injury and how quickly each resource and associated service returns to baseline. Primary restoration actions that speed resource recovery will reduce the amount of required compensatory restoration.

The Trustees considered restoration concepts and alternatives with the potential to provide compensatory restoration. These were evaluated based on selection criteria developed by the Trustees, consistent with the legal guidelines provided in the OPA regulations (15 C.F.R. 990.54(a)). Section 4.2 presents OPA-based selection criteria developed by the Trustees for the spill. Based on the Trustees' evaluation, and after considering public comments on the Draft DARP/EA, a suite of preferred restoration projects were selected and are summarized below.

Additional details on all projects that met the threshold screening criteria are presented in Section 5.

The Trustees have grouped the injuries into categories, sometimes combining impacts to similar species. In this way, one restoration project, benefiting a suite of species or one primary species, may address all injuries for that category. In accordance with OPA, all of the selected projects have been "scaled" in size, such that the benefits of the restoration offset the injuries caused by the spill. Summaries of the selected restoration projects are provided below. More details on the projects are provided in Section 5.

Under OPA, the responsible party is liable for the cost of the compensatory restoration projects, as well as the costs incurred by the Trustees to undertake this damage assessment. The Trustees have settled this claim for natural resource damages with the responsible party for $22.3 million. The following amounts are allocated to fund the projects described in this document:

Shoreline Habitats $5.5 million

- Remove the Ellwood seawall that is currently constraining natural functioning condition of sandy beach and subtidal habitats;
- Restore black abalone populations to enhance the overall health of rocky intertidal habitats; and
- Restore degraded sand dune habitats by removing invasive/non-native vegetation, and/or precluding disturbance to sensitive areas to allow native dune vegetation to regrow.

Subtidal and Fish Habitats $6.1 million

- Restore abalone populations in Marine Protected Areas along the Gaviota coast to enhance the overall health of subtidal habitats;
- Restore eelgrass beds on the Gaviota Coast to enhance overall health of subtidal habitat; and
- Extend a pilot project for restoring sand-dwelling kelp offshore of Goleta Beach to determine the feasibility of this novel method for restoring kelp forests.

Birds $2.2 million

- Remove invasive plants from brown pelican nesting colonies on Anacapa Island to prevent these important breeding sites from becoming unsuitable for nesting;
- Reduce seabird injuries from recreational fishing; and
- Implement conservation actions for western snowy plovers at Coal Oil Point Reserve to protect and enhance breeding success.

Marine Mammals $2.3 million

- Increase the capability to recover and rehabilitate marine mammals in distress in Santa Barbara and Ventura Counties to increase survivorship of pinnipeds; and
- Expand the capacity to respond to instances of cetacean entanglement in the Santa Barbara Channel to increase survivorship of entangled cetaceans.

Human Use $3.9 million

- Restoration funds (53%) to be administered by State Parks for use on projects benefiting camping and shore-based recreation from Gaviota State Park to El Capitan State Beach;
- Restoration funds (46%) to be administered by State Trustees for use on projects outside of State Park property benefiting coastal recreation in Ventura County, Los Angeles County, and Santa Barbara County downcoast of El Capitan State Beach; and
- Restoration funds (approximately 1%) to be administered by the University of California for use on projects benefiting research, education, or outreach at the Coal Oil Point Reserve.

The remaining funds will be used by the Trustees for restoration planning and oversight. Any unused funds will be allocated toward one or more projects described in this document, or identified through further project scoping.

2.0 Affected Environment

This section presents a brief description of the physical, biological, and cultural environment affected by the oil spill.

The physical environment considered in the NRDA encompasses approximately 155 miles of shoreline from Gaviota to Long Beach, as well as the Santa Barbara Channel, and supports a rich diversity of coastal and marine species[6]. Many areas within the affected environment are protected by state or federal designations to preserve the biological integrity of the habitat, while other areas are available to the public for recreation. The affected environment also is home to a wide variety of culturally and historically important resources.

This section also provides information on the affected environment for the preferred restoration projects which are located within the general spill-affected area. For restoration projects that occur outside of the spill-affected area, information on the affected environment is provided along with the project descriptions in Section 5.

2.1 Physical Environment

This subsection describes the physical setting of the coastal areas affected by the Refugio Beach Oil Spill, including areas where restoration projects are proposed. The geographical extent of the physical environment described herein extends from Gaviota to Long Beach.

2.1.1 Climate

The atmospheric climate in the region is generally, consistently mild and considered Mediterranean-like. Winters are rainy and summers are dry, and predominant coastal breezes suppress wide air temperature changes. Air temperatures generally range between the mid-60s and mid-70s (16-21°C). The years 2015 and 2016 were characterized by El Niño conditions, officially beginning in March 2015. El Niño conditions in southern California typically mean increased precipitation in the winter and higher sea surface temperatures (NOAA 2016; SCCOOS 2019).

2.1.2 Land Use and Geology

The spill originated at Refugio State Beach, in an area known as the "Gaviota Coast" which is one of southern California's largest remaining continuous stretches of undeveloped rural coastline. As described in the Gaviota Coast Plan, the Gaviota Coast includes the shoreline between Vandenberg Air Force Base to the west and Coal Oil Point to the east (Figure 6). It is world renowned as a biodiversity hotspot and one of the most ecologically diverse regions on the planet. The Gaviota Coast Plan, developed by Santa Barbara County, describes natural resources in the area. The Plan is intended to preserve the rural character of Gaviota by protecting and

[6] Not all areas within this physical environment were impacted by the spill.

enhancing its varied and unique natural and cultural resources, agricultural productivity, and by enhancing public recreation and access consistent with the capacity of its resources. Downcoast from Gaviota, beginning with the cities of Goleta and Santa Barbara and extending into Ventura County, the majority of the land use is residential, light commercial, and agricultural, with areas of undeveloped open space. The spill-affected area extends into Los Angeles County, from Santa Monica to Long Beach, which is heavily populated, developed, and industrialized.

The coastal terrestrial landscapes are equally significant, diverse, and rare, representing a high degree of endemism. They include such diverse vegetation alliances as active coastal fore dunes, coastal terrace prairie, and northern coastal salt marsh. The shoreline and offshore physical environment are typically sandy beaches and submerged sandy seabed, but also include boulder cobble fields and rock bench platforms in the intertidal and subtidal rocky reefs in the nearshore area. The Gaviota Coast also includes tidally influenced lagoons, harbors, and jetties. Because of the range of habitats, the marine biodiversity in the region is high.

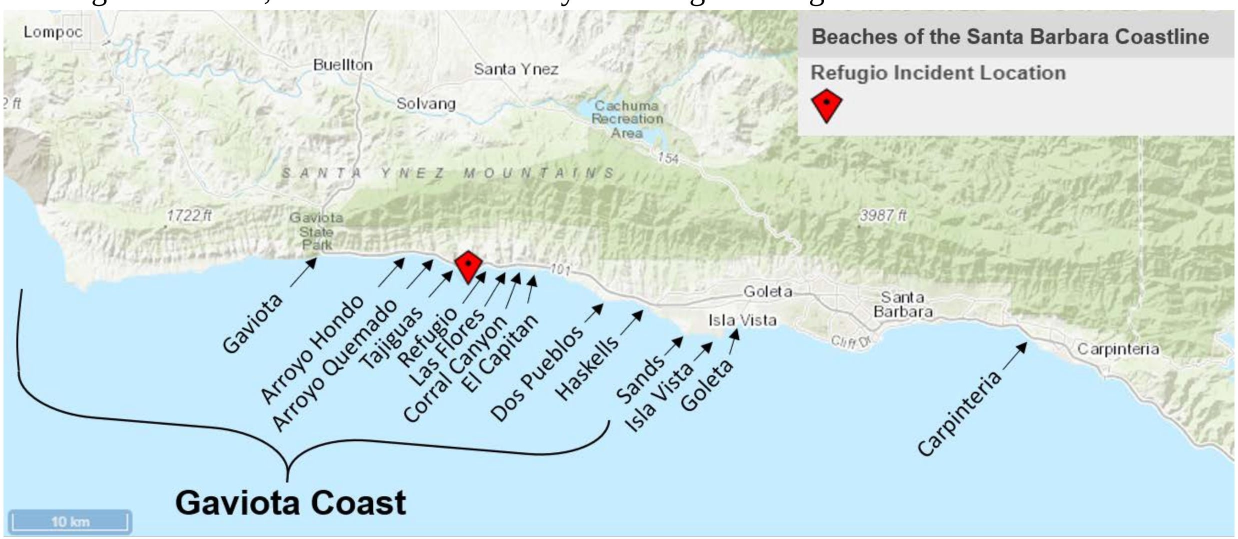


Figure 6. The location of the spill origin and various Trustee post-spill study sites along the Santa Barbara Coastline.

2.1.3 Ocean Waters

The waters offshore of the mainland comprise the Santa Barbara Channel with surface seawater temperatures typically ranging from about 54°F (12°C) in spring to about 66°F (19°C) in fall. The Channel is oriented east-west, extending from Point Conception to Ventura and bounded on the north side by the mainland coast and on the south side by the northern Channel Islands (San Miguel, Santa Rosa, Santa Cruz, Santa Barbara, and Anacapa). The Santa Barbara Channel is where the California Current of cold water flowing south meets and mixes with the warmer water of the Davidson Current flowing north. The convergence and mixing in the marine region tends to occur as a counterclockwise gyre or eddy in the Channel (Nishimoto and Washburn 2002). As a result, the Santa Barbara Channel is a transition zone where the composition of many groups of marine species (fishes, invertebrates, and algae) shifts from species typically associated with the cooler waters north of Point Conception to species typically associated with the warmer waters south of Point Conception. The Channel area can thus be recognized as a dividing line between two bioregions that represent geographically distinct ecological systems, the Oregonian Province from Point Conception northward and the San Diegan Province from Point Conception southward (Stephens, et.al. 2016). The fact that the affected area overlaps with the transition region in the Santa Barbara Channel underscores the importance of this section of the California coastline being unique for its diversity and sensitivity to environmental changes.

Unusual ocean weather and climate patterns were observed throughout 2014 and 2015 across the North Pacific basin. An area of the North Pacific from Alaska into California was as much as 5°C (9° F) warmer than average. This atmospheric anomaly nicknamed “the blob,” due to its amoeba-like form, impacted oceanic productivity and food availability for marine life in some areas. In addition, El Niño conditions, which strengthened in early March 2015, are also associated with warmer sea surface temperatures.

2.1.4 Petroleum Seeps

Natural oil seeps are common in the area (Hornafius et al. 1999; Lorenson et al. 2009). For example, the seep field just offshore from Coal Oil Point in Goleta extends over approximately one square mile. These seeps slowly release weathered oil from fractures in the ocean floor. Because of the slow nature of seep oil traveling through the ocean floor substrate before making its way into the water column, some of the volatile, more toxic, components of seep oil dissipate before the oil reaches the ocean surface. At the surface, the oil continues to weather, forming tarballs generally less than one centimeter (0.4 inches) in diameter that may be moved by winds and currents to strand on the shoreline (Del Sontro 2007). The weathered nature and pattern of slow release of seep oil poses a lower exposure risk to marine life and has a lower acute toxicity than fresh oil that contains more toxic fractions. In contrast, during an oil spill, the amount of more toxic fresh oil released from a point source in a short time can overwhelm an ecosystem (National Research Council 2003).

In 1969, an oil spill occurred five miles off the coast of Summerland from a blow-out at Union Oil Platform A. Over 3,000,000 gallons (11 million liters) of crude oil was released that mainly affected the area from Gaviota to Carpinteria. Some oil from the spill was detected as far north as Pismo Beach, located approximately 75 miles (121 km) north from the spill point (straight line distance), and as far south as Mexico located approximately 200 miles (322 km) south from the spill point (straight line distance). At that time, this was the largest oil spill in U.S. history, and is credited as having catalyzed the U.S. environmental movement.

2.2 Marine and Coastal Managed and Protected Areas

Several Marine Protected Areas (MPAs) occur near or within the general area affected by the spill from Point Conception to Ventura. MPAs are protected areas of ocean where human activity, such as fishing, is restricted for conservation purposes. MPAs come in a variety of forms that include National Marine Sanctuaries and State Marine Protected Areas. MPAs are a versatile management tool for helping to maintain biological diversity and productivity, rebuild fishery stocks, support sustainable fisheries, and conserve and protect historical and cultural artifacts. In addition, the Channel Islands National Park and portions of the California Coastal National Monument provide protected habitat for resources in the area. Finally, public beaches, including high use beaches were affected by the spill (Figure 7).

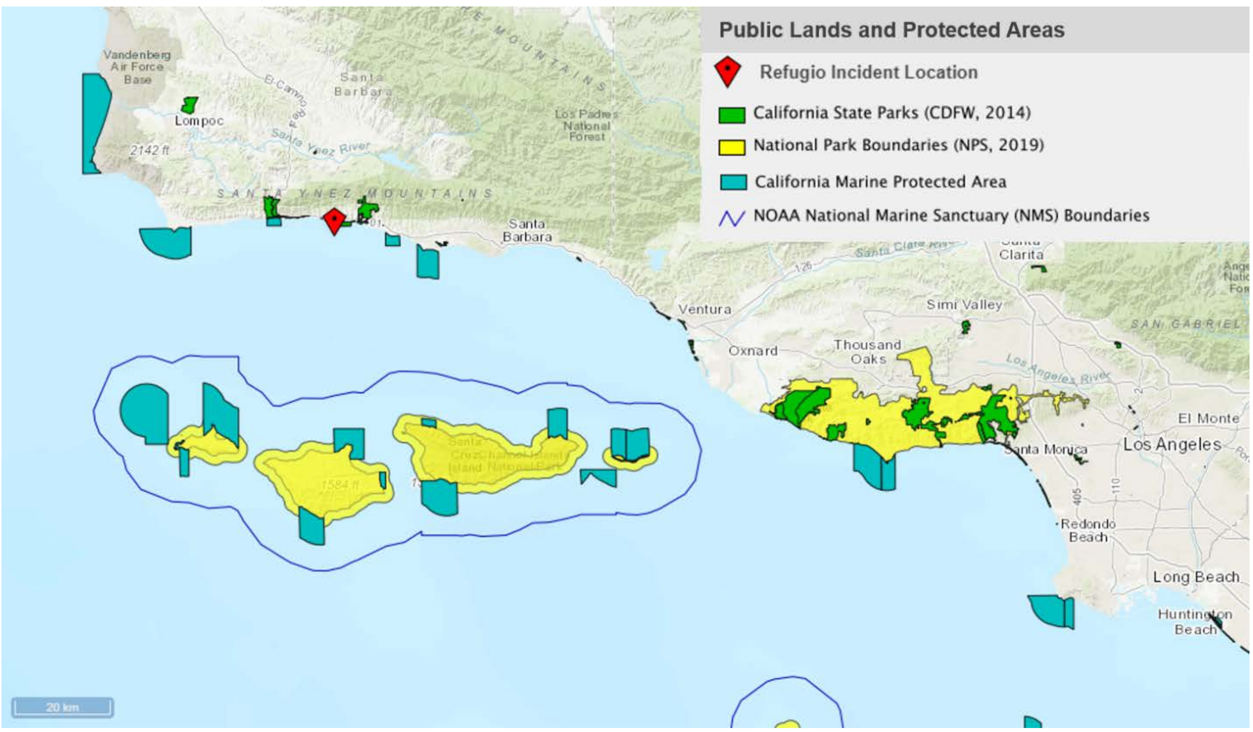


Figure 7. Public lands and protected areas in the vicinity of the Refugio Beach Oil Spill origin. Additional public lands managed by Counties and Cities occur in the area but are not shown on this map. See Appendix B for data associated with this figure.

2.2.1 County and City Beaches

Several County and City beaches were affected by the spill within Santa Barbara, Ventura, and Los Angeles Counties. For example, Goleta Beach Park is a day use facility managed by the Santa Barbara County Parks. It is located on a section of sand beach east of the University of California, Santa Barbara (UCSB). Amenities include a fishing pier, picnic tables, BBQs, trails, grass park, play areas, restaurant, and launch/hoist for small boats at the end of the pier. Isla Vista Beach at Isla Vista is used extensively by UCSB students and the community. Haskell’s Beach (previously known as Tecolote Canyon Beach) is a high public use beach and surfing area in the City of Goleta. City and County beaches within Ventura and Los Angeles Counties are frequently used as recreation access points for surfing, fishing, diving, boating, and general beach use.

2.2.2 University of California Santa Barbara Natural Reserve System

The Coal Oil Point Reserve is part of the University of California Natural Reserve System. The reserve protects coastal dune, estuarine, tidal lagoon, sandy beach, and rocky reef habitats to support research, education, outreach, and stewardship.

2.2.3 State Beaches

Within the spill-affected area, Gaviota State Park, Refugio, El Capitan, Carpinteria, Emma Wood and McGrath State Beaches are areas of high public use with amenities for overnight camping and shore access. The State Beaches along the Gaviota coast provide the public with unique camping and recreational opportunities that are highly sought after and are booked well in advance. Additionally, San Buenaventura and Mandalay State Beaches provide coastal day use access. The pier at Gaviota State Beach was closed in 2014 due to storm damage, so public use was precluded prior to the spill.

2.2.4 State Marine Protected Areas

In 1999, the State legislature enacted the Marine Life Protection Act. This directed the CDFW to restructure the state's MPA system to increase the ability to protect marine life, habitats, and ecosystems. In 2012, MPAs were designated along the Santa Barbara County coast south of Point Conception.

Seven state marine conservation areas occur in the spill-affected area with varying levels of resource protection ranging from no-take to limited take involving fishes, invertebrates, kelp, and restoration, maintenance, and operation of artificial structures; these are Kashtayit, Naples, Campus Point, Goleta Slough, Point Dume, and Point Vincente State Marine Conservation Areas (Figure 7). The Goleta Slough Ecological Reserve overlaps with a portion of the Goleta Slough State Marine Conservation Area where no human activities are allowed, except access on an established trail/bike path. Public access is limited because the airport is next to the Reserve. To the west of the spill-affected area is the Point Conception State Marine Reserve of no-take.

2.2.5 National Marine Sanctuary System

NOAA's Office of National Marine Sanctuaries serves as the trustee for a network of underwater parks encompassing more than 600,000 square miles of marine and Great Lakes waters. The network includes a system of 13 national marine sanctuaries and two marine national monuments. The program's function through the creation of National Marine Sanctuaries is to protect marine environments with special ecological, historical, cultural, archeological, scientific, educational, recreational, and aesthetic qualities.

There was no oil observed or collected matching Line 901 oil within the waters of the Channel Island National Marine Sanctuary (CINMS). However according to the GNOME trajectory, it is possible that scattered tarballs did travel through CINMS waters at some point in time. The CINMS, designated in 1980, warrants inclusion in this report for its importance with regards to environmental protection and public interest proximate to the spill. The CINMS (Figure 7) encompasses the waters surrounding five Channel Islands (San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara) below the mean high tide level and out 6.9 miles (6 nautical miles, 11 km). Associated with the Channel Islands are 20 other MPAs. Within five Federal, and 11 State Marine Reserves, it is unlawful to injure, damage, take, or possess any living geological, or cultural marine resource. In another five State Marine Conservation Areas, limited take is allowed, and within two State Special Closure Areas boating activities are restricted in waters adjacent to sea bird rookeries and/or marine mammal haulout sites.

2.2.6 National Park System

The Channel Islands National Park consists of San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara Islands (Figure 7) and the waters extending out one nautical mile around each island. Congress established the Channel Islands as a National Park in 1980 in order to protect their natural, scenic, wildlife, marine, ecological, archeological, cultural, and scientific values. The Islands are home to over 2,000 plant and animal species, of which 145 are found nowhere else in the world, and much of the terrestrial environment is managed as proposed or potential Wilderness Area. Important to this incident, West Anacapa and Santa Barbara Islands provide the only breeding colonies for the California Brown Pelican in the western United States. Tourism is allowed, and hiking, camping, and kayaking occur at varying levels on and around each island.

2.2.7 California Coastal National Monument

The California Coastal National Monument, managed by the Bureau of Land Management, consists of the rocky areas above the mean high tide level, including over 20,000 offshore rocks, islands, reefs, and pinnacles within 13.8 miles (12 nautical miles, 22 km) of the mainland shore. Sixty-two of these rocky features occur along the shore from the Gaviota Pier east to Campus Point at U.C. Santa Barbara. The monument provides untrammeled nesting habitat for breeding seabirds and protected haulout habitat for seals and sea lions.

2.3 Biological Resources

The affected area has one of the most diverse and abundant assemblages of marine organisms in the world. A rich array of habitats including the open ocean, rugged rocky shores, sandy beaches, lush kelp forests, and wetlands, support large numbers of seals and sea lions, whales, fish, otters, and seabirds. For many migratory species such as whales, seals, salmonids, and brown pelicans, the affected area is also an important link to other habitats. This section includes a broad description of all biological resources in areas that were affected by the spill, as well as resources that weren't affected by the spill but may be included in restoration projects. A description of resources that were injured is presented in Section 5.

2.3.1 Marine Mammals

The mainland coast of southern California that includes Santa Barbara County and the Channel Islands provides important breeding, pupping and resting areas for most of the pinniped species in the region. These include two species of sea lions (California sea lion and Stellar sea lion), four species of seals (northern elephant seal, Pacific harbor seal, northern fur seal, and the endangered Guadalupe fur seal). The threatened southern sea otter also occurs along the mainland coast of Santa Barbara County, primarily west of Gaviota.

California sea lions are the most abundant pinniped. Nearly all breeding and pupping occurs in the California Channel Islands area. Sea lions also haul out on offshore rocks and beaches on the mainland and Channel Islands.

Northern elephant seals breed in the winter months, molt in spring, and forage in offshore waters throughout the eastern North Pacific during summer and fall. Peak haul out abundances occur during spring when juveniles and females come ashore to molt.

Pacific harbor seals are year-round residents in the area. They haul out on several mainland beaches within the spill-affected area and on the Channel Islands. Mainland haulouts include near El Capitan State Beach, Naples, Haskell’s, and a major rookery at Carpinteria, peaking in February-June when breeding, pupping and molting is occurring. Harbor seals typically forage relatively close to where they haul out.

More than 20 species of whales, dolphins, and porpoises occur regularly in the waters off Santa Barbara and Ventura Counties and the Channel Islands, but the following are the most common: gray, blue and humpback whales, long- and short-beaked common dolphins, common bottlenose dolphins, and Pacific white-sided dolphins. The whales are migratory and are most often sighted during spring and summer. Dolphins are considered year-round residents. The region is also the migratory pathway of gray whales (adult females and calves), which migrate within 1 km of shore as they travel north to their summer foraging grounds. Other large baleen whales also forage in the area. The coastal ecotype of common bottlenose dolphin, a distinct population, live within 1 km of shore, and both species of common dolphin can be regularly sighted from shore.

2.3.2 Seabirds

The spill-affected area is also within the Pacific Flyway, which is a major north-south flyway for migratory birds in America, extending from Alaska to Patagonia, South America. The spill-affected area includes several areas identified by the Audubon Society as Important Bird Areas (IBAs): Point Conception, Santa Barbara Basin, Point Mugu, Santa Cruz Basin, Northern Channel Islands, and Palos Verdes. The Goleta Coast IBA is also within the spill-affected area, and includes Coal Oil Point and Goleta Slough and the beaches between.

Seabirds characteristic of open water areas within the spill-affected area include surf and white-winged scoters; horned and western grebes; red-throated and common loons; brown pelicans;

Brandt’s, double-crested, and pelagic cormorants; and many species of gulls and terns. Pelagic seabirds that were present in the area during the summer when the spill occurred include black-footed albatrosses, shearwaters, storm-petrels, phalaropes, jaegers, and several alcids including Scripp’s murrelets.

Seabirds characteristic of rocky shores within the spill-affected area include black oystercatchers, Brandt’s and pelagic cormorants, and pigeon guillemots. Rocky platforms exposed during low tide tend to be occupied by black and ruddy turnstones, great and snowy egrets, brown pelicans, black-crowned night-herons, shorebirds, and gulls. Western snowy plovers, California least terns, and horned larks all nest on sandy beaches and dune areas within the spill area; the same areas are also utilized by shorebirds that include black-bellied plovers, whimbrels, long-billed curlews, marbled godwits, sanderlings and willets, gulls (mew, ring-billed, western, California, glaucous-winged), and Forster’s and royal terns. Beach wrack in the upper zones of sandy beaches are used by short-billed and long-billed dowitchers, black and Say’s phoebes, American pipits, and yellow-rumped warblers.

2.3.3 Subtidal and Fish Habitats

Fish composition and abundance are both strongly associated with habitat type and structure, and each type of habitat generally supports its own characteristic assemblage of fishes. The Santa Barbara County nearshore coastal fish habitats described and defined here are the habitats inshore of the -66 ft (-20 m) depth contour relative to the mean lower low water (MLLW) tide level. This nearshore zone includes kelp forests, rocky reefs, sandy bottom, seagrass beds, and the pelagic water column.

Submerged rocky reefs support forests of giant kelp. Anchored by holdfasts to the rocky seafloor, the buoyant stipes and fronds rise through the water column and spread out on the sea surface. Kelp forests thus provide benthic (seafloor), mid-water, and surface habitats that are utilized by many fish species, many of which are residential in kelp forests (Schiel and Foster 2015). Fishes, such as kelp rockfish, surfperch, sheephead, opaleye, halfmoon, señorita, white seabass, and kelp bass tend to occur in the mid-water and swim about freely in the kelp forest. Kelp forests also provide habitat for certain sharks, such as leopard and smoothhound sharks.

In addition to kelp, submerged rocky reefs also support macroalgae and surfgrass species, often occurring as understory to giant kelp. Fish, such as gopher rockfish, grass rockfish, giant kelpfish, scorpion fish, cabezon, and painted greenlings are bottom-dwellers (demersal fishes) and are often associated with the foliose algal understory. Adult spiny lobsters inhabit cracks and crevices of the rocky reef, while juvenile spiny lobsters use surfgrass habitat in the shallow subtidal for refuge and feeding.

Along sand flats and in sand channels bisecting rocky reefs, rays, skates, and flat fishes (halibut, sandabs, flounders, soles) are more common. Seagrasses (eelgrass and surfgrass) occur as meadows of long grass-green leaves (blades) that provide refuge and foraging areas for many of the same species of fish that occur in kelp forests and on sand flats. Eelgrass beds also provide spawning habitat for fish.

The pelagic water column habitat contains numerous species of plankton, or life forms that cannot swim against the current but rather move primarily by drifting. Many of these plankton are important food sources for fishes and other marine creatures, providing a foundation for the complex food webs that make up the marine environment in the marine region. The larvae and eggs of many fish and invertebrate species are also considered plankton, though their adult stages are sessile or free-swimming organisms. These marine larvae develop and grow while subject to the movement of ocean currents that can transport them many miles from their natal (spawning) habitat. Eventually, these planktonic larvae mature into their non-planktonic life stage and settle out in their adult habitats, which can include kelp forests, rocky reefs, seagrass beds, sand flats, and deep offshore water. The nearshore pelagic water column habitat is also the main habitat for many species of schooling fishes, such as anchovies, sardines, and topsmelt, and also includes mobile invertebrates (e.g., market squid). In turn, these forms are the basis food source for larger forms (e.g., predatory fishes, sharks, seabirds, and marine mammals).

The rocky intertidal zone, the shore between the high and low tidal levels, is also habitat for fishes. The fishes in this zone are characterized by a smaller group of species specially adapted for life in tidepools and in the spaces beneath and between cobbles and boulders. The most representative intertidal fish species are tidepool sculpins, juvenile opaleye, and blennies.

Sandy beaches are extensive along the Santa Barbara, Ventura, and Los Angeles County coasts, and many beaches in south Santa Barbara County are important spawning habitat for California grunion. A variety of other fish species, such as barred surfperch, walleye surfperch, and corbina, forage on the burrowing intertidal invertebrates in surf and swash zones.

Several fishes that occur in the area have special protections. The Southern California Coast Distinct Population Segment (DPS) of steelhead trout is a federally endangered species. Steelhead are rainbow trout that spend the majority of their life in the ocean and return to freshwater streams to spawn (anadromous species). However, unlike the closely related salmon that are also anadromous, adult steelhead return to spawn in freshwater several times, not just once. In addition to steelhead trout, coho (silver) salmon and Chinook (king) salmon can also occur in the marine region. The coho salmon is both a state and federally listed endangered species, and the Chinook (king) salmon is a federally threatened species in California coastal waters.

Giant (black) sea bass is a marine species prohibited from commercial and recreational fishery take, and the International Union for Conservation of Nature classifies giant (black) sea bass as a critically endangered species. However, one giant (black) sea bass may be taken incidentally per trip in gill or trammel nets in the commercial fisheries, which is not uncommon. Take of great white sharks is also prohibited, with exceptions for possible incidental and accidental take in commercial fisheries. Broomtail grouper is another fully protected marine fish species with a large range (San Francisco-Peru, South America) that can occur along the Santa Barbara, Ventura, and Los Angeles County coasts. One of the more visible fishes is the garibaldi, a very recognizable, bright orange damselfish. California State Legislature designated the garibaldi as the state marine fish and prohibited from take in California coastal waters.

2.3.4 Shoreline Habitats

The richness and diversity of intertidal invertebrates in any given area is closely related to the composition, rugosity, and stability of the substrate, tidal level, depth, and exposure to waves. Much of the rocky intertidal habitat in the affected environment consists of low-lying shale or sandstone occurring as ridges parallel to shore with lower elevation portions heavily exposed to periodic sand burial and sand scour. Some intertidal areas near creek mouths can be characterized as being largely boulder fields. Mussel beds are limited to the areas of larger and harder rock substrate in areas above sand burial depths. Common intertidal invertebrates can also include sand castle (honeycomb) worms, acorn and gooseneck barnacles, sea anemones, purple sea urchins, bryozoans, tunicates, and sponges. Common mobile invertebrate species in the intertidal zone include ochre sea stars, bat stars, hermit crabs, turban snails, limpets, whelks, nudibranchs, chitons, lined shore crabs, polychaete and nemertean worms, and more. The high intertidal splash zone is inhabited by periwinkle snails and limpets. Many more invertebrates occur in the mid- and low-intertidal zone, and also in the subtidal zone. These include octopus, top snails, abalone, red sea urchins, clams, California spiny lobsters, shrimp, rock crabs, decorator crabs, cup corals, feather duster worms, and more.

Sandy beaches are the most common intertidal habitat in the spill-affected area, and support a diversity of invertebrates tolerant of the constantly shifting sands from wave action and strong directional longshore transport of sand. Bivalve mollusks, polychaete worms (including bloodworms), beach endemic insects, and crustaceans that include sand or mole crabs, and beach hoppers (i.e., talitrid amphipods) are the predominant invertebrates on sandy beaches. The accumulation of drift algae (wrack) that is stranded on sandy beaches provides food and habitat for many species of beach hoppers, terrestrial isopods, and insects. Insects include the kelp fly, flightless beetles such as the globose dune beetle (candidate for federal listing), and predatory rove beetles. The sand bottom of the surf zone and immediately beyond support sand dollars, clams, and gastropods such as the purple olive snail.

2.3.5 Algae and Seagrasses

Macroalgae such as kelp and marine grasses (discussed above in the Subtidal and Fish Habitats section) such as surfgrass and eelgrass are examples of foundational species for the nearshore environment along the Gaviota Coast. A foundational species is one where the organism itself creates ecological communities by providing habitat structure and primary productivity.

Intertidal algae tend to occur as bands parallel to shore and their distribution depends on exposure to waves, tidal height, and rock structure. The upper vertical range of an algal species in the rocky intertidal is largely determined by its ability to withstand desiccation. Accordingly, the high intertidal zone that is only occasionally wetted by wave splash is sparsely populated with algae. The barren appearance of the splash zone disappears lower in the intertidal zone, below the +3 ft (1 m) Mean Low-Low Water (MLLW) tide level and lower, with algal cover being more prevalent and persistent. Algal forms can be blade/sheet-like, branch-like, turf, filamentous, and crustose. Some of the more conspicuous intertidal species include the turf-like nailbrush seaweed and the blade-like grapestone seaweed, which are perennial species. A species group characteristic of most mid-intertidal zones in California but conspicuously absent or in low abundances along the Santa Barbara, Ventura, and Los Angeles County coast are brown rockweed species of the order Fucales. In the low-intertidal, Turkish-towel seaweed can be abundant with articulated coralline algae. The lowest zones will include brown feather boa kelp, bladder kelp, and branched red alga.

Unlike algal species, seagrasses are true plants. They have vascular tissue to transport internal metabolites and nutrients, and they reproduce via flowers and seeds instead of spores, as is the case with algae. The plants are attached to the substrate by rhizomes, and the remaining structure consists of long narrow emerald green leaves (blades) up to 1.5 m long. Seagrasses are important primary producers, and they provide important habitat functions, including shelter and nursery grounds for invertebrates and fishes. Seagrasses also stabilize sand from shifting about. Surfgrass occurs on boulders and rocky reefs from the low-intertidal to as deep as approximately -23 ft (-7 m) MLLW with abundance declining with depth (Williams 1995). Along the south coast, eelgrass grows in soft sediments between depths of approximately -20 ft (-6 m) and -40 ft (-12 m) (J. Altstatt, personal communication, April 9, 2018). Seagrass habitat is classified as Essential Fish Habitat by NOAA, National Marine Fisheries Service (NMFS).

Subtidal algal composition is largely dependent on the stability of the substrate and available light based on water clarity and depth. Giant kelp are the predominant kelp along the coast, occurring as dense forests growing on rocky reefs from the low-intertidal to depths of approximately -18 m MLLW. Bladder chain kelp and feather boa kelp are common in shallower water along the inshore fringes of giant kelp forests. The algal understory is generally characterized by mostly red algal species of various sizes, morphology, distribution, and abundance.

The wrack created from the seasonal loss of these plants (e.g., beach-stranded drift algae and surf grass) through storms also fuels the productivity of local sand beach and nearshore sand bottom habitats. Loss of or damage to these plants, particularly in the spring and summer, have cascading consequences for multiple associated fish and invertebrate species in the affected area.

2.3.6 Threatened and Endangered Species

Federal and state levels of special-status designations include:

- Federally Endangered;
- Federally Threatened;

- State Endangered;
- State Threatened;
- State Fully Protected Species; and
- California Species of Special Concern (pursuant to the 2008 list).

The federal Endangered Species Act (ESA) of 1973 (16 USC Section 1531 et seq.) and the California Endangered Species Act (CESA) of 1970 (Ca. Fish and Game Code Section 2050 et seq.) require the protection and conservation of listed endangered and threatened fishes, plants, and wildlife. The habitat of endangered, threatened, and rare species also takes on special importance because of these laws, and the protection and conservation of these species requires diligent management. At least three state- and/or federally-listed species were exposed to Line 901 oil from the spill: the threatened western snowy plover, the endangered black abalone, and the endangered humpback whales.

Several other state- and federally-listed or protected species occur in areas exposed to the spill. However, these species are not thought to have been affected by the spill either because they were not present in the area at the time of the spill due to migration timing, low overall population density or scarcity, or because oil never reached their habitat. These species include the California red-legged frog, Gaviota tarplant, light-footed Ridgway rail, Belding's savannah sparrow, California least tern, southern sea otter, Steller sea lion, Guadalupe fur seal, blue whale and fin whale, green turtle, hawksbill turtle, leatherback turtle, and loggerhead turtle. For pelagic seabirds such as the Scripps's murrelet it is possible that these birds could have encountered oil from the spill, but there was no evidence of mortality.

Two federally endangered fish species, the tidewater goby and Southern California Coast Steelhead DPS, are known to occur in coastal watersheds along the Gaviota Coast (USFWS 2005; NMFS 2012). Following the spill, a visual assessment of the entrances to streams and estuaries was completed by USFWS and NOAA. It was determined that there were large natural berms or artificial booms in place at the entrances to the streams and estuaries in the spill-affected area, making exposure to oil unlikely. Thus, the Trustees did not pursue further studies in these watersheds.

2.4 Archeological and Cultural Resources

The affected environment along the Gaviota coast is home to a wide variety of culturally and historically important resources. A number of Federal and State laws, regulations, and policies govern the protection of cultural and historic resources during an emergency response and subsequent NRDA restoration, including the National Historic Preservation Act of 1966, The Native American Graves Protection and Repatriation Act of 1990, and California Executive Order B-10-11.

To protect cultural and archeological resources during the spill response, the Unified Command established a Cultural/Historic Group comprised of State, Federal and tribal representatives with knowledge and expertise of the cultural and historical resources in the area. The Unified Command invited California tribes listed by the Native American Heritage Commission, regardless of federal recognition status, to be a part of the response (CDFW 2016). The Cultural/Historic Group's participating tribes included:

- Santa Ynez Band of the Chumash Indians (federally-recognized);
- Coastal Band of the Chumash Nation, including the Owl Clan;
- Barbareno Band of Chumash Indians; and
- Barbareno Ventureno Band of Mission Indians.

A report of cultural resource monitoring that occurred during the spill, along with a summary of impacts to cultural resources, was compiled by Nocerino et al. (2016) of Applied Earth Works. Because it contains archeological site information, it is confidential. The sections below are excerpted largely from Nocerino et al. (2016) and contain the non-confidential details summarizing the general nature of archeological and cultural resources in the spill-affected area, as well as impacts to those resources from the spill and response activities.

The Chumash Indians and their Native American ancestors have occupied the Santa Barbara Channel region for at least 13,000 years and thousands of their descendants live in the area today. Prior to European contact, the coastal Chumash had some of the highest population densities recorded for hunter-gatherers in North America. The Chumash people lived in villages along the California coast from Malibu to Morro Bay, and extended to the northern Channel Islands (McGinnis et al. 2004). Along the Santa Barbara Channel, the antiquity and density of Chumash occupation has led to a very large number of archeological sites ranging from historic Chumash coastal towns to ancient villages, cemeteries, campsites, and temporary locations. The density of Native American sites is particularly high within the central response area along the western Santa Barbara Channel, where the narrow coastal plain concentrated settlement within a thin band of land. The area also contains numerous historical sites dating to the Spanish, Mexican, and American periods, including shipwrecks, homesteads, ranching and fishing facilities, roads, railroads, oil facilities, and more. In some cases, historical facilities such as piers and seawalls extended into the intertidal zone and into nearshore waters. As was the case with Native American sites, coastal erosion has also resulted in the exposure or redeposition of historic artifacts or properties in the intertidal zone or on beaches of the Santa Barbara Coast.

The archeological sites along the Gaviota coast demonstrate an intimate use of coastal resources for subsistence of native people and their cultural traditions through time. Sites dating back to at least 13,000 years contain stemmed points and flaked stone crescents associated with remains of shellfish, fish, marine mammals, seabirds, and waterfowl, including a number of species closely associated with kelp forest habitats. The Channel Islands region is considered the place of origin for the Chumash people and is central to their cosmology (Office of National Marine Sanctuaries 2019). A Chumash creation story tells of the crossing of Chumash people from the Channel Islands to the mainland across a wištoyo (rainbow), during which some become dizzy and fall from the bridge and are transformed into ‘alolk’oy (dolphins) by Hutash (Earth Goddess) (Tumamait-Stenslie 2014). This story exemplifies the foundational importance of the Santa Barbara Channel and its natural resources to the Chumash people, and illustrates the cultural importance of key species, such as dolphins. Dolphins and abalone are regarded as Chumash brothers and sisters of the ocean (Office of National Marine Sanctuaries 2019).

Applied Earthworks initiated a records search on May 20, 2015, in order to identify the types of cultural resources that may be encountered in the response area. The records search encompassed the area within 0.5 mile of the shoreline between Point Conception and Rincon Point. A review of the records identified 99 archeological sites were within the “response envelope” between Gaviota and Rincon Point, from the low tideline to 0.25 mile inland. Only one other cultural resource (a row of historic palm trees at Refugio State Beach) is within the response envelope. Of the 99 archeological sites within the response envelope, 26 sites plus the row of palm trees were assessed for potential impacts resulting from response activities. The remaining 73 sites were not in or near response activities and were not assessed. Three previously unrecorded archeological sites, six previously unrecorded historic seawalls, and a historical culvert were identified within the response envelope during the cleanup monitoring and survey.

During beach and shoreline cleaning operations, the Cultural/Historical Group, led by a Cultural/Historical Technical Specialist from CDFW, coordinated tribal representatives and non-tribal archeologists to be present to identify bones, artifacts, and potential artifacts encountered. Additional details of this coordination are available in the Refugio Oil Spill Response Evaluation Report (CDFW 2016). In several areas, access to beaches necessitated foot travel by cleanup crews across archeological sites because no safe alternatives could be identified. Trail delineations, carpet anchored with sandbags, and all–terrain vehicle restrictions were implemented for these locations. In addition, archaeologists and tribal representatives were present to ensure crews remained on the paths and protective measures remained in place.

During cleaning operations, isolated redeposited artifacts were noted in the intertidal zone at Refugio State Beach and El Capitan State Beach, within the jurisdiction of California State Parks, beginning on the first day of the incident response. The majority of the items were ground stone fragments (e.g., bowl or mortar fragments). These artifacts were evaluated by the Cultural/Historical Group. Because their original context could not be identified, these items were considered ineligible for listing on the National Register of Historic Places and California Register of Historical Resources. Some tribal representatives expressed concerns regarding sensitive cultural values associated with these intertidal artifacts and their desire to avoid oiling or other disturbance of these items during response activities.

The incident’s Historic Properties Treatment Plan called for leaving isolated intertidal artifacts in place unless there was an imminent risk of oiling or disturbance by incoming tides, in which case such artifacts were to be temporarily collected until such risk abated. During the spill, the Cultural/Historical Group collected 37 artifacts from the intertidal zone, as well as numerous other items that were inspected and determined not to be artifacts. Of the items collected, two were redeposited at sea during the response, following consultation among the Cultural/Historical Group. The remaining artifacts were archived at the La Purisima Mission State Historic Park following discussion and consent among California State Parks and the involved tribes.

Nocerino et al. (2016) conclude that there were no significant impacts to potentially significant archeological deposits due to the oil release or resulting response operations, and that efforts made by the Unified Command, and the Cultural/Historical Group successfully avoided significant impacts to cultural resources.

2.4.1 Coordination with Native American Tribes

During the course of the NRDA, the Trustees coordinated with several tribes identified during the oil spill response with cultural and traditional affiliation to the area affected by the spill, including:

- Santa Ynez Band of the Chumash Indians (federally-recognized);
- Coastal Band of the Chumash Nation, including the Owl Clan;
- Barbareño Band of Chumash Indians; and
- Barbareño/Ventureño Band of Mission Indians.

Most of these tribes participated in the oil spill response by providing monitors to protect historic sites during cleanup operations. Under OPA, federally-recognized tribes may designate tribal officials to act as trustee for their tribal natural resources and may make a claim for injuries to those resources, such as in cases where reservation lands or a treaty right has been injured by the spill. In this case, reservation lands of the Santa Ynez Band of Chumash Indians were not impacted, and no treaty rights were identified to have been injured by the spill. However, the natural resources that are the subject of the NRDA are culturally important to all of the affected tribes and, as such, the Trustees made efforts to communicate with the tribes throughout the NRDA process and to seek their input on restoration priorities.

While the other bands do not have trustee status under OPA, the trustees from the State of California communicated with as many tribes as possible throughout the process consistent with state law and policies. During the public comment period following the release of the Draft DARP/EA, the Trustees were informed that additional tribes, bands and clans may have an interest in some of the Tier 1 and 2 projects impact natural cultural resources important to the Chumash community and/or restore sensitive ecosystems critical to Chumash lifeways.

Following the public comment period, the Trustees contacted the Native American Heritage Commission to obtain an updated list of tribes with cultural and traditional affiliation to the area of impact. In addition, through the public comment process the Trustees were provided the names of the additional tribes, bands and clans that may have an interest in some of the Tier 1 and 2 projects. Through these combined efforts, the following additional tribes were identified:

- Barbareño Chumash Tribal Council;

- Chumash Indian Council of Bakersfield of California;
- Northern Chumash Tribal Council;
- Salinan-Chumash Nation;
- San Luis Obispo County Chumash Council;
- Tejon Indian Tribe; and
- Yak Tityu Tityu Yak Tilhini Northern Chumash.

The Trustees conducted additional coordination with tribes following the public comment process and before finalizing the DARP/EA. We anticipate continued coordination with tribes throughout the implementation of restoration to ensure that restoration is conducted in a way that is protective of sacred sites and is respectful of cultural keystone species that have significance beyond their role in the ecosystem. This coordination will allow tribes to share traditional and local knowledge of managing the resources that were damaged as a result of the spill (Sea Grant Network 2018).

2.5 Recreational Services

The impacted beaches are some of the most popular in the state. Refugio and El Capitan State Beaches are among the few places on the California coast where one can camp immediately adjacent to the beach in the shade of coast live oaks, western sycamores, and in the case of Refugio, palm trees. These campgrounds are often full in the summer and require reservations made long in advance. In addition to these camping areas, there are numerous coastal access points where the public can enjoy beach access along undeveloped areas with a variety of recreation activities. The affected environment also supports boating and offshore recreation opportunities such as diving and fishing. There are significant recreational impacts from the spill that are described further in Section 5.5.

3.0 Coordination and Compliance

3.1 Federal and State Trustee Agencies

United States Department of Commerce represented by NOAA; the United States Department of the Interior represented by USFWS, NPS and BLM; the CDFW-OSPR; the CDPR; the CSLC; and the Regents of the University of California are the Trustees who are addressing the natural resources injured by the spill. NOAA and DOI are designated Trustees for natural resources pursuant to the Oil Pollution Act (33 U.S.C. §§ 2701–2762) and subpart G of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 C.F.R § 300.600) and Executive Order 12580 (3 CFR, 1987 Comp., p. 193, 52 Fed. Reg. 2923 (January 23, 1987), as amended by Exec. Order No. 12777 (56 Fed. Reg. 54757 (October 22, 1991)). CDFW and CDPR have been designated as state trustees for natural resources pursuant to Section 1006(b)(3) of the OPA. In addition, CDFW has state natural resource trustee authority pursuant to Fish and Game Code §§ 711.7 and 1802 and the Lempert-Keene-Seastrand Oil Spill Prevention and Response Act (Government Code § 8670.1 et seq.). CDPR and UC Regents also have jurisdiction over natural resources within the state park system and the natural reserve system, respectively, which are held in trust for the people of the State of California. Finally, CSLC is participating as a Trustee pursuant to its jurisdiction under Public Resources Code §§ 6009 and 6301 over all state sovereign lands, including ungranted tidelands and submerged lands. As a designated Trustee, each agency is authorized to act on behalf of the public under state and/or federal law to assess and recover natural resource damages and to plan and implement actions to restore, rehabilitate, replace, or acquire the equivalent of the affected natural resources injured as a result of a discharge of oil.

3.2 Coordination

3.2.1 Coordination Among the Trustees

Federal regulations implementing OPA with respect to natural resource damages (“OPA NRDA regulations”) provide that where an oil spill affects the interests of multiple Trustees, they should act jointly to ensure that full restoration is achieved without double recovery of damages (15 CFR § 990.14(a)). The Trustees in this matter have worked together closely in a shared effort to fully assess the nature and extent of injuries to natural resources and plan appropriate actions to restore the injured resources.

At the beginning of the NRDA, the Trustees jointly designated CDFW as the Lead Administrative Trustee (LAT) to act as coordinator pursuant to 15 CFR § 990.14(a)(1). The Trustees also designated NOAA as the Federal Lead Administrative Trustee (FLAT) to coordinate those activities, such as NEPA compliance, that must be undertaken by a Federal agency. In addition to coordinating amongst themselves, the Trustees also coordinated NRDA activities with other affected entities, including Santa Barbara County, the City of Goleta and others.

3.2.2 Coordination with Federally Recognized and Non-Federally Recognized Tribes

The Trustees coordinated with several American Indian tribes in the course of this NRDA. These included:

- Santa Ynez Band of the Chumash Indians (federally-recognized);
- Coastal Band of the Chumash Nation, including the Owl Clan;
- Barbareno Band of Chumash Indians; and
- Barbareno Ventureno Band of Mission Indians.

These tribes participated in the oil spill response by providing monitors to protect historic sites during cleanup operations. Under OPA, federally-recognized tribes may serve as natural resource trustees and make a claim for NRD. In this case, the Santa Ynez Band of Chumash Indians elected not to join the claim, but remain interested in the restoration process generally. For this reason, the Trustees continue to engage with Santa Ynez Band of Chumash regularly, simultaneously fulfilling the federal Trustees' tribal consultation obligations. While the non-federally recognized tribes are not eligible to be a natural resource trustee under OPA, the state Trustees have communicated with these tribes throughout the process, regardless of recognition status.

3.2.3 Coordination with the Responsible Party

The OPA NRDA regulations encourage natural resource trustees and responsible parties to cooperate in the assessment and restoration process, providing broad discretion to the parties to determine the nature and extent of participation (15 C.F.R. § 990.14(c)). However, the Trustees retain sole authority to make determinations regarding injury and restoration (15 C.F.R. § 990.14(c)(4)).

In accordance with the regulations, the Trustees extended an invitation to the responsible party, Plains, within days of the Incident, and Plains accepted (15 C.F.R. § 990.14(c)). Thereafter, the Parties established an active cooperative assessment process, by which Trustee representatives would coordinate studies and other technical activities in the injury determination and quantification stages of the assessment with representatives of Plains. The Trustees formed technical working groups that included biologists, economists, toxicologists, and other specialists, and developed work plans that were used to guide injury assessment activities. Plains commented on work plans and participated in some studies.

This DARP/EA, while prepared solely by the Trustees, reflects consideration of the input provided by Plains' representatives. Plains does not agree with certain conclusions presented in this document.

3.2.4 Coordination with the Public

Throughout the NRDA process, the Trustees have made information available to the public. The Trustees held a public meeting in Santa Barbara shortly after the oil spill on January 20, 2016, and they published a series of newsletters to keep the public up to date on the progress of the NRDA.

The Trustees published a Notice of Intent (NOI) to Conduct Restoration Planning on March 8, 2019, pursuant to the OPA NRDA regulations (15 C.F.R § 990.44), and concurrently opened an administrative record (15 CFR § 990.45). The Record includes documents relied upon or considered by the Trustees during the assessment and restoration planning process.

A 45-day public review period was held for the Draft DARP/EA that began on April 22, 2020 and closed on June 8, 2020. During the public review period, the Trustees received extensive comments on the DARP/EA, which can be found with the Trustees' responses in Appendix O.

The Trustees held virtual public meetings on May 13, 2020 at 1:00 and 6:00 pm PDT. At these meetings, the Trustees presented an overview of the Draft DARP/EA, answered questions, and accept public comments.

The Administrative Record is available at: https://www.diver.orr.noaa.gov/web/guest/diver-admin-record/6104. The administrative record is also available upon request at:

Ventura Fish and Wildlife Office
U.S. Fish and Wildlife Service
2493 Portola Road, Suite B
Ventura, California 93004
(805) 644-1766.

3.3 Compliance with Environmental Laws, Regulations, and Policies

3.3.1 The Oil Pollution Act

The Oil Pollution Act (33 U.S.C. § 2701–2762) establishes a liability regime for oil spills into navigable waters or adjacent shorelines that injure or are likely to injure natural resources and the services that those resources provide to the ecosystem or humans. Pursuant to OPA, federal and state agencies and Indian tribes may act as Trustees on behalf of the public to assess the injuries, scale restoration to compensate for those injuries, and implement restoration. The DARP/EA has been prepared jointly by DOI, NOAA, CDFW, CSPR, CSLC, and UC Regents. As described above, each of these agencies is a designated Trustee for natural resources injured by the spill.

OPA defines "natural resources" to include land, fish, wildlife, water sources, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States, any State or local government or Indian tribe, or any foreign government (33 U.S.C. § 2701(20)). OPA authorizes the Trustees to assess damages for injured natural resources under their trusteeship, and develop and implement a plan for the restoration, rehabilitation, replacement, or acquisition of the equivalent of those injured natural resources (33 U.S.C. § 2706(c)).

The regulations for natural resource damage assessments under OPA are found at 15 C.F.R Part 990. These regulations provide the Trustees with guidelines on processes and methodologies for carrying out an NRDA, including guidelines for conducting assessments cooperatively with the responsible parties. While the decision whether or not to follow the NRDA regulations is left to the discretion of the Trustees, OPA provides that if the Trustees conduct the NRDA in accordance with the regulations, their determination or assessment of damages to natural resources will have the force and effect of a rebuttable presumption in an administrative or judicial proceeding under OPA (33 U.S.C. § 2706(e)(2); 15 C.F.R. § 990.13). In this case, the Trustees elected to conduct the NRDA in accordance with the OPA NRDA regulations.

3.3.2 National Marine Sanctuaries Act, 16 USC. § 1431, et seq.

The National Marine Sanctuaries Act (NMSA) authorizes the Secretary of Commerce (Secretary) to designate and manage areas of the marine environment with special national significance due to their conservation, recreational, ecological, historical, scientific, cultural, archeological, educational, or esthetic qualities as national marine sanctuaries. Day-to-day management of national marine sanctuaries has been delegated by the Secretary to the Office of National Marine Sanctuaries (ONMS). The primary objective of the NMSA is to protect marine resources, such as coral reefs, sunken historical vessels or unique habitats.

The NMSA prohibits the destruction, loss of, or injury to any sanctuary resource. The Secretary is required to conduct such enforcement activities as are necessary and reasonable to carry out the Act. The Secretary may issue special use permits which authorize specific activities in a sanctuary to establish conditions of access to and use of any sanctuary resource or to promote public use and understanding of a sanctuary resource. The NMSA also establishes, similar to OPA, liability for response costs and natural resource damages for injury to sanctuary natural resources.

In this case, the ONMS participated because of potential injury to the Channel Islands Marine Sanctuary (CINMS). CINMS staff participated as part of the Trustee group early on to identify potential injury to Sanctuary resources concurrently with similar work being conducted under OPA. However, no injuries were assessed within Sanctuary boundaries, although oiled marine mammals and birds use marine sanctuaries as part of their habitats.

The CINMS also participated in restoration planning, identifying appropriate restoration projects occurring within the CINMS. This coordination will continue for restoration projects that have the potential to affect resources within a sanctuary.

3.3.3 The National Environmental Policy Act

The National Environmental Policy Act (NEPA) is the basic national charter for the protection of the environment, and it sets forth a specific process of impact analysis and public review for federal agency actions that may significantly affect the environment (42 U.S.C. §§ 4321–4335; 40 C.F.R. § 1500.1). Its purposes are to "encourage productive and enjoyable harmony between man and the environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; and to enrich the understanding of the ecological systems and natural resources important to the Nation" 42 U.S.C. §4321. NEPA provides a mandate and a framework for federal agencies to consider all reasonably foreseeable environmental effects of their proposed actions and to potentially involve and inform the public in their process. NEPA also established the Council on Environmental Quality (CEQ) in the Executive Office of the President to formulate and recommend national policies which ensure that the programs of the federal government promote improvement of the quality of the environment. CEQ also promulgated regulations to provide Federal agencies with procedures to comply with NEPA (40 C.F.R. § 1500.1(a)).

Where potential environmental impacts are unknown or considered not likely to be significant, federal agencies will prepare an environmental assessment (EA). The EA may undergo a public review and comment period, and the process concludes with either a finding by the action agency of no significant impact (FONSI) or a determination that an Environmental Impact Statement (EIS) should be prepared. An EIS is prepared for actions considered to have significant effects on the environment, and after public review and comment, findings are documented in a record of decision (ROD).

In accordance with the regulations implementing the OPA NRDA process, the Trustees have integrated OPA restoration planning with the NEPA process (15 C.F.R. § 990.23). Accordingly, the DARP/EA serves as both an OPA restoration plan and a NEPA EA document. The Trustees anticipate that this DARP/EA will meet NEPA requirements for most of the restoration projects described herein. However, subsequent NEPA compliance may be required prior to implementation of some of the restoration actions pending development of sufficient project-level detail. The need for additional NEPA review will be determined once detailed engineering design work or operational plans are developed for selected projects. Additional review may also be required if any second tier projects are implemented.

3.3.4 Other Federal and State Laws, Regulations, and Policies

As described above, OPA, NMSA, and NEPA, and federal regulations implementing these laws are the major federal laws and regulations guiding the development of this DARP/EA for restoration of injured resources and services resulting from the spill. However, there are other federal and state laws, regulations or policies that may be pertinent to this DARP/EA or to implementation of the specific restoration actions described herein. Potentially relevant laws, regulations, and policies are set forth below.

Clean Water Act

The federal Water Pollution Control Act (commonly referred to as the Clean Water Act or CWA) is the principal federal statute governing water quality (33 U.S.C. §§ 1257–1387). The CWA's objective is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. The CWA regulates both the direct (point source) and indirect (non-point source) discharge of pollutants into the Nation's waters.

Section 402 of the CWA established the National Pollution Discharge Elimination System (NPDES) program. The CWA allows EPA to authorize state governments to implement the NPDES program. Section 301 of the CWA prohibits the discharge into navigable waters of any pollutant by any person from a point source unless it is in compliance with a National Pollution Discharge Elimination System (NPDES) permit. Section 319 of the CWA directs states to identify best management practices and measures to reduce non-point source pollution.

Section 311 of the CWA regulates, among other things, the discharge of oil and other hazardous substances into navigable waters, adjoining shorelines, and waters of the contiguous zone. The CWA allows the federal government to remove the discharges and assess the removal costs against the responsible party. The CWA defines removal costs to include costs for the restoration or replacement of natural resources damaged or destroyed as a result of a discharge of oil or a hazardous substance.

Section 404 of the CWA authorizes the U.S. Army Corps of Engineers (the Corps) to issue permits, after notice and opportunity for public hearings, for the discharge of dredged or fill material into the waters of the United States. Section 401 of the CWA provides that any applicant for a federal permit or license to conduct any activity which may result in any discharge into navigable waters must obtain certification of compliance with state water quality standards.

The Trustees anticipate that some restoration projects may trigger CWA permitting requirements. For those projects, such as the Ellwood seawall removal, the implementing entity will be required, as a condition of receiving restoration funds, to obtain the appropriate permits prior to project implementation.

Rivers and Harbors Appropriation Act of 1899

The Rivers and Harbors Appropriation Act of 1899 regulates the development and use of the nation's navigable waterways (33 USC. §§ 401–427). Section 10 of the Act prohibits unauthorized obstruction or alteration of navigable waters and vests the U.S. Army Corps of Engineers with authority to regulate discharges of fill and other materials into such waters.

The Trustees do not believe that any of the restoration projects set forth in this DARP/EA have the potential to negatively affect navigable waters because none of the projects will result in the obstruction or alteration of navigable waters.

Coastal Zone Management Act

The goal of the Coastal Zone Management Act (CZMA) is to encourage and assist states to preserve, protect, develop and, where possible, restore and enhance valuable natural coastal resources (16 U.S.C. §§ 1451–1466). Participation by states is voluntary. California developed the California Coastal Management Program pursuant to the requirements of the federal CZMA, and NOAA approved the program in 1977. The State has also enacted the federally approved California Coastal Act.

Section 1456 of the CZMA requires that any federal action inside or outside of the coastal zone that affects any land or water use or natural resources of the coastal zone shall be consistent to the maximum extent practicable with the enforceable policies of approved state management programs. It states that no federal license or permit may be granted without giving the State the opportunity to concur that the project is consistent with the state's coastal policies. The regulations implementing the CZMA outline the consistency procedures.

The California Coastal Commission (CCC) is designated under California’s federally approved Coastal Management Program as the state agency responsible for reviewing all consistency documents concerning most coastal lands in California. Under the California Coastal Management Program, the CCC is empowered to use the authority of the federal CZMA to ensure that federal projects and activities within the coastal zone are consistent with the policies of the California Coastal Management Program and state law.

The Trustees believe that the projects set forth in this DARP/EA can be implemented in a manner that will either have no adverse effect on coastal resources or uses or will be consistent to the maximum extent practicable with the CZMA, the California Coastal Act (California Public Resources Code Sections 30000, et seq.), and the California Coastal Management Program. Prior to implementation, the Trustees and/or the project implementers, as appropriate, will seek concurrence from the CCC for these projects.

Endangered Species Act

The purpose of the Endangered Species Act (ESA) is to conserve endangered and threatened species and the ecosystems upon which they depend (16 U.S.C. §§ 1531–1544). The ESA, among other things, directs all federal agencies to utilize their authorities to further these purposes. Pursuant to Section 7 of the ESA, federal agencies shall, in consultation with the Secretaries of the Interior and/or Commerce, ensure that any action that they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species, or result in the destruction or adverse modification of designated critical habitat.

Under the ESA, the National Marine Fisheries Service (NFMS) and the USFWS publish lists of endangered and threatened species. Before initiating an action, the federal action agency (i.e., the federal agency authorizing, funding, or carrying out a discretionary activity or program), or its non-federal permit applicant, must ask the USFWS and/or NMFS to provide a list of threatened, endangered, proposed, and candidate species and designated critical habitat that may be present in the project area. If no species or critical habitats are known to occur in the action area[7], the federal action agency has no further ESA obligations under Section 7. If the federal action agency determines that a project may affect a listed species or designated critical habitat, consultation is required.

If the federal action agency concludes that the project will not adversely affect listed species or critical habitat, the agency submits a "not likely to adversely affect" determination to the USFWS and/or NMFS. If the USFWS and/or NMFS concur with the federal action agency's determination of "not likely to adversely affect," then the consultation (informal to this point) is completed and the decision is put in writing.

If the federal action agency determines that the project is likely to adversely affect either a listed species or its critical habitat, then more formal consultation procedures are required. There is a designated period in which to consult (90 days), and beyond that, another set period for the USFWS and/or NMFS to prepare a biological opinion (45 days). The determination of whether or not the proposed action would be likely to jeopardize the species or adversely modify its critical habitat is contained in the biological opinion. If a jeopardy or adverse modification determination is made, the biological opinion must identify any reasonable and prudent alternatives that could allow the project to move forward.

Several federally-listed species occur in the project areas for this DARP/EA. For each selected project described in this Final DARP/EA, the Trustees and/or the project implementer, as appropriate, will evaluate the potential effects of the project on listed species and critical habitat. Based on this analysis, the Trustees and/or project implementer will perform the appropriate level of consultation with the USFWS and/or NMFS pursuant to Section 7 of the ESA.

Magnuson-Stevens Fishery Conservation and Management Act

The federal Magnuson-Stevens Fishery Conservation and Management Act, as amended and reauthorized by the Sustainable Fisheries Act of 1996, establishes a program to promote the protection of essential fish habitat (EFH) in the review of projects conducted under federal permits, licenses, or other authorities that affect or have the potential to affect such habitat (16 U.S.C. §§ 1801–1869). After EFH has been described and identified in fishery management plans by the regional fishery management councils, federal agencies are obligated to consult with the Secretary of Commerce with respect to any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by such agency that may adversely affect any EFH.

[7] An "action area" consists of all areas that may be affected directly or indirectly by the proposed action and not merely the immediate area involved in the action.

EFH occurs within the project areas for this DARP/EA. For each selected project in this Final DARP/EA, the Trustees and/or the project implementer, as appropriate, will evaluate the potential effects of the project on EFH. Based on this analysis, the Trustees and/or project implementer will perform the appropriate level of consultation with NMFS.

Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (FWCA) provides the basic authority for the USFWS involvement in the evaluation of impacts to fish and wildlife from proposed water resource development projects (16 U.S.C. §§ 661–667d). The FWCA requires that federal agencies consult with the USFWS (and/or NMFS as may be appropriate) and state wildlife agencies for activities that affect, control or modify waters of any stream or other bodies of water, in order to minimize the adverse impacts of such actions on fish and wildlife resources and habitat. This consultation is generally incorporated into the process of complying with Section 404 of the Clean Water Act, NEPA or other federal permit, license or review requirements.

The Trustees or the project implementer, as appropriate, will consult with the necessary agencies on any of the selected restoration projects that involve activities that affect, control, or modify streams or other bodies of water.

Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) prohibits, with certain exceptions, the take of marine mammals in US waters and by US citizens on the high seas, and the importation of marine mammals and marine mammal products into the United States. (16 U.S.C. §§ 1361–1423h). Under the MMPA, the Secretary of Commerce, through NMFS, is responsible for the conservation and management of pinnipeds (other than walruses) and cetaceans, and the Secretary of the Interior, through USFWS, is responsible for walruses, sea and marine otters, polar bears, manatees, and dugongs. Title II of the MMPA established an independent Marine Mammal Commission which provides independent oversight of the marine mammal conservation policies and programs being carried out by federal regulatory agencies. The Commission is charged with developing, reviewing, and making recommendations on domestic and international actions and policies of all federal agencies with respect to marine mammal protection and conservation. The MMPA provides for several exceptions to the moratorium on taking and importing marine mammals and marine mammal products. NMFS and USFWS may issue permits for take or importation for purposes of scientific research, public display, photography for educational or commercial purposes, enhancing the survival or recovery of a species or stock, importation of certain polar bear parts taken in sports hunting in Canada, and incidental taking in the course of commercial fishing operations.

The restoration actions set forth by the Trustees in this DARP/EA are permitted actions under the MMPA. The Trustees will consult with NMFS and/or USFWS to ensure the selected restoration projects do not violate the MMPA.

Migratory Bird Treaty Act of 1918

The Migratory Bird Treaty Act (MBTA) implements four international treaties involving protection of migratory birds, including all marine birds, and is one of the earliest statutes to provide for avian protection by the federal government (16 U.S.C. §§ 703–712). The MBTA generally prohibits actions to "pursue, hunt, take, capture, kill, attempt to take, kill, possess, offer for sale, sell, offer to purchase, deliver for shipment, ship, cause to be shipped, deliver for transportation, transport, cause to be transported, carry, or cause to be carried by any means whatever, receive for shipment, transportation or carriage, or export, at any time, or in any manner, any migratory bird...or any part, nest, or egg of such bird." Exceptions to these prohibitions are only allowed under regulations or permits issued by the USFWS. Hunting of migratory game birds is regulated annually through a process in which the USFWS sets "framework regulations" and "special regulations" designed to maintain sustainable hunting levels. All other actions prohibited by the MBTA are only allowed under specific permits issued by the USFWS Regional Bird Permit Offices.

Implementation of restoration projects selected in this Final DARP/EA will be conducted in full compliance with the MBTA.

Executive Order 11988 – Construction in Flood Plains

The 1977 Executive Order 11988 seeks to avoid, to the extent possible, the long-and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct or indirect support of development in flood plains wherever there is a practicable alternative. Each federal agency is responsible for evaluating the potential effects of any action it may take in a flood plain. Before taking an action, the federal agency should determine whether the proposed action would occur in a flood plain. For any major federal action significantly affecting the quality of the human environment, the evaluation would be included in the agency's environmental impact statement prepared pursuant to NEPA. The agency should consider alternatives to avoid adverse effects and incompatible development in flood plains. If the only practicable alternative requires siting in a flood plain, the agency should: (1) design or modify the action to minimize potential harm, and (2) prepare and circulate a notice containing an explanation of why the action is proposed to be located in the flood plain.

None of the restoration projects set forth in this DARP/EA involve construction in a floodplain.

Executive Order 13112 – Invasive Species

The 1999 Executive Order 13112 requires that all federal agencies whose actions may affect the status of invasive species shall, to the extent practicable and permitted by law, (1) identify such actions, and (2) take actions specified in the Order to address the problem consistent with their authorities and budgetary resources; and (3) not authorize, fund, or carry out actions that they believe are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless, "pursuant to guidelines that it has prescribed, the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions."

The Trustees do not believe that any of the restoration projects set forth in this DARP/EA have the potential to cause or promote the introduction or spread of invasive species. However, some of the restoration projects considered in this DARP/EA are aimed at the removal or control of non-native species.

Executive Order 12898 – Environmental Justice

The 1994 Executive Order 12898 requires each federal agency to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations. In the memorandum to heads of departments and agencies that accompanied executive Order 12898, the President specifically recognized the importance of procedures under NEPA for identifying and addressing environmental justice concerns. The memorandum states that "each federal agency shall analyze the environmental effects, including human health, economic and social effects, of federal actions, including effects on minority communities and low-income communities, when such analysis is required by [NEPA]." The memorandum particularly emphasizes the importance of NEPA's public participation process, directing that "each federal agency shall provide opportunities for community input in the NEPA process." Agencies are further directed to "identify potential effects and mitigation measures in consultation with affected communities, and improve the accessibility of meetings, crucial documents, and notices." The CEQ has oversight of the federal government's compliance with Executive Order 12898 and NEPA.

The Trustees have involved the affected communities by providing notice to the public, seeking public comments, holding public meetings and providing public access to the Administrative Record. In addition, all selected actions described in this Final DARP/EA are expected to have positive environmental impacts and not to impose any adverse impacts on any community.

Information Quality Act, Public Law 106-554, Section 515

Information disseminated by federal agencies to the public after October 1, 2002, is subject to information quality guidelines developed by each agency pursuant to Section 515 of Public Law 106-554 that are intended to ensure and maximize the quality of the objectivity, utility and integrity of such information. This DARP/EA is an information product covered by information quality guidelines established by NOAA and DOI for this purpose. The quality of the information contained herein is consistent with the applicable parts of these guidelines.

3.3.5 State Laws, Regulations, and Policies

California Lempert-Keene-Seastrand Oil Spill Prevention and Response Act, Government Code § 9574.1, et seq.

The Lempert-Keene-Seastrand Oil Spill Prevention and Response Act became effective on September 24, 1990. This legislation and subsequent amendments are the key state compensatory mechanism for oil spills and establishes a comprehensive liability scheme for damages resulting from oil spills into waters of the state, excluding groundwater. The legislation also established an Administrator for oil spill response, appointed by the Governor, and the Office of Spill Prevention and Response (OSPR) within the CDFW. The Administrator is required to ensure that, as part of the response to any significant spill, damages to natural resource are assessed. Recoverable damages include damages for the injury to, destruction of, or loss of natural resources, including the reasonable costs of assessing the injury, destruction, or loss, the cost of rehabilitating wildlife, habitat, and other resources, and the loss of use and enjoyment of natural resources, public beaches, and other public resources.

The Administrator, a chief deputy director of CDFW, must coordinate all actions required by state or local agencies to assess injury to, and provide full mitigation for injury to, or to restore, rehabilitate, or replace, natural resources, including wildlife, fisheries, wildlife or fisheries habitat, and beaches and other coastal areas, that are damaged by an oil spill. Such actions include actions required by state trustees under Section 1006 of OPA (requiring state trustees to assess natural resource damages under their trusteeship and to develop and implement a plan for restoration of natural resources).

In this case, the state Trustees participated as part of the Trustee group to identify and quantify injuries to natural resources, including wildlife, fisheries, wildlife or fisheries habitat, and beaches and other coastal areas, and the loss of their use, under the Lempert-Keene-Seastrand Oil Spill Prevention and Response Act concurrently with similar work being conducted under OPA.

The Lempert-Keene-Seastrand Oil Spill Prevention and Response Act does not contain public participation requirements like OPA; however, since the natural resources belonging to, managed by, controlled by, or appertaining to the State of California or political subdivision thereof that were injured by the spill are also compensable under OPA, they are dealt with concurrently in this document.

California Environmental Quality Act, Pub. Res. Code 21000-21178.1
The California Environmental Quality Act (CEQA) was adopted in 1970. Its basic purposes are to inform California governmental agencies and the public about the potentially significant effects of proposed activities, to identify ways that environmental damage can be avoided or significantly reduced, to prevent significant avoidable damage to the environment through adoption of feasible alternatives or mitigation measures, and to disclose the reasons for agency approval of a project resulting in significant environmental effects.

The CEQA process begins with a preliminary review as to whether CEQA applies to the project in question. Generally, a project is subject to CEQA if it involves a discretionary action that is carried out, funded or authorized by an agency (i.e., the lead agency), and has the potential to impact the environment, including tribal cultural resources. Once the lead agency determines that the project is subject to CEQA, the lead agency must then determine whether the action is exempt from CEQA compliance under either a statutory or categorical exemption. Examples of categorical exemptions include actions taken by regulatory agencies for protection of natural resources and actions by regulatory agencies for protection of the environment (Title 14 CCR, Chapter 3, §§ 15307-15308).

If the lead agency determines that the project is not exempt, then an Initial Study is generally prepared to determine whether the project may have a significant effect on the environment. Based on the results of the Initial Study, the lead agency determines whether to prepare a Negative Declaration (i.e., the project will not result in significant adverse effects to the environment) or an Environmental Impact Report (EIR). The test for determining whether an EIR or negative declaration must be prepared is whether a fair argument can be made based on substantial evidence that the project may have a significant adverse effect on the environment. Lead agencies must also provide notice to tribes that are traditionally and culturally affiliated with the geographic area of a proposed project and who have requested notice of projects proposed within that area. If the tribe requests consultation, the lead agency must consult with the tribe and consider any alternatives or mitigation measures recommended by the tribe.

CEQA encourages the use of a federal EIS or FONSI prepared pursuant to NEPA when such documents are available, or the preparation of joint state/federal documents, in lieu of preparing a separate EIR or negative declaration under CEQA. Accordingly, this DARP/EA and subsequent FONSI, if issued, may be relied upon by the lead agency towards compliance with CEQA as required for discretionary projects that are authorized, funded or carried out by California state or local agencies. Toward this end, the state Trustees will coordinate with the federal Trustees to ensure the Final DARP/EA and FONSI (if issued) are consistent with the provisions of CEQA Guidelines including state public review requirements. (Title 14 CCR, Chapter 3, § 15220 *et seq*.).

The Trustees anticipate that this DARP/EA and subsequent FONSI, if issued, will comply with the CEQA guidelines for most of the restoration projects described herein. However, subsequent CEQA compliance may be required prior to implementation of some of the restoration actions that are conceptual at this stage, pending development of sufficient project-level detail. This will be determined once detailed engineering design work or operational plans are developed for the selected projects, and once human use projects have been defined.

California Coastal Act, California Public Resources Code § 30000, et seq.

The California Coastal Act was enacted by the California State Legislature in 1976 to provide long-term protection of California’s 1,100-mile coastline for the benefit of current and future generations. The Coastal Act created a partnership between the state (acting through the California Coastal Commission [Commission]) and coastal cities and counties to manage the conservation and development of land and water in the coastal zone through a comprehensive planning and regulatory program. New development in the coastal zone may require a permit from the Commission or the appropriate local governmental agency. Development activities are broadly defined to include construction projects, divisions of land, and activities that change the intensity of use of land or public access to coastal waters. The Commission also reviews and approves Local Coastal Programs, which are the basic planning tools used by local governments to guide development in the coastal zone. The coastal zone established by the Coastal Act does not include San Francisco Bay which is regulated by the BCDC pursuant to the McAteer-Petris Act (California Government Code Sections 66690, et seq.).

While the Trustees do not anticipate that any of the restoration projects will adversely affect coastal resources, some of the projects may meet the definition of development under the California Coastal Act, such as the Ellwood seawall removal project. The implementing entity for each selected project will be required to apply for any necessary permits and approvals, including any required coastal development permit. In addition, the federal Trustees or the implementing entity, as appropriate, will conduct consultation with the CCC, as discussed above under the CZMA.

California Endangered Species Act, Fish and Game Code 2050 et seq.

Pursuant to CESA (California Fish and Game Code Sections 2050 et seq.), it is the policy of the State of California that state agencies should not approve projects that would jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat essential to the continued existence of those species if there are reasonable and prudent alternatives available. However, if reasonable alternatives are infeasible, individual projects may be approved if appropriate mitigation and enhancement measures are provided.

Pursuant to the CESA, the Fish and Game Commission has established a list of threatened and endangered species based on criteria recommended by the California Department of Fish and Game. Section 2080 of the California Fish and Game Code prohibits “take” of any species that the Commission determines to be an endangered species or a threatened species. Take is defined in Section 86 of the Fish and Game Code as “hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill.” The CESA allows for take incidental to otherwise lawful development projects. The CESA emphasizes early consultation to avoid potential impacts to rare, endangered, or threatened species and to develop appropriate mitigation planning to offset project-caused losses of populations of listed species and their essential habitats.

Several state-listed species occur in the spill-affected area. While the Trustees do not believe the restoration projects set forth in this DARP/EA will result in the take of any state-listed species, the Trustees will evaluate the potential effects of the projects on these species and consult with the CDFW as may be appropriate pursuant to the requirements of the CESA.

Public Resources Code, Division 6, § 6001, et seq.
The Public Resources Code, Division 6, gives the California State Lands Commission trustee ownership over State sovereign tide and submerged lands. Permits or leases may be required from the State Lands Commission if a restoration project is located on such lands.

3.3.6 Other Potentially Applicable Statues and Regulations

Additional legal requirements may be applicable to NRDA restoration planning activities. The statutes listed below, or their implementing regulations, may require permits from federal or state permitting authorities:

- National Park Service Organic Act of 1916, 54 U.S.C. 100101-104907;
- Archaeological Resources Protection Act, 16 USC 460, et seq.;
- National Historic Preservation Act of 1966 as amended (16 USC 470-470t, 110);
- Clean Air Act, 42 USC 7401, et seq.; and
- Porter-Cologne Water Quality Control Act, Water Code Sections 13000 et seq.

4.0 Injury Quantification and Restoration Planning Methods

The Oil Pollution Act NRDA regulations define injury as "an observable or measurable adverse change in a natural resource or impairment of a natural resource service." The goal of an injury assessment is to determine the nature, extent and severity of injuries to natural resources, thus providing the technical basis for evaluating and properly scaling potential restoration actions to compensate for resource injuries. An impairment or loss of human uses of the natural resources, e.g., lost recreation, is compensable under the OPA NRDA regulations, as well. In contrast, natural resource damages are the monetary damages recoverable by natural resource trustees to compensate the public for the injuries to natural resources and the loss or impairment of human uses of natural resources resulting from an oil spill. Such damages include the cost to restore the injured natural resources, the monetary value of spill-related human use impacts, as well as the reasonable cost of the assessment.

For each of the injury categories evaluated following the spill and discussed in this DARP/EA, the Trustees, informed in part by the contributions of the responsible party, selected assessment procedures based on (1) the range of procedures available under section 990.27(b) of the OPA regulations; (2) the time and cost necessary to implement the procedures, and considering whether the additional cost of more complex procedures were related to the expected increase in the quantity and/or quality of the information to be acquired; (3) the potential nature, degree, and spatial and temporal extent of the injury; (4) potential restoration actions for the injury; (5) the relevance and adequacy of information generated by the procedures to meet information requirements of planning appropriate restoration actions; and (6) input from scientific experts. (15 C.F.R. § 990.27(c)).

4.1 Quantification of Damages

Each injury assessment focused on determining both the magnitude of the injury to a resource or a natural resource service (e.g., number of animals killed, acres impacted, or days of lost recreational opportunity) and the time to full recovery. This produced an estimate of the initial and interim (from the time of injury until full recovery) losses resulting from the oil spill.

The Trustees' next task is to determine the scale of restoration actions that adequately compensate the public for the injuries resulting from the spill. For wildlife and habitat, the Trustees have used Resource Equivalency Analysis (REA) or Habitat Equivalency Analysis (HEA), an approach that quantifies both the injury from the spill and the benefits of potential restoration projects, such that they may be compared with each other. For human recreational losses, the Trustees have used a valuation approach, estimating the number of lost user days for various activities and locations, and then calculating the lost value, in dollars, of that lost use. These methods are further described below.

4.1.1 Equivalency Analysis

For the quantification of injuries to wildlife and habitat, the Trustees have relied on a service-to-service restoration-based approach, in accordance with 990.53(d)(2). In other words, the Trustees have sought appropriate restoration projects to both restore the injured resources and compensate for the interim losses between the time of the spill and full recovery to the conditions that would have existed had the spill not occurred (see NOAA 1997). Restoration scaling is the process of determining the appropriate size of a restoration project, so as to compensate for the injuries and lost services. These projects, because of their compensatory nature, are intended to restore, replace, rehabilitate, or acquire the equivalent resources "of the same type and quality, and of comparable value" as those injured (NOAA 1995). For this task, the Trustees relied upon equivalency methods, sometimes specified as HEA when applied to habitat injuries or REA when applied to resources in general. These methods are described in greater detail in Appendix C.

4.1.2 Value of Lost Human Uses

To quantify lost and impaired human uses resulting from the Incident, the Trustees, partially in cooperation with the responsible party, have gathered data regarding visitor use of impacted sites and associated activities. To value those lost uses the Trustees used a travel cost model for beach camping and are employing the benefits transfer method for other shoreline and offshore uses. In other words, the Trustees determined the lost monetary value of each lost trip, and multiplied the resulting value by the number of lost trips. To compensate for the lost and diminished human uses arising from the spill, the Trustees intend to solicit project ideas from public agencies, non-governmental organizations, as well as from the general public. The Trustees will then select restoration actions using a value to cost approach, by which the cost of the restoration actions is equivalent to the lost monetary value of human uses.

For a number of reasons, the value-to-cost method is the most commonly used approach to address lost recreational use in NRD cases across the nation. The Trustees' determined that a value-to-value or service-to-service approach, which attempts to compare the value or benefits of specific restoration actions to the injury, would be impractical as the scope and/or number of studies required to implement either approach would be prohibitively time-consuming and expensive, and therefore less desirable under the assessment procedure criteria laid out in 990.27(c) and listed above.

A wide variety of recreational activities were affected by the spill. Examples include camping, sunbathing, beach combing, exercising, swimming, wildlife viewing, and dog-walking, as well as more specialized activities such as fishing, diving, boating, and surfing. Additionally, a wide variety of shoreline locations in Santa Barbara, Ventura, and Los Angeles Counties were impacted. The Trustees anticipate implementing a suite of restoration projects to compensate for impacts to various types of activities across the spill-affected area. The Trustees' anticipate that multiple projects will compensate for recreational use impacts. Each project will require significant coordination among the landowner or manager where the projects will be implemented, the local governments and the public. To properly implement a value-to-value or service-to-service approach in these circumstances would have required the Trustees to separately study, evaluate and determine the value and benefits of each individual proposed project in a range of locales. Such studies of the potential benefits of the proposed projects could easily take several years and cost several times more than the value-to-cost method employed by the Trustees.

4.2 Restoration Project Selection Criteria

The Trustees considered numerous restoration alternatives to compensate the public for spill-related injuries. Each restoration alternative presented in this plan was evaluated using the factors outlined in section 990.54 of the OPA regulations, as well as additional criteria deemed necessary to identify the optimal suite of restoration projects. The criteria are described below. Applying these criteria to the restoration project concepts received to date resulted in the Trustees' selection of preferred restoration alternatives described in this Final DARP/EA. All restoration alternatives submitted by the public or developed by the Trustees, other than Human Use projects, are presented in Section 5 and/or Appendix N. Appendix N includes both selected projects and second tier projects (that may be implemented if funding allows), as well as projects that did not meet the Threshold Criteria and were not further evaluated.

Threshold Criteria	**If a project does not meet these criteria, it will not be considered further per OPA 990.53(a)(2).**
1. Consistency with Trustees' Restoration Goals	• Does the project provide tangible benefits to plants, animals, and their habitats that were affected by the spill (e.g., shoreline habitats and resources, subtidal and fish habitats and resources, birds, marine mammals)? • Does the project provide tangible benefits for enhancing recreational opportunities that were affected by the spill?
2. Technical Feasibility	• Is the project technically and procedurally sound, and not already been funded or completed?
Evaluation Criteria	
1. Nexus between the Restoration Project and the Impacts of the spill on Natural Resources	• To what extent does the project benefit shoreline habitats and resources, subtidal habitats and resources, birds, marine mammals, or recreational opportunities and users that were affected by the spill? • To what extent does the project location or geographic scope of project benefits correspond to areas impacted by the spill?
2. Compliance with Applicable Laws	• Will the potential project implementer have the legal right to access the project site and conduct the project, including all necessary long-term maintenance? • Are there willing landowners who support the project?

	• How difficult and complex are the permitting processes required to implement the project? • How readily will the likely project implementer be able to meet all applicable laws and obtain all relevant permits.
3. Cost-Effectiveness	• Projects that deliver greater benefits relative to their costs will be preferred over projects that provide fewer benefits relative to their costs.
4. Range of Restoration Project Benefits	• Will the project benefit more than one natural resource and/or service? • Does the project fit within a total suite of selected restoration projects that address the geographic distribution and types of injuries or recreation impacts associated with the spill? • The Trustees consider the extent to which a project contributes to the overall restoration plan. This includes the degree to which a project may benefit any otherwise uncompensated spill injuries.
5. Time to Provide Benefits	• Projects that begin providing benefits to the target resource or public sooner are preferred to projects where the onset of benefits is not expected until far into the future. • For capital improvements, projects that are "shovel ready" will be preferred over those projects that are in the design or pre-design phases. Projects where permitting is completed (or otherwise straightforward) will be preferred to projects that require complex permitting processes that will take significant time. • For projects in general, those projects that can articulate how target resource benefits or public benefits will begin in the near future will be preferred to projects that cannot.
6. Duration of Project Benefits, and Maintenance Requirements	• Projects expected to have longer term benefits are favored over those that have shorter term benefits. • If long term benefits are expected, is there a mechanism in place to ensure that those benefits are realized and maintained through time? • Is there an entity that will be responsible for maintaining the project over time?
7. Avoidance of Collateral Injury from Project Implementation	• Project should not benefit one natural resource to the detriment of others. • A project that addresses ongoing diminishment of natural resources that resulted from the spill will be preferred.
8. Likelihood of Project Success	• Projects with a higher likelihood of successful implementation (e.g., obtaining necessary permits, constructing improvements, carrying out project-related activities), and that are otherwise more technically feasible are preferred.

	• Will there be objective indicators to measure project success and demonstrate that the project has provided natural resource benefits?
9. Total Project Cost and Accuracy of Estimate	• Trustees prefer the least costly project of otherwise equivalent alternatives • Projects with greater certainty of the costs related to successful implementation will be preferred over projects with high budget uncertainty.
10. Effect of Project on Public Health and Safety	• Projects that enhance public health and safety are preferred.
11. Opportunities for Collaboration	• Projects with matching funds are preferred to projects without matching funds.
12. Non-Duplication	• Projects funded through damages should not displace other funds. • Project should not duplicate other efforts already ongoing at the same location.
13. Education/Research Value	• Does the project have the potential for public education and outreach or to advance scientific knowledge for the benefit of natural resources management?
14. Cultural Value	• Does the project have the potential for cultural resources conservation and/or education?
15. Ability to Document Benefits to the Public	• The Trustees consider the ability to document receipt or delivery of benefits to the public as a result of a project or other use of funds.

5.0 Injury Quantification and Restoration Alternatives

This section describes the nature, extent, and severity of injuries to natural resources and human uses resulting from the spill, as well as potential restoration alternatives, including selected alternatives, to compensate for these injuries. This section is divided into the following resource categories:

- Shoreline Habitats;
- Subtidal and Fish Habitats;
- Birds;
- Marine Mammals; and
- Human Uses.

At the time of the spill, the Trustees created these categories to organize the assessment of injuries to natural resources. The Trustees used available information, field data, focused studies, and expert scientific judgment to arrive at their best estimate of the injuries. Scientific investigators included state and federal scientists, academic research scientists, consultants with damage assessment experience, and recognized experts within each resource category. During, and for some time following the spill, field teams were organized that included the investigators above, as well as one or more representatives of Plains (see Section 3.2.3).

In addition, the Trustees divided the spill footprint into four geographic zones (Zones A, B, C, and D) based on level of oiling (Figure 8). This was primarily done for purposes of assessing injury to shoreline and subtidal habitat.

Zone A

- Location: Gaviota State Park to Arroyo Hondo (approximately 6 miles of coastline)
- Level of oiling: moderately to lightly oiled

Zone B

- Location: Arroyo Hondo to Coal Oil Point (approximately 18 miles of coastline)
- Level of oiling: heavy to moderately oiled

Zone C

- Location: Coal Oil Point to the Santa Barbara Harbor (approximately 18 miles of coastline)
- Level of oiling: moderately to lightly oiled

Zone D

- Location: Santa Barbara Harbor to Long Beach (approximately 296 miles of coastline)
- Level of oiling: intermittent oil, characterized as moderate to no observed oil.

Figure 8. Exposure zones A-D defined for the Refugio Beach Oil Spill NRDA (black lines) with shoreline oiling categories documented during Shoreline Cleanup Assessment Technique surveys conducted by the Unified Command. See Appendix B for data associated with this figure.

The Trustees assessed injury by comparing oiled areas to "baseline" conditions, as that term is used in the OPA regulations. Baseline describes the ecological services that are present "but for" the oil spill, including factors such as the abundance, biomass, diversity, age classes of characteristic plants and animals, the availability of suitable habitat for shelter, foraging, and reproduction, and the availability of food items for fish and wildlife.

As discussed throughout this section, the Trustees concluded that the magnitude of the injuries caused by the spill has been sufficiently delineated through the various studies described herein to enable the Trustees to identify and scale appropriate restoration. While there is some uncertainty inherent in the assessment of impacts from oil spills, and while collecting more information may increase the precision of the estimate of the impacts, the Trustees believe that the type and scale of potential restoration actions would not substantially change as a result of more studies. Therefore, the Trustees sought to balance the desire for more information with the reality that further research would be costly and would delay the implementation of the restoration projects.

Each resource category section below begins with an overview of the studies conducted during the assessment and the results of those studies. The pathway of the oil and exposure are discussed and the conclusions of the injury assessment are then summarized, and the injury is quantified. Finally, the potential restoration alternatives are described, with the selected projects described in greater detail. The project descriptions include a discussion of the anticipated environmental impacts, or consequences, of the selected projects. The second tier projects are also listed and described, in lesser detail, as well (Appendix N). These projects may be reconsidered and selected for implementation if funds become available or if selected projects prove to be infeasible. Potential cumulative impacts of implementing restoration projects are summarized in Section 6.0.

5.1 Shoreline Habitats

After the release, Line 901 oil mixed into the surf and coated Refugio State Beach and nearby beaches. Oil was also carried offshore and down shore by wave action, currents and winds. The oil spread along the Gaviota coastline and then stranded intermittently downcoast for over 155 miles, depositing oil from Gaviota State Park to the north-west, along Santa Barbara County, and intermittently throughout Ventura and Los Angeles Counties to the southeast. Affected shorelines were assessed for injuries and losses to natural resource services that they provide. For the purposes of the shoreline injury assessment, separate analyses were conducted for sand beach and rocky intertidal habitats. Each habitat assessment relied upon field data and a variety of literature sources to examine effects of the spill on shoreline biota and document the effects of oil on beaches and intertidal flora and fauna. Injuries occurring within each habitat type were quantified within distinct exposure zones (Figure 8) based upon proximity to the oil release point and oiling characteristics. Potential restoration projects also were identified and scaled appropriately based on injuries quantified within each exposure zone.

5.1.1 Overview of Data Collection and Studies

The list below summarizes various field studies, data collection tasks, and analyses used by the Trustees to assess shoreline habitat injuries.

Response Information - Compilation of Oiled Shoreline Data

Immediately after and throughout the duration of the spill, Shoreline Cleanup and Assessment Technique (SCAT) Teams were dispatched to document the location and severity of shoreline oiling and to develop cleanup recommendations. These response teams reported on details concerning the approximate location, thickness, and percent cover of oil on intertidal habitats throughout the spill-affected shorelines. This information is primarily collected to assist response crews in prioritizing cleanup decisions. Along with NRDA team member observations, the Trustees used SCAT information during their injury assessment to gain an understanding of the severity of oiling along the affected shoreline segments over time.

Extent of Oiling Quantification and Mapping

The SCAT data and supplemental information described below were compiled to create maps showing the geographical extent and maximum observed degree of oiling along each shoreline segment. The oiling of shoreline habitats was quantified in terms of area in acres and degree of oiling using SCAT descriptions (e.g. heavy, moderate, light, very light) and mapped according to shoreline type (rocky intertidal, sandy beach, mixed rocky sandy shoreline, etc.). The area of affected shoreline, in acres, was calculated for each oiling category and each habitat type (Nixon

2018). The Trustees used the compilation from this effort to define the exposure zones discussed above (Figure 8).

Oil Sample Collection and Analysis

Polycyclic aromatic hydrocarbons (PAHs) are a suite of chemical components found in petroleum products, and all oil sources display a "fingerprint" of the unique proportions of the different PAHs and other chemical markers. This enables forensic evaluation of the source(s). Forensic analyses were conducted on oil, tarballs, and tissues to confirm the shorelines affected by Line 901 oil (Stout et al. 2018).

Environmental Sample Collection and Chemical Analysis

The Trustees collected invertebrate samples (i.e., mussels, sand crabs, beach hoppers, sand-associated polychaete worms, see Section 2.3.4) and water samples (surf zone, sediment pore water, Figure 9) from a wide variety of intertidal locations within the spill-affected area and analyzed for PAHs and other components of oil. Samples were collected before and after Line 901 oil impacted the shoreline to confirm and provide estimates of degree and duration of exposure to shoreline fauna. PAHs are toxic to organisms, and some of the animal body burden concentrations were compared to toxicology literature values as an indicator for potential health effects to marine invertebrates. PAHs were elevated in all media collected at locations oiled by Line 901 compared to reference locations. Chemistry data are provided in Appendix B and results are further discussed herein, in Appendix D, and in "Shoreline data summary" (Donohoe and Joab 2018).

Figure 9. Sediment porewater sample location showing oil sheen on the surface. Photo Credit: Natural Resource Damage Assessment Trustees.

Sandy Beach Intertidal Invertebrate Population Surveys

Study sites were established by the Trustees to monitor changes in populations of beach hoppers. Sites were surveyed approximately 1 month after the oil spill, 4 months after the spill and again two years later to document changes in population abundance, biomass and size structure of these indicator animals. Data from previous surveys of populations of beach hoppers at a subset of the sites were also compared to post spill data. Study sites within the spill area showed reductions in population numbers, when compared to unoiled sites, indicative of oil spill-related impacts. For further information, see the report "Population survey results on talitrid amphipods for the Refugio Beach Oil Spill NRDA" (Dugan 2018).

Rocky Intertidal Habitat Photo Transect

The Trustees conducted Rocky Intertidal substrate surveys to monitor changes in abundances of sessile organisms, substrate, and "condition" (oil/tar presence, bleaching), within fixed plots established along vertical or horizontal shoreline transects over time (post spill and six/twelve months post-spill). Assessment sites were selected throughout the primary spill area, using a survey protocol developed for oil spills. Additionally, teams visited permanent Long Term Monitoring plots (https://www.eeb.ucsc.edu/pacificrockyintertidal/index.html) that occur within the approximate spill area footprint for comparison to historical data. Photos were collected at fixed plots along the transects, i.e., photoplots, and were then scored and analyzed for substrate, condition (oiling/bleaching), species composition and proportion within the photo plot. Sites were re-visited in Fall 2015, and Spring 2016, to examine for community differences, presence/absence, or proportional changes to communities or substrate. Study sites within the Zone B showed most of the species examined were more common in sites that did not experience oiling, with the exception of Ulva and Porphyra, shorter lived opportunistic seaweeds that are often associated with disturbance. For further information, see the report "Assessment of potential impacts to rocky intertidal community following the Refugio Beach Oil Spill, Santa Barbara County" (Raimondi, 2019).

Laboratory Tests with Shoreline Species

The Trustees performed laboratory studies (i.e., bioassays) with mussels and sand crabs to determine the aquatic toxicity of the Line 901 oil and its constituents. Results were then compared to the measured concentration of oil constituents in the surf zone and sediment porewater on sandy beaches. Toxicity of Line 901 oil was observed in juvenile sand crabs, mussel larvae, and larval silversides. Appendix E provides an overview of the Line 901 bioassays performed. Appendix D includes an evaluation of the toxic impacts of Line 901 oil on these organisms based on measured concentrations of PAHs in surf and pore water following the spill.

Shoreline Clean Up Data

Clean up activities, primarily beach trampling and wrack (kelp/seaweed) removal, contributed to shoreline injuries caused by the spill. The Trustees compiled information on effort, such as number of days of cleaning, mass of materials removed by cleaning teams, and the types of cleaning expected to affect shoreline organisms as summarized in the report "Refugio Beach Oil Spill shoreline cleanup effort data report 30 Aug 2016" (Hubbard 2016)

5.1.2 Shoreline Injury

As mentioned in Section 4.1.1, the Trustees used the HEA method to estimate injury for each of the shoreline habit types[8]. Inputs to the HEA include the area of shoreline habitat impacted, the reduction in ecological services because of the spill, and time and trajectory for recovery of the affected environment. The degree of injury was related to the degree of oiling and quantified by zones (Figure 8). All rocky intertidal, sandy beach and mixed rocky sandy shorelines within the spill area were quantified in terms of acreages impacted by the spill. Degree of injury to the ecological services provided by each habitat and duration of injury until full recovery were estimated based on evidence from collected data including chemical, biological, and toxicological studies, inputs from scientific literature, and consultation with regional ecologists. Benefits of potential restoration projects were estimated and quantified in terms of their likely long-term ecological benefits. In this way, each project was "scaled" to be appropriate in size to the injury that incurred in each habitat type. Details are provided below and in Appendix F.

5.1.3 Sandy Beach Habitat Injury

Background

Much of the sandy shoreline affected by the spill is a mixture of cobble, sand, and boulders. For sandy beach environments, the Trustees chose to focus the assessment largely on invertebrates that dwell on and in sand and serve as prey items for both fish and birds, and to use these invertebrates as indicators of both exposure to and injury from the oil and its chemical components.

Line 901 oil from the release site at Refugio State Beach washed over and stranded along the Gaviota coast, and also stranded sporadically in Ventura County and some Los Angeles County beaches. Services provided by the sandy beach habitat to fish, birds and other wildlife were affected. In the most heavily oiled areas, there was smothering and fouling of invertebrates and other fauna. In areas of oil deposition, the entire intertidal zone was exposed to the oil, as it traveled back and forth with individual waves throughout the tidal cycle, until it either washed back out to sea, was stranded on the shore by the receding tides, or was buried by cycles of sand accumulation on the beach. Oil moved into the substrate as droplets, tarballs or dissolved liquid into sediment pore water as wave run-up percolated into pore spaces during higher tides. Larger oil deposits formed and persisted for long periods during periods of sand accumulation following the spill. Injuries resulting from the spill were attributed to direct contact (i.e., fouling) with oil, as well as the toxic effects of oil, including those attributed to PAHs.

In addition, shoreline cleanup efforts extended for many months and caused impacts to intertidal habitats and organisms over an extended period. In heavily oiled areas, the macrophyte wrack

[8] Plains disagrees with the extent of shoreline injury assessed by the Trustees and asserts shoreline injury is materially lower than the Trustee's estimate.

(stranded drift algae and surfgrass) was often oiled, and initially wrack was removed as part of cleanup operations. Wrack is of prime importance as food and habitat for a variety of invertebrate species that are a critical food source for higher trophic level organisms, including birds, fish, and crabs. Suspended detritus is another major food source for the masses of invertebrates living in the intertidal zone, and can be fouled by adhesion to oil particles or film. Conceptual diagrams shown in Figure 10 illustrate the movement of beach invertebrates and predators with tidal flux, as well as sediment porewater flow with oiling.

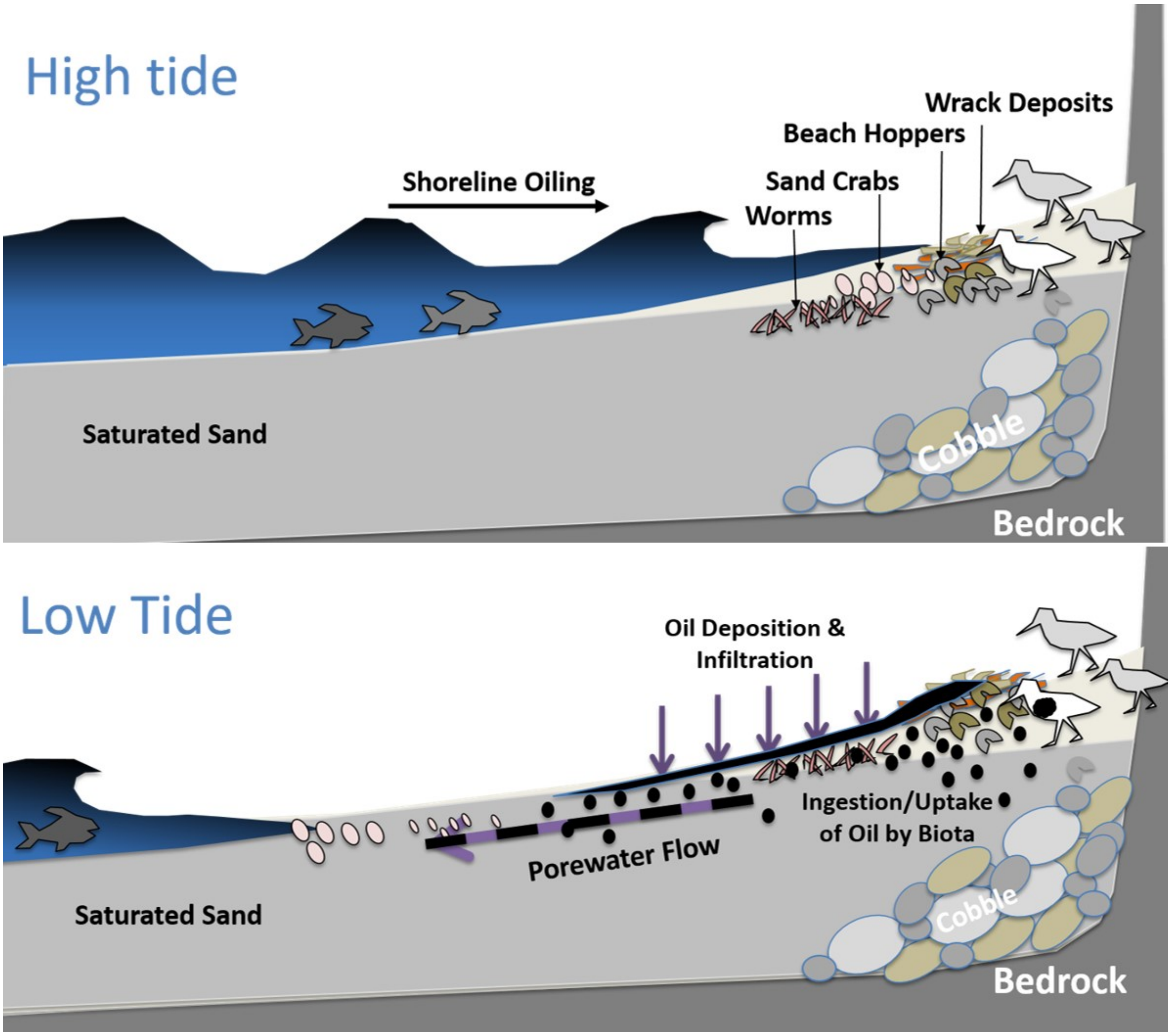


Figure 10. Conceptual diagrams of Refugio coast shoreline, sandy beach environments at high tide (top) and low tide (bottom). Sand crabs, polychaete worms, and beach hoppers are prey for birds and fish. Porewater flow down the beach profile is shown at low tide.

Sandy Beach Habitat Injury Assessment

Area of Impact

The Trustees split the area of impact into four geographic zones (Zones A through D, Figure 8) that covered the spill-affected area from west to east. Most data were collected in Zone B, the most heavily oiled zone. The area of affected shorelines within Zones A-D, in acres, was calculated based on beach width, tidal swell, and run-up data available during the oiling period. A summary of the shoreline acres affected and the duration of the injury is further discussed below and in Appendix F.

Baseline Conditions

The Trustees assessed injury by comparing oiled areas to baseline conditions, per the OPA regulations. The Trustees estimated those baseline conditions from the collection and chemical analysis of water and shoreline invertebrate samples, data on beach hopper populations from earlier studies, and other data and scientific literature pertinent to the occurrence and abundance of organisms by habitat type and location. These data were collected either before the spill, outside of the spill area or up to two years after the incident when the Trustees assumed continued exposure to Line 901 oil would have been eliminated or greatly reduced. For example, monthly to yearly sampling of sediment porewater and invertebrate tissues for chemical analysis over a two-year period in the spill area was used to estimate baseline conditions. See Appendix D for further details.

Figure 11. Oil on the shoreline at Refugio State Beach, May 19, 2015. Photo Credit: Natural Resource Damage Assessment Trustees.

Injury

The initial acute injury to sandy beach resources (direct smothering/fouling and toxicity) from the spill occurred over a period of many days. The incident started on May 19, 2015, at Refugio State Beach in Santa Barbara County, California, and the oil was transported up and down the coastline by winds and currents and deposited along the shoreline (Figure 11).

Near the end of May 2015, Line 901 oil from the spill eventually reached beaches in Ventura County and some beaches in Los Angeles County (i.e., Manhattan Beach and Redondo Beach). Spill impacts including impacts from cleanup were most severe and continued for months near the release site to El Capitan and then decreased downcoast. Mortality caused by the oil fouling and smothering of intertidal-associated organisms such as sand crabs and beach hoppers was also highest in areas near the release point to El Capitan and decreased downcoast (Figure 12; Figure 13).

Figure 12. Oiled young sand crabs on Refugio State Beach, May 19, 2015. Photo Credit: Natural Resource Damage Assessment Trustees.

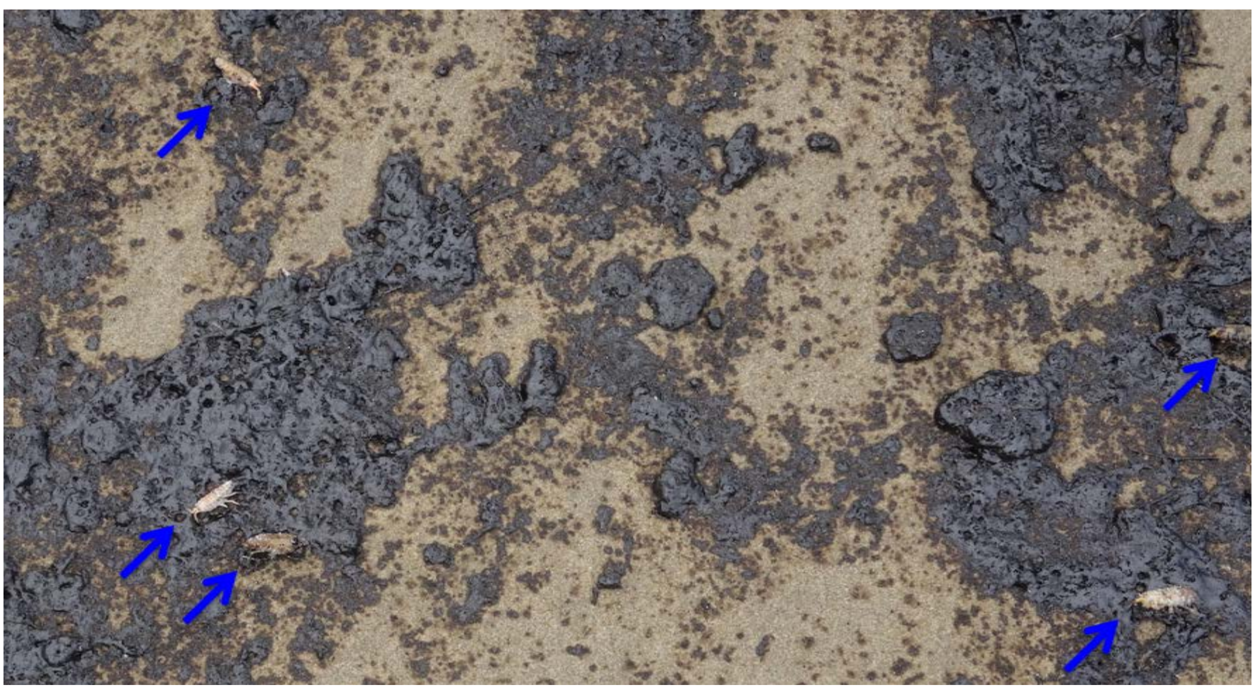


Figure 13. Oiled beach hoppers (talitrid amphipods) on Refugio State Beach, May 22, 2015. Photo Credit: Natural Resource Damage Assessment Trustees.

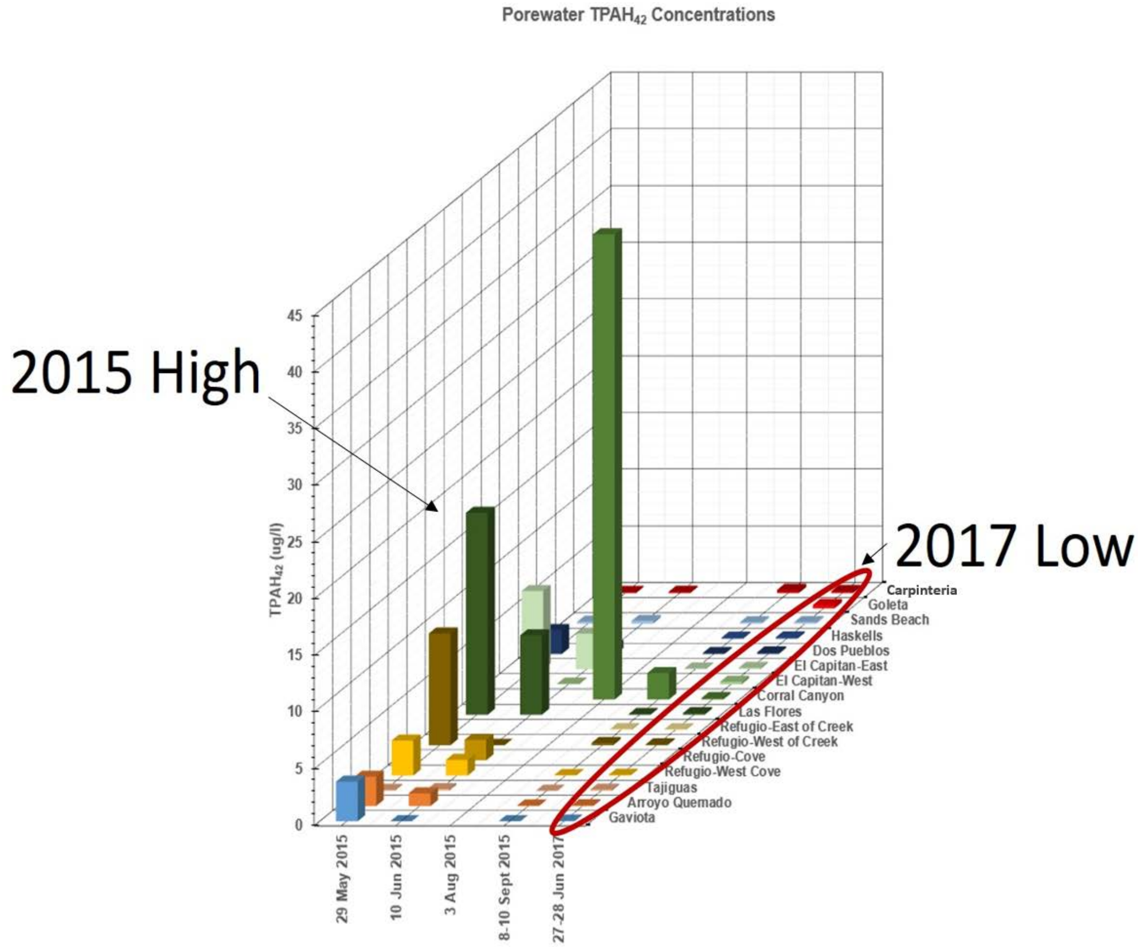


Figure 14. Total PAH concentrations in sediment porewater measured at several locations over time. 2017 values indicated by the red circle are representative of baseline conditions. See Appendix B for data associated with this figure.

Sediment porewater concentrations of PAHs between Gaviota and Haskell's along the Gaviota Coast became elevated soon after the spill and remained elevated months later, as shown in Figure 14. While seep oil is known to occur on shorelines in this area, the porewater data demonstrated a pattern over space and time that shows the spilled Line 901 oil increased the amount of PAHs in the porewater to an appreciable extent in May of 2015 and beyond. Initial PAH concentrations were highest at the locations closest to the release site and decreased as distance from the spill site increased. For example, porewater PAH concentrations decreased at locations between June and September of 2015, and by 2017, all locations were found to have very low (baseline) PAH concentrations (Figure 14). These trends suggest that the peak concentrations at the sampling sites were immediately following the spill, and then they began to decrease over time. Following a similar trend as porewater, Figure 15 shows elevated tissue concentrations of PAHs in beach hopper tissues immediately after the spill, with lower concentrations in 2016 and 2017 when compared to 2015.

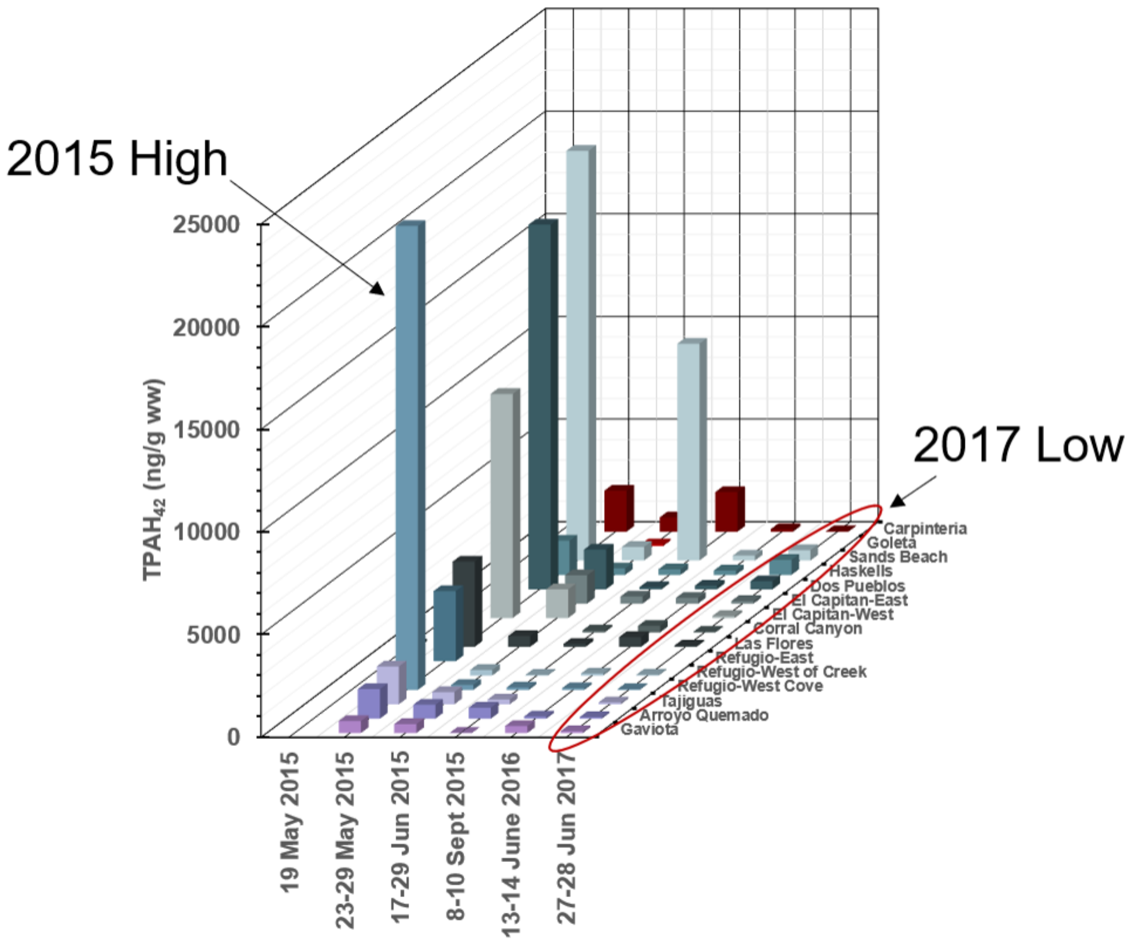


Figure 15. Total PAH concentrations in beach hopper tissue measured at several locations over time. See Appendix B for data associated with this figure.

Tissues of other shoreline organisms, including mussels, sand crabs, and sand-associated polychaete worms, also showed significant increases in tissue PAH concentrations (Appendix D, Donohoe and Joab 2018).

Sand crab toxicity thresholds for PAHs were exceeded in surf water, based on Line 901 bioassay results (Appendix D, Appendix E). Studies have shown that ultraviolet light (UV) from sunlight can enhance the toxicity of PAHs by a factor from 2-1000 (Barron 2017). Some PAHs in fish and invertebrate tissues are photo-activated by UV forming reactive products that cause oxidative damage. For the purpose of this evaluation, the Trustees adjusted LC_{50} values by a 10-fold factor to estimate photo-enhanced toxicity.

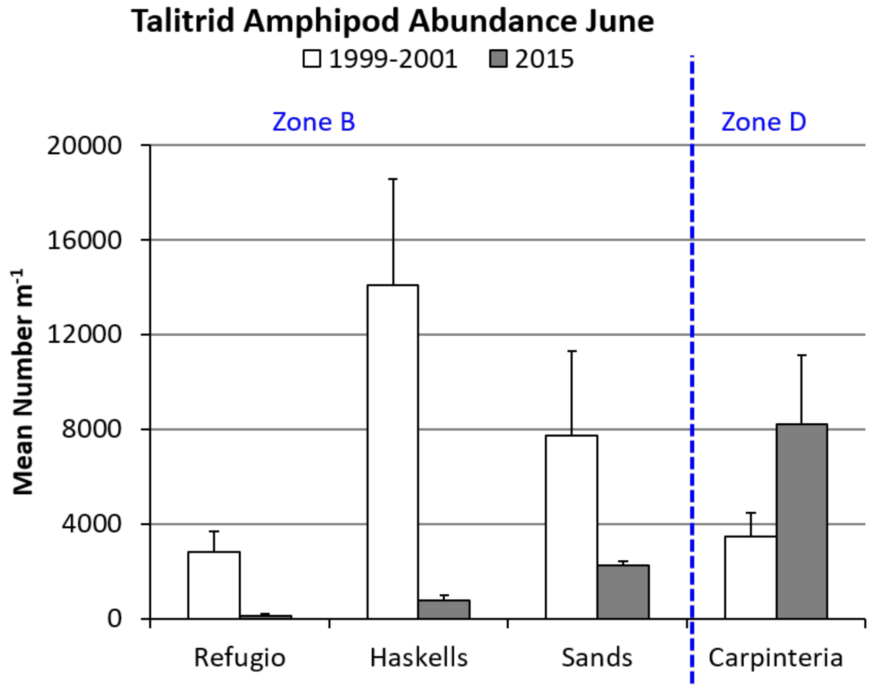


Figure 16. Mean values (+1 standard error) for population abundance of talitrid amphipods in June 1999-2001 and June 2015 at four sites on the spill-affected shoreline including three sites in Zone B, and one site in Zone D.

The shoreline assessment focused on two categories of impacts: 1) fouling and removal of beach wrack as well as other cleanup impacts and 2) oil exposure to intertidal invertebrate populations. Treatment or cleaning options for oiled wrack or stranded seaweed were limited. Oiling of wrack results in invertebrate contamination and mortality, leading to lessened and contaminated prey resources for birds. The removal of wrack material from the beach removes an exposure mechanism to the oil, but also removes the associated invertebrates and has long-term effects on foraging options for birds due to reduced invertebrate community abundance and biomass (Dugan et al. 2003; Beeler 2009). Both of these occurred in the aftermath of the spill as oiled wrack was collected and removed from heavily oiled beaches, but remained in place on more lightly oiled or unvisited stretches.

Sand crabs and beach hoppers dominate the invertebrate biomass on southern California sandy beaches (Dugan et al. 2003). As a defining ecological characteristic of lower intertidal communities, sand crabs were used to estimate and describe injury to lower intertidal habitats. Beach hoppers were selected as a proxy for assessing impacts to the upper intertidal community, as they are an important part of the sandy beach ecosystem. Beach hoppers process organic matter such as wrack. In addition, they make up a significant portion of the diet for several shorebird and other bird species. Finally, because they dominate the upper-intertidal invertebrate community it was relatively easy to assess their populations through field sampling.

Large decreases in the abundance of beach hoppers (talitrid amphipods) were documented in Zone B as well, as can be seen in Figure 16. A similar trend was apparent with biomass measurements of these organism (Dugan 2018).

The degree of injury resulting from fouling, toxicity and cleanup was estimated by the Trustees within subzones (i.e., further described as “micro-zones” in Appendix F) of Zone B. The Trustees focused on Zone B for logistical reasons and because this was the zone where oiling was the heaviest and cleanup activities were the most intense. Injury was estimated separately for lower intertidal fauna and for upper intertidal fauna. Upper and lower intertidal results were then averaged to estimate ‘whole-beach’ injury for a given zone. The sandy beach injury and much of the resulting HEA details are shown in Figure 17 and in Table 1. In Zones A and C, injury per acre was estimated as a fixed percent of the average per-acre injury found in Zone B: 20% in Zone A and 25% in Zone C. Those percentages approximate impacts associated with a lesser amount of oiling in Zones A and C when compared to Zone B. Zone D was estimated to be 5% injured in year one only, with no injury in subsequent years. Impacts in Zone D were lower because they were primarily based on removal of organisms by direct contact with oil or tarballs and other cleanup activities, along with the removal of a portion of the wrack material during cleanup activities.

Recovery

The Trustees estimates of recovery time for injured sandy beach communities were based on literature values and life history patterns of California sandy beach species, as well as monitoring data. First consideration was given to recovery of heavily disturbed sites in which there was evidence that representative fauna (sand crabs and beach hoppers) had been substantially impacted (a large percentage of mortality in several age classes). Cleanup and driving impacted some sandy beaches through at least January 2016, approximately eight months after the spill. The animals on sandy beaches have highly seasonal reproduction and will take several years to re-establish populations with full size and age structures and biomass. In addition, some sandy beach animals are more sensitive to disturbance and can take much longer to recover from severe disturbances (i.e., Pismo clams, olive snails, upper beach isopods).

Recovery to baseline is the attainment of 100% of the ecological services that would be present but for the spill, including abundance, biomass, diversity, and age classes of organisms in the affected habitats. Time to recovery was based on monitoring data, observations, and the life histories of the specific flora and fauna present in each habitat type, and relative to the degree of initial acute injury.

Sand crabs lost substantial proportions of three age classes during the Refugio Beach Oil Spill incident, and because recruitment is seasonal and episodic, recovery time for lower intertidal portion of sandy beaches was assessed as approximately three years in Zone B.

Most of the upper beach species have life histories that do not include planktonic larval stages (i.e., beach hoppers, beetles, isopods). This means there is no recruitment from planktonic sources to replenish their populations. These species rely exclusively on the reproduction of resident individuals for population replenishment. If local populations of these taxa are extinguished or severely depressed, population recovery will be protracted. Recovery time for upper beach species (i.e., beach hoppers) was therefore assessed as approximately four years in Zone B.

Habitat Equivalency Analysis Results

As previously described, injury in Zones A and C was estimated to be a percentage or fraction of the injury determined in Zone B, since the same mechanisms of injury were present, just with lesser amounts of oil and generally less severe impacts present. In Zone D, farthest from the spill location, injury resulted from contact with oil and the resulting fouling of organisms, as well as the cleanup activities, and was much more limited (Table 1, Figure 17).

Table 1. Summary of Sandy and Mixed Sand/Rocky Substrate Injury (losses) and Habitat Equivalency Analysis results by zone.

Zone - Predominant max. oiling category	**Acres exposed**	**Fraction of Zone B**	**dSAY[1] lost/ acre**	**Acre – years for compensation (dSAYs)**
Zone A – Moderate/Lightly Oiled	63.2	0.2	0.2954	18.66
Zone B – Heavily Oiled	345.8	1	1.4771	510.70
Zone C – Moderately Oiled	191.3	0.25	0.3693	70.64
Zone D – Lightly Oiled	888.0	0.034	0.0500	44.40
Total	1488	---	---	**644.4**

[1]dSAY = discounted service acre-year. See Appendix C.

Figure 17. Map showing the summary of shoreline injury by zones. See Appendix B for data associated with this figure.

A total of 1,488 acres of sandy beach habitat was exposed to and injured by the oil spill and is expected to recover within approximately four years, depending on oiling level. Appendix D provides additional information on the injury assessment and quantification of sandy beach habitat injuries, and the scaling details are further described in Appendix F.

5.1.4 Rocky Intertidal Habitat Injury

Background

The shoreline habitat within the area affected by the Refugio Beach Oil Spill includes a variety of rocky and mixed rocky/sand substrates, ranging from artificial to natural and an approximately six-foot tidal range. Substrates investigated by the Trustees included bedrock, boulder, cobble, and some man-made riprap and seawall. The habitat used by biota is three dimensional, with organisms on the surfaces of rocks, as well as along the sides, undersides, and between substrates. The biota present on these substrates vary depending upon tidal elevation. Figure 18 shows the conceptual diagrams of the rocky intertidal habitats and some of the immediate and longer-term impacts of oil exposure.

Rocky Intertidal Habitat Injury Assessment

Area of Impact

The Trustees quantified the number of impacted acres by using SCAT data, as described above. Injury categories were subdivided based on regional differences in biota and exposure and by differences between more natural rocky substrates and rip-rap as described below. The Gaviota Coast shoreline includes a mixture of sandy and rocky intertidal habitat. Sand migrates significantly throughout the year, burying boulders and rock outcroppings, a process that tends to scour any sessile organisms and prevent them from forming significant communities. The Trustees assessed that a total of 5.4 acres of pure rocky intertidal habitat was injured in the HEA (Appendix F), with the remainder of the shoreline (mixed rocky/sandy and sandy beach) included in the sandy beach assessment and quantification.

Baseline Conditions

The Trustees evaluated pre-spill data that provides a quantitative description of rocky intertidal biota within the spill-affected area. Historical long-term monitoring data, generated by the Multi-Agency Rocky Intertidal Network (MARINe) program, were used to determine general “pre-spill” conditions. Historical data are located at https://www.eeb.ucsc.edu/pacificrockyintertidal/index.html.

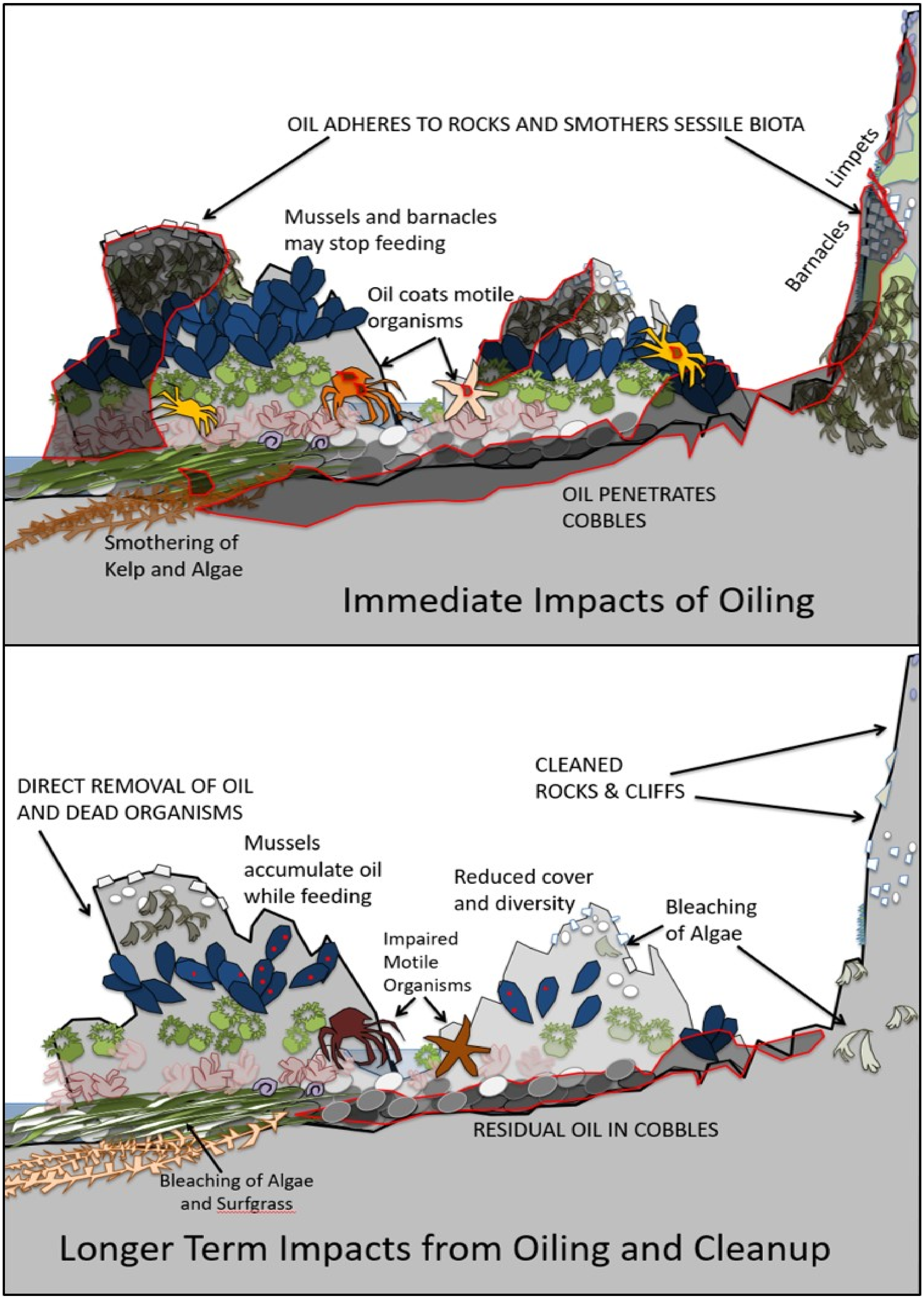


Figure 18. Conceptual model of oil immediate effects (top) and long-term effects (bottom) of oil in rocky intertidal habitats.

Figure 19. Photographs of oiled rocky habitat and organisms following the spill. Photo Credit: Natural Resource Damage Assessment Trustees.

Injury

The Trustees determined that the degree of impacts varied with the amount of oiling. The most significant fouling was noted in locations directly adjacent to the release site (rocky outcrops adjacent to Refugio, Corral Canyon, and El Capitan, Figure 19). Impacts to rocky intertidal habitat were assessed through a number of field-based studies. Similar to the sandy beach habitat, the degree of oiling was classified in rocky intertidal habitat based on descriptors used in the SCAT data. In additional to the field studies conducted after the oil spill, the Trustees also relied on other monitoring programs (e.g., MARINe) that had pre-existing, long-term monitoring data in locations affected by the spill. The Trustees determined that the initial acute injury was caused by direct smothering/fouling and toxicity of individual organisms and habitats at those locations nearest to the oil release site. Subsequent injury was the result of tissue necrosis/bleaching of the sessile organisms populating these habitats within the same locations. Furthermore, injury due to trampling (from spill assessment and cleanup activities), physical cleaning of rocky intertidal habitats, and sublethal effects from exposure to PAHs were evaluated.

The Trustees collected mussels from intertidal habitats throughout the spill-affected area for PAH analysis, both immediately after the release and several weeks later. This provided an indication of those shorelines most significantly fouled by the oil, as well as the duration of exposure. Mussels collected soon after the spill from rocky shores adjacent to Refugio beach and El Capitan contained the highest PAH concentrations of all samples and continued to contain the highest concentrations two weeks later (Appendix B).

The Trustees conducted rocky intertidal photo-plot surveys to monitor changes within fixed plots over time. These were conducted at nearby long-term monitoring sites and compared to sites selected in the spill-affected area. The sites were re-visited in Fall 2015, and Spring 2016, to survey for community differences or proportional changes to communities or substrate. Study sites within the heaviest oiling areas (Refugio, El Capitan, and Coal Oil Point) documented oiled organisms and substrate after the spill. Further, community changes in follow-up surveys, potentially indicative of oil-related impacts, were noted when compared to less impacted sites away from the heaviest oiling area (Raimondi et. al., 2019).

Recovery

The Trustees based recovery on the life histories of affected biota and on notable increases of "disturbance indicator" species (sea lettuce and the red algae, *Porphyra*) quantified during anniversary surveys at the most impacted sites. In addition, recovery estimates were based upon the recovery time of key intertidal assemblages (fucoid, barnacle, mussel, and mid-intertidal red algae) following disturbance. Recovery was also estimated based upon key intertidal assemblages (fucoid, barnacle, mussel, and mid-intertidal red algae) as summarized in a UC Santa Cruz disturbance study (Conway-Cranos 2012).

Habitat Equivalency Analysis Results

The Trustees estimated that a total of 5.4 acres of rocky intertidal habitat was exposed to and injured by the oil spill and is expected to have recovered after two years (Table 2). Appendix F provides additional information on the injury assessment and quantification of these habitat injuries.

Table 2. Summary of Rocky Intertidal Injury (losses) and Habitat Equivalency Analysis results

Zone - Predominant max. oiling category	**Acres exposed**	**dSAY[1] lost/acre**	**Acre – years for compensation (dSAYs)**
Zone B– Heavily oiled	5.4	0.34	1.83
Total	5.4	---	**1.83**

[1]dSAY = discounted service acre-year. See Appendix C.

5.1.5 Summary of Injury

Shoreline habitats were subject to heavy oiling near the spill site in the days following the oil spill on May 19, 2015. Rocky (bedrock and cobble), sandy beach, and mixed shores received heavy coatings of liquid oil that were transported up and down the shore by waves and spring high tides. In the splash zone, oil was deposited much higher than the reach of the tides.

The oil remained in the environment in the weeks and months after the spill, attaching to rocky habitat, settling into intertidal cobble beds, and percolating into, or being buried by, accumulating sand on sandy beaches. As a result, beach porewater retained elevated concentrations of PAHs much longer than the surf zone water, with elevated values continuing for weeks and months after the spill.

Shoreline plants and animals at all intertidal levels were exposed to Line 901 oil and were fouled by it. Toxic effects on a variety of intertidal marine species were evident in field observations as well as in toxicity tests run in the laboratory with shoreline invertebrates.

Shoreline animal tissues sampled before the spill had low concentrations of PAHs. These concentrations increased dramatically after exposure to Line 901 oil and then declined over weeks to months.

Some elements of the shoreline cleanup continued until January 2016. Clean up involved removing oil, sand, and wrack from the shoreline, scraping, blasting, shoveling, sifting and driving on shoreline habitats. Two of these activities, removing wrack and driving, have significant impacts on beach ecosystems.

As the spill spread more than 155 miles east and southward, the character of the oil changed. The oil that landed on Los Angeles County beaches[9] was less liquid but still sticky and buoyant. It was deposited with kelp and other wrack in the intertidal zone where abundant beach organisms live. The decision was made that it should be removed from the shoreline. This cleanup effort removed oil, wrack, and the animals associated with that material.

[9] Tarballs matching Line 901 oil landed on two South Los Angeles County beaches – Manhattan Beach and Redondo Beach.

Recovery of the impacted shoreline zones is expected to vary from one to four years, varying by zone, and based on the severity of the initial acute injury.

5.1.6 Selected Restoration Projects

The Trustees selected four projects described below to compensate for injuries to sandy beach and rocky intertidal habitats caused by the oil spill (Table 3).

For the shoreline habitats, no single preferred restoration project was able to compensate for all the injury. For this reason, four restoration projects were selected. These projects ranked as providing the greatest benefits to the injured ecosystem.

Table 3. Four selected projects to compensate for shoreline injury

ID#	SELECTED PROJECTS	BENEFITS
SHORE-1	Ellwood Seawall Removal	shoreline habitats, sandy beach
SHORE-2	Ventura County Dunes Restoration	shoreline habitats, sandy beach
SHORE-3	Santa Monica Dune and Beach	shoreline habitats, sandy beach
SHORE-4	Black Abalone Restoration and Relocation	shoreline habitats, rocky intertidal

Ellwood Seawall Removal (SHORE-1)

The goal of this project is to restore sandy beach and mixed shoreline ecosystems and dynamics in Zone B, the area where the greatest impacts of the spill were realized. This project will also benefit subtidal and fish habitats offshore of the seawall (section 5.2.3). The project site is Ellwood Beach in Goleta, CA (Santa Barbara County). A wooden seawall currently constrains natural functioning of the ecosystem as well as lateral access along the shoreline at high tide.

Affected Environment

The project will have impacts to intertidal shoreline (currently sandy beach, mixed rocky habitat, sandy shore, artificial structures, creosote preserved timber bulkhead, and rock/concrete rubble revetments), coastal bluff and shallow subtidal habitats.

Environmental Consequences (Beneficial and Adverse)

Overall, this project is anticipated to have only minimal adverse environmental consequences and multiple beneficial impacts. In reaching this conclusion, the Trustees evaluated several types of potential impacts, as described below.

1. *Biological Impacts* – The removal of the armoring structure will allow overall intertidal habitat to increase in width, functions and diversity, specifically restoring upper beach and supralittoral zone habitats that are currently absent from the armored coastline. Intertidal zones that have been lost will be restored along with ecosystem functions and biota dependent on those zones, including wrack deposition and processing, invertebrate abundance and diversity, bird abundance and diversity, and grunion spawning habitat.

There is potential adverse biological impact to vegetation and habitat established on the bluff faces and tops during the removal activities and from the removal activities and the expected erosion that takes place once the intact portions of the seawall are removed. During the removal activity there will be crushing of some of the sandy beach organisms, such as invertebrates in and under the surface of the sand, from the machinery used in the processes of removal. Birds are expected to temporarily be disturbed on the affected shoreline while removal activities are undertaken. These impacts are anticipated to affect a small number of organisms for a limited amount of time, and will have long-term beneficial effects for these biological resources.

2. *Physical Impacts* – Longer term, post removal, the beach is expected to be wider than it is currently where the seawall is intact, and there will be a reduction of reflective processes that remove sand from the beach. Removal will also eliminate the source for creosote-contaminated debris along the shoreline as the wall deteriorates and is broken up by wave action. Movement of equipment and machinery needed to remove the seawall is expected to temporarily block some portions of this shoreline and temporarily compact the substrate. Noise from this activity will be present in the short term, until the removals are completed. Short-term adverse effects from construction activities (potentially higher turbidity, sediment transport) are expected to be minimal but may occur. Longer term impacts will include a return to natural bluff erosion rates and mobilization of loose material at the bluff toe during extreme high tides.

3. *Human Impacts* – Lateral access to people along the shoreline at high tide is expected to increase where the seawall is currently intact. Temporary disturbance to recreation in the demolition area will occur during removal activities. Human uses of any land on the slope to and on top of the bluff, near the edge that is expected to erode, will be changed as erosion occurs; however, the removal of the seawall allows for the potential future installation of pathways to access the beach from the bluff. Overall, there will be a small temporary loss of beach use by the public during the construction, but an overall long-term increase in public access in the area where the seawall will be removed. Overall, there will be a small temporary loss of beach use by the public during the construction, but an overall increase in public access to the beach in the area where the seawall will be removed.

Probability of Success

Project success is likely as the implementation actions will lead to immediate adjustments in the physical properties of the shoreline. Project implementation will require a high level of planning and coordination to work within short tidal periods; however these factors have been considered and planned for, and the probability of success is high. Ecological services should respond within a few years of the physical changes. Longer term responses will depend on the balancing of sediment supply, bluff erosion and sea level rise. While the exact progression of bluff erosion is uncertain over the long term, this project removes a barrier that is interfering with natural coastal dynamics in the area, and removing that barrier is anticipated to benefit ecological resources.

Performance Criteria and Monitoring
The success of the restoration project will be evaluated by assessing metrics associated with natural resource functions and services. Metrics will be compared with: 1) initial conditions at the project site and/or 2) conditions at an appropriate nearby natural reference site or sites. The restoration of natural coastal dynamics at the restoration project site should allow for recovery of physical and ecological functions and services over time. Monitoring efforts should track indicators associated with the structure and function of the restored ecosystem. In addition, the responses of bluff topography, profile and vegetation should be monitored to document shoreline evolution at the site. Key physical and ecological indicators will be measured and monitored regularly at the project and reference site or sites for five years.

Performance criteria may include:
- Intertidal beach habitat area: area and distribution of ecological habitat zones;
- Marine subsidies: standing crop of marine macrophyte wrack;
- Sandy intertidal invertebrates: diversity, biomass and abundance of key taxa by intertidal zone; and
- Bird use: use of beach zones by shorebirds, gulls, roosting seabirds, other species.

Performance criteria will be calculated based on multiple surveys at an appropriate reference site or sites or multiple transects within the site.

Evaluation
The Trustees have evaluated this project using the threshold and additional screening criteria developed to select restoration projects and concluded that this project aligns favorably with these criteria. This type and scale of project will effectively provide appropriate compensation for injured sandy intertidal habitat because of the spill, and the Trustees have therefore selected this project as one of four preferred alternatives.

Ventura County Dune Restoration (SHORE-2)
Three dune enhancement projects at Ormond Beach, San Buenaventura and McGrath State Beaches in Ventura County will reduce invasive plant abundance and restore native plants, dune forms and processes that will support rare coastal species. These projects are all located in Zone D.

Affected Environment
The project site will include intertidal sandy beach and degraded (trampled and invaded by non-native plants) dune habitat. Portions of the three project sites are nesting and brood-rearing areas for special status birds: western snowy plovers and California least terns.

Environmental Consequences (Beneficial and Adverse)
Overall, this project is anticipated to have only minimal adverse environmental consequences and multiple beneficial impacts. In reaching this conclusion, the Trustees evaluated several types of potential impacts, as described below.

1. *Biological Impacts* – The project will restore a higher level of ecological functioning to degraded dune habitat. The current ecosystem services of the degraded dune area are reduced by high cover of non-native plants, altered physical processes and trampling in un-fenced areas. Removal of invasive plants will increase the amount of useable nesting areas for the western snowy plover (threatened) and, in some locations, the California least tern (endangered) and reduce cover for predators of eggs, chicks and adult birds. The presence of workers to implement the non-native plant removal in the dunes, along with their equipment, may temporarily disturb or displace birds and other wildlife. These temporary adverse effects are anticipated to be minor, and the overall long-term biological impacts are anticipated to be make a tangible improvement in the habitat quality for listed birds and other coastal wildlife.

2. *Physical Impacts* – Enhancement of native vegetation also permits the development of more natural dune dynamics that promotes the maintenance of more suitable slope faces and important material exchanges between the dunes and the intertidal sandy beach that can buffer erosion on beaches. This allows the dunes to provide a physical benefit to the intertidal sandy beach. Any adverse physical impacts during the implementation of the project are expected to be negligible, and long term benefits to the physical environment are anticipated upon completion of the project through restoration of dune habitats and processes.

3. *Human Impacts* – The Trustees do not anticipate noteworthy impacts from this project on socio-economics, aesthetics, health and safety, historical properties, etc. Increased bird use, such as by western snowy plover or California least tern could be expected to increase birdwatching interest in the restored dune areas. Dunes could become somewhat less stable and allow for movement to a greater extent than this sand currently does. If such movement affects parking, driving, or other developed areas, this may be undesired.

Probability of Success

The project is very likely to succeed in all three project sites. The proposed restoration methods—weed control and fencing to reduce trampling disturbance—have been shown to be effective in nearby sites and elsewhere in southern California as well as throughout the State.

Performance Criteria and Monitoring

The success of the restoration project will be evaluated by assessing metrics associated with natural resource functions and services. Metrics will be compared with: 1) initial conditions at the project site and/or 2) conditions at an appropriate nearby natural reference site or sites. Key ecological indicators to be measured and monitored include cover of native and non-native vegetation, as well as nest monitoring of western snowy plovers and California least terns. These efforts will be compatible and complementary with existing monitoring programs and continue for a period of up to five years to evaluate the ecological integrity of the site following implementation of restoration.

- For dunes, the target goals may include but are not limited to:
    - Restoring and increasing resiliency of dune habitat;
    - Reducing non-native vegetation cover to <99% in project area during lifetime of project; non-native vegetation cover should remain at <1% throughout project monitoring phase; and
    - Increasing native dune vegetation in areas where non-natives have been removed; native vegetation should persist into project monitoring phase.
- For bird use, the project will include monitoring the following attributes up to a period of five years:
    - Number of nests per year;
    - Number of fledglings per year; and
    - Comparison with baseline assessment.

Evaluation
The Trustees have evaluated this project using the threshold and additional screening criteria developed to select restoration projects and concluded that this project aligns favorably with these criteria. The dune restoration projects in Ventura County are located within the spill-affected area, and are the closest option that the Trustees have identified for this type of restoration. This type and scale of project will effectively provide appropriate compensation for sandy beach habitat injured as a result of the spill, and the Trustees have therefore selected this project as one of four preferred alternatives.

Santa Monica Bay Beach and Dune Restoration (SHORE-3)
The goal of this project is to restore sandy beach and coastal dune habitat that has been degraded by intensive mechanical grooming. The project site is a public beach in Santa Monica Bay in Zone D (Los Angeles County).

Affected Environment
The project site will include intertidal sandy beach and degraded (unvegetated) coastal strand and dune habitat.

Environmental Consequences (Beneficial and Adverse)
Overall, this project is anticipated to have only minimal adverse environmental consequences and multiple beneficial impacts. In reaching this conclusion, the Trustees evaluated several types of potential impacts, as described below.

The project will restore ecosystem function of sandy beach, coastal strand and dune habitats by protecting approximately five acres from the daily disturbance caused by mechanical beach grooming with heavy equipment and vehicle traffic and by planting upland portions of the site with native dune plants. The project will restore a high level of ecological functioning to degraded beach and dune habitat. The current ecosystem services of the degraded dune area is close to zero due to mechanical grooming activities, and those of the beach habitat is severely depressed.

1. *Biological Impacts* **–** By eliminating intense regular disturbance with heavy equipment, this restoration project will allow natural coastal processes to reshape the topography and ecology of the site, promoting the recovery of natural biodiversity and function. With appropriate stewardship, hummocks and vegetation will develop on the shoreline supporting native plants, birds and invertebrates that are currently extirpated at the site. The restored habitat will retain macrophyte wrack subsidies, increase intertidal and invertebrate abundance and diversity, increase the abundance and diversity of birds and will be more suitable for grunion spawning. No adverse biological impacts are anticipated, as the restoration area has very low sandy beach ecological services currently. Following restoration, the area is expected to increase in ecological functionality due to the foundational habitat that will be replaced where none currently exists.

2. *Physical Impacts* – The topography is expected to change at the restored site, with the formation of natural hummocks which is consistent with increased resilience to sea level rise. Fencing around the site will be present once the restoration is underway. Any adverse physical impacts during the implementation of the project are expected to be negligible, and long term benefits to the physical environment are anticipated upon completion of the project.

3. *Human Impacts* – The Trustees do not anticipate noteworthy impacts from this project on socio-economics, aesthetics, health and safety, historical properties, etc. Fencing will restrict the access through and around the restored site to some extent, but human access will continue on the site, although the types of recreational activities may change somewhat toward wildlife viewing. Increased plant, floral, and wildlife activity on the site may attract increase interest from bird watchers and others interested in the flora and fauna that will repopulate the site.

Probability of Success

The project is very likely to succeed in both of the target habitat zones. Cessation of grooming has been shown to be an effective beach restoration technique. The dune restoration plan will be based on a pilot project currently underway in Santa Monica. This model has been effective through planning and early implementation phases.

Performance Criteria and Monitoring

The success of the restoration project will be evaluated by assessing metrics associated with natural resource functions and services. Metrics will be compared with: 1) initial conditions at the project site and/or 2) conditions at an appropriate nearby natural reference site or sites. Project site selection will likely be based on very low initial function level (mechanically groomed with no vegetation or dunes, low nutrient beach sand). Ecological responses to restoration actions will likely begin slowly and increase over the five-year monitoring period. Performance criteria may be expressed as trajectories of increasing function over time and divergence from groomed reference sites.

Performance Criteria may include the following key physical and ecological indicators:

- Project Area: acres measured each year to ensure project is not encroached upon.
- Topography/elevation/profile:
  - Dune and hummock building (sand storage, increased topography and resilience);
  - Increased elevations of topography and sand storage;
  - Altered profile (formation of foredune); and
  - Criterion: maximum elevation of dune features to increase across the site to increase at 0.1 m per year in the first five years.
- Vegetation:
  - Absolute cover of native dune plant species;
  - Absolute cover of non-native plant species (less than 1%); and
  - Native dune plant species richness.

Evaluation

The Trustees have evaluated this project using the threshold and additional screening criteria developed to select restoration projects and concluded that this project aligns favorably with these criteria. The Santa Monica Bay beach and dune restoration project is conceived to be implemented within Los Angeles (LA) County. Since shoreline resources were the largest area of habitat impacted by the oil spill, implementing this restoration in LA County offers an opportunity to compensate for injured resources near the ends of the spill-impacted area. This type and scale of project will effectively provide appropriate compensation for sandy intertidal habitat injured as a result of the spill, and the Trustees have therefore selected this project as one of four preferred alternatives.

Black Abalone Restoration and Relocation (SHORE-4)

The goal of this project is to aid in restoration of intertidal black abalone populations in areas affected by the spill. The project is comprised of four tasks: (1) characterization of the genetic structure of the donor and recipient population, (2) clearing areas of fouling organisms and placing recruitment modules to make habitat suitable for transplanted post-emergent black abalone and for settlement of larval black abalone, (3) transplantation of post-emergent black abalone from a donor population, and (4) adaptive assessment and management of transplants.

Affected Environment

Locations will be identified throughout the Gaviota coast, which are suitable for abalone. These will have the specific habitat attributes associated with abalone occupation (in general, deep cracks and crevices within the tidal range of black abalone).

Environmental Consequences (Beneficial and Adverse)

Overall, this project is anticipated to have only minimal adverse environmental consequences and multiple beneficial impacts. In reaching this conclusion, the Trustees evaluated several types of potential impacts, as described below.

1. *Biological Impacts* **–**This project seeks to ameliorate current conditions in suitable intertidal habitat, by preparing the substrate for better recruitment, while also transplanting adults to augment the likelihood of future recruitment. Recovery of a species from massive decline requires successful recruitment of new individuals into areas where local populations were impacted. Recruitment is dependent on both an available supply of new individuals and specific environmental conditions required to induce settlement. The goal is to restore a viable population of black abalone in suitable intertidal locations that are selected. Areas will be cleared of fouling organisms, leaving clean surfaces in the cracks and will be maintained until donor individuals are transplanted. The impacts of clearing the fouling organisms from the transplant areas are anticipated to be negligible to the ecosystem function, and will result in long term ecological benefits when viable populations of black abalone are reestablished.

2. *Physical Impacts* – The Trustees do not anticipate major impacts to the physical environment, such as water, air, sediment, etc. Any adverse physical impacts are expected to be negligible. Areas will be cleared of fouling organisms, leaving clean surfaces in the cracks and will be maintained until donor individuals are transplanted.

3. *Human Impacts* – The Trustees do not anticipate noteworthy impacts from this project on socio-economics, aesthetics, health and safety, historical properties, etc.

Probability of Success
Project implementers have been monitoring regional black abalone populations for nearly 25 years, and have been assessing the recruitment of new individuals and the biogenic habitats required for successful recruitment. The project implementers will strive to maximize the probability of success based on their knowledge and experience with black abalone.

Performance Criteria and Monitoring
The success of the project will be evaluated by assessing metrics associated with natural resource services. An important step towards recovery is the aggregation of abalone at densities high enough for successful fertilization, through both success of transplantation and aggregation of individuals, and recruitment of new juveniles. Because black abalone larvae have never been reared successfully in the lab to settlement stage, a field approach is required. Metrics for success include maintenance of an appropriate density of adult individuals (approximately 2 individuals per square meter), and the other is the recruitment of new juveniles. Based on previous studies, recruitment modules, consisting of small stacked tiles that mimic small crevice features of boulder fields, may be used to effectively attract new recruits. These modules may then be used to attract larvae to restored habitat areas, or move newly settled juveniles from sites with recruitment, to areas where recruits are absent. These modules will allow easy monitoring of recruitment and growth, for up to 10 years, to determine success of the project.

Success may be assessed relative to controls. Should greater recruitment occur in areas subjected to restoration via translocation of adults than in control areas, we would conclude the translocation enhanced repopulation of black abalone. The ratio of recruitment in restored areas relative to controls could be a quantitative metric of enhancement value. Should no recruitment occur in either control or restoration areas we will compare results to other areas not demographically affected by withering disease. If recruitment occurred over the 10-year period in the unaffected sites but not in the restored areas, then the effectiveness of the restoration will be called into question and methods for future restoration efforts will be modified accordingly.

Evaluation
The Trustees have evaluated this project using the threshold and additional screening criteria developed to select restoration projects and concluded that this project aligns favorably with these criteria. The Trustees believe that this type and scale of project will effectively provide appropriate compensation for rocky intertidal habitat injured because of the spill and have therefore selected this project as a preferred alternative.

5.1.7 Second Tier Restoration Projects Considered

The Trustees also considered the following projects (Table 4), and determined that many are valid projects that would provide benefits to shoreline habitat. However, these projects were not selected as preferred for various reasons described below. These projects may be reconsidered if a selected project cannot be implemented or if remaining funds allow.

Table 4. Second tier shoreline restoration projects that may be implemented if funds allow.

ID#	OTHER PROJECTS CONSIDERED	BENEFITS
SHORE-5	Surfer's Point Phase II	Sandy beach
SHORE-6	Matilija Dam removal	Sandy beach, riparian
SHORE-7	Gaviota Creek Watershed Restoration	Riparian, lagoon, sandy beach
SHORE-8	El Capitan State Park Concrete Removal Project/Bike Path and Rip Rap Removal	Sandy beach
SHORE-9	Santa Barbara County Seawall Removals	Sandy beach
SHORE-10	Coastal Hazards Removal, Goleta Beaches from hazards removal, Arroyo Hondo to Coal Oil Point	Not clear. Sandy beach
SHORE-11	Coal Oil Point Research and Education	Coal Oil Point Preserve
SHORE-12	Devereux Slough Restoration	Slough and meadow
SHORE-13	Funding a Quick Reaction Cleanup Crew for Tar Found on Beaches	Sandy and rocky shoreline
SHORE-14	BEACON, San Ysidro and Cold Springs/Montecito Creek, and San Antonio Creek Debris Basin Removal Projects to Improve Sediment Transport for Beach Nourishment. Removal of Unnecessary Sediment Basins from the Gaviota Coast	Sandy beach

SHORE-15	Refugio and Gaviota Coast Human Impact Mitigation and Protection Program (Tajiguas, Mariposa Reina South, and Vista) Human Impact Mitigation	Sanitation, recreational
SHORE-16	Other Dune Restoration Projects, including but not limited to, Hollywood Beach, Ellwood Invasive Plant Restoration, Ventura City Beaches, Vandenberg AFB	Sandy beach
SHORE-17	Coal Oil Point Pilings and Debris Removal	Lagoon, human safety, possible sandy beach
SHORE-18	Classroom Education and Outreach	Rocky intertidal
SHORE-19	Refugio and El Capitan Rocky Intertidal Docent Program	Rocky intertidal
SHORE-20	Increase Substrates for Rocky Intertidal Species	Rocky intertidal
SHORE-21	Cessation of Beachgrooming	Sandy beach
SHORE-22	Rindge Dam Removal	Sandy beach, riparian

Surfer's Point Phase II (SHORE-5)

This project includes infrastructure and habitat enhancements to the Surfer's Point shoreline area in Ventura. It is not currently among the preferred projects as its focus is on recreational use rather than ecological benefit. Therefore, it does not appear feasible at the time of this plan, unless it receives support from recreational use funding from the Trustees or other sources. Ecological restoration costs would be expected to be a small part of the total project.

Matilija Dam Removal (SHORE-6)

This project is the removal of Matilija Dam, which is full of sediment and does not function as a drinking water reservoir which was its intended purpose. Removal of the dam would restore natural sediment flows, which enrich beaches through sand deposition. This project was not selected, as it is not yet clear if it is technically feasible, and due to the very high cost associated with the project (estimates over $100 million). Also, this project is too early in the planning and environmental review phase to be properly evaluated at the time this restoration plan was prepared.

Gaviota Creek Watershed Restoration (SHORE-7)

This project includes the relocation of the Gaviota State Park entrance road along with riparian/estuarine enhancements. The relationship to injured resources directly on the shoreline is more tenuous, though it may have recreational benefits to human uses. The time to provide benefits to sandy beach resources is potentially distant. Also, while this project meets some sandy shore restoration goals as a beach nourishment project, it is not a preferred approach to achieving these benefits. The duration of benefits is projected to be short for the sandy beaches and the costs are relatively high (estimated at approximately $10 million). This project was not selected to be carried forward for implementation at this time because the project does not contain sufficient information for the Trustees to understand the benefits to shoreline resources injured by the spill.

El Capitan State Park Concrete Removal Project/Bike Path and Rip Rap Removal (SHORE-8)
This project involves the removal of large rip-rap boulders and concrete that are located at the base of a portion of the bicycle trail between Refugio and El Capitan State Parks. The concept is to remove legacy rip-rap (currently serving no purpose) outside of the area where riprap currently exists to protect the Exxon-owned pipeline located there. Removal of legacy rip-rap may partially restore a segment of this shoreline to a more natural and unarmored condition. Feasibility and cost-benefit of this project has not been fully assessed.

Santa Barbara County Seawall Removals (SHORE-9)
This project would involve the removal of concrete seawall structures located in Santa Barbara County to restore the shoreline to a less armored condition. The Trustees evaluated selected sites proposed by the County and determined that seawall removal could cause structural compromises to the railroad infrastructure. As of the release of this plan, no formal written proposal has been submitted or reviewed on this effort, so it is not clear if this is a fully developed plan or project.

Coastal Hazards Removal, Goleta Beaches Extending From Arroyo Hondo To Coal Oil Point (SHORE-10)
This project would involve removal of coastal hazards other than the Ellwood seawall. The elements evaluated to date by the Trustees, such as iron material protruding from the shoreline surface, would not provide any tangible benefits to plants, animals, and their habitats that were affected by the spill. The State Lands Commission, the proponent of this project, has successfully pursued other funding sources for this work, primarily as an effort to reduce hazards to humans. The nexus to restoring shoreline resource services that were injured during the spill event is unclear, so this project is not currently among the selected projects.

Coil Oil Point Research and Education (SHORE-11)
This is a proposal to fund staff to provide research and education at the Coal Oil Point Preserve. The elements evaluated to date by the Trustees, such as funding an endowment for the education coordinator at Coal Oil Point Preserve, would not provide any direct benefits to plants, animals, and their habitats that were affected by the spill. Any identified benefits to the impacted resources would be indirect.

Devereux Slough Restoration (SHORE-12)
This is a proposal to restore Devereux Slough through acquisition of a former golf course to expand the slough to a greater portion of its historical extent. The elements evaluated to date by the Trustees, such as habitat enhancement and monitoring in the former golf course, while beneficial to some natural resources, would not provide any tangible benefits to the shoreline natural resources that were affected by the spill. While no slough or meadow habitats were injured by the spill, this project may, however, provide broad ecosystem benefits for multiple

species that utilize shoreline habitats and its proximity to shoreline habitats creates ecosystem connectivity that may benefit coastal resources that were affected by the spill.

Funding a Quick Reaction Cleanup Crew for Tar found on Beaches (SHORE-13)
This proposal is to fund a personnel that would respond quickly to perform cleanup duties on the shoreline when tar is found. The Trustees have concerns that the likelihood of success for this would be very difficult to determine. Cost effectiveness is likely to be low, and benefits to the public would be challenging to quantify. Duplication would also be high in the event of an oil spill incident, given that the spill response effort oversees the task of oil removal and cleanup. Hazardous material handling and disposal cost and liability questions are also significant considerations.

Removal of unnecessary sediment basins from the Gaviota coast (SHORE-14)
This is a proposal to remove sedimentation basins to allow more natural transport of materials to the shorelines for the purposes of beach nourishment. Only basins that are deemed no longer necessary to protect public safety and property would be considered for removal. Recent fire and flow events call into question the viability of removing sediment basins along the Gaviota coast.

Refugio and Gaviota Coast Human Impact Mitigation (SHORE-15)
This proposal aims to reduce human waste material on the Refugio and Gaviota shoreline by providing portable toilet facilities. The Trustees considered this to be less a sandy beach or shoreline restoration project and more of a sanitation project, given that it that would install restroom services. It does not provide significant tangible benefits to plants, animals, and their habitats that were affected by the spill. Any benefits that might exist would be challenging to quantify and primarily human sanitation and recreational in nature.

Other Dune Restoration Projects (SHORE-16)
These are dune restoration projects similar to the other ones listed in the selected project section, but in different locations. Some of these projects lack owner consent, have a need for partner funding, or are not proximal to the spill area. Those with owner consent, funding resources, permitting in place, long term stewardship, and well described costs within the spill area have been selected as preferred. The remaining dune restoration projects would require more details to be better understood, or need more clarification regarding technical feasibility before being considered preferred projects. However, these projects may be considered at a later time, as more information on these projects is gathered or if the selected dune restoration projects become infeasible.

Coal Oil Point Pilings and Debris Removal (SHORE-17)
This project involves removal of pilings and debris from a lagoon area. However, it appears to have benefits associated with human use and safety rather than the injured shoreline resources. There also appears to be some permitting issues associated with the removal effort that may disturb sensitive natural resources located at or near the lagoon. Much of the identified debris is associated with the lagoon habitat rather than shoreline, making the nexus to the injured

resources weaker. Benefits would be challenging to quantify and scale for the injured resources. Both ecological benefits and the cost benefit need to be more clearly understood before the Trustees would reconsider funding this project.

Outdoor Classroom Education and Outreach (SHORE-18)
Building on the successful implementation of the Channel Islands Marine Sanctuary's Rocky Intertidal Protection Program, students from local schools would be engaged to learn about the ecology of rocky intertidal habitats, including hands-on implementation of rocky intertidal monitoring. Students would also be engaged in docent programs to share their knowledge of rocky intertidal habitats with the public at popular tidepool areas. Benefits would be less direct, as they would rely on an overall change in behavior and attitudes by users of rocky intertidal areas.

Refugio and El Capitan State Beach Rocky Intertidal Docent Programs (SHORE-19)
This project involves the development and implementation of a docent program at rocky intertidal sites at Refugio and El Capitan State Beaches to educate and oversee visitors and contact law enforcement personnel, if needed. Benefits would be less direct and would rely on an overall change in behavior and attitudes by users of rocky intertidal areas.

Increase Substrate for Rocky Intertidal Species (SHORE-20)
This project involves the creation of new shoreline habitat or modification of existing habitat to increase substrate for rocky intertidal species. Examples include wrapping pier pilings, or creating "living walls" at hardened shoreline structures such as breakwaters. No viable locations or methods were identified as of the drafting of this plan, but the concept may be viable in the future.

Cessation of Beachgrooming (SHORE-21)
This project involves the cessation of beach grooming along beaches in Los Angeles and Ventura Counties. No specific locations identified as of the drafting of this plan. There is a need for a project proponent and partnerships that do not currently exist.

Rindge Dam Removal (SHORE-22)
This project is the removal of the Rindge Dam and/or dams upstream. The Rindge Dam is full of sediment and does not function as a water reservoir which was its intended purpose. Removal of the dam would restore natural sediment flows, which enrich beaches through sand deposition. This has a very high cost associated with the project (estimates over $100 million) and is too early in the planning and environmental review phase to be properly evaluated at the time this restoration plan was prepared.

5.2 Subtidal and Fish Habitats

In the initial days and weeks after the Refugio Beach Oil Spill, the Trustees investigated the potential for injuries to subtidal fish, invertebrates, and aquatic vegetation. Animals and plants may be harmed by oil spills if they are exposed directly to the oil, to the fraction of the oil that dissolves into the water, or if they eat oil-contaminated prey. When the Line 901 oil reached the ocean, wave action actively mixed the oil throughout the water column within the surf zone. In addition, the oil was transported offshore and along shore by wind and currents (Figure 2). Offshore, much of the oil floating on the surface was mixed into the water column as oil droplets or particulates, some fraction of the oil dissolved into the water column, and some was taken up into the food chain (Figure 20).

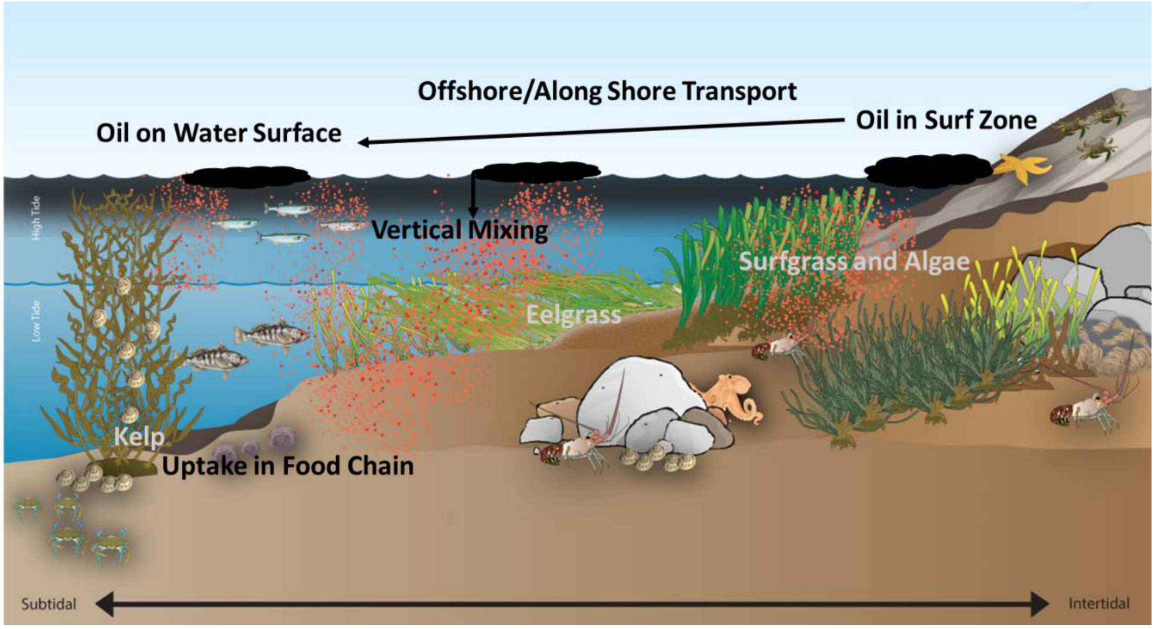


Figure 20. Oil exposure in subtidal habitats.

As discussed in Section 2, the spill occurred along the Gaviota coast. Ocean waters in this area are generally in a transition zone where warmer waters off southern California mix with cooler waters off northern and central California. The Gaviota Coast subtidal habitats include sensitive rocky reefs where plants, such as kelp and surfgrass, provide a physical structure that connects the ocean floor to the sea surface. These habitats support diverse communities of plants and animals, and several are designated as Essential Fish Habitat (EFH) under the Magnuson-Stevens Fishery Conservation and Management Act. Other subtidal habitats include eelgrass beds and sand bottom. Given the ecological importance of rocky reef habitats, the Trustees conducted an in-depth assessment of the potential for injuries to coastal subtidal habitats.

Aquatic vegetation was used as a proxy for determining the health of subtidal habitats[10]. Surfgrass, eelgrass, and kelp provide essential food and habitat for a diverse group of fish and

[10] Plains does not agree with a number of Trustee interpretations in the subtidal and fish habitats section. In particular, Plains does not agree with Trustees use of a seagrass proxy for the deeper water column injury and does not agree that grunion are a valid indicator species for determining subtidal injury since grunion eggs are exposed on the beach.

invertebrate species. Fish in these habitats include California sheephead, kelp bass, rockfishes, red urchins, California spiny lobster, and sea cucumbers. These rocky reef habitats also serve as spawning and nursery grounds for fish and invertebrates. Early life stages of many species were present during the time of the spill and are expected to be sensitive to the effects of oil.

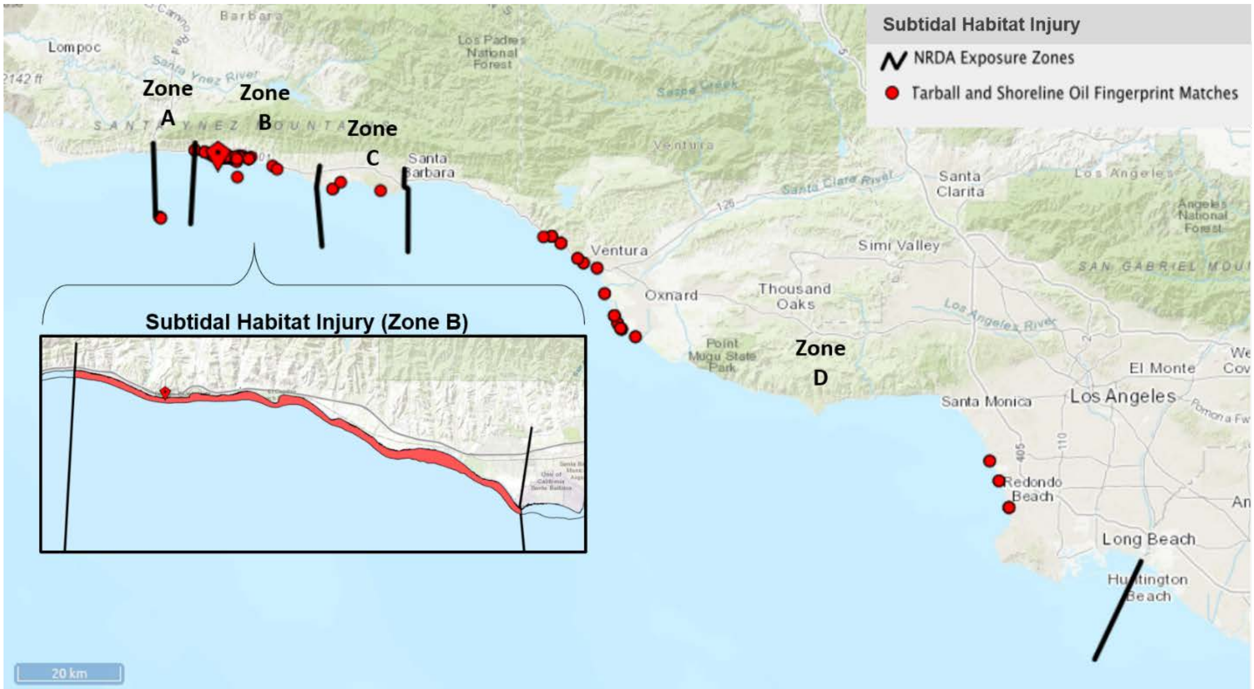


Figure 21. Exposure Zones defined for the Refugio Oil Spill NRDA showing shoreline tarball fingerprint matches (red circles). Zone B is the area of heaviest oiling and the extent of subtidal habitat injuries assessed. The inset shows the subtidal assessment area identifying the 10 m depth offshore extent of injury (red polygon). See Appendix B for data associated with this figure.

In the shallower, nearshore environment (0-3 m depth interval) within Zone B (Figure 21), surfgrass and many algal species were visibly coated with oil. Farther offshore (3-10 m depth interval) within Zone B, eelgrass beds and giant kelp attached to rocky reefs were exposed to oil in the water column, and there was documentation that the surface of the kelp forest canopy was oiled.

5.2.1 Overview of Data Collection and Studies

The list below summarizes the various field studies, data collection tasks, and analyses used to assess subtidal and fish habitat injuries.

Fish and Invertebrate Mortality Observations

Immediately following the spill, and for several days after, dead fish and invertebrates were observed on the beaches along the Gaviota coast within Zone B. From May 19 to June 19, 2015, the Trustees deployed boxes as repositories for response crews to deposit dead animals during beach cleanup operations. Thereafter, on a daily basis, the Trustees photo-documented, counted, and identified the dead animals in the boxes (Figure 22). Dead fish and invertebrates were also recorded, when feasible, on wildlife search effort log forms and NRDA daily field forms. Fish and invertebrate species comprising well over 30 taxa that inhabit surfgrass, eelgrass, kelp and open sand habitats were found dead on the beaches, primarily during the first week after the spill from Refugio State Beach to El Capitan State Beach. These dead animals indicate that subtidal fish and invertebrates were injured as a result of the spill, but the relatively opportunistic collection method and the limited number of collection times and locations prevented rigorous injury quantification from these data.

Table 5. Dead fish and invertebrates found in 2015 during the spill, and one year later in 2016.

Dead Fish and Invertebrates (abridged)	**2015**	**2016**
Sand crabs	Y	N
Rock crabs	Y	Y
Shore crabs	Y	N
Kelp crabs	Y	Y
Spiny lobster	Y	Y*
Beach hopper	Y	N
Urchins	Y	N
Starfish	Y	N
Octopus	Y	N
Limpets	Y	N
Sea Hare	Y	Y
Skate/rays	Y	Y
Rockfish	Y	N
Kelp greenling	Y	N
Surfperch	Y	N

One lobster was identified that may or may not be a molt, all others were molts.

In June 2016, the Trustees conducted a follow-up survey of dead organisms along the Gaviota Coast. While direct comparisons using statistical methods (comparing 2015 to 2016 data) were not possible due to differences in study designs, it appears that the species composition and apparent abundance of dead fish and invertebrates found on the beaches was substantially lower in 2016 than in 2015, supporting the conclusion that the oil spill caused acute mortality of fish and invertebrates (Table 5). For example, intact dead lobsters were frequently found during the 2015 collections; however, only one dead lobster was found in the 2016 survey, and may or may not have been a molt (see Table 5). A more detailed summary of the findings is presented in Appendix G-1.

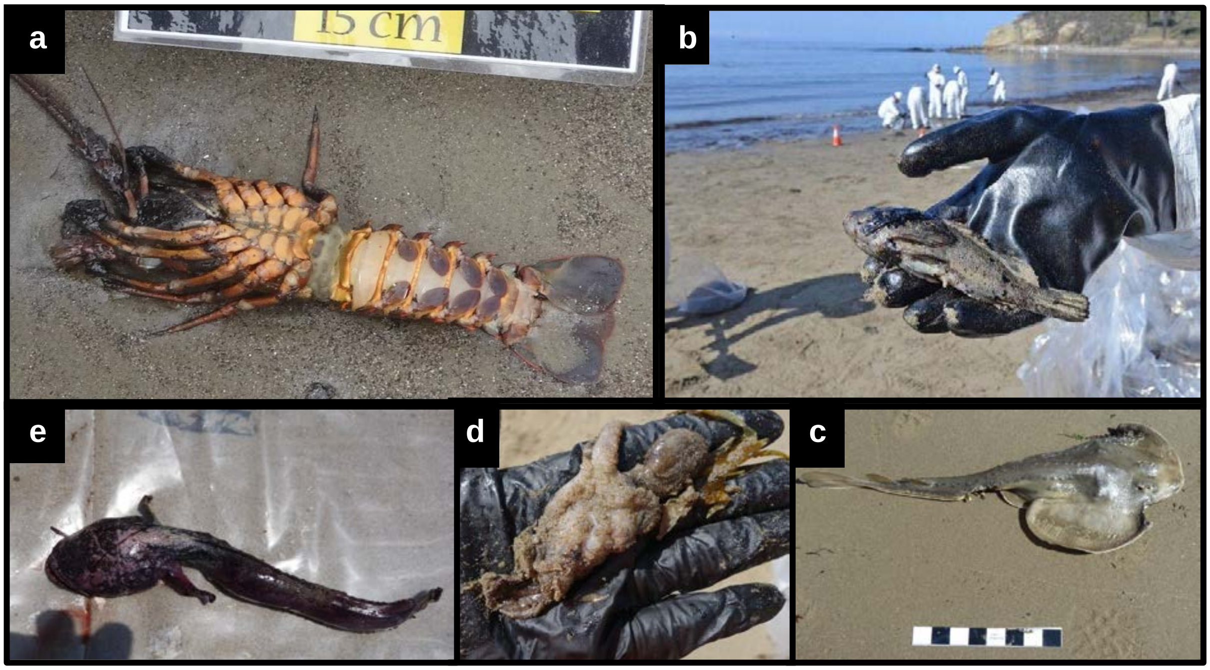
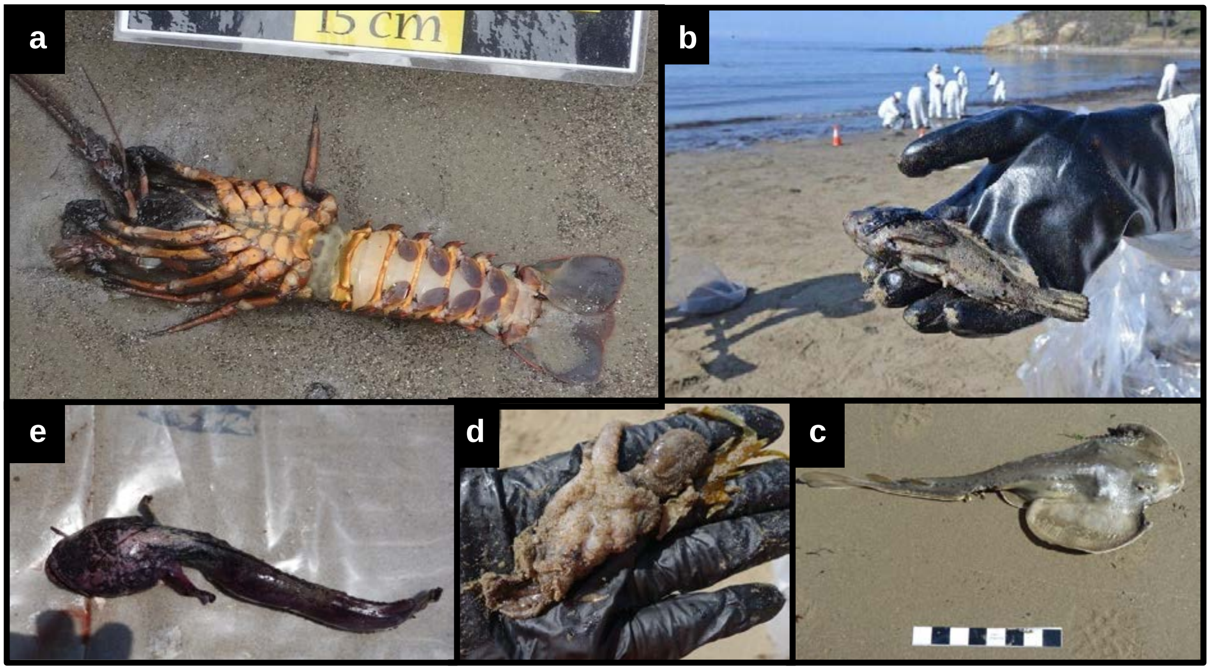


Figure 22. Examples of unprecedented diversity of dead, oiled fish and invertebrates from diverse subtidal habitats found in the days immediately following the Line 901 spill (clockwise): a. spiny lobster; b. rockfish; c. guitarfish; d. octopus; e. midshipman. Photo Credit: Natural Resource Damage Assessment Trustees.

California Grunion Assessment

California grunion were spawning on some beaches in the spill-affected area during and after the spill (May – September). During semi-lunar high tides these fish bury their eggs in the sand where they incubate until hatching approximately two weeks later during the next semi-lunar high tide (Martin, 2015) (Figure 23). Following the spill, adults and newly hatched larvae would have been exposed to oil in the surf zone, and the incubating eggs may have been adversely impacted by oil stranded on the beach or by cleanup activities (such as raking, machinery, trampling) disturbing nests. In addition to observing and evaluating direct impacts of Line 901 oil on grunion, the life history and accessibility of grunion early life stages make them an ideal model for evaluating the impacts of Line 901 oil on marine fish early life stages in field conditions. Accordingly, the Trustees studied grunion as an indicator of injury.

Grunion spawning was observed at oiled beaches (Refugio State Beach and El Capitan State Beach) and relatively unoiled beaches (East Beach and Topanga Beach) during 2015 and 2016. Based on predator behavior during the days of and immediately following the spill, adult grunion were staging for spawning runs at Refugio State Beach on those evenings. However, the Trustees were not able to access the beach to collect samples of eggs prior to shoreline oiling and/or cleanup activities, therefore, when the trustees attempted to collect eggs, none were found and were presumed to have been removed by cleanup activities. In areas were the Trustees were able to collect eggs from the observed spawning locations, eggs were incubated in the laboratory (Figure 23).



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Water Chemistry and Effects to Fish and Invertebrate Early Life Stages

In order to evaluate the toxicity of the spilled oil, the Trustees conducted bioassays using early life stages of inland silversides and sand crabs and exposed them to different concentrations of Line 901 oil. The bioassay was a seven-day exposure study for fish or a six-day exposure study for sand crabs to evaluate survival and growth (Appendix E). The inland silverside is representative of nearshore fish in the spill-affected area. It is in the same family as grunion and topsmelt, both common surf zone fish in the Santa Barbara area. Sand crabs are prey species of surfperch and other fish and birds in the Santa Barbara area. The bioassay studies quantified the relationships between PAH water concentrations and mortality for both juvenile fish and early life stage invertebrates. Bioassay results also were compared to PAH concentrations measured in surf water during the first two months after the spill. Surf water chemistry results were compared to crude oil bioassay results with other fish and invertebrate species that have been reported in the scientific literature. Surf water concentrations following the spill exceeded lethal PAH concentrations for fish and invertebrate early life stages. See Appendices D, E and G for more information.

As discussed previously, the Trustees also considered the potential for enhanced toxicity caused by exposure to UV light. Studies have shown that ultraviolet light (UV) from sunlight can enhance the toxicity of PAHs by a factor from 2-1000 (Barron 2017). Some PAHs in fish and invertebrate tissues are photo-activated by UV forming reactive products that cause oxidative damage. Oil sheen exposure was documented throughout the spill-affected area and is known to cause toxicity to fish and invertebrate early life stages. A summary of the evaluation is provided in Appendix G-4.

Subtidal Habitat Exposure Assessment

Divers from the University of California at Santa Barbara (UCSB) reported patches of oil and heavily oiled wrack on the seafloor in Refugio Bay four days after the spill occurred (Michel 2015). In response to this reported sighting of sunken oil, the Unified Command conducted a sunken oil assessment in Refugio Bay between 11 and 13 days after the spill. Methods included multi-beam sonar surveys, side scan sonar surveys, videos and photographs from a remotely operated vehicle and diver inspections at priority sites. The area surveyed was from near the shoreline to depths of 10m from the spill origin, north of Refugio State Beach, to El Capitan State Beach. Thirteen days after the spill, the divers only observed small tarballs near El Capitan Beach (Michel 2015). The Trustees also sent a team of divers to Refugio Bay 13 days after the spill to collect sediment, vegetation, and invertebrates from three habitat types: kelp bed habitat, eelgrass habitat, and surfgrass habitat in the bay. Tissues samples were analyzed for PAHs, and fingerprinting analyses were conducted (Stout, 2018). In each habitat type, oil (as PAHs) was detected in vegetation and fingerprinted to Line 901 oil. A variety of invertebrate species in the kelp and surfgrass habitats had detectable oil (as PAHs) that was consistent with Line 901 oil. Additionally, NOAA modelers estimated that, based on wave, wind and temperature conditions, dissolved oil and oil droplets likely mixed to a depth of approximately 14 m in this area. Overall, the study showed that these subtidal habitats were exposed to Line 901 oil. A summary of the results is presented in Appendix G-6.

PAHs in Nearshore Fish and Invertebrate Tissues

On May 19, 2015, the California Office of Environmental Health Hazard Assessment (OEHHA) recommended that CDFW initiate a fishing and shellfish harvesting closure for the coastal area near Refugio Beach. A closure was therefore initiated by CDFW on May 19, 2015, extending from approximately 1 mile upcoast of Refugio Beach to 1 mile downcoast of the beach, from the shoreline to one quarter mile offshore. The closure area was expanded on May 21, 2015, based on aerial observations and oil trajectory models, to include the coastal areas from Canada de Alegria downcoast to Coal Oil Point, and extending from the shoreline to 6 miles offshore (approximately 138 square miles). Between May 24 and June 18, 2015, OEHHA collected and analyzed several species of commonly caught fish and invertebrates, as well as kelp, to determine levels of contamination and safety for human consumption. After the last sampling period, benzo(a)pyrene PAH carcinogenic equivalents had fallen below the limit of concern for human health, and the closure was lifted on June 29, 2015 (OEHHA 2015). For the purposes of evaluating exposure of fish and invertebrates in the spill-affected area, the sum of 45 PAHs in the sampled tissues were evaluated. Elevated PAH concentrations were detected in drift kelp consumers (urchins and sea cucumbers) that were collected from fishing blocks close to the release point. PAH concentrations in tissue samples from animals collected from less than 10 m depth were higher than tissue samples collected from animals greater than 10 meters depth, supporting the conclusion that exposure was highest in the 0-10 m subtidal habitats near the spill origin. The analysis is provided in Appendix G-7.

Surfgrass and Algae Surveys

Approximately two months after the spill, discolored and dead surfgrass was observed at Refugio State Beach and El Capitan State Beach—both areas of heavy oiling (Figure 8). Based on these

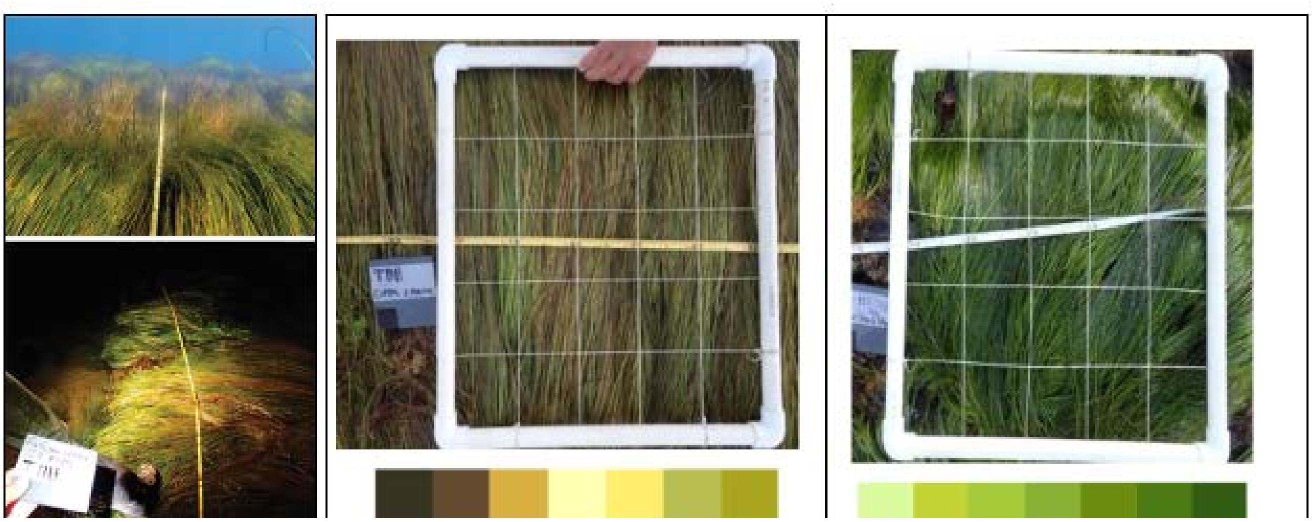

Figure 24. Surfgrass injury studies (left to right). The first two pictures show an example of how brown and necrotic surfgrass looked in the field. Middle picture shows an injured experimental plot. Far right shows a reference plot with bright green, healthy plants. Photo Credit: Natural Resource Damage Assessment Trustees.

observations, additional intertidal and subtidal surveys were initiated to quantify the extent of discolored surfgrass and algae. Condition and abundance of surfgrass and algae were assessed at eight sampling sites over several dates from July 2015 to June 2016. Oil-related injuries, including bleaching, necrosis, loss of biomass, cellular death and loss of surfgrass leaf tensile strength, occurred throughout the range of surfgrass habitats within Zone B (Figure 24). During the August 2015 survey, the proportion of dying surfgrass ranged from 37.4% at Arroyo Hondo to 82% at Corral Canyon, compared to 2.2% at the reference site (Mussel Shoals located in Zone D where shoreline oiling was absent, sporadic or light-to-moderate). For algae, the cover of dead and dying plants ranged from 86.1% at Coal Oil Point to 99.2% at Corral Canyon, compared to 6.1% at the reference site. An area-weighted average of the percent area of dead and dying plants was used to quantify injury for subtidal habitats. By the 2016 field season, surfgrass was not fully recovered at the heavily oiled Arroyo Hondo site. Survey methods and results are detailed in Appendix G-5.

5.2.2 Subtidal and Fish Habitat Injury

Area of Impact

Due to the nature of the Refugio oil release into the surf zone, the nearshore coastal processes and the physical properties of the oil, the Trustees concluded that exposure of aquatic organisms was likely to be highest in nearshore, relatively shallow subtidal habitats[11]. Therefore, the Trustees focused the subtidal injury assessment within Zone B where oiling was heaviest, for depths of up to 10 meters (m) (Figure 21). The Trustees selected 10 m depth as the outer boundary for subtidal resources within Zone B based upon the following considerations:

1. Submerged oil droplets and masses were observed within Zone B to 10 m depth;
2. Ten meters is the depth at which there was fairly high confidence that oil would mix throughout the water column to the bottom (Appendix A);
3. There was direct evidence that animals and plants in the near shore environment within Zone B were injured and/or exposed to oil (Appendix G), and
4. Aquatic vegetation such as kelp or seagrass provide critical foundational subtidal habitat, and rarely extends beyond 10 m deep.

Baseline Condition

The Trustees assessed injury by comparing oiled areas to baseline conditions, per the OPA regulations. The Trustees estimated those baseline conditions by using unoiled reference sites in 2015 (for grunion studies, surfgrass studies and surfperch exposure studies) and by repeating one-year, post-spill anniversary studies (grunion studies, surfperch studies and mortality observation studies), when the Trustees assumed continued exposure to Line 901 oil would have been eliminated or greatly reduced.

[11] Plains disagrees with the extent of subtidal injury assessed by the Trustees and asserts subtidal injury is materially lower than the Trustee's estimate.

Injury Determination and Quantification

For injury determination, the Trustees considered the presence and species composition of dead, oiled fish and invertebrates in mortality observation studies, the observed reduction in hatching success in grunion, the poor health of oiled macroalgae and seagrass, and a large number of recent toxicity studies on the effects of crude oil to early life stages of fish and macroinvertebrates. These provided, at a minimum, qualitative evidence for the Trustees to conclude that there was injury to natural resources in the shallow subtidal (0-10 m depth) area in Zone B.

For injury quantification, the Trustees used injury observed from surfgrass and algae studies as a proxy for general injuries to subtidal benthic[12] and water column habitats, and their associated biota. The Trustees determined that surfgrass/algal habitat (surfgrass habitat) was a reasonable proxy for other similar vegetated subtidal benthic habitats (e.g., kelp and eelgrass) because: (1) surfgrass is a foundational habitat for a highly diverse group of fish and invertebrates species that occupy the 0-10 m depth interval; (2) surfgrass habitat includes all of the major taxa found in other subtidal habitats (vascular plants, red and brown algae); and (3) surfgrass habitat is more accessible for the comprehensive surveys needed to quantify injury.

Surfgrass and algae surveys were conducted throughout Zone B (Figure 8) to identify the percent cover of discolored, dead, and dying surfgrass and algae (Figure 24). Injury was defined as the area-weighted average across all study sites, representing a maximum injury of 54%. This was used as the basis for the injury assessment for subtidal habitat (Figure 25), with weighting factors for relative habitat types and depth strata (i.e., 0-3 m versus 3-10 m depth interval):

0-3 m Depth interval

For the 0-3 m depths, the Trustees applied the weighted average 54% injury to all eelgrass, rocky reef, kelp, and surfgrass habitats within Zone B. Because sand bottom habitats are less biologically productive, the Trustees applied an ecological injury of 5.4%, representing one tenth of the injury of vegetated and rocky reef habitat (Appendix H).

3-10m Depth interval

For the 3-10 m depth interval, the Trustees assessed injury separately for benthic habitats, for surface water (top 2 m of water column), and for midwater (2-10 m depth interval) (Figure 26).

[12] Benthic means relating to the bottom of the ocean and to the organisms that live there.

Figure 25. The surfgrass and algal injury quantification was driven by studies where the area of discolored, dead and dying plants were assessed. Injury was defined as the percent cover of discolored, dead and dying surfgrass and algae at a study site. The overall area-weighted average percent injury was 54%. Green dots are sampling sites.

For the benthic habitat the Trustees calculated losses based on areal dispersion of submerged oil across the benthic footprint of Zone B to a depth of 10 m. Sunken oil would not necessarily dilute out into the water column, but would persist as small sediment-laden oil particles and droplets and spread across the sea bottom due to wave action and currents. Sunken oil also has a high likelihood of being trapped in or slowed by the bottom vegetation. The Trustees considered that injury to the benthic community would decrease linearly with distance from the shore. This would range from an 54% injury in the nearshore (0-3 m depth) to 0% injury at the 10 m depth, after calculating average offshore distances to the 10 m depth stratum. This resulted in the application of a 13% injury across the 3-10 depth range for benthic rocky reef, surfgrass, kelp, and eelgrass habitats. As with the 0-3 m zone, for sand bottom habitats in this depth stratum the Trustees are claiming one tenth of that loss due to lower productivity/services associated with sand bottom habitats. This resulted in a 1.3% loss for sand bottom habitats (Table 6). More detailed discussion of the injury quantification is presented in Appendix H.

For the top 2 m of the water column in the 3-10 m depth interval (Figure 26, light blue area), exposure would have primarily come from the short term exposure of surface oil in the approximately 2 weeks post spill. The Trustees determined there were short-term losses to the biota in the water column, ranging from 54% loss (determined by using surfgrass as a proxy) to 80% loss (based on literature). Studies in recent years have demonstrated high mortality (approximately 80%) to fish early life stages and planktonic organisms at low levels of PAH exposure, especially when exposed to UV light (Morris et al. 2015). The Trustees also assessed injuries to fish and planktonic organisms in the mid-water column of the 3-10 m depth stratum, at a 5% loss (Figure 26, dark blue area). The midwater injuries are based on the concept of oil mixing from the surface and from the bottom, but with a recognition that dilution, weathering and dispersion will greatly reduce exposure, and thus, the level of injury (Table 6).

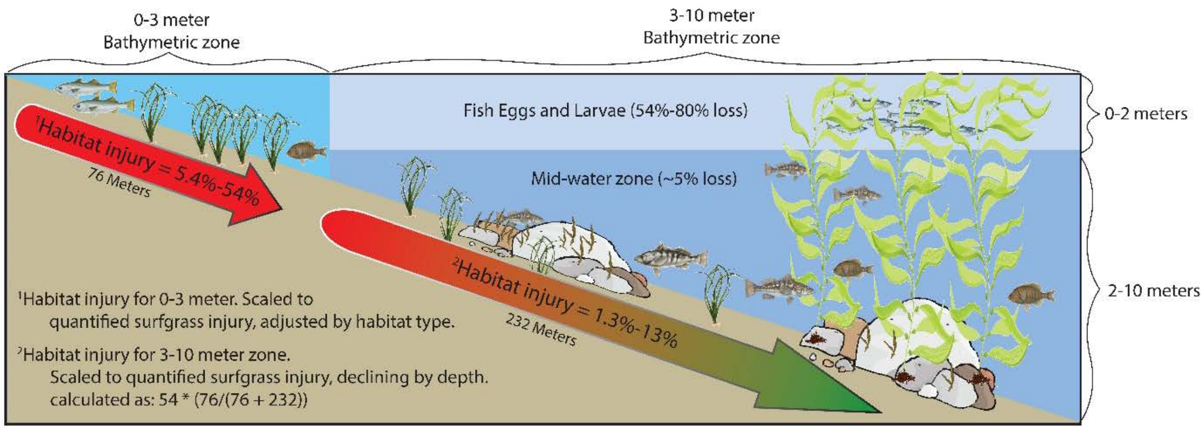

Figure 26. Summary of subtidal injury quantification. The average distance offshore from the 0 to 3 m depth range is 76 m. The average distance from 3 m to 10 m depth range is 232 m. The benthic habitat injury of 13% in the 3-10 m depth range was calculated by multiplying the injury in the 0-3 m depth range (54%) by the proportion of the offshore linear distance 0-3m depth compared to the total offshore linear distance of 0-10 m depth.

Habitat Equivalency Analysis Results

The Trustees used HEA (Appendix C) to scale compensatory restoration for the subtidal benthic injury. The HEA was based on the percent injury for the various components of the subtidal environment, which in turn were based on the documented injury to surfgrass and algae. For the recovery component, the HEA calculations take into account the rapid initial loss that occurred in the first 6 months of the spill. This was evidenced by a high percentage of discolored, dying surfgrass and algae in August of 2015 and January 2016. Recovery was assumed to be rapid, -88% recovered after a year (consistent with 2016 study observations), 94% after two years, and 100% after 5 years. Applying the injury levels discussed above, this analysis resulted in a loss of 178.5 acre-years in the 0-3 m depth interval and 117.4 acre-years in the 3-10 m depth interval (Appendix H).

The Trustees considered how to address injuries to the upper- and mid-water zones of the 3-10 m depth interval and ultimately chose not scale restoration for these areas because the restoration projects selected to benefit benthic resources will likely provide significant benefits to water column resources as well. In addition, the injury to fish early life stages, while significant, would also have been ephemeral and the Trustees were unable to readily identify restoration projects that were both targeted to water column species and highly scalable to the estimated injury. Given these facts, the Trustees decided to defer until later a determination on how best to compensate for any remaining injury to water column species. The Trustees anticipate having subtidal restoration funds available after the completion of the projects discussed below. If selected, these projects should yield additional information on their beneficial impacts. The Trustees will then decide whether remaining funds should be spent to augment an existing subtidal project or implement a new water column-focused project.

Table 6. Subtidal injury (losses) and Habitat Equivalency Analysis results.

Depth Zone	Habitat type	Max injury (% Loss)	Recovery time (years)	Habitat area (acres)	Acre – years for compensation (dSAY[1])
Nearshore Benthic Habitats (0-3 m depth zone)	Rocky reef, kelp canopy, seagrass, and sand bottom	54%	5	514	178.5
Offshore Benthic Habitats (3-10 m depth zone)	Rocky reef, kelp canopy, seagrass, and sand bottom	13%	5	1657	117.4

[1]dSAY = discounted service acre-year. See Appendix C.

5.2.3 Selected Restoration Projects

The Trustees identified four categories of restoration activities (abalone restoration, eelgrass restoration, kelp restoration, and seawall removal) to compensate for losses to subtidal habitats caused by the release of Line 901 oil. Subtidal projects were selected and prioritized by their ability to enhance and restore subtidal habitats in the region affected by the spill. Projects within Zone B were heavily prioritized over other projects that were located in the region affected by the spill but outside Zone B. These projects are discussed below in order of priority (Table 7).

Table 7. Subtidal selected restoration projects.

ID#	SELECTED PROJECTS	BENEFITS
SubT-1	Abalone Restoration	Rocky reef habitats and associated fish and invertebrates
SubT-2	Coastal Eelgrass Restoration	Eelgrass habitats and associated fish and invertebrates
SubT-3	Sand-dwelling Kelp Project	Kelp habitats, and associated fish and invertebrates
SubT-4	Ellwood Seawall Removal	Rocky reef habitats

Abalone Restoration in Naples Reef and Campus Point MPAs (SubT-1)

The goal of this project is to enhance the function of rocky reef habitats within the two Marine Protected Areas (Campus Point and Naples Reef) off the Gaviota Coast that were directly affected by the spill. This project would supplement abalone populations through outplanting of juvenile abalone and translocating adult abalone from a nearby system.

To maximize success, the Trustees propose applying multiple approaches when possible (e.g., adult translocation and juvenile captive propagation and outplanting) over a multi-year period, with repeated outplanting and translocation events. The Trustees propose a 10-acre restoration project (5 acres within each of the Marine Reserves) that will be implemented over a 5-year period and subsequently monitored for an additional 5 years.

Affected Environment

The restoration sites to which abalone will be translocated or outplanted comprise over 5 acres at each of the Naples Reef and Campus Point Marine Protected Areas. The donor population for adult abalone translocation is from San Miguel Island or another similarly robust southern California population. The Trustees will work with the appropriate local, state, and federal agencies, as well as abalone experts and NGOs to identify appropriate commercial or research abalone farm(s) for juvenile abalone outplants.

Environmental Consequences (Beneficial and Adverse)
Overall, this project is anticipated to have only minimal adverse environmental consequences and multiple beneficial impacts. In reaching this conclusion, the Trustees evaluated several types of potential impacts, as described below.

1. *Biological Impacts* - The long term biological impacts of this project to the marine protected areas are highly beneficial to the public, as abalone become re-established. Red abalone are an iconic resident of California kelp forests. Ecologically, abalone are grazers that keep rocky habitat available for diverse algal and benthic invertebrate occupants of rocky reefs. Abalone are competitors with sea urchins, but are less destructive grazers than sea urchins, thus abalone promote a healthy rocky reef system. There is the potential for minor adverse biological impacts to the abalone population of San Miguel Island or other selected donor population through the removal of abalone adults. In addition, there is the potential for injury to the translocated abalone. However, any removal will be done under permit, using best practices, and carefully planned to avoid any injury to translocated abalone or adverse reduction to the donor population or associated habitats. In addition, the project proponents are fully aware of the potential for disease in abalone populations and will use local abalone experts to screen and test outplants and transplants to avoid any chance of introducing disease into a wild population.

2. *Physical Impacts* – The Trustees do not anticipate major impacts to the physical environment, such as water, air, sediments, etc. Any negative physical impacts (e.g., harm to reef structure) would be unlikely and, at worst, would likely be mitigated by the use of best practices. Ultimately, any adverse physical impacts are expected to be negligible.

3. *Human Impacts* - The Trustees do not anticipate noteworthy impacts from this project on socio-economics, aesthetics, health and safety, historical properties, etc. There is likely a benefit to human recreational use as the presence of abalone and a more robust rocky reef/kelp habitat create a more diverse, healthy ecosystem, which will benefit divers and other recreational users of the MPAs.

Probability of Success
This project has high likelihood of success if implemented at this scale. In addition, abalone outplanting and translocation presents few environmental risks that are easily mitigated through established best management practices (BMPs). The CDFW has already developed many of

these BMPs as part of the red abalone outplanting work they have initiated in Los Angeles and San Diego Counties. Furthermore, abalone outplanting and translocation require no on site construction or physical modification of the sea floor, so permitting requirements will be limited to scientific collection and stocking permits, which will allow for a streamlined implementation process.

Performance Criteria and Monitoring

The success of the restoration project will be evaluated by assessing metrics associated with natural resource functions and services. Metrics will be compared with: 1) initial conditions at the project site and 2) conditions at an appropriate a nearby natural reference site or sites. The success of this project will be measured through up to 10 years of post-transplant/outplant monitoring of abalone population density and size structure, as well as an evaluation of rocky reef ecosystem for success.

Specifically, the Trustees may use the following measures to determine the effectiveness of the restoration:

- Number and size of abalone deployed to site per outplanting event as compared to pre-project levels pre-outplanting;
- Density of abalone present on site over time as compared to pre-project levels pre-outplanting; and
- Rocky reef ecosystem response will be measured through kelp density and stipe counts and fish, invertebrate and algae and habitat characterization surveys.

Evaluation

The Trustees have evaluated this project using the threshold and additional screening criteria developed to select restoration projects and concluded that this project is consistent with and meets the objectives of these selection factors. This type and scale of project will effectively provide appropriate compensation for injured subtidal habitat as a result of the spill, and the Trustees have therefore identified this project as a preferred alternative.

Refugio Bay Eelgrass Restoration (SubT-2)

The goal of this project is to enhance habitat services within Zone B through the restoration of eelgrass. There are limited opportunities for coastal eelgrass restoration within Zone B because of depth, substrate and wave energy limitations. However, the Trustees have identified a subtidal site where the substrate, depth and wave energy are likely to support eelgrass, but which is far enough from existing beds that natural recruitment is unlikely (Altstatt, personal communication).

Affected Environment

The project includes creating additional eelgrass habitat in areas in or adjacent to Refugio Bay, including the southeastern portion of the Gaviota Coast, an area that was directly and heavily impacted by Line 901 oil. This would be accomplished through harvesting of plants from a donor site and transplanting them to the project site.

Environmental Consequences (Beneficial and Adverse)

Overall, this project is anticipated to have only minimal adverse environmental consequences and multiple beneficial impacts. In reaching this conclusion, the Trustees evaluated several types of potential impacts, as described below.

1. *Biological Impacts* – This project would provide long-term beneficial biological impacts to the environment. Eelgrass habitat provides unique and critical ecosystem services to the shallow subtidal component of the California coastal shelf. Eelgrass beds are an important source of primary productivity and create 3-dimensional biogenic habitat that is used by a diverse assemblage of fish and invertebrates as nursery and foraging habitat. Eelgrass habitat is also identified by NOAA as a Habitat of Particular Concern under the Magnuson-Stevens Fishery Conservation and Management Act. There is a slight possibility of adverse biological impacts if the project implementer takes too much eelgrass from donor sites. However, given the Trustees' experience and expertise in eelgrass restoration, this risk is extremely small. The Trustees, in addition to having implemented similar projects successfully in the past, would draw on the expertise of local experts in implementing this project.

2. *Physical Impacts* – The Trustees anticipate only minor impacts to the physical environment. The project will likely create beneficial impacts because eelgrass provides a three-dimensional habitat for fish and invertebrate species and stabilizes sediments, reducing scour and enhancing light penetration in the water column. Any adverse impacts would be associated with implementation (i.e., project implementers moving in and around the donor and transplant sites) and are expected to be negligible.

3. *Human Impacts* – The Trustees do not anticipate any impacts from this project on socio-economics, aesthetics, health and safety, historical properties, recreational use, etc.

Probability of Success

Eelgrass restoration in southern California has proven successful in many coastal locations. However, most of these projects were conducted with estuarine species. Because this project focuses on the coastal species, the Trustees are proposing to implement the restoration based on the successful methods used by Altstatt (2014). Based on that work, it is expected that full maturation of the restored eelgrass bed may take 7-10 years.

Performance Criteria and Monitoring

The success of the restoration project will be evaluated by assessing metrics associated with natural resource functions and services. Metrics will be compared with: 1) initial conditions at the project site and 2) conditions at an appropriate a nearby natural reference site or sites. The project includes up to 10 years of monitoring for restoration success. The specific details of the monitoring actions will be outlined in the project monitoring plan

Specifically, the Trustees may use the following measures to determine the effectiveness of the restoration:

- Acres restored;
- Density of eelgrass shoots, cover, and blade length before and after; and
- Ecosystem response measured through fish and invertebrate and habitat characterization surveys.

Evaluation
The Trustees have evaluated this project using the threshold and additional screening criteria developed to select restoration projects and concluded that this project is consistent with and meets the objectives of these selection factors. This type and scale of project will effectively provide appropriate compensation for injured subtidal habitat as a result of the spill, and the Trustees have therefore identified this project as a preferred alternative.

Sand-Dwelling Kelp Restoration (SubT-3)
The goal of this project is to support an existing effort to re-establish sand-dwelling kelp canopy to the Goleta Beach area. There are no other opportunities for direct kelp forest restoration within Zone B. The existing project is currently underway under separate funding, initiated by a small group of dedicated citizen scientists who are attempting to restore the kelp forest that once existed in Goleta Bay. While there is no rocky reef habitat in the bay that typically supports kelp forests, it has been speculated that the kelp had once established itself on tube-forming worm colonies that frequent open sand habitats (e.g., colonies of the tube worms belonging to the genus *Diopatra*). The project aims to restore these “sand-dwelling” kelp plants by inserting small granite columns into the sediment, exposing the top 10-20 cm of the column to kelp recruitment. The ultimate goal of this project is that kelp holdfasts will spread beyond the area occupied by the granite column and form a kelp forest of sufficient density to support kelp canopy.

The scope of the NRDA project is to extend the existing project by expanding the permits associated with the current one-acre project and to implement a systematic monitoring program. At this time, the Trustees are not proposing a larger scale buildout of this project because the results are still preliminary, and the longer-term viability of the approach is unknown. However, if the project continues to show success, the Trustees will consider expansion, subject to permits and other considerations.

Affected Environment
The location of the project currently encompasses sand bottom offshore of Goleta Beach, just outside of Zone B, the heaviest oiled area. The project would re-introduce sand-dwelling kelp to the area. There are limited opportunities for other kinds of kelp restoration due to lack of rocky reef habitat.

Environmental Consequences (Beneficial and Adverse)

Overall, this project is anticipated to have only minimal adverse environmental consequences and multiple beneficial impacts. In reaching this conclusion, the Trustees evaluated several types of potential impacts, as described below.

1. *Biological Impacts* - The Trustees' proposal regarding this project does not include any additional active restoration work. Rather, it covers only an extension in the duration of the existing project and associated monitoring activities. Extending the current project will have no negative effects to the environment and may have beneficial effects, as the project currently provides some ecosystem benefits to fish and invertebrates. Kelp also provides food to subtidal, intertidal and beach communities (e.g., a large component of beach wrack is produced by giant kelp). If the Trustees extend the time period of the project, the beneficial impacts will increase accordingly. As the monitoring activities would be the Trustees' only physical interaction with the project, any adverse impacts are expected to be negligible.

2. *Physical Impacts* – As with biological impacts, the Trustees expect any physical impacts from this project to be negligible.

3. *Human Impacts* - The Trustees do not anticipate any impacts from this project on socio-economics, aesthetics, health and safety, historical properties, recreational use, etc.

Probability of Success

The project was implemented as a pilot project, and to date has shown some success, in that kelp plants have recruited to a number of the granite columns. Longer-term monitoring of the existing project will help the trustees evaluate success, especially from consequences of large storm events.

Performance Criteria and Monitoring

The success of the restoration project will be evaluated by assessing metrics associated with natural resource functions and services. This time series of metrics will be compared with: 1) initial conditions at the project site and 2) conditions at an appropriate a nearby natural reference site or sites. This proposal calls for 5 years or more of monitoring for success of the pilot project. The specific details of the monitoring actions will be outlined in the project monitoring plan.

Specifically, the Trustees may use the following measures to determine the effectiveness of the restoration:

- Density of kelp plants as compared to pre-project conditions;
- Kelp stipe counts and canopy cover compared to pre-project conditions; and
- Ecosystem response will be measured through fish and invertebrate and habitat characterization surveys.

Evaluation

The Trustees have evaluated this project using the threshold and additional screening criteria developed to select restoration projects and concluded that this project is consistent with and meets the objectives of these selection factors. This type and scale of project will effectively provide appropriate compensation for subtidal habitat as a result of the spill, and the Trustees have therefore identified this project as a preferred alternative.

Ellwood Seawall Removal (SubT-4)

This project will benefit shoreline (sandy beach) resources and is discussed in Section 5.1.6 (Shoreline) above. However, the Trustees agree that there are likely benefits to subtidal resources offshore of the existing structure. The subtidal component of this project consists of pre- and post-removal monitoring to confirm and document benefits.

Affected Environment

The project site is Ellwood Beach in Goleta, CA. A wooden seawall currently constrains natural functioning of the ecosystem as well as lateral access along the shoreline at high tide.

Environmental Consequences (Beneficial and Adverse) (to the subtidal environment)

This project will only be undertaken if it is ultimately selected to compensate for sandy beach injuries, as discussed in Section 5.1.6 above. Accordingly, its status as a preferred alternative to compensate for subtidal injuries will have no impact on the potential environmental impacts described above. The only additional activity associated with the subtidal "component" is non-invasive monitoring, which the Trustees anticipate will have negligible, if any, environmental impacts.

1. *Biological Impacts* – The project is expected to benefit the environment by reducing scour and turbidity to the nearshore environments (due to the reduction in reflective wave energy after removal of the seawall). Scour inhibits settlement and success of algal and seagrass species, as well as benthic invertebrates. Turbidity inhibits algal and seagrass growth. Reduction in scour is expected to increase species diversity and habitat function in the affected offshore area. Short-term adverse effects from construction are expected to be negligible with respect to the existing offshore environment.

2. *Physical Impacts* – The benefits to subtidal habitats include an expected reduction in turbidity and scour in the offshore habitats resulting from the reduction in reflective wave energy that will occur after the seawall has been removed. Short term adverse effects from construction activities (potentially higher turbidity, sediment transport) are expected to be negligible.

3. *Human Impacts* - The Trustees do not anticipate any impacts from this project on socio-economics, aesthetics, health and safety, historical properties, recreational use, etc. in the offshore environment.

Probability of Success
The Trustees consider this project to have a good likelihood of success in providing benefits to the nearshore subtidal habitats because wave reflectivity and scour will be significantly reduced compared to current conditions.

Performance Criteria and Monitoring
The success of the restoration project will be evaluated by assessing metrics associated with natural resource functions and services. Metrics will be compared with: 1) initial conditions at the project site and 2) conditions at an appropriate a nearby natural reference site or sites. The project envisions up to 10 monitoring events, pre- and post-removal over a five-year period. The specific details of the monitoring actions will be outlined in the project monitoring plan

Specifically, the Trustees may use the following measures to determine the effectiveness of the restoration:

- Presence of sessile macrofauna and macroalgae sensitive to scour relative to pre-project conditions; and
- Decrease in turbidity relative to pre-project conditions.

Evaluation
The Trustees have evaluated this project using the threshold and additional screening criteria developed to select restoration projects and concluded that this project is consistent with and meets the objectives of these selection factors. This type and scale of project will effectively provide appropriate compensation for injured subtidal habitat as a result of the spill, and the Trustees have therefore identified this project as a preferred alternative.

5.2.4 Second Tier Restoration Projects Considered

The Trustees also considered the following projects (Table 8) and determined that many are valid projects that would provide benefits to subtidal and fish habitat. However, these projects were not selected for various reasons described below. These projects may be reconsidered if a selected project cannot be implemented or if remaining funds allow.

Table 8. Second tier subtidal restoration projects that may be implemented if funds allow.

ID#	OTHER PROJECTS CONSIDERED	BENEFITS
SubT-5	Net and Trap Removal (marine debris)	Fish, some benefit to benthic invertebrates
SubT-6	Artificial Reef	Fish and subtidal habitats
SubT-7	*Undaria* Removal at Anacapa Island	Subtidal habitat
SubT-8	Marine Protected Area Management and Stewardship Program	Subtidal habitat
SubT-9	Grunion Habitat Restoration and Education	Beach, subtidal and fish
SubT-10	Slough and Salt Marsh Restoration	Early lifestage fish
SubT-11	Kelp Restoration in Santa Barbara Channel Area	Subtidal habitat
SubT-12	Sargassum Removal	Early lifestage fish
SubT-13	Lobster Restoration	Lobster
SubT-14	Boater Outreach to Reduce the Spread of Invasive Algae	Subtidal habitat
SubT-15	Gaviota Creek Fish Barrier Removal	Fish

Net and Trap Removal (marine debris) (SubT-5)

This project was considered because marine debris removal, particularly derelict fishing gear, can have some benefits to marine habitats and can also reduce mortality of marine fish, birds, invertebrates and mammals. Marine debris removal is identified as a lower priority for a number of reasons. The degree of benefit that fishing gear removal has to each of these resources depends greatly on the location and habitat from which the gear is removed, and the nature of the items removed. While there are some opportunities to remove fishing gear from the greater southern California Bight, opportunities to remove gear from Zone B have proven to be limited. Thus, direct benefits of gear removal to the benthic marine habitats that were injured by the spill are also limited. Gear removal would be more likely to address injuries to water column species, so the Trustees may reconsider this project if they determine later that it is appropriate to conduct water column species-specific restoration (as opposed to using remaining funds to expand habitat projects with water column species benefits).

Artificial Reef (SubT-6)

The Trustees considered proposed artificial reef creation via reef balls or imported rock near Bird Island. Artificial reef creates new hard structure, promoting rocky reef habitat enhancement, potentially including kelp establishment. However, for the purposes of NRDA, the Trustees determined that significant barriers, such as permitting and maintenance issues, exist. These barriers will lessen the likelihood of timely implementation of the project. Therefore, the Trustees dropped this project from further consideration at this time.

Undaria Removal at Anacapa Island (SubT-7)

Undaria pinnatifida is an Asian seaweed of the intertidal and shallow subtidal zone, which was first discovered invading Anacapa Island in 2016. Invasive seaweeds crowd out native seaweeds and potentially introduce co-occurring invertebrates, with potential for cascading effects to the ecosystem. The proposed project would implement an *Undaria* removal program in subtidal areas around the Channel Islands. Although the Trustees consider this a beneficial project, in general, there was concern that the project had high costs that may not achieve lasting benefits to subtidal habitats. Further, the habitat and ecosystem benefits occur outside of the subtidal area affected by the spill.

Marine Protected Area Management and Stewardship Program (SubT-8)
This project focuses on ecological and human use monitoring to support adaptive management and agency enforcement of MPA regulations. This project may include cleanup of marine debris identified within MPAs, removal of invasive kelps, and education and outreach to promote awareness, compliance, and stewardship of MPAs. The project is heavily focused on monitoring, and the tangible subtidal benefits are undefined, making it a less attractive project for implementation than those listed as “preferred” in Table 7. The Trustees will consider whether this project can be combined with the abalone restoration project that is also focused within MPAs.

Grunion Habitat Restoration and Education (SubT-9)
This project focuses on developing management practices that restrict grunion capture and other impacts to Grunion until after the first 2-3 days of spawning. Public outreach to raise awareness would be a necessary component of the project. Also, increased public awareness of this species' presence at Refugio and El Capitan State Beaches is directly attributed to the Refugio Beach Oil Spill cleanup, and an interpretive program would help to mitigate expected increased fishing pressure for grunion at these locations. Also, increasing the number of grunion greeters and/or increased CDFW enforcement would help protect grunion. The Trustees consider these measures to be beneficial to grunion. However, there are several other projects targeting shoreline restoration that provide significant benefits to grunion spawning habitat. This project would require a change in the current regulatory framework by the Fish and Game Commission, which is outside the authority of the Trustees. Thus, a specific grunion shoreline project is not preferred at this time.

West Goleta, Carpinteria and Devereux Slough Restoration Projects (SubT-10)
These are three separate projects considered for wetland, tidal marsh and upland restoration to benefit estuarine and marsh habitats. These habitats benefit early life stage fish and crab species by serving as refugia and feeding habitat. While the habitat injured by the oil spill was marine, shallow subtidal habitats, these projects may provide broad ecosystem benefits and contribute to subtidal health by supporting early life stages of subtidal species and through indirect effects to subtidal habitats such as water quality improvement.

Kelp Restoration in the Santa Barbara Channel Area (SubT-11)
Restoration of kelp could lend to protection of shoreline habitats from storms, provide habitat for prey of marine mammals and birds, provide additional habitat for fish, provide wrack for sandy beach, and improve recreational diving. However, the project lacked specific descriptions,

locations, and timelines to gauge its feasibility. The Trustees believe that the abalone project and the sand kelp project (identified as "selected" projects) meet the goals of restoring kelp habitat. The Trustees will continue to monitor opportunities and feasibility for such projects for the future.

Sargassum Removal (SubT-12)

Sargassum is an invasive, floating kelp that has recently invaded southern California. Invasive seaweeds crowd out native seaweeds and potentially introduce co-occurring invasive invertebrates, with potential for cascading effects to the ecosystem. The Trustees agree that *Sargassum* establishment and dispersal in Santa Barbara Channel is a concern, but there was no project proposed that specified activities, timeframe, locations or scope to gauge feasibility for a *Sargassum* removal project. This project was not selected to be carried forward for implementation at this time because the project does not contain sufficient information for the Trustees to understand the benefits to subtidal resources injured by the spill.

Lobster Restoration (SubT-13)

This project concept involves multiple methods for conducting lobster restoration including various studies, purchasing Global Positioning System units for permit holders, fishermen surveys, enforcement assistance, and education programs. The benefits of these projects are indirect to subtidal habitats and to lobsters. The ecosystem-level benefits from the projects listed as "selected" in Table 7 are anticipated to also provide benefits to lobsters.

Boater Outreach to Reduce the Spread of Invasive Algae (SubT-14)

This project involves educating boaters about reducing the spread of invasive algae by sending educational materials to boaters along with their registration information, and providing resources for removing algae from boats at launch locations. The benefits of this project are anticipated to be less than would be achieved through direct restoration of habitat, and the effectiveness of education in reducing the spread of invasive algae is uncertain.

Gaviota Creek fish barrier removal (SubT-15)

This project involves removing numerous fish barriers along the Gaviota Creek watershed. Some of these barriers restrict the ability of fish to migrate upstream while others interfere with the creek's natural functions. This project will benefit Southern California steelhead and other aquatic organisms that live within the Gaviota Creek Watershed. The removal of steelhead barriers is focused on one species that was not documented to be injured by the spill, therefore it did not rise to the level of a "selected" project. Furthermore the commencement of watershed-wide restoration is contingent on the relocation of the access road to Gaviota State Beach and Hollister Ranch, and removal of the current road that comprises a substantial impediment in the watershed. The scale of this project exceeds the resources that could be provided through NRDA settlement funds; however, the Trustees have included this as a second tier project.

5.3 Birds

Birds are especially vulnerable to oil spills, as the oil compromises the ability of their feathers to keep them warm in the cold ocean water (Moskoff 2000). For a species that forages in the water, even a relatively small amount of oil (e.g., the size of a nickel) may result in death. Like a hole in a wetsuit, the oil destroys the feathers' ability to insulate the bird, thus allowing cold ocean water to spread against the bird's skin. Birds which contact oil typically die of hypothermia. With their rapid metabolism, birds also suffer starvation when they cannot forage for a few days (Oka and Okuyama 2000). They can also ingest toxic amounts of oil while preening, as they attempt to clean themselves. Finally, larger amounts of oil can smother birds, affecting their mobility and ability to survive.

A total of 269 birds were collected live and dead after the oil spill, encompassing at least 28 species. The Trustees structured our assessment of bird injury into three injury categories based on the birds' behavior patterns and location of the affected species. These categories are:

- Brown pelicans;
- Western snowy plovers; and
- All other bird species.

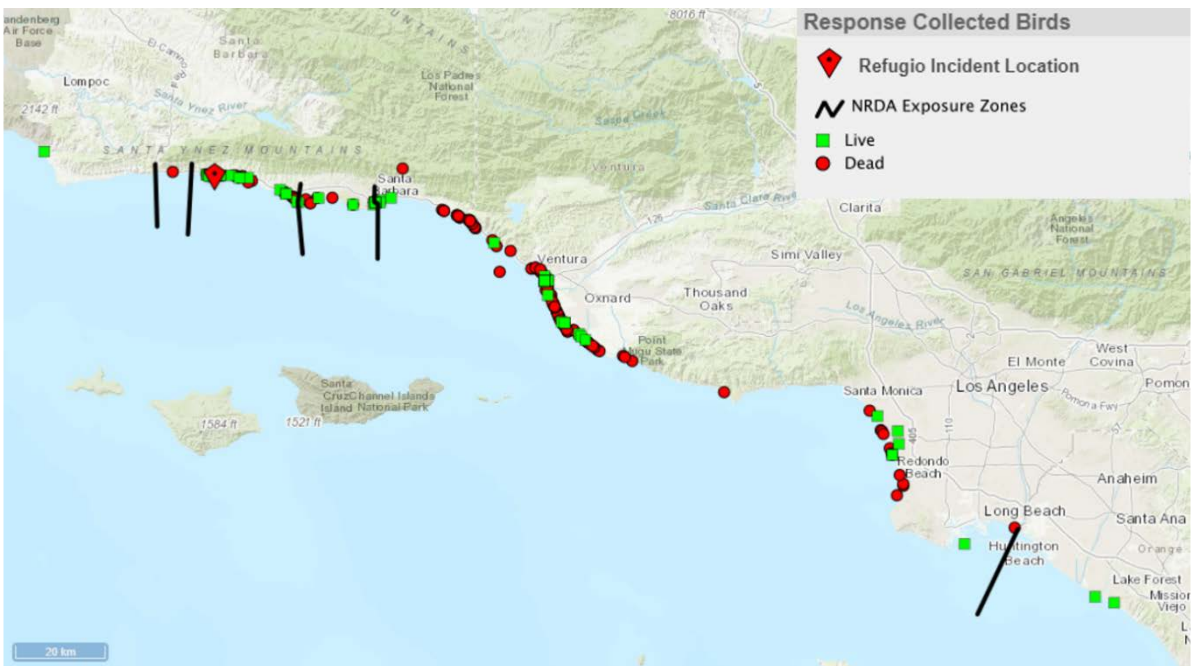

Figure 27. Location of live and dead birds recovered during wildlife operations. The back lines show the NRDA Exposure Zone boundaries for reference; however these boundaries were not used in the quantification of injury to birds.

5.3.1 Overview of Data Collection and Studies

This section describes the data that were collected or analyzed by the Trustees in order to assess injury to birds resulting from the spill. These data were generated by several efforts, including studies that were conducted by the spill cleanup, data collected by the NRDA team, and studies that were not specifically developed for the spill but that provide relevant information for understanding and determining injuries to birds resulting from the spill. These studies are listed below and described in more detail in Appendix I.

Wildlife Reconnaissance Aerial Surveys

On May 21, 2015, aerial surveys for pelagic birds were conducted roughly between Point Conception and the City of Goleta. The objective of these surveys was to understand the general location and quantity of seabirds in the vicinity of the spill-affected area in order to inform spill response activities. These surveys, conducted by the Unified Command, documented at least 13 unique pelagic bird species in groups ranging in size from a single individual to 120 individuals.

Live and Dead Bird Intake Data

Documentation of live and dead birds was collected as a normal part of the spill response. These data describe the collection of each bird, with such information as date, location, species, condition of bird, degree of oiling, etc. Locations of live and dead birds collected are shown in Figure 27, and the species collected are identified in Table 9. During spill response operations all live distressed birds were taken to rehabilitation centers for further care. All dead birds encountered within the spill area were collected. A total of 66 live birds and 203 dead bids comprised of over 28 species were collected between May 20, 2015 and June 24, 2015 (OWCN 2015).

Table 9. All birds collected live and dead by species (or closest known taxon).

Species	Collected Live	Collected Dead	Total
Black storm-petrel	0	1	1
Barn owl	0	1	1
Black skimmer	0	1	1
Brandt’s cormorant	2	11	13
Masked/Nazca booby	0	1	1
Brown pelican	47	26	73
California gull	1	5	6
Cassin’s auklet	0	1	1
Clark’s grebe	0	2	2
Common loon	0	3	3
Common murre	5	33	38
Cormorant sp.	0	4	4
Double-crested cormorant	0	14	14
Domestic duck sp.	0	2	2
Eared grebe	0	1	1
Elegant tern	0	1	1
Forster’s tern	0	1	1
Grebe sp.	0	3	3
Heermann’s gull	0	3	3
Loon sp.	0	5	5
Mew gull	0	1	1
Northern fulmar	0	5	5

Pacific loon	6	17	23
Pelagic cormorant	0	2	2
Pigeon guillemot	0	1	1
Rhinoceros auklet	0	2	2
Rock pigeon (feral)	0	1	1
Red-throated loon	1	12	13
California scrub-jay	0	1	1
Shorebird sp.	0	1	1
Sooty shearwater	0	16	16
Surf scoter	1	2	3
Western grebe	1	8	9
Western gull	2	9	11
Unknown	0	6	6
TOTAL	**66**	**203**	**269**

Search Effort Data Compilation

Understanding how well beaches within the spill area were searched is important to estimating how many carcasses may have been missed. The Trustees compiled and analyzed records from SCAT teams, wildlife reconnaissance teams, cleanup crews, and NRDA operations to understand the geographic extent and frequency of beach searches that would have had the potential to identify live and dead birds during the cleanup period.

Figure 28. Western snowy plover at Coal Oil Point during cleanup operations. Photo Credit: Coal Oil Point Reserve, UCSB.

Western Snowy Plover Studies

Western snowy plovers utilize several sandy beaches within Santa Barbara and Ventura Counties for nesting, including Coal Oil Point Reserve, San Buenaventura State Beach, McGrath State Beach, Mandalay State Beach, Ormond Beach, Hollywood Beach, and on Naval Base Ventura County at Point Mugu. Routine monitoring of plovers nest numbers and nest success were conducted at each of these beaches during the 2015 nesting season (Coal Oil Point Reserve 2015; Hartley 2015; Barringer 2015; Frangis and Cox 2015). All nesting beaches are located in Ventura County, with the exception of Coal Oil Point Reserve in Santa Barbara County, which was subject to elevated oil exposure and extensive cleanup operations (Figure 28).

Anacapa Island Brown Pelican Surveys

Anacapa Island is home to the largest breeding colony of California brown pelicans in the United States. The only other significant U.S. breeding colony is located on Santa Barbara Island, which is much farther from the mainland and was unlikely to be heavily impacted by the spill. A much larger number of pelicans breed in Baja California, Mexico. After breeding, many of these birds migrate north and make up the majority of pelicans in the state in summer and fall. During the oil spill, many of the Baja pelicans were already migrating north, due to a failed breeding season in Mexico, and were passing through the spill-affected area. A reconnaissance level, boat-based survey of the nesting colony on Anacapa was conducted by Channel Islands National Park staff on June 5, 2015 during the initial cleanup effort, and no oiled pelicans were observed (Larramendy et al. 2018); however, the survey did not include direct, on-island access. Ground surveys were conducted later on September 20 and 21, 2015 (following the end of the nesting season).

Hundreds of nests were inspected for oiling. Evidence of oiling was limited to one juvenile brown pelican carcass on Middle Anacapa Island, in which a small amount of weathered oil was found on several wing tips, and a few specks on the downy feathers around its shoulder (Larramendy et al. 2018). The survey team estimated the bird was about 6 weeks of age at the time of death, which is essentially full grown.

Brown Pelican Roost Surveys

Due to their large size, pelicans can survive for many days after oiling. In order to assess the extent of oiling of brown pelicans, surveys of known pelican roost sites on the mainland from Morro Bay to Los Angeles were performed in the days immediately after the spill (Jaques et al. 2015). Surveys were conducted by ground and by boat to evaluate the proportion of pelicans at each roost site that showed visible oiling. An aerial survey of pelican roosts were conducted on May 27, 2015 (Jaques et al. 2015). Aerial surveys are ideal for documenting the total number of individuals at each roost by taking photographs and counting brown pelicans (which are easily distinguishable from other birds due to their body size) at each roost. Because no single survey method is able to detect both the proportion of oiled individuals at any given roost and the total number of individuals at the roost, the Trustees analyzed these datasets together to estimate the total number of oiled pelicans at each roost site.

Brown Pelican Rehabilitation Survival Studies

The Oiled Wildlife Care Network (OWCN) assisted with wildlife operations during the spill, including rehabilitation of oiled birds. In order to understand the survival rate of rehabilitated oiled wildlife, the OWCN and other collaborators tracked rehabilitated pelicans to determine their survival and distribution relative to birds that were not oiled and rehabilitated during the spill (Fiorello et al. 2017). Several individuals traveled >5000 km, migrating to northern California or central Oregon in late summer and early fall. In the spring, most birds traveled south, some as far as Baja California. It appeared that both pelicans from Anacapa and Baja were impacted because they flew to those locations after being released. Mortality was documented among both rehabilitated and control birds.

Sandpiper Pier Cormorant Colony Surveys

Brandt's cormorants in the spill-affected area nest in a single colony on four nesting platforms that were constructed offshore of Ellwood Beach in Santa Barbara County. Surveys were conducted from the shore to assess the number and status of nests throughout the 2015 breeding season (Figure 29). Based on these observation, the Trustees concluded that nests were not abandoned and chicks successfully hatched during the spill period at a normal rate. Adverse effects from exposure to oil were not visibly apparent during these surveys. However, health effects from ingestion of oil may not have culminated during the survey period, and cannot be easily assessed based on a visual survey.

Figure 29. Cormorant nests on platform 1 during a May 22, 2015 survey. Red circles indicate nests that were monitored during the May and June surveys. Photo Credit: Natural Resource Damage Assessment Trustees.

Baseline Carcass Deposition Surveys

Information about the baseline rate of bird deposition on beaches throughout the spill-affected area is available from information collected through the Beach Coastal Ocean Mammal and Bird Education & Research Surveys (BeachCOMBERS) program. The program utilizes highly trained citizen scientists to conduct monthly beach surveys using a dedicated protocol for documenting the number and status of beached birds and mammals within each survey segment. Data collected includes species identification, decomposition state, observations of carcass scavenging, observations of carcass oiling, and other factors. All carcasses encountered during a survey are marked to identify whether the carcass has been observed on previous surveys (a new mark is made each month). The goal of the BeachCOMBERS program is to establish long-term data on baseline bird and mammal stranding rates, so that when unusual mortality events occur (e.g., oil spills, disease events, etc.), resource managers can understand and explore the magnitude and cause of the bird and/or mammal mortality. The spill occurred within the South Coast Chapter of BeachCOMBERS which began collecting monthly data in January 2013.

5.3.2 Brown Pelican injury analysis

Background

The California brown pelican is a subspecies of brown pelican that ranges throughout the west coast of North America. It nests in Mexico and on the Channel Islands. The brown pelican was delisted as a protected species by the State in June 2009 and by the federal government in December 2009. During the spill, brown pelicans were nesting on the Channel Islands, and many were migrating north through the spill area following breeding failure in Mexico. Brown pelicans typically forage in relatively shallow coastal waters, feeding almost entirely on surface-schooling fish caught by plunge diving. Brown pelicans are rarely found away from salt water and do not normally venture more than 32 kilometers (20 miles) out to sea. During the non-breeding season, brown pelicans roost communally on offshore rocks and structures such as piers and wharfs. Brown pelicans have wettable plumage so they must have roost sites to dry after feeding or swimming (Jaques and Anderson 1987). Roost sites are also important for resting and preening. The essential characteristics of roosts include: nearness to adequate food supplies; presence of physical barriers to protect the bird from predation and disturbance; sufficient surface space for individuals to interact normally; and adequate protection from adverse environmental factors such as wind and surf (Jaques and Anderson 1987).

Brown Pelican Injury Assessment

Brown pelicans were the most numerous bird species to be found alive and dead during the spill period. Of the birds collected during the spill, 72% of the live birds (n=47), and 13% of the dead birds (n=26) were brown pelicans. Not all of the live and dead brown pelicans affected by the spill were captured or collected. Brown pelicans are capable of long-distance flights and oiled individuals can survive for several days to weeks before becoming weak and either succumb to their exposure or become lethargic enough to be captured. To estimate the total number of brown pelicans injured by the spill, the Trustees applied the following methodology which is discussed in detail in Appendix I.

1) Determine brown pelican distribution during the spill;
2) Determine brown pelican oiling rate;
3) Calculate brown pelicans injured within the cleanup zone;
4) Calculate brown pelicans injured outside the spill cleanup zone;
5) Adjust for rehabilitated birds; and
6) Calculate total number of brown pelicans injured.

Summary of Brown Pelican Injury

Based on the number of brown pelicans recovered live and collected dead during the cleanup, the estimated number injured by the spill but missed by the cleanup, and the rehabilitation success of pelicans that were treated and released, the Trustees estimate that a total of 319 brown pelicans were injured by the spill (Table 10)[13].

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[13] Plains disagrees with the Trustee estimate of brown pelicans injured by the spill.

Table 10. Total Brown Pelican injury from the Refugio Beach Oil Spill.

Brown pelicans injured within the spill cleanup zone	72
Brown pelicans missed by the spill cleanup	+ 279
Rehabilitation credit	- 32
TOTAL Brown Pelican Injury	**319**

5.3.3 Western snowy plover injury analysis

Background

When the spill occurred, federally threatened western snowy plovers, were in the midst of their breeding season, with many chicks recently hatched and foraging on sandy beaches. Western snowy plovers are among very few species that nest directly on sandy beaches, which makes them vulnerable to conflicts with human activities. In the spill-affected area, there are several locations where plovers nest: Coal Oil Point Reserve (COPR) at University of California Santa Barbara, San Buenaventura State Beach, McGrath State Beach, Mandalay State Beach, Hollywood Beach, Ormond Beach, and Point Mugu (Figure 30). All of the beaches shown in Figure 30 received oiling and/or tar balls in varying degrees during the spill. The maximum amount of oil observed by SCAT teams ranged from heavy at COPR to very light at Ormond Beach. The presence of cleanup crews corresponded to the degree of oiling.

As COPR was exposed to the greatest oiling and most intense cleanup activities of any western snowy plover breeding sites within the spill-affected area, it was also the most intensively studied to determine injury to plovers from oil exposure and cleanup actions. Injury to plovers from cleanup actions, wrack removal, and food web impacts at McGrath Beach, Hollywood Beach, and Ormond Beach are incorporated into the assessment of shoreline habitat injury described in Section 5.1 of the DARP/EA.

Western Snowy Plover Injury Assessment

Effects of the spill on western snowy plovers were assessed using the following methodology, which is described further in Appendix I.

1) Determine effect of the spill on western snowy plover population size at COPR;
2) Determine effect of the spill on behaviors and breeding success at COPR in 2015;
3) Determine amount of body oiling on western snowy plovers at COPR during the spill;
4) Conduct a literature review to identify risk of toxicity from oil ingestion;
5) Determine effects of the spill on western snowy plover fertility at COPR; and
6) Estimate western snowy plover injury.

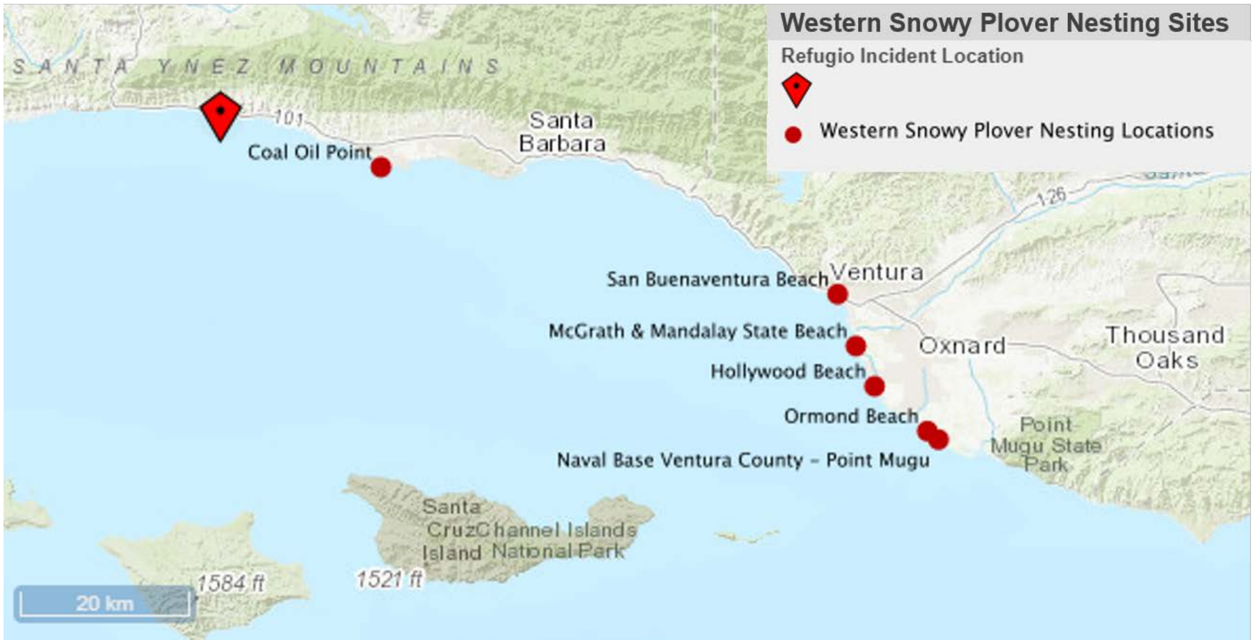

Figure 30. Refugio oil spill release location relative to nesting western snowy plover nesting sites.

Estimate of Western Snowy Plover Injury

Western snowy plovers at Coal Oil Point Reserve in Santa Barbara County, and various locations within Ventura County, were exposed to Line 901 oil during the Refugio Beach Oil Spill. The spill occurred during the breeding season, and at the time of the spill many nests had been formed and eggs had been laid. COPR was exposed to heavy oiling and extensive cleanup actions, and the Trustees determined that an assessment of injury to this population was warranted.

All western snowy plover populations in Ventura County were also exposed to some level of tarball oiling and disturbance from cleanup actions. Due to the relatively low injury expected from this oiling and disturbance, these effects are captured as part of the shoreline habitat injury assessment which considers impacts to western snowy plover's prey base and disturbances to their habitat from cleanup actions.

Cleanup workers and land managers at COPR worked closely together to minimize impacts to western snowy plovers from oil spill cleanup actions. Managers documented oiling on western snowy plovers at COPR and disturbances to the birds from the presence of cleanup crews; however, no mortality was recorded and hatching and fledging rates met or exceeded long term averages. Therefore no injury to western snowy plovers at COPR was estimated in 2015, above impacts to food webs (through depressed beach invertebrate populations) and cleanup impacts that are quantified as part of the shoreline injury assessment.

The year following the spill (2016), western snowy plover infertility substantially increased compared to the long term average, with a total of 12 infertile eggs, none of which contained embryos. Background infertility under normal conditions is around 2%, therefore, of the 12 infertile eggs, two would be expected to occur without the effects of the spill. The additional 10 infertile eggs cannot be explained by background infertility rates. These infertilities were likely caused by oil exposure to western snowy plover adults during the 2015 breeding season. Adults were observed with oil on their plumage and beaks, which they preened and ingested. Adults were also observed foraging within oiled wrack, and their prey species (e.g., sandy beach invertebrates such as sand crabs) were documented to have increased hydrocarbons in their tissue. In 2017, the infertility rate reduced to a level that is within the range of normal variation. Based on typical hatching and fledging rates at COPR, the Trustees anticipate that of the 10 infertile eggs documented at COPR in 2016, four would have hatched and fledged. Therefore, we assert that at least four western snowy plovers at COPR were injured through reproductive injury from the Refugio Beach Oil Spill. Additional injury to western snowy plovers may have occurred from direct oil exposure, prey reduction, and impacts from cleanup operations. Effects to plovers from injuries to their habitat are captured in the shoreline injury analysis.

5.3.4 Other Bird Injury Analysis

Background

This category includes all birds other than brown pelicans and western snowy plovers that were impacted by the spill. This category includes at least 29 species of seabirds, shorebirds, and landbirds. Table 9 lists all the birds by species collected alive and dead during the spill cleanup. Figure 31 groups the species into related categories. After pelicans, impacts were spread among a variety of marine waterbirds. Because the spill occurred during the nesting season for most North American birds, and most affected species do not nest locally, the impacts to other birds were largely limited to non-nesting individuals, such as sub-adults that were likely over-summering in the area. Had the spill occurred in winter, many more individuals from these species groups would have been impacted.

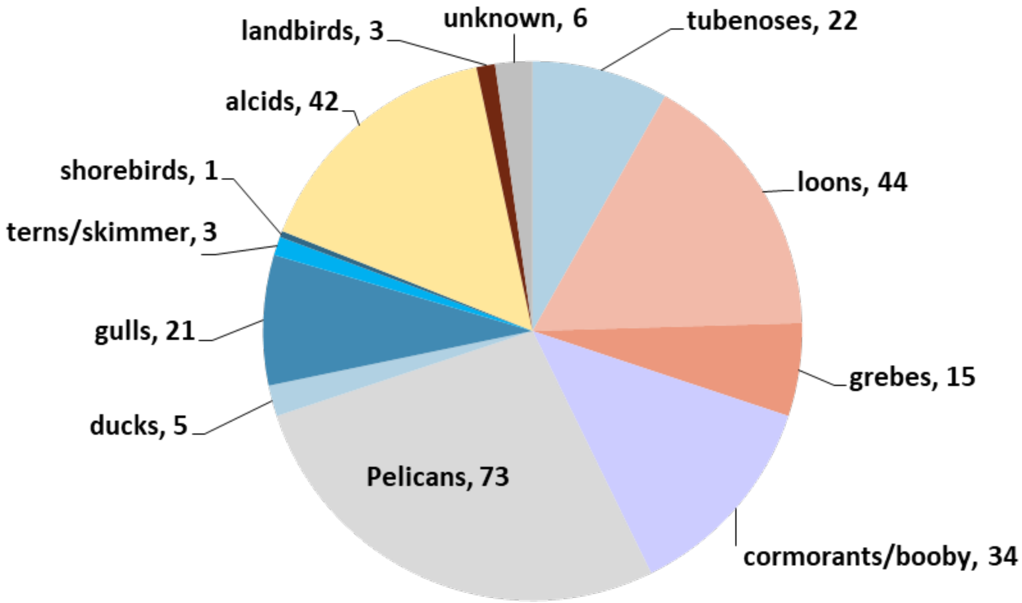

Figure 31. Total live and dead birds captured and collected following the spill.

Other Bird Injury Assessment

In order to estimate mortality for these species, the Trustees applied the following methodology, which is described in Appendix I.

1) Determine which of the collected birds were related to the spill:
    a. Identify species and numbers of birds collected;
    b. Identify number of oiled and non-visibly oiled birds;
    c. Oiled dead birds – adjust for baseline oiling from natural seeps; and
    d. Non-visibly oiled dead birds – adjust for background deposition.
2) Use the Beached Bird Model to identify how many birds were missed:
    a. Determine carcass persistence on beaches;
    b. Determine search effort and efficiency; and
    c. Calculate total injury.

Beached Bird Model

As with the pelican assessment above, it is very likely that the actual number of other species impacted by the spill exceeds the number collected and attributed to the spill. Birds impacted by an oil spill may not be collected for a variety of reasons:

1. They may travel outside of the response area. As described above, this occurred with the large number of pelicans migrating north.
2. They may die at sea, sink, or be carried away from beaches that were searched.
3. They may come ashore on inaccessible beaches that cannot be searched.
4. Once on the beach, they may be removed by other animals scavenging on the beach.

5. For carcasses that do make it to accessible beaches and are not removed by scavengers, searchers may miss them.

In this case, with the non-pelican species, it is difficult to assess the first two reasons. Some species, such as loons, were migrating north, but most non-pelican species may have been more acutely debilitated by the oil, limiting their dispersal distance. Because the spill was nearshore, substantial loss of birds at sea was unlikely. Given these caveats, we did not specifically apply any correction factors for these first two reasons for non-pelican bird species.

The remaining three factors, inaccessible beaches, carcass removal, and search efficiency, can be incorporated into a Beached Bird Model in order to estimate total mortality. The model is based on the number of birds recovered, the probability of a beached bird persisting over a given time interval, and the likelihood that searchers will detect a beached bird. Derivation of the basic equation is from Ford et al. (1996) and Page et al. (1990). This approach has been used for most major oil spill bird mortality events for several decades. Using a simplified example, if the probability of a bird being removed by a scavenger in the course of a day is 50 percent, and the probability of it being overlooked by a searcher is 50 percent, then the probability of it being recovered is 25 percent. This would imply that, for every one bird found, three more are missed. This would result in a "beached bird multiplier" of four. That is, one bird found implies that four birds were impacted.

Estimated Injury to Other Birds

The final results of the Beached Bird Model, incorporating scavenging, search efficiency, and unsearched areas, were that 236 birds, not including pelicans and western snowy plovers, were killed by the spill (Table 11).

Table 11. Summary of estimated mortality of "other birds" based on the results of the Beached Bird Model.

Bird Taxon	Total Carcasses Collected[1]	Total Estimated Mortality
Alcids	42	56
Loons	44	53
Procellarids/Boobies	23	35
Gulls/Terns/Skimmer	24	33
Cormorants	33	24
Grebes	15	21
Surf Scoter	3	6
Other/Unknown	9	8
TOTAL	**193**	**236**

[1] Not including pelicans, domestic ducks, rock pigeons, and three birds collected live, rehabilitated and released. Note that a proportion of these carcasses were found to not be spill-related.

5.3.5 Summary of Bird Injury

In summary, the assessment of injury to birds from the Refugio Beach Oil Spill was conducted by dividing all affected birds into three categories: brown pelicans, western snowy plovers, and all other birds. The assessment methods for each category were designed around the species' life history strategy and feasible methods for quantifying injury. Table 12 shows the overall summary of estimated bird mortality by species group.

Table 12. Summary of total estimated bird mortality caused by the Refugio Beach Oil Spill.

Bird Taxon	Total Estimated Mortality
Brown Pelicans	319
Western Snowy Plovers	4
Alcids	56
Loons	53
Procellarids/Boobies	35
Gulls/Terns/Skimmer	33
Cormorants	23
Grebes	21
Surf Scoter	6
Other/Unknown	8
TOTAL	**558**

5.3.6 Selected Restoration Projects

Restoration alternatives for brown pelicans fall into two broad categories: improvement or protection of nesting habitat, and reduction of human-caused mortality during the non-breeding season. Selected projects that benefit brown pelicans are listed in Table 13 below.

The Trustees selected brown pelican colony protection at Anacapa Island as the primary restoration project for brown pelicans. The Trustees also selected a project to reduce or prevent injury to seabirds from recreational fishing to restore brown pelicans. This project will also benefit other seabird species, and is the restoration project selected for other birds. To address injury to western snowy plovers, the Trustees selected a project to fund management actions at Coal Oil Point Reserve that protect western snowy plovers from human activities and predators during their nesting season. Each of these projects are described further below. Other proposed second tier projects (Table 14) were not selected due to concerns over feasibility or lower anticipated benefits, but could be implemented if funds allow.

Table 13. Selected restoration projects for birds

ID#	SELECTED PROJECTS	SPECIES BENEFITS
BIRD-1	Brown Pelican Colony Protection at Anacapa Island	Brown Pelican
BIRD-2	Prevention of Injury to Seabirds Related to Recreational Fishing	Seabirds
BIRD-3	Western Snowy Plover Management at Coal Oil Point Reserve	Western snowy plovers

Brown Pelican Colony Protection at Anacapa Island (BIRD-1)

This project is intended to protect the largest United States breeding colony of California brown pelicans, on Anacapa Island, from nest displacement and loss caused by invasive Cape ivy.

The goal of this project is to eradicate the Cape ivy infestation on West Anacapa Island. Methods will include: 1) initial assessment of infested areas and baseline vegetation, along with pelican surveys, 2) two initial herbicide treatments to infested areas via helicopter and hand application in the first year, 3) follow-up treatment for the following 4 years, and 4) follow-up vegetation and pelican surveys. As part of the project, a water cache will be installed to allow for follow-up treatments over a longer timeframe. Treatments will occur outside the pelican breeding season, during fall/early winter when native vegetation is dormant and before winter rains.

Affected Environment

Anacapa Island is composed of a series of narrow islets, with the three main islets being East, Middle and West Anacapa. Despite its small size, Anacapa Island supports nearly 200 types of native plants from 50 plant families (Junak and Philbrick 2018). There are several infestations of Cape ivy on the north side of West Anacapa Island. This invasive plant displaces native vegetation and reduces the amount of available nesting and roosting habitat for pelicans. The largest infestation is in Summit Canyon (Figure 32). Anacapa Island has the largest breeding colony of the California brown pelican in the United States, and one of the only three in California. Middle and West Anacapa Islands serve as critical breeding and roosting habitat for the California brown pelican. Anacapa Island also supports the largest western gull (*Larus occidentalis*) colonies in the Channel Islands. A total of 17 landbird species are also known to breed on Anacapa Island (Davidson et al. 2014).

Figure 32. Project location for the brown pelican colony protection at Anacapa Island, the grey outline indicates a nesting area where Cape ivy is expanding and may decrease habitat suitability.

Environmental Consequences (Beneficial and Adverse)

Overall, this project is anticipated to have only minimal adverse environmental consequences and multiple beneficial impacts. In reaching this conclusion, the Trustees evaluated several types of potential impacts, as described below.

1. *Biological Impacts* –This project will benefit brown pelicans by enhancing nesting and roosting habitat through controlling invasive Cape ivy. By targeting active areas of infestation, the project will reduce the non-native cover and allow for native vegetation recovery and use by brown pelicans. The eradication of this species will protect nesting habitat and the native plant community which brown pelicans use to construct and support its nests. An increase in suitable habitat will allow for an increase in the number of nesting birds and subsequent fledglings on Anacapa Island.

   In addition, control of this invasive plant at its current locations will prevent its spread and additional loss of adjacent occupied habitat for brown pelicans. Additionally, the eradication of Cape ivy will protect the native flora and fauna on West Anacapa Island, and will also help prevent the introduction to the other Anacapa islets, as well as the other northern Channel Islands where Cape ivy is currently not found. The eradication of Cape ivy on West Anacapa Island will also protect rare plants found throughout the islets, which are currently outcompeted by this invasive plant. Overall, a diverse assemblage of native flora and fauna depend on intact vegetation communities. This project will benefit a range of species, including nesting seabirds (in particular the brown pelican and western gull), terrestrial songbirds, migratory birds, rare plants, and invertebrates that depend on the native vegetation communities.

   Herbicide applications for invasive plant treatments are covered under a NPS Categorical Exclusion (NPS 2019). Herbicide treatments can have impacts to non-target native vegetation within the treatment area. To reduce potential impacts, efforts will be made to minimize over spray and drift onto non-target species, including spot treatment of invasive plants adjacent to intact native vegetation. Herbicides will be applied by a certified applicator and in accordance with application guidelines and the manufacturer label. Although there may be short-term impacts to native plants within the treatment area, the long-term, negative consequences of not treating the Cape ivy or other invasive plant species far outweigh impacts to individual plants. Another potential adverse consequence of this project could be the unintentional spread of invasive plants from the treatment sites to other parts of the island via due to foot traffic. In order to reduce this potential, extreme caution will be used to reduce the spread of seeds via clothing and footwear by implementing existing biosecurity protocols for the Channel Islands. Also, in order to avoid impacts to nesting birds, including seabirds and resident terrestrial birds, herbicide treatment and vegetation monitoring will occur in fall/early winter, well before nesting season begins. Overall, any biological impacts from the implementation of the project are anticipated to be minor in comparison to the overall long-term beneficial impacts from restoring the native plant community to protect brown pelican nesting habitat.

2. *Physical Impacts* – The Trustees do not anticipate major adverse impacts to the physical environment, such as water, air, sediments, etc. Any negative physical impacts would be unlikely and, at worst, would likely be mitigated by the use of best practices. Ultimately, any adverse physical impacts are expected to be negligible.

3. *Human Impacts* – The Trustees do not anticipate adverse impacts from this project on socio-economics, aesthetics, health and safety, historical properties, etc. There is likely a benefit to the public as the sustained or increased presence of brown pelicans would create more opportunities for wildlife viewing.

Probability of Success

With the relatively small footprint of Cape ivy on West Anacapa Island (1-2 acres as of September 2018), the probability of successfully eradicating this species from this location is high. This multi-year, sustained effort would enable successive treatments over a six-year period as needed. This continued follow-up after initial treatment is critical to retreating any sprouts and ensuring success.

The control of other invasive species (Russian thistle, ice plant, etc.) in the project area also has a high probability of success. Herbicide treatment and manual removal are proven techniques to help control populations and limit the spread of invasive weeds. The eradication and control methodologies proposed have been tested and utilized successfully on the Channel Islands.

Performance Criteria and Monitoring

The success of the restoration project will be evaluated by assessing metrics associated with natural resource functions and services. Metrics will be compared with: 1) initial conditions at the project site and/or 2) conditions at an appropriate nearby natural reference site or sites. The success of this project will be measured with a minimum of three monitoring events are proposed which will be outlined in project monitoring plan. Additional monitoring of brown pelicans will continue post project as part of Channel Islands National Park's Inventory and Monitoring Program. Specifically, monitoring may include, but is not limited to:

- Documenting brown pelican abundance, distribution, phenology, and reproductive success in and adjacent to the treatment areas.
- Monitoring annual vegetation during all six years of the project within the project area. Monitoring will follow established protocols and will document treatment area, efficacy of treatments, and recovery of native vegetation communities.
- Analyzing treatment efficacy though post treatment monitoring. Post treatment monitoring will include both visual estimates of percent cover of Cape ivy and counts of stem number within permanent quadrats.
- Establishing photo points to document the progression of the treatment areas.

- Eradicating Cape ivy from Summit Canyon. Efforts to control other invasive weeds within the scope of this project will be prioritized upon initial assessments. Additional control efforts on Anacapa Island will be documented and mapped each year.

Evaluation

The Trustees have evaluated this project using the threshold and additional screening criteria developed to select restoration projects and concluded that this project is consistent with and meets the objectives of these selection factors. This type and scale of project will effectively provide appropriate compensation for brown pelicans injured as a result of the spill, and the Trustees have therefore selected this project as a preferred alternative.

Birds and Fishing Conflict Reduction (BIRD-2)

In an analysis of all seabirds brought to International Bird Rescue rehabilitation centers in Los Angeles and San Francisco between 2002 and 2015, fishing hook and line injuries were by far the most common anthropogenic injury, totaling 2,957 birds (Duerr 2016). Brown pelicans and other seabirds, including cormorants and gulls, are often attracted to nearshore areas where schooling bait fish are abundant. If anglers are fishing in these areas (e.g., from coastal piers), seabirds can be inadvertently hooked or entangled in fishing line. In addition, discarded waste fishing line can entangle seabirds. This project would use outreach to raise public awareness and educate anglers about ways to reduce their chances of hooking birds and what to do if one is hooked. Outreach could include printed materials and/or training of docents. This project may also provide support to bird rehabilitation centers to help recover and rehabilitate seabirds with fishing hook and line injuries.

This project is also intended to reduce seabird injury in areas where birds are attracted to fishing waste disposal areas. Brown pelicans and various gull species are often attracted to commercial fishing vessels off-loading small fish (e.g., sardines and anchovies) and squid, and to fish waste receptacles used by recreational anglers. These birds may attempt to dive into open bins of fish and may get injured by off-loading machinery and vehicles. In addition, repeated bodily contact with fish and fish oil can lead to a loss of waterproofing on the birds, resulting in hypothermia and other health issues.

Affected Environment

This project will be located in various locations along the Santa Barbara, Ventura, and Los Angeles County coastlines where recreational and commercial fishing activities are causing injuries to seabirds. Locations with fishing piers, harbors, and other fishing facilities will be targeted. This project may also focus on offshore fishing activities, if needed.

Environmental Consequences (Beneficial and Adverse)

Overall, this project is anticipated to have only minimal adverse environmental consequences and multiple beneficial impacts. In reaching this conclusion, the Trustees evaluated several types of potential impacts, as described below.

1. Biological Impacts – The Trustees do not anticipate any adverse effects to biological resources. Beneficial effects to seabirds are anticipated to be achieved by providing resources and training to recreational and commercial fishermen to reduce entanglements by implementing best practices, and being trained to capture and disentangle birds or transport birds to rehabilitation centers for professional treatment.

2. Physical Impacts – The Trustees do not anticipate any adverse impacts to the physical environment, such as water, air, sediments, etc. Beneficial effects to the physical environment are anticipated from reduced fishing line and fishing waste from entering coastal habitats.

3. Human Impacts – The Trustees do not anticipate adverse impacts from this project on socio-economics, aesthetics, health and safety, historical properties, etc. This project is not intended to reduce any recreational and commercial fishing opportunities, rather it is focused on working with willing recreational and commercial fishermen and fisherwomen to allow them to continue fishing while reducing their impact on seabirds.

Probability of Success
The probability of success of implementing the project is high. The effectiveness of the project in reducing seabird entanglements, however is dependent on the willingness and ability of the target audience to effectively implement what they learn. In order to maximize the probability that the outreach efforts implemented are successful in reducing entanglements, the project will be implemented by people that are knowledgeable about seabird handling/rehabilitation and will seek to create opportunities for anglers to participate in the program in a way that is convenient and approachable for them. For example, trainings may be held at piers, or tackle shops.

Performance Criteria and Monitoring
The performance of this project will be measured by evaluating incidence of birds with fishing hook and line injuries that enter rehabilitation centers after the program is implemented. The goal of the project is to reduce 60 bird deaths per year from fishing hook and line entanglement. It is not possible to measure the performance of the project in terms of the exact number of birds saved; however, evaluating the instances of birds with fishing hook and line injuries being admitted to rehabilitation centers will be a proxy for estimating whether the program is successful.

Evaluation
The Trustees have evaluated this project using the threshold and additional screening criteria developed to select restoration projects and concluded that this project is consistent with and meets the objectives of these selection factors. This type and scale of project will effectively provide appropriate compensation for seabirds injured by the spill, and the Trustees have therefore selected this project as a preferred alternative.

Western Snowy Plover Management at Coal Oil Point Reserve (BIRD-3)
The goal of this project is to protect a breeding colony of threatened western snowy plovers from predation and human disturbance. The focal colony, one of the largest in the region, is located in UC Santa Barbara's Coal Oil Point Reserve and became established largely due to species management efforts. The project aims to compensate for lost fledges due to infertility, as well as for additional unquantified injuries resulting from the oil spill, such as low over-winter survival and decreased breeding effort. Activities may include: predator control, upgraded signage and fences, outreach to reduce disturbances, leashes to lend for pets, and eradication of iceplant in areas of nesting habitat on Ellwood Beach.

Affected Environment
Coal Oil Point Reserve is part of the University of California Natural Reserve system, and protects a variety of coastal and estuarine habitats and fauna, including the threatened western snowy plover. Specifically, this reserve protects coastal dune, estuarine, tidal lagoon, sandy beach, and rocky reef habitats. Coal Oil Point Reserve, which is utilized by western snowy plovers for nesting, was exposed to the greatest oiling and most intense cleanup activities of any plover breeding sites within the spill-affected area.

Environmental Consequences (Beneficial and Adverse)
Overall, this project is anticipated to have only minimal adverse environmental consequences and multiple beneficial impacts. In reaching this conclusion, the Trustees evaluated several types of potential impacts, as described below.

1. Biological Impacts – This project benefits the population of western snowy plovers that was directly impacted by the spill. Management actions at Coal Oil Point Reserve aim to protect the plovers from predators and human activities during their nesting season. Benefits include maintaining the current colony of snowy plovers at COPR, along with preventing its displacement and loss. Many of the potential proposed activities will also be beneficial to other bird species and native plants in the area.

2. Physical Impacts – The Trustees do not anticipate any major or minor impacts to the physical environment, such as water, air, sediments, etc. Any physical impacts from activities such as installing symbolic fencing are temporary and negligible to the physical environment.

3. Human Impacts – The Trustees do not anticipate noteworthy impacts from this project on socio-economics, aesthetics, health and safety, historical properties, etc. COPR has struck a balance between human recreation and access to the coastal environment, while protecting western snowy plovers and other wildlife species and their habitats. This project will seek to continue and expand that dual mission of allowing recreation and protecting natural resources.

Probability of Success
The probability of success is high. Western snowy plover breeding was extirpated at COPR in the 1980s due to high human use of the coastal environment in close proximity to UC Santa Barbara. Due to targeted protective measures, Coal Oil Point Reserve has established a robust nesting population that continues to thrive today. This project has a high probability of success due to the knowledge and expertise of staff at Coal Oil Point Reserve that will be implementing the project.

Performance Criteria and Monitoring
Metrics such as nest success will be compared to initial conditions at the project site. Staff at Coal Oil Point Reserve monitor the western snowy plover population annually to track the number of pairs, nest success, and other parameters. This monitoring will continue throughout the implementation of this project and will be used to determine the success of the project.

Evaluation
The Trustees have evaluated this project using the threshold and additional screening criteria developed to select restoration projects and concluded that this project is consistent with and meets the objectives of these selection factors. This type and scale of project will effectively provide appropriate compensation for western snowy plovers injured as a result of the spill, and the Trustees have therefore selected this project as a preferred alternative.

5.3.7 Second Tier Restoration Projects Considered
The Trustees also considered the following projects (Table 14), and determined that many are valid projects that would provide benefits to seabirds. However, these projects were not selected for various reasons described below. These projects may be reconsidered if a selected project cannot be implemented or if remaining funds allow.

Table 14. Second tier bird restoration projects that may be implemented if funds allow.

ID#	OTHER PROJECTS CONSIDERED	BENEFITS
BIRD-4	Social Attraction for Brown Pelicans at Alcatraz Island	Brown pelicans
BIRD-5	Enhancement of Brown Pelican Nesting Habitat at San Clemente Island	Brown pelicans
BIRD-6	Continue Revegetation Projects on Santa Barbara Island to Promote and Expand Suitable Brown Pelican Nesting Habitat.	Brown pelicans
BIRD-7	Western Snowy Plover Predator Control	Western snowy plovers
BIRD-8	Raven Exclusion Devices for Nesting Ashy-storm Petrels on Channel Islands	Ashy-storm petrels

BIRD-9	Western Snowy Plover Monitoring and Habitat Protection at McGrath, Mandalay, and San Buenaventura State Beaches	Western snowy plovers
BIRD-10	Dune Restoration	Western snowy plovers
BIRD-11	Reduction of Disturbances to Seabirds at the Channel Islands (Seabird Protection Network Channel Islands Chapter)	Various seabirds
BIRD-12	Andre Clark Bird Refuge	Various seabirds
BIRD-13	Protection of Nesting Grebes	Grebe species
BIRD-14	Artificial Nest Habitat Creation at Anacapa, Santa Barbara, and/or San Clemente Island	Scripps's murrelets
BIRD-15	Restore and Increase Artificial Nest Habitat at San Miguel Island	Scripps's murrelets, Cassin's auklets
BIRD-16	Restore Native Habitat at Anacapa Island	Scripps's murrelets, western gulls
BIRD-17	Establishment of Bird and Marine Mammal Rescue and Rehabilitation Facility	Various seabirds, marine mammals

Brown pelican restoration at Alcatraz Island (BIRD-4)
This project involves restoring habitat and using social attraction to try and establish brown pelican breeding on Alcatraz Island. This project could be considered as a second tier project and social attraction could potentially result in recolonization of Alacatraz Island by breeding brown pelicans, but the feasibility of this project is unknown. Alcatraz Island is outside of the current breeding range for brown pelicans, and is substantially distant from the spill-affected area.

Brown pelican restoration on San Clemente Island (BIRD-5)
Brown pelicans have nested on San Clemente Island in the recent past and could benefit from protection actions such as the establishment of exclusion zones from cats, fox, and rats. This action may benefit other seabirds as well. The feasibility of this project is unknown at this time, and would require additional planning. Greater benefits to brown pelicans would be achieved where nesting densities are greater.

Restoration through revegetation on Santa Barbara Island (BIRD-6)
Building on restoration that has begun on Santa Barbara Island, this project would involve promoting suitable brown pelican nesting habitat by revegetating habitat areas. Currently access to Santa Barbara Island is limited due to a damaged boat landing. Upon repair of landing facilities at Santa Barbara Island, this project may become cost effective.

Western snowy plover predator control (BIRD-7)
Provide funding for control of ravens and other predators that kill nesting western snowy plovers in FWS recovery unit 5 (including the spill-affected area) and unit 4 (north of the spill-affected area). Predator control at COPR is listed as a preferred project because that is the location where

western snowy plovers were injured by the Refugio Beach Oil Spill. Predator control efforts could be expanded to other areas, if funds allow.

Raven Exclusion Devices for Nesting Ashy-Storm Petrels on the Channel Islands (BIRD-8)
This project involves providing enhanced protection for nesting Ashy-storm petrels that are preyed upon by common ravens. This project may be funded as a second tier project if funds allow, as the impact of the spill on this species was low compared to other seabirds.

Western Snowy Plover Monitoring and Habitat Protection at McGrath, Mandalay, and San Buenaventura State Beaches (BIRD-9)
Much of the suitable habitat for western snowy plovers and California least terns is within California State Parks ownership. This project would include monitoring and protecting western snowy plovers and California least terns in State Parks through installation of symbolic fencing, signage, docent programs, predator control, and other measures necessary to monitor and protect nesting shorebirds. These sites have been identified as secondary priorities, and could be implemented if preferred locations become infeasible.

Dune restoration (BIRD-10)
By removing invasive non-native plants that degrade dune ecosystems, these projects will restore dune habitats, native species and landscapes, and enhance ecosystem functions. Removal of invasive plants will increase the amount of useable nesting areas for the western snowy plover and, in some locations, the California least tern. It will also reduce cover for predators of eggs, chicks and adult birds. This project is a selected project in the Shoreline Restoration section of this plan. Additional project locations could be funded if birds would benefit, and if funds allow.

Seabird Protection Network – Channel Islands (BIRD-11)
This project would implement tasks identified by the Channel Islands Seabird Protection Network that are aimed at reducing human disturbances to seabirds at the Channel Islands. This is a second tier project, as the anthropogenic threats to seabirds are greater along the mainland coastline where the human population is greater. If funds allow, this project would be implemented.

Andre Clark Bird Refuge Restoration (BIRD-12)
Located near the Santa Barbara Zoo, this project is designed to improve water quality and habitat for both bird and aquatic species, and to allow the bird refuge to function as nursery habitat for ocean going fish. The proposed project includes five primary components: 1) restoration of 1.5 acres of coastal dune habitat; 2) restoration of 5 acres of coastal salt marsh habitat; 3) construction of a new multi-use recreational loop trail around the restored lagoon; 4) dredging of flow channels and deep pools to improve circulation and provide refuge for fish and other aquatic organisms; and 5) removal of flow barriers to improve flushing between the ocean and the lagoon in order to improve water quality, bird, and fish habitat. The benefits of this project to bird species impacted by the spill are unclear. The existing habitat at the Andre Clark Bird

Refuge serves as resting habitat for seabirds, and the improvements from the project to seabirds are unclear.

Protection of nesting grebes (BIRD-13)

Western and Clark's grebes have historically nested at Cachuma Lake in Santa Barbara County and Lake Casitas in Ventura County. This project would improve nesting success of grebes at these lakes. Restoration projects to improve grebe nesting success have been successfully implemented in northern California, focused primarily on outreach to reduce human disturbance at nesting colonies. No specific project has been proposed for lakes in Santa Barbara or Ventura Counties, and it is not known what management actions at these lakes would result in greater nesting success.

Artificial nest habitat creation at Anacapa, Santa Barbara, and/or San Clemente Islands (BIRD-14)

This project would improve nesting success of Scripps's murrelets at Anacapa, Santa Barbara, and/or San Clemente Islands. On Anacapa Island, the project would benefit murrelet populations by placing structures in the habitat adjacent to traditional nesting areas in Landing Cove and newly restored upland habitat. Scripps's murrelets have been utilizing artificial nest burrows placed within the habitat restoration area near Landing Cove at Santa Barbara Island. Additional artificial modules placed in other restored areas on this island would enhance murrelet populations by providing additional nest sites that typically have high nest success. Scripps's murrelet populations are severely limited by nest sites on San Clemente Islands. Several areas occur at San Clemente Island within the Seal Cove area where artificial nest sites could be installed and significantly increase the size of the nesting population at this island. This project is a second tier project as there was no evidence of injury to Scripp's murrelets and other alcids by the spill and the damages were not quantified.

Restore and increase artificial nest habitat at San Miguel Island (BIRD-15)

Increase the number of nesting boxes and improve older auklet boxes to protect the continued existence of this colony well into the future. Both Scripps's murrelet and Cassin's auklets could utilize artificial nests. This project is a second tier project as there was no evidence of injury to Scripp's murrelets and other alcids by the spill and the damages were not quantified.

Restore native habitat at Anacapa Island (BIRD-16)

The project would benefits Scripps's murrelets, western gulls, as well as many other native birds, insects, amphibians, reptiles, and restores ecosystem functions. The project could contribute to ongoing efforts to restore native habitat at Anacapa Island and help restore additional nesting habitat for both Scripps's murrelets and western gulls. This project is a second tier project as there was no evidence of injury to Scripp's murrelets and other alcids by the spill and the damages were not quantified.

Establishment of bird and marine mammal rescue and rehabilitation facility (BIRD-17)

This project would facilitate the establishment of a bird and marine mammal rescue and rehabilitation facility in Ventura County. This project is a second tier project because establishing a new bird and mammal rescue is beyond the Trustees' ability to implement.

5.4 Marine Mammals

Marine mammal species exposed to oil may suffer immediate or long-term health problems, leading to death or reproductive impairment. Small doses of oil may impact and animal's physiology or behavior by causing skin or gastrointestinal irritation, impairing reproduction, and compromising its immune system. Marine mammals can be exposed to oil through ingestion of contaminated food and water, grooming, absorption through wounds or eyes, inhalation of oil-derived volatiles, and aspiration of oil droplets directly to the lungs.

Most marine mammal species of California occur in the waters adjacent to the Gaviota coast, some transitory, some resident. These include pinnipeds, such as California sea lions, harbor seals, Guadalupe fur seals, and northern elephant seals; mustelids, such as southern sea otters; and cetaceans, such as bottlenose dolphins, long beaked common dolphins, gray whales, and humpback whales.

Marine mammals are generally difficult to study because of their wide-ranging pelagic life styles. Accordingly, comprehensive marine mammal surveys and studies can be logistically prohibitive to conduct and may last years. Therefore, the Trustees relied heavily on mammal stranding[14] data in conducting their assessment because visible and easily-tracked strandings can provide an index to what is happening in the marine mammals' environment. Records of strandings from May 19, 2015, through July 7, 2015, formed the basis of the Trustees' assessment and quantification of injuries to marine mammals (Figure 33)[15].

[14] A stranding can be defined as (1) a dead marine mammal on the beach or in the water, (2) a live marine mammal on the beach and unable to return to the water, or (3) a live mammal in the water that is unable to function normally due to sickness or injury.

[15] Plains disagrees with the Trustees' injury quantification, scaling, and restoration projects for marine mammals.

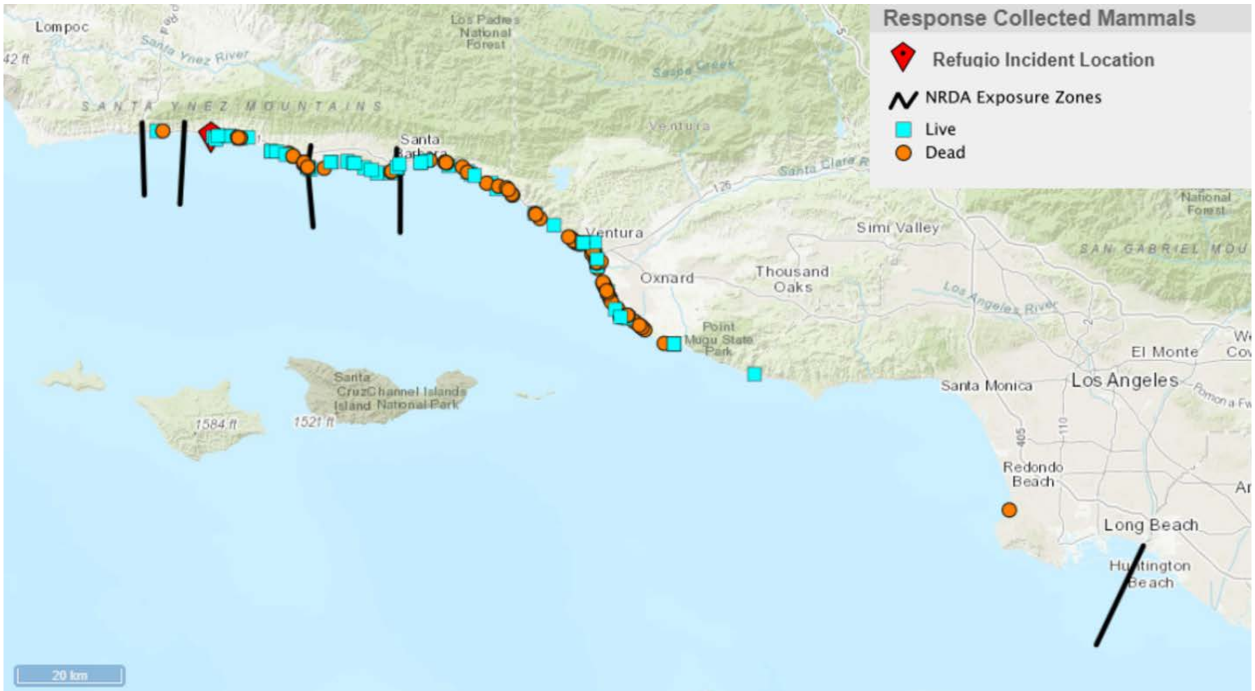

Figure 33. Location of marine mammal strandings, live and dead, collected during the spill cleanup period. The back lines show the NRDA Exposure Zone boundaries for reference; however these boundaries were not used in the quantification of injury to marine mammals.

5.4.1 Overview of Data Collection and Studies

This list below summarizes field surveys, data collection tasks, and analyses for the assessment of marine mammal exposure and injuries.

Live and Dead Marine Mammal Intake Data—Unified Command

Documentation of oiled live and dead animals is performed as a normal part of the spill response through the Unified Command. Intake logs describe the collection of each mammal, including the date, location, species, sex, condition (*e.g*. live or dead), and degree of oiling at the time of collection. These data provided the foundation for estimating mammal injury. Oiled wildlife were collected from May 19 through June 24, 2015.

California Marine Mammal Stranding Network Data

In addition to the intake logs for the marine mammals collected as part of the spill response (including date, location, species, sex, and condition), data on stranded, or beached marine mammals are routinely collected along the Santa Barbara and Ventura County coast lines through NOAA's Marine Mammal Health and Stranding Response Program. These data collected by the stranding network from 2000-2015 provided key information for estimating total marine mammal mortality for this assessment. A total of 264 marine mammals were recovered between May 19 and July 7, 2015, the period considered for this assessment.

Figure 34. Oiled California sea lion recovered during cleanup operations. Photo Credit: Santa Barbara Channelkeeper.

Wildlife Response Reconnaissance surveys

The Unified Command conducted aerial surveys on May 21, 2015, between Point Conception and Goleta to document wildlife in the area and search for oiled animals. Additional surveys were performed on May 24 and May 26, 2015. Marine mammal sightings included California sea lions (Figure 34), harbor seals and unidentified whales and dolphins. No sea otters were observed during the survey. One additional aerial survey was conducted on May 28, 2015, to document presence or exposure of southern sea otters in the area. During this survey, no southern sea otters were detected in the cleanup area, and were therefore not considered further for the NRDA.

Table 15. Daily summary of marine mammal sightings (and average group size per sighting) during boat-based surveys in 2015.

Species	6/2	6/3	6/4	6/5	6/6	6/7	Total sighting
Dolphin, Coastal Bottlenose	0	2 (5)	3 (3)	2 (6)	2 (7)	4 (4)	13
Dolphin, Long-beaked Common	1 (1050)	3 (42)	0	1 (70)	0	6 (205)	11
Dolphin, Common, unidentified to species	1 (41)	0	0	0	0	0	1
Pinniped, California Sea Lion	6 (7)	3 (7)	4 (1)	3(1)	8 (1)	5(7)	29
Pinniped, Harbor Seal	1 (1)	1 (1)	4 (1)	0	6 (1)	4 (2)	16
Whale, Gray	1 (2)	0	1 (2)	0	0	1 (2)	3
Whale, Humpback	0	1 (2)	0	2(1)	0	1 (14)	4

Pre-Assessment Marine Mammal Surveys

To estimate the number of common bottlenose dolphins in the affected area and to document exposure of marine mammals to oil, photo-identification surveys were conducted from small boats and from shore along the Santa Barbara and Ventura County coastline from May 24 to June 7, 2015. Figure 35 gives an example trackline of one of the survey days. Dolphins, whales and pinnipeds were sighted on all days of the survey. Table 15 shows sightings from the boat-based surveys, which include group size estimates.

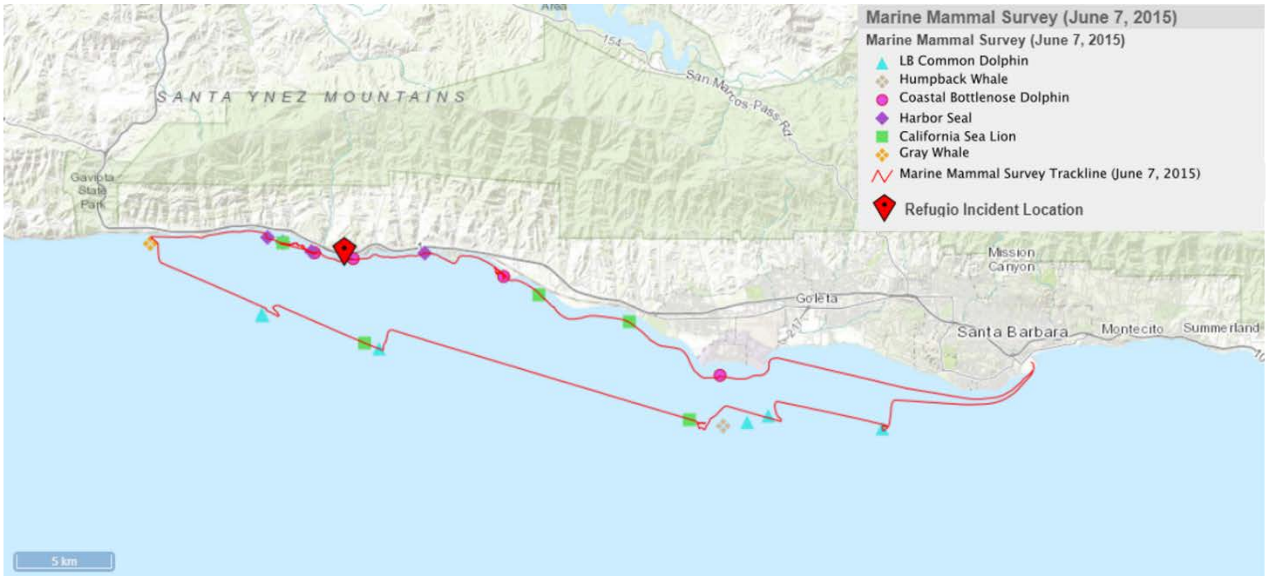

Figure 35. Tracklines of one day of NRDA mammal surveys, including sightings for that day. See Appendix B for data associated with this figure.

5.4.2 Pinniped Injury Analysis

Background

California sea lions are the most frequently stranded marine mammal in California. The stranding numbers vary seasonally by age class and stranding patterns are correlated with the reproductive cycle. Pups strand in the highest numbers during the spring, when they are being weaned. The spill year, 2015, was an anomalous stranding year[16] for California sea lion pups, with unusually high numbers stranding much earlier in the year than usual. By the time of the oil spill, after this surge of unusual strandings, pup stranding rates had lowered. Typically, fewer older animals, i.e., non-pups, strand throughout the year although, reproductive females frequently strand in the spring, just prior to the annual birth pulse.

Northern elephant seals and Pacific harbor seals strand in much lower numbers than California sea lions, which largely reflects their relative population sizes. However, like the California sea lions, strandings vary seasonally and are correlated with the reproductive cycle. Stranding numbers are highest when pups are weaning, which is in late winter/early spring in the cleanup area. The Guadalupe fur seal, an endangered species, was not observed either stranded or at-sea during any NRDA post-spill surveys and so were not considered further for the assessment. Similarly, the northern fur seal, a depleted species, was not observed and therefore not considered for the assessment.

[16] This was the third year of an unusual mortality event for California sea lions, declared January 1, 2013. The unusual mortality event was in part attributed to reduced prey availability (McClatchie et al. 2016).

Injury assessment
The Trustees assessed injuries to California sea lions, northern elephant seals and harbor seals by determining the number of strandings that occurred in the spill-affected area (Santa Barbara and Ventura Counties) from May 19 through July 7, 2015, and comparing that number to the baseline stranding patterns for the region. This provided a framework for the Trustees' injury assessment by providing insight into how many strandings would be expected "but for" the oil spill.

In addition to quantifying stranding baseline numbers for each species, the Trustees reviewed the available data for individual strandings recorded during the assessment period to determine whether the recovered strandings could be attributed to non-spill related causes (e.g. fishery related deaths). The Trustees also reviewed carcass decomposition information to remove strandings that likely occurred before the spill (i.e., dead, highly decomposed animals). Once it was determined how many documented strandings were likely due to the spill, they applied a correction factor for animals that would likely have died from the spill but were not found due to drift, sinking, scavenging or other factors. No correction factor was applied to live stranding numbers to account for animals that might have been exposed to oil and moved out of the area. The number of observed strandings attributed to the spill are given in Table 16.

For harbor seals and northern elephant seals, past stranding numbers during the time of year in which the cleanup occurred were low (i.e., fewer than 5 per year) and often zero. Because of this and the highly unusual fact that the strandings of these species were alive and oiled and died during rehabilitation, no baseline correction was applied to the stranding numbers. That is, the observed number of strandings for both species were considered spill-related injuries after removing any pre-spill and fishery-related strandings.

Table 16. Strandings of pinnipeds recorded in Santa Barbara and Ventura Counties after the spill. Records for each stranding were reviewed to determine whether they likely died before the spill (i.e., "pre-spill") or had injuries consistent with fishery entanglement (i.e., "fishery related"). "Pre-spill" animals were removed prior to adjusting for stranding baseline.

Species	**Total Stranded May 19-July 7**	**Stranded**			
		Pre-spill	Fishery-related	Baseline	Spill Period
California sea lion	221 (89 live, 132 dead)	-40	0	-87	94
Northern elephant seal	9 (8 live, 1 dead)	-1	0	0	8
Harbor seal	2	0	0	0	2

5.4.3 Cetaceans

Background
Long-beaked common dolphins (LBCO) are the most frequently stranded cetacean (whales, dolphins and porpoises) in the affected area and throughout southern California. Strandings of common bottlenose dolphins are rare, in part because their population off the California coast is

small (~500 individuals) and mobile, with dolphins ranging from Ensenada, Mexico, to San Francisco, California. From the pre-assessment survey, approximately 20% of the common bottlenose dolphin coastal ecotype population was estimated to be present in the area in the weeks following the spill. Dolphins of both species as well as other cetaceans were observed from shore and at sea in the weeks following the spill (Figure 36; Table 17)

No large whales stranded during the spill period, but several were observed (including a mother/calf pair) in the spill area both by local news agencies in the first days of the spill and during NRDA marine mammal boat surveys between May 27 and June 6, 2015 (see Figure 36).

Injury assessment

Similar to pinnipeds, the Trustees assessed injuries to long-beaked common dolphins and bottlenose dolphins by comparing strandings observed during the assessment period to a baseline of strandings for the area, after removing records of strandings that likely occurred prior to the spill. A correction factor was applied to the strandings deemed to be likely spill related to account for animals that likely died but were not been found due to drift, sinking, scavenging or other factors

The number of observed strandings attributed to the spill is given in Table 17. For both dolphin species considered for the injury assessment, previous years' strandings are variable, and for the LBCO have been tied to episodic algal blooms. While algal blooms were present during the spill period, principally north of Point Conception, there were no data that tied dolphin deaths to algal blooms in the oil spill-affected area. The Trustees concluded that oil was the more likely causal factor in the dolphin strandings in Santa Barbara and Ventura Counties during the timeframe considered.

Table 17. Dead dolphin strandings collected after the spill. Records were reviewed and dolphins were not considered potential spill-related injuries if they were determined to have stranded before the spill (i.e., "pre-spill") or had injuries consistent with fishery entanglement (i.e., "fishery related"). Baseline refers to the expected "natural" deposition that would occur under non-spill conditions.

Species	**Total Stranded May 19-July 7, 2015**	**Stranded**			
		Pre-spill	Fishery-related	Baseline	Spill period
Dolphin, long-beaked common	22	-2	-2	0	18
Dolphin, bottlenose	1	0	0	0	1

Figure 36. Top - gray whale observed on June 7, 2015, near Gaviota State Beach during boat-based surveys. Bottom - long-beak common dolphins swimming in an oil slick during NRDA boat surveys. Photo Credit: Natural Resource Damage Assessment Trustees.

5.4.4 Final Injury Determination

The final step in quantifying marine mammal injuries for both pinnipeds and cetaceans was to account for animals that died but were not observed. The Trustees assumed that for mammals, all carcasses that reached the beach were found. However, the Trustees could not account for animals that died at sea and either sank, floated, or were scavenged before being observed and counted. Therefore, the Trustees applied a correction factor ('lost at sea factor') to the observed dead, spill-related strandings based on a study by local marine mammal scientists on common bottlenose dolphin carcass recovery off the southern California coastline (Table 17) (Carretta et al. 2016). The final injury numbers are given in Table 18[17].

Table 18. Final injury numbers for marine mammals affected by the Refugio Beach Oil Spill.

Species	Dead	Live	Observed spill related strandings	Lost-at-sea factor (for dead animals)	Estimated number injured
California sea lion	52	42	94	2	146
Northern elephant seal	0	8	8	NA	8
Harbor seal	0	2	2	NA	2
Long-beaked common dolphin	18	0	18	4	72
Bottlenose dolphin	1	0	1	4	4

5.4.5 Selected Restoration Projects

The Trustees are proposing the projects described below to compensate for injuries to marine mammals caused by the oil spill (Table 19). The two selected projects benefit pinnipeds (MAMM-1) and cetaceans (MAMM-2).

Table 19. Selected projects for marine mammals

ID#	SELECTED PROJECTS	BENEFITS
MAMM-1	Pinniped rehabilitation survival improvement	Pinnipeds
MAMM-2	Cetacean entanglement response	Cetaceans

Pinniped Rehabilitation Survival Improvement (MAMM-1)

The goal of this project is to supplement and improve stranding response capabilities in Santa Barbara and Ventura Counties by providing enhanced rehabilitation capacities and veterinary facilities for stranded marine mammals. The program will augment the stranding cleanup and treatment activities of an existing, local facility which is authorized and permitted to respond to and treat stranded marine mammals. The project includes labor and supplies to treat sick and injured pinnipeds, including food, medical evaluations and treatments.

[17] Plains does not agree with the Trustees' final injury numbers for marine mammals.

Affected Environment
The project area is mainland Santa Barbara and Ventura Counties. Sick or injured pinnipeds are rarely rescued at sea. Stranding response most often takes place on beaches and rehabilitation centers.

Environmental Consequences (Beneficial and Adverse)
Overall, this project is anticipated to have only negligible, if any, adverse environmental consequences and multiple beneficial impacts. In reaching this conclusion, the Trustees evaluated several types of potential impacts, as described below.

1. *Biological Impacts.* Stranding response removes sick and injured live pinnipeds from beaches, potentially reducing the spread of disease amongst other populations. Treatment of diseased and injured marine mammals improves animal health, and thus the biological environment. Because the activities will be carried out by personnel trained and experienced in marine mammal recovery, no adverse biological impacts are anticipated, as most outdoor project activities will occur on beaches, which are already heavily-trafficked by humans. There will be minimal, if any, interaction with particularly sensitive habitats. No adverse biological impacts are anticipated

2. *Physical Impacts.* This project involves trained personnel removing stranded mammals from beaches and treating them. The project is expected to have negligible adverse or beneficial impacts to the physical environment.

3. *Human Impact.* Removal of sick and injured live pinnipeds from beaches and rocky coast will reduce the risk of spread of disease and other adverse interactions with humans. Humans should experience improved beach experience with the removal and treatment of diseased animals. No adverse effects to humans are expected.

Probability of Success
This project will expand the rehabilitation facility's capacity to treat live pinnipeds and increase the number of healthy animals released, approximately 30% of animals treated. Rescue and rehabilitation/ treatment of pinnipeds under veterinary care has a successful track record. Increasing capabilities are expected to further improve the success rate.

Performance Criteria and Monitoring
This project will expand the rehabilitation facility's capacity to treat live pinnipeds and increase the number of healthy animals released, approximately 30% of animals treated. Rescue and rehabilitation/ treatment of pinnipeds under veterinary care has a successful track record. Increasing capabilities are expected to further improve the success rate. The proposed time period of the project is three to seven years, depending on the need of the program with a goal of a total of 150 additional marine mammals successfully responded to and/or treated through the program.

Specifically, the Trustees may use the following measures to determine the effectiveness of the restoration. Based on responses and outcomes from before implementation of the project, we will monitor:

- The number of animals (and species) taken in per year for treatment/rehabilitation;
- The number of live and dead animals responded to per year; and
- Outcomes from live strandings, including from treatment at the facility or in the field.

Evaluation

The Trustees have evaluated this project using the threshold and additional screening criteria developed to select restoration projects and concluded that this project is consistent with and meets the objectives of these selection factors. This type and scale of project will effectively provide appropriate compensation for pinnipeds injured as a result of the spill, and the Trustees have therefore selected this project.

Cetacean Entanglement Response (MAMM-2)

Entanglement in fishing gear is a source of mortality to whales and dolphins off the California coast and nearly all entangled animals die. The program will augment an existing permitted and authorized program by providing additional gear and personnel to disentangle cetaceans in areas not currently covered off the southern California coast.

Affected Environment

This project will operate within the southern California to respond to entangled cetaceans reported off Santa Barbara, Ventura, Los Angeles and Orange County coastlines.

Environmental Consequences (Beneficial and Adverse)

Overall, this project is anticipated to have only negligible, if any, adverse environmental consequences and multiple beneficial impacts. In reaching this conclusion, the Trustees evaluated several types of potential impacts, as described below.

1. *Biological Impacts.* Increased preparedness for entanglement response will provide a beneficial biological impact by reducing fishing gear-related mortality to whales and dolphins. Personnel implementing this this project would be trained and experienced in entanglement response and would operate using best practices to avoid adverse impacts to the environment. Therefore, no adverse biological effects are anticipated.

2. *Physical Impacts.* This activity will minimally increase boat use because of increased response capabilities. Personnel implementing this this project would be trained and experienced in entanglement response and would operate using best practices to avoid adverse impacts to the environment. Therefore, no adverse physical effects are anticipated.

3. *Human Impacts*. Human enjoyment of wildlife viewing will be enhanced by (1) encountering fewer dead cetaceans floating in the water or beached and (2) seeing fewer animals in distress due to gear entanglements. For larger whales, a dead whale can be a hazard to navigation, so reducing mortality will reduce the number of potential hazards. While this project will minimally increase boat use, the Trustees anticipate that this will have negligible adverse impacts to boaters.

Probability of Success

This Project is anticipated to double the response capacity of the current cetacean disentanglement program operating off California's coast, which has a proven record of success. For this reason, the probability of success for the project is very high.

Performance Criteria and Monitoring

The number of whales with gear successfully removed compared to the number of entangled whales reported will be the criteria used to measure success. These data will be available to the Trustees because entangled whales are reported to the NMFS, which authorizes and coordinates entanglement response activities. Disentanglement response meet the guidelines and protocols of the MMPA and Animal Welfare statutes.

Specifically, the Trustees may use the following measures to determine the effectiveness of the restoration:

- Increased capacity to respond to entanglement events, measured by numbers of responses during the funding period compared to past performance; and
- Outcomes from entanglement response, by species.

Evaluation

The Trustees have evaluated this project using the threshold and additional screening criteria developed to select restoration projects and concluded that this project is consistent with and meets the objectives of these selection factors. This type and scale of project will effectively provide appropriate compensation for cetaceans injured as a result of the spill, and the Trustees have therefore selected this project.

5.4.6 Second Tier Restoration Projects Considered

The Trustees also considered the following projects (Table 20), and determined they are valid projects that would provide benefits to marine mammals. However, these projects were not selected for various reasons described below. They may be reconsidered if a selected project cannot be implemented or if remaining funds allow.

Table 20. Second tier marine mammal restoration projects that may be implemented if funds allow

ID#	SECOND TIER PROJECTS CONSIDERED	BENEFITS
MAMM-3	Reduce California Sea Lion Entanglement Mortality on San Miguel Island	Pinnipeds
MAMM-4	Mitigate Entanglement Risk for Pinnipeds	Pinnipeds
MAMM-5	Protect Marine Mammal Haulouts and Rookeries	Pinnipeds
MAMM-6	Mitigate Cetacean Ship Strikes	Cetaceans
MAMM-7	Remove Derelict Fishing Gear	Cetaceans/pinnipeds
MAMM-8	Establish a Bottlenose Dolphin Protection Area	Cetaceans

Reduce California sea lion entanglement mortality on San Miguel Island (MAMM-3)

The goal of this project is to remove fishing gear from live pinnipeds on San Miguel Island and identify the source fishery from the recovered gear. Individual pinnipeds would be branded and tagged to monitor their survival after gear removal. The project benefits pinnipeds by directly removing entangled gear, a known source of mortality. A secondary, unquantified benefit to all marine mammals is identifying the source fishery causing the entanglements and likely bycatch. The Trustees are satisfied with the feasibility of this project and consider it a potential alternative to the selected pinniped project, if necessary.

Mitigate Entanglement Risk for Pinnipeds (MAMM-4)

The goal of this project is to remove fishing gear from live pinnipeds that come ashore on mainland beaches in Orange, Los Angeles, Ventura and Santa Barbara Counties. The project was not selected because it did not specify how success would be measured, and it would be implementing new, unproven technology. This project could be reconsidered if the selected pinniped project is not feasible.

Protect Mammal Haulouts and Rookeries (MAMM-5)

The goal of this project is to further protect the Pacific harbor seal rookery and haulout areas at various areas throughout Santa Barbara and Ventura Counties. Other than Carpinteria, no specific locations or actions were identified.

A specific project at Carpinteria proposed to enhance protection by purchasing conservation easements at Carpinteria Beach to provide further buffers for the rookery. It would also consider other areas that that could provide additional protected rookery habitat. This proposal includes an outreach component to reduce human disturbance to marine mammals at rookeries. The rookery is already protected under the MMPA, and the proposed additional conservation easements would increase existing buffers to reduce risk of harassment. Routine monitoring of the rookery would provide data to estimate pupping success, but it would be difficult to specifically quantify the beneficial effects of the project separate from those protections already provided by the MMPA. This project was not selected to be carried forward for implementation at this time because the project does not contain sufficient information for the Trustees to understand the benefits to marine mammals injured by this spill.

Mitigate Cetacean Ships Strikes (MAMM-6)
The goal of this project is to quantify ship strike risk to large whales attributable to a voluntary vessel speed reduction program in the Santa Barbara Channel shipping lane. This project would monitor ship speed and ship strike rate of large cetaceans to compare to historic data. This project may provide data to evaluate how much the vessel reduction program would reduce large ship-strike cetacean mortality. However, the program's methods to estimate and monitor ship strike risk are unclear, the voluntary nature of the program makes implementation uncertain, and metrics for measuring success in terms of whales saved are currently unavailable. The Trustees determined that this could be reconsidered as a pilot project if other preferred projects became infeasible.

Remove Derelict Fishing Gear (MAMM-7)
The goal of this project is to reduce entanglement risk of lost fishing gear for marine mammals by removing large nets and traps. Based on recent past gear removal projects conducted in southern California, there appear to be a low number of marine mammals entangled in lost nets. The Trustees concluded that this program could be beneficial to both cetaceans and pinnipeds, but the benefits would be difficult to quantify. Other projects proposed and evaluated in this Plan provide more direct benefits to marine mammals. The Trustees could reconsider this project if the selected projects became infeasible.

Establish a Bottlenose Dolphin Protection Area (MAMM-8)
The goal of this project is to improve habitat for the coastal population of bottlenose dolphin by establishing a bottlenose dolphin protection area along the Santa Barbara county coastline. The protection area would regulate chemical contamination and anthropogenic noise. The proposal did not identify a specific area, provide criteria to identify one, or indicate how success would be measured. This project would also be challenging, as it involves complex legal and regulatory issues that are not within the direct control of the Trustee agencies. The Trustees would consider this project if other projects to benefit cetaceans are not possible.

5.5 Human Uses

In the wake of an oil spill, some people may decide not to visit the shoreline. Others choose to visit alternative sites. Some visit affected shorelines but experience reduced enjoyment due to the spill. These all represent spill impacts.

The Trustees quantified impacts to selected human uses resulting from the Refugio Beach Oil Spill. Effects were identified from as far north as Gaviota State Beach to as far south as Long Beach. This stretch of coastline includes a range of public access points with rich natural resources and scenic vistas that provide exceptional recreational opportunities. People in the region engage in a variety of recreational activities. Examples include camping, sunbathing, beach combing, exercising, swimming, wildlife viewing, and dog-walking, as well as more specialized activities such as fishing, diving, boating, and surfing. Trustees did not quantify impacts from third-party claims (e.g., from non-government parties, such as commercial fisheries and affected businesses), pursuant to NRDA regulations.

The Refugio Beach Oil Spill entered the ocean in Santa Barbara County just west of Refugio State Beach. Spill impacts on human recreation were highest in this area. Refugio and El Capitan State Beaches, popular state campgrounds and day use areas, were closed for 59 and 37 days, respectively. Access to adjacent small pocket beaches was restricted through August 28, 2015. There was significant oiling along the Gaviota Coast down to the University of California Coal Oil Point Reserve, where cleanup operations and closures disrupted normal reserve operations. Recreational fishing in this region was closed for 41 days (see Figure 37).

Spill impacts on recreation were less severe south of Coal Oil Point Reserve. Although spill-related oiling, advisories, and significant media coverage of the incident occurred, no closures were identified along the remaining sections of the Santa Barbara and Ventura County coastlines. This stretch includes several incorporated cities (Santa Barbara, Carpinteria, Ventura, Oxnard), county properties, and additional State Park holdings. While the impacts were not as prominent as those found along the Gaviota Coast to the north, many of the affected beaches have significant visitation, particularly during and after Memorial Day weekend. Thus, even a small percentage decrease in use can translate into a sizeable reduction in the number of trips taken.

In Los Angeles County, there were two separate beach closures after an unusual amount of tar balls washed up on beaches. The first occurred in southern Santa Monica Bay from May 27 to 29, 2015. The second occurred in Long Beach (June 3 to 5, 2015). Both events triggered cleanup operations and resulted in closures of the beach seaward of the lifeguard towers.

This assessment and restoration plan focuses primarily on impacts to public recreational use and does not include private claims for losses to commercial fishing or recreation-based concessionaires. Impacts to commercial activities and other private party claims may be addressed through third party claims procedures under OPA or in private civil litigation.

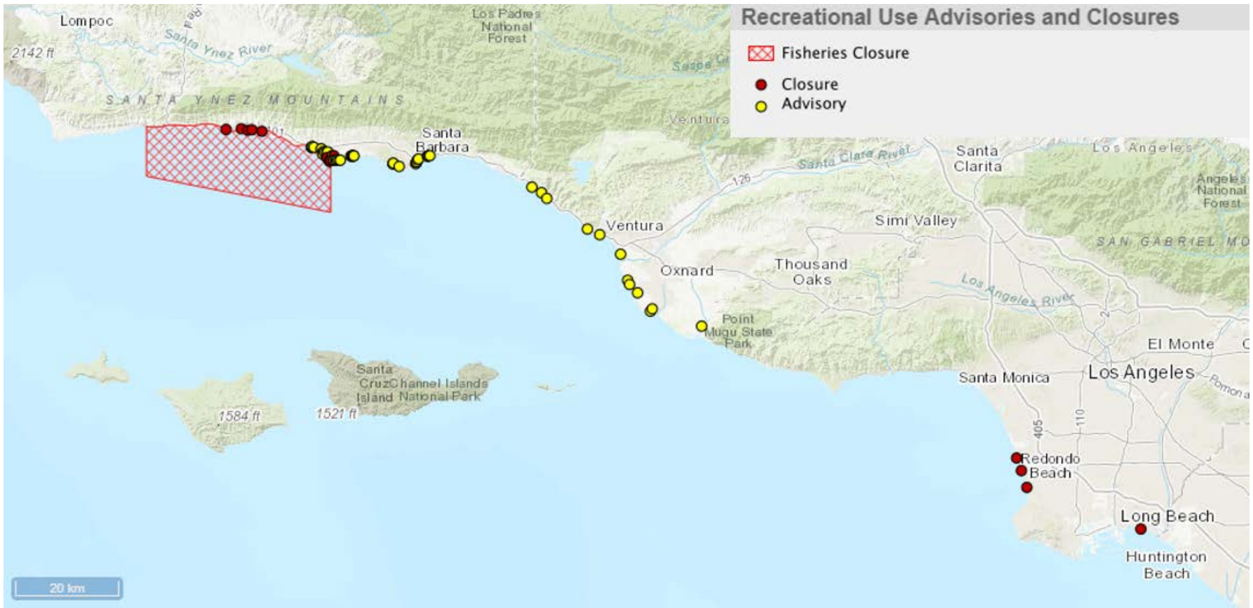

Figure 37. Overview of posted Closures and Advisories after the Refugio Beach Oil Spill.

5.5.1 Scaling Approach

The natural resource damages for human uses are based on the monetary value of spill-related human use impacts. Monetary value is measured using the economic concept of "consumer surplus". For recreation, consumer surplus is the value that an individual places on their recreational activities above and beyond the cost they incur to engage in those activities. It is not a calculation of the cost of participating in various recreational activities, nor is it the resulting economic impact in the community. Lost income to recreational businesses, lost tax revenue to municipalities, and lost user fees to public parks, while related to lost public use, are third-party claims that are not compensable under NOAA's NRDA regulations under OPA. However, these losses are indicative of loss of public recreation.

For calculating lost value, human uses were broken up into four general categories. These categories were delineated based upon the qualitative character of the use and the inherent separability of the relevant data available to identify losses:

Coastal Camping

Coastal camping includes overnight stays at campgrounds that are within relatively short walking distance to the beach or shoreline. In addition to camping, these users typically engage in a range of related day use activities (e.g., general beach use, bike riding, swimming, fishing, picnicking). Coastal camping impacts were measured in camping nights at identified camping areas.

Non-Camping Shoreline Recreation

Non-camping shoreline recreation captures a broad range of day use activities pursued by non-campers. It includes traditional beach use activities, such as sunbathing, walking, exercising, picnicking, beach combing, wildlife viewing, swimming, and surfing. However, it also includes diving, kayaking, standup paddle boarding and similar activities that originate from the adjacent shoreline, rather than from a marina or specified boat launch. Different quantification methods were used for (1) Santa Barbara and Ventura Counties (Section 5.5.4) and (2) Los Angeles County (Section 5.5.5). Impacts to non-camping shoreline use were measured in user days for the northern two counties and in direct lost value for Los Angeles County.

Boating and Offshore Recreation

Boating and offshore recreation includes motor boating, sail boating, and use of the Channel Islands National Park, as well as non-motorized boating originating from harbor marinas or identified boat launches that are not associated with specific recreational day use shoreline areas. Non-motorized boating includes activities such as kayaking, standup paddle boarding, and canoeing, as long as they originate from a marina or specified boat launch. Launches associated with data connected to "Non-Camping Shoreline Recreation" are addressed under that category of use (Sections 5.5.4 and 5.5.5). Motorized boating includes charter fishing trips, charter dives, and charter boat-based wildlife viewing. Lost use for these activities was measured in user days.

Research, Education, and Outreach

Research, Education, and Outreach refers to trips to the University of California Coal Oil Point Reserve for the purpose of conducting research, participating in university-level classes, and reserve related outreach activities. Lost use for these activities was measured in user days.

Our quantification of lost value incorporates measures of affected human use activity (e.g., lost, diminished, and substituted trips). Total lost value is further adjusted by a three-percent annual percentage rate (compounded monthly) to reflect the change in value associated with delaying compensation.

5.5.2 Overview of Data Collection and Studies

The list below summarizes various field studies, data collection tasks, and analyses used for the assessment of human use impacts.

Documentation of Closures, Advisories, and Spill-related Notifications

The Trustees tracked site closures and posted advisories by location and date. The Trustees also evaluated conventional media coverage of the spill along with social media posts and public announcements from selected organizations (e.g., public agencies).

Data Collection around the Time of the Spill

The Trustees conducted systematic counts of people on the beach in selected locations in Santa Barbara and Ventura Counties. The Trustees also tracked foot and bike entries to El Capitan State Beach and conducted daily monitoring of automatic car counters at Goleta Beach and Arroyo Burro County Parks. Finally, the Trustees contacted water- and shore-oriented recreation businesses regarding impacts to their customers.

Compilation and Evaluation of Existing Data Related to Spill-Effects or Baseline Use
The Trustees compiled historical data related to the public use of various sites, and then assessed these data for their relevance and efficacy for estimating spill-effects and baseline use. The data sources compiled and evaluated included:

- Paid vehicles at State Park properties from Gaviota to Point Mugu;
- Overnight stays at State Park properties from Gaviota to Point Mugu;
- Parking fee data from select coastal lots between Santa Barbara and Malibu;
- Historic records of automated car counters at Santa Barbara County Parks;
- Marine Protected Area (MPA) Watch shoreline user counts;
- South Coast MPA Baseline Program survey data, collected by researchers at Point 97/Ecotrust and Natural Equity;
- Jalama County Park Camping Occupancy;
- Commercial Passenger Fishing Vessel (CPFV) log summaries;
- California Recreational Fisheries Survey (CRFS) angler estimates;
- Fuel Sales at Santa Barbara Harbor fuel dock;
- Channel Islands National Park visitation;
- University of California, Santa Barbara (UCSB) Coal Oil Point spot counts;
- USCB Coal Oil Point Reserve annual estimates of research, education, and outreach use;
- Long Beach lifeguard beach user estimates; and
- Los Angeles County lifeguard beach user estimates.

Data Collection on the First Anniversary of the Spill
The Trustees evaluated gaps in the assessment data listed above. These gaps guided the prioritization and research design of data collection around the first anniversary of the spill. The Trustees conducted interviews and user counts to estimate baseline use and augment existing data to estimate spill-related changes in use at selected sites.

Analysis of Camping Losses
The Trustees evaluated data and other information on coastal camping in Santa Barbara and Ventura Counties. Data from the spillthe spill period were compared to historical information. Camping impacts were identified at Refugio State Beach, El Capitan State Beach, and Gaviota State Park. Site-specific economic models were developed from existing data on camping reservations to estimate the value of a camping night. See Appendix K.

Analysis of Non-Camping Shoreline Recreation Losses in Santa Barbara and Ventura Counties
The Trustees examined data on recreational use along the Santa Barbara and Ventura County coast. In general, data from outside the spill period were used to create statistical predictions of recreational use had the spill not occurred. These predictions accounted for weather, day-of-the-week, and other site-specific factors. Where reductions in recreation were identified, the trustees translated these reductions into estimates of lost user days. Lost value was calculated by

multiplying the number of lost user days by an estimated dollar value per user day derived from economic research on shoreline recreation in California (English 2010). See Appendix L.

Analysis of Shoreline Recreation Losses in Los Angeles County
The Trustees' estimate of lost value in Los Angeles County focuses on the relatively short periods where shoreline areas were closed in southern Santa Monica Bay and in Long Beach. The estimate of lost value was determined utilizing the southern California Beach Recreation Valuation Model (Hanemann et al. 2004), a state of the art recreation demand model designed specifically for the Los Angeles County beaches affected by the spill. See Appendix L.

Analysis of Boating and Offshore Recreation Losses
The Trustees considered a range of data sources for evaluating losses to boating and offshore recreation. The estimate of offshore recreation losses was based upon a series of phone contacts to recreational businesses that collected information on the reduction in passenger trips that these businesses experienced following the spill. The estimate of lost value per trip was based on a study of the consumer surplus value of boating trips to the Channel Islands (Gornik et al. 2013). See Appendix M.

5.5.3 Coastal Camping
The trustees identified spill impacts at Refugio State Beach, El Capitan State Beach, and Gaviota State Park campgrounds. The Refugio State Beach campground was closed for the longest time period (59 days). El Capitan State Beach experienced a shorter closure period (37 days), but it has more campsites and therefore more users were affected per day of closure. Both of these campgrounds are popular and reach capacity in summer months. Once the closures were lifted, the campsite occupancy recovered to near baseline conditions rather quickly at both locations (i.e., within a few weeks). Thereafter, small trailing reductions in use occurred over the entire summer. Gaviota State Park did not experience a closure. However, reductions in camping use were identified during the first two weeks after the spill. A total of 49,188 camping nights were lost across all three sites.

Data on the origin of visitors (by zip code) was combined with census data to create an economic model to estimate the value per camping night. This analysis resulted in an estimate of $29.57 (July 2018 dollars) per camping night lost. The total undiscounted damages are therefore $1,454,663, and the resulting total lost value is $1,593,571 (July 2018 dollars and present value). The model, along with the analysis of lost camping nights, is described in more detail in Appendix K.

5.5.4 Non-Camping Shoreline Recreation Use: Santa Barbara and Ventura Counties
The Trustees identified impacts to recreational shoreline users at multiple locations along the Santa Barbara and Ventura County coastlines (Table 21). Reductions in recreational use were assessed through quantitative analyses of a range of data indicators related to shoreline recreation (see Appendix L).

The observed impacts were greatest upcoast of Coal Oil Point Reserve, where sections of shoreline were subject to relatively long access and recreational fishing restrictions. Refugio and El Capitan State Beaches, and associated day use recreation opportunities, were officially closed for extended periods (59 and 37 days, respectively). Access to pocket beaches at Tajiguas, Venadito, and Las Flores were limited through August 28, 2015 by spill-related restrictions to roadside parking at historic highway pull offs. After the closures, recreational use at most of the sites returned to expected levels relatively quickly, within two to four weeks. The only exception was Refugio State Beach, where recreational use did not return to baseline until 8 weeks after the park reopened.

Shoreline recreation impacts on the Santa Barbara and Ventura Coastlines downcoast of Coal Oil Point were less severe. These locations were subject to a range of posted advisories, oilings, and media coverage about the “Santa Barbara spill”. However, relative reductions in recreational use were generally modest, returning to baseline within two to four weeks after the initial spill. The only exception to this was at Leadbetter Beach on the Santa Barbara Waterfront, where lower levels of recreational use were observed in the data for 12 weeks.

A total of 89,380 shoreline recreation user days in Santa Barbara and Ventura Counties were estimated as lost due to the spill. Each user day was assigned a value of $21.45 (July 2018 dollars) based on an evaluation of economic research of shoreline recreation in California. Associated undiscounted damages are $1,917,317, and total lost value is $2,101,467 (July 2018 dollars and present value) This analysis is described in detail in Appendix L.

Table 21. Non-Camping Shoreline Losses in Santa Barbara and Ventura Counties

Section of Coastline	**Estimate of Lost Value (July 2018 dollars)**
Gaviota State Park through El Capitan State Beach	$ 723,987
El Capitan to Coal Oil Point	$ 295,335
Coal Oil Point to Santa Barbara Waterfront	$185,783
Santa Barbara Waterfront	$297,957
Santa Barbara Waterfront to Ventura County Line	$43,006
Ventura County Line through Emma Wood State Beach	$21,635
Surfers’ Point/San Buenaventura to Pt. Mugu	$349,614
Total Undiscounted Damages	$1,917,317
Total Value Lost	**$2,101,467**

5.5.5 Non-Camping Shoreline Recreation Use: Los Angeles County

The Trustees quantified spill-related losses in Los Angeles County based on the number of days with oil-related beach closures following the spill (Table 22). Closures in south Santa Monica Bay began on May 27 and ended on May 29. Closures at Long Beach City Beach were initiated on June 3 and ended on June 5. The affected beaches were closed seaward of the lifeguard towers.

Damages for the Los Angeles County closures were based upon the southern California Beach Recreation Valuation Model (Hanemann et al. 2004), an economic model that was constructed to evaluate the impact of closures and water quality changes to recreational use on southern California beaches. Specific sites affected by the closures are included in the model (Manhattan Beach, Hermosa Beach, Redondo Beach, Long Beach, and Belmont Shore). See Appendix L.

Table 22. Non-camping shoreline recreation losses in Los Angeles County

Section of Coastline	**Estimate of Lost Value (July 2018 dollars)**
South Santa Monica Bay (Manhattan Beach to Redondo Beach), May 27-29	$445,125
Long Beach (1st Place to 72nd Place), June 3-5	$92,444
Total Undiscounted Damages	$537,568
Total Lost Value	**$590,067**

5.5.6 Boating and Offshore Recreation

The spill closed an area of fishing off the Gaviota Coast for 41 days. Cleanup vessels conducted cleanup operations in the cove at Refugio State Beach and elsewhere in the days following the spill. Information about the spill was reported in the media throughout the summer. Businesses that provide boat transport and other services to recreational users reported a total loss of 2,379 client trips (See Appendix M). These trips originated from marinas along the Santa Barbara, Ventura, and Los Angeles County coastline. These trips do not include launches of non-motorized boats (e.g., canoes, kayaks, standup paddle boards) that occurred from shoreline areas covered in the estimated loss of “Non-Camping Shoreline Recreational Use”. These trips were assigned a value of $59.01 (July 2018 dollars) based upon Gornik et al. (2013). Total undiscounted damages are $140,384. Total lost value for this category of human use is $153,867 (July 2018 dollars and present value).

5.5.7 Research, Education, and Outreach

The Coal Oil Point Reserve at the University of California, Santa Barbara was closed for 26 days. In addition to providing opportunities for traditional beach recreation (e.g., sunbathing, beach combing, exercising, and swimming, which are covered above), the University of California operates the reserve to benefit its mission to provide high quality educational opportunities and conduct research. The Coal Oil Point Reserve provides a real world laboratory in which these activities can occur.

The University of California Natural Reserve System reports 7,521 research, education, and outreach user days for the 339 days that the Coal Oil Point Reserve was open between July 1, 2014 to June 30, 2015. Staff at the reserve system believe that the amount of research, education, and outreach activities on the days that the reserve was open provides a reasonable basis for estimating use over the 26 days that the reserve was closed. Applying the resulting overall rate of 22.2 users per day to the 26 days of closure yields a user day loss estimate of 577 user days.

A value of $47.00 (July 2018 dollars) was attached to each of these user days. The Trustees were not able to identify a direct measure of consumer surplus for research, education, and outreach. This estimate is based upon the approximate tuition and fee cost of a course-day of instruction at the University of California, Santa Barbara, accounting for the proportion of undergraduate versus graduate and in-state versus out-of-state students. This results in a $27,116 estimate of undiscounted damage, and a total lost value estimate of $29,735 for this category (July 2018 dollars and present value).

5.5.8 Summary of Injury

The lost recreation use value estimated by the Trustees (July 2018 dollars and present value) is summarized in Table 23 by general geography and type of use.

Table 23. Total lost value by section of shoreline and quantified human uses.

Section of Shoreline	Camping	Non-Camping Shoreline	Boating, Offshore	Research, Education, Outreach	All Activities Combined
Gaviota SP to El Capitan SB	$1,593,571	$792,815			$2,386,385
El Capitan to Ellwood		$285,425			$285,425
Sands Beach / Coal Oil Point Reserve		$38,392		$29,735	$68,126
Santa Barbara Waterfront		$326,364	$127,592		$453,956
Santa Barbara County (Other)*		$250,795			$250,795
Ventura County		$407,677	$1,580		$409,258
Los Angeles County		$590,067	$24,695		$614,762
Total Lost Value	**$1,593,571**	**$2,691,534**	**$153,867**	**$29,735**	**$4,468,707**

*This includes sections of coastline both upcoast and downcoast of Santa Barbara Waterfront.

As explained above, the lost use value represents the lost consumer surplus value to the public. It does not represent the cost of participating in these activities, nor the sum of their travel expenditures and resulting economic impact in the community. Table 23 represents the Trustees' best estimate of lost value, i.e., $4.47 million[18].

5.5.9 Proposed Restoration

The Trustees (including the University of California) intend to select a suite of restoration projects to compensate the public for lost use of the recreational resources caused by the spill. The Trustees will work cooperatively with local government agencies and non-governmental organizations to identify a suite of potential restoration projects according to the relative magnitude of spill impacts. These projects may include improvements or enhancements to public piers, parks, bike paths, boat ramps, fishing areas, or other infrastructure in order to increase the value of recreational experiences involving beach use, boating, and/or fishing. Specific examples include, but are not limited to: beach and waterfront access; boardwalk construction and improvements; fishing pier and dock improvements; beach sand management and replacement; beach fire rings; beach shower and restroom improvements; picnic facilities; Coastal Trail improvements; public access components of large ecological restoration projects; interpretive, educational, and wildlife viewing facilities.

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[18] This is less than the amount to be recovered for lost recreation through the pending settlement process, i.e., $3.90 million. However, the Trustees believe the amount to be recovered through the settlement is adequate based on the following considerations: the amount is within the range of values the Trustees deem plausible given the uncertainties in some of the data; the Trustees' desire to reach a settlement and commence restoration more quickly; and the inherent risks involved in litigation if a settlement is not reached.

It is a goal of the Trustees to select projects spanning the geographic area of the spill and to address the various types of activities (e.g. camping, fishing, day use, other uses) that were impacted by the spill. To that end, and to the extent feasible, funds will be allocated among the regions affected by the spill according to the relative magnitude of the spill impacts, as described in Table 24.

Table 24. Geographic distribution of lost value across all quantified human uses.

Section of Shoreline	Share of Total Lost Value
Gaviota SP to El Capitan SB	53.40%
El Capitan to Coal Oil Point (excluding Research, Education, Outreach)	7.25%
Coal Oil Point Reserve (Research, Education, Outreach only)	0.67%
Santa Barbara Waterfront	10.16%
Santa Barbara County (Other)*	5.61%
Ventura County	9.16%
Los Angeles County	13.76%

*This includes sections of coastline both upcoast and downcoast of Santa Barbara Waterfront.

These percentages reflect the approximate estimated distribution of losses across the spill area. In the event funds allocated to one or more geographic area(s) remain, and such funds are insufficient to implement additional recreation project(s) and/or insufficient feasible recreation projects are identified for one or more geographic areas, the Trustees shall have discretion to spend the money in another geographic area identified in Table 23. Compliance with environmental and other applicable laws will be the responsibility of the implementing agency for each selected project.

The distribution of the $3.9 million in damages recovered for lost recreational value will be administered as follows:

State Parks

State Parks will administer 53.4% ($2.08 Million) of the restoration funds for projects to be selected by State Parks with the approval of the Trustee Council. State Parks will work cooperatively with Santa Barbara County and other local government and non-government organizations to identify appropriate projects located within State Parks' property. These projects are to benefit recreational activities associated with units of CDPR from Gaviota to El Capitan. Funds are intended to compensate for all shore-based recreation losses, with approximately two-thirds being directed to camping and approximately one-third being directed other shoreline uses (including non-camping day use, shore-based fishing, diving, etc.).

South Coast Shoreline Parks and Outdoor Recreation Grants Program – Other Coastal Areas
The State Trustees (including University of California) will administer 45.93% ($1.79 Million) of the restoration funds for projects to be selected by the Trustees to primarily benefit recreational activities to compensate for recreational losses downcoast of El Capitan State Beach. The Trustees will work cooperatively with Santa Barbara, Ventura, and Los Angeles Counties, local cities, and other public and private organizations to identify a suite of potential projects according to the relative magnitude of the spill impacts, considering the availability of viable projects and types of affected uses. Projects will then be selected for funding using a competitive grant process, until all funds are spent.

University of California
The University of California Natural Reserve System will administer 0.67% ($26,000) to fund projects selected by University of California in coordination with the Trustee Council and with input from the public. These will address the research, education, and outreach missions of the University of California at Coal Oil Point Reserve.

6.0 NEPA Alternatives Analysis

6.1 Preferred Alternatives

The preferred alternative involves the implementation of the projects listed in Table 25. Anticipated impacts to the environment from implementation of each of these projects is described in Section 5. In the event any of these projects cannot be implemented, the Trustees will look at second tier projects also described in Section 5. Recreation projects to compensate for oil impacts to human uses will be administered by State Parks or handled under a grants program, administered by the State Trustees, and may undergo additional environmental analyses in subsequent NEPA reviews as needed. Project ideas submitted by the public will be considered by State Parks or through this grants program. Appendix N lists all projects submitted by the public and considered by the Trustees.

Table 25. Restoration projects that would be implemented under the preferred alternative.

Shoreline Habitat Restoration		
Shore-1	Ellwood Seawall Removal	Restore sandy beach and mixed shoreline ecosystems and dynamics by removing a wooden seawall at Ellwood Beach that is currently constraining natural functioning condition of the sandy beach ecosystem as well as lateral access along the shoreline at high tide.
Shore-2	Ventura County Dunes Restoration	Remove invasive dune species, protect sensitive bird populations, and enhance public access routes.
Shore-3	Santa Monica Beach Restoration Pilot Project	Restoration of a highly impacted beach system in Santa Monica by stopping beach grooming and

		restoring a diverse, endemic-rich, coastal plant and wildlife community.
Shore-4	Black Abalone Restoration and Relocation	Transplant black abalone into specific locations within rocky intertidal habitat to enhance the overall health of the rocky intertidal ecosystem by returning this important grazer to the community.
Subtidal and Fish Habitat Restoration		
SubT-1	Abalone Restoration	Transplant abalone from donor sites and cultivated populations to a target population within MPAs, in order to bolster the abalone population within MPAs that serve an important ecological role as benthic grazers.
SubT-2	Eelgrass Restoration	Eelgrass restoration in Refugio Cove.
SubT-3	Sand-Dwelling Kelp Restoration Offshore of Goleta Beach	Funding for this project would extend monitoring of the existing pilot project to assess long-term benefits of the project, and viability of the restoration design.
SubT-4	Ellwood Seawall Removal	Removing the Ellwood seawall primarily benefits sandy beach ecosystems, but subtidal habitats adjacent to the seawall are also projected to improve.
Bird Restoration		
Bird-1	BRPE Colony Enhancement on Anacapa Island	Enhance brown pelican breeding habitat on Anacapa Island by removing invasive plants or taking other actions to improve breeding attempts and success.
Bird-2	Prevention of Injury to Seabirds Related to Recreational Fishing	This project would use outreach to raise public awareness and educate anglers about ways to reduce their chances of hooking birds and what to do if one is hooked, and to make improvements to fishing areas to prevent fishing waste from entering the environment.
Bird-3	Coal Oil Point Western Snowy Plover Protection	This may include: predator control; upgraded signage and fences; outreach to reduce disturbances at COPR; leashes to lend; and eradicate iceplant over nesting habitat on Ellwood Beach.
Marine Mammal Restoration		
Mamm-1	Improve Pinniped Rehabilitation Survival	Increase survival rates for live stranded pinnipeds recovered in Santa Barbara and Ventura Counties.
Mamm-2	Cetacean Entanglement Response	Expand response capacity for cetacean entanglement response program to increase survival rates of cetaceans entangled in fishing gear by staging gear in additional locations for quick response to reports of entangled whales in the Santa Barbara Channel.

6.2 Non-Preferred Alternatives

This alternative includes consideration of second tier projects. These projects are discussed in Section 5, and listed in Appendix N. The Trustees may consider these projects for implementation in the event that the preferred projects are no longer available or are infeasible due to unforeseen circumstances. A full environmental review in this DARP/EA was premature for second tier projects considered non-preferred, as they are not yet ready for NEPA analyses for various reasons (e.g., project details and feasibility unknown at this time). Should the Trustees consider these projects for implementation in the future, additional review may be required as project-specific details become available, in which case any subsequent NEPA analyses needed would tier from this DARP/EA.

6.3 No Action Alternative

NEPA requires the Trustees to consider a “no action” alternative, and the OPA regulations require consideration of a roughly equivalent “natural recovery” alternative. Under this alternative, the Trustees would take no direct action to restore injured natural resources or to compensate for lost services. Instead, the Trustees would rely on natural processes for recovery of the injured natural resources.

The principal advantages of the natural recovery approach are the ease of implementation and the absence of monetary costs. However, while natural recovery may occur over time for many of the injured resources, the public would not be compensated for interim losses under the “no action” alternative. In some cases, changing environmental conditions may prevent the environment from recovering to baseline. For example, native kelp species that were killed by the spill may be replaced by invasive kelp that do not support the same ecosystem functions as native species. OPA clearly establishes Trustee responsibility to seek compensation for interim losses pending recovery of natural resources. Losses were, and continue to be, suffered during the period of recovery from the spill, including the loss of an estimated 558 birds, 232 marine mammals, degradation of nearly 1,500 acres of shoreline habitat, degradation of over 2,200 acres of benthic subtidal habitat, and the loss of human uses estimated at 49,000 camping nights and over 80,000 other user days (i.e., general beach use, surfing, boating, fishing, research, etc.). Technically feasible project alternatives exist to compensate for these losses. Thus, the Trustees reject the “no action” alternative and instead have selected the appropriately scaled restoration projects described above as the preferred alternatives.

By definition, the no action alternative lacks physical interaction with the environment. Accordingly, the no action alternative would cause no direct biological, physical, or human impacts to the environment. However, if the Trustees undertook no action, the environment would not benefit from the ecological uplift created by active restoration. Active restoration would restore injured areas and resources, and potentially prevent further injury. The no action alternative may have minor to moderate short or long-term adverse indirect effects on the environment.

6.4 Cumulative Impacts

The Trustees examined a variety of alternatives to restore resources and/or services lost because of the Refugio Beach Oil Spill. Anticipated environmental consequences arising from each of the selected projects are provided in Section 5. As required by NEPA, this section addresses the potential overall cumulative impacts of implementing the projects selected in this restoration plan.

Cumulative impacts are impacts that result from an action along with other past, present, and reasonably foreseeable near-term future actions taken together. Significant cumulative impacts can result from a combination of actions that do not have significant impacts individually. Taken collectively, the effects of several actions may be additive, countervailing, or synergistic. Impacts are considered regardless of the agencies or parties involved. Thus, in considering cumulative impacts, this analysis is not limited to the impacts of restoration projects detailed herein, but also considers other significant activities and anthropogenic impacts throughout the region.

Overall, the Trustees' selected restoration projects for the Refugio NRDA will result in long-term net improvement in fish and wildlife habitat, restored ecological balance in areas where disturbances have led to adverse impacts on sensitive native species, and improved natural resource services provided to and by fish and wildlife in the region. The Trustees evaluated the restoration projects selected in this DARP/EA in conjunction with other known past, proposed, or foreseeable closely related projects, activities, and anthropogenic impacts that could potentially add to or interact with these projects within the spill-affected area to determine whether significant cumulative impacts may occur. Each resource category is quite different regarding the geographic scope of restoration projects, so cumulative impacts for each category are first treated separately followed by a summary statement regarding aggregate cumulative impacts.

Cumulatively, it is anticipated that there would be a long-term adverse effect to the biological, physical, and cultural environment were the no action/natural recovery alternative selected because no active restoration would occur. However, relative to the magnitude of adverse ecological impacts that currently exist in the project area, the adverse cumulative effect of the no action alternative is not expected to be significant as defined under NEPA.

6.4.1 Shoreline

All shoreline restoration projects are proposed to occur within the habitats formed at the interface of the land and Pacific Ocean, including sandy beaches, rocky intertidal habitats, and rocky-sandy mixed habitats. Within Santa Barbara, Ventura, and Los Angeles Counties, the condition of these habitats is influenced by a variety of anthropogenic activities including coastal armoring, sediment diversion/stabilization, beach nourishment, and beach grooming, as described further below.

Cumulative Impacts Issues

Some projects may have minor, short-term adverse effects, such as heavy equipment use on the beaches adjacent to the Ellwood seawall removal area; however, the cumulative effects of any short-term effects are anticipated to be negligible to the overall shoreline environment.

Geographic Scope of Restoration Projects

The geographic scope of the shoreline restoration projects includes sandy beach and rocky intertidal habitats in Santa Barbara, Ventura, and Los Angeles County.

Timeframe for Project Implementation

After the DARP/EA is finalized, projects are anticipated to begin within one year, and will be implemented for a period between five and ten years.

Other actions affecting the resources, ecosystems, and human communities of concern

Major anthropogenic stressors that affect the shoreline environment can be grouped into five categories:

1. *Sediment deficit*. Southern California beaches are now receiving less than 50% of their historical sand budgets. This loss of sediment has a significant negative affect on the extent of shoreline habitat, the ecosystem services provided by shoreline habitats, and the amount and intensity of coastal erosion.
2. *Coastal armoring*. Approximately 27% of the southern California coast is armored and shoreline armoring associated with sea level rise is increasing every year. This removes habitat directly from a finite and shrinking resource, and further diminishes ecological and public uses.
3. *Beach nourishment.* Nourishment is an expensive, and as practiced in southern California, only a short-term approach to address sand deficits. Unless nourishment is implemented with great skill and consideration, it can have negative impacts on beach and other coastal environments.
4. *Beach grooming*. Beach cleaning or grooming includes removing trash and kelp wrack with heavy equipment and causes substantial disturbance, loss of productivity, and reduction in species diversity to the shoreline ecosystem.
5. *Invasive species*. Invasive, non-native, plant species such as iceplant and European beach grass have been planted or introduced into the shoreline environment and have spread and out-competed native plant species. In some instances, the spread of these invasive plant species have degraded the diversity and quality of sand dune ecosystems, and precluded species such as the western snowy plover from using these habitats for breeding.

6. *Changing environmental conditions (e.g., sea level rise, ocean acidification, etc.)* Future climate scenarios predict rising sea levels, which results in increased overall coastal erosion. Ocean acidification is projected to cause impacts to animals with calcium-carbonate shells (oysters, abalone, sand crabs, etc.), which are a major component of shoreline habitats. Larger storms may also impact coastal areas in the future, causing shoreline habitat degradation and loss.

Individually and in aggregate, all of these stressors have reduced the environmental quality of the shoreline ecosystem. The shoreline restoration projects selected by the Trustees, aim to reverse a portion of the negative effects that these stressors have had. For example, the Ellwood seawall project will remove a section of unnecessary coastal armoring in the City of Goleta, the Santa Monica dune and beach restoration project will discontinue beach grooming in an area of high potential for ecological recovery, and the Ventura County dune restoration project will remove invasive non-native plants from dunes that can be used by rare birds. All selected shoreline restoration projects are anticipated to have long-term beneficial effects.

6.4.2 Subtidal and Fish Habitats

The Trustees believe that the projects selected in this restoration plan that address injuries to subtidal habitats, in conjunction with other existing and anticipated coastal restoration projects, including those funded from damage recoveries from other OPA and CERCLA cases, will have a local and regional, long term, moderate beneficial impact on the extent and productivity of subtidal habitats within the geographic scope of the project implementation footprint. The majority of projects are geared toward restoring or enhancing subtidal rocky reef, kelp forest and eelgrass habitats. All three of these habitats provide ecosystem benefits to a diverse community of fish and invertebrates. As an example, kelp forests provide food to subtidal, intertidal and beach communities (e.g., a large component of beach wrack is produced by giant kelp). Southern California kelp forests have experience profound losses in area coverage and in some cases losses in diversity and abundance of the key species that serve to regulate the complex community of algae and invertebrates that are foundational to the habitat.

Cumulative Impacts Issues

Some projects may have minor, short-term adverse effects, such as minor air quality impacts via the use of boats to transport divers and equipment to restoration sites and heavy equipment use on the beaches adjacent to the Ellwood seawall removal area; however, the cumulative effects of any short-term effects are anticipated to be negligible to the overall subtidal environment.

Geographic Scope of Restoration Projects

The geographic scope of the subtidal restoration projects is subtidal habitats within three miles of the Santa Barbara County coast.

Timeframe for project Implementation

After the DARP/EA is finalized, projects are anticipated to begin within one year, and will be implemented for a period between five and ten years.

Other actions affecting the resources, ecosystems, and human communities of concern

Major processes or anthropogenic stressors that affect the nearshore subtidal environment can be grouped into six categories:

1. *Loss of kelp forest substrate*. The Santa Barbara coast has experienced a loss of approximately 215 acres of productive kelp forest habitat due to the loss of appropriate structure for kelp holdfasts to attach.
2. *Loss of coastal marine eelgrass habitat*. Eelgrass habitat provides unique and critical ecosystem services to the shallow subtidal component of the California coastal shelf. Eel grass beds are an important source of primary productivity and create 3-dimensional biogenic habitat that is used by a diverse assemblage of fish and invertebrates as nursery and foraging habitat. Eelgrass habitat is also identified by NOAA as a Habitat of Particular Concern under the Magnuson-Stevens Fishery Conservation and Management Act.
3. *Invasive species.* Invasive, non-native, species such as *Sargassum horneri* and *Undaria pinnatifida* have been introduced into the southern California bight and have spread and out-competed native species. The spread of these invasive plant species have degraded the diversity and quality of giant kelp and other subtidal vegetated habitat, making restoration of native habitat critically important.
4. *Coastal erosion and associated turbidity and scour.* A variety of coastal activities (seawall armoring, excessive irrigation practices, beach nourishment, etc) have been shown to reduce productivity of subtidal habitats due to the impacts of sedimentation (leading to burial of structured habitats), chronic turbidity (leading to reductions in primary production and growth of algae and plants that create three dimensional habitat), and scour (sediment washing over hard substrate and removing algae, attached invertebrates and other living habitat elements).
5. *On-going activities associated with oil extraction*. Numerous activities associated with oil extraction can have significant cumulative impacts on subtidal habitats. Clearly pipeline ruptures and spills from other sources have catastrophic impacts, but ongoing impacts associated with establishing and maintenance of the infrastructure needed to support oil extraction (e.g., pipeline construction and maintenance) can result in impacts to marine habitats.
6. *Changing environmental conditions (e.g., warming temperatures, ocean acidification, altered circulation)*. Future climate scenarios predict rising sea levels, which results in increased overall coastal erosion. Ocean acidification is projected to cause impacts to animals with calcium-carbonate shells (oysters, abalone, sand crabs, etc.), which are a major component of shoreline habitats. Larger storms may also impact coastal areas in the future, causing shoreline habitat degradation and loss.

Individually and in aggregate, these processes or anthropogenic stressors have reduced the environmental quality of the subtidal ecosystem. The subtidal restoration projects selected by the Trustees, aim to reverse a portion of these negative effects. Projects were selected with the primary goal of creating positive benefits in the face of the numerous anthropogenic stressors described above. All selected and second tier subtidal restoration projects are anticipated to have beneficial effects. Any adverse effects would be temporary and minor, and are not anticipated to cumulatively have any substantial adverse effects on subtidal resources within the project area.

6.4.3 Bird and Marine Mammal Projects

Unlike shoreline and subtidal habitats, birds and marine mammals travel widely within and outside of the spill-affected area, and the restoration projects selected to benefit these species are likewise located both within and outside of the spill-affected area, in places where the projects can have the greatest benefits. The selected projects will create positive benefits to birds and mammals in the face of anthropogenic effects, such as the ones described above. In many cases, restoration projects were selected to counter-act negative effects that existing human activities are having on bird and mammal resources.

Cumulative Impacts Issues

All selected bird and mammal restoration projects are anticipated to have beneficial effects. Any adverse effects would be temporary and minor, and are not anticipated to cumulatively have any substantial adverse effects on bird and mammal resources within the project area.

Geographic Scope of Restoration Projects

Projects are proposed to occur along the California mainland coast of Santa Barbara, Ventura, and Los Angeles Counties, and on the Channel Islands.

Timeframe for project Implementation

After the Final DARP/EA is released, projects are anticipated to begin within one year, and will be implemented for a period between five and ten years.

Other actions affecting the resources, ecosystems, and human communities of concern: Environmental quality in the project areas has been affected by a number of anthropogenic stressors grouped into four categories as follows:

1. *Modification of the coastline.* Extensive modification and human use of the shoreline has drastically changed the use of the coastline by birds and marine mammals. Bird and mammal breeding activities are not well-tolerated by human disturbance, and so many birds and mammals have adjusted the location of breeding to move away for areas that humans have modified and inhabited.

2. *Fishing gear entanglement*. As described elsewhere in this document, fishing hook and line injuries are by far the leading source of anthropogenic injury to seabirds brought to rehabilitation centers in Los Angeles and San Francisco.
3. *Harmful algal blooms*. Harmful algal blooms, such as the acute proliferation of plankton that produce the neurotoxin domoic acid, are becoming somewhat more frequent in southern California. These acute harmful algal blooms affect birds and mammals, often lethally.
4. *Changing environmental conditions*. Warmer ocean waters in the southern California area in the past decade have effects on upwelling and primary productivity, which has cascading effects up the food chain. Low prey availability for birds and mammals has caused increased mortality due to starvation.

The selected projects aim to to create positive benefits to birds and mammals in the face of anthropogenic effects, such as the ones described above. In many cases, restoration projects were selected to counter-act negative effects that existing human activities are having on bird and mammal resources.

6.4.4 Human Uses

Human uses along the shoreline are comprised of a variety of activities including boating, camping, surfing, general beach use, and other forms of recreation. The Trustees believe that, overall, the alternatives selected in this restoration plan, when considered along with past and reasonably foreseeable future projects, will have long term local and regional beneficial impacts to natural resources and recreation. Any negative impacts are anticipated to be short term, and minor.

Cumulative Impacts Issues

The proposed projects to improve human uses have not yet been selected and will be the subject of a future decision process. However, we anticipate that the benefits of these projects will significantly enhance recreational opportunities along the shoreline. Some projects may create a temporary closure or re-routing of coastal access. For example, one possible project is improved beach access from Ellwood Mesa to Ellwood Beach. Currently, there is a steep dirt trail, which could be improved by the installation of a ramp or staircase to provide safe public access. While the construction of this project may create a month or longer temporary closure of the trail, the completed project will ultimately improve coastal access and provide recreational benefits for many years to come.

Geographic Scope of Restoration Projects

Projects are proposed to occur along the California coast of Santa Barbara, Ventura, and Los Angeles Counties.

Timeframe for project Implementation: CDPR will select projects that will enhance camping and/other shoreline recreational activities associated with units of CDPR from Gaviota to El

Capitan at State Beaches. A grants program will be initiated to solicit and select proposals for remaining projects to compensate for lost recreation. The Trustees anticipate that projects would be implemented for a period between one and eight years after the grant program has begun.

Other actions affecting the resources, ecosystems, and human communities of concern
In many areas of the coastline within Santa Barbara, Ventura, and Los Angeles Counties, access to the coastline for recreation is precluded or curtailed due to private ownership of coastal property and potential access points. As part of the restoration project selection criteria [in Section 4.2], recreational use projects will be selected and prioritized based on the degree to which they provide positive benefits to recreation in the face of numerous conflicting private and public interests. For example, projects will be selected to ameliorate limitations that exist for public access due to private ownership or limited beach access points. All proposed projects are anticipated to have beneficial effects for human uses within the affected area. Any adverse effects would be temporary and minor, and would not be anticipated to have any substantial adverse cumulative effects. The types of human use projects that are anticipated to be implemented through this plan are generally described by the categories below. When specific projects are selected for implementation, project-specific environmental reviews will be completed and assess the impacts of each project to the environment. Types of projects being considered to be selected by the Trustees may be grouped into the following four categories:

1. Shoreline Access and Amenity Improvements. Create, improve, and maintain access or otherwise improve recreational enjoyment of a day use recreation sites and public amenities that are both adjacent to land along the coast or and on the water. This includes, but is not limited to:
   - Trail improvement;
   - Pier repair, construction and accessibility improvements;
   - Boardwalk repair, construction, and accessibility improvements;
   - Boat launch repair, construction, and accessibility improvements;
   - Beach sand management;
   - Parking improvements at day use recreation sites
   - General infrastructure upgrades that can facilitate access;
   - Signage designed to enhance recreational experience; and
   - Infrastructure upgrades that improve recreational enjoyment of shoreline recreation sites, including locations where on-water recreation is initiated (e.g., dive sites, boat launches, harbors, marinas).

2. Camping. Add, improve, and maintain camping amenities and associated day use amenities at campgrounds. This includes, but is not limited to:
   - Benches and/or picnic facilities;
   - Fire rings;
   - Restrooms/showers;
   - Parking lot improvements;

- Fish/bait cleaning stations, fishing rod holders;
- Interpretive programs and/or signage;
- Shoreline access improvements at campground sites; and
- General infrastructure improvements that increase the efficiency, utilization, or enjoyment of campground amenities.

3. Recreational Programs. Programs including but not limited to:
   - Guided trips;
   - Education aimed at increasing public utilization of shoreline and on-water recreation resources; and
   - Equipment that supports recreation programs (e.g., kayaks, fishing gear).

4. Research, Education, and Outreach at University of California, Santa Barbara property.

The Trustees believe that, overall, the alternatives selected in this restoration plan, when considered along with past and reasonably foreseeable future projects, will have long term local and regional beneficial impacts to natural resources, as well as short term, minor negative impacts to human uses.

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Appendix A. Oil Fate and Transport
Appendix B. Data Management and Access
Appendix C. Resource Equivalency Analysis
Appendix D. Shoreline Exposure and Injury Evaluation Studies
Appendix E. Supplemental Bioassay Report Information
Appendix F. Shoreline Habitat Equivalency Analysis
Appendix G-1. Fish, Invertebrate, and Other Mortality Observations
Appendix G-2. Field and Laboratory Assessment of Injury to Grunion
Appendix G-3. Assessment of Surfperch Exposure
Appendix G-4: Oil Exposure and Potential Effects to Fish, Invertebrate Early Life Stages, and Kelp
Appendix G-5: Changes in the Condition of Surfgrass and Macroalgae
Appendix G-6: Field Assessment of Subtidal Exposure
Appendix G-7: Polycyclic Aromatic Hydrocarbons in Nearshore Fish and Invertebrate Tissues
Appendix H. Subtidal Injury Quantification and Habitat Equivalency Analysis
Appendix I. Bird Injury Assessment
Appendix J. Marine Mammal Exposure, Injury, and Restoration
Appendix K. Recreational Camping Damages
Appendix L. Recreational Shoreline Use Damages
Appendix M. Recreational Boating and Offshore Use Damages
Appendix N. Summary of Proposed Restoration Projects
Appendix O. Response to Public Comments on the Draft Damage Assessment and Restoration Plan/Environmental Assessment (DARP/EA)

Appendix A. Oil Fate and Transport

The following papers were prepared to better understand (1) surface transport of oil downcoast using NOAA's GNOME model, and (2) to better understand basic physical properties that cause oil to mix within the water column. The first paper, 'Modeling Transport of Oil from the Refugio Beach Oil Spill' was prepared as part of the 2017 International Oil Spill Conference, largely for the response community. The second paper, 'Mixing depth estimates for nearshore oil from Refugio Beach Oil Spill' was prepared for the Trustees in October 2016.

Modeling Transport of Oil from the Refugio Beach Oil Spill

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2017-288 ABSTRACT

The Refugio Beach oil spill originated from a pipeline break on 19 May 2015 near Refugio State Beach, which is located approximately 20 miles west of Santa Barbara, California. An estimated 500 barrels (21,000 gallons) of crude oil flowed from the shore side of Highway 101 into the Pacific Ocean. Trajectory and fate modeling of the oil were provided to the Incident Command to support the response. Several factors were particularly challenging for oil spill modeling in this incident. The spill entered the ocean through the surf zone, a distinct dynamical region with variability on small spatial and temporal scales, which coastal circulation models generally do not resolve. The regional winds were also highly variable and in some locations forecast models did not reflect the on-scene observations. A final complication was the presence of numerous natural oil seeps in the region. This posed challenges both for model initialization and validation of modeling results.

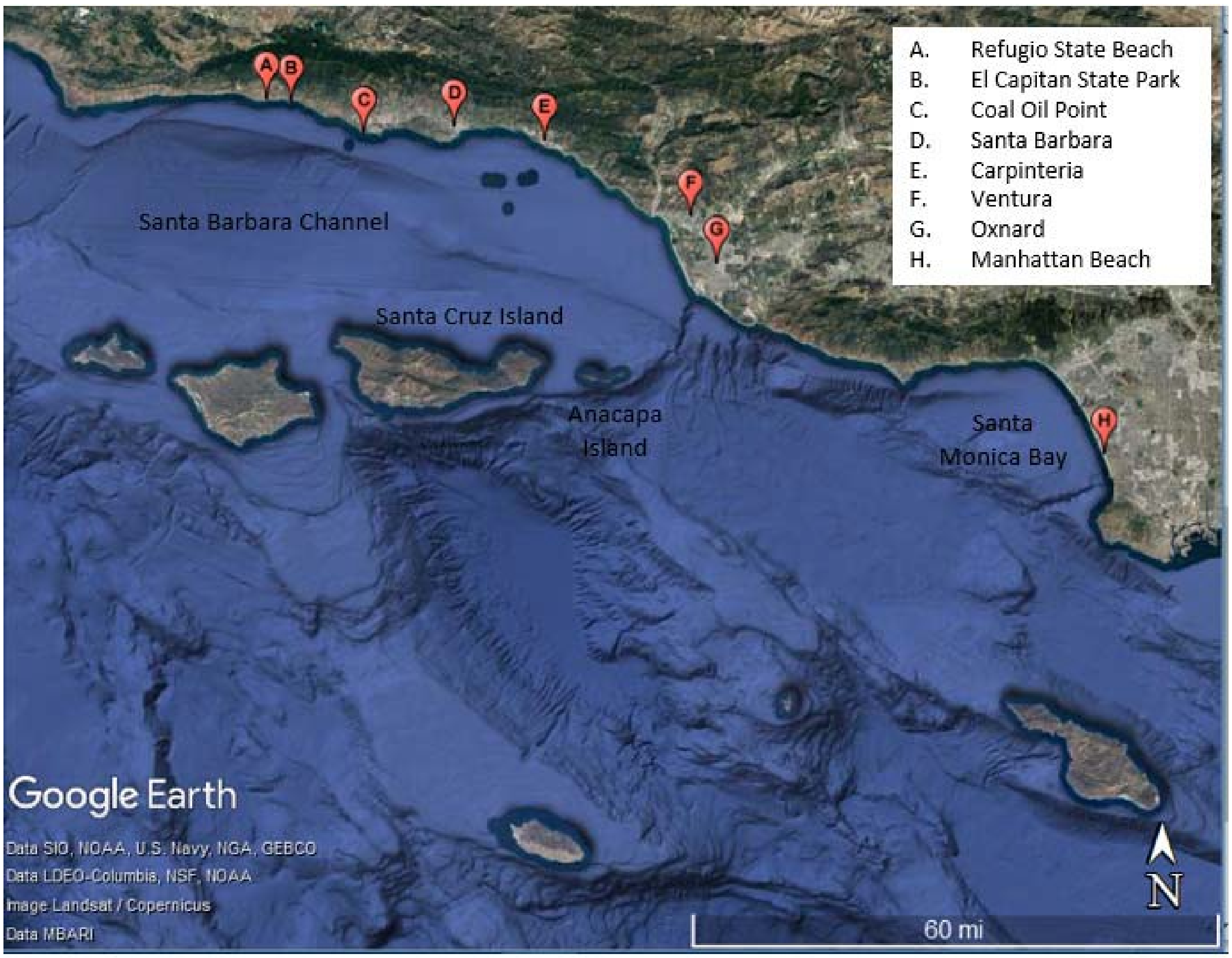
In the days following the spill, above-background levels of tarballs were observed coming ashore on various beaches remote from the spill. Chemical analyses indicate that some of the tarballs likely originated from the spill. Hindcast modeling of the spill was conducted to examine transport between these locations and the spill source. Modeling simulations showed regional connectivity in approximately the correct time frame between the spill site and beaches in Ventura County and Santa Monica Bay.

INTRODUCTION

On 19 May 2015, a break in Plains Pipeline Line 901 resulted in a spill of approximately 2,500 barrels (105,000 gallons) of oil. An estimated 500 barrels (21,000 gallons) of the oil flowed from the shore side of Highway 101 into the Pacific Ocean at Refugio State Beach, near Santa Barbara, California (Figure 1). The oil released from the pipeline was a blend of crude oils being transported from the Heritage, Harmony, Hondo, and Holly oil production platforms.

As part of the oil spill response effort, NOAA's Office of Response and Restoration provided scientific support including overflight observation of the spill, information on fate and effects of the crude oil, and forecasts of surface oil movement. Operational forecasting of surface oil movement is critical to the response for planning, allocation of resources, and timely direction of response assets. This particular spill presented several unique challenges for oil trajectory modeling.

One challenge was the location of the release. Oil flowed down the beach and entered the ocean through the surf zone. The surf zone, the nearshore region of breaking waves, is dynamically distinct from the coastal ocean. Transport and dispersion within the surf zone is influenced by much smaller scale dynamic features (e.g., longshore currents, rip currents). Oil is moved alongshore by breaking-wave and wind-driven currents, and may be ejected offshore from the surf zone to the inner shelf by transient rip currents and/or offshore winds. Although detailed surf zone modeling is possible, it requires high resolution and inclusion of wave-current interactions. The surf zone is not typically resolved by the regional coastal ocean models that are used to drive transport in oil spill modeling. This is also a limitation for trajectory modeling of oil spills that originate offshore. In this case, it limits the ability to provide detailed information on variability in shoreline oiling below the model grid scale (typically >1 km). However, in the case of the Refugio spill, the origination of the spill on the beach affected the *initialization* of the model, requiring assumptions to be made about the initial transport and footprint of the floating oil.



F*igure 1 Location of Refugio State Beach and other locations mentioned in the text.*

Uncertainty in the oil footprint used in the model initialization can be reduced by overflight surveys, which map the observed floating oil. NOAA overflights began the morning of 21 May, two days after the initial release, which occurred in an area known for its abundant natural oil seeps. The Coal Oil Point area is home to seeps that release on the order of 100 barrels of oil per day and are among the most active in the world [Hornafius et al., 1999]. It is not generally possible for aerial observers to determine if observed floating oil is from a spill or a natural source, unless the oil can be clearly traced back to an origin point. In the Refugio spill, the oil from the local natural seeps and the leaking pipeline both originated from the same geologic formation so even their chemical makeup was similar, requiring sophisticated chemical analyses to differentiate the two.

In spite of these challenges, oil spill trajectory forecasts were produced and utilized by the response to guide operations from the first day of the spill through 26 May. These forecasts identified with reasonable accuracy the heaviest regions of shoreline oiling along the coast adjacent to the spill site and extending several miles. However, several incidents of above-background levels of tarball deposition also occurred on beaches remote from the spill site, e.g., along the Ventura coastline, in Santa Monica Bay, and in the Channel Islands. This prompted a hindcast analysis to examine regional transport pathways and time scales of transport to examine the likelihood of these incidents arising from the Refugio spill. This hindcast modeling was further refined as part of the Natural Resource Damage Assessment following the spill response.

MODELING APPROACH

Movement of oil was modeled using the General NOAA Operational Modeling Environment (GNOME) [Zelenke et al., 2012]. GNOME is an oil spill trajectory model in which the surface oil is divided into a large number of small particles of equal mass that move under the influence of surface ocean currents, wind drift, and horizontal mixing. GNOME also includes algorithms that simulate surface oil weathering, e.g., evaporation and dispersion.

Oil spill trajectory models rely on hydrodynamic model forecasts and/or observations of winds and currents as inputs. Real-time forecasting during spill response necessitates reliance on meteorological and ocean forecast model results, increasing the uncertainty associated with the oil trajectories. In contrast, hindcast modeling can incorporate observational data from the time of the spill or reanalysis products (models that are re-run with available observational data assimilated).

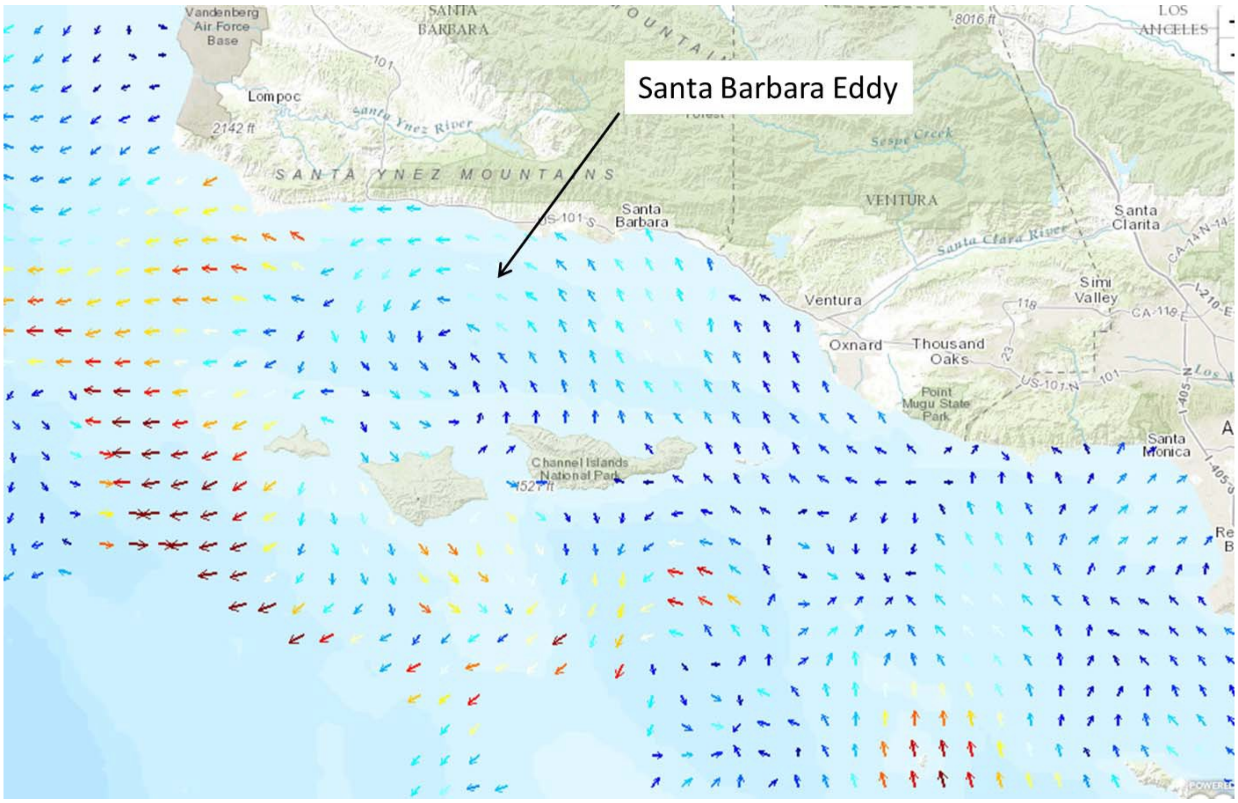


Figure 2 Surface current data (6 km) from coastal radar obtained early in the spill. Source: NOAA CENCOOS

For the hindcast analysis presented in this paper, surface currents were obtained from coastal radar data operated with funding from the Southern California Coastal Ocean Observing System (sccoos.org). Coastal radars measure surface currents in the coastal ocean with coverage throughout the Southern California Bight at 6-km resolution (Figure 2; a higher resolution of 2 km is available for the region within the Santa Barbara Channel).These data resolve the mesoscale features of the surface circulation (e.g., counter-clockwise Santa Barbara Eddy, Southern California Countercurrent [Hickey, 1992]).

Wind forcing was obtained from the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS®), developed and run by the Naval Research Laboratory in Monterey, CA (http://www.nrlmry.navy.mil/coamps-web/web/home). COAMPS is a numerical model used for wind nowcasts and forecasts. The implementation of COAMPS used in this study has a spatial resolution of 4 km and covers the coastal ocean from Oregon to Mexico. COAMPS was run as a forecast with re-initialization every 12 hours with available observations interpolated together with the previous model forecast. Atmospheric fields were then projected forward in time.

In spill trajectory models, it is common to combine a number of physical processes related to wind forcing (e.g., Stokes drift, surface drift, Langmuir circulation) into a wind-drift factor [Galt, 1994]. This has been determined experimentally to be ~3-4% of the wind speed for fresh oil in light winds without breaking waves [Reed et al., 1994]. As the oil weathers and/or if wind speed increases, the oil may spend a significant portion of time away from the surface and out of the influence of many of the processes associated with the wind forcing, and the average drift factor may be much lower. In general, this parameterization is a very useful approach but requires observational feedback during spill events [Galt, 1994]. GNOME allows the user to specify a range of values for the wind drift along with a persistence time scale, simulating the time-varying windage as the wind and wave conditions are not generally spatially or temporally constant. A base-case model run used a range of windage values from 1-4% with a persistence time scale of 15 minutes, i.e., individual particles are randomly re-assigned a windage value between 1-4% every 15 minutes. Sensitivity studies were performed using reduced (1-2%) and increased (3-4%) windage values.

Turbulent diffusive processes that spread spills horizontally are simulated in GNOME by a random walk. A diffusion coefficient of 1 m^2s^{-1} was used to calculate random step lengths in the x- and y-directions from a uniform distribution. The current version of GNOME does not allow for spatial variability in the horizontal diffusion, so this results in a uniform spreading of the particles over time.

MODEL INITIALIZATION

As discussed previously, the 6-km resolution regional coastal radar derived surface currents do not include data in the surf zone where the oil first entered the ocean. Due to this limitation, rather than initiate the spill as a point source, observations during the first 24 hours of the spill were used to initialize floating oil nearshore. Although detailed NOAA overflight surveys did not begin until 21 May, aerial photographs indicated some of the floating oil began moving offshore the afternoon of 19 May, coincident with the development of an offshore wind in the late afternoon. U.S. Coast Guard personnel flying over the site observed a 2-mile alongshore extent of shoreline oiling at 5:30 PM on 19 May and observed some floating oil remaining in the surf zone and extending offshore during a mid-morning overflight on 20 May.

Based on these limited observations, particles were initialized in the GNOME model within a polygon in a nearshore area extending out to ~1/3 km off the coastline with an east-west extent similar to the 19 May overflight. For each simulation, ~100,000 particles were released over a 24-hour period beginning 19 May 5:30 PM. A linear decay rate in the number of particles released per timestep was applied.

Without a detailed surf zone modeling component or a quantitative estimate on how much oil beached along the shoreline adjacent to Refugio Beach, we did not think it reasonable to estimate how much oil may have moved offshore versus oil that remained in the surf zone and beached in the near-field. Model results are therefore reported as relative particle densities rather than oil concentrations. For the same reason, oil weathering is not included in this analysis and the particles are conservative with no loss processes.

SHORELINE OIL OBSERVATIONS

Shoreline Cleanup Assessment Technique (SCAT) teams began surveying the coastline adjacent to the spill site very early in the response. SCAT survey data are presented in Figure 3. This map includes data collected over multiple days: the coloring of shoreline segments represents the maximum level of oiling observed on any survey. For a temporal perspective, on 20 May, SCAT teams reported observing oiled shoreline extending approximately 7 miles from Arroyo Hondo Preserve (western extent) to El Capitan State Beach (eastern extent). By 23 May, SCAT maps indicated moderate shoreline oiling extending several miles further east of El Capitan and also variable degrees of shoreline oiling around Coal Oil Point and University of California, Santa Barbara.

High densities of tarball deposition were subsequently reported by the public at Manhattan Beach in southwestern Los Angeles County on May 28 and in Ventura County between Carpinteria and Oxnard around the same time. Surveys were also conducted in these areas and reported light to moderate oiling conditions. An atypical tarball event was also reported by U.S. Fish and Wildlife in the Channel Islands between 1-7 June.

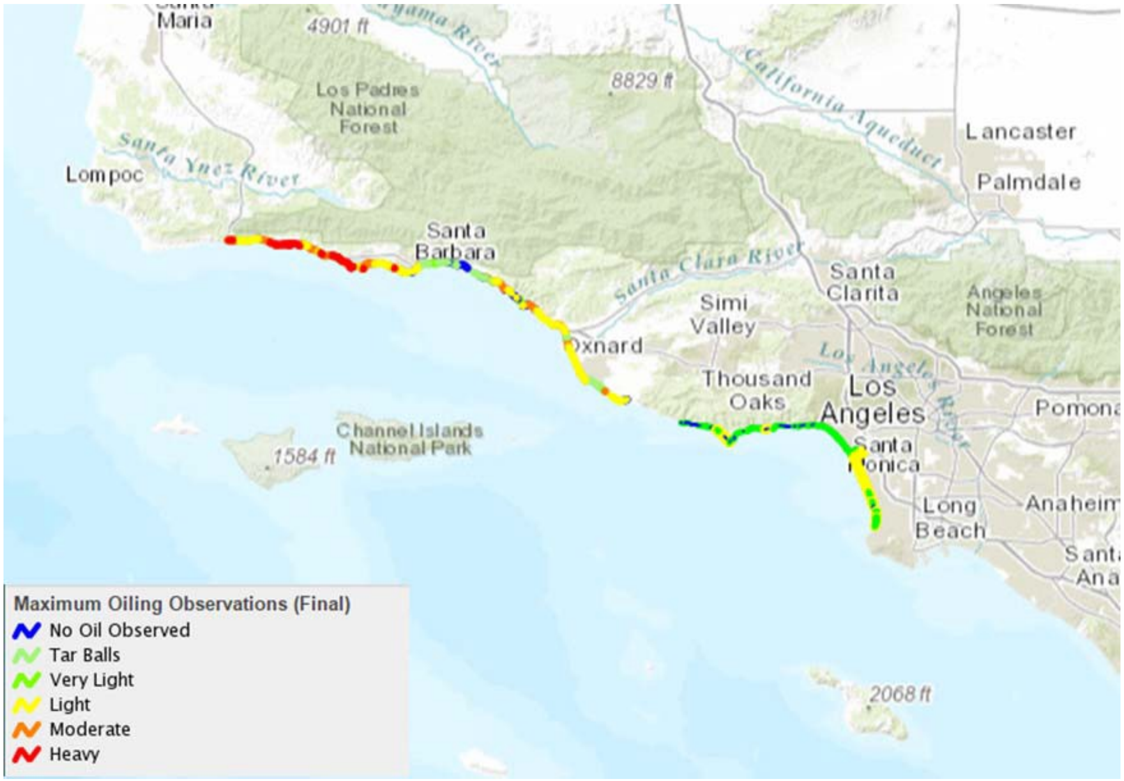


Figure 3 SCAT survey map showing maximum oil observed at each segment. Image from the Environmental Response Management Application (ERMA®) Southwest.

This region has a level of background shoreline oiling due to the active natural seep field, which is an order of magnitude higher in summer than winter [Del Sontro et al., 2007, Lorenson et al., 2009]. This complicates interpretation of the semi-quantitative SCAT data. The map shown in Figure 3 certainly incorporates both spill oil and natural seep oil. In the first few days of surveys described previously, the proximity to the source and nature of the oiling indicated much of this oiling was likely due to the pipeline release. As the observations become more remote in time and space from the spill origin, sophisticated chemical analyses are required to differentiate between the two possible sources. The model results described in the next section can also aid in describing potential connectivity between the spill site and the impacted regions.

MODEL RESULTS

Snapshots of relative particle densities at various model times are shown in Figure 4 for the base-case run described previously (windage values ranging from 1-4%). In this simulation, model particles move offshore into the Santa Barbara Channel and enter the counter-clockwise Santa Barbara Eddy on 20-21 May. Very few particles make landfall on the Channel Islands. Instead, particles move east, making landfall along the Ventura coastline by 25 May. The remaining floating particles move southeast, with some portion advected eastward into Santa Monica Bay and making landfall by 29 May, approximately one day later than the observed event. The highest beached particle densities occur near Refugio Beach and in the eastern Santa Barbara Channel.

A sensitivity study with the wind influence reduced to 1-2% of the wind speed (Figure 5) demonstrates the importance of westerly winds prevalent in the Santa Barbara Channel in reducing landfall on the Channel Islands. In this lower windage simulation, particles make landfall initially on the north facing shorelines of Santa Cruz and Anacapa Islands within several days of the release. Shoreline impacts still occur in Ventura County but are delayed by several days. However, in this case, no particles enter Santa Monica Bay.

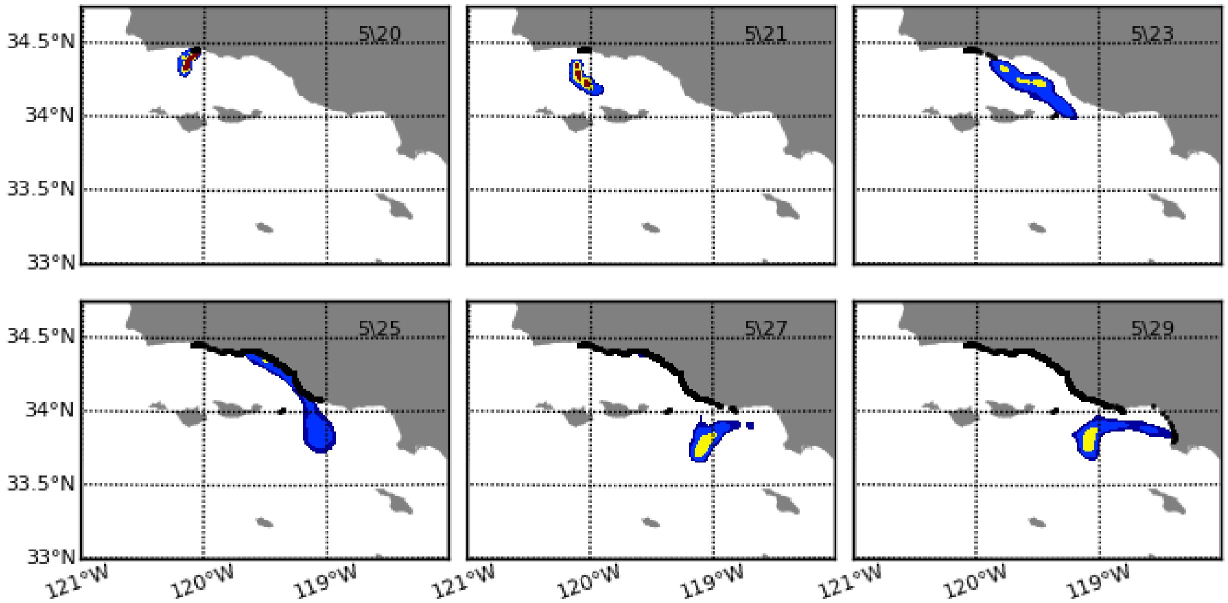


Figure 4 Particle densities (relative to maximum for the entire simulation) for the base-case of 1-4% windage. Black dots mark the locations where particles contact the shoreline.

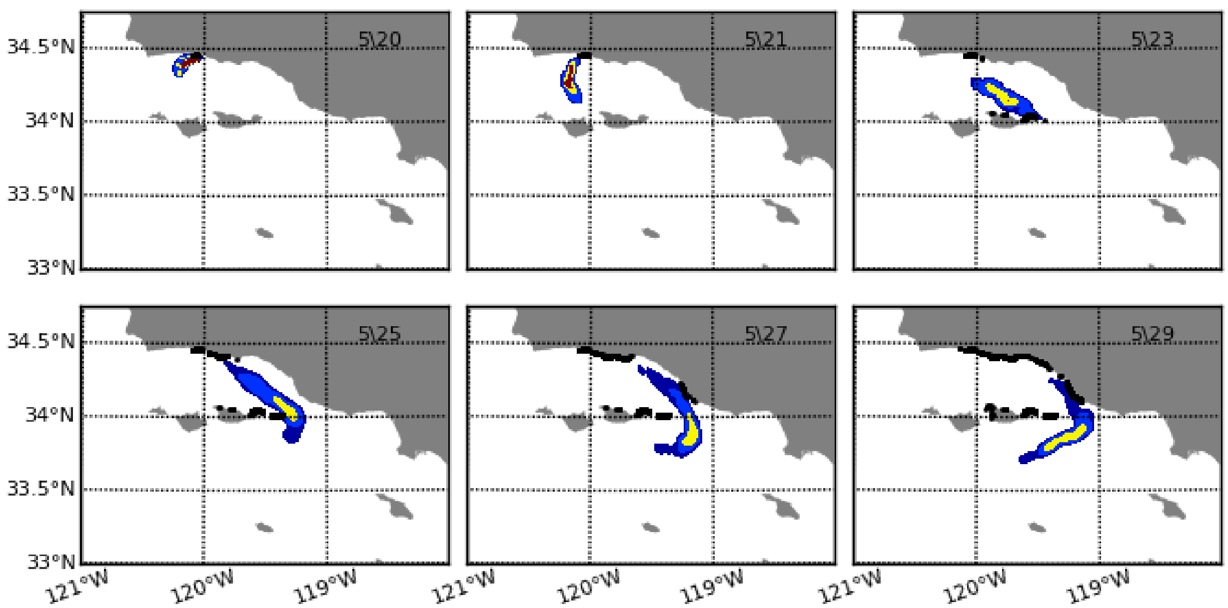


Figure 5 As in Figure 4, for the reduced windage, 1-2% case.

A sensitivity study with a larger wind influence, a 3-4% range, was also conducted (not shown). In this case, particles move eastward in Santa Barbara Channel much quicker, making landfall in Ventura County by 23 May. The impacts in Santa Monica Bay are also magnified and occur by 27 May, preceding observations slightly.

SUMMARY AND DISCUSSION

Following the Refugio Beach Oil Spill on 19 May 2015, several incidents of increased tarball accumulation occurred on beaches remote from the spill site. This study examined the movement of modeled particles simulating floating oil that originated nearshore of Refugio Beach, with the goal of elucidating regional transport pathways and time scales of transport.

The model simulations show particles making landfall in southern Santa Monica Bay and Ventura County in a time frame approximately agreeing with observations. In the base-case scenario, a range of values of 1-4% were used for the model windage parameter, resulting in downwind movement averaging about 2.5% of the wind speed. This resulted in initial landfall impacts in Ventura County by 25 May and at Manhattan Beach by 29 May. Interestingly, the majority of public reporting of tarballs were around the same time for both sites, with Santa Monica Bay (28 May) actually leading Ventura slightly. Based on the modeling studies alone, this seems confounding—however, the modeling studies only considered movement of oil originating from the spill. Oil observations from overflights indicated very active natural seep activity throughout the time period of surveys, which under the right environmental conditions, could also manifest as notable tarball events on remote beaches. We would expect tarballs that arrived on beaches in both these locations during this time frame to likely contain a mixture of spill and seep oil.

Another notable event was the increased tarball accumulation observed in the Channel Islands beginning around 1 June. By this time, the modeling simulations suggest most of the floating oil had moved to the southeast or already beached. A NOAA overflight on 29 May saw little oil remaining in nearshore waters off Refugio Beach, but traced an approximately 10 mile long band of dark oil several miles offshore of the spill location back towards the Coal Oil Point seep field (Figure 6). By this time, the position of the Santa Barbara Eddy as observed by the coastal radar data had shifted westward in the Santa Barbara Channel. When combined with prevailing wind patterns, this shift in the position of the eddy made transport from the spill region to the Channel Islands much more likely during this time period. These data suggest the Channel Islands event may have been a result of natural seep activity rather than from the Refugio spill.

Finally, due to the lack of data in the surf zone region, the model likely underestimates shoreline oiling in the "near-field," i.e., the coastline adjacent to Refugio Beach extending several miles. Observations indicate a significant portion of oil initially beached along this shoreline (Figure 3). The volume that beached in this near-field region was likely a function of many processes that were not included in this regional scale modeling effort, for example, variability in local onshore/offshore winds (sea breeze), the phase of tides, the strength of longshore currents, and the holding capacity and orientation of the shoreline. Higher resolution re-analysis ensemble wind products could better capture the temporal and spatial variability in the wind patterns. This, combined with high resolution surf zone modeling, could potentially provide a better prediction of alongshore transport in the near-field, including exchange between the surf zone and inner shelf, and hence provide a better prediction of shoreline oiling probabilities along this section of coastline.

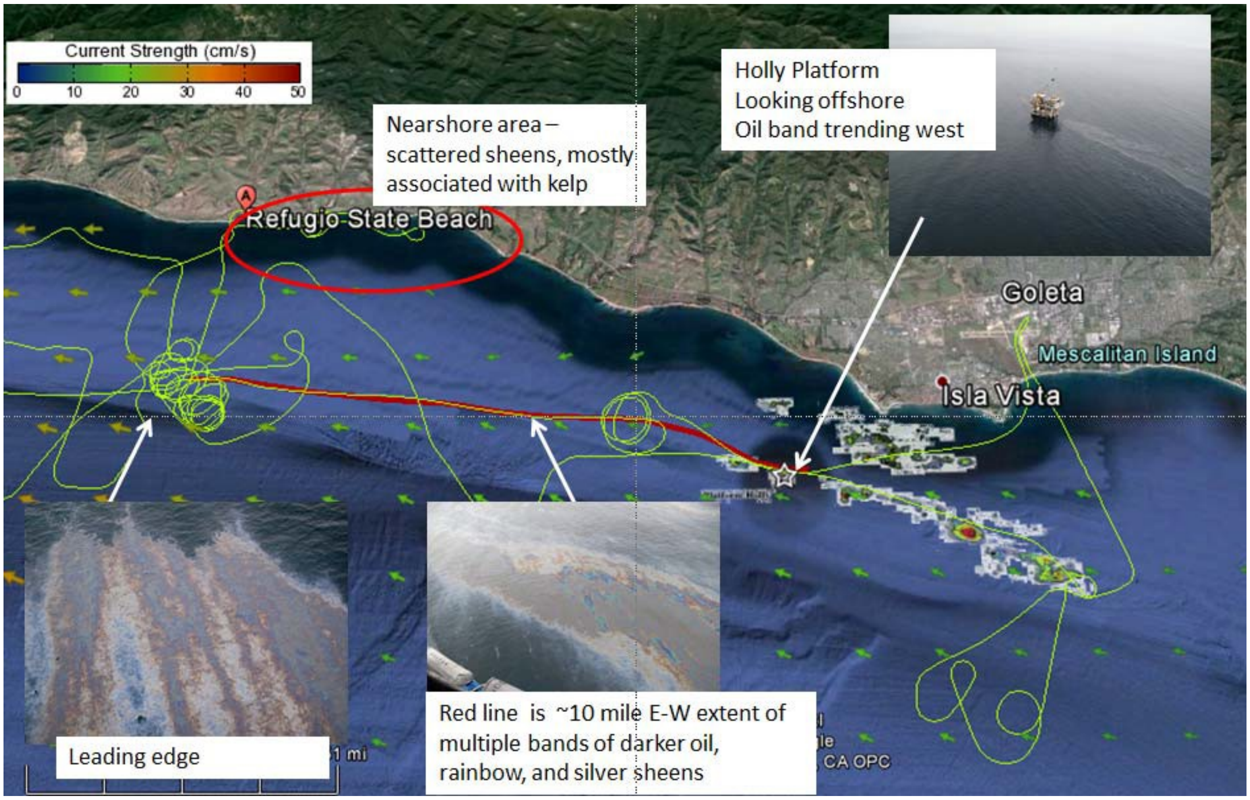


Figure 6 Summary of observations from 29 May NOAA overflight. Green track shows the flightpath. Important observations are annotated. Seep field heat map courtesy of Ira Leifer, UCSB.

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Zelenke, B., C. O'Connor, C. Barker, C.J. Beegle-Krause, and L. Eclipse (Eds.). 2012. General NOAA Operational Modeling Environment (GNOME) Technical Documentation. U.S. Dept. of Commerce, NOAA Technical Memorandum NOS OR&R 40. Seattle, WA: Emergency Response Division, NOAA. 105 pp.

Mixing depth estimates for nearshore oil from Refugio Beach Oil Spill

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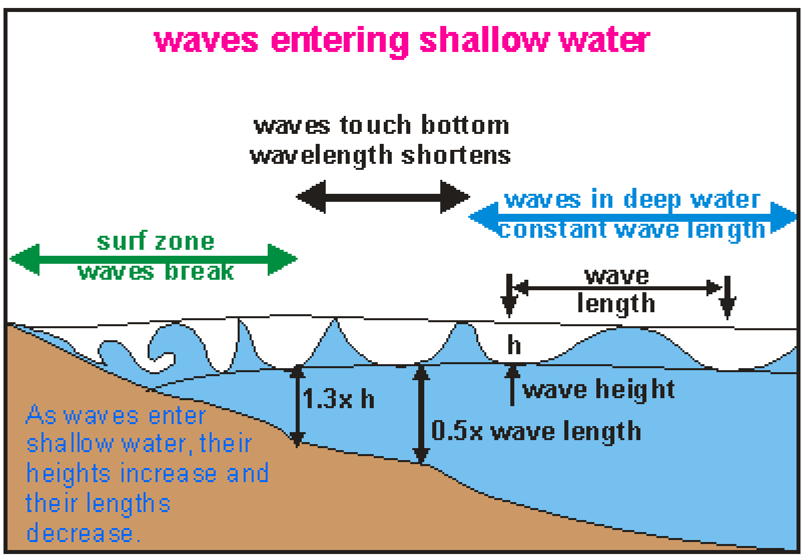
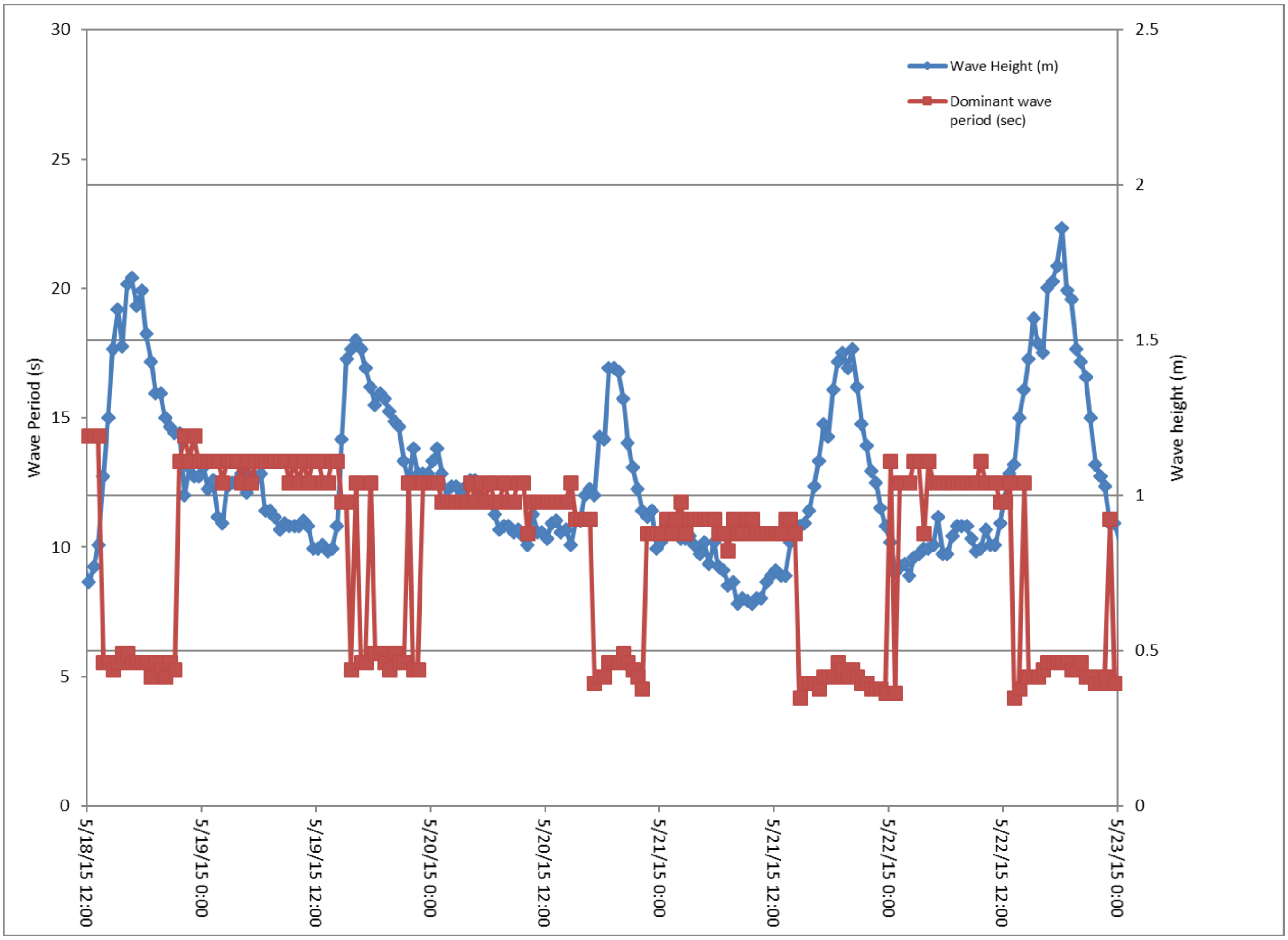
Estimation of surf zone depth during Refugio Spill

The surf zone is defined as the region which contains waves that are breaking due to the shallow water depth. Within the surf zone we would expect soluble components of oil and oil droplets to be mixed throughout the water column. The width and character of the surf zone continually vary with changes in tide level, incident waves, and local wind speed and direction. However, by examining wave conditions during the time of the spill, we can estimate the water depth at which waves begin to break, i.e. the water depth at the outer (offshore) edge of the surf zone.



Wave breaking equations can be used to estimate the offshore depth of the surf zone. As the waves approach shallow water, they shoal and get shorter and steeper. Once the wave height reaches about 0.8 of the water depth, the wave begins to break. By matching the energy flux from deep to shallow water, the water depth at initiation of wave breaking as a function of offshore wave length and height can be derived (Fredsoe et al, 1992). Using the deep water dispersion relationship, wavelength can be converted to wave period – both wave height and period are measured at offshore wave buoys. The plot below shows wave conditions during the first few days of the Refugio Oil Spill measured at the Scripps Waverider Buoy off Goleta Point (ID: 46216).



In this time series, there are two dominant wave periods. The swell (longer wave period, smaller wave height) was approximately 1 m at 12 s. Associated with higher winds that typically occur in the afternoon, wave heights would increase and periods decrease. During these periods, the seas were up to almost 2 m at 5 s (although more often reaching a maximum around 1.5 m). Using these relationships, the surf zone depth for 12 seconds and 1.00 m wave height is 1.90 m and the surf zone depth for 5 seconds and 2.00 m wave height is: 2.33 m. This suggests oil would be mixed in the surf zone to a maximum depth of ~2m.

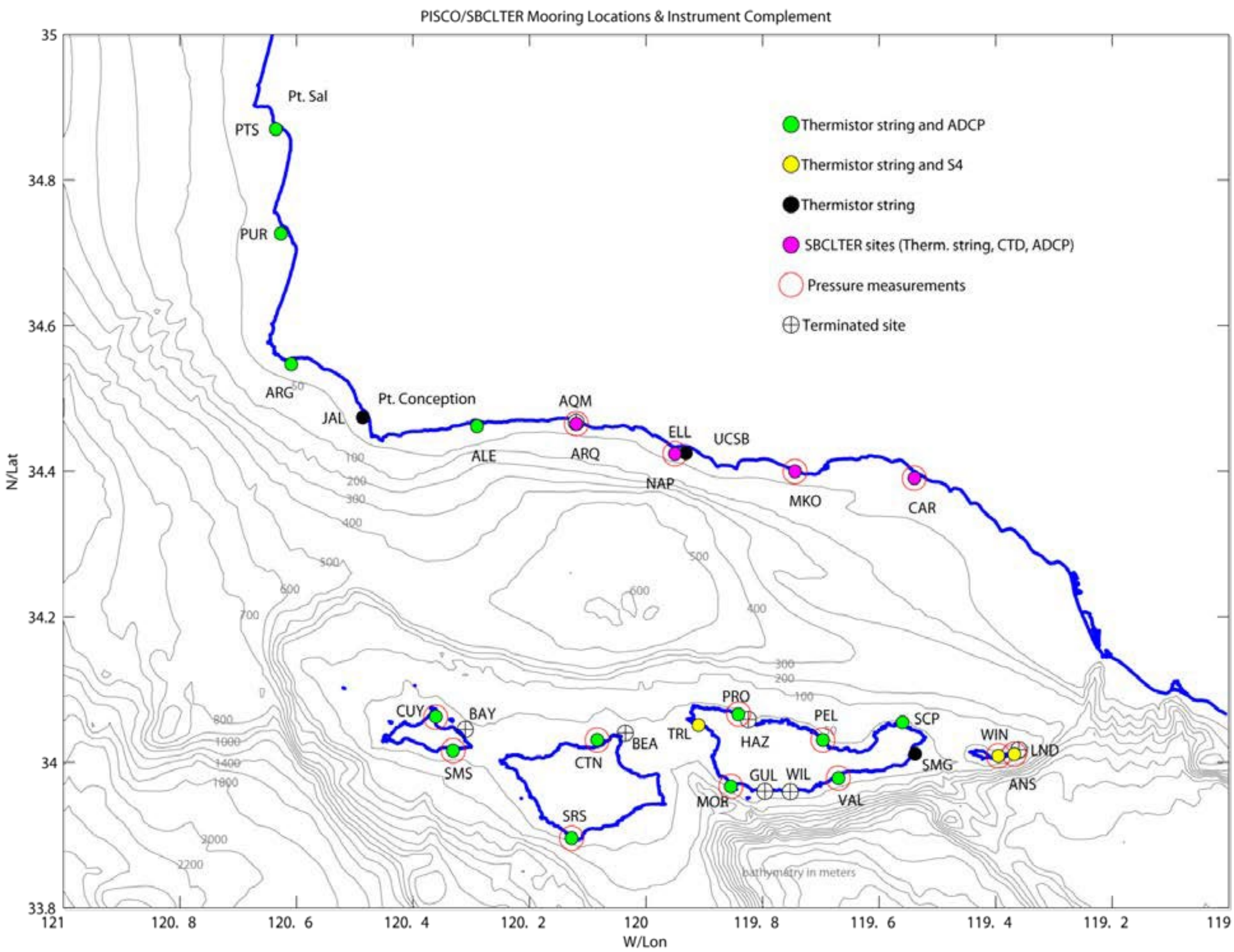
Since the oil entered the water through the surf zone, there is also potential that the oil interacted with sediments and formed oil-sediment aggregations which would be potentially dense enough to sink to the bottom. These aggregates could also be transported around in the surf zone and move offshore onto the inner shelf.

Inner shelf

The inner shelf region begins just offshore of the surf zone. The exchange of tracers (e.g. dissolved oil components) between the surf zone and the inner-shelf is poorly understood. Rip currents (both transient and bathymetrically controlled) can eject water from the surf zone onto the inner-shelf.

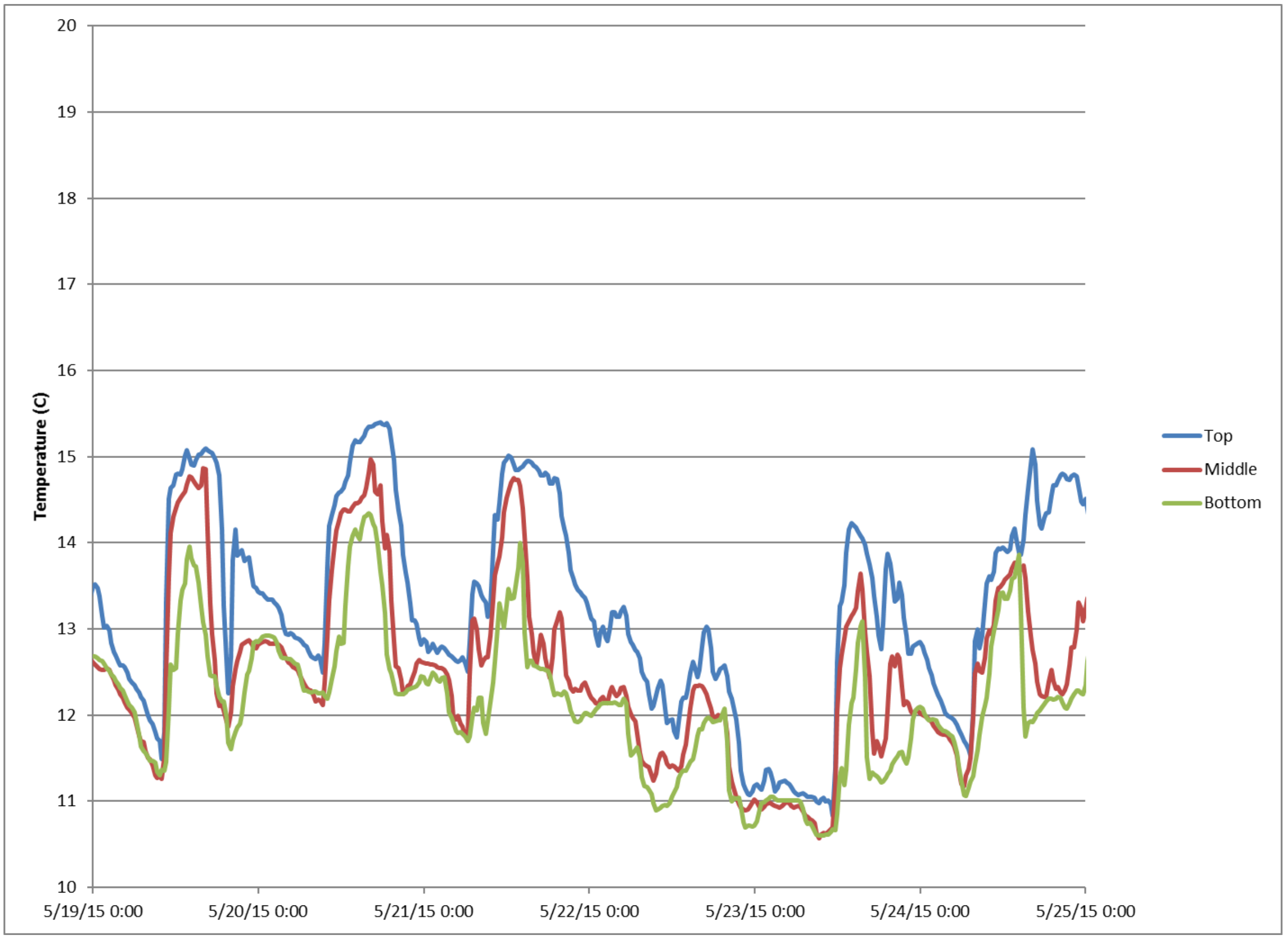
Dissolved oil components and floating slicks ejected from the surf zone can be mixed vertically on the inner shelf, due to waves, winds, and surface heat fluxes.

To examine the amount of mixing on the inner shelf, data is available from nearshore moorings with thermistors placed near the surface, at mid-depth, and near the bottom. The locations of these moorings, which are part of the Santa Barbara Coastal Long Term Ecological Research Project (sbc.lternet.edu), are shown in the figure below. The moorings are generally in 10-15 m of water.

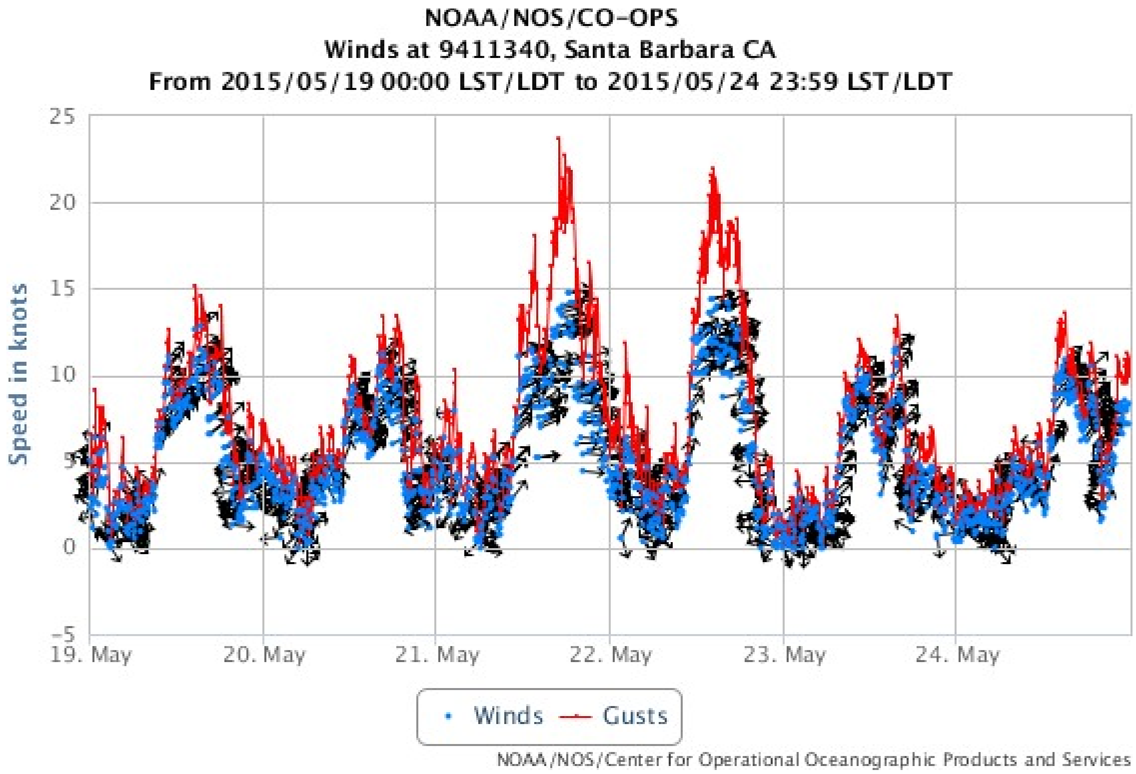


Temperature data from the ARQ mooring (west of Refugio) is shown below. This mooring is in ~15 m of water and is the closest site to where the oil entered the water at Refugio beach. The mooring has three thermistors, located near-surface (at about 3-4m depth), mid-water column, and ~1m above the bottom.

Temperature (°C) at ARQ LTER mooring (15 m)



The diurnal cycle of daytime heating and night time cooling is evident at this location and other sites along the coast. Stratification is generally quite low, suggesting a well-mixed water column at least to mid-depth (~7.5 m) much of the time.



Mixing is driven by surface wind and wind-wave interactions (e.g. Langmuir circulation or windrows). Winds measured at the NOAA COOPS buoy near Santa Barbara are shown above. They tend to be strongest during the afternoon (land/sea breeze effect), typically exceeding 10 kts by late afternoon. In the absence of winds, the signature of daytime heating would be confined to a thin layer at the surface. However, the strong afternoon winds mix heat downwards through the water column so the diurnal heating and cooling signature is evident at all depths.

Mixing also occurs at night due to cooling surface waters, which leads to convection. This is evident in the nearly uniform temperatures at all 3 depths at night.

Based on these data, it is reasonable to assume that dissolved oil constituents and small oil droplets could have been mixed to the depth of the lowest thermistor – approximately 14 m.

Draft Refugio Beach Oil Spill (RBOS) Damage Assessment and Restoration Plan (DARP)

APPENDIX B – Data Management and Access

1. Introduction

A number of datasets were collected by Technical Working groups (TWG) to support the Refugio Beach Oil Spill (RBOS) Natural Resources Damage Assessment (NRDA) and its determination of oil exposure and injury to habitats and resources, as described in the Damage Assessment and Restoration Plan (DARP). This document briefly describes how the public can access NRDA data and provides information on NRDA data management.

2. Data Access

In general, supporting data can be accessed in several ways:

1. On NOAA's DIVER website (Data Integration Visualization Exploration and Reporting) with links to queries and download options.
2. On Southwest ERMA (Environmental Response Management Application); geospatial layers with a shapefile download option.
3. Within the RBOS NRDA administrative record, as PDF documents or zipped data packages
4. By request via email.

This document also provides direct chapter by chapter data links (to numbers 1-3 above) for specific data used to prepare the DARP.

a. DIVER

Data collected in support of the NRDA were collected and managed in the DIVER platform, an environmental data warehouse developed and maintained by the National Oceanic and Atmospheric Administration (NOAA) Office of Response and Restoration (ORR) Assessment and Restoration Division (ARD). DIVER is a web-based data warehouse that allows the secure storage, management, query and dissemination of data and information.

Direct access to RBOS NRDA data is provided in the Data Links section of this document, organized by DARP chapter. Data are accessed through hyperlinked saved queries in the DIVER Explorer query tool.

To access DIVER use the links below that will take you directly to the DIVER Queries or visit https://www.diver.orr.noaa.gov/.

b. ERMA

Spatial data or analyses are also made available using ERMA, an online mapping and visualization tool. For the RBOS NRDA, ERMA was used to provide a spatial representation of some datasets that have been processed and exported to an ESRI shapefile and can be downloaded by using the ERMA download tab.

To access ERMA use the links below that will take you directly to the ERMA layers or visit https://erma.noaa.gov/southwest/.

c. Administrative Record

Datasets that were not integrated into DIVER or into a GIS format and uploaded into Southwest ERMA will be made available in the RBOS NRDA administrative record. These files will be mainly available in folders called "Data Documents."

To access the administrative record visit https://www.darrp.noaa.gov/oil-spills/refugio-beach-oil-spill.

d. Data Available Upon Request

There are some datasets that were not made immediately available on DIVER or in Southwest ERMA due to volume or complexity. To access these data sets or to request further information on RBOS data please contact orr.diver@noaa.gov or orr.erma@noaa.gov.

3. Data management

a. Field Data Collection and Processing Workflow

Field data collection activities were completed following a standard protocol that maintains chain of custody (COC) Field teams were dispatched with data collection equipment that included a subset of the following sampling equipment or supplies: handheld GPS devices, digital cameras, notebooks, sample containers, and field forms. Upon return from the field to a data intake location, field staff worked with data managers to download GPS and photos and scan field forms, notes and documentation. Chain of custody forms were filled out, scanned and included with samples shipped to laboratories for analysis. Once all of the data files were transferred to the data managers' laptop, they were loaded into DIVER for secure storage and sharing among the project teams.

b. Laboratory Data

After samples were collected, relevant field data were transcribed and loaded into DIVER. The samples were sent to laboratories for chemical, forensic or toxicological analyses. The four primary laboratories used during the damage assessment were: California Department of Fish and Wildlife (CDFW) State Water Pollution Control Lab (Rancho Cordova, CA), Alpha Analytical (Boston, MA), NOAA Northwest Fisheries Science Center (Seattle, WA) and Pacific Eco Risk (Fairfield, CA). Laboratories conducted analyses and transcribed field data found on the sample labels and COCs into their Laboratory Information Management System (LIMS) along with the analysis results. Laboratories exported the analysis result data into an Electronic Data Deliverable (EDD) and sent it back to NOAA data managers for integration with the existing field data in DIVER.

c. Quality Assurance

Quality assurance of field data was conducted at various stages during the processing of data. Field data were reviewed by the responsible party and trustee data representatives, while analytical result data were validated by a third party, Moss Landing Marine Laboratories (MLML). A final data validation report from MLML can be found in the administrative record.

4. DARP Chapter-by-Chapter Data Links

Below are links to ERMA layers and DIVER data queries referenced throughout the RBOS Damage Assessment and Restoration Plan (DARP). The outline below refers back to the DARP chapter organization. Only chapters that discuss or reference data are included below.

DARP Section 1. Introduction and Purpose

1.1 Overview of Incident

1.1.2 Transport and Fate of Spilled Oil

Figure 2. Particle densities (relative to maximum for the entire simulation) for the base-case of 1-4% windage. Black dots mark the locations where particles contact the shoreline.
ERMA Link

- Layer Name: GNOME NRDA Oil Trajectory Time Animation

NOTE: This is a time animation layer that allows the user to see an animation of the modeled trajectory through time. To view, press the play button on the time slider bar at the bottom right of the screen. The clock icon on the layer name should be green. If it is not, click the clock icon to start the animation and activate the time slider bar.

- Layer Name: GNOME NRDA Shoreline Oiling (NOAA) Multiple Days (May 20 – 29, 2015)
- Layer Name: GNOME NRDA Trajectory (NOAA) Multiple Days (May 20 – 29, 2015)

Figure 3. Map showing total U.S. Coast Guard overflight observations of surface oil over a 14 day period between May 21, 2015 and June 3, 2015. Note that the representations of sheen in this graphic are cumulative, i.e., oil was not in all of these locations at any given time.
ERMA Link

- Layer Name: Overflight Observation of Sheen (500 Meters)
- Layer Name: Oil Exposure Boundaries

1.1.3 Forensic Identification of Line 901 Oil in the Environment

Figure 4. Geographic extent of Line 901 oil. This Figure shows oil samples collected and analyzed on behalf of the Trustees through June 2, 2015, when the Trustees' trajectory modeling suggests that oil would have moved through the impacted area. This does not include samples collected by the response and analyzed for the criminal investigation. In People of the State of California v Plains All American Pipeline, L.P., Sup. Court of State of California, County of

Santa Barbara, Case No. 1495091, People's Trial Exhibit 078.0001 oil was documented as far south as Seal Beach in Orange County.
ERMA Link

- Layer Name: NRDA Oil Fingerprint Results from May 19th to June 2nd, 2015

1.3 Summary of Natural Resource Injuries

Figure 5. Refugio Beach Oil Spill fingerprint matches (red circles) along with the habitats and resources that were injured by the spill.
ERMA Link

- Layer Name: NRDA Exposure Zones
- Layer Name: RBOS All Fingerprint Matches
- Layer Name: Refugio Incident Location

2.0 Affected Environment

2.1 Physical Environment

Figure 7. Public lands and protected areas in the vicinity of the Refugio Beach Oil Spill origin. Additional public lands managed by Counties and Cities occur in the area but are not shown on this map.
ERMA Link

- Layer Name: Refugio Incident Location
- Layer Name: Coal Oil Point Reservation Boundary
- Layer Name: DARP California State Parks (CDFW, 2014)
- Layer Name: DARP California Marine Protected Areas
- Layer Name: DARP National Park Boundaries
- Layer Name: DARP NOAA National Marine Sanctuary Boundaries

5.0 Injury Approved Quantification and Restoration Alternatives

Figure 8. Exposure zones A-D, defined for the Refugio Beach Oil Spill NRDA (black lines) with shoreline oiling categories documented during Shoreline Cleanup Assessment Technique surveys conducted by the Unified Command.
ERMA Link

- Layer Name: NRDA Exposure Zones
- Layer Name: Shoreline Oiling Categories (Nixon, 2018)

5.1 Shoreline Habitats

5.1.1 Overview of Data Collection and Studies

Environmental Sample Collection and Chemical Analysis

DIVER Query Link

- Query Name: Refugio DARP All NRDA Chemistry Analysis Results

Sandy Beach Intertidal Invertebrate Population Surveys

- Data available upon request.

Rocky Intertidal Habitat Photo Transect

- Data available upon request.

Laboratory Tests with Shoreline Species

- Data available upon request.

Shoreline Clean Up Data

- Data available upon request.

5.1.2 Sandy Beach Habitat Injury

Figure 17. Map showing the summary of shoreline injury by zones.
ERMA Link

- Layer Name: Shoreline Oiling Categories (Nixon, 2018)
- Layer Name: NRDA Exposure Zones

Porewater Individual Chemical Analysis Results
DIVER Query Link

- Query Name: Refugio DARP Porewater Chemistry Analysis Results

Talitrid Tissue Individual Chemical Analysis Results
DIVER Query Link

- Query Name: Refugio DARP Beach Hopper (Talitrid) Chemistry Analysis Results

Tissue Individual Chemical Analysis Results of Other Shoreline Organisms (mussels, sandcrabs, polychaete worms)
DIVER Query Link

- Query Name: Refugio DARP Sandy Beach Chemistry Analysis Results for "Other Shoreline Organisms"

Talitrid Amphipod Abundance

- Data available upon request.

Sandy and Mixed Sand/Rocky Substrate Exposure Acreage
ERMA Link

- Layer Name: Intertidal Habitat Exposure Zones with Max Oiling - Exposure (UPDATED 2018)

5.1.3 Rocky Intertidal Habitat Injury

Rocky Intertidal Chemical Analysis Results
DIVER Query Link

- Query Name: Refugio DARP Rocky Intertidal Mussel Chemistry Analysis Results

Rocky Intertidal Photo Plot Surveys

- Data available upon request.

5.2 Subtidal and Fish Habitats

Figure 21. Exposure Zones defined for the Refugio Oil Spill NRDA showing shoreline tarball fingerprint matches (red circles). Zone B is the area of heaviest oiling and the extent of subtidal habitat injuries assessed. The inset shows the subtidal assessment area identifying the 10 m depth offshore extent of injury (red polygon).
ERMA Link

- Layer Name: RBOS All Fingerprint Matches
- Layer Name: Subtidal Exposure Zones

5.2.1 Overview of Data Collection and Studies

Fish and Invertebrate Mortality Observations – Dead Box Observations

- Data available upon request.

California Grunion Assessment - Grunion Spawning Observations

- Data available upon request.

California Grunion Assessment - Grunion Hatching Observations

- Data available upon request.

Surfperch Assessment - Surfperch Individual Chemical Analysis Results
DIVER Query Link

- Query Name: Refugio DARP California Surfperch Chemistry Analysis Results

Water Chemistry and Toxicity to Fish and Invertebrate Early Life Stages

- Data available upon request.

Sunken Oil Subtidal Habitat Exposure Observations

- Data available upon request.

Subtidal Habitat Exposure Assessment - Subtidal Tissue Individual Chemical Analysis Results
DIVER Query Link

- Query Name: Refugio DARP Subtidal Tissue Chemistry Analysis Results

Subtidal Habitat Exposure Assessment - Fingerprinting Results
ERMA Link

- Layer: Subtidal Tissue Fingerprint Matches
- Layer: Additional Forensic Matches (Stout, Reddy, Valentine)

PAH's in Nearshore Fish and Invertebrate Tissue
DIVER Query Link

- Query Name: Refugio DARP Office of Environmental Health Hazard Assessment (OEHHA) Individual Chemical Analysis Results

Surfgrass and Algae Surveys

- Data available upon request.

5.2.2 Subtidal and Fish Habitat Injury

Figure 25. The surfgrass and algal injury quantification was driven by studies where the area of discolored, dead and dying plants were assessed. Injury was defined as the percent cover of discolored, dead and dying surfgrass and algae at a study site. The overall area-weighted average percent injury was 54%. Green dots are sampling sites.
ERMA Link

- Layer: Surfgrass Sampling Locations
- Layer: NRDA Exposure Zones

5.3 Birds

Figure 27. Location of live and dead birds recovered during wildlife operations. The back lines show the NRDA Exposure Zone boundaries for reference; however these boundaries were not used in the quantification of injury to birds.
ERMA Link

- Layer Name: Response Collected Birds

- NRDA Exposure Zones

5.3.3 Western snowy plover injury analysis

Figure 30. Refugio oil spill release location relative to nesting western snowy plover nesting sites.
ERMA Link

- Layer Name: Western Snowy Plover Nesting Locations

Wildlife Reconnaissance Aerial Surveys

- Data available upon request.

5.4 Marine Mammals

Figure 33. Location of marine mammal strandings, live and dead, collected during the spill cleanup period. The back lines show the NRDA Exposure Zone boundaries for reference; however these boundaries were not used in the quantification of injury to marine mammals.
ERMA Link

- Layer: Response Collected Mammals

California Marine Mammal Stranding Network Data

- Data available upon request.

5.4.1 Overview of Data Collection Studies

Wildlife Response Reconnaissance Surveys – Unified Command
ERMA Link

- Layer: Wildlife Observations Multiple Days (May 21 – May 26, 2015)

Figure 35. Tracklines of one day of NRDA mammal surveys, including sightings for that day.
ERMA Link

- Layer: Marine Mammal Survey (Multiple) (June 3, 2015 – June 7, 2015)
- Layer: Marine Mammal Survey Tracklines (Multiple) (June 3, 2015 – June 7 2015)

5.5 Human Use

Figure 37. Overview of posted Closures and Advisories after the Refugio Beach Oil Spill.
ERMA Link

- Layer: Recreational Use Large Area Closures
- Layer: Recreational Use Advisories and Closures Compilation

APPENDIX C: RESOURCE EQUIVALENCY ANALYSIS

Background
There are two basic approaches to measuring the compensation for natural resources injuries. One is to focus on the demand side, the "consumer valuation approach"; the other is to focus on the supply side, the "replacement cost" approach. In the former, we seek to measure the monetary value that the public puts on the natural resources (i.e., how much the public demands the services of natural resources); in the latter, we seek to measure how much it costs to replace the natural resource services that the public loses as a result of the injury (i.e., how much it costs to supply natural resource services). See the Glossary for complete definitions of some of the terms used here.

FIGURE 1: Consumer Valuation versus Replacement Cost Approaches for Natural Resource Damage Calculation

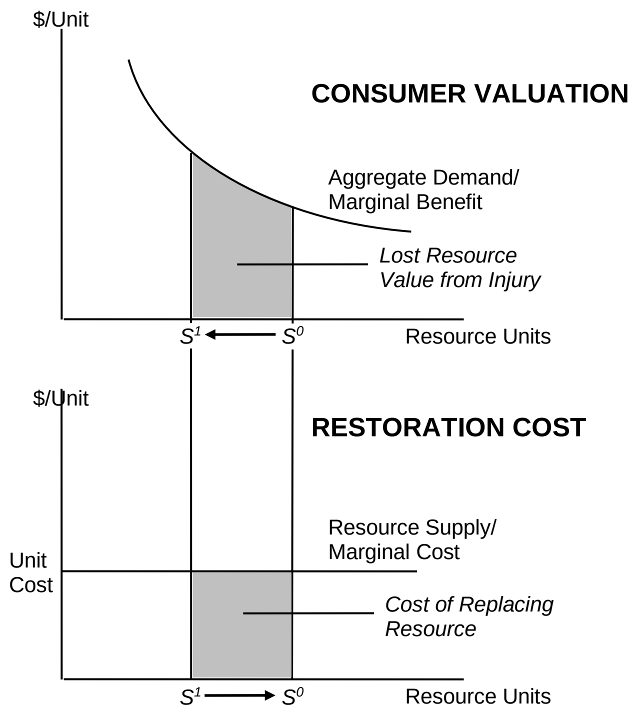


Figure 1 illustrates the difference between these two approaches. In both graphs, the supply of natural resources shifts from S^0 to S^1 as a result of an incident (e.g., oil spill, sediment discharge into a stream, illegal removal of vegetation). The shaded area in the top graph illustrates the dollar value of the resource loss as measured by the monetary payment that would make the public indifferent to the incident. For example, if each individual in a 30 million person society would need a $.05 payment (on average) to make them indifferent to the resource loss, the shaded area in the top graph would equal $1.5 million. Because the difficulty in observing market prices that reveal the level of cash payment that would compensate individuals for resource losses, the quantitative characteristics of the demand curve(s), and consequently the size of the shaded area in the upper graph, are difficult to measure. Contingent Valuation (CV) and other types of analyses are designed to estimate this dollar value. These methodologies typically involve large surveys and can be costly.

The lower graph illustrates a replacement cost approach. Beyond noting that the injured resource has value, the actual extent to which the public values it is not directly considered. Instead, the determination of adequate compensation depends on the level of natural resource provision (versus monetary payments) that compensates society for what it has lost as a result of the incident. The cost of providing this compensation becomes the estimate of damages. Resource Equivalency Analysis (REA) is the primary methodology for conducting this type of measurement in natural resource damage assessment. It is depicted by a resource supply shift in the lower graph from S^1 back to S^0. The shaded area is the total monetary cost of funding the supply shift. For example, if 2 acres of wetland enhancement are estimated to compensate for an incident that temporarily reduced the service value of 1 acre of wetland habitat, the cost of performing 2 acres of wetland enhancement becomes the estimate of damages.

It is clear from Figure 1 that the public's valuation of the resource (the shaded area in the top graph) is not necessarily equal to the total replacement cost (the shaded area in the bottom graph). This is especially true when unique resources or rare species are involved, as the slope of the aggregate demand curve (top figure) may be much steeper due to resource scarcity. This would result in a much larger monetary payment being necessary to compensate the public. In such a case, the replacement cost approach of REA may result in damages far less than the losses as valued by the public. However, because it is easier and less costly to measure the total replacement cost than the total public value, REA has an advantage over other methods, especially for small to medium-sized incidents with minimal impact on rare species.

Resource Equivalency Analysis

In this assessment, REA has been used to determining compensatory damages. This method is relatively inexpensive and relies primarily on biological information collected in the course of determining natural resource injuries caused by the spill. It is consistent with approaches recommended in the language of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the Oil Pollution Act of 1990 (OPA).

REA involves determining the amount of "natural resource services" that the affected resources would have provided had it not been injured, and it equates the quantity of lost services with those created by proposed compensatory restoration projects that would provide similar services. The unit of measure may be acre-years, stream feet-years, or some other metric. The size of the restoration project is scaled to the injury first; the cost of restoration is then calculated after the scaling has been done. The cost of restoring a comparable amount of resources to those lost or injured is the basis for the compensatory damages. In this sense, REA calculates the *replacement cost* of the lost years of natural resource services.

Future years are discounted at 3% per year, consistent with National Oceanic and Atmospheric Administration recommendations for natural resource damage assessments. Discounting of future years is done based on the assumption that present services are more valuable than future services. When it comes to natural resources, the question of whether or not society should value the present more than future is a philosophical question (e.g., one can recall the "greenhouse effect" and the question of how much expense we should incur today to preserve the future). However, the question of how much society actually discounts the value of future natural resources is an empirical one. The 3% figure is currently the standard accepted discount rate for natural resource damage assessments.

REA involves three steps: 1) the debit calculation, 2) the credit calculation, 3) the computation of the costs of restoration. These calculations may be done in a variety of ways, but the most common are to estimate the injury and the restoration benefits in terms of area years of habitat or animal years.

Habitat Example

For example, suppose a 10-acre area is degraded due to an oil spill such that it supplies only 30% of its previous habitat services during the year following the incident. In the second year after the incident, the habitat begins to recover, supplying 90% of its baseline services. By the third year it is fully recovered. In this case, the lost acre years of habitat services would be 70% x 10 acres x 1 year + 10% x 10 acres x 1 year = 8 acre years of habitat services. Figure 2 illustrates this example by showing the recovery path of the habitat over time.

As stated above, future years are discounted at a 3% rate, thus the injuries in the second year count a little less. Incorporating this, 7.97 acre years of habitat services were lost. This difference appears minimal here, but becomes significant (due to compounding) if injuries persist many years into the future.

The credit calculation focuses on the gain in habitat services that result from a restoration project. Creating acre years of habitat services is a function of both area and time. Hypothetically, compensation could involve taking 7.97 acres of land with no habitat value (e.g., a parking lot) and turning it into productive habitat for 1 year. Alternatively, we could achieve compensation by creating 1 acre for 7.97 years. In reality, most restoration projects involve taking previously degraded habitat (at another nearby location) and restoring it over a number of years, and maintaining it into the future.

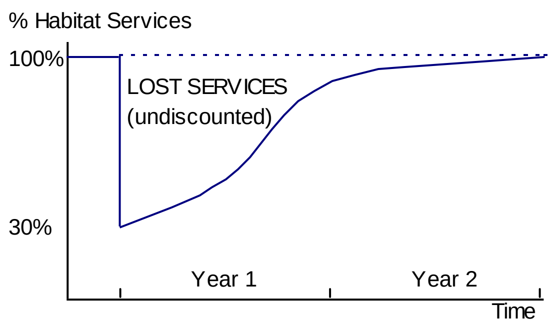


FIGURE 2: Biological Injury and Recovery

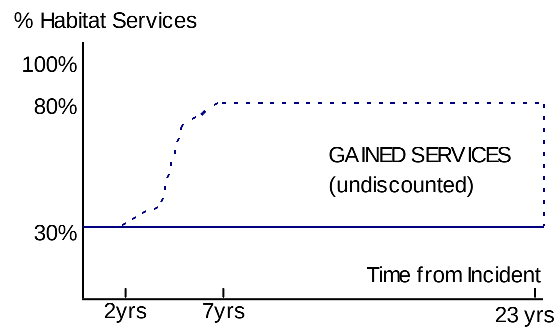


FIGURE 3: Restoration Trajectory/Credit

Suppose the restoration project improves the quality of a nearby degraded area, so that, if it previously provided only 30% of potential services, it would provide 80% of potential habitat services after restoration. Also suppose the project begins two years after the incident and it takes an additional 5 years for the 80% level to be achieved. Figure 3 provides an illustration of this restoration trajectory. In our hypothetical example, the project is expected to have a lifespan of 20 years. Note that, with future years discounted, the 20th year of the project (22-23 years after the incident) counts little; years after that are effectively completely discounted due to uncertainty regarding the future.

Mathematically, we seek to restore an area that will provide 7.97 acre years of services over the discounted 20-year phased-in life span of the restoration project. In this example, that would be an area of about 1.3 acres. That is to say, restoration of 1.3 acres for 20 years would compensate the public for the 7.96 lost acre years of habitat services due to the spill. Visually, the area identified in Figure 2 (multiplied by the affected acres and calculated to measure the present discounted value) should equal the area identified in Figure 3 (again, multiplied by the acres targeted for restoration and calculated to measure the present discounted value, thus discounting future years).

The percentage of habitat services lost (or gained, in the case of the restoration project) may be measured in a variety of ways. For our hypothetical oil spill case, three examples might include (1) the use of a habitat-wide evaluation index, (2) the use of one or more surrogate species, or (3) the use of an estimate based on the degree of oiling. Care must be taken when using a surrogate species to represent the entire affected habitat. Ideally, this surrogate is the population of one or more species that is immobile (that is, the animals do not move easily in and out of the affected area) and that has significant forward and/or backward ecological links to other species in the affected ecosystem. For example, the population of red crossbills, a bird that feeds primarily on pinecone seeds and migrates erratically from year to year, would be a poor surrogate for measuring injuries to a streambed. The aquatic macroinvertebrate community within the stream, however, provides an ideal surrogate, as they play a key role in the streambed food chain. Likewise, on the restoration side, care must taken when the project targets one or a few species rather than the entire habitat. Ideally, a project that seeks to restore the population of a key indicator species will also benefit the entire habitat and, thus, other species as well. Indeed, such projects typically focus directly on habitat improvements. However, it is important to verify that such a species-centered project is indeed benefiting the entire habitat.

Animal Example

When the injury is primarily to individual animals rather than a complete habitat, the REA may focus on lost animal-years. For example, suppose an oil spill causes negligible injury to a body of water, but results in the death of 100 ducks. Using information about the life history of the ducks (e.g., annual survival rate, average life expectancy, average fledging rate, etc.), we can estimate the “lost duck years” due to the spill. On the credit side, we can examine restoration projects designed to create duck nesting habitat and scale the size of the project such that it creates as many duck years as were lost in the incident.

Restoration Costs = Natural Resource Damages

Once the proposed restoration projects are scaled such that they will provide services equal to those lost due to the incident, the cost of the projects can be calculated. Note that this is the first time dollar figures enter the REA process. Until now, all the calculations of the “equivalency” have been in terms of years of resource services. The cost of the restoration projects is the compensatory damage of the incident.

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GLOSSARY

Aggregate demand

the demand of all consumers combined; e.g., if there are 20,000 people in a town and each person demands two pieces of bread each day, the aggregate demand is 40,000 pieces of bread per day.

Compensatory restoration

a restoration project which seeks to compensate the public for temporal or permanent injuries to natural resources; e.g., if a marsh is injured by an oil spill and recovers slowly over ten years, a compensatory project (which may be off site) seeks to compensate the public for the ten years of diminished natural resources.

Discount rate

the rate at which the future is discounted, i.e., the rate at which the future does not count as much as the present; e.g., a dollar a year from now is worth less than a dollar today; if the bank offers a 3% rate, whereby $1.00 becomes $1.03 in one year, the future was discounted at 3%.

Primary restoration

a restoration project which seeks to help an injured area recover more quickly from an injury; e.g., if a marsh is injured by an oil spill and would recover slowly over ten years if left alone, a primary restoration project might seek to speed the recovery time of the marsh and achieve full recovery after five years.

Replacement cost

the cost of replacing that which was lost; e.g., if fifty acre-years of habitat services were lost due to an oil spill, the cost of creating fifty acre-years of similar habitat services would be the replacement cost.

Appendix D. Shoreline Exposure and Injury Evaluation Studies

The Shoreline Technical Work Group (TWG) consisted of two subgroups during the early stages of the Refugio Beach Oil Spill Natural Resource Damage Assessment (NRDA): one focused on sandy beach habitat and the other on rocky intertidal habitat. Subsequently, these subgroups merged to become the Shoreline TWG. The TWG identified several goals early on, including documenting the presence of the oil on shorelines, then documenting oil exposure and injury to shoreline organisms on those stretches of oiled shoreline. The injury evaluations proceeded by bifurcating the assessment of injuries attributable to oil exposure and injuries attributable to cleanup operations. Table 1 shows the planning strategy for the Sandy Beach TWG in October 2015. A similar strategy, documenting exposure and effects, was employed to assess rocky intertidal habitat injuries. Data and other information used to prepare this report are found in the Administrative Record for the case at https://www.diver.orr.noaa.gov/web/guest/diver-admin-record/6104.

		Planning - Sandy Beach TWG
	Injury Assessment	
Category	**Assessment Goal**	**Data type**
Contaminant	Oil presence	Photographs of oil
		Tarball samples & Observational Data (field notes, SCAT, etc.)
Exposure	Exposure of beach organisms to oil	Photos of oiled organisms
		Chemistry of tissue; Emerita, Euzonus, Talitrids
		Pore water chemistry on sandy beaches
		Mussel tissue chemistry results; PAHs
		Surf water chemistry results (PAHs)
Effects	1. Effects of oil on organisms	Dead organisms (photos, waypoints, and 'dead box' counts)
		Talitrid population survey data
		Grunion data, reproductive success
		Chemistry of beach invertebrate tissues; Emerita, Euzonus, Talitrids
		Mussel tissue chemistry results
		Bioassay results
	2. Effects of cleanup operations on organisms	Form 214 &/or 204 forms from response and notes documenting cleanup activity
		Wrack removal data
		Cobble and sand removal data
		Wrack survey data
		Talitrid survey data
		Vehicle use on beaches

Table 1. A draft table detailing the planning done for the sandy beach TWG from October 2015.

Presence of Oil

The presence of oil on shoreline was verified in several ways, including documenting it with photographs (Figure 1). These photos were generated from various sources, including Trustee personnel from the US Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA), University of California at Santa

Barbara (UCSB), and California Department of Fish and Wildlife (CDFW), as well as other contractors, partners and the media.

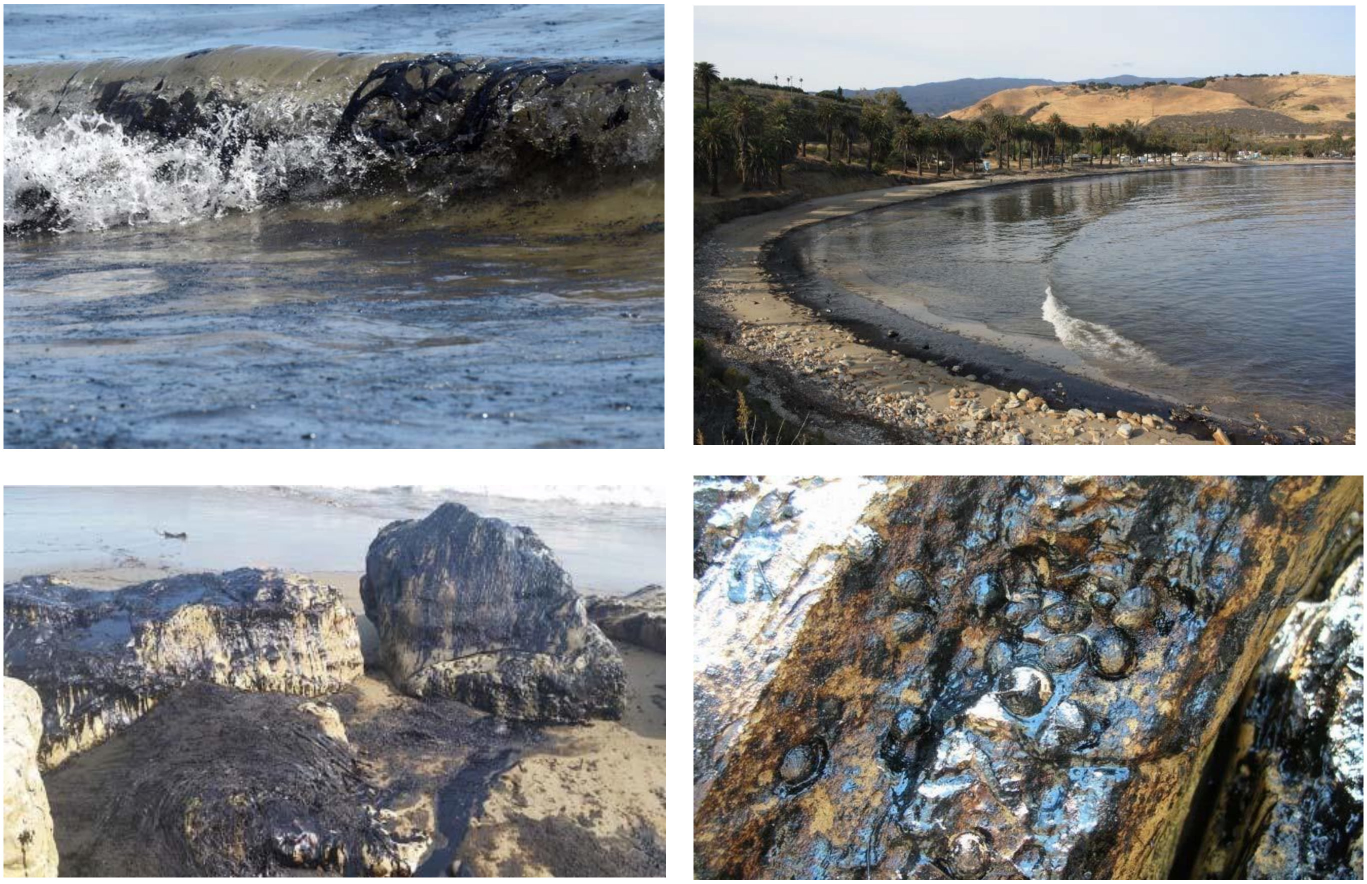

Figure 1. Photographs of Line 901 oil in the surf and on the shoreline, May 2015.

Because oil from natural seeps can be found along the southern California coast, it was important to verify the presence of Line 901 oil at oiled locations. Samples of ‘source oil’ were collected from the source of the spill on May 21, 2015, by the Trustees for forensic purposes. The Trustees also collected field samples of oil at a variety of shoreline locations in Santa Barbara, Ventura, and Los Angeles Counties. The samples were analyzed and then compared to the source oil to confirm the presence of Line 901 oil at the various oiling locations. In addition, the Trustees documented observations of oiling condition and other relevant observations of oiling on the shorelines.

The Trustees also considered observations of shoreline oiling documented by spill response Shoreline Cleanup and Assessment Technique, or SCAT teams, for response and cleanup purposes, i.e., “SCAT data”. Spill trajectory modeling results were also considered in conjunction with field observations and oil chemistry results. For example, the NOAA GNOME (General NOAA Operational Modeling Environment) model generated a trajectory showing the oil moving southeast all the way to Redondo Beach in Los Angeles County in late May 2015 (Appendix A of the Damage Assessment and

Restoration Plan). This was consistent with observations of shoreline oiling and the chemical analysis results for a tarball collected at Manhattan Beach.

Figure 2. Sand crabs fouled and affected by the Line 901 oil on 19 May 2015, at Refugio State Beach.

Exposure to Oil

Exposure to Line 901 oil was documented in several ways, ranging from observations that were recorded in field notes to photographs of oil on or in association with organisms (Figures 1 and 2), as well as a variety of chemical measurements of oil constituents in field samples. Chemical analysis results, including concentrations of polycyclic aromatic hydrocarbons (PAHs), were obtained from both surf water and porewater samples. Porewater is the water that exists in the pore spaces between sand grains. PAHs are known to be a toxic fraction of crude oil that is taken up by organisms. Surf water and porewater come into contact with a wide range of organisms, including three species sampled on sandy beaches: sand crabs (*Emerita analoga*), polychaete worms commonly referred to as Euzonus (*Thoracaphelia spp*.), and talitrids, more commonly known as beach hoppers (*Megalorchestia spp.*).

Multiple tissues types were collected at multiple locations at multiple points in time following the spill and analyzed for PAHs to document the extent of exposure to these toxic components of crude oil (Figure 3). This allowed for both a spatial and a time series data evaluation, providing a better understanding of where PAH uptake was occurring, its magnitude, and how long it persisted. Details on the forensic chemical results for tissues can be accessed in Appendix B of the Damage Assessment and Restoration Plan.

Mussels (*Mytilus spp.*), which attach to rocky substrates, were also sampled and chemically analyzed. The chemistry results confirmed that mussels were exposed to oil-derived PAHs in the surf water. The Trustees obtained hundreds of chemistry results from these different environmental media (e.g., water, sediment, tissues) to document the exposure of shoreline habitats and selected organisms to the chemical components of Line 901 oil (see Appendix B of the Damage Assessment and Restoration Plan).

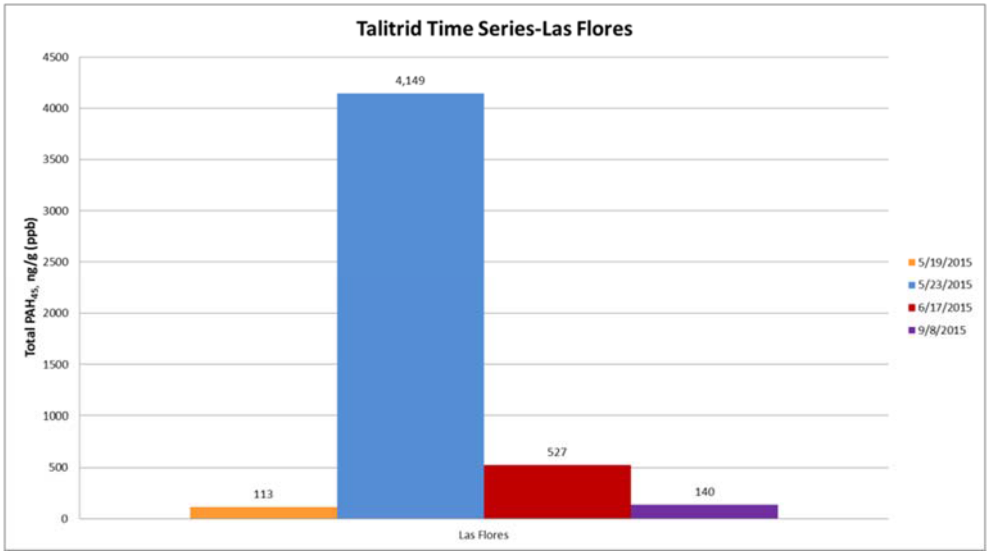

Figure 3. Talitrid tissue chemistry results for one sandy beach location, Las Flores, from a time series in 2015.

Injury

Shoreline injuries were categorized into two primary areas, injuries attributable to exposure to the oil and injuries attributable to the cleanup effort.

Effects of Oil

There was early and obvious evidence of the toxicity of the spilled material to aquatic and terrestrial organisms in the days following the Line 901 rupture and oil spill (Figure 4). Dozens of dead subtidal organisms (multiple species of various life stages) washed up on nearby shorelines in the days following the spill and were observed by NRDA teams and cleanup crews. The organisms were so numerous that response personnel overseeing early-phase cleanup activities and debris removal from Refugio State Beach contacted NRDA staff to discuss how best to capture and document the carcasses being found on the shoreline before they were disposed of along with all the other oily debris being removed by cleanup workers. A system for collecting these carcasses in boxes was quickly arranged. By day two or three of the spill cleanup, cleanup workers began separating the carcasses from other oily materials being removed from the beach and placing them into boxes to be photographed and enumerated by an NRDA team each day. This data set became known as the “dead box” data by the NRDA Trustees. This data provides evidence of injury to the subtidal- and shoreline-associated organisms that had washed up dead or in a moribund condition on nearby shorelines immediately following the spill. A summary of the types and numbers of organisms collected during this effort can be found in Appendix G-1 of the Damage Assessment and Restoration Plan.

Figure 4. A subset of the dead organisms found on 21 May 2015, Refugio State Beach.

The Trustees conducted talitrid population surveys to evaluate the impacts of the oil spill on these important sandy beach organisms. Talitrids are important processors of organic matter, especially kelp, also known as wrack deposits, and are also an important food source for shorebirds foraging on sandy beaches in California. The talitrid population survey results (Dugan, 2018) indicated their abundance, biomass, and age class distribution were affected by shoreline oiling as well as response operations. Talitrids were surveyed using standard methodologies developed by Dr. Jenny Dugan of the University of California at Santa Barbara. Where possible, the results of these surveys were compared to prior or reference conditions from earlier surveys at the same locations to evaluate the impacts of the oil spill on these organisms. In addition to the population surveys, survey teams photographed moribund or dead talitrids found in the oil that was deposited on the shoreline (Figure 5).

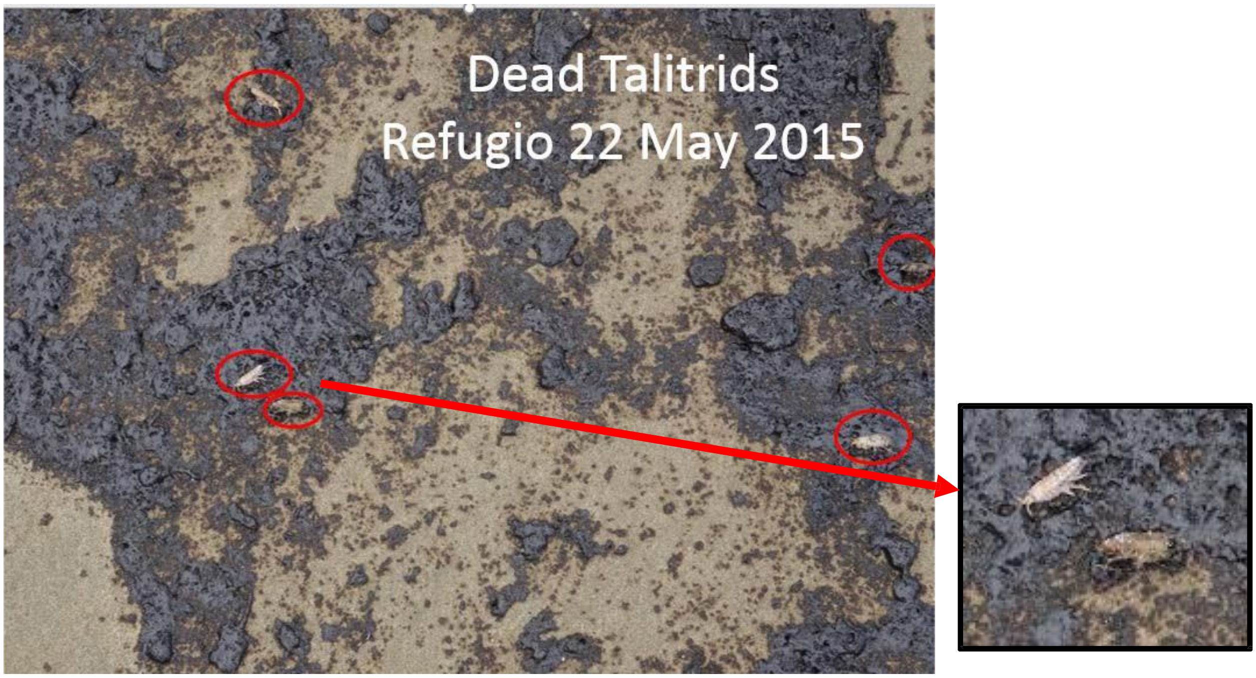

Figure 5. Talitrids found dead in oil deposits on the beach on 22 May 2015, Refugio State Beach.

To evaluate the toxic of effects of the 901 oil, bioassays, also known as toxicity tests, were conducted with the oil collected near the site of the Line 901 pipe rupture. Two common shoreline organisms were tested: the sand crab (*Emerita analoga)*, and the mussel (*Mytilus spp*). Early life stage organisms were utilized in these tests, as this spill occurred in the spring season when young organisms were present on the shoreline (Figure 6 is a photograph of the sand crabs). Results of the sand crab bioassays were compared to the chemistry results of both surf water and porewater samples collected following the spill, to estimate the toxic effects of the spilled material on this species (Figure 7). The results indicate that concentrations of oil constituents in surf-water samples exceeded levels found to affect growth and levels found to cause mortality (lethal concentration exceeded at Los Flores; lethal concentration exceeded at multiple locations when phototoxicity is taken into account). More details on the bioassay methods and results can be found in Appendix E of the Damage Assessment and Restoration Plan.

Figure 6. Early life stage sand crabs (megalope stage, the first non-pelagic life stage) collected for use in the bioassay, or toxicity tests, seen next to three grains of sand

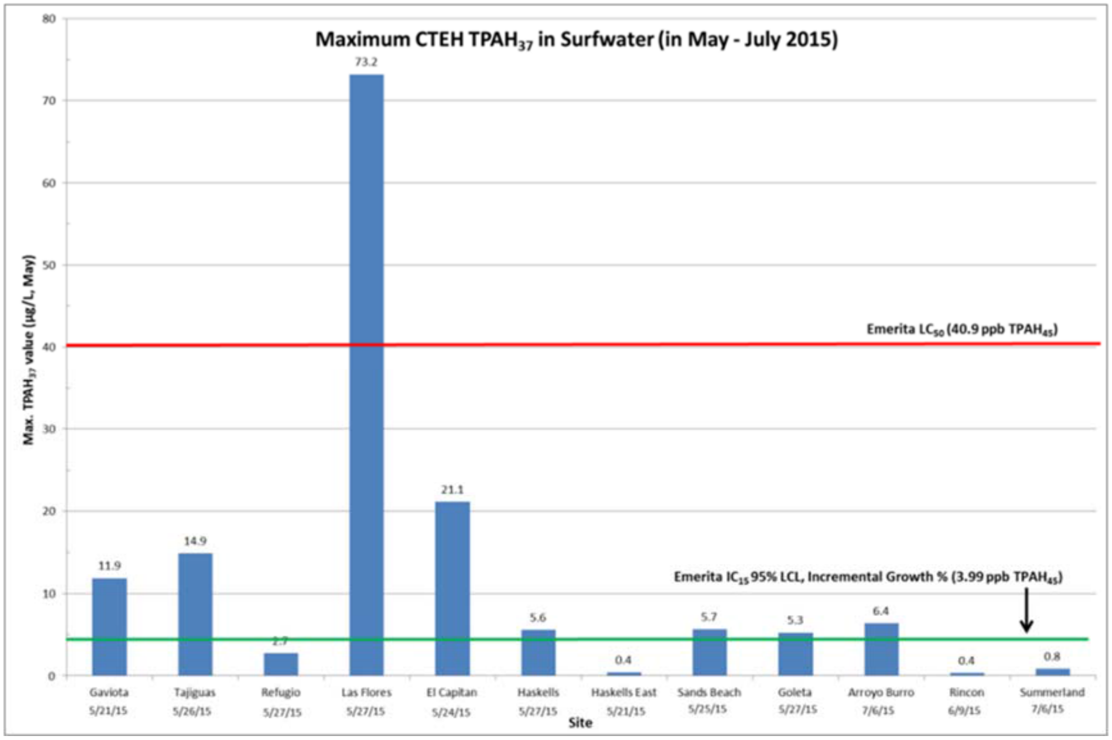

Figure 7. A. Results of bioassay work compared to maximum surf water concentrations measured in May through July 2015. For background on enhanced toxicity of PAHs to organisms with exposure to ultraviolet (UV) radiation, see Barron 2007.

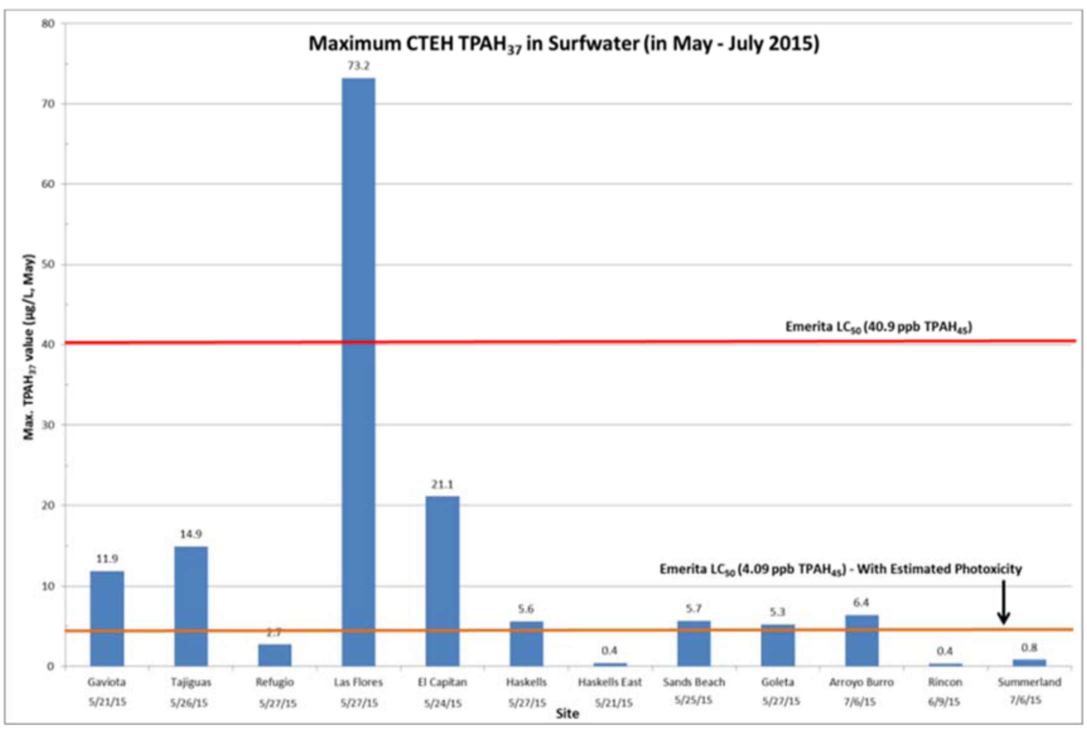

Figure 7 B. The phototoxicity benchmark shown is 10 times below the lab determined LC_{50}, and falls within the literature range of toxicity values from 2 to > 50,000 times less than non-UV exposed LC_{50} determinations for invertebrates. All other toxicity results are referenced in the bioassay report, Appendix E of the Damage Assessment and Restoration Plan.

The Trustees conducted rocky intertidal surveys to determine whether the oiling of rocky intertidal substrates (Figure 8) affected rocky intertidal communities, i.e., species composition. The surveys monitored for changes in abundances of sessile organisms, substrate, and “condition” (oil/tar presence, bleaching), within fixed plots over time (post spill and both six and twelve months post-spill). Teams surveyed permanent, “Long Term Monitoring” plots that already occurred within or adjacent to the approximate spill area footprint, allowing for comparison to historical data. In addition, several “Rapid Assessment” sites (sites selected specifically to incorporate the footprint of the oiling) were surveyed to collect data shortly after the spill, using the same protocols. Transects of each site was established, running the length of the intertidal zone, and representative photographs were taken within quadrats (Figure 9) placed throughout the transects. Each photograph was quantified for overall proportion of substrate type and species presence, as well as general condition (oiled/bleached) of each. A more detailed discussion of methods and results can be found in Raimondi et al. (2019).

Figure 8. Oiled intertidal cobble/boulders near Refugio Beach soon after spill (left). Lower intertidal cobble at Refugio Beach, January 2016, showing lingering tar in heavily oiled locations (right).

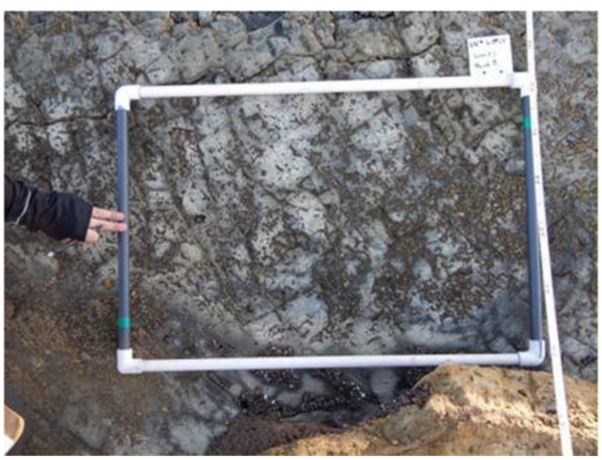

Figure 9. Rectangular quadrat used for photo-plot documentation.

Both “Long Term Monitoring” plots and “Rapid Assessment” sites were re-visited in Fall 2015 and Spring 2016 to examine for community differences, presence/absence of organisms, or proportional changes to communities or substrate. Study sites within the heaviest spill zone exhibited oiled biota, with some oil/tar persisting in anniversary sampling. In addition, minor community changes, including increases of algae species potentially indicative of oil-related impacts, were noted in the heaviest oiled locations when compared to less impacted sites (Figure 10).

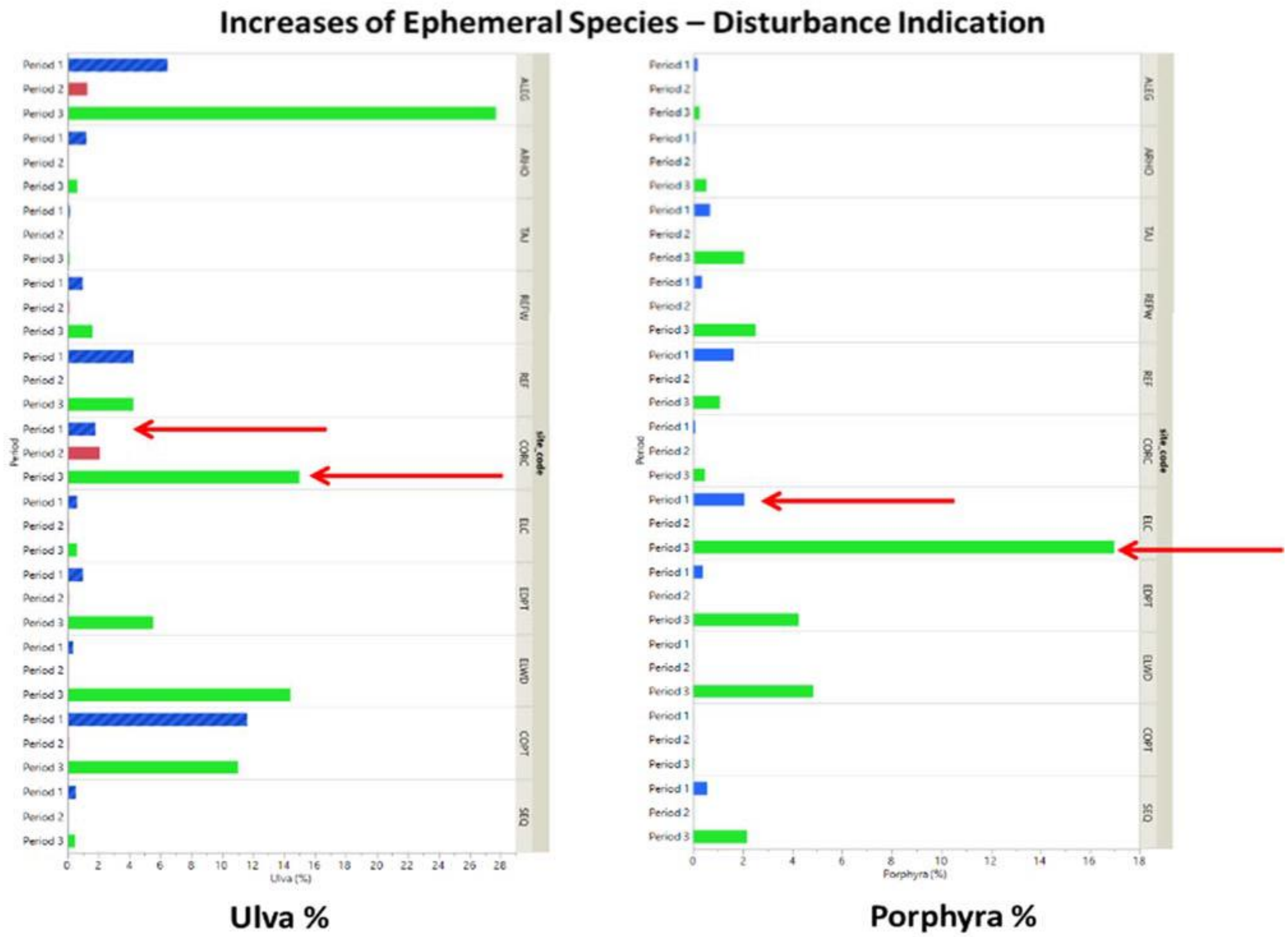

Figure 10. Proportion of *Ulva sp*. (green algae) and *Porphyra sp*. (red algae) presence across sites and time (Period 1 – post spill; Period 2 – 6mo post spill; Period 3 – 12mo post spill).

Effects of Cleanup Operations

The cleanup of the oil began not long after the release occurred, and while this removal of oil is helpful to the organisms and ecosystems affected in the long-term, there were some impacts to natural resources that were a direct consequence of the cleanup activities. The NRDA team tracked these impacts in several ways, including direct observation, review of Incident Command System (ICS) forms that documented the cleanup activities (i.e., ICS 204 forms), and the quantification of the organic and inorganic materials removed from the shoreline.

Oil removal operations included the use of several tools and techniques. Manual removal was one method employed, using crews of workers on the sandy beach portions of the shoreline. These efforts removed oil and oily materials to a visual endpoint (Figure 11).

Figure 11. Manual removal of oil and oily material from sandy shorelines. Stranded kelp, also known as wrack, was one material that was removed from shorelines.

Other cleanup efforts involved the scraping of rock and hard substrates on the shorelines, though crews were instructed not to remove visible biota in the process. Some cobble beaches were disassembled in the cleaning process, and cobble was placed in the surf zone for the final phase of the cleaning (Figure 12).

Figure 12. A highly disturbed shoreline in the process of being cleaned by the response operations workers.

The shoreline habitats were also impacted by the use of vehicles. Often vehicles were used to transport workers alongshore to worksites. This imposed physical injury to sand dwelling organisms such as talitrids, and left visible signs of tire tracks on the shoreline in some locations (Figure 13). Records were reviewed and summarized (Hubbard and Dugan, 2016) to estimate the amount of cleanup activity, quantified in days, on the shoreline habitats following the spill (Figure 14).

Figure 13. Vehicle use and tracks near Arroyo Quemado.

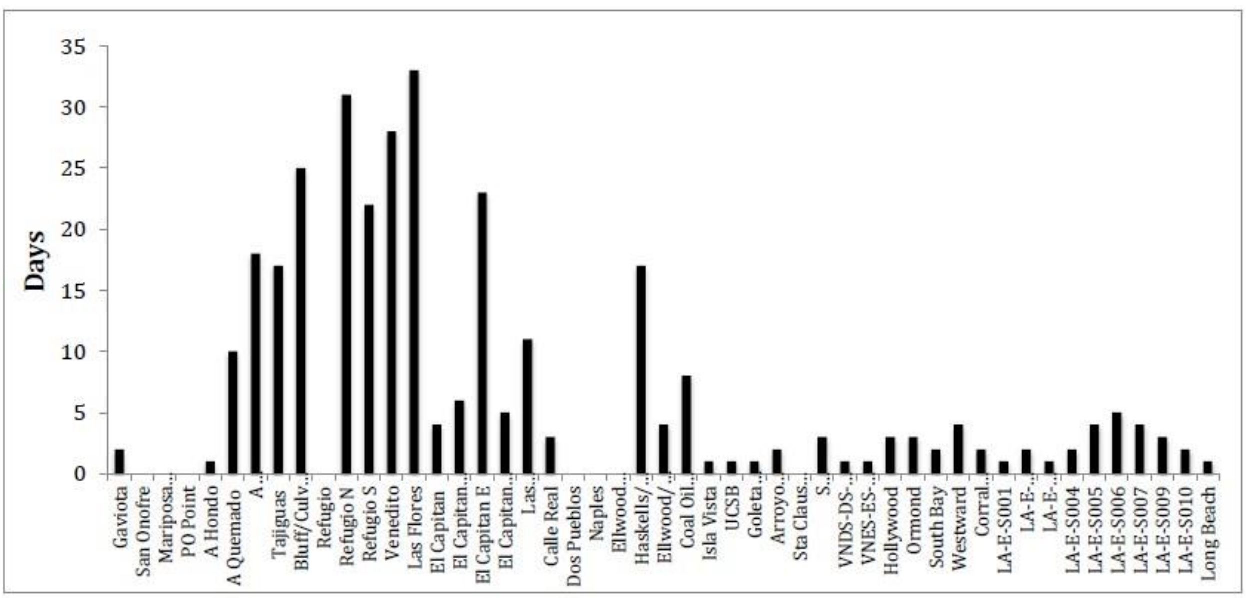

Figure 14. Documented days of clean up activity by location for 19 May to 21 August 2015.

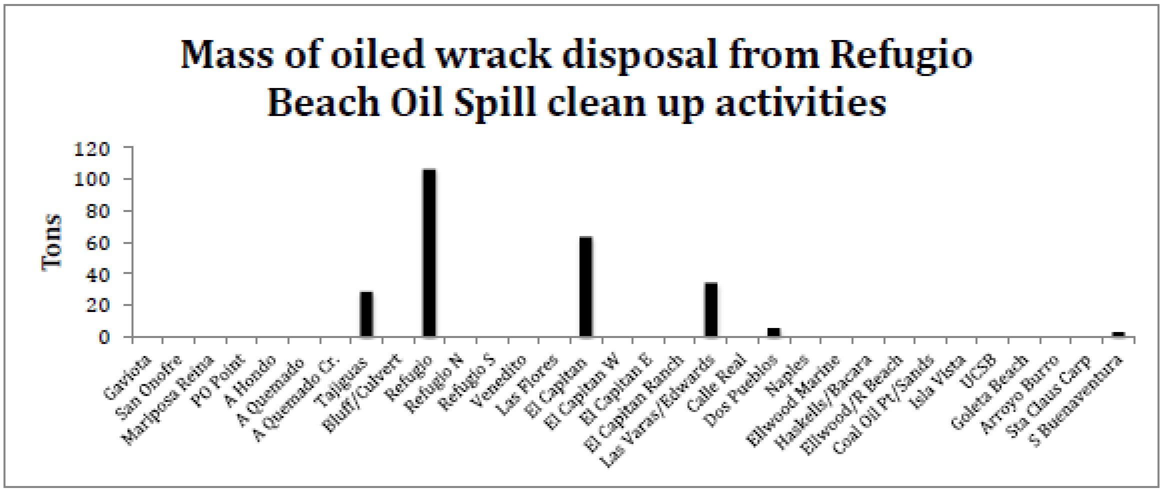

Figure 15. Mass of wrack (kelp, surf grass, and other biological materials) removed at six locations during the cleanup period. Locations are organized from West to East, or up-coast to down-coast.

The operations unit of the response effort quantified (Figure 15), the mass of oily waste removed from beaches (e.g., wrack, sand and cobble). This response operations activity directly removed wrack community organisms, as well as a food source for birds, fish, and other vertebrates that feed on the organisms in that community. These data were used in evaluating the effects of clean up activity on shoreline ecosystems.

References

Barron, M., 2007. Sediment-Associated Phototoxicity to Aquatic Organisms. *Human and Ecological Risk Assessment*, 13:317-321. DOI: 10.1080/10807030701226285

Dugan, J., 2018. Population Survey Results on Intertidal Talitrid Amphipods for the Refugio Beach Oil Spill NRDA October 2018. 9 pp. NRDA Technical Report. RBOS Administrative Record.

Hubbard, D. and J. Dugan. 2016. Refugio Beach Oil Spill Shoreline Clean Up Effort Data Report 30 Aug 2016. 10 pp. NRDA Technical Report. RBOS Administrative Record.

Raimondi, P., Bell, C., Ammann K., Gaddam, R., Lohse, D., Douglas, M., George, M., Fletcher, N., Anderson, L., and M. Miner. 2019. Assessment of potential impacts to rocky intertidal community following the Refugio Beach Oil Spill, Santa Barbara County 05 September 2019. 166 pp. NRDA Technical Report. RBOS Administrative Record.

Appendix E. Supplemental Bioassay Report Information

Toxicity Bioassays

When oil spills occur in marine environments, concentrations of petroleum constituents dissolved or suspended in the water column are known to result in acute toxicity to marine organisms. Because petroleum products differ in chemical makeup, it is important to design toxicity bioassays that take into account the solubility and toxicity of the specific petroleum products whenever possible. With this in mind, laboratory toxicity bioassays were conducted on April 21-27, 2016, by Pacific EcoRisk Laboratory in Fairfield, CA, at the request of the Refugio Beach Oil Spill Trustees. These toxicity bioassays were conducted using dilutions of a high energy water accommodated fraction (HEWAF) of Line 901 oil that contained polycyclic aromatic hydrocarbons (PAHs), measured as the sum total of 45 PAHs (500, 100, 50, 10, 5, 1, and 0.5 µg/L as $TPAH_{45}$ and a seawater control). The laboratory toxicity bioassays used seawater and were designed to assess the effect of Line 901 oil on three marine species. These organisms were *Mytilus galloprovincialis* (mussels), *Menidia beryllina* (silverside – fish) and *Emerita analoga* (sand crabs). Endpoints included survival and sublethal endpoints (*e.g.* weight). For a detailed discussion of bioassay methods, as well as results and additional information, please see the toxicity bioassay report written by Pacific EcoRisk (2016).

Bioassay Methods

Adult mussels *M. galloprovincialis* were obtained from Taylor Shellfish Company in Shelton, WA. Embryos were generated from gravid adults. Prior to spawning, the adult mussels were held in seawater at a temperature of 12˚C. To induce spawning, the adults were placed into glass trays of clean seawater (filtered Granite Canyon seawater) at 20˚C. This increase in temperature induced the mussels to release sperm and eggs, and embryos were collected. Embryos were exposed to dilutions of the Line 901 HEWAF for 48 hours and survival was monitored.

The larval fish *M. beryllina* were obtained from Aquatic Indicators, St. Augustine, FL (a commercial supplier). Fish were maintained at 25˚C in aerated aquaria containing artificial seawater at a salinity of 34 parts per thousand (ppt) prior to their use in testing. Larval fish were exposed to dilutions of the Line 901 HEWAF for seven days after which the effects on survival and growth were evaluated.

Juvenile sand crabs *E. analoga* (megalopae) were collected from a field population at Salmon Creek Beach, Sonoma, CA, by Dr. Jenifer Dugan (University of California Santa Barbara) and California Department of Fish and Wildlife (CDFW) personnel.

Upon receipt at the Pacific EcoRisk laboratory, the organisms were maintained in aerated tanks of 34.0 ppt and 0.45-µm filtered seawater (collected from the U.C. Granite Canyon Marine Laboratory, Carmel, CA) at 15˚C prior to use in the testing. The sediment used as a substrate for the organisms in this test consisted of 50-70 mesh sized white quartz sand obtained from Sigma-Aldrich Corporation. Sand crabs were exposed to dilutions of the Line 901 HEWAF for six days after which the effects on survival and growth were evaluated.

CETIS

CETIS is a professional toxicity data analysis application developed and published by TidePool Scientific Software in McKinleyville, CA. Because of its comprehensive design, CETIS is frequently used by environmental toxicity laboratories to analyze bioassay dose-response data to estimate the lethal concentration to 50% of the test organisms (LC_{50}) and the effective concentration to 50% of the test organisms (EC_{50}). Definitions of the CETIS terms and results generated for and used in the bioassay report are included as well (Pacific EcoRisk, 2016).

Water Chemistry Conversions

As detailed in the Pacific EcoRisk Report (2016) samples of the HEWAF dilutions were collected daily and analyzed for 45 PAHs (Table 1) by the CDFW Water Pollution Control Laboratory. Detected PAH concentrations were summed to determine the total PAH_{45} ($TPAH_{45}$) concentration. During the Refugio Beach Oil Spill, surf water samples were collected by the Center for Toxicology and Environmental Health (CTEH). Their analyte list included 37 PAHs (Table 1). 1-Methylnaphthalene (1-MN) and 2-methylnaphthalene (2-MN) were summed to estimate the C1-naphthalene group and detected PAHs were summed to determine the total PAH_{37} ($TPAH_{37}$) concentration. For the bioassay chemistry data, the grand mean of the ratio of $TPAH_{37}$ to $TPAH_{45}$ was 0.84. This ratio was applied to adjust $TPAH_{45}$ bioassay endpoints to $TPAH_{37}$ equivalents (Table 2). Before the bioassay was initiated, dilutions of the HEWAF were made using water at 15°C and 25°C. The dilutions were analyzed for both $TPAH_{45}$ and total petroleum hydrocarbons (TPH). There was a linear relationship between the two variables (Figure 1) and the regression equation was used to estimate bioassay endpoints based on TPH (Table 2).

Table 1. PAHs measured by CDFW ($TPAH_{45}$) and CTEH ($TPAH_{37}$)

	PAH	CDFW-Total PAH_{45}	CTEH Total PAH_{37}
1	Naphthalene	•	•
2	Naphthalenes, C1 -	•	1-MN + 2MN
3	Naphthalenes, C2 -	•	•
4	Naphthalenes, C3 -	•	•
5	Naphthalenes, C4 -	•	•
6	Acenaphthylene	•	•
7	Acenaphthene	•	•
8	Fluorene	•	•
9	Fluorenes, C1 -	•	•
10	Fluorenes, C2 -	•	•
11	Fluorenes, C3 -	•	•
12	Phenanthrene	•	•
13	Anthracene	•	•
14	Phenanthrene/Anthracene, C1 -	•	•
15	Phenanthrene/Anthracene, C2 -	•	•
16	Phenanthrene/Anthracene, C3 -	•	•
17	Phenanthrene/Anthracene, C4 -	•	•
18	Pyrene	•	•
19	Fluoranthene	•	•
20	Fluoranthene/Pyrenes, C1 -	•	•
21	Fluoranthene/Pyrenes, C2-	•	•
22	Fluoranthene/Pyrenes, C3 -	•	•
23	Fluoranthene/Pyrenes, C4 -	•	Not Included
24	Benz[a]anthracene	•	•
25	Chrysene	•	•
26	Chrysenes, C1 -	•	•
27	Chrysenes, C2 -	•	•
28	Chrysenes, C3 -	•	•
29	Chrysenes, C4 -	•	•
30	Benzo(a)pyrene	•	•
31	Perylene	•	•
32	Benzo(e)pyrene	•	•

	PAH	CDFW-Total PAH_{45}	CTEH Total PAH_{37}
33	Benzo(b)fluoranthene	•	•
34	Benzo(k)fluoranthene	•	•
35	Benzo(g,h,i)perylene	•	•
36	Indeno(1,2,3-c,d)pyrene	•	•
37	Dibenz(a,h)anthracene	•	•
38	Dibenz(a,h)anthracene, C1-	•	Not Included
39	Dibenz(a,h)anthracene, C2-	•	Not Included
40	Dibenz(a,h)anthracene, C3-	•	Not Included
41	Dibenzothiophene	•	Not Included
42	Dibenzothiophenes, C1 -	•	Not Included
43	Dibenzothiophenes, C2 -	•	Not Included
44	Dibenzothiophenes, C3 -	•	Not Included
45	Biphenyl	•	Not Included

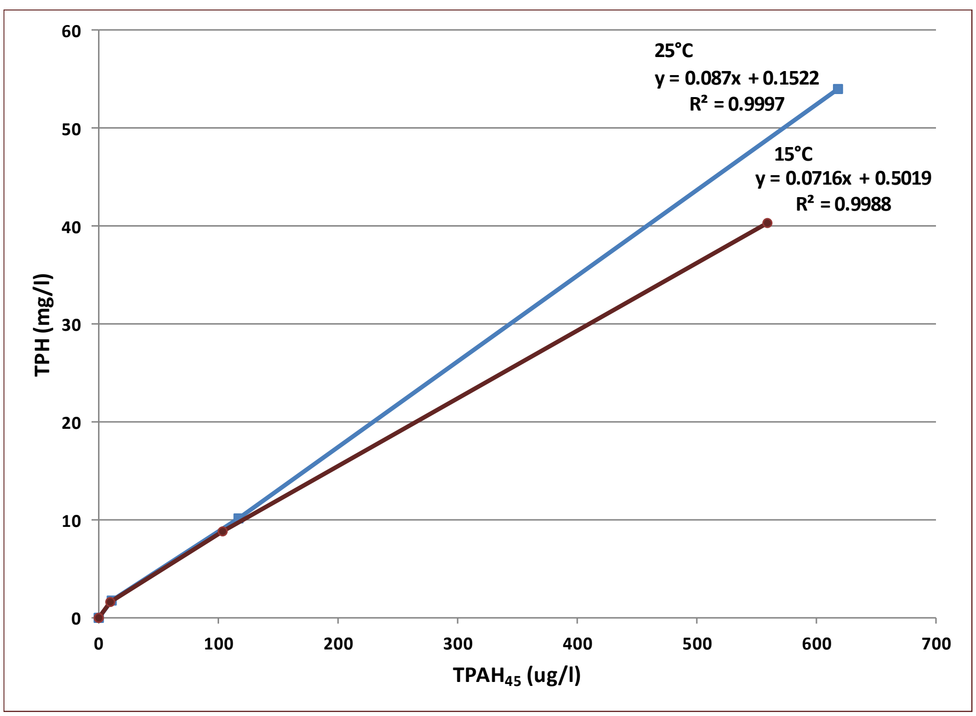

Figure 1. Relationship between total petroleum hydrocarbons (TPH mg/l) and total PAHs ($TPAH_{45}$ µg/l) for water accommodated fraction dilutions prepared at 25°C and 15°C.

Results

LC50's were calculated for bioassay endpoints in Table 2 (see below) for *E. analoga*, and *M. beryllina.* An EC50 (based on larval development) was calculated for *M. galloprovincialis*. In water-only exposures, where both $TPAH_{45}$ and $TPAH_{37}$ were measured, the order of increasing sensitivity is *E. analoga>M. beryllina >M. galloprovincialis.* Similarly, with TPH the order of increasing sensitivity is *E. analoga>M. beryllina* (Pacific EcoRisk, 2016).

Sand crabs (*E. analoga*) data in Table 2 were subsequently compared to porewater and surf water data collected during shoreline assessments. Silverside fish (*M. beryllina*) and mussel embryos (*M. galloprovincialis*) were subsequently compared to surf water data evaluated during subtidal habitat assessments.

Table 2. Bioassay endpoints expressed at total PAHs ($TPAH_{45}$ and $TPAH_{37}$) and total petroleum hydrocarbons (TPH).

Bioassay Endpoint	**$TPAH_{45}$ (µg/l)**	**$TPAH_{37}$ (µg/l)**	**TPH (mg/l)**
E. analoga LC_{50} – 6 days	40.9	34.4	3.4
M. beryllina LC_{50} – 7days	75.6	63.5	6.7
M. galloprovincialis EC_{50} 48 hours	381	320	Not available at 20° C

Reference

Pacific EcoRisk, 2016. Acute and Chronic Toxicity Testing in Support of the Natural Resource Damage Assessment of the Refugio Oil Spill 2 September 2016. 160 pp. NRDA Technical Report. RBOS Administrative Record.

Appendix F. Shoreline Habitat Equivalency Analysis

The Refugio Beach Oil Spill began on 19 May 2015 near Refugio State Beach in Santa Barbara County, California. Oil travelled down coast to Ventura and Los Angeles Counties. The initial injury (i.e., the percentage injury representing the first month after the spill) to shoreline resources occurred as fresh oil deposited along the shorelines, fouling beaches, adhering to the rocky substrate, and smothering fauna. Impacts to the habitats continued for months, as oil remained adhered to rocks and was buried in sand throughout several locations. There were additional impacts in some areas along the shoreline due to clean-up efforts, which included driving on beach habitat to access remote locations, scouring and/or movement of cobble, and removing beach wrack. In some of the more heavily oiled areas, it was not possible to clean up buried oil, and the response relied on fall and winter swells to remove accreted sand that had buried oil deposits, delaying biological recovery.

This appendix describes a habitat equivalency analysis (HEA) for spill impacts to shoreline intertidal habitats. The intertidal zone is an area of transition that provides unique habitat for aquatic and terrestrial species. Dozens of bird and fish species utilize this zone to feed on macroinvertebrates in the lower and upper intertidal areas of the shoreline. When evaluated in terms of biomass, sand beaches are dominated by sand crab (*Emerita analoga*) communities in the lower intertidal zone, and by beach hoppers (talitrid amphipods, including *Megalorchestia spp.*) in the upper intertidal zone. The upper intertidal is inhabited by a wide variety of other invertebrates, but their biomass is significantly lower than that of beach hoppers. Sand crabs and beach hoppers dominate the invertebrate biomass on Southern California sandy beaches (Dugan et al., 2003). As a defining ecological characteristic of lower intertidal communities, sand crabs were used as a measure to estimate and describe injury to lower intertidal habitats as a whole. Beach hoppers were selected as a proxy for assessing impacts to the upper intertidal community, as they are an important part of the sandy beach ecosystem that: 1) process organic matter such as stranded kelp material, also known as wrack; 2) make up a significant portion of food items for several bird species; and, 3) are amenable to assessment of their populations through field sampling.

Shoreline habitat injury is quantified in terms of acres of exposed habitat within the entire intertidal zone and characterized by the intensity or degree of initial impacts. Given the wide geographic spread of the oil and the magnitude of exposed acreage, the injury estimate is split into four geographic exposure zones (A through D), which cover the affected areas from west (up-coast) to east (down-coast) (Figure 1).

Figure 1. Oil exposure zones, as determined from Shoreline Cleanup and Assessment Team (SCAT) data.

Calculations of the injury integrated over time account for acreage, intensity, and duration of injury. Recovery in Zone B is characterized in monthly time steps that capture the seasonality in the recruitment of the key indicator species (Table 1). Zones A and C (outside the main area of impact) are expected to be subject to the same recovery mechanism as Zone B, but the biological impacts in these areas are only a fraction of what was experienced in Zone B. Injuries in Zone D were significantly less and were approximated only where Line 901 tarball-oiling was observed (Figure 1).

The majority of the shoreline of the spill affected area is comprised of mixed sandy and rocky habitats. Sand covers and scours boulders and other rocky outcrops through seasonal movement, preventing typical rocky intertidal communities (i.e., barnacles, mussels, algae, and other sessile organisms) from populating many of these areas. A large proportion of the area quantified as shoreline habitat within the spill zone was comprised of this mixed sandy/rocky habitat. Since many of these locations are devoid of significant rocky intertidal fauna/floral communities, the Trustees considered these areas to function mostly as sand beach habitat ecologically. To facilitate injury quantification, mixed sandy/rocky habitat was assessed as sandy beach. Based on the Trustees' calculation of shoreline habitat acreages (Appendix D of the Damage Assessment and Restoration Plan), a total of 1488 acres of sandy beach within Zones A-D, and 5.4 acres of rocky intertidal habitat (all within Zone B) were injured. The determination of area and the severity of the injury within each habitat type and exposure zone is further described below.

Quantification

The shoreline injury assessment (Appendix D of the Damage Assessment and Restoration Plan) involved studies that elucidated both exposure and injury to shoreline habitat species, including studies of representative fauna from different elevations of the shoreline (lower, middle, and upper intertidal), rather than attempting to study all species present on the shoreline. Sand crabs (*Emerita analoga*) were used to assess the lower intertidal habitat, bloodworms (*Thoracophelia mucronata,* formerly *Euzonus*) for the middle intertidal habitat (exposure only), beach hoppers (*Megalorchestia spp*.) for the upper intertidal habitat, and California mussels (*Mytilus californianus*) as a proxy for rocky intertidal species. Chemical analyses of body burdens of polycyclic aromatic hydrocarbons (PAHs) accumulated in these species, were used as indicators of oil exposure from the spill. Further, the first three species have different roles in the sandy beach food web, different levels of exposure to seawater and porewater (water table within the beach), different modes of respiration, and different pathways of exposure to buoyant material, such as oil and tarballs, that tend to strand in the upper beach. Exposure and injury studies concentrated on these and other representative taxa with the intention of using the information gathered to inform injury levels for the rest of the sandy beach community.

Rocky intertidal substrate surveys were conducted to monitor changes in abundances of sessile organisms, substrate, and "condition" (oil/tar presence, bleaching), along transects within fixed plots over time (post spill and six/twelve months post-spill), using a "RAPID assessment" protocol developed specifically for oil spills (Raimondi and Miner, 2009; Raimondi et al., 2012). Teams also surveyed permanent Long Term Monitoring sites within the approximate spill affected area that have been sampled over time using a similar protocol for comparison to historical data. In addition, biodiversity data gathered from Long Term Monitoring sites were used to examine patterns of community similarity among sites. Photos collected within each transect were scored and analyzed for substrate, condition (oiling/bleaching), species composition and proportion within the zone of view. Sites were re-visited in Fall 2015 and Spring 2016 to examine for community differences, presence/absence, or proportional changes to communities or substrate (Raimondi et al., 2019).

Shoreline injury estimates are based on multiple lines-of-evidence including abiotic data (e.g., chemistry), biotic data (e.g., biological surveys, toxicity bioassays) and information about the clean-up effort. See Appendix C of the Damage Assessment and Restoration Plan for a further explanation of HEA and Appendix D for more details on shoreline injury assessment methods.

Area

The Trustees identified four broad geographic zones based on documented shoreline oiling. For quantifying injuries to sandy beach habitat, the zone directly surrounding the release (Zone B) was further subdivided into nine "micro-zones", centered on nine beach sampling locations (i.e., Arroyo Hondo, Arroyo Quemado, Tajiguas, Refugio, Venedito, El Capitan, Dos Pueblos, Haskell's, and Coal Oil Point) with sufficient data to evaluate initial injuries. The area of shoreline habitat in each broad or micro-zone was calculated from the NOAA Geographical Information System (GIS) database displayed in the Environmental Response Management Application Southwest (ERMA Southwest, Appendix B of the Damage Assessment and Restoration Plan) and prepared by RPI (2018). Micro-zone acreages within Zone B were calculated by summing the acres of sand/mixed cobble beach habitat between the beach site sampled and the midway point between that site and the next site to the: 1) east, and 2) west. In cases for which the site was closest to the boundary of Zone B (Arroyo Hondo at the west end of Zone B, Coal Oil Point at the east end of Zone B), and all sandy beach acres between the site and the nearest boundary were included in the micro-zone area calculation. In total, Zone B contained 345.76 acres that were assessed for injury. All of the intertidal area in Zone A (63.18 acres) and C (191.29 acres) was evaluated for sandy beach injury, but only the SCAT confirmed tarball-oiled areas in Zone D (Figure 1) were evaluated for sandy beach injury (888 acres). For rocky intertidal habitat, 5.4 acres of habitat was assessed as injured.

Intensity of Oiling

The shoreline injury estimates relied on the Trustees' initial characterizations of oiling in the four geographic zones based on SCAT documented oiling levels [Figure 1 and RPI (2018)]. In some cases, Trustee photographs or field notes containing information about oil exposure were also considered, particularly within the individual micro-zones assessed in Zone B.

Mechanisms of Injury

Shoreline injury was estimated using three general mechanisms of injury: toxicity, fouling, and clean-up effort. Brief definitions for these are:

1. Toxicity. *The quality of being toxic or poisonous; the effects of oil or components of the oil (i.e., PAHs absorbed dermally or via ingestion) exerting a deleterious effect on organisms*.
2. Fouling. *Defined here as making foul or dirty with oil, in particular resulting from the contact between an organism(s) and the oil, and the organism(s) being directly oiled. As an example, fouling may result in coating and clogging of feeding appendages with oil, rendering them less able to perform their function.*
3. Clean-up Effort. *All methods used to clean up the oil, including hand removal, digging or excavation activity, raking, scraping, washing, blasting, trampling, driving, and crushing that occurred as part of that effort.*

Estimates of Injury

The initial impacts of the spill on sand beach habitat were calculated by aggregating estimates of the effects of fouling, toxicity, and clean-up effort during the first few months after the spill. Total injury captures these effects from the time of the spill until the resources are recovered and ecosystem services return to baseline. See Appendix D of the Damage Assessment and Restoration Plan for more details on shoreline injuries caused by the spill.

Full recovery from the spill requires having the entire suite of ecosystem services that were present before the spill fully restored and for pre-impact conditions to prevail, including the full complement of species and age classes that existed before the spill. Ecological services include those services related to secondary productivity or the ability to provide a full range of prey diversity, biomass and size structure to feed fish, birds and other predators; the production of propagules (eggs, larvae, juveniles); and functions such as nutrient recycling capacity. Representative fauna in upper and lower intertidal zones can live for several years and their population structures include multiple year classes (e.g., representative of larvae, juveniles, and adult life stages). Most beach invertebrates, excluding insects, continue to grow throughout their lives, producing more mass, processing more food, and providing more ecosystem services. Larger and older female invertebrates produce much greater numbers of offspring than small ones. For some species, larger individuals are more robust and better at surviving through harsh winter conditions.

Estimates of recovery time for oil disturbed sandy beach communities were based on monitoring data (beach hopper population data for upper beach), literature values for recovery from past spills/disturbances, and life history patterns of California sandy beach species. Because the representative sandy beach species assessed in Zone B lost substantial proportions of three age classes (first year, second year, and third year) during the spill, and recruitment is seasonal and episodic, full recovery to baseline would be three years at a minimum. Beach hoppers tend to occupy the upper beach elevations that were more heavily impacted by oil and clean-up during the spill. These and other beach-associated amphipods and other upper beach organisms rely exclusively on 'direct' development, whereby the dispersion of their propagules is highly constrained to a small area. For example, if a local population is extirpated or severely depressed, recovery will be protracted because few new individuals will be transported or recruit into the area (Hubbard et al., 2013). This contrasts with sand crabs, which reproduce by releasing planktonic larvae. Planktonic larvae may be transported many miles downcoast by longshore currents, allowing for greater dispersion of new recruits into areas that were reduced in population size. Unlike the beach hoppers, recovery of sand crabs (three years in this case) is faster as it is aided by the quick recolonization of the sandy beach by these new recruits, while the beach hoppers cannot quickly re-establish a large cohort on the beach due to their more constrained direct development method of reproduction.

As described above, Zone B was divided into specific "micro-zones". Within each micro-zone, the degree of injury resulting from fouling, toxicity and clean-up were added together within both the lower intertidal and upper intertidal habitats. Then, the upper and lower intertidal sums were averaged to get the "whole-beach injury" for the given micro-zone. The following is an example calculation:

		Mechanism	
Example:	Tajiguas (Lower Intertidal)	Fouling	0.55
		Toxicity	0.20
		Clean-up	0.10
	Total of 3 mechanisms		0.85
	Tajiguas (Upper Intertidal)	Fouling	0.58
		Toxicity	0.00
		Clean-up	0.05
	Total of 3 mechanisms		0.63

Whole-beach Injury (avg. upper & lower beach) = **0.74**. This is the initial injury in the Tajiguas micro-zone within Zone B.

In Zone B, the initial injury percentage was an area-weighted average of the values of the calculations for the nine micro-zones. Then, monthly time steps were applied using monitoring data and life history characteristics to calculate the injury percentage over time until complete recovery from the injury was predicted. The sandy beach injury trajectory is detailed in Table

1. Zone B injury was assessed at 510.7 discounted service acre years (dSAYs). In Zones A and C, injury per acre was estimated as a fraction or fixed percent of the average per-acre injury in Zone B: 20% in Zone A (18.66 dSAYs) and 25% in Zone C (70.64 dSAYs). Those percentages were selected to approximate impacts associated with a lesser amount of oiling in Zones A and C when compared to Zone B. Zone D was estimated to be 5% injured in year one only, with no injury in subsequent years. Impacts in Zone D were lower because they were primarily based on removal of organisms by direct contact with tarballs, along with the removal of a subset of wrack material during cleanup activities (44.4 dSAYs).

Rocky intertidal habitat was modeled in the HEA as having a 29% service loss in year one, a 5% loss in year two, with no loss modeled in subsequent years. Initial injury was primarily due to direct smothering/fouling and subsequent tissue necrosis/bleaching of the sessile organisms populating this substrate. In addition, injury was caused by trampling (from spill assessment and clean-up activities), physical cleaning of rocky substrates, and sublethal effects from exposure to petroleum (e.g., impaired reproduction or growth). The degree of initial injury also relied on the assumption that the degree of impacts varied with the amount of oiling within Zone B, as more significant fouling was noted in locations adjacent to the release site (i.e., rocky outcrops adjacent to Refugio, Coral Canyon, and El Capitan). Recovery time was quantified based on the life histories of affected biota, and on notable increases of ‘disturbance indicator’ species (i.e., *Ulva sp.* and *Porphyra sp*.) identified during anniversary surveys at the highest impacted sites.

Using the standard economic discount rate of three-percent[1], total dSAYs lost for shoreline ecosystems, summed over all four zones (A-D) were 646.23: 644.4 dSAYs for sandy beach ecosystems, and 1.83 dSAYs for rocky intertidal ecosystems.

Restoration

The Trustees propose four projects to compensate for the injury described above; three projects for the sandy beach, and one project for the rocky intertidal habitat.

Ellwood Seawall Removal and Sandy Beach Restoration. The goal of this project is to restore lost sandy beach ecosystem services, allowing for more sand to accumulate on the beach and improving the quality of the existing habitat. The project site is Ellwood Beach in Goleta, CA. A creosote-treated wooden seawall currently constrains natural functioning of the ecosystem and lateral access along the shoreline at high tide. Removal of the seawall along 1600 meters of shoreline (approximately one mile) would improve ecological function on about 20 acres of intertidal shoreline seaward of and underneath the footprint of the structure. To quantify the benefits of the Ellwood Seawall Removal, the Trustees estimated that 20 acres of sand beach habitat would benefit from a 60% increase in ecosystem services over 6 years at a rate of 10% per year beginning in 2021. We also estimated that project benefits would end in May 2067 to account for long-term uncertainties in site condition, including those related to sea level rise. The total credit for this project is 232.3 dSAYs.

[1] This is an adjustment made to reflect the fact that services provided in the future are less valuable than services being provided now.

Santa Monica Sandy Beach and Dune Restoration. The goal of this project is to restore sandy beach and coastal dune habitat that has been degraded by intensive mechanical grooming. The project site is a public beach in Santa Monica Bay. The benefits of this project are estimated to be a 75% increase in ecological services over five acres that improves habitat in both the lower and upper intertidal zones. Invertebrate species richness in the lower intertidal zone is estimated to attain a 50% ecosystem services increase. In the upper intertidal zone, an increase from zero to four species of native plants in the dune and coastal strand zone will occur, which will help to initiate natural dune building processes. The Trustees estimate that this will lead to a 100% ecosystem services increase in the upper intertidal. So, adding both of those zone estimates together for purposes of the HEA, the Trustees expect a 10% ecosystem service increase each year over 7 years beginning in 2021, followed by 5% increase in the eighth year, with a 46-year project life ending in May 2067. This represents a 75% increase in ecosystem services overall by averaging benefits provided to the lower and upper intertidal zones. The total credit for the five-acre project is 70.4 dSAYs.

Coastal Dune Enhancement Projects. The goal of these projects is to reduce invasive plant abundance and restore native plants, dune forms and processes. Restoration costs per acre of dune habitat will vary by site, but the following parameters represent an average benefit to shoreline environments estimated from three proposed dune restoration project locations within Ventura County: Ormond Beach, San Buenaventura, and McGrath. To quantify restoration benefits, the Trustees estimated a 60% increase in ecosystem services over 6 years at a rate of 10% per year beginning in 2020. The Trustees estimate a 23-year project life, with benefits tapering off after 18 years at a rate of 10% per year to account for uncertainties related to maintenance of the dune vegetation. Under these assumptions, 50.1 acres of dune restoration would compensate for the sand beach injuries not addressed by the Ellwood Seawall Removal and Santa Monica Sandy Beach and Dune Restoration projects described above. The project would yield an estimated 341.7 dSAYs of credit.

Black Abalone Transplantation and Restoration. The goal of this proposal is to restore black abalone populations in areas affected by the spill and enhance the function of rocky intertidal habitat. The proposal is based on four tasks: 1) characterization of the genetic structure of the donor and recipient black abalone populations, 2) restoration to make habitat suitable for transplanted post-emergent (50-75 mm) black abalone and settlement of larval and subsequent growth of juvenile black abalone, 3) transplantation of post-emergent black abalone from a donor population, and 4) assessment of transplantation efficacy through monitoring population and habitat maintenance and local recruitment success. Based on the target density of abalone, the Trustees would transplant approximately 100 individuals (within a total of 0.4 acres), with subsequent intensive recruitment monitoring. For scaling, the Trustees estimated a 50% increase in ecosystem services over 17 years at a rate of 4% per year beginning in 2020 with a 23-year project life to account for uncertainties, including sea level rise. The Trustees estimate 0.4 acres will be restored, yielding 1.83 dSAYs.

Table 1. Injury trajectory used for sandy beach habitats in Zone B.

Month Interval No.	Start Month	Start Date	End Month	End Date	Zone B Injury Percentage (as decimal)
1	May	19	June	18	0.8000
2	June	19	July	18	0.8167
3	July	19	Aug	18	0.8333
4	Aug	19	Sept	18	0.8500
5	Sept	19	Oct	18	0.8500
6	Oct	19	Nov	18	0.8500
7	Nov	19	Dec	18	0.8500
8	Dec	19	Jan	18	0.8500
9	Jan	19	Feb	18	0.8500
10	Feb	19	Mar	18	0.8150
11	Mar	19	Apr	18	0.7550
12	Apr	19	May	18	0.6700
13	May	19	June	18	0.5850
14	June	19	July	18	0.5000
15	July	19	Aug	18	0.4750
16	Aug	19	Sept	18	0.4750
17	Sept	19	Oct	18	0.4750
18	Oct	19	Nov	18	0.4750
19	Nov	19	Dec	18	0.4750
20	Dec	19	Jan	18	0.4750
21	Jan	19	Feb	18	0.4750
22	Feb	19	Mar	18	0.4450
23	Mar	19	Apr	18	0.3900
24	Apr	19	May	18	0.3350
25	May	19	June	18	0.2800
26	June	19	July	18	0.2250
27	July	19	Aug	18	0.2000
28	Aug	19	Sept	18	0.2000
29	Sept	19	Oct	18	0.2000
30	Oct	19	Nov	18	0.2000
31	Nov	19	Dec	18	0.2000

32	Dec	19	Jan	18	0.2000
33	Jan	19	Feb	18	0.2000
34	Feb	19	Mar	18	0.1850
35	Mar	19	Apr	18	0.1500
36	Apr	19	May	18	0.1150
37	May	19	June	18	0.0800
38	June	19	July	18	0.0450
39	July	19	Aug	18	0.0250
40	Aug	19	Sept	18	0.0250
41	Sept	19	Oct	18	0.0250
42	Oct	19	Nov	18	0.0250
43	Nov	19	Dec	18	0.0250
44	Dec	19	Jan	18	0.0250
45	Jan	19	Feb	18	0.0250
46	Feb	19	Mar	18	0.0250
47	Mar	19	Apr	18	0.0000
48	Apr	19	May	18	0.0000

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The 2015 Refugio Beach Oil Spill: Fish and Invertebrate Mortality Observations

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I. Introduction

On May 19, 2015, a pipeline owned and operated by Plains All America Pipeline ruptured near Refugio State Beach. Over 100,000 gallons of crude oil spilled, much of which ran down a storm drain and into a ravine under the freeway, entering the ocean. As part of the Natural Resource Damage Assessment (NRDA) process, field teams documented species and habitats that were exposed to oil or may have been impacted by response activities.

During approximately the first month of response all live and dead birds and marine mammals were reported to the oiled wildlife hotline, where staff in the Wildlife Operations Branch responded. Other marine organism mortalities (e.g., fish, lobsters, octopus, sea hares, etc.) were documented by NRDA staff through the deployment of boxes as a repository for clean-up crews to deposit dead fish and invertebrates for the NRDA team to later document (a.k.a. dead organism surveys). Due to the collection being done by a variety of clean-up crews, there was no standardized methodology established for the 2015 dead organism surveys. NRDA staff also documented beached, dead organisms during other ephemeral data collection efforts.

An anniversary beached organism survey was conducted over three weeks in June of 2016. The intent of the anniversary sampling was to compare results of 2016 surveys to deposition of marine organisms during the period when Line 901 oil was present in 2015 to further evaluate baseline conditions. The comparison of the two surveys was qualitative due to the fact that the sampling methodology varied between years and within the 2015 sampling period. Protocols utilized in the anniversary sampling may provide a model for future response efforts.

II. Survey Methods

A. 2015 Dead Organism Surveys

Fish kills in the shoreline or nearshore environment are difficult to document and quantify because the causes of acute mortality are often ephemeral and dead organisms are subject to intense scavenging. Past coastal oil spills in California did not include reports or observations of fish and invertebrate mortality at the scale seen at during the Refugio Beach Oil Spill, so the Trustees had not developed a pre-defined protocol for documenting dead fish and invertebrates as part of an ephemeral data plan.

In the first days following the pipeline release to the ocean, a number of oiled, dead fish and invertebrates representing species from subtidal and intertidal habitats were reported washed up on heavier oiled beaches, prompting the Trustees to undertake documenting these mortalities. From May 19, 2015 to June 19, 2015, the Trustees documented and photographed oiled, dying, and/or dead fish and large invertebrates that had washed up on the beach. This documentation was performed opportunistically under three scenarios:

(1) NRDA staff recorded and photographed mortalities as they were observed during planned NRDA rocky intertidal and sandy beach ephemeral data collection efforts;

(2) The Wildlife Operations Branch noted fish and large invertebrate mortalities observed during its surveys in the Wildlife Search Effort Logs (WSELs), and

(3) NRDA staff recorded daily observations and photo-documented dead animals that were placed in boxes along beach cleanup segments by the clean-up crews. Because clean-up crews were directed by the response, collection of organisms in boxes occurred according to response cleanup priorities.

These approaches ensured some documentation of dead and dying fish and invertebrates, but since there was no standardized survey design for data collection during 2015, quantifying loss was not possible.

Documentation of small invertebrate organisms (beach hoppers, mole crabs, amphipods etc.) is difficult due to their small size and the large number of dead organisms. However, photo documentation was used to capture mortality/oiling of these small invertebrates, which play a critical role in food chain dynamics. Impacts to these small invertebrate organisms are addressed in Appendix D, Shoreline Exposure and Injury Evaluation Studies.

B. 2016 Beached Organism Surveys

The 2016 beached organism survey was pre-planned and included a structured survey design, which means that comparisons with the 2015 data are limited. Three teams of two people each (one natural resource trustee and one responsible party representative) used a modified BeachCOMBERS (Coastal Ocean Mammal and Bird Education and Research Surveys) protocol to observe and document beached marine organisms along the shoreline in three segments (Figure 1):

Segment 1: Tajiguas to Refugio
Segment 2: Refugio to El Capitan
Segment 3: Haskell's to Ellwood

Each team utilized the NRDA Daily Field Team and BeachCOMBERS datasheets. The surveys were conducted one day a week for three weeks (June 1, 8 and 13, 2016). Surveys utilized the same two-person sampling teams for each survey segment. Each survey was initiated from the western end of the survey segment and continued eastward along sandy portions of the survey segment. Survey segments were designed to avoid rocky headlands that disrupted safe movement along the survey area. The two-person team walked in parallel for the targeted segments; one walked at the low tide and the other the high tide line to cover the tidal exchange area. Additionally, the two-person team rotated their parallel walking path mid-way through the survey segment to ensure accuracy and quality of each survey.

Figure 1. 2016 anniversary survey segments: Tajiguas to Refugio in blue (2.0 miles); Refugio to El Capitan in yellow (2.9 miles); and Haskell's to Ellwood in green (2.9 miles)

III. Data Analysis

A. 2015 Survey Analysis

In order to track the dead fish and large invertebrates observed during the first month of response, all raw photographic documentation collected by NRDA staff prior to 8 September 2015 were reviewed and compiled to summarize the observed mortality. Mortalities documented in the WSEL datasheets were also tallied and all fish and invertebrate mortality observations were compiled.

B. 2016 Anniversary Survey Analyses

In 2016, counts were tallied separately for a few key species: lobster, sea hares, octopus, fish, and crabs. The remaining taxa counts were combined in an "other" invertebrate category for all the anniversary sampling dates.

California spiny lobster mortality counts required further evaluation due to the initially high number of potential molts observed during the 2016 sampling. Photographs were carefully examined to distinguish molts (exoskeletons that are shed multiple times a year by juvenile lobsters and one or two times a year by adults) from actual carcasses (Engle 2016). Additionally, lobster molts have the tendency to be in multiple parts, which further complicated the Trustees' ability to accurately estimate of the number of dead individuals observed. A low and high estimate of dead individuals observed was developed to address this uncertainty.

C. 2015 and 2016 Survey Comparison

Due to the variability in survey methodologies, there was no statistically relevant way to compare the 2015 and 2016 sampling events. However, basic comparisons were done to provide qualitative evidence of the impacts from the 2015 oiling event to fish and invertebrates. The first comparison of the 2015 and 2016 surveys was the single day maximum observations for both sampling periods at Refugio Beach. Due to the difference in the number of species observed, a diversity analysis was also completed for the two sampling years. Invertebrates were compared at the species level. Fish were classified to the lowest taxonomic level possible, to genus level, using the photos.

IV. Results

The 2015 Trustee fish and invertebrate mortality counts and the 2016 Trustee fish and invertebrate high/low estimates are presented in Table 1. Invertebrate taxonomic groups were organized by closely related taxa that could be obviously distinguishable through photographs. For example, northern and southern kelp craps were grouped into one category of “kelp crabs” instead of two separate groups for “northern kelp craps” and “southern kelp crabs”. Over 467 dead invertebrate observations were noted in 2015, excluding observations of dead beach hoppers, sand crabs, and hermit crabs that weren’t quantified, but are identified by a plus symbol (+) in Table 1.

The 2016 Trustee dead invertebrate estimates were significantly lower, totaling between 36 and 38 individuals (Table 1). The variation in high and low estimates reflects uncertainties associated with photo analyses. Additionally, variation in high and low estimates were affected by carapace fragments (e.g., if a head and tail portion were the same individual or potentially multiple individuals). The condition of lobsters observed in 2015 was notably distinguishable from the 2016 sampling (Figure 2). Many of the lobsters documented in 2015 showed flesh/tissue, indicating that the specimen was a dead animal not a molt. In 2016, all lobsters documented were clearly identified as molts, with only two noted as “likely a molt” and one “unclear from photo” (Engle 2016).

Table 1. The 2015 Trustee fish and invertebrate dead counts and Trustee fish and invertebrate high/low estimates. While silversides (members of the Artherinidae) were not specifically identified in 2015 it is unclear if silversides were represented in the "unidentified fish" and therefore denoted by a # instead of a zero.

SPECIES	2015 TRUSTEE Total Counts	2016 TRUSTEE Low/High
INVERTEBRATES	**467**	**36/38**
Crabs, subtidal	20+	13
Crabs, sandy beach	50+	0
Crabs, rocky intertidal	17+	0
Unidentified crabs	4	0
Rock crabs/Cancer spp.	8	6
Shore crabs	17	0
Sand crabs	50+	0
Sheep crabs	1	4
Kelp crabs	11	2
Hermit crabs	50+	0
Anemone spp.	1	0
Bat star	3	0
Beach hopper	51+	0
Keyhole limpet	1	0
Limpet spp.	9	0
Lobster	67	1/3
Octopus/squid	10	0
Sea Star/Pisaster spp.	1	0
Purple urchin	16	1
Red urchin	3	1
Salp	2	0
Sea hare	75	8
FISH	**28**	**8**
Rockfish spp.	5	0
Perch spp.	3	0
Silversides (*Atherinidae*)	#	7
Sharks/rays/skates	6	1
Unidentified fish	14	0

Figure 2. (TOP right and left) 2015 oiled lobster carapaces with visible tissue in tail segment. (BOTTOM) 2016 lobster carapace portions required close examination by Trustees to distinguish dead individuals from molts.

The species composition of dead organisms varied between 2015 and 2016 sampling years (Table 2). Twenty-one different taxonomic groups (taxa) of invertebrates were identified in the 2015 sampling and only eight invertebrate taxa were observed in 2016. Similarly, at least 15 different genera of fish were observed in 2015 and only 2 genera in 2016. Fish initially unidentified were later identified to include species such as midshipman (*Porichthys*), brotula (*Brosmophycis*) blenny (*Hypsoblennius*), kelpfish (*Heterostichus*), sculpin, and kelp greenling (*Hexagrammos*).

Table 2. Dead organism diversity comparison between 2015 amd. 2016

Dead Organisms Observed	2015 Diversity	2016 Diversity
Invertebrate taxa	21	8
Fish Genera	15	2

The maximum observed deposition of dead fish and invertebrates at Refugio beach occurred on May 21, 2015 (116 observed) for the 2015 surveys and June 8, 2016 for the 2016 anniversary surveys (16 observed; Figure 3). Seven of the 16 observations in 2016 were fish observations and represented all but one other fish observation for the entire 2016 anniversary sampling. It should be noted that many specimens documented in 2015 had visible oiling, while in 2016 only one invertebrate was documented with a small globule of oil.

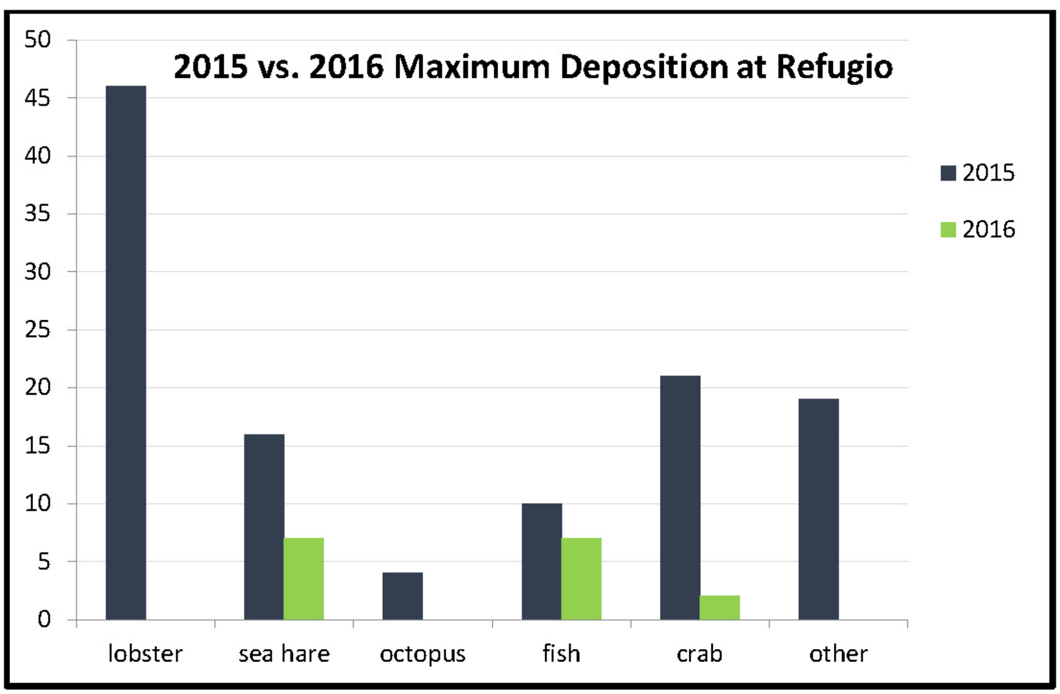

Figure 3. 2015 vs. 2016 Maximum Observed Deposition at Refugio State Beach.

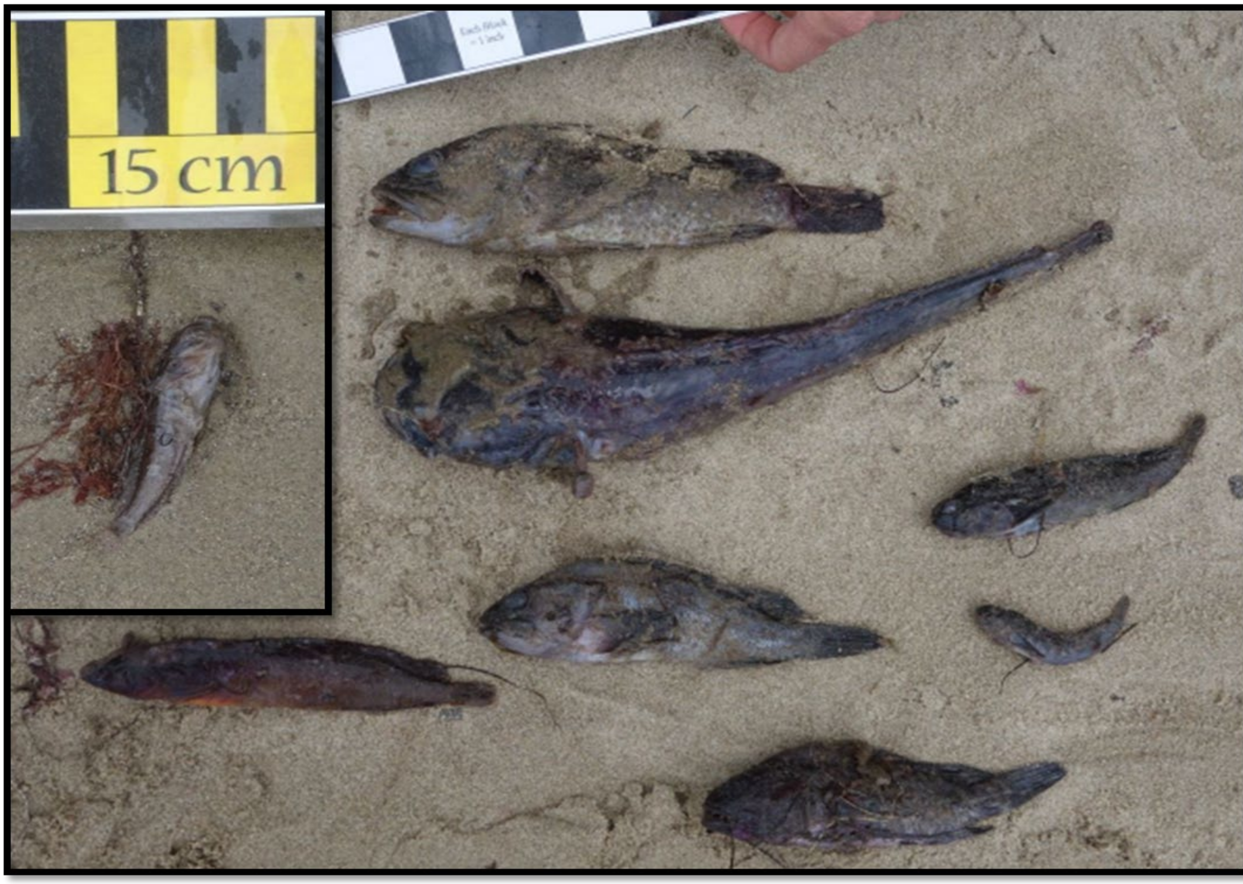

Figure 4. (TOP) During 2015, fish documented in the photos "FishMortalityPhotosA-TL edits" and "FishMortalityPhotosB-TL edits" showed 8 of the 12 fish observed on 5/21/15 to be visibly oiled. (BOTTOM) None of the seven fish observed in 2016 were oiled.

V. Discussion and Conclusions

The lack of standardized methodology for the 2015 response sampling and the unique strategy employed for the 2016 anniversary sampling made it difficult to compare dead organism observations between the two years. It is rare to have the ability to implement a highly structured and statistically robust field study in response to emergency events (Paine et. al 1996). Nonetheless, these surveys provided important qualitative evidence regarding the impact of the May 19, 2015, Plains All American pipeline spill. Studies have shown that only a fraction of animals killed by an oil spill are washed ashore (Ford et al, 1996; French-McCay et al, 2003), indicating that the observed 2015 mortality counts were an underestimate. It is not uncommon for dead intact organisms to wash up on shore and in fact, southern California beach ecosystems depend on these inputs (Polis and Hurd 1996, Dugan et al 2003). What was unusual about the 2015 observations was the diversity of species, unusually high number of carcasses, and the oiled condition of carcasses observed.

The diversity of fish genera observed in the 2015 surveys was not only 7.5 times higher than 2016 surveys, but was also unique in composition. Some of these species, such as the plainfin midshipman (*Porichthys notatus*), are rarely observed alive off the southern California Coast despite monitoring of recreational catches (CERFS Mortality Report). The 2015 surveys identified at least three and likely a fourth midshipman (all included in the "FishMortalityPhotosA-TL edits" and "FishMortalityPhotosB-TL edits" files). Three of the four midshipman carcasses observed in 2015 were visibly oiled. During the late spring and early summer midshipman migrate from their offshore winter habitat to the rocky intertidal and subtidal zones where spawning and rearing of young take place. The male of this nocturnal species digs a burrow under a rock and prepares a nest. The female locates the male, attaches her eggs to the nesting rock and returns to deeper water leaving the male to guard and care for the brood (Hubbs 1920, Arora 1948). The life history of midshipman links deeper subtidal habitat and the shallow subtidal/intertidal zone thus making this species particularly vulnerable to impacts in either habitat zone.

Similarly, the ecology of the California spiny lobster makes the timing of the Plains All American spill potentially detrimental to the lobster population in the impacted subtidal area (Withy-Allen and Hovel 2013, Engel 1979). The condition of the individuals observed and how drastically they differed between the two sampling years was of greatest note. A total of 67 lobsters were observed by the Trustees during the 2015 response sampling (Table 1). None of the 2016 survey photos were specifically identified as lobster carcasses (potentially all molts). Of the 38 potential lobster carcasses observed in the 2016 surveys, all were identified as molts except two noted as "likely a molt" and one "unclear from photo". While the total number of oiled dead lobsters could not be determined through the 2015 surveys the surveys provided some understanding of oiling impacts on lobsters in 2015 following the spill.

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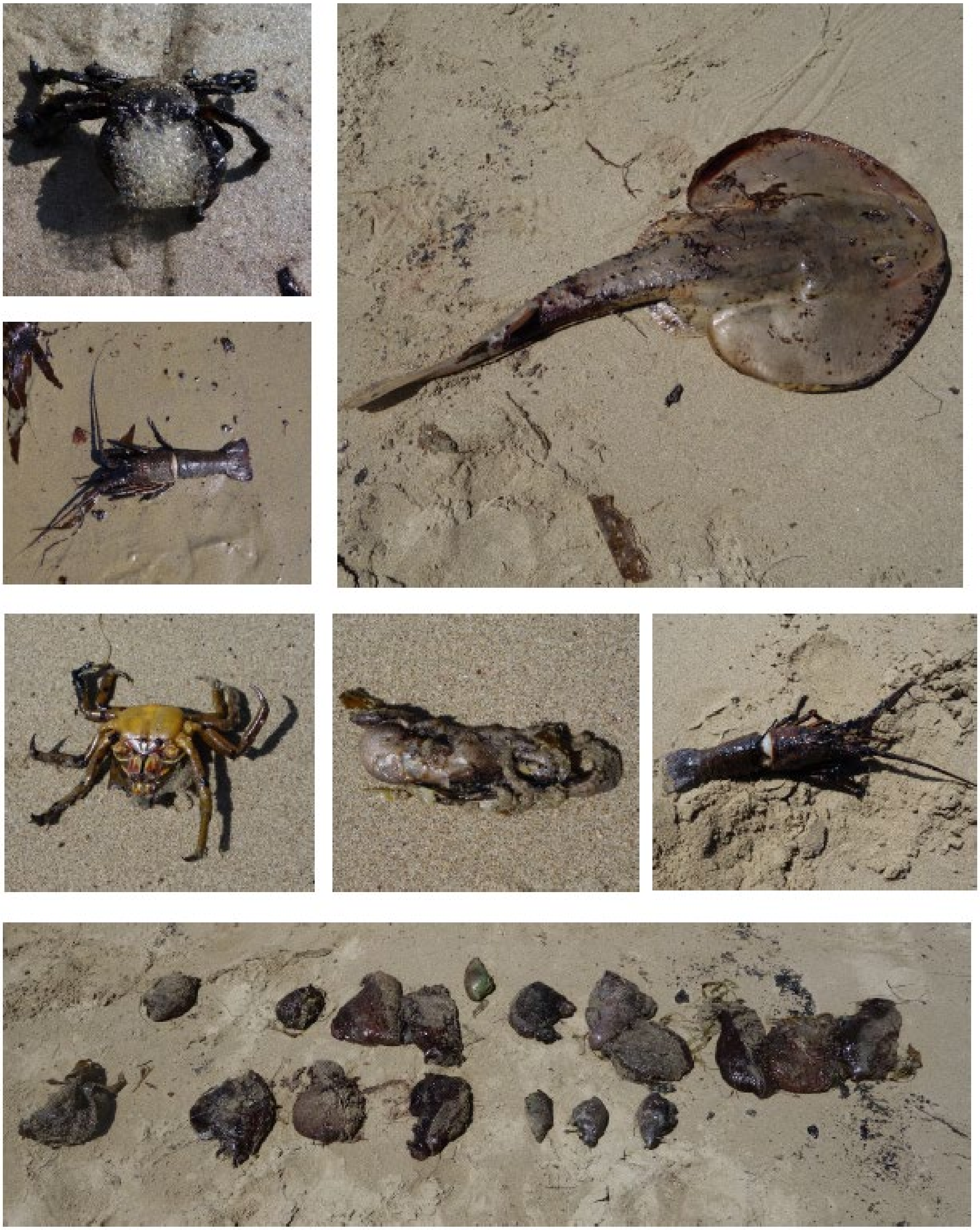
Attachment 1: Example photos of invertebrates and fish observed on May 20, 2015 and May 21, 2015 at Refugio State Beach (Photo Credit: Jenny Marek, USFWS)













The 2015 Refugio Beach Oil Spill: Field and Laboratory Assessment of Injury to Grunion (*Leuresthes tenuis*)

August 2019

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Table of Contents

INTRODUCTION

On May 19 2015, an underground pipeline (Line 901), owned and operated by Plains Pipeline, L.P. sustained an accidental release of crude oil near Refugio State Beach in Santa Barbara County, California (Figure 1). Oil from the pipeline flowed down a culvert and entered the Pacific Ocean in the surf zone. Fish in the nearshore environment were exposed to the oil by direct contact, and via the water and food chain. One native fish species, the California grunion (*Leuresthes tenuis)*, may have been exposed to oil by additional pathways. Grunion spawn on the beach with full emergence from the water at semi-lunar high tides on the four nights following a new or full moon from March to September. Grunion eggs are buried under about 10-20 cm of sand, where they incubate until hatching is triggered by rising semilunar tides approximately two weeks later. Thus, adult grunion may have also been exposed to oil on the beach during spawning and the fertilized eggs may have been exposed to oil via direct contact with oiled sand, sediment porewater, or surf zone water during the tidal regimes of their two week incubation period. Exposure of grunion to oil, especially sensitive early life stages, may have adverse effects on growth, survival and reproduction (Hose and Puffer, 1984; Heintz et al, 2000; Meador et al, 2006, Incardona et al, 2012).

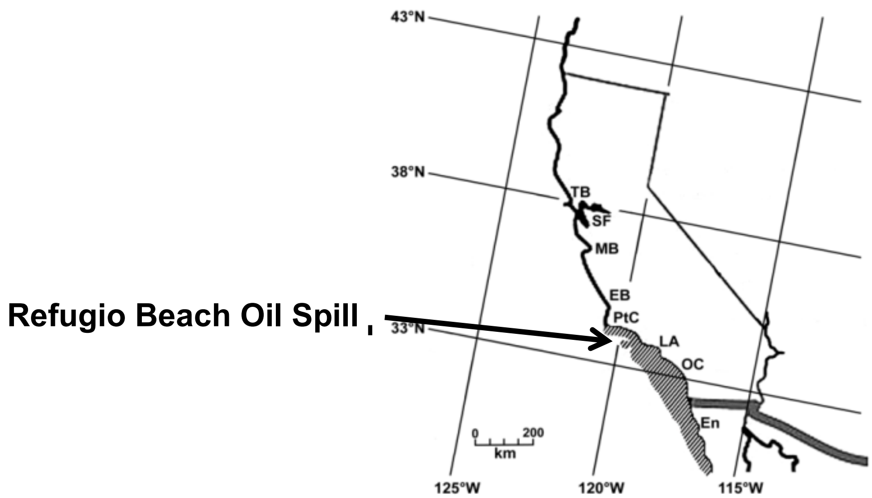

Figure 1. Habitat range for the California Grunion (Leuresthes tenuis) is primarily along the coast of southern California, where 95% of the population of this endemic species lives (Johnson et al., 2009).

Sandy beaches are a critical habitat for this species, and 95% of the grunion spawning occurs between Pt Conception, CA, and Ensenada, Mexico (Figure 1; Johnson et al., 2009). This managed species is protected by a closed fishing season in April and May, and by gear restrictions and management actions at other times. Two beaches heavily oiled by the spill, Refugio State Beach and El Capitan State Beach, are known spawning grounds for the California Grunion. Lunar conditions were such that spawning runs in this area were predicted to occur 18-21 May 2015, spanning a period immediately before, during and after the Refugio Beach Oil Spill. Several other nearby beaches, which were oiled to varying degrees, hosted significant grunion runs in 2015.

In addition to evaluating direct impacts of Line 901 oil on grunion, the life history and accessibility of grunion early life stages make them an ideal model for evaluating the impacts of Line 901 oil on marine fish early life stages in field conditions.

The objectives of this assessment were to: 1) document exposure pathways by verifying grunion were present and spawning in the spill-affected area; 2) quantify exposure of grunion eggs to oiling conditions in the spill affected area during the month after the spill, 3) initiate evaluation of potential effects of oiling on grunion early life stages that may have occurred during the spawning runs during the month after the spill and 4) evaluate potential effects of oiling one year after the spill. Beach sampling locations were selected because they were suitable for grunion spawning and represented varying degrees of Line 901 oiling (Figure 2). Refugio State Beach and El Capitan were heavily oiled, while East Beach received only light tarball oiling. It should be noted that several natural oil seeps are known to occur in the Santa Barbara Channel, especially near Coal Oil Point (Lorensen et al., 2009). Forensic chemistry analysis was used to distinguish between Line 901 oil and seep oil (Stout, 2016). A long-term grunion monitoring location, Topanga State Beach, Malibu, California, served as another reference location.

Figure 2. Grunion spawning observation and sampling locations.

METHODS

Spawning Observations

Beach observations occurred on the evening high tides from approximately 2300-0130 hours on the dates of the anticipated grunion runs. Observations were made at Refugio State Beach, El Capitan State Beach, and, East Beach (Figure 2). A standard data collection form developed by the Grunion Greeter[1] program was used to collect information on the density of a run, using the Walker Scale (Appendix 1), as well as conditions that might affect grunion spawning. The GPS locations of the spawning runs were recorded, and the runs were photo-documented. The Grunion Greeter database was also queried to identify spawning locations in the spill affected area that were reported by trained volunteer monitors.

[1] Grunion Greeter, a citizen science group, works in conjunction with local university researchers, non-profits and government agencies to observe and record beaches on nights of grunion runs during the peak season (http://grunion.pepperdine.edu/ggproject.htm)

Field Collection of Grunion Eggs

Grunion eggs and the surrounding sand were collected from oiled (Refugio State Beach, El Capitan State Beach) and reference (East Beach, Topanga State Beach) beaches after multiple spawning events in 2015 and 2016. Eggs were collected five to seven days after the 2015 spawning observations, eight days after spawning in May 2016 and one day after spawning in June 2016. Grunion nests were located by digging with a gentle scraping motion in the sand where grunion spawning was observed. When a clutch was found, the GPS location, depth of the clutch in the sand and egg color were noted, and a photograph was taken. Grunion eggs are typically orange in color. Approximately half of the clutch was removed for chemical analysis, using a clean wooden tongue depressor to place the material in a pre-cleaned, amber glass sampling jar with a Teflon-lined lid. Sand surrounding the clutch was also removed for chemical analysis, using a clean wooden tongue depressor to place the material in a separate pre-cleaned, foil-wrapped, clear glass sampling jar with a Teflon-lined lid. The remaining eggs in the clutch were collected into a zip-top quart plastic bag, along with some surrounding sand, labelled by clutch, and stored in a cooler without ice and transported to Pepperdine University, Malibu, CA for subsequent hatching analysis. Photographs of the samples and sample labels were taken. For the chemical analysis, samples of eggs or sand from three clutches were pooled in the field to obtain sufficient mass for analysis and were then immediately placed in a cooler on ice. For the June 2016 collection, egg and sand samples from each clutch were collected in separate jars, then composited in the lab in order to pool egg clutches with similar hatch rates. No sand or egg samples for chemical analysis were collected from Topanga State Beach. Samples were delivered, under chain of custody, to the California Department of Fish and Wildlife Petroleum Chemistry Laboratory, Rancho Cordova, California. These grunion egg and sand samples were later transferred to Newfields Analytical Laboratory, Rockland, Massachusetts, for polycyclic aromatic hydrocarbon (PAH) analysis.

Laboratory Hatching

All the collected eggs were taken to Pepperdine University and held in environmental chambers at 20°C, with seawater sprayed onto the clutches to maintain moisture levels of the natal sand, in accordance with standard animal care protocols for this species.

Grunion eggs require an environmental cue, agitation in seawater, to hatch (Griem and Martin, 2000; Martin et al., 2011). That happens naturally when tides rise before a new or full moon, about 10-12 days after fertilization after the high semilunar tides of the previous new or full moon. Because grunion require this environmental trigger to hatch, some embryos or entire clutches fail to hatch during the first exposure to seawater. These embryos are capable of delaying hatching beyond the time that they first develop competence to hatch. If eggs are not washed out at the semilunar high tide series immediately following spawning, they can incubate an additional two weeks and most will still hatch (Moravek and Martin, 2011). We will refer to embryos that hatch during the first exposure to seawater 10-12 days post fertilization as the “primary” hatch and embryos that delay hatching until the subsequent high tide as “delayed” hatch.

The field collected eggs were triggered to hatch in the laboratory by agitation in seawater, using previously established protocols (Matsumoto and Martin, 2008). A primary hatch was initiated two weeks post spawning and a delayed hatch was initiated for a subset of the clutches approximately four weeks post spawning. Small batches of approximately 100 eggs from each clutch were counted, placed in seawater, and agitated for one minute. After 5 minutes, eggs were agitated again for one minute. After 10 minutes, any unhatched eggs were counted. The hatchling behavior and survival was closely observed during the first few hours after hatching. Surviving larvae from the June 11, 2015 collections at El Capitan and East Beach (no eggs were collected at Refugio) were cultured, separated by clutch, in clean seawater without feeding for ten days to observe larval survival over time. Yolk reserves are generally depleted within four days and mortality occurs after that time point without feeding.

Estimates of Baseline Grunion Embryo Mortality Rates

Few published estimates of grunion embryo mortality rates exist. Published values for embryo morality rates are based on a variety of methods that are unlikely to be comparable to the methods used in this study. We therefore chose to use embryo mortality rate data derived from clutches collected from reference beaches in 2015 (East Beach and Topanga Beach) and from all anniversary clutches collected in 2016 to estimate a baseline grunion hatch rate. Collectively, these reference and anniversary clutches will be referred to as baseline clutches. Baseline embryo mortality rates were determined for primary and delayed hatch separately. Differences in baseline mortality among years and beaches were tested using a mixed model ANOVA to determine if a single base line hatch rate estimate could be calculated based on the average mortality estimate among all beaches and years. Average mortality was estimated by calculating the average mortality among individual clutches within beaches and years, then among beaches within years, and finally among years. This approach reduced pseudo-replication bias and balanced the impact of unequal distribution of samples among beaches and years.

Analytical Methods

Grunion egg and sand extracts were analyzed for PAHs by GC/MS-SIM (USEPA Method 8270 mod). Results for 50 individual PAHs and alkylated homologue groups were summed to estimate total PAHs ($TPAH_{50}$): naphthalene; naphthalenes, C1; naphthalenes, C2; naphthalenes, C3; naphthalenes, C4; acenaphthylene; acenaphthene; fluorene; fluorenes, C1; fluorenes, C2; fluorenes, C3; phenanthrene; anthracene; phenanthrene/anthracene, C1; phenanthrene/anthracene, C2; phenanthrene/anthracene, C3; phenanthrene/anthracene, C4; pyrene; benzo(b)fluorene; fluoranthene; fluoranthene/pyrenes, C1 -; fluoranthene/pyrenes, C2; fluoranthene/pyrenes, C3; fluoranthene/pyrenes, C4; benz[a]anthracene; chrysene; chrysenes, C1; chrysenes, C2; chrysenes, C3; chrysenes, C4; benzo(a)pyrene; benzo(e)pyrene; benzo(b)fluoranthene; benzo(k)fluoranthene; benzo(a)fluoranthene; benzo(g,h,i)perylene; indeno(1,2,3-c,d)pyrene; dibenz(a,h)anthracene; dibenzothiopene; dibenzothiophenes, C1; dibenzothiophenes, C2; dibenzothiophenes, C3; dibenzothiophenes, C4; biphenyl; dibenzofuran; naphthobenzothiophene; naphthobenzothiophene, C1; naphthobenzothiophene, C2; naphthobenzothiophene, C3 and naphthobenzothiophene, C4. When calculating $TPAH_{50}$, non-detects were assumed to be zero (Forth et al, 2015). Tissue results are reported on a wet weight basis and sand on a dry weight basis. Fingerprinting methods are detailed in Stout (2016).

RESULTS

Spawning Observations

Grunion spawning runs were anticipated from 18-21 May 2015, immediately before, during, and following the oil spill. Due to spill response efforts, it was not possible to gain nighttime access to Refugio and El Capitan State Beaches on 20-21 May 2015, so direct observations were not possible. However, it is likely that adult grunion were staging for spawning runs during the day of the spill and the following days based on observations of pelicans and sea lions feeding on fishes in the surf zone nearshore at Refugio State Beach on 22 May 2015, the morning following a predicted run. Clean-up activities extended into the night and bright lights on the beach may have deterred the grunion from spawning on Refugio Beach on 21-22 May. Response activities involved removing the top layers of oiled sand and this action may have also impacted any grunion egg nests that were present. Additionally, hatchlings from the 4-7 May spawning run, and perhaps earlier runs, would likely have been in the nearshore plankton during the early days after the spill and were likely exposed to oil.

Grunion spawning runs were observed on Refugio and El Capitan State Beaches on the next lunar tide series the nights of 4-5 June 2015 (Table 1). The response operation was advised to avoid removing sand from the spawning areas and to avoid disturbing or removing any nests in areas where the runs occurred. Observations from Grunion Greeter volunteers that were recorded and submitted to the Grunion Greeter database indicated similar large runs on other beaches in Santa Barbara County during the months of May, June, and early July. Typically, larger runs occur in more southern parts of the habitat range, in Los Angeles, Orange, and San Diego Counties, and smaller runs occur in Santa Barbara. During 2015, Santa Barbara had the largest runs in the range since records have been kept.

In 2016, teams returned to Refugio State Beach, El Capitan State Beach and East Beach to observe grunion runs (Table 1). On 8 May 2016, the substrate at El Capitan State Beach was primarily cobble and was not suitable for grunion spawning but spawning was observed there on 7 June 2016 when sandy substrate was available.

Table 1. Grunion Run Observations based on the Walker Scale (Appendix 1)

Observation Date	Beach	Walker Scale*
21 May 2015	Refugio State Beach El Capitan State Beach	No Access
4 June 2015	El Capitan State Beach	W4
4 June 2015	Refugio State Beach	W3
5 June 2015	El Capitan State Beach	W3
5 June 2015	Refugio State Beach	W3
8 May 2016	Refugio State Beach	W2+
8 May 2016	East Beach	W2
7 June 2016	Refugio State Beach	W2+
7 June 2016	El Capitan State Beach	W4

*W4 = thousands of fish; W3 = hundreds of fish; W2 =100-500 fish; W2+ = higher end of W2 range

Egg Collection Observations

Refugio State Beach. On 11 June 2015, no eggs were located during two hours of searching by a team of four people, in spite of the spawning run previously observed there on 4-5 June (Figure 3). On 23 June 2015, grunion egg nests were located on the western portion of Refugio beach where previous spawning runs were observed (Table 2). Three of the clutches were located adjacent to oiled sand/cobble (Figure 4). In 2016, oiled sand/cobble was not observed around grunion clutches (Figure 5).

Table 2. Grunion Egg Collection Observations

Date	Beach	# Clutches	Color	Depth (cm)
10 June 2015	Topanga	3	orange	NA
11 June 2015	Refugio	0		
11 June 2015	El Capitan	9	light yellow	4-20
11 June 2015	East Beach	9	light orange	7-23
23 June 2015	Refugio	9	light orange	6-14
23 June 2015	El Capitan	3	light orange	12-14
23 June 2015	El Capitan	3 (delayed)	light yellow	NA
23 June 2015	East Beach	3	orange	10-11
23 June 2015	East Beach	1 (delayed)	light orange	NA
10 May 2016	Topanga	6	NA	NA
16 May 2016	Refugio	6	orange	8-20
16 May 2016	East Beach	9	light orange	2-5
8 June 2016	Refugio	9	orange	4-8
8 June 2016	El Capitan	9	orange	7-9
9 June 2016	Topanga	9	NA	NA

NA = Not available

Figure 3. Grunion egg collection at Refugio State Beach on 11 June 2015 (left; no clutches found) and 23 June 2015 (right; 9 clutches found).

Figure 4. Grunion egg clutches located next to oiled sand/cobble at Refugio State Beach on 23 June 2015.

Figure 5. Grunion egg collection at Refugio State Beach on 16 May 2016.

El Capitan State Beach. On 11 June 2015 at El Capitan State Beach clutches were initially difficult to locate because they were very pale in color, and more transparent than expected for the amount of incubation time (Figure 6, Table 2). Additionally, clutches were located in one area more widely spaced apart than expected for the large size of the run observed. On 23 June 2015, it was again difficult to locate egg clutches, such that only 3 recently spawned clutches were located during one hour (Figure 7, Table 2). In addition, 3 clutches of unhatched eggs from the 4-5 June run were collected and labelled as “delayed” for hatching study purposes. Egg clutches were easily located in 2016 as they were sampled the day after spawning (Figure 8).

Figure 6. El Capitan State Beach on 11 June 2015 (left) and pale colored grunion eggs (right).

Figure 7. El Capitan State Beach on 23 June 2015 (left) and light orange colored grunion eggs (right).

Figure 8. El Capitan State Beach on 8 June 2016 (left) and orange colored grunion eggs (right).

East Beach. On 11 June 2015, grunion egg clutches were located based on the Grunion Greeter volunteers' spawning observations (Figure 9). On 23 June 2015, only 3 clutches were located after searching for one hour (Figure 10). One clutch of pale orange eggs from the 4-5 June run was collected and labelled as "delayed" for hatching study purposes. In 2016, egg clutches were orange in color and at relatively shallow depths (Figure 11).

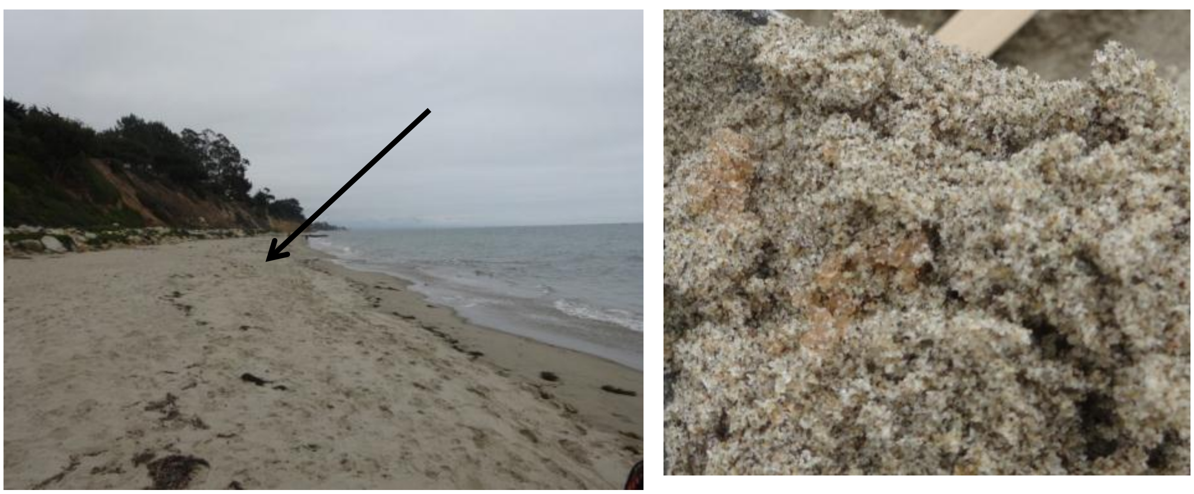

Figure 9. East Beach on 11 June 2015 (left) and pale orange colored grunion eggs (right).

Figure 10. East Beach on 23 June 2015 (left) and orange colored grunion eggs (right).

Figure 11. East Beach on 16 May 2016 (left) and orange colored grunion eggs (right).

Grunion Egg and Sand Chemistry

The $TPAH_{50}$ concentrations varied among samples of grunion eggs and the sand associated with the grunion egg clutches (Figure 12 and 13). In 2015, during Run 1 (11 June egg collection), the egg $TPAH_{50}$ concentrations from the oiled beach (El Capitan) were higher than the concentrations at the reference beach (East Beach; Figure 12). Eggs were not collected during Run 1 at Refugio. No major differences in egg $TPAH_{50}$ concentrations were noted between oiled and the reference beach during Run 2 (23 June 2015). In 2016, no major differences in egg $TPAH_{50}$ concentrations were noted among runs or beaches (Figure 12).

Sand samples collected in 2015 did not vary between the oiled beach (El Capitan) and reference beach (East Beach; Figure 13).

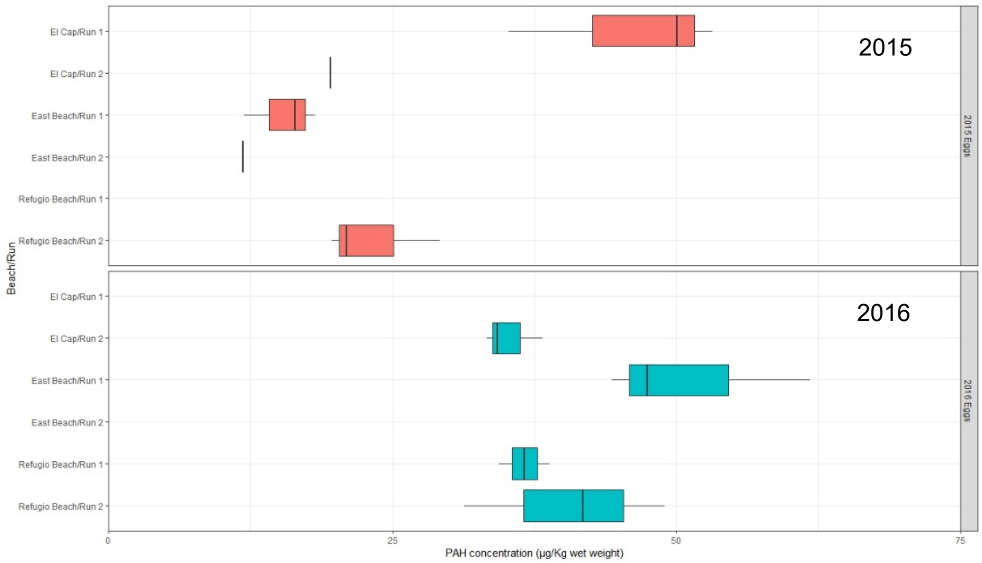

Figure 12. $TPAH_{50}$ concentrations in grunion egg samples (ug/kg wet weight) collected during and after the oil spill. In 2015, Run 1 egg collection occurred on 11 June (El Capitan n=3, East Beach n=3, Refugio n=0), and Run 2 egg collection occurred on 23 June (El Capitan n=1, East Beach n=1, Refugio n=3). In 2016, Run 1 egg collection occurred on 16 May (El Capitan n=0, East Beach n=3, Refugio n=2),, and Run 2 egg collection occurred on 8 June (El Capitan n=3, East Beach n=0, Refugio n=3),.

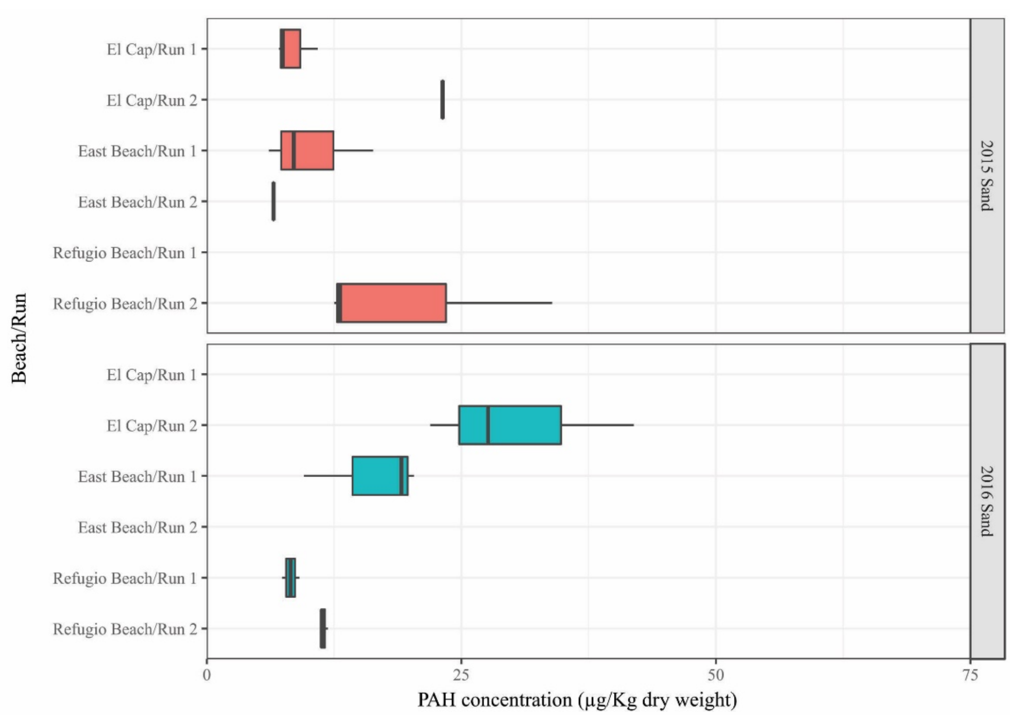

Figure 13. $TPAH_{50}$ concentrations in sand samples (ug/kg dry weight) collected during and after the oil spill. In 2015, Run 1 sand collection occurred on 11 June (El Capitan n=3, East Beach n=3, Refugio n=0), and Run 2 sand collection occurred on 23 June (El Capitan n=1, East Beach n=1, Refugio n=3). In 2016, Run 1 sand collection occurred on 16 May (El Capitan n=0, East Beach n=3, Refugio n=2) and Run 2 sand collection occurred on 8 June (El Capitan n=3, East Beach n=0, Refugio n=3).

Hatching Observations in the Laboratory.

The egg envelope, or chorions, after hatching showed that the eggs collected from El Capitan on 11 June 2015 had a dark, oily appearance that contrasted with the clear chorions from eggs of East Beach from the same date (Figure 14). In addition, embryos hatched very rapidly out of eggs from El Capitan but less quickly from the eggs from East Beach, collected on 11 June 2015.

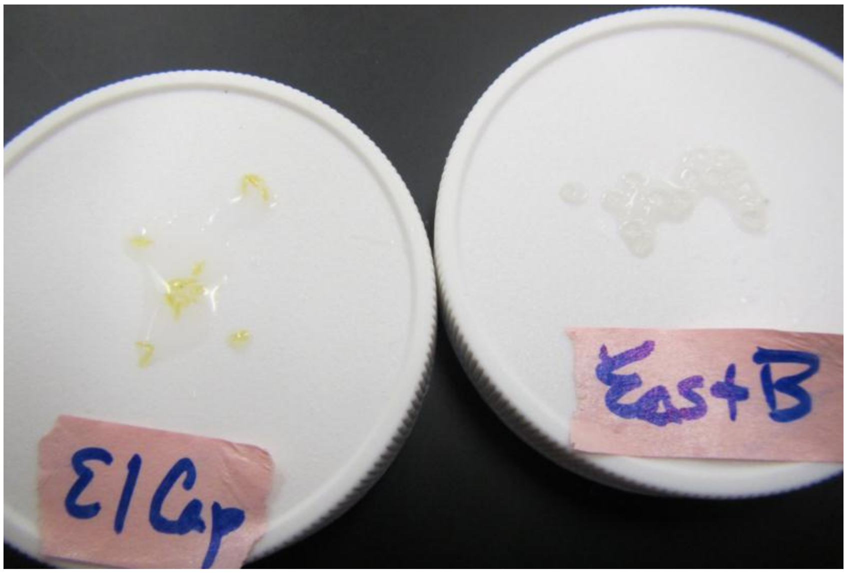

Figure 14. El Capitan chorions (left) had a dark, yellow appearance compared to clear chorions from East Beach (right) collected on 11 June 2015.

Primary Hatching and Mortality Rates

Baseline mortality estimates (primary hatch): Mortality rates were similar among baseline beaches, either within or between years (Table 3). Mortality of embryos from all baseline beaches was low (<10%, Table 3) and did not vary significantly among beaches or between years (Table 4).

Table 3. Mean grunion embryo mortality from 2015 reference and 2016 anniversary samples from all beaches (primary hatch; n = number of clutches).

Year	Beach	n	Average Mortality
2015	East	11	0.09
2015	Topanga	1	0.04
2015	Mean	2	0.06
2016	East	8	0.05
2016	El Capitan	9	0.07
2016	Refugio	15	0.09
2016	Topanga	15	0.07
2016	Mean	4	0.07
Grand Mean		2	0.07

Table 4. ANOVA testing for effect of year and beaches within year for primary hatch of clutches collected from baseline beaches (2015 reference beaches and all 2016 collections).

Source of Variation	Df	Sum of Sq	Mean sq	F	Pr(>F)
Year	1	0.0035	0.003502	0.1545	0.6959
Beach within Year	4	0.02431	0.006077	0.2681	0.8972
Residuals	53	1.20141	0.022668		

We used the average mortality rate among the baseline beaches to estimate a baseline grunion embryo mortality rate. First, the individual clutch mortality rates (the number of eggs that do not hatch and the number of hatchlings that die within 24 hours of hatching expressed as a fraction of the total number of eggs) were averaged within beaches; second, the average mortality for the beaches were averaged within years; and finally, a grand average was calculated from the two yearly averages (Table 3). Average mortality among reference and anniversary beaches ranged from 0.04 at Topanga Beach in 2015 and 0.09 at East Beach in 2015 and at Refugio Beach in 2016. The grand mean of 0.07 (7% mortality after 24 hours) was used as a baseline level of mortality.

Primary hatch mortality rates: Primary hatch (2 week incubation period) grunion embryo mortality rates were significantly higher than estimated baseline values for both of the beaches that were exposed to Line 901 oil in 2015 at the time the grunion eggs were collected (Refugio and El Capitan, Figure 15, Table 5). Mortality rates at the reference site (East Beach) were not significantly higher than baseline values.

Table 5. Egg clutch sample size, mean, and variance of mortality rates of grunion eggs collected in 2015. Run refers to the spawning run from which eggs were collected (1 = clutch collected on 6/10/2015 from Topanga and 6/11/2015 from Refugio and El Capitan. 2 = clutches collected on 6/23/2015). T-values and P-values refer to the comparison of the mean morality to the estimated baseline mortality of 0.07. P-values that are less than 0.05 indicate that differences between the mean mortality and baseline mortality are statistically significant.

			Mortality			
Beach	Run	n	Mean	Variance	t-value	p-value
East	1	8	0.069	0.005	0.087	0.466
East	2	3	0.139	0.005	1.818	0.083
El Capitan	1	9	0.181	0.012	3.147	0.006
El Capitan	2	3	0.260	0.030	1.940	0.074
Refugio	2	9	0.108	0.002	2.613	0.014
Topanga	1	1	0.037	NA	NA	NA

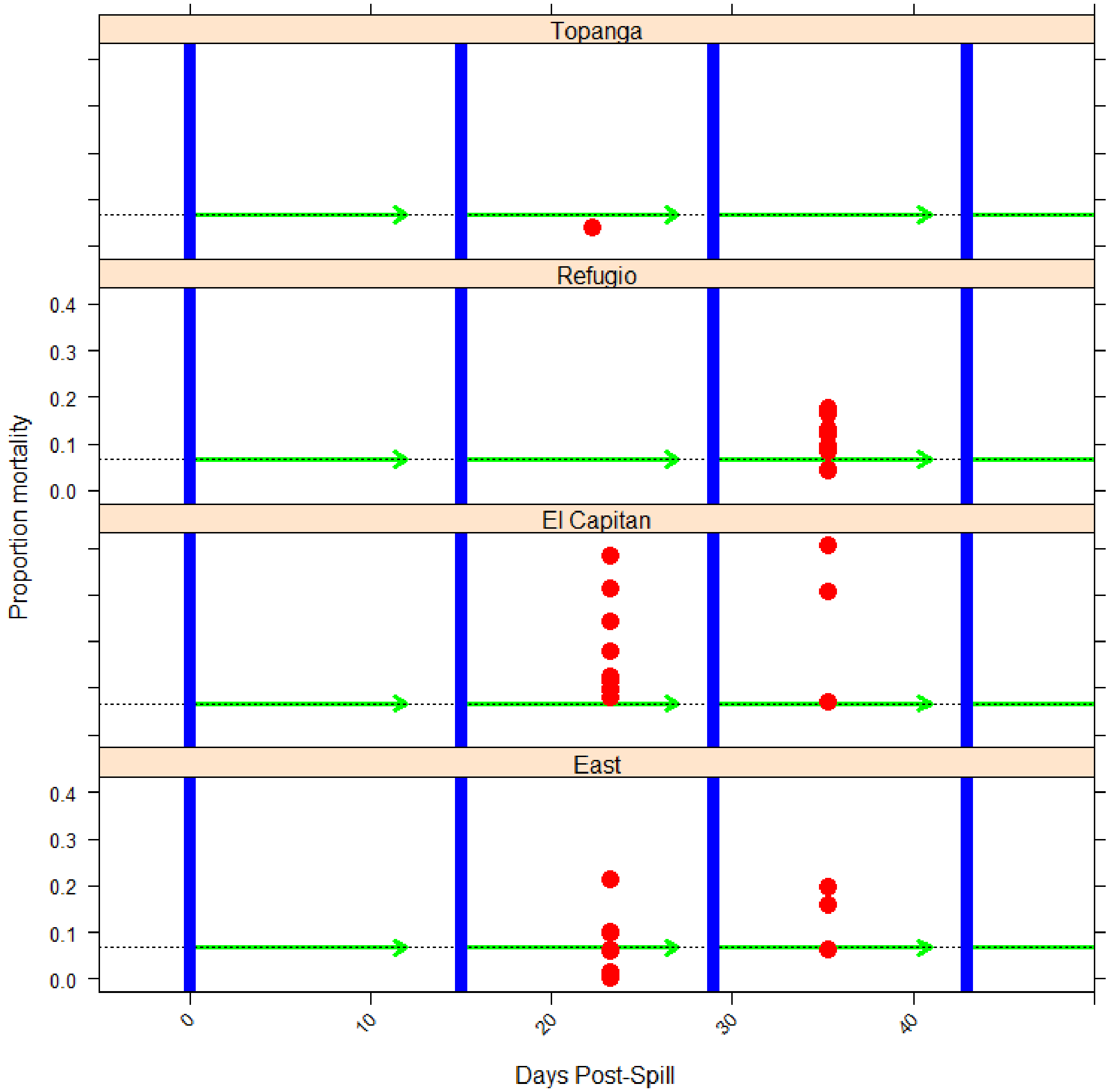

Figure 15. Grunion egg mortality in 2015 by beach (Primary Hatch) plotted against the number of days post oil spill. Blue vertical bars represent the timing of spawning events; horizontal green arrows represent baseline egg mortality and incubation duration.

Delayed Hatching and Mortality Rates

Mortality rates of embryos whose hatch was delayed by two weeks were more variable among beaches within years (Table 6). This variability among beaches was driven by mortality rates at El Capitan beach where nearly all the eggs in one or the two clutches failed to hatch. This level of clutch failure is anomalous among all the clutches tested in the study is likely due to poor egg quality or lack of fertilization. Results from this clutch were retained in the estimate of baseline mortality of delayed clutches to account for the impacts of poor egg quality or fertilization failure (Table 7).

Table 6. ANOVA testing for effect of year and beaches within year for delayed hatch of clutches collected from baseline beaches (2015 reference beaches and all 2016 collections).

Source of Variation	Df	Sum of Sq	Mean sq	F	Pr(>F)
Year	1	0.09083	0.09083	1.3384	0.257447
Beach within Year	3	1.11852	0.37284	5.4937	0.004445
Residuals	27	1.83242	0.06787		

Delayed hatch (4 week incubation period) grunion embryo mortality rates were significantly higher than estimated baseline values for both of the beaches that were exposed to Line 901 oil in 2015 at the time the grunion eggs were collected (Refugio and El Capitan, Figure 16, Table 8). Mortality rates at the reference site (East Beach) were not significantly higher than baseline values.

Table 7. Mean grunion embryo mortality from 2015 reference and 2016 anniversary samples from all beaches (delayed hatch).

Year	Beach	n	Average Mortality
2015	East	10	0.25
2015	Mean	1	0.25
2016	East	8	0.15
2016	El Capitan	2	0.64
2016	Refugio	6	0.07
2016	Topanga	6	0.07
2016	Mean	4	0.23
Grand Mean		2	0.24

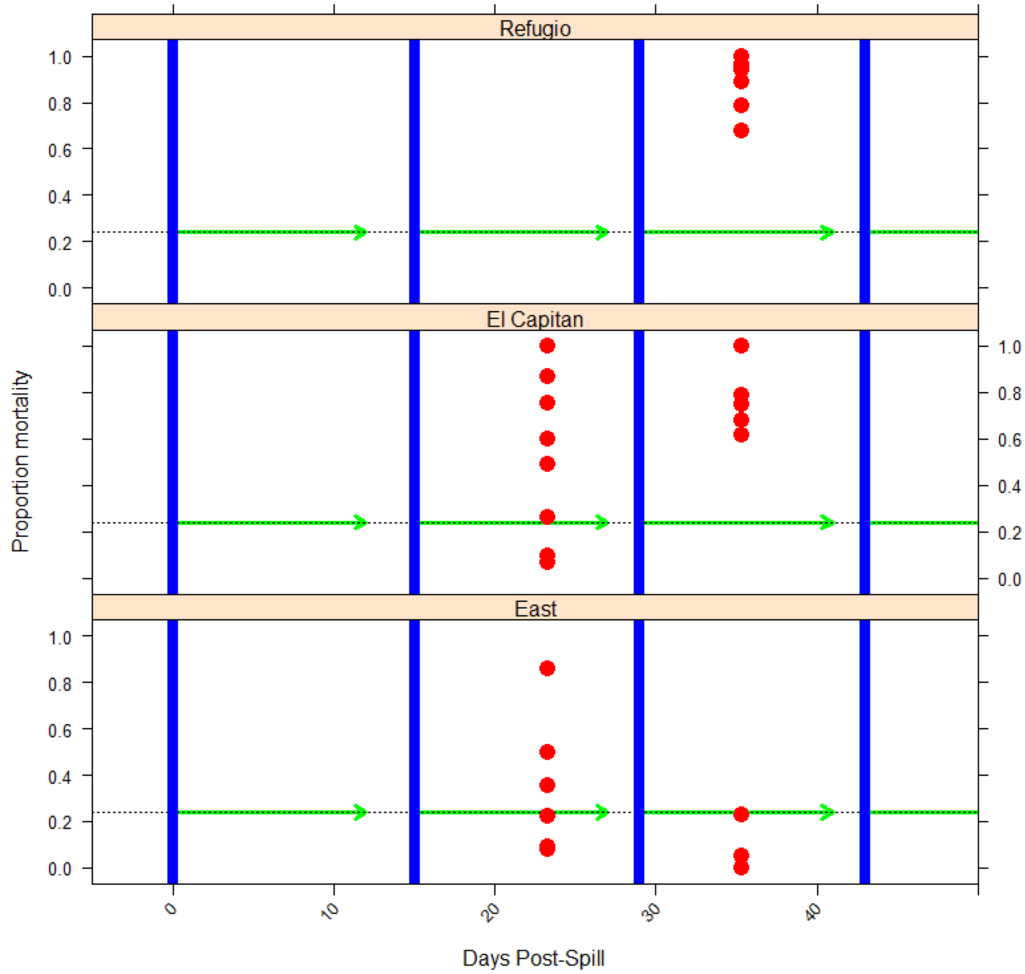

Figure 16. Grunion egg mortality in 2015 by beach (Delayed Hatch) plotted against the number of days post oil spill. Blue vertical bars represent the timing of spawning events, horizontal green arrows represent baseline egg mortality and incubation duration.

Table 8. Egg clutch sample size, mean, and variance of mortality rates of delayed hatch grunion eggs collected in 2015. Run refers to the spawning run from which eggs were collected (1 = clutch collected on 6/10/2015 from Topanga and 6/11/2015 from Refugio and El Capitan. 2 = clutches4r collected on 6/23/2015). T-values and P-values refer to the comparison of the mean morality to the estimated baseline mortality of 0.07. P-values that are less than 0.05 indicate that differences between the mean mortality and baseline mortality are statistically significant.

				Mortality			
Year	Beach	run	n	Mean	Variance	t-value	p-value
2015	East	1	3	0.092	0.014	2.146	0.061
2015	East	2	7	0.314	0.083	0.681	0.259
2015	El Capitan	1	5	0.766	0.022	7.992	0.000
2015	El Capitan	2	9	0.571	0.135	2.700	0.012
2015	Refugio	1	9	0.905	0.012	18.114	0.000

Post-hatching Survival of Grunion from Oil-Exposed and Reference Beaches

Post-hatching survival was tracked in grunion larvae from seven clutches from East Beach (reference) and nine clutches from El Capitan Beach (oiled beach) in 2015. Post hatching survival was used as a proxy to compare the amount of yolk reserve available to larvae from the two beaches. Larvae that survived longer without food were assumed to have larger yolk reserves than larvae that died earlier. The larvae were held without food for 10 days because approximately 4-5 days has been found to be the typical amount of time to deplete the yolk reserve. Survival data (age at death) was analyzed using the Kaplan-Meier Method and Log Rank Test, which is a non-parametric statistic that estimate the survival function. The log-rank test can be used to compare survival curves of two groups. The log-rank test is a statistical hypothesis test that tests the null hypothesis that survival curves of two populations do not differ.

The survival curves of larvae from the two beaches were similar, but with higher mortality of larvae from East Beach between day 5 and 8 of the trial (Figure 17). The log-rank test indicated that the differences between the two survivorship curves was statistically significant ($p<0.05$).

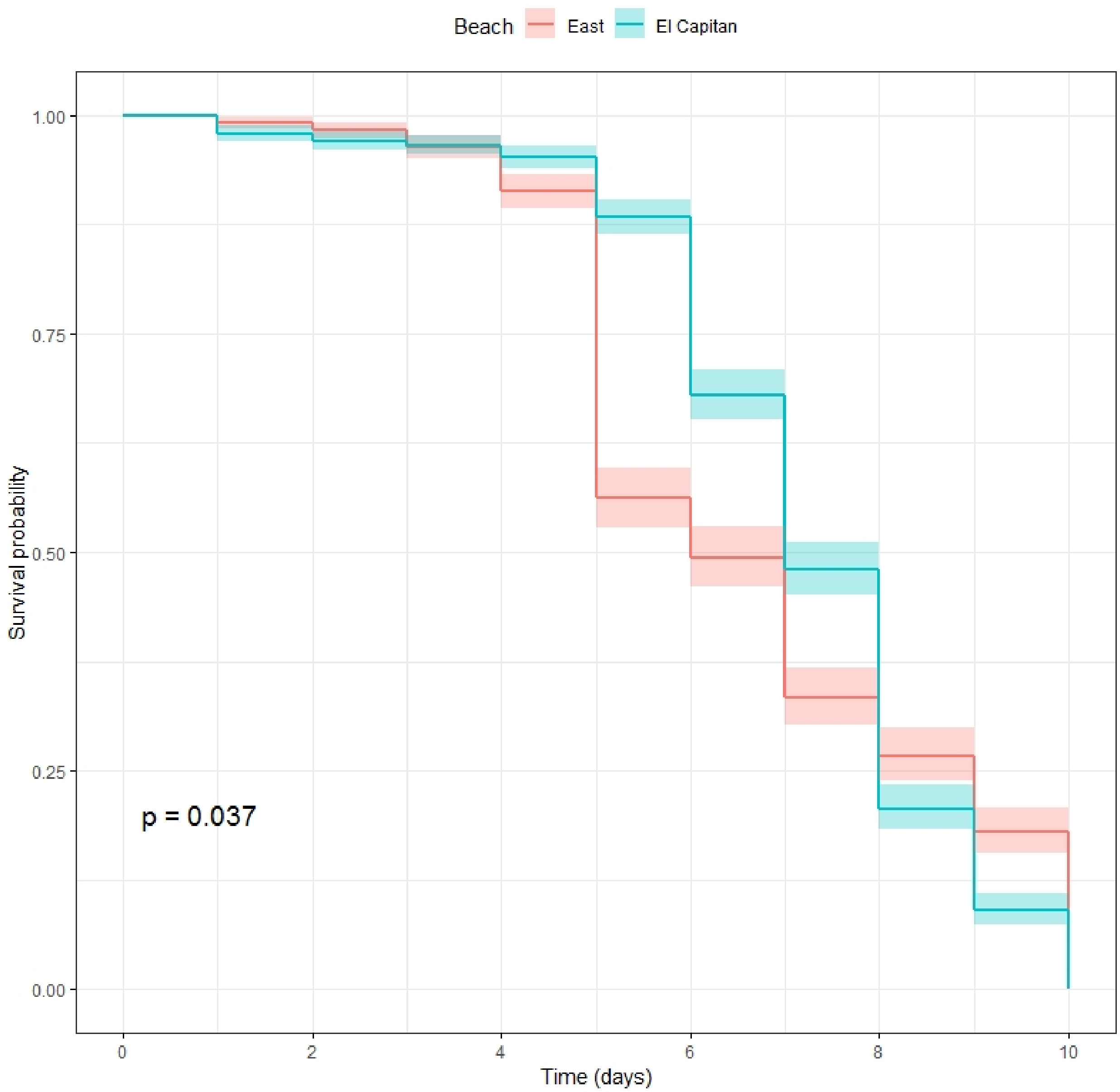

Figure 17. Survivorship curves for starved grunion larvae from reference (East) and oil exposed (El Capitan) beaches. Survivorship curves are represented by solid lines and thicker bar represent 95% confidence intervals around the survivorship estimates.

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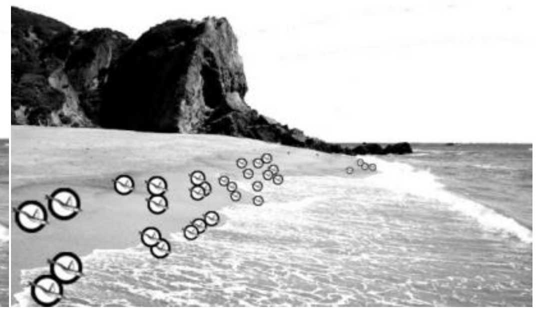
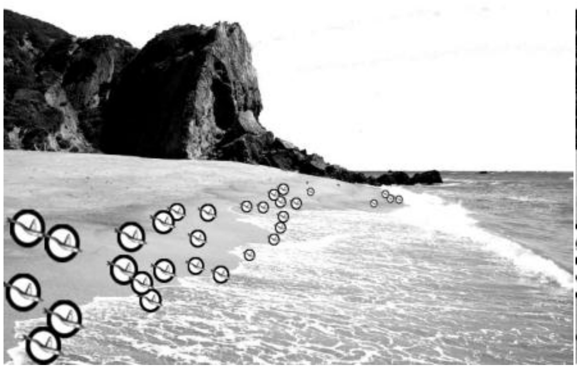
APPENDIX 1: Walker Scale for Grunion runs

W-0: no fish, or 1 or 2 scouts
no spawning

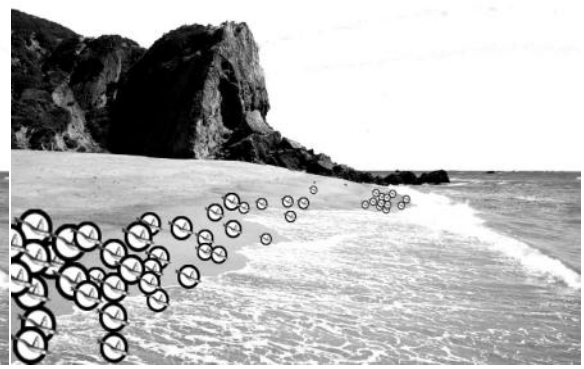
W-1: 10-100 fish spawning at different times
in one or several locations



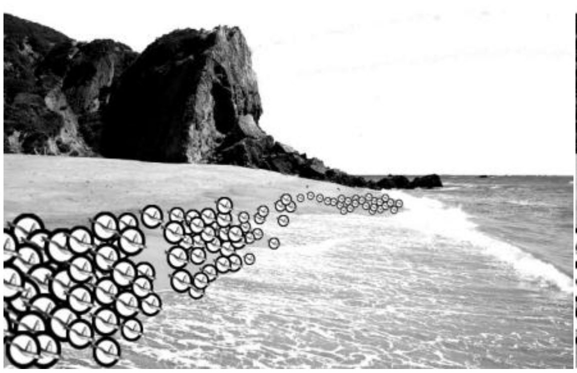
W-2: 100-500 fish spawning at different times,
in one or several locations



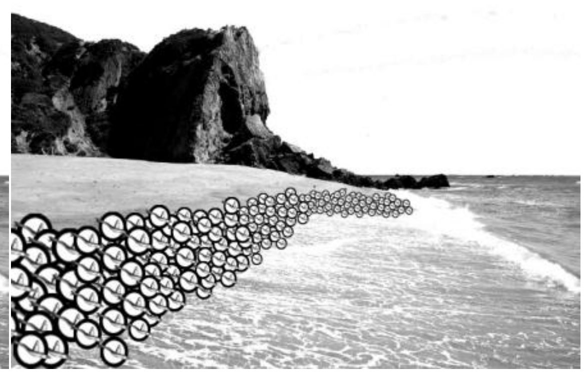
W-3: hundreds of fish spawning in
several locations or over a broad area
of the beach



W-4: thousands of fish together,
little sand visible between them over
relatively small area for less than one hour



W-5: fish covering the beach, not possible to walk
through the run without stepping on fish,
run lasts for an hour or more over large area.



The 2015 Refugio Beach Oil Spill: Assessment of Surfperch (Embiotocidae) Exposure

August 2019

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Table of Contents

INTRODUCTION

On May 19, 2015, an underground pipeline (Line 901), owned and operated by Plains All American Pipeline, L.P., sustained a release of crude oil near Refugio State Beach in Santa Barbara County, California. Oil released from the pipeline pooled, then overflowed into a nearby culvert, across land and other drainage systems, and entered the Pacific Ocean in the surf zone. The surf zone in this area supports relatively large populations of fish, such as silversides, surfperches, croakers, flatfishes and rays (Allen and Pondella, 2006). These fish would have been exposed by direct contact with floating or submerged oil, uptake from oil dissolved or suspended in the water column and the food chain. Additionally, the spill occurred during the spawning season of several surf zone fish species, such that sensitive early life stages may have been exposed to oil. For example, the barred surfperch (*Amphistichus argenteus*) and walleye surfperch (*Hyperprosopon argenteum*) give birth to live young from March to July in this area (Carlisle et al., 1960; California Department of Fish and Game, 2001).

Crude oil contains hundreds to thousands of chemicals that are potentially toxic to fish. Exposure to one class of chemicals, polycyclic aromatic hydrocarbons (PAHs), has been associated with developmental abnormalities, immunosuppression, hepatic lesions and altered growth in fish (Myers et al. 1994; Heintz et al. 2000; Arkoosh et al. 2001; Meador et al. 2006; Reynaud and Deschaux 2006; Incardona et al. 2004; Incardona et al. 2012). Fish rapidly take up PAHs present in their food and the environment and quickly metabolize these compounds to more polar compounds. The more polar PAH metabolites are then secreted into fluids such as bile and urine for elimination via the gastroenteric tract or kidneys (Roubal et al., 1977; Varanasi et al., 1989; Krahn et al., 1984). Therefore, assessment of bile for PAH metabolites provides information on recent uptake and exposure to these compounds. Elevated biliary PAH metabolites have been measured in fish following oil spills (Krahn et al., 1986; Sol et al., 2000; Murawski et al, 2014; Snyder et al., 2015). Additionally, fish living near the Coal Oil Point oil seeps in Santa Barbara have been shown to have elevated levels of PAH metabolites in bile, compared to nearby reference locations (Spies et al., 1996; Roy et al., 2003).

The primary objective of this assessment was to obtain a quantitative estimate of PAH exposure in fish by measuring bile and muscle tissue concentrations in an indicator fish, as well as concentrations in the water. Surfperches (Embiotocidae) were selected because they are relatively resident and occupy the surf zone and shallow subtidal areas where significant oiling occurred (Carlisle et al, 1960). Barred surfperch and walleye surfperch were the two species evaluated. Exposure at Refugio State Beach, a heavily oiled area, was compared to a lesser oiled area, Gaviota State Beach, and an area near the Coal Oil Point oil seep, Campus Point, using samples from all three sites collected at both four days and approximately one year after the oil spill.

METHODS

Field Sampling Procedures

Sampling locations were selected based on shoreline oiling observations on 22 May 2015 (Figure 1). Gaviota State Beach was not reported as being oiled at that time. Refugio State Beach was adjacent to the spill location and was heavily oiled. Campus

Figure 1. *Sampling locations for surfperch bile on 23 May 2015 and 18 May 2016.*

Point was not reported as oiled but may have had some oil exposure from Line 901 oil and adjacent Coal Oil Point seeps. On 23 May 2015, surfperches were caught by hook and line at Refugio State Beach due to safety limitations of entering oil contaminated water. A beach seine was used at Campus Point and hook and line was used at Gaviota State Beach due to wind and surf conditions. On 18 May 2016, a beach seine was used at the same three locations to collect surfperch. Fish were identified to species and maintained alive until sample processing within one to two hours. Total length was measured and the fish were killed by cervical dislocation. The gall bladder was immediately extracted and bile was collected in 4 milliliter Sun-Sri™ amber vials and stored on ice in the field. Bile samples were then frozen at -20°C until analysis at the Northwest Fisheries Science Center, Seattle, WA. The sex was determined by examining gonadal tissue. The remaining carcass was wrapped in foil, placed in a zip-top bag, stored on ice in the field, and then frozen at -20°C until analyses were conducted at the California Department of Fish and Wildlife, Water Pollution Control Laboratory (CDFW-WPCL), Gold River, CA. As part of the fisheries closure assessment (OEHHA, 2015), barred surfperch were collected by hook and line at Gaviota State Beach and Refugio State Beach on 10 June 2015. No fish were collected from Campus Point. Fish were wrapped in foil, placed in a zip-top bag, stored on ice in the field, and then frozen at -20°C until analyses were conducted at the CDFW-WPCL.

Triplicate surf water samples were collected on 27 May 2015 and 17 May 2016 at Gaviota State Beach, Refugio State Beach and Campus Point. Samples were collected in one-liter amber glass bottles by submerging the bottle in the surf zone until filled with minimal headspace. Samples were immediately placed on ice and transported to the CDFW-WPCL for analysis.

Bile Analysis

Bile samples were analyzed using a high-performance liquid chromatography fluorescence (HPLC-F) method described in Krahn et al. (1984). This method results in the determination of the concentrations of classes of PAH metabolites fluorescing in the regions typified by naphthalene (NPH), phenanthrene (PHN) and benzo[a]pyrene (BaP). Bile was injected directly onto a Waters HPLC-F system equipped with a C-18 reverse-phase column (Phenomenex Synergi Hydro). The PAH metabolites were eluted with a linear gradient from 100% water (containing a trace amount of acetic acid) to 100% methanol at a flow of 1.0 mL/min. Chromatograms were recorded at the following wavelength pairs: 1) 292/335 nm where many 2-3 benzene ring aromatic compounds (e.g., NPH) fluoresce, 2) 260/380 nm where several 3-4 ring compounds (e.g., PHN) fluoresce and 3) 380/430 nm where 4-5 ring compounds (e.g., BaP) fluoresce. Peaks eluting after 9 minutes were integrated and the areas of these peaks were summed. The concentrations of fluorescent PAHs in the bile samples of the fish were determined using NPH, PHN or BaP as external standards and converting the fluorescence response of bile to PHN (ng PHN equivalents/g bile), NPH (ng NPH equivalents/g bile) or BaP (ng BaP equivalents/g bile) equivalents on a wet weight basis. In addition, protein analysis as described in da Silva et al. (2006) was completed for all bile samples as previous laboratory contaminant exposure studies on fish have shown that normalization of biliary PAH metabolite concentrations to protein values may help account for variation in metabolite levels based on feeding status (Collier and Varanasi 1991).

To ensure that the HPLC-F system was operating properly, a NPH/PHN/BaP calibration standard was analyzed numerous times ($n \geq 5$) until a relative standard deviation < 15% was obtained for each PAH. As part of the laboratory quality assurance plan (Sloan et al. 2006), a method blank and a fish bile positive control sample (bile of Atlantic salmon exposed to 25 mg/L of Monterey crude oil for 48 hours) were analyzed with each batch of fish bile samples. All sample batches met the laboratory quality assurance criteria.

Fish Tissue and Water Analysis

For the 23 May 2015 collection, skinless filets of individual barred surfperch were composited into one sample for each site: Gaviota (n=6 fish), Refugio (n=9 fish), and Campus Point (n=6 fish). For the 10 June 2015 collection, skinless filets of individual barred surfperch were again composited into one sample for each site: one sample for Gaviota (n=9 fish), and one for Refugio (n=4 fish). Tissues were extracted by pressurized fluid extraction, followed by gel permeation chromatography and silica clean-up. Water samples and tissue extracts were analyzed for PAHs by GC/MS-SIM (USEPA Method 8270 mod). Results for these 45 individual PAHs and alkylated homologue groups were summed to estimate total PAHs ($TPAH_{45}$): naphthalene; C1-naphthalenes; C2-naphthalenes; C3-naphthalenes; C4-naphthalenes; acenaphthylene; acenaphthene; fluorene; C1-fluorenes; C2-fluorenes; C3-fluorenes; phenanthrene; anthracene; C1-phenanthrene/anthracene; C2-phenanthrene/anthracene; C3-phenanthrene/anthracene; C4-phenanthrene/anthracene: pyrene; fluoranthene; C1-fluoranthene/pyrenes; C2-fluoranthene/pyrenes; C3-fluoranthene/pyrenes; C4-fluoranthene/pyrenes; benz[a]anthracene; chrysene; C1-chrysenes; C2-chrysenes; C3-

chrysenes; C4-chrysenes; benzo(a)pyrene; perylene; benzo(e)pyrene; benzo(b)fluoranthene; benzo(k)fluoranthene; benzo(g,h,i)perylene; indeno(1,2,3-c,d)pyrene; dibenz(a,h)anthracene; C1-dibenz(a,h)anthracene; C2-dibenz(a,h)anthracene; C3-dibenz(a,h)anthracene; dibenzothiopene; C1-dibenzothiophenes; C2-dibenzothiophenes; C3-dibenzothiophenes and biphenyl. When calculating $TPAH_{45}$, non-detects were assumed to be zero. Tissue results are reported on a dry weight basis.

RESULTS

Field Observations

Total lengths of surfperch caught on 23 May 2015 ranged from 153 to 297 mm at Gaviota, 130 to 230 mm at Refugio and 142 to 205 mm at Campus Point. At each location, one female barred surfperch was observed to contain live young upon dissection. For the 18 May 2016 sampling, total lengths of surfperch ranged from 115-190 mm at Gaviota, 145-225 mm at Refugio and 145-195 mm at Campus Point. Two female with live young were observed at Campus Point and Refugio. In 2016, other species caught in the surf zone via beach seine included: shiner surfperch (*Cymatogaster aggregate*), kelp surfperch (*Brachyistius frenatus*), corbina (*Menticirrhus undulates*), topsmelt (*Atherinops affinis*), Pacific sardine (*Sardinops sagax*), jacksmelt (*Atherinopsis californiensis*), black perch (*Embiotoca jacksoni*), sargo (*Anisotremus davidsoni*), opaleye (*Girella nigricans*), white croaker (*Genyonemus lineatus*); giant kelpfish (*Heterostichus rostratus*), and diamond turbot (*Hypsopsetta guttulata*).

Biliary PAH Metabolite Concentrations

Concentrations of biliary PAH metabolites (based on wet weight or biliary protein) are provided in Appendices 1 and 2. The mean (± SD) biliary NPH, PHN and BaP equivalent concentrations measured in surfperch collected at Gaviota State Beach (n=6 for barred), Refugio State Beach (n=21 for barred) and Campus Point (n=5 for barred; n=9 for walleye) in 2015 are shown in Figure 2 (ng/g bile, wet weight) and Figure 3 (ng/mg protein). Significant differences (ANOVA $p < 0.05$; Tukey-Kramer HSD test) in mean NPH, PHN and BaP equivalent concentrations (based on wet weight or biliary protein) were found among collection sites. For each PAH metabolite, barred surfperch from Refugio State Beach, adjacent to the oil release site, had a significantly higher mean level than those determined in fish from Campus Point or Gaviota. Mean PAH metabolite concentrations measured in bile of barred surfperch from Campus Point, adjacent to offshore oil seeps, were significantly higher than the same metabolites measured in barred surfperch from Gaviota, a lesser oiled site. At the Campus Point site, mean levels of biliary NPH and PHN equivalents (based on wet weight only) were significantly higher (ANOVA $p < 0.05$; t-test) in barred surfperch than in those measured in walleye surfperch. Mean concentrations of NPH and PHN were higher than BaP equivalents.

Mean (± SD) NPH, PHN and BaP equivalent concentrations based on wet weight (Figure 4) or biliary protein (Figure 5) for each species collected at Gaviota (n=7 for barred; n=1 for walleye), Refugio State Beach (n=8 for barred; n=20 for walleye) and

Campus Point (n=1 for barred; n=13 for walleye) were not significantly different (ANOVA $p > 0.05$; $\log_{10}$ transformed data) in fish collected one year after the spill except PHN equivalent levels (wet weight only) in barred surfperch from the Refugio Beach site and Gaviota ($p = 0.0487$).

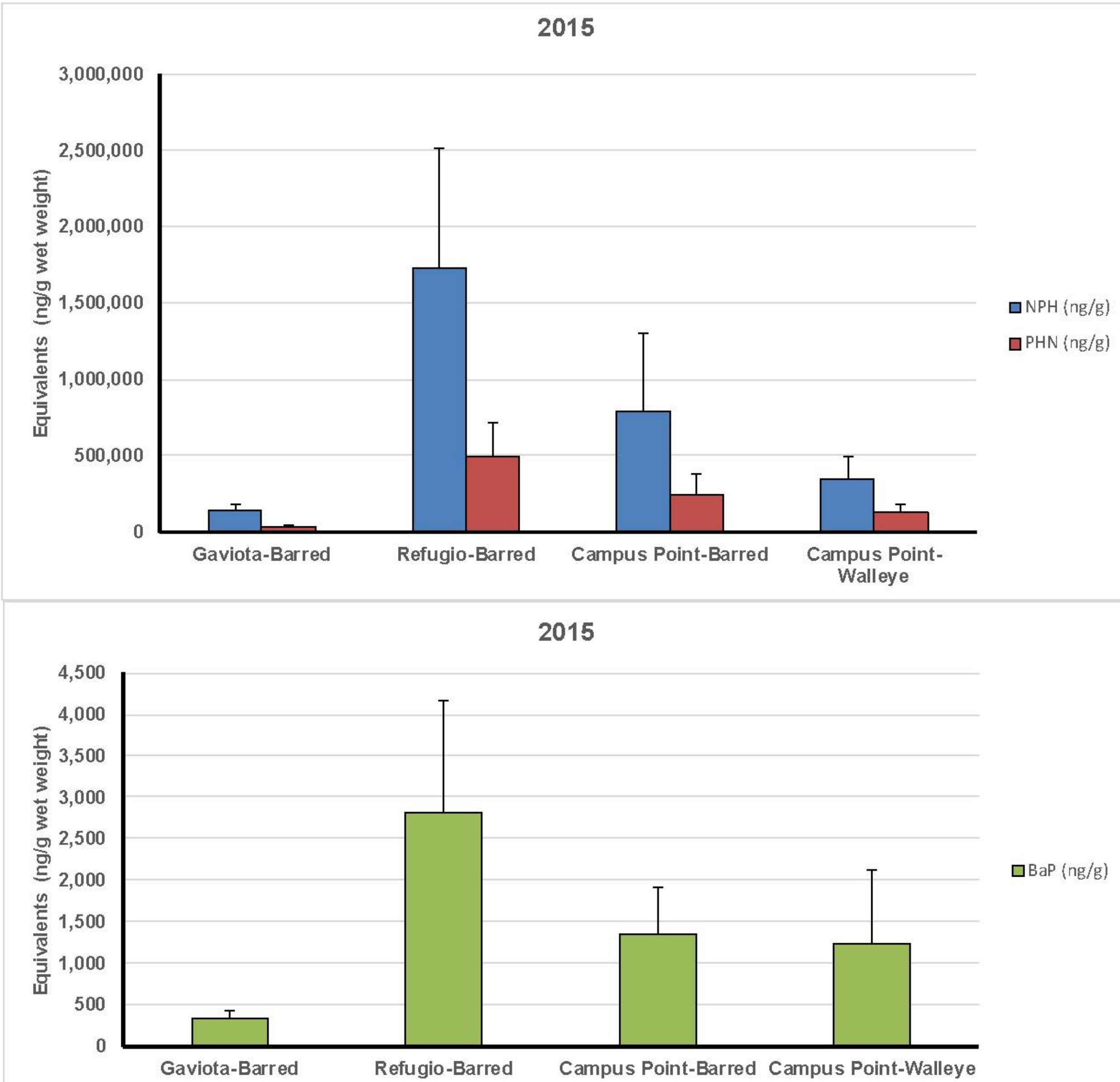
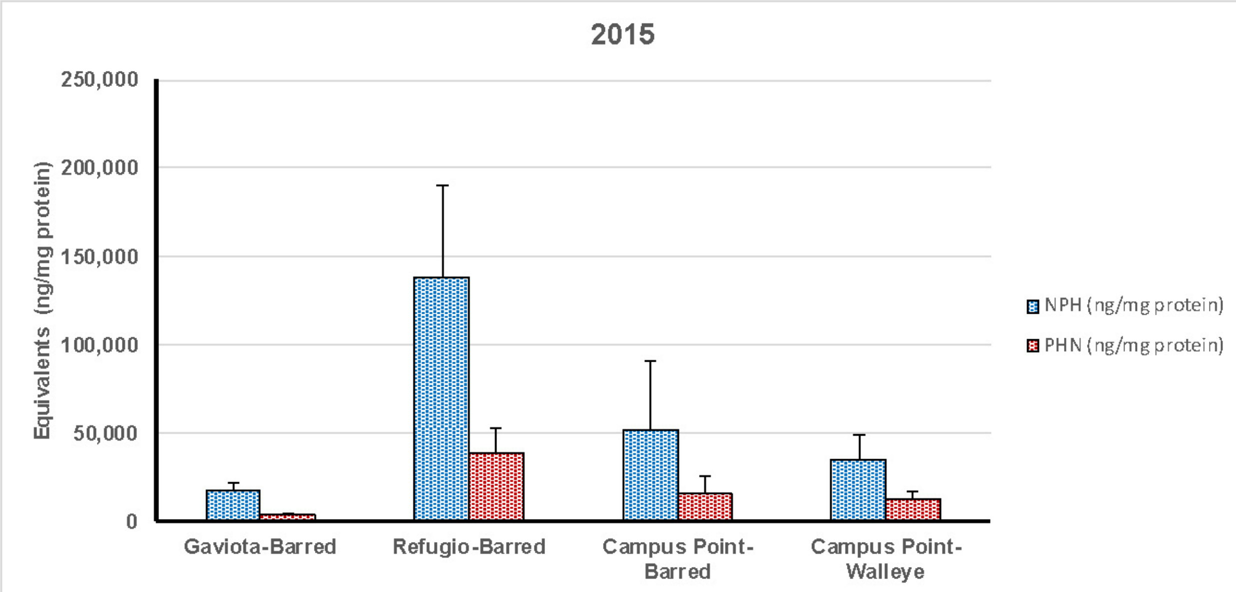


Figure 2. *Mean (±SD) concentrations of bile equivalents (ng/g bile wet weight) measured in barred and walleye surfperch collected in 2015: naphthalene (NPH), and phenanthrene (PHN; Top) and benzo[a]pyrene (BaP; Bottom).*



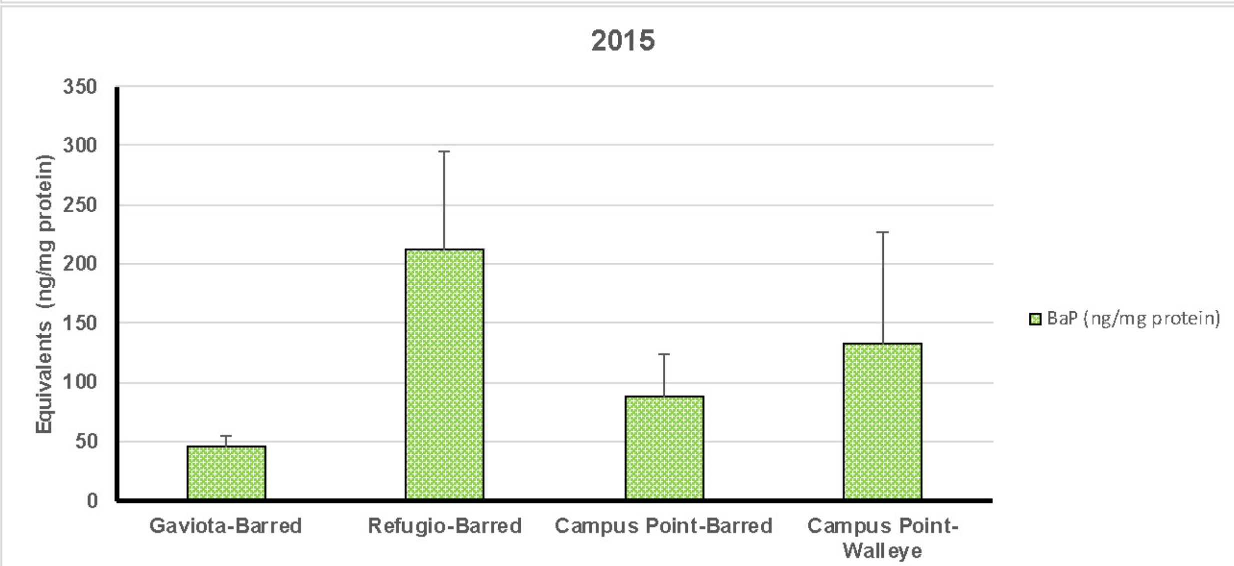


Figure 3. *Mean (±SD) concentrations of bile equivalents (ng/mg bile protein) measured in barred and walleye surfperch collected in 2015: naphthalene (NPH) and phenanthrene (PHN; Top) and benzo[a]pyrene (BaP; Bottom).*

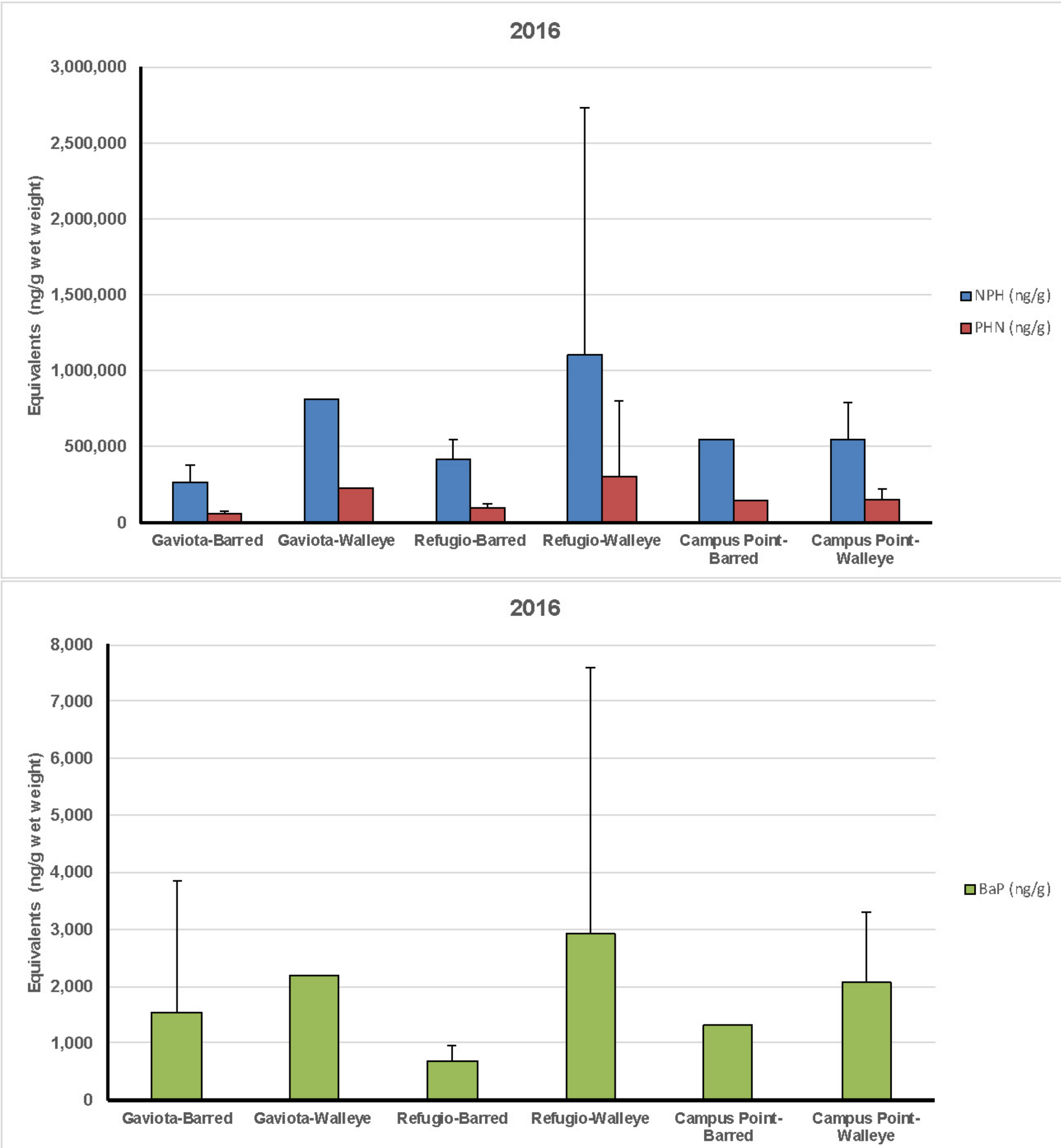


Figure 4. *Mean (±SD) concentrations of bile equivalents (ng/g bile wet weight) measured in barred and walleye surfperch collected in 2016: naphthalene (NPH) and phenanthrene (PHN; Top); and benzo[a]pyrene (BaP; Bottom).*

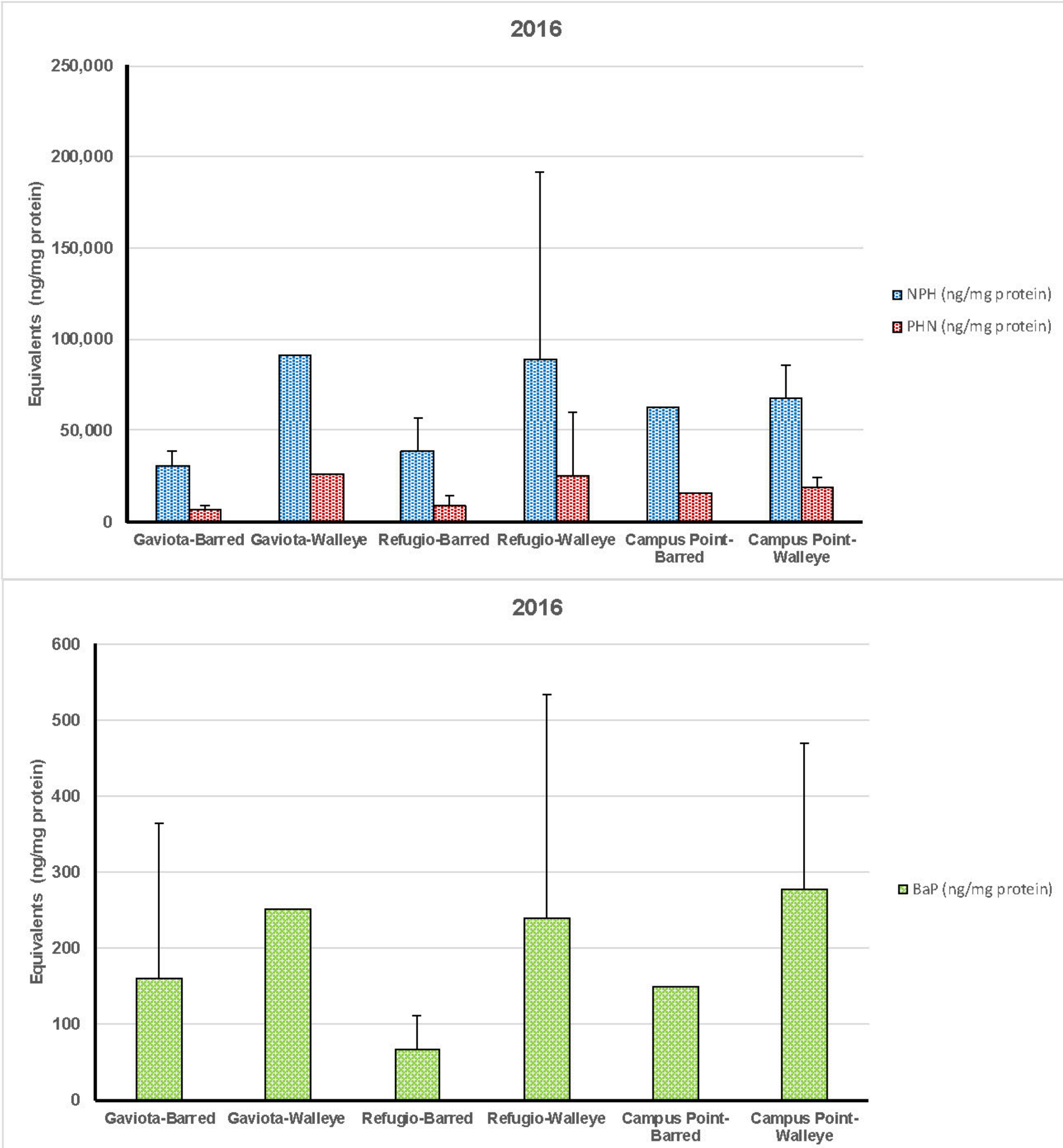


Figure 5. *Mean (±SD) concentrations of bile equivalents (ng/mg bile protein) measured in barred and walleye surfperch collected in 2016: naphthalene (NPH) and phenanthrene (PHN; Top); and benzo[a]pyrene (BaP; Bottom).*

At the Refugio State Beach site, mean concentrations of all PAH metabolites based on wet weight (Figure 4) in the 2016 collected fish were significantly higher in walleye surfperch compared to barred surfperch (ANOVA $p < 0.05$; t-test; $\log_{10}$ transformed data). Similarly, mean levels of protein-corrected PAH metabolites were significantly higher (ANOVA $p < 0.05$; t-test) in walleye compared to barred surfperch except protein-corrected NPH ($p = 0.0505$). Comparisons between species at the other two collection sites were not conducted due to inadequate numbers of bile samples.

Differences in mean concentrations of PAH metabolites based on sampling year for each species collected at the same site were examined. Barred surfperch collected at Refugio Beach in 2015 had significantly higher (ANOVA $p < 0.0001$; t-test; $\log_{10}$ transformed data) mean NPH, PHN and BaP concentrations (wet weight and protein-corrected) than those determined in the 2016 (Figure 6). In contrast, Gaviota barred surfperch collected in 2016 (Figure 6) had significantly higher mean concentrations (ANOVA $p < 0.05$; t-test; $\log_{10}$ transformed data) of NPH equivalents (wet weight and protein-corrected) and PHN equivalents (wet weight only) than the mean values of the 2015 fish. Walleye surfperch collected from Campus Point in 2016 had significantly higher mean concentrations of protein-corrected NPH, PHN and BaP equivalents, as well as NPH equivalents (wet weight only), compared to the 2015 fish. No other significant differences (ANOVA $p > 0.05$) in mean concentrations of PAH metabolites were found for walleye surfperch from this site.

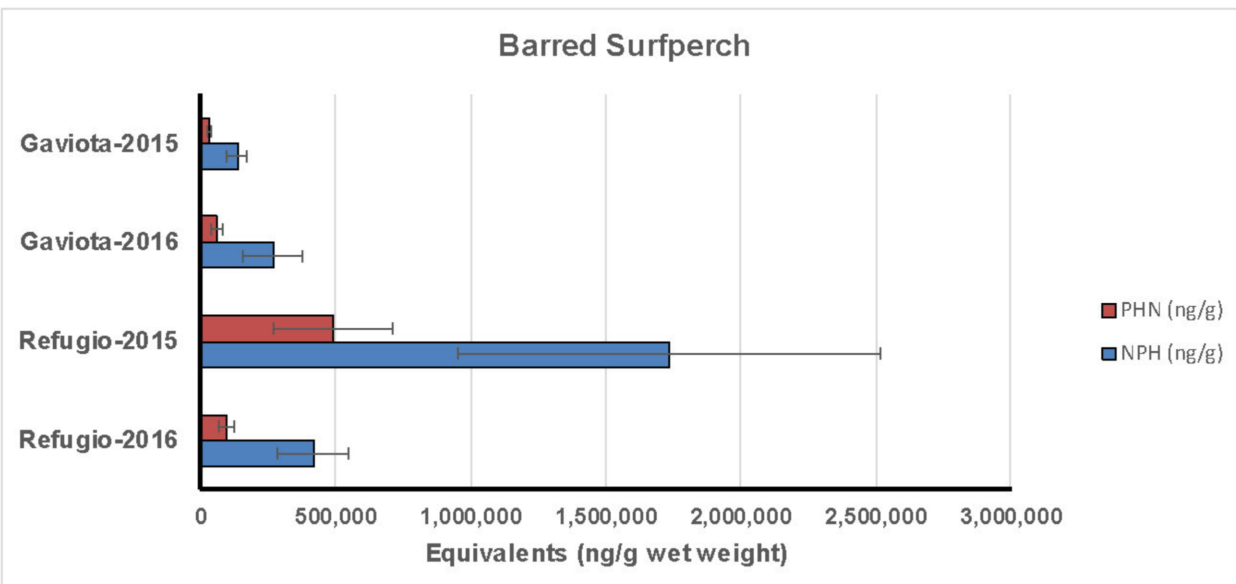


Figure 6. *Mean (±SD) concentrations of bile naphthalene (NPH) and phenanthrene (PHN) equivalents (ng/g bile wet weight) measured in barred surfperch collected in 2015 and 2016.*

Fish Muscle PAH Concentrations

The $TPAH_{45}$ concentration in skinless filets collected four days after the spill followed the pattern seen in bile, with highest concentrations observed at Refugio (88 ug/kg dw; Figure 7). Naphthalenes (parent and C1-C4 alkylated) were the primary PAHs detected at Gaviota (100%), Refugio (91%) and Campus Point (78%). Tricyclic PAHs were also detected at Refugio (e.g., acenaphthene, dibenzothiophenes, and C1-phenanthrene/anthracene) and Campus Point (C1-phenanthrene/anthracene). Concentrations were almost three times lower at Refugio (30 ug/kg dw) 22 days post spill but were similar at Gaviota, consisting only of naphthalenes at both locations.

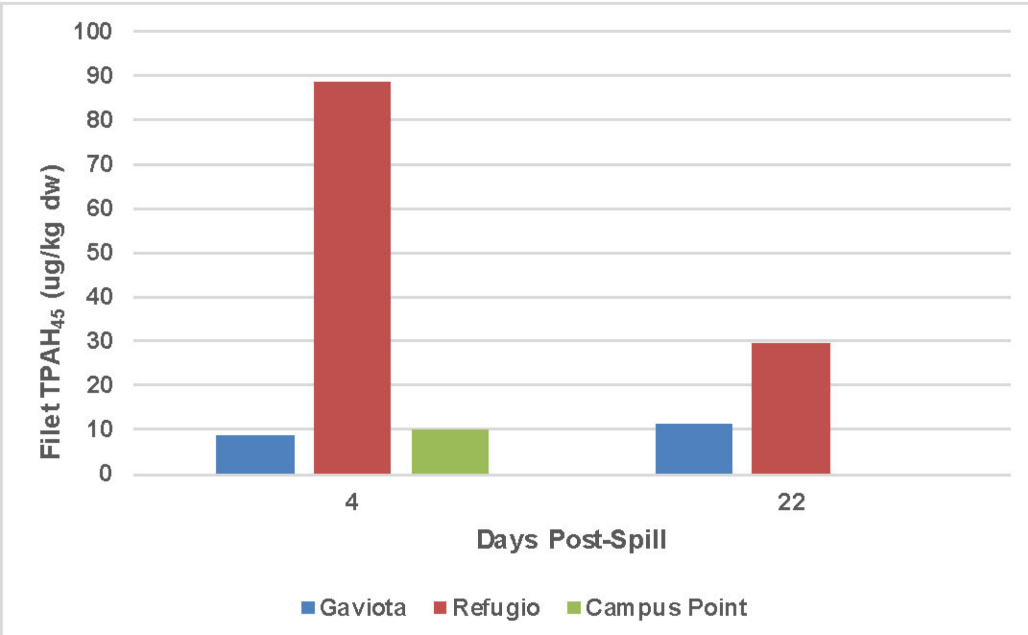


Figure 7. *$TPAH_{45}$ concentrations (ug/kg dw) in a composite sample of barred surfperch skinless filets 4 and 22 days after the spill from Gaviota (4; n=6: 22; n=9 fish)and Refugio (4; n=9: 22; n= 4 fish) and 4 days after the spill from Campus Point (4; n=6 fish).*

Surf Water PAH Concentrations

$TPAH_{45}$ concentrations in surf water 8 days after the spill were highest at Refugio (1.8 – 12.8 µg/l) when compared to Gaviota (0.06 – 0.18 µg/l) and Campus Point (0.12 – 0.30 µg/l; Figure 8). This is consistent with the 2015 spatial pattern observed in fish bile and muscle tissue. One year after the spill, $TPAH_{45}$ concentrations were lower at Refugio (0.16 – 0.53 µg/l) and Gaviota (0.0 – 0.04 µg/l), but variable at Campus Point (0.3 – 12.4 µg/l; Figure 8). Based on fingerprinting analysis (Stout, 2016), it was determined that the maximum concentrations at Refugio in 2015 and Campus Point in 2016 contained crude oil micro-droplets or emulsions, due to the presence of minimally soluble 4- to 6-ring PAHs. Further PAH composition analysis revealed that the Refugio 2015 sample was a probable match to the Line 901 oil, due to the high proportion of dibenzothiophenes, but the Campus Point 2016 PAH distribution was consistent with seep oil. The PAH composition in the maximum Campus Point 2015 sample was also consistent with seep oil.

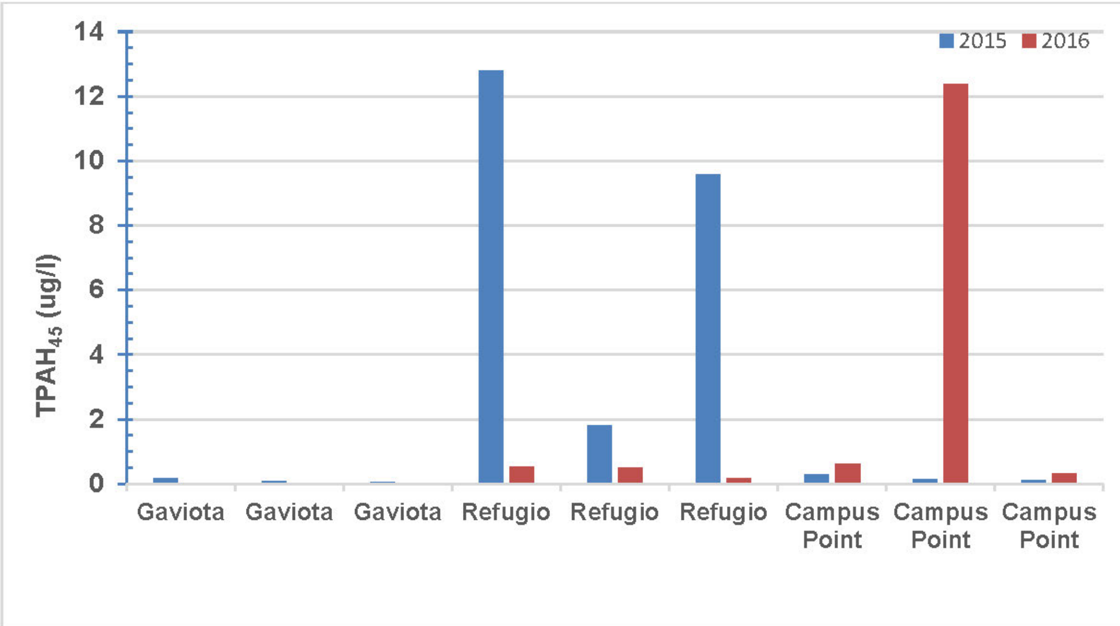


Figure 8. *$TPAH_{45}$ concentrations (µg/l) in triplicate surf water samples from Gaviota, Refugio and Campus Point collected 8 days after the spill (27 May 2015) and approximately one year after the spill (17 May 2016).*

DISCUSSION

Four days after the Line 901 oil release, surfperch biliary PAH metabolite concentrations were significantly higher at Refugio State Beach, compared to Campus Point and Gaviota State Beach. $TPAH_{45}$ concentrations in surfperch muscle and surf water reflected a similar spatial pattern in 2015. These results indicated surf zone fish exposures to PAHs were higher in the area adjacent to the oil release. One year after the oil spill, mean biliary PAH metabolite concentrations at Refugio declined, such that there was no longer a significant difference between the three sampling locations. Campus Point surfperch, continued to show elevated biliary PAH metabolite levels, compared to Gaviota State Beach, likely due to the presence of nearby natural oil seeps, consistent with elevated $TPAH_{45}$ levels in surf water at this location in 2016. Within site species differences between barred and walleye surfperch bile metabolite levels may have resulted from differences in food and habitat preferences (Carlisle et al, 1960; Feder et al, 1974; Hobson and Chess, 1986) but additional research would have to be conducted to further assess interspecies differences.

PAH metabolites in 2015 and 2016 bile samples were predominately naphthalene and phenanthrene derived metabolites, consistent with exposure to fresh crude oils, rather than higher molecular weight PAHs (e.g., BaP) that are associated with pyrogenic sources (Lee and Anderson, 2005). Exposure of fish to oil seep sediment has also resulted in bile PAH metabolites being dominated by NPH and PHN equivalents (Roy et al., 2003). However, levels measured in this study were somewhat higher than previously measured near Santa Barbara oil seeps. Spies et al (1996) sampled rainbow surfperch near the Isla Vista seeps at Coal Oil Point, at depths of 8-15m, and the Goleta

Pier in September 1990. Bile NPH and PHN equivalents were elevated near the seep site, compared to Goleta Pier (Figure 9). Liver cytochrome P-450 enzyme levels and mean gill and liver lesion scores were significantly higher in fish collected from the seep area, compared to Goleta.

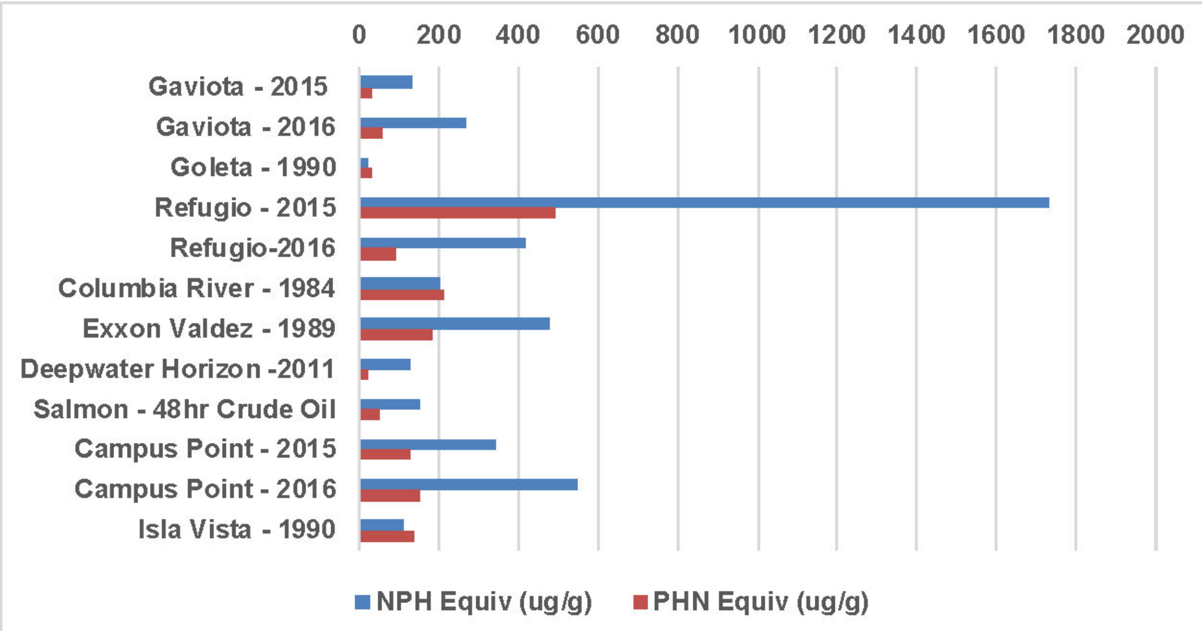


Figure 9. *Comparison of biliary naphthalene (NPH) and phenanthrene (PHN) equivalents (ug/g wet weight) mean concentrations from this study (2015, 2016 and salmon-48hr crude oil standard; barred surfperch at Gaviota and Refugio and walleye surfperch at Campus Point), previous studies in Santa Barbara (Goleta and Isla Vista, 1990; Spies et al., 1996) and following other oil spills (Krahn et al, 1986; Hom et al., 2008; Snyder et al., 2015).*

NPH equivalent mean concentrations measured in barred surfperch bile at Refugio State Beach in 2015 were higher than measured following other oil spills (Figures 9 and 10). In 1984, a tanker released more than 170,000 gallons of residual fuel oil into the Columbia River (Krahn et al., 1986). White sturgeon collected 5 days later and 57 miles downriver from the spill had significantly elevated mean concentrations of NPH (200 ug/g) and PHN (210 ug/g) equivalents, compared to the upriver reference site (32 and 9.7 ug/g respectively). Fish downriver of the spill were observed to have oil in their mouths and showed physical signs of stress (e.g., excess mucus secretion; Kennedy and Baca, 1984). In March 1989, 11 million gallons of Prudhoe Bay crude oil from the Exxon Valdez were released into Prince William Sound. Sol et al (2000) collected Dolly Varden (*Salvelinus malma*) 2-3 months after spill and found elevated levels of PAH metabolites in bile, associated with reduced plasma estradiol. Hom et al (1996; 2008) reported elevated PHN equivalents in pink salmon bile collected at an oiled site in 1989, compared to a reference location. Several studies documented that the Exxon Valdez spill adversely effected early life stages resulting in adverse effects on salmonid populations (Geiger et al., 1996; Incardona et al, 2013). One month following the North Cape oil spill of No. 2 fuel oil, winter flounder (*Pleuronectes americanus*) had elevated levels of NPH and PHN equivalents in bile, compared to a reference site (Collier et al., 1997; Figure 10). It was concluded that exposure levels were sufficient to cause reproductive impairment, associated with reduced plasma estradiol levels. Effects to winter flounder early life stages were also reported (Hughes, 1999). Most recently, elevated levels of fish biliary PAH metabolites were reported following the 2010 Deepwater Horizon oil spill in the Gulf of Mexico (Snyder et al, 2015). An elevated incidence of skin lesions was observed in fish in 2011 and the incidence rate declined in 2012 (Murawski et al., 2014).

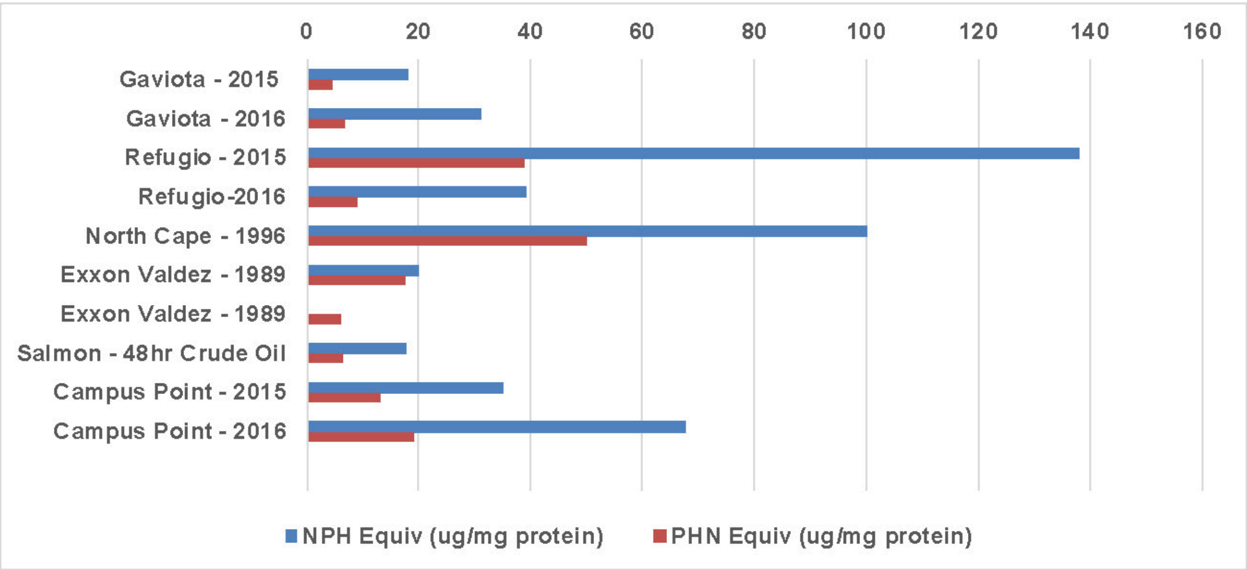


Figure 10. *Comparison of biliary naphthalene (NPH) and phenanthrene (PHN) equivalents (ug/mg bile protein) mean concentrations from this study (2015, 2016 and salmon-48hr crude oil standard; ; barred surfperch at Gaviota and Refugio and walleye surfperch at Campus Point) and following other oil spills (Collier et al., 1997; Hom et al., 1996; Sol et al., 2000).*

Biliary PAH metabolites have been shown to indicate uptake to fish from all exposure routes, providing an integrated estimate of recent PAH exposure (Meador et al., 2008). Many studies have used them as a biomarker of exposure for petroleum related contamination. In this assessment, a quantitative estimate of PAH exposure to surfperch was obtained, indicating that elevated exposure occurred in the surf zone at Refugio State Beach following the 2015 oil spill.

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Appendices:

Appendix 1: Analysis of Bile of Fish for Metabolites of Polycyclic Aromatic Compounds (PACs): Results from Samples Collected following the Refugio Beach Oil Spill, May 2015

Appendix 2: Analysis of Bile of Fish for Metabolites of Polycyclic Aromatic Compounds (PACs): Results from Samples Collected One Year after the 2015 Refugio Beach Oil Spill

Analysis of Bile of Fish for Metabolites of Polycyclic Aromatic Compounds (PACs): Results from Samples Collected Following the Refugio Beach Oil Spill, May 2015

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Summary

Analyses that screen for metabolites of polycyclic aromatic compounds (PACs) were conducted for bile samples of fish collected from three sites in Santa Barbara, CA in the area of the Refugio Beach oil spill. Bile samples were collected from barred surfperch (*Amphistichus argenteus*) from the three sites that included the spill site, a natural oil seep site that was not reported as being oiled the day prior to the 23 May 2015 sampling and a reference site. Additionally, walleye surfperch (*Hyperprosopon argenteum*) were collected at the natural seep site. Concentrations of bile PAC metabolites showed site differences in the 3 types of metabolites measured, naphthalene (NPH), phenanthrene (PHN) and benzo[*a*]pyrene (BaP), based on wet weight or protein content. The levels in fish collected at both the spill and natural seep sites were higher than the reference site, and the concentrations in fish from the spill site were higher overall than the natural seep site. Barred surfperch from the Refugio Beach oil spill site had the highest levels of PAC metabolites, with concentrations being an order of magnitude higher than barred surfperch from Gaviota, the reference site, and approximately two times higher than barred surfperch from Campus Point, the natural seep site. Concentrations of PAC metabolites measured in bile of barred surfperch and walleye surfperch collected from Campus Point, the natural seep site, were 3 to 8 times higher than those in barred surfperch from Gaviota, the reference site. Bile PAC metabolites levels in barred surfperch from Refugio Beach were 2 times higher than those measured in barred surfperch from Campus Point and were 2 to 5 times higher compared to the walleye surfperch collected at this seep site.

Introduction

PACs are chemical contaminants that include polycyclic aromatic hydrocarbons (PAHs) such as naphthalene, phenanthrene, pyrene, benzo[*a*]pyrene), as well as heterocyclic aromatic compounds (e.g., dibenzothiophene) that are primarily derived from petroleum or their combustion products. Concerns have been raised over the effects of exposure to PACs, alone or in combination with other toxic contaminants, on terrestrial and marine organisms because of the worldwide use of fossil fuels (Geraci and St. Aubin 1990; Peterson et al., 2003) and the occurrence of oil spills in regions that support populations of fish, birds, turtles and amphibians. In other vertebrates, such as fish, biological effects associated with exposure to PACs include developmental abnormalities, immunosuppression, hepatic lesions and altered growth (Myers et al. 1994; Heintz et al. 2000; Arkoosh et al. 2001; Meador et al. 2006; Reynaud and Deschaux

2006; Incardona et al. 2004; Incardona et al. 2012). Routes of PAC exposure in fish include consumption of contaminated food, inhalation, and dermal absorption.

Vertebrates (e.g., fish, marine mammals) rapidly take up PACs present in their food and the environment and quickly metabolize these compounds to more polar compounds. The more polar PAC metabolites are then secreted into fluids such as bile and urine for elimination via the gastroenteric tract or kidneys (Roubal et al., 1977; Varanasi et al., 1989; Krahn et al., 1984). Therefore, assessment of bile for PACs provides information on recent input and exposure to these compounds.

Methods

Bile samples were collected on May 23, 2015, 4 days after the spill occurred. Bile of barred surfperch was collected from Refugio Beach (n= 20), Campus Point (n = 5), and Gaviota (n = 5). Bile from walleye surfperch was collected from Campus Point (n= 7). Bile samples were collected from the gall bladder immediately after fish were sacrificed, placed into 4mL amber vials and kept on ice. Then, the samples were frozen and transported to the Northwest Fisheries Science Center and stored at -20°C until analyses.

Bile samples were analyzed using a high-performance liquid chromatography/fluorescence (HPLC-F) method described in Krahn et al., 1984. Briefly, bile was injected directly onto a Waters high-performance liquid chromatography/fluorescence system equipped with a C-18 reverse-phase column (Phenomenex Synergi Hydro). The fluorescent PAC metabolites were eluted with a linear gradient from 100% water (containing a trace amount of acetic acid) to 100% methanol at a flow of 1.0 mL/min. Chromatograms were recorded at the following wavelength pairs: 1) 292/335 nm where many 2-3 benzene ring aromatic compounds (e.g., naphthalene) fluoresce, 2) 260/380 nm where several 3-4 ring compounds (e.g., phenanthrene) fluoresce and 3) 380/430 nm where 4-5 ring compounds (e.g., benzo[a]pyrene) fluoresce. Peaks eluting after 9 minutes were integrated and the areas of these peaks were summed. The concentrations of fluorescent PACs in the bile samples of the fish were determined using naphthalene (NPH), phenanthrene (PHN) or benzo[a]pyrene (BaP) as external standards and converting the fluorescence response of bile to phenanthrene (ng PHN equivalents/g bile), naphthalene (ng NPH equivalents/g bile) or benzo[*a*]pyrene (ng BaP equivalents/g bile) equivalents. In addition, protein analysis as described in da Silva et al. (2006) was completed for all bile samples as previous laboratory contaminant exposure studies on fish have shown that normalization of biliary PAC metabolite concentrations to protein values can help account for variation in metabolite levels based on feeding status (Collier and Varanasi 1991).

To ensure that the HPLC/fluorescence system was in proper operating condition, a NPH/PHN/BaP calibration standard was analyzed numerous times ($n \geq 5$) until a relative standard deviation < 15% was obtained for each PAC. As part of our laboratory quality assurance (QA) plan (Sloan et al. 2006), a method blank and a fish bile control sample (bile of Atlantic salmon exposed to 25 µg/mL of Monterey crude oil for 48 hours) were analyzed with each batch of fish bile samples. In addition, an aliquot of a harbor seal bile sample (Bile_Ref_Mat) was also analyzed during the sample sequence as part of the QA plan.

Results

Concentrations of fluorescent PAC metabolites (based on wet weight or biliary protein) and levels of protein measured in the bile samples reported in Table 1. Two bile samples (RFB011BI and RFB001BI) were not analyzed for protein content due to inadequate bile volume (< 10 µL). For the barred surfperch from Refugio Beach, NPH equivalent concentrations ranged from 780,000 to 4,400,000 ng/g bile, wet weight and 67,000 to 270,000 ng/mg protein, PHN equivalents ranged from 200,000 to 1,200,000 ng/g bile, wet weight and 20,000 to 74,000 ng/mg protein and BaP equivalent values ranged from 1,100 to 6,700 ng/g bile, wet weight and 91 to 410 ng/mg protein. For the barred surfperch from Campus Point, NPH equivalent concentrations ranged from 420,000 to 1,800,000 ng/g bile, wet weight and 31,000 to 130,000 ng/mg protein, PHN equivalents ranged from 150,000 to 500,000 ng/g bile, wet weight and 10,000 to 35,000 ng/mg protein and BaP equivalent values ranged from 880 to 2,300 ng/g bile, wet weight and 55 to 160 ng/mg protein. For the walleye surfperch from Campus Point, NPH equivalent concentrations ranged from 150,000 to 610,000 ng/g bile, wet weight and 11,000 to 52,000 ng/mg protein, PHN equivalents ranged from 49,000 to 200,000 ng/g bile, wet weight and 3,700 to 19,000 ng/mg protein and BaP equivalent values ranged from 550 to 3,500 ng/g bile, wet weight and 48 to 340 ng/mg protein. For the barred surfperch from Gaviota, NPH equivalent concentrations ranged from 86,000 to 200,000 ng/g bile, wet weight and 14,000 to 26,000 ng/mg protein, PHN equivalents ranged from 22,000 to 43,000 ng/g bile, wet weight and 3,400 to 5,500 ng/mg protein and BaP equivalent values ranged from 240 to 510 ng/g bile, wet weight and 32 to 65 ng/mg protein. In addition, biliary protein concentrations ranged from 6.2 to 21.0 mg/mL in the barred surfperch bile samples and 4.2 to 15.2 mg/mL in the walleye surfperch.

The mean (± SD) biliary NPH, PHN and BaP equivalent concentrations (ng/g bile, wet weight) measured in barred surfperch collected at Refugio Beach, Campus Point and Gaviota are shown in Figure 1A–C. Significant differences (ANOVA $p < 0.05$; Tukey-Kramer HSD test) in mean NPH, PHN and BaP equivalent concentrations (based on wet weight or biliary protein) were found among collection sites. For each PAC metabolite, barred surfperch from the oiled site had a significantly higher mean level than those determined in fish from the seep site or from the reference site. Mean PAC metabolite concentrations measured in bile of barred surfperch from the seep site were significantly higher than the same metabolites measured in barred surfperch from the reference site. At the Campus Point site, mean levels of biliary NPH and PHN equivalents (based on wet weight only) were significantly higher (ANOVA $p < 0.05$; t-test) in barred surfperch than those measured in walleye surfperch; no other significant differences were found for mean PAC equivalent concentrations between species.

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Appendix 1

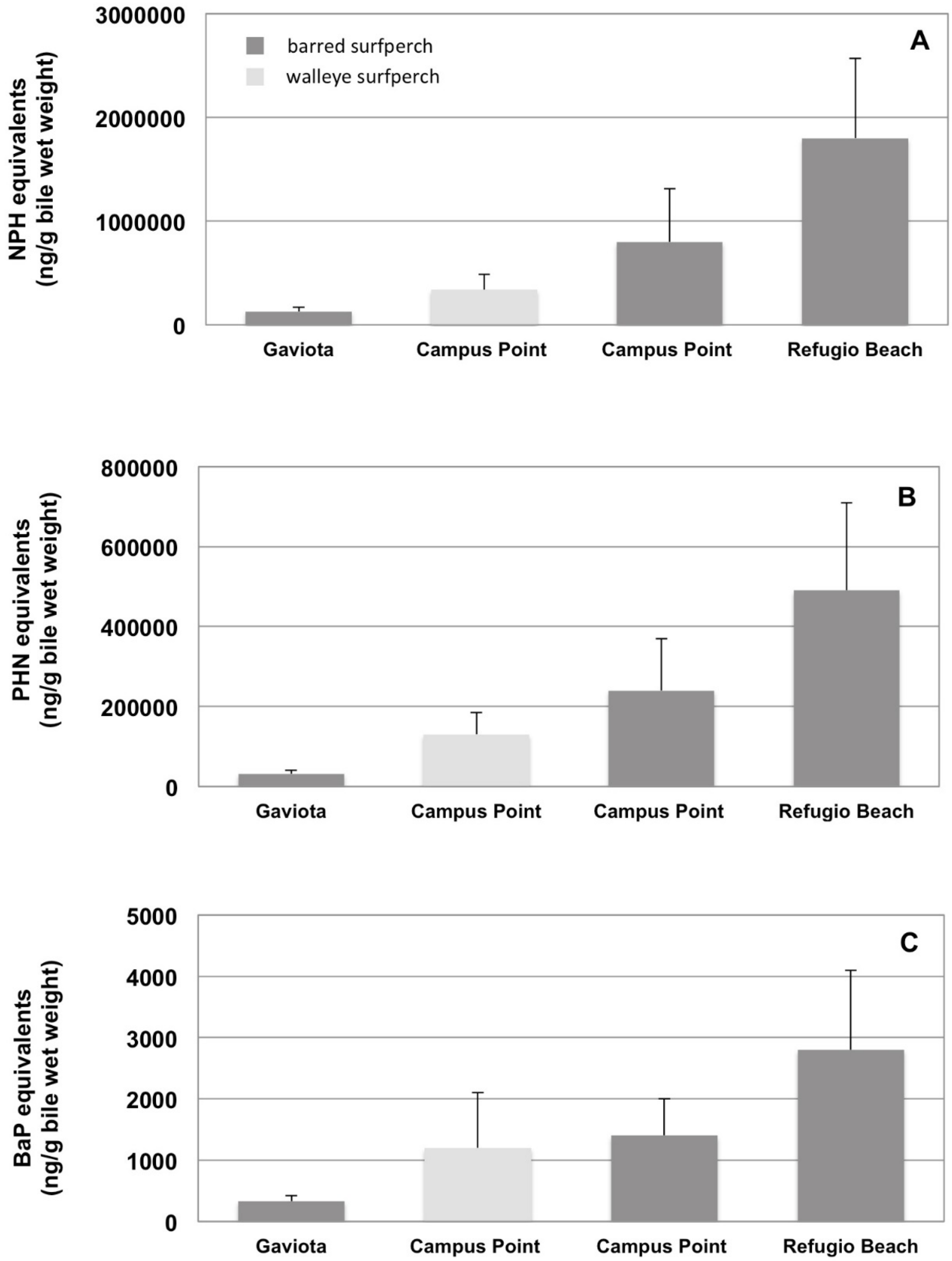

Figure 1. Mean (±SD) concentrations of bile equivalents of (A) naphthalene, NPH, (B) phenanthrene, PHN and (C) benzo[*a*]pyrene, BaP (ng/g bile wet weight) measured in two fish species collected from three sites in the area of the Refugio Beach oil spill.

Appendix 1

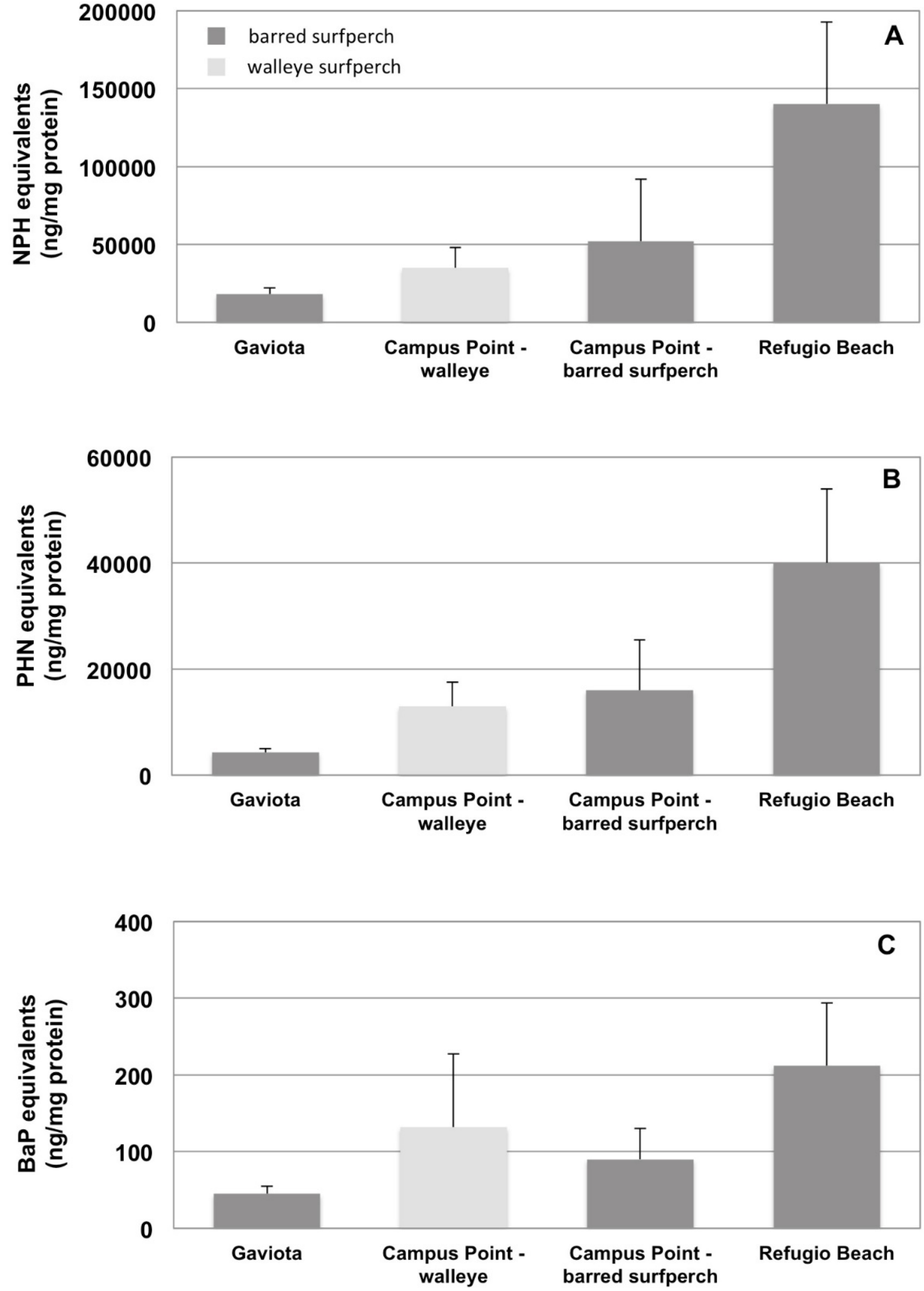

Figure 2. Mean (±SD) concentrations of bile equivalents (A) naphthalene, NPH, (B) phenanthrene, PHN and (C) benzo[*a*]pyrene, BaP (ng/mg protein) measured in two fish species collected from three sites in the area of the Refugio Beach oil spill.

Appendix 1

Table 1. Concentrations of metabolites in polycyclic aromatic compounds measured in bile of fish collected on May 23, 2015 in the area of the Refugio Beach oil spill, Santa Barbara, CA

				Equivalents of fluorescent aromatic compounds (ng/g bile, wet weight)			Equivalents of fluorescent aromatic compounds (ng/mg protein)		
Site	**FIELD NUMBER**	**SPECIES**	**Protein mg/mL**	**NPH Equivalents[1]**	**PHN Equivalents[2]**	**BaP Equivalents[3]**	**NPH Equivalents[1]**	**PHN Equivalents[2]**	**BaP Equivalents[3]**
Refugio Beach	RFB009BI	barred surfperch	12.6	1,000,000	280,000	1,500	79,000	22,000	120
Refugio Beach	RFB007BI	barred surfperch	15.1	3,100,000	940,000	5,100	210,000	62,000	340
Refugio Beach	RFB015BI	barred surfperch	9.0	1,500,000	400,000	2,300	170,000	44,000	260
Refugio Beach	RFB019BI	barred surfperch	9.9	2,100,000	560,000	3,100	210,000	57,000	310
Refugio Beach	RFB012BI	barred surfperch	8.7	1,100,000	320,000	2,000	130,000	37,000	230
Refugio Beach	RFB018BI	barred surfperch	16.3	4,400,000	1,200,000	6,700	270,000	74,000	410
Refugio Beach	RFB002BI	barred surfperch	17.6	1,400,000	370,000	1,600	80,000	21,000	91
Refugio Beach	RFB020BI	barred surfperch	9.3	1,700,000	440,000	2,500	180,000	47,000	270
Refugio Beach	RFB017BI	barred surfperch	15.5	1,500,000	560,000	2,800	97,000	36,000	180
Refugio Beach	RFB014BI	barred surfperch	19.7	1,900,000	530,000	3,000	96,000	27,000	150
Refugio Beach	RFB004BI	barred surfperch	8.8	780,000	200,000	1,100	89,000	23,000	130
Refugio Beach	RFB011BI	barred surfperch	*ND*	2,200,000	560,000	5,300			
Refugio Beach	RFB008BI	barred surfperch	7.2	1,100,000	280,000	1,300	150,000	39,000	180

Appendix 1

Refugio Beach	RFB006BI	barred surfperch	16.1	2,200,000	620,000	3,300	140,000	39,000	200
Refugio Beach	RFB010BI	barred surfperch	8.6	1,500,000	430,000	2,400	170,000	50,000	280
Refugio Beach	RFB001BI	barred surfperch	*ND*	1,900,000	560,000	3,500			
Refugio Beach	RFB016BI	barred surfperch	13.0	1,400,000	380,000	2,200	110,000	29,000	170
Refugio Beach	RFB003BI	barred surfperch	12.0	1,400,000	380,000	2,100	120,000	32,000	180
Refugio Beach	RFB005BI	barred surfperch	10.6	1,700,000	470,000	2,700	160,000	44,000	250
Refugio Beach	RFB013BI	barred surfperch	16.5	1,100,000	330,000	1,800	67,000	20,000	110
Campus Point	CMP002,003BI	barred surfperch	12.6	420,000	150,000	920	33,000	12,000	73
Campus Point	CMP004,005BI	barred surfperch	14.9	480,000	180,000	1,000	32,000	12,000	67
Campus Point	CMP006,007BI	barred surfperch	16.1	570,000	180,000	880	35,000	11,000	55
Campus Point	CMP008,009BI	barred surfperch	14.4	1,800,000	500,000	2,300	130,000	35,000	160
Campus Point	CMP010,011BI	barred surfperch	21.0	660,000	210,000	1,700	31,000	10,000	81
Campus Point	CMP017BI	walleye surfperch	4.2	220,000	79,000	550	52,000	19,000	130
Campus Point	CMP012,013BI	walleye surfperch	7.3	380,000	140,000	1,900	52,000	19,000	260
Campus Point	CMP025,026BI	walleye surfperch	11.7	610,000	190,000	1,200	52,000	16,000	100
Campus Point	CMP018,019BI	walleye surfperch	10.3	240,000	97,000	3,500	23,000	9,400	340
Campus Point	CMP020,021BI	walleye surfperch	13.1	150,000	49,000	630	11,000	3,700	48

Appendix 1

Campus Point	CMP014,015BI	walleye surfperch	15.2	500,000	200,000	990	33,000	13,000	65
Campus Point	CMP023,024BI	walleye surfperch	8.0	250,000	92,000	740	31,000	12,000	93
Gaviota	GAV002BI	barred surfperch	6.2	96,000	26,000	270	15,000	4,200	44
Gaviota	GAV004,005BI	barred surfperch	7.9	110,000	27,000	250	14,000	3,400	32
Gaviota	GAV006,007BI	barred surfperch	7.4	140,000	35,000	340	19,000	4,700	46
Gaviota	GAV008BI	barred surfperch	7.8	200,000	43,000	510	26,000	5,500	65
Gaviota	GAV009BI	barred surfperch	8.7	170,000	40,000	390	20,000	4,600	45

[1]Concentrations in part per billion (ng/g) based on total area compared to the fluorescence of naphthalene standard at 292/335 nm wavelengths.

[2]Concentrations in part per billion (ng/g) based on total area compared to the fluorescence of phenanthrene standard at 260/380 nm wavelengths.

[3]Concentrations in part per billion (ng/g) based on total area compared to the fluorescence of benzo[*a*]pyrene standard at 380/430 nm wavelengths.

ND – no data due to inadequate amount of sample to conduct protein analyses.

Appendix 2: Analysis of Bile of Fish for Metabolites of Polycyclic Aromatic Compounds (PACs):

Results from Samples Collected One Year after the 2015 Refugio Beach Oil Spill

Analysis of Bile of Fish for Metabolites of Polycyclic Aromatic Compounds (PACs):

Results from Samples Collected One Year after the 2015 Refugio Beach Oil Spill

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Summary

Analyses that screen for metabolites of polycyclic aromatic compounds (PACs) have been completed for bile samples of fish collected from three sites in Santa Barbara, CA one year after the 2015 Refugio Beach oil spill. Bile samples were collected from barred surfperch (*Amphistichus argenteus*) and walleye surfperch (*Hyperprosopon argenteum*) from the three sites that included the spill site, a natural oil seep site that was not reported as being oiled the day prior to the 23 May 2015 sampling but may have had some oil exposure subsequently and a reference site. Mean biliary concentrations of PAC metabolites did not show significant site differences in the three types of metabolites measured, naphthalene (NPH), phenanthrene (PHN) and benzo[*a*]pyrene (BaP), based on wet weight or protein content except the mean PHN equivalent concentrations in barred surfperch from the oiled Refugio Beach site and the reference site (Gaviota). At the Refugio Beach oiled site, mean concentrations of all PAC metabolites in the 2016 collected fish were significantly higher in walleye surfperch compared to barred surfperch except protein-corrected NPH. Barred surfperch collected at Refugio Beach in 2015 had significantly higher mean NPH, PHN and BaP concentrations (wet weight and protein-corrected) than those determined in the 2016 barred surfperch collected one year later. In contrast, Gaviota barred surfperch collected in 2016 had significantly higher mean concentrations of NPH equivalents (wet weight and protein-corrected) and PHN equivalents (wet weight only) than the mean values of the 2015 Gaviota barred surfperch. Similarly, walleye surfperch collected from Campus Point in 2016 had significantly higher mean concentrations of protein-corrected NPH, PHN and BaP equivalents, as well as NPH equivalents (wet weight only) than walleye collected from this site in 2015.

Introduction

Polycyclic aromatic hydrocarbons (PACs) are chemical contaminants that include polycyclic aromatic hydrocarbons (PAHs) such as naphthalene, phenanthrene, pyrene, benzo[*a*]pyrene), as well as heterocyclic aromatic compounds (e.g., dibenzothiophene) that are primarily derived from petroleum or their combustion products. Concerns have been raised over the effects of exposure to PACs, alone or in combination with other toxic contaminants, on terrestrial and marine organisms because of the worldwide use of fossil fuels (Geraci and St. Aubin 1990; Peterson et al., 2003) and the occurrence of oil spills in regions that support populations of fish, birds, turtles and amphibians. In other vertebrates, such as fish, biological effects associated with exposure to PACs include developmental abnormalities, immunosuppression, hepatic lesions and altered growth (Myers et al. 1994; Heintz et al. 2000; Arkoosh et al. 2001; Meador et al. 2006; Reynaud and Deschaux 2006; Incardona et al. 2004; Incardona et al. 2012). Routes of PAC exposure in fish include consumption of contaminated food or sediment, respiration and dermal absorption.

Vertebrates (e.g., fish, marine mammals) rapidly take up PACs present in their food and the environment and quickly metabolize these compounds to more polar compounds. The more polar PAC metabolites are then secreted into fluids such as bile and urine for elimination via the gastroenteric tract or kidneys (Roubal et al., 1977; Varanasi et al., 1989; Krahn et al., 1984). Therefore, assessment of bile for PACs provides information on recent input and exposure to these compounds.

Methods

Bile samples were collected on May 18, 2016, one year after the Refugio Beach oil spill occurred. Bile samples of barred surfperch were collected from Refugio Beach (n = 7), Campus Point (n = 1), and Gaviota (n = 5). Bile from walleye surfperch were collected from Refugio Beach (n = 13), Campus Point (n= 19), and Gaviota (n = 1). Bile samples were collected from the gall bladder immediately after fish were sacrificed, placed into 4mL amber vials and kept on ice. Then, the samples were frozen and transported to the Northwest Fisheries Science Center and stored at -20°C until analyses.

Bile samples were analyzed using a high-performance liquid chromatography/fluorescence (HPLC-F) method described in Krahn et al., 1984. Briefly, bile was injected directly onto a Waters high-performance liquid chromatography/fluorescence system equipped with a C-18 reverse-phase column (Phenomenex Synergi Hydro). The fluorescent PAC metabolites were eluted with a linear gradient from 100% water (containing a trace amount of acetic acid) to 100% methanol at a flow of 1.0 mL/min. Chromatograms were recorded at the following wavelength pairs: 1) 292/335 nm where many 2-3 benzene ring aromatic compounds (e.g., naphthalene) fluoresce, 2) 260/380 nm where several 3-4 ring compounds (e.g., phenanthrene) fluoresce and 3) 380/430 nm where 4-5 ring compounds (e.g., benzo[*a*]pyrene) fluoresce. Peaks eluting after 9 minutes were integrated and the areas of these peaks were summed. The concentrations of fluorescent PACs in the bile samples of the fish were determined using naphthalene (NPH), phenanthrene (PHN) or benzo[*a*]pyrene (BaP) as external standards and converting the fluorescence response of bile to phenanthrene (ng PHN equivalents/g bile), naphthalene (ng NPH equivalents/g bile) or benzo[*a*]pyrene (ng BaP equivalents/g bile) equivalents. In addition, protein analysis as described in da Silva et al. (2006) was completed for all bile samples as previous laboratory contaminant exposure studies on fish have shown that normalization of biliary PAC metabolite concentrations to protein values can help account for variation in metabolite levels based on feeding status (Collier and Varanasi 1991).

To ensure that the HPLC/fluorescence system was in proper operating condition, a NPH/PHN/BaP calibration standard was analyzed numerous times ($n \geq 5$) until a relative standard deviation < 15% was obtained for each PAC. As part of our laboratory quality assurance (QA) plan (Sloan et al. 2006), a method blank and a fish bile control sample (bile of

Atlantic salmon exposed to 25 µg/mL of Monterey crude oil for 48 hours) were analyzed with each batch of fish bile samples.

Results

Concentrations of fluorescent PAC metabolites (based on wet weight or biliary protein) and protein content measured in the bile samples collected in 2016 are reported in Table 1. One bile sample from a walleye surfperch from Refugio Beach (RSBFI1051816BI7) was not analyzed for protein content due to inadequate bile volume (< 10 µL). All sample batches met our laboratory quality assurance criteria (Tables 2 and 3).

A wide range of fluorescent PAC metabolite concentrations were measured in the bile of the fish collected in 2016 (Table 1). For the barred surfperch from Refugio Beach, the NPH equivalent concentrations ranged from 230,000 to 590,000 ng/g bile, wet weight and 23,000 to 78,000 ng/mg protein, PHN equivalents ranged from 51,000 to 140,000 ng/g bile, wet weight and 4,900 to 22,000 ng/mg protein and BaP equivalent values ranged from 430 to 1,200 ng/g bile, wet weight and 33 to 180 ng/mg protein. For the barred surfperch from Campus Point, NPH equivalent concentrations were 550,000 ng/g bile, wet weight and 63,000 ng/mg protein, PHN equivalents were 140,000 ng/g bile, wet weight and 16,000 ng/mg protein and BaP equivalent values were 1,300 ng/g bile, wet weight and 150 ng/mg protein. For the barred surfperch from Gaviota, the NPH equivalent concentrations ranged from 190,000 to 530,000 ng/g bile, wet weight and 22,000 to 44,000 ng/mg protein, PHN equivalents ranged from 44,000 to 100,000 ng/g bile, wet weight and 4,400 to 9,800 ng/mg protein and BaP equivalent values ranged from 540 to 7,200 ng/g bile, wet weight and 29 to 650 ng/mg protein. For the walleye surfperch from Refugio Beach, the NPH equivalent concentrations ranged from 410,000 to 6,700,000 ng/g bile, wet weight and 29,000 to 420,000 ng/mg protein, PHN equivalents ranged from 93,000 to 2,000,000 ng/g bile, wet weight and 7,300 to 130,000 ng/mg protein and BaP equivalent values ranged from 550 to 19,000 ng/g bile, wet weight and 74 to 1,200 ng/mg protein. For the walleye surfperch from Campus Point, the NPH equivalent concentrations ranged from 150,000 to 1,100,000 ng/g bile, wet weight and 19,000 to 94,000 ng/mg protein, PHN equivalents ranged from 41,000 to 290,000 ng/g bile, wet weight and 5,100 to 27,000 ng/mg protein and BaP equivalent values ranged from 550 to 5,900 ng/g bile, wet weight and 68 to 840 ng/mg protein. For the walleye surfperch from Gaviota, the NPH equivalent concentrations were 810,000 ng/g bile, wet weight and 91,000 ng/mg protein, PHN equivalents were 230,000 ng/g bile, wet weight and 26,000 ng/mg protein and BaP equivalent values were 2,200 ng/g bile, wet weight and 250 ng/mg protein. Biliary protein concentrations in barred surfperch and walleye surfperch ranged from 4.5 to 22.5 ng/mg and 4.3 to 19.9 ng/mg, respectively.

Mean NPH, PHN and BaP equivalent concentrations based on wet weight (Figure 1) or biliary protein (data not shown) (log_{10} transformed data) for each species collected at the oiled (Refugio Beach), natural seep (Campus Point) and reference (Gaviota) sites were not significantly different (ANOVA $p > 0.05$) in fish collected one year after the spill except PHN equivalent levels (wet weight only) in barred surfperch from the oiled Refugio Beach site and Gaviota (reference site) ($p = 0.0487$). This is in contrast to our findings for barred surfperch collected at the same three sampling sites approximately one week (May 2015) after the spill occurred (Anulacion and Ylitalo 2015), in which the mean PAC metabolite levels in fish collected at both the spill and natural seep sites were significantly higher than those at the reference site, and the concentrations in barred surfperch from the spill site were higher overall than the natural seep site.

At the Refugio Beach site, mean concentrations of all PAC metabolites based on wet weight (Figure 1) (log_{10} transformed data) in the 2016 collected fish were significantly higher in walleye surfperch compared to barred surfperch (ANOVA $p < 0.05$; t-test). Similarly, mean levels of protein-corrected PAC metabolites were significantly higher (ANOVA $p < 0.05$; t-test) in walleye compared to barred surfperch except protein-corrected NPH ($p = 0.0505$). Comparisons between species at the other two collection sites were not conducted due to inadequate numbers of bile samples ($n = 1$ for barred surfperch from Campus Point and $n = 1$ for surfperch from Gaviota).

We examined differences in mean concentrations of PAC metabolites based on sampling year for each species collected at the same site (Figure 2). Barred surfperch collected at Refugio Beach in 2015 had significantly higher (ANOVA $p < 0.0001$; t-test) mean NPH, PHN and BaP concentrations (wet weight and protein-corrected) (log_{10} transformed data) than those determined in the 2016 collected barred surfperch. In contrast, Gaviota barred surfperch collected in 2016 had significantly higher mean concentrations (log_{10} transformed data) (ANOVA $p < 0.05$; t-test) of NPH equivalents (wet weight and protein-corrected) and PHN equivalents (wet weight only) than the mean values of the 2015 fish; no other significant differences were found for barred surfperch from this site. Walleye surfperch collected from Campus Point in 2016 had significantly higher mean concentrations of protein-corrected NPH, PHN and BaP equivalents, as well as NPH equivalents (wet weight only). No other significant differences (ANOVA $p > 0.05$) in mean concentrations of PAC metabolites were found for walleye surfperch from this site.

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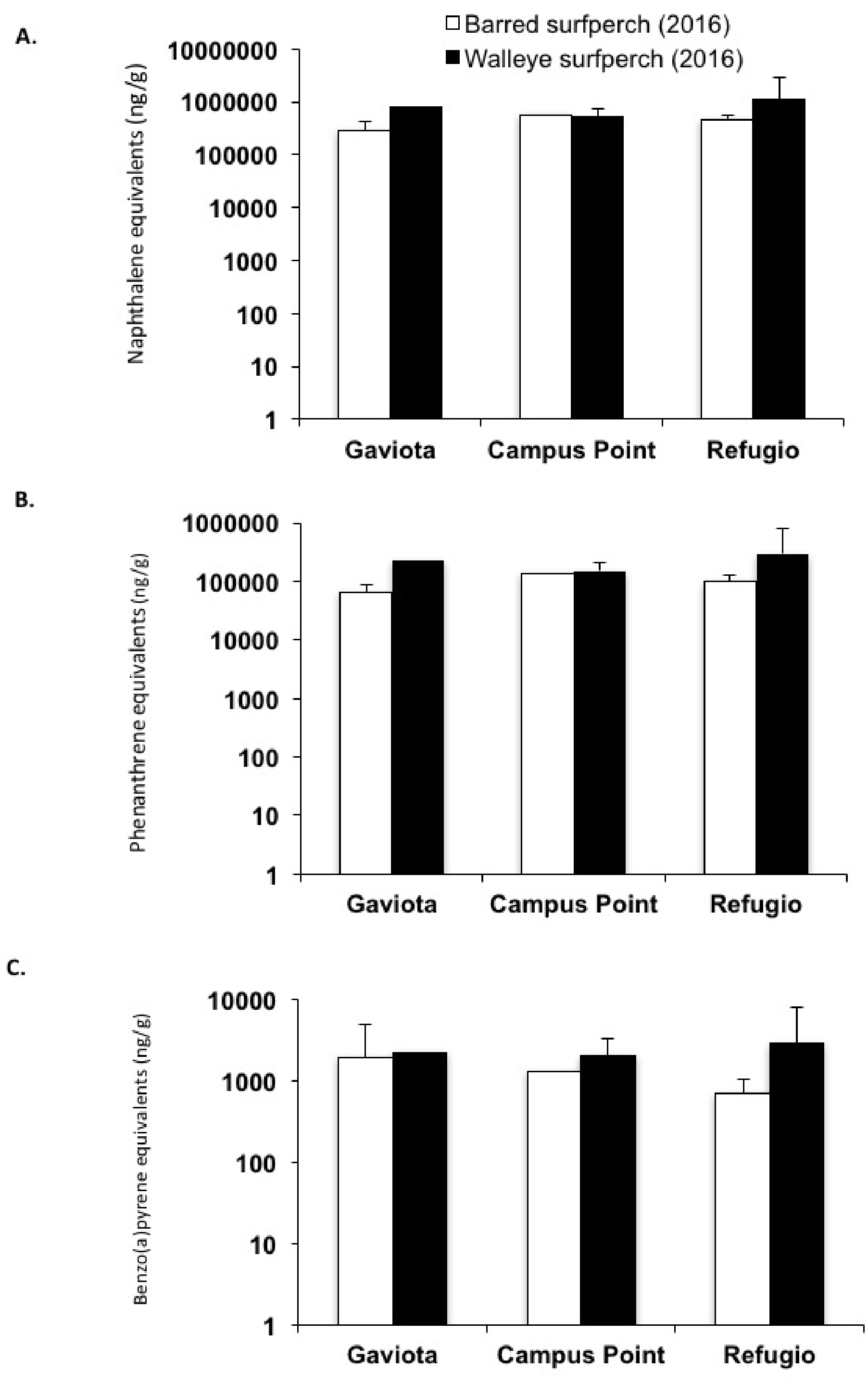
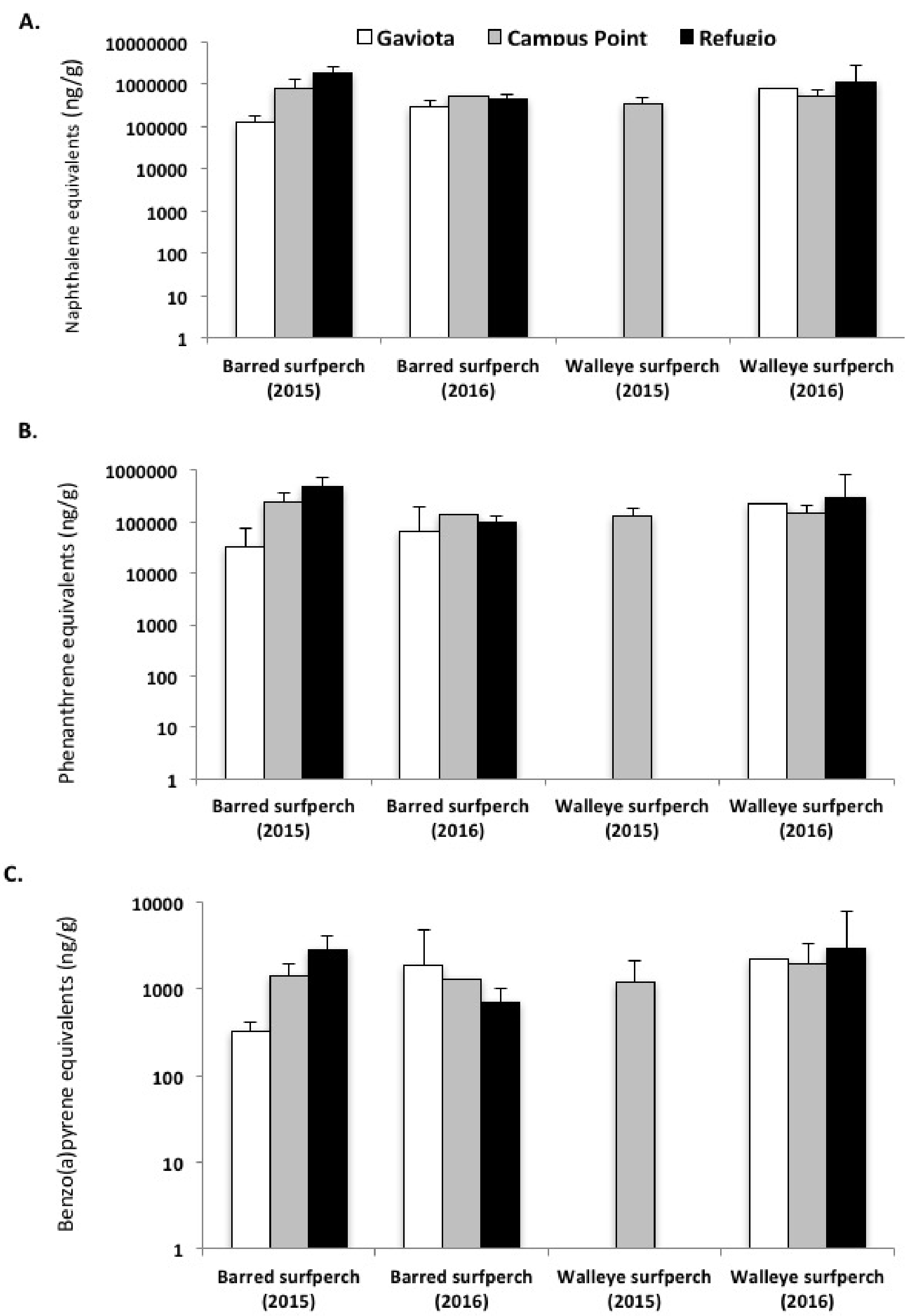
Appendix 2

Figure 1. Mean (±SD) concentrations of bile equivalents of (A) naphthalene, NPH, (B) phenanthrene, PHN and (C) benzo[*a*]pyrene, BaP (ng/g bile wet weight) measured in two fish species collected one year following the 2015 Refugio Beach oil spill.



Appendix 2

Figure 2. Mean (±SD) concentrations of bile equivalents (A) naphthalene, NPH, (B) phenanthrene, PHN and (C) benzo[*a*]pyrene, BaP (ng/g bile wet weight) measured in two fish species collected in 2015 and 2016 showing the differences in mean concentrations of PAC metabolites based on sampling year for each species collected at the same site



Appendix 2

Table 1. Concentrations of metabolites of polycyclic aromatic compounds measured in bile of barred surfperch and walleye surfperch collected in 2016, one year after the 2015 Refugio Beach Oil Spill.

					Equivalents of fluorescent aromatic compounds (ng/g bile, wet weight)			Protein-corrected equivalents of fluorescent aromatic compounds (ng/mg biliary protein)		
Species	**Laboratory ID number**	**Collection site**	**Field ID number**	**Protein mg/mL**	**NPH[1]**	**PHN[2]**	**BaP[3]**	**NPH[1]**	**PHN[2]**	**BaP[3]**
Barred surfperch	136-0436	Campus Point	CMPFI1051816BI20	8.8	550,000	140,000	1,300	63,000	16,000	150
	136-0444	Gaviota	GAVFI1051816BI5	4.5	200,000	44,000	540	44,000	9,800	120
	136-0393	Gaviota	GAVFI1051816BI4	7.7	220,000	47,000	560	29,000	6,100	73
	136-0422	Gaviota	GAVFI1051816BI2	11.1	240,000	63,000	7,200	22,000	5,700	650
	136-0434	Gaviota	GAVFI1051816BI3	10.4	280,000	64,000	630	27,000	6,200	61
	136-0404	Gaviota	GAVFI1051816BI1	22.5	530,000	100,000	650	24,000	4,400	29
	136-0406	Refugio Beach	RSBFI1051816BI4	7.1	240,000	52,000	460	34,000	7,300	65
	136-0400	Refugio Beach	RSBFI1051816BI5	15.4	360,000	75,000	510	23,000	4,900	33
	136-0414	Refugio Beach	RSBFI1051816BI6	14.6	360,000	80,000	500	25,000	5,500	34
	136-0412	Refugio Beach	RSBFI1051816BI1	14.4	500,000	110,000	950	35,000	7,600	66
	136-0402	Refugio Beach	RSBFI1051816BI17	6.5	510,000	140,000	1,200	78,000	22,000	180
	136-0431	Refugio Beach	RSBFI1051816BI2	20.2	560,000	120,000	910	28,000	5,900	45
	136-0432	Refugio Beach	RSBFI1051816BI3	10.3	590,000	120,000	430	57,000	12,000	42
Walleye surfperch	136-0413	Campus Point	CMPFI1051816BI10	8.1	150,000	41,000	550	19,000	5,100	68
	136-0405	Campus Point	CMPFI1051816BI17	5.5	290,000	81,000	4,600	53,000	15,000	840
	136-0430	Campus Point	CMPFI1051816BI8	4.3	290,000	81,000	1,000	67,000	19,000	230
	136-0440	Campus Point	CMPFI1051816BI11	4.5	330,000	98,000	1,100	73,000	22,000	240
	136-0398	Campus Point	CMPFI1051816BI1	4.5	360,000	110,000	1,100	80,000	24,000	240
	136-0443	Campus Point	CMPFI1051816BI3	5.7	370,000	110,000	1,100	65,000	19,000	190
	136-0401	Campus Point	CMPFI1051816BI19	8.8	390,000	98,000	5,900	44,000	11,000	670
	136-0437	Campus Point	CMPFI1051816BI2	10.9	410,000	130,000	1,000	38,000	12,000	92
	136-0397	Campus Point	CMPFI1051816BI18	4.9	440,000	120,000	2,900	90,000	24,000	590
	136-0396	Campus Point	CMPFI1051816BI4	6.1	480,000	120,000	1,700	79,000	20,000	280
	136-0421	Campus Point	CMPFI1051816BI14	7.4	510,000	160,000	1,500	69,000	22,000	200
	136-0435	Campus Point	CMPFI1051816BI16	6.8	540,000	170,000	1,700	79,000	25,000	250
	136-0419	Campus Point	CMPFI1051816BI12	9.1	550,000	150,000	1,800	60,000	16,000	200
	136-0442	Campus Point	CMPFI1051816BI13	8.4	670,000	200,000	1,900	80,000	24,000	230
	136-0418	Campus Point	CMPFI1051816BI15	8.6	730,000	230,000	2,200	85,000	27,000	260
	136-0420	Campus Point	CMPFI1051816BI6	7.8	730,000	210,000	1,800	94,000	27,000	230
	136-0415	Campus Point	CMPFI1051816BI5	15.1	740,000	170,000	2,000	49,000	11,000	130
	136-0394	Campus Point	CMPFI1051816BI9	9.1	760,000	200,000	2,700	84,000	22,000	300
	136-0425	Campus Point	CMPFI1051816BI7	15.3	1,100,000	290,000	2,400	72,000	19,000	160
	136-0408	Gaviota	GAVFI1051816BI6	8.9	810,000	230,000	2,200	91,000	26,000	250
	136-0399	Refugio Beach	RSBFI1051816BI15	9.4	410,000	93,000	1,300	44,000	9,900	140
	136-0426	Refugio Beach	RSBFI1051816BI14	6.8	420,000	120,000	1,000	62,000	18,000	150
	136-0407	Refugio Beach	RSBFI1051816BI7	IS[5]	470,000	96,000	550	ND	ND	ND
	136-0433	Refugio Beach	RSBFI1051816BI16	13.3	520,000	120,000	1,300	39,000	9,000	98
	136-0441	Refugio Beach	RSBFI1051816BI18	17.8	520,000	130,000	1,400	29,000	7,300	79
	136-0438	Refugio Beach	RSBFI1051816BI12	14.8	540,000	110,000	1,100	36,000	7,400	74
	136-0439	Refugio Beach	RSBFI1051816BI20	8.1	550,000	160,000	1,600	68,000	20,000	200
	136-0416	Refugio Beach	RSBFI1051816BI13	11.1	600,000	170,000	1,900	54,000	15,000	170
	136-0417	Refugio Beach	RSBFI1051816BI10	5.6	740,000	200,000	1,600	130,000	36,000	290
	136-0424	Refugio Beach	RSBFI1051816BI9	14.5	780,000	210,000	2,100	54,000	14,000	140
	136-0395	Refugio Beach	RSBFI1051816BI11	12.3	870,000	240,000	2,300	71,000	20,000	190
	136-0423	Refugio Beach	RSBFI1051816BI8	19.9	1,200,000	320,000	2,800	60,000	16,000	140
	136-0403	Refugio Beach	RSBFI1051816BI19	15.9	6,700,000	2,000,000	19,000	420,000	130,000	1,200

[1]Concentrations in part per billion (ng/g) based on total area compared to the fluorescence of naphthalene standard at 292/335 nm wavelengths.
[2]Concentrations in part per billion (ng/g) based on total area compared to the fluorescence of phenanthrene standard at 260/380 nm wavelengths.
[3]Concentrations in part per billion (ng/g) based on total area compared to the fluorescence of benzo[a]pyrene standard at 380/430 nm wavelengths.
[4]IS - insufficient sample available for protein analysis
ND = protein-corrected PAC metabolite concentrations not determined due to insufficient sample available for protein analysis

Appendix 2

Table 2. Concentrations of metabolites of polycyclic aromatic compounds measured in bile reference material and method blanks analyzed one year after the 2015 Refugio Beach Oil Spill.

Quality assurance sample type	Quality assurance sample information	Analysis date	Equivalents of fluorescent aromatic compounds (ng/g bile, wetweight)		
			NPH[1]	PHN[2]	BaP[3]
ASMBC2[4]	Atlantic salmon exposed to Monterey Bay crude oil for 48 hours.	06/22/16	160,000	53,000	1,500
	Atlantic salmon exposed to Monterey Bay crude oil for 48 hours.	06/22/16	180,000	58,000	1,700
	Atlantic salmon exposed to Monterey Bay crude oil for 48 hours.	06/22/16	180,000	56,000	1,700
	Atlantic salmon exposed to Monterey Bay crude oil for 48 hours.	06/24/16	160,000	52,000	1,500
	Atlantic salmon exposed to Monterey Bay crude oil for 48 hours.	06/24/16	160,000	52,000	1,500
	Atlantic salmon exposed to Monterey Bay crude oil for 48 hours.	06/24/16	160,000	52,000	1,600
	Atlantic salmon exposed to Monterey Bay crude oil for 48 hours.	06/25/16	160,000	52,000	1,600
	Atlantic salmon exposed to Monterey Bay crude oil for 48 hours.	06/25/16	160,000	50,000	1,400
	Atlantic salmon exposed to Monterey Bay crude oil for 48 hours.	06/25/16	160,000	51,000	1,500
Method blank[5]	Methanol blank A	06/22/16	610	83	21
	Methanol blank C	06/22/16	400	54	26
	Methanol blank F	06/22/16	640	94	26
	Methanol blank A	06/24/16	600	100	29
	Methanol blank C	06/24/16	890	100	27
	Methanol blank F	06/24/16	810	90	26
	Methanol blank A	06/25/16	640	130	27
	Methanol blank C	06/25/16	780	91	27
	Methanol blank F	06/25/16	590	99	23

Bile Reference Material ASMBC2	Equivalents of fluorescent aromatic compounds (ng/g bile, wet weight)		
	NPH[1]	PHN[2]	BaP[3]
Mean	150,000	50,000	1,200
SD	14,000	4,900	230
Upper Control Limit	180,000	60,000	1,700
Lower Control Limit	120,000	40,000	740

[1]Concentrations in part per billion (ng/g) based on total area compared to the fluorescence of naphthalene standard at 292/335 nm wavelengths.
[2]Concentrations in part per billion (ng/g) based on total area compared to the fluorescence of phenanthrene standard at 260/380 nm wavelengths.
[3]Concentrations in part per billion (ng/g) based on total area compared to the fluorescence of benzo[a]pyrene standard at 380/430 nm wavelengths.
[4]NWFSC Quality Assurance Criterion (from Sloan et al. 2006): Reference material (3/set): analyte concentrations will be ≤ 2 SD of historic values
[5]NWFSC Quality Assurance Criterion (from Sloan et al. 2006): Method blank (3/set): analyte concentrations in samples will be ≥ 10 times the maximum blank value.

Appendix 2

Table 3. Results of duplicate analyses[1] for metabolites of polycyclic aromatic compounds of selected bile samples of field captured fish analyzed one year after the 2015 Refugio Beach Oil Spill.

Species	Laboratory ID number	Collection site	Field ID number	Protein mg/mL	Equivalents of fluorescent aromatic compounds (ng/g bile, wet weight) NPH[2]	PHN[3]	BaP[4]	Protein-corrected equivalents of fluorescent aromatic compounds (ng/mg biliary protein) NPH[2]	PHN[3]	BaP[4]
Barred surfperch	136-0444	Gaviota	GAVFI1051816BI5	4.5	200,000	44,000	540	44,000	9,800	120
	136-0444R	Gaviota	GAVFI1051816BI5	4.5	190,000	42,000	560	42,000	9,300	120
Barred surfperch	136-0406	Refugio Beach	RSBFI1051816BI4	7.1	240,000	52,000	460	73,000	34,000	65
	136-0406R	Refugio Beach	RSBFI1051816BI4	7.1	230,000	51,000	480	72,000	32,000	68
Walleye surfperch	136-0425	Campus Point	CMPFI1051816BI7	15.3	1,100,000	290,000	2,400	72,000	19,000	160
	136-0425R	Campus Point	CMPFI1051816BI7	15.3	1,100,000	280,000	2,400	72,000	18,000	160

[1]NWFSC Quality Assurance Criterion (from Sloan et al. 2006): Sample duplicates (at least 1 for every 20 field samples analyzed): relative percent difference for each analyte ≤ 60% for duplicates.
[2]Concentrations in part per billion (ng/g) based on total area compared to the fluorescence of naphthalene standard at 292/335 nm wavelengths.
[3]Concentrations in part per billion (ng/g) based on total area compared to the fluorescence of phenanthrene standard at 260/380 nm wavelengths.
[4]Concentrations in part per billion (ng/g) based on total area compared to the fluorescence of benzo[a]pyrene standard at 380/430 nm wavelengths.

The 2015 Refugio Beach Oil Spill: Oil Exposure and Potential Effects to Fish, Invertebrate Early Life Stages, and Kelp

Draft Final Report
November 2019

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Table of Contents

INTRODUCTION

On May 19, 2015, the underground Line 901 pipeline, owned and operated by Plains All American Pipeline, L.P., and Plains Pipeline, L.P., sustained a release of crude oil near Refugio State Beach in Santa Barbara County, California. Oil released from the pipeline pooled, then overflowed into a nearby culvert, across land and other drainage systems, and entered the Pacific Ocean in the nearshore environment. *Phyllospadix spp*. (surfgrass), *Zostera marina* (eelgrass) and *Macrocystis pyrifera* (giant kelp) beds were observed to be oiled. Additionally, dead fish and invertebrates associated with these habitat types were observed on beaches in the spill affected area. Surf water samples were collected by the Center for Toxicology and Environmental Health (CTEH), in support of the Unified Command, to assess potential exposure to members of the public and ecological receptors from chemical constituents related to the crude oil release. Additionally, the National Oceanic and Atmospheric Administration (NOAA) conducted overflights over the spill affected area to observe the presence of oil on the ocean surface. The purpose of this report is to summarize these water chemistry data and oil sheen observations in order to evaluate potential effects on fish and invertebrate early life stages and kelp in the nearshore environment.

METHODS

Field Sampling Procedures

Field sampling procedures were documented in the Emergency Response Environmental Sampling and Analysis Work Plan (CTEH, 2015). Surf water samples were collected from nine locations from 20 May 2015 to 20 July 2015 (Figure 1) by wading into the surf zone and filling a 1-L amber glass bottle for polycyclic aromatic hydrocarbon (PAH) analysis and a 1-L amber glass bottle for total petroleum hydrocarbon (TPH) analysis. Visual observations were denoted, and photographs were taken at each surface water sampling location. Daily overflights were conducted by NOAA from 21 May 2015 to 3 June 2015, and the GPS locations of oiling observations were recorded and mapped.

Chemical Analysis

CTEH water samples were shipped to Pace Analytical Laboratories and Gulf Coast Analytical Laboratories. Extracts were analyzed for PAHs by USEPA Method 8272SIM and for TPH (sum of gasoline, diesel and motor oil ranges; C5-C36) by USEPA Method 8015. Analytical data were not surrogate recovery corrected. Results for 37 individual PAHs and alkylated homologue groups were summed to estimate total PAHs ($TPAH_{37}$): naphthalene; 1-methylnaphthalene, 2-methylnapthalene; C2-naphthalenes; C3-naphthalenes; C4-naphthalenes; acenaphthylene; acenaphthene; fluorene; C1-fluorenes; C2-fluorenes; C3-fluorenes; phenanthrene; anthracene; C1-phenanthrene/anthracene; C2-phenanthrene/anthracene; C3-phenanthrene/anthracene; C4-phenanthrene/anthracene; pyrene; fluoranthene; C1-fluoranthene/pyrenes; C2-fluoranthene/pyrenes; C3-fluoranthene/pyrenes; benz[a]anthracene; chrysene; C1-chrysenes; C2-chrysenes; C3-chrysenes; C4-chrysenes; benzo(a)pyrene; perylene, benzo(e)pyrene; benzo(b)fluoranthene; benzo(k)fluoranthene; benzo(g,h,i)perylene;

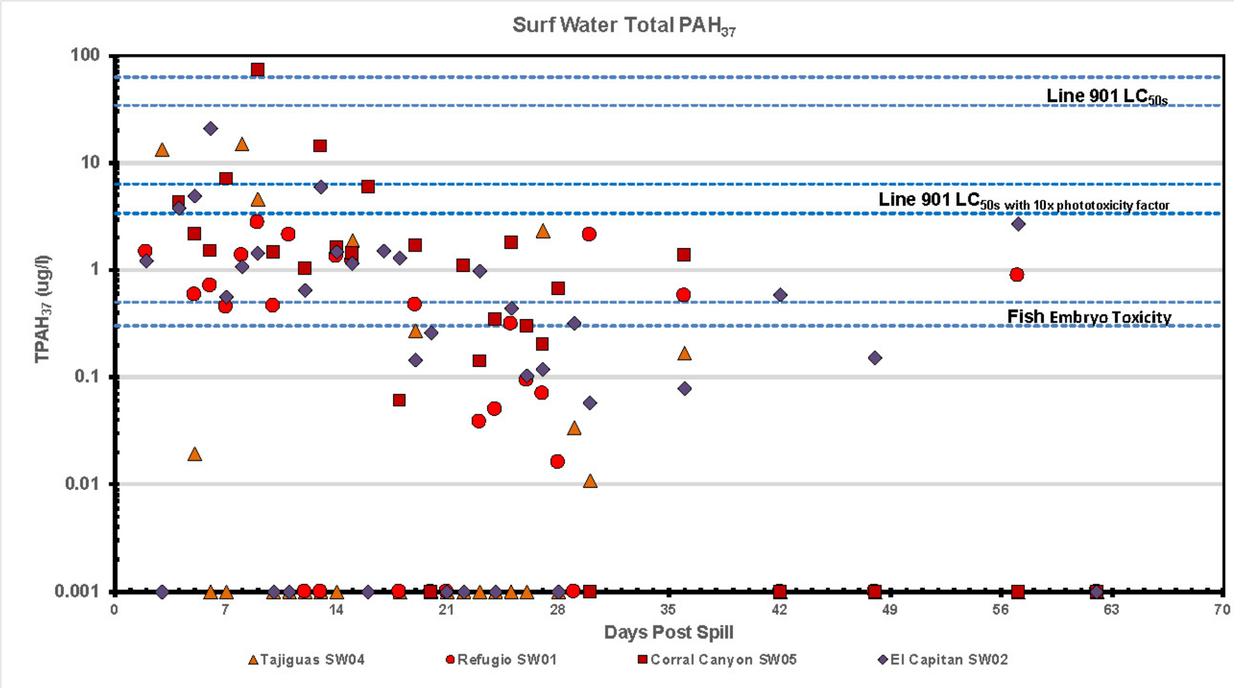
indeno(1,2,3-c,d)pyrene; and dibenz(a,h)anthracene. When calculating $TPAH_{37}$, non-detects (ND) were assumed to be zero.

Figure 1. *CTEH Surf Water Sample Locations within Exposure Zones A, B and C.*

RESULTS and DISCUSSION

Surf Water Chemistry

$TPAH_{37}$ surf water concentrations measured in Zone B, adjacent to the release site, ranged from not detected (ND) to 14.9 µg/l at Tajiguas (n=30), ND – 2.7 µg/l at Refugio (n= 29), ND – 73.2 µg/l at Corral Canyon (n=27), and ND – 21.1 µg/l at El Capitan (n=34; Figure 2). In the eastern portion of Zone B, $TPAH_{37}$ surf water concentrations ranged from ND – 9.1 µg/l at Haskells (n=32) and ND – 5.6 µg/l at Sands Beach (n=33), (Figure 3). $TPAH_{37}$ concentrations in Zones A and C ranged from ND – 11.9 µg/l at Gaviota (n=32), ND –5.3 µg/l at Goleta (n=27) and ND – 6.4 µg/l at Arroyo Burro (n=31; Figure 4). Samples were not consistently collected at Zone B locations until 5 days after the spill (23 May 2015). Hence, these concentrations do not represent the maximum concentrations that likely occurred in Zone B immediately after the spill. Highest $TPAH_{37}$ concentrations were measured at sampling locations near the release point in the first two weeks after the spill and then generally declined.



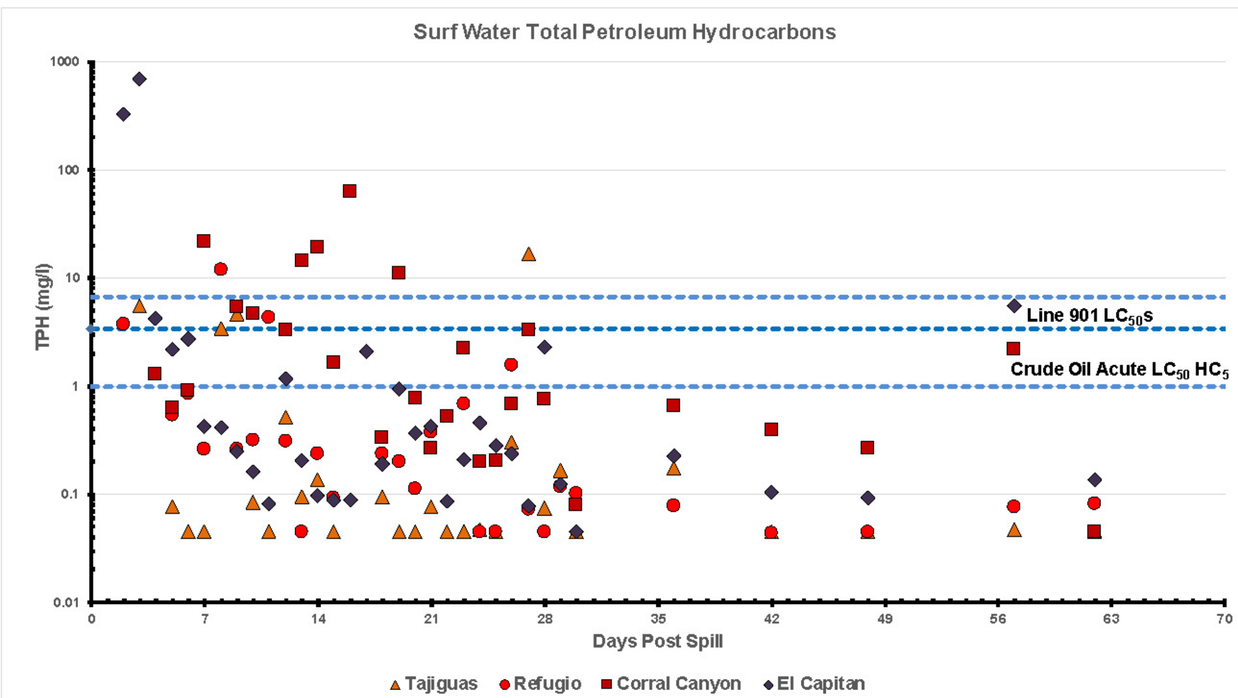
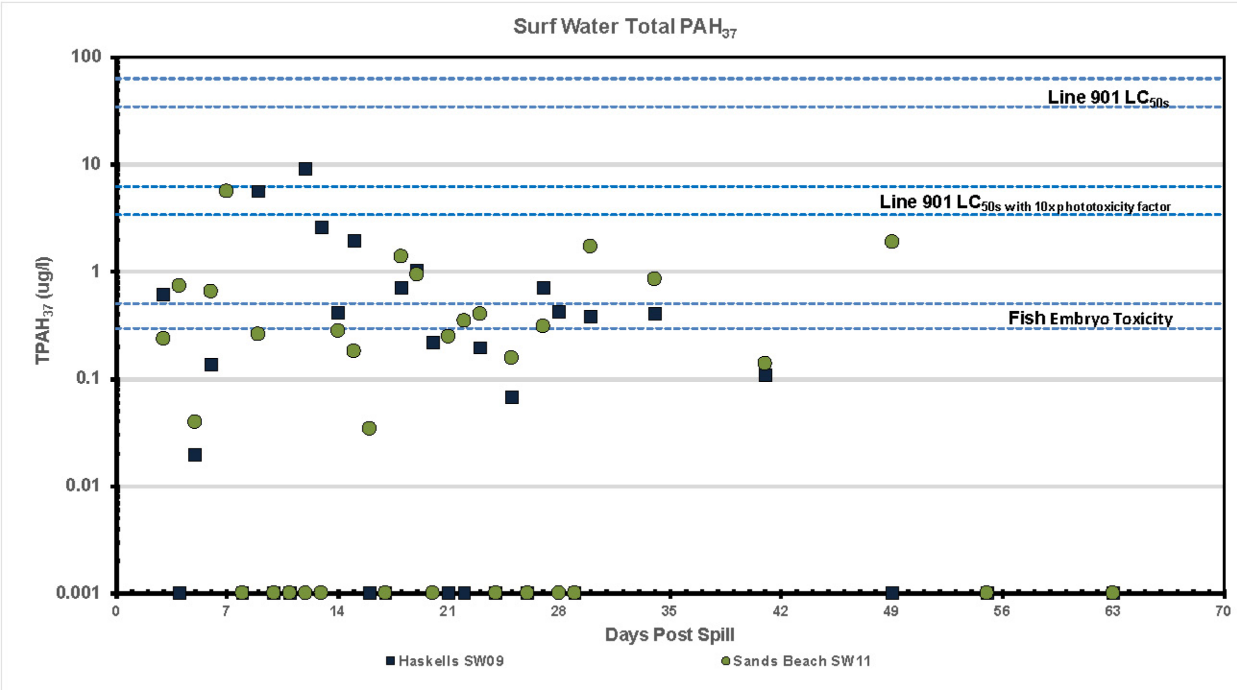


Figure 2. *Surf water TPAH$_{37}$ (ug/l; top; ND was zero but was set to 0.001 for graphing on a log scale) and TPH (mg/l; bottom) concentrations in Zone B, adjacent to the release point.*



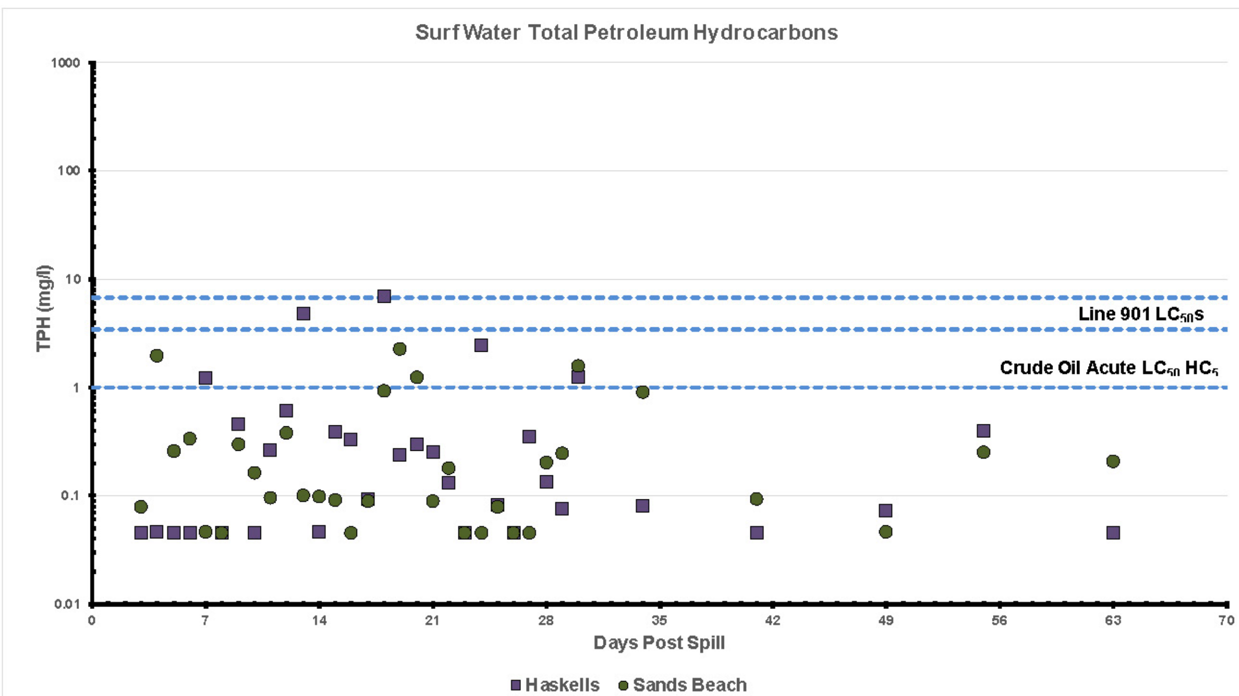
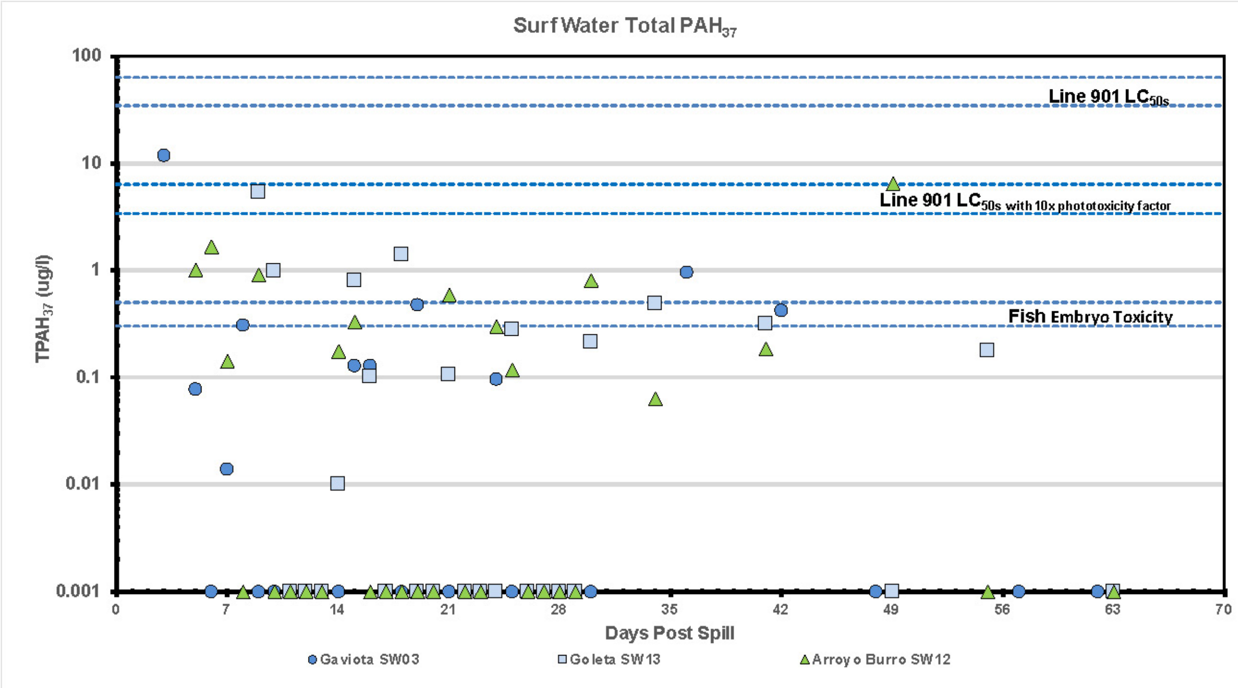


Figure 3. *Surf water TPAH$_{37}$ (ug/l; top; ND was zero but was set to 0.001 for graphing on a log scale) and TPH (mg/l; bottom) concentrations in Zone B, farther east of the release point.*



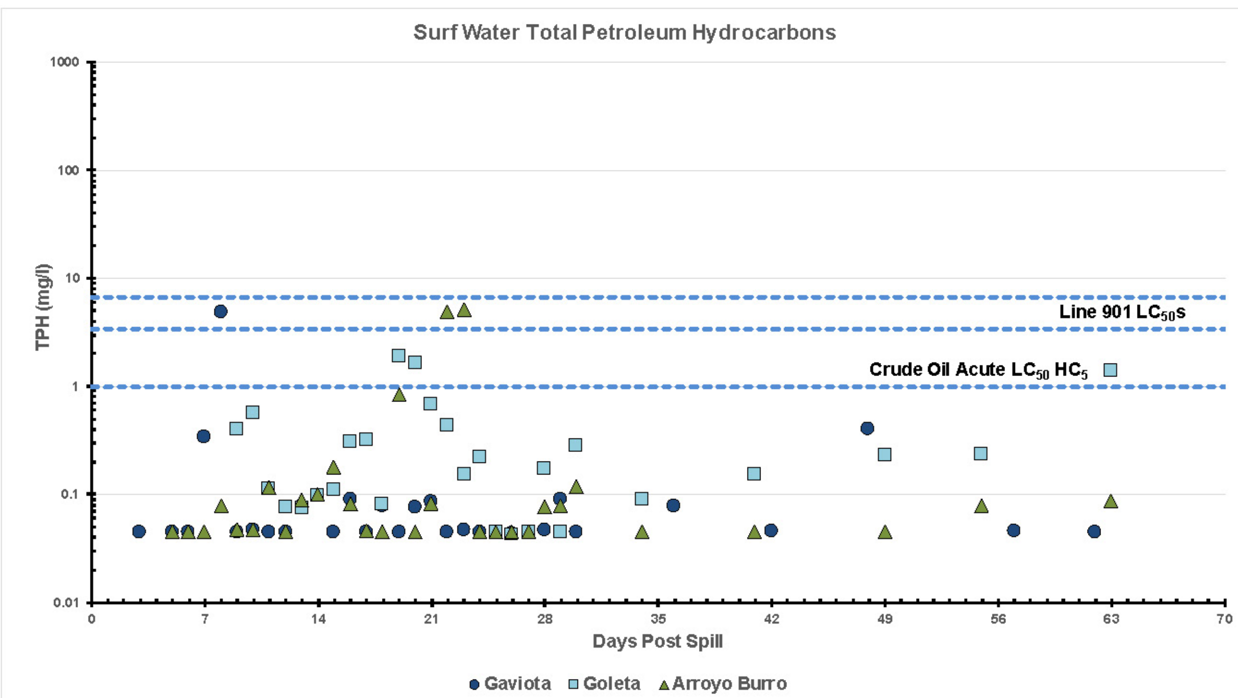


Figure 4. *Surf water $TPAH_{37}$ (ug/l; top; ND was zero but was set to 0.001 for graphing on a log scale) and TPH (mg/l; bottom) concentrations in Zone A and C.*

TPH concentrations were not directly correlated to $TPAH_{37}$ concentrations because they were collected as separate samples, and surf water was likely heterogeneous due to the presence of oil droplets and particulates. Field samplers noted the presence of tarballs and sheen during sampling, and the highest frequency of reported sheen observations was in Zone B (Figure 5).

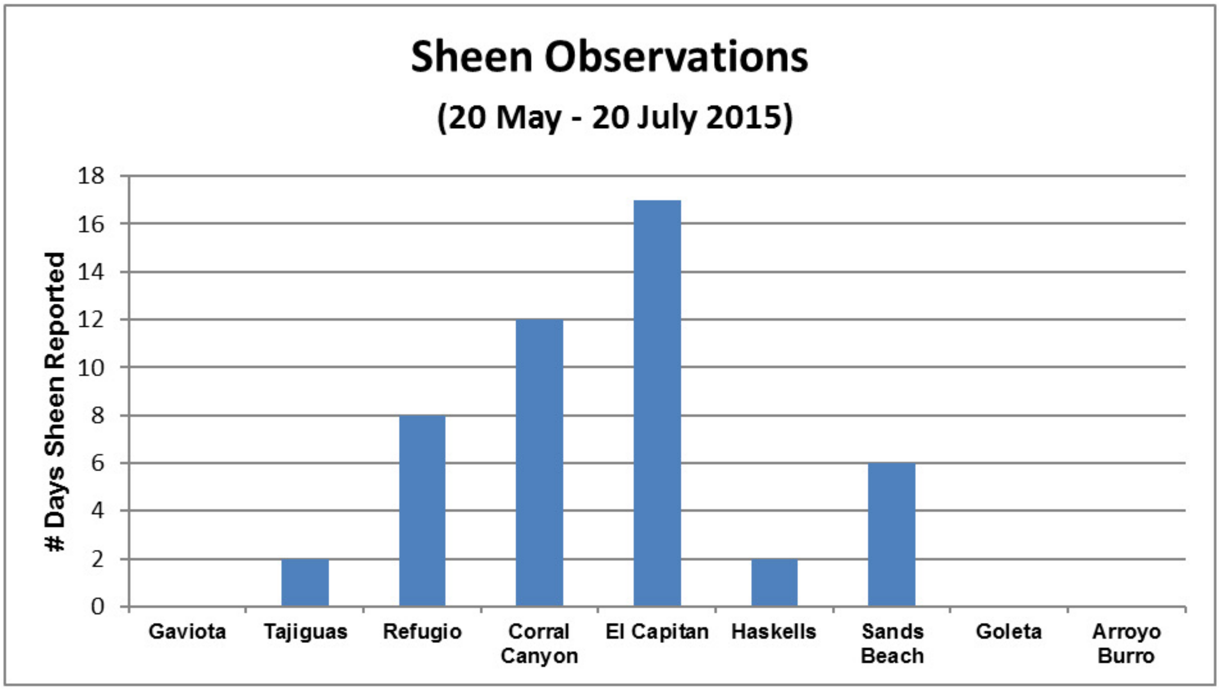


Figure 5. *Number of Days Field Samplers Observed and Recorded Sheen from 20 May to 20 July 2015.*

TPH surf water concentrations measured in Zone B, adjacent to the release site, ranged from 0.04 – 16.6 mg/l at Tajiguas (n=30), 0.04 – 11.9 mg/l at Refugio (n= 29), 0.04 – 63.1 mg/l at Corral Canyon (n=28), and 0.04 – 697 mg/l at El Capitan (n=34; Figure 2). In the eastern portion of Zone B, further from the spill site, TPH surf water concentrations ranged from 0.04 – 6.9 mg/l at Haskells (n=33) and 0.04 – 2.3 mg/l at Sands Beach (n=33; Figure 3). TPH concentrations in Zones A and C ranged from 0.04 – 4.9 mg/l at Gaviota (n=32), 0.04 – 1.9 mg/l at Goleta (n=27), and 0.04 -5.1 mg/l at Arroyo Burro (n=31; Figure 4). These concentrations do not represent the maximum concentrations that likely occurred in Zone B immediately after the spill for the reasons mentioned above.

Comparison of Surf Water Chemistry to Fish and Invertebrate Toxicity Benchmarks

An acute (6-day) survival and growth bioassay with sand crab (*Emerita analoga*) megalopae and 7-day survival and growth bioassay with inland silverside (*Menidia beryllina*) juveniles were conducted with a high energy water accommodated fraction of Line 901 source oil (Appendix E). The lethal concentration to 50% of the test animals (Line 901 LC_{50}s) at the end of the bioassays ranged from 34.4 – 63.5 µg/l $TPAH_{37}$. On a TPH basis, the Line 901 LC_{50}s ranged from 3.4 – 6.7 mg/l. These values are similar to LC_{50} values generated for crude oils with other species. For example, the acute (2-4 day) TPH lethal (LC_{50}) hazardous concentration affecting 5% of the species in the community (HC_5) was 1 mg/l (Barron et al., 2013). This TPH HC_5 (1 mg/l) addressed acute toxicity via the narcosis mode of action without the presence of ultraviolet light (UV). Studies have shown that UV light can enhance the toxicity of PAHs by a factor from 2 – 1000 (Barron, 2017). For the purpose of this evaluation, Line 901 LC_{50} values were adjusted with a 10x factor (3.4 – 6.3 µg/l $TPAH_{37}$) to estimate phototoxicity. In a recent literature review, Lee et al (2015) reported that the EC_{50} – LC_{50} for sublethal or chronic exposures ranged from 0.3-60 µg/l for TPAH and from 0.03-11 mg/l for TPH. Oil induced fish embryotoxicity, such as pericardial and yolk sac edemas, and craniofacial, spinal and cardiac deformities have been reported to occur at the lower end of the range (0.3 µg/l TPAH; Incardona et al., 2015) and Hodson (2017) concluded that concentrations greater than 0.1 µg/l TPAH following oil spills should be considered hazardous. In a series of toxicity tests conducted following the Deepwater Horizon oil spill, the EC_{20} for fish embryo cardiotoxicity for TPAH was reported at be as low as 0.5 µg/l, and UV exposure produced lethality (LC_{50}) as low as 0.1 µg/l for TPAH (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). The percentages of surf water samples at each location (Figures 2-4) exceeding the lowest $TPAH_{37}$ Line 901 LC_{50} (34.4 µg/l), the lowest $TPAH_{37}$ Line 901 LC_{50} adjusted for phototoxicity (3.4 µg/l), the TPAH fish embryo toxicity benchmark (0.3 µg/l; Lee et al., 2015), and the TPH Acute LC_{50} HC5 (1 mg/l; Barron et al., 2013) were calculated (Figure 6). These benchmark exceedances indicate surf water concentrations were potentially lethal to fish and invertebrate early life stages.

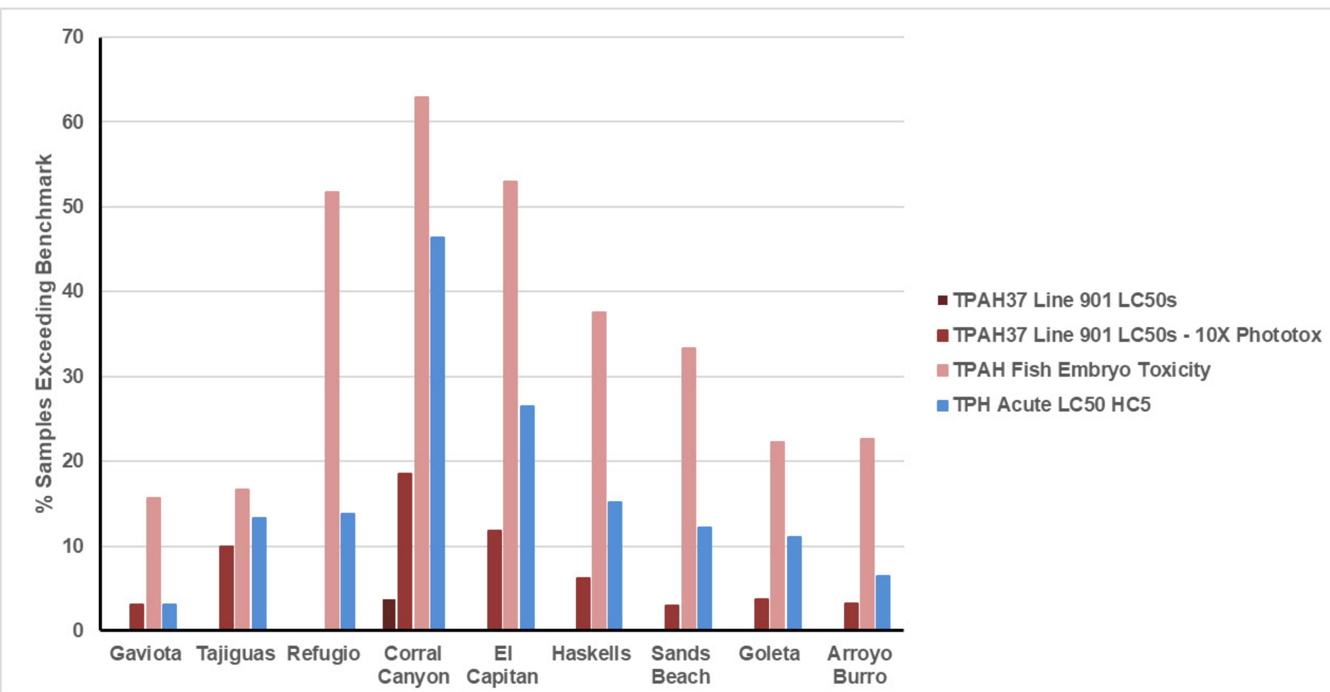


Figure 6. *Percent of surf water samples collected 20 May to 20 July 2015 at each location that exceeded fish and invertebrate early life stage toxicity benchmarks.*

Surface Oil Observations from Overflights and SCAT Data

The first overflight occurred on the third day of the spill (May 21, 2015), and oil was observed on the surface of the ocean throughout Zones A and B and beyond the 10m bathymetric line (Figure 7). Surface oiling continued to be observed during the first week as the oil moved eastward within Zone B and southward (May 25, 2015; Figure 7). Surface oil continued to be observed until the last overflight on June 3, 2014. During the overflights, oil was observed in the kelp canopy in Zone B, as depicted in Figure 8. A composite of the surface oil observations, with a 0.5 km buffer around each observation, made from May 21 – June 3, 2015, is depicted in Figure 9. Surface oil was observed throughout Zone B, both within the 0-10 m bathymetric zone where kelp occurs and farther offshore (> 10 m bathymetric zone).

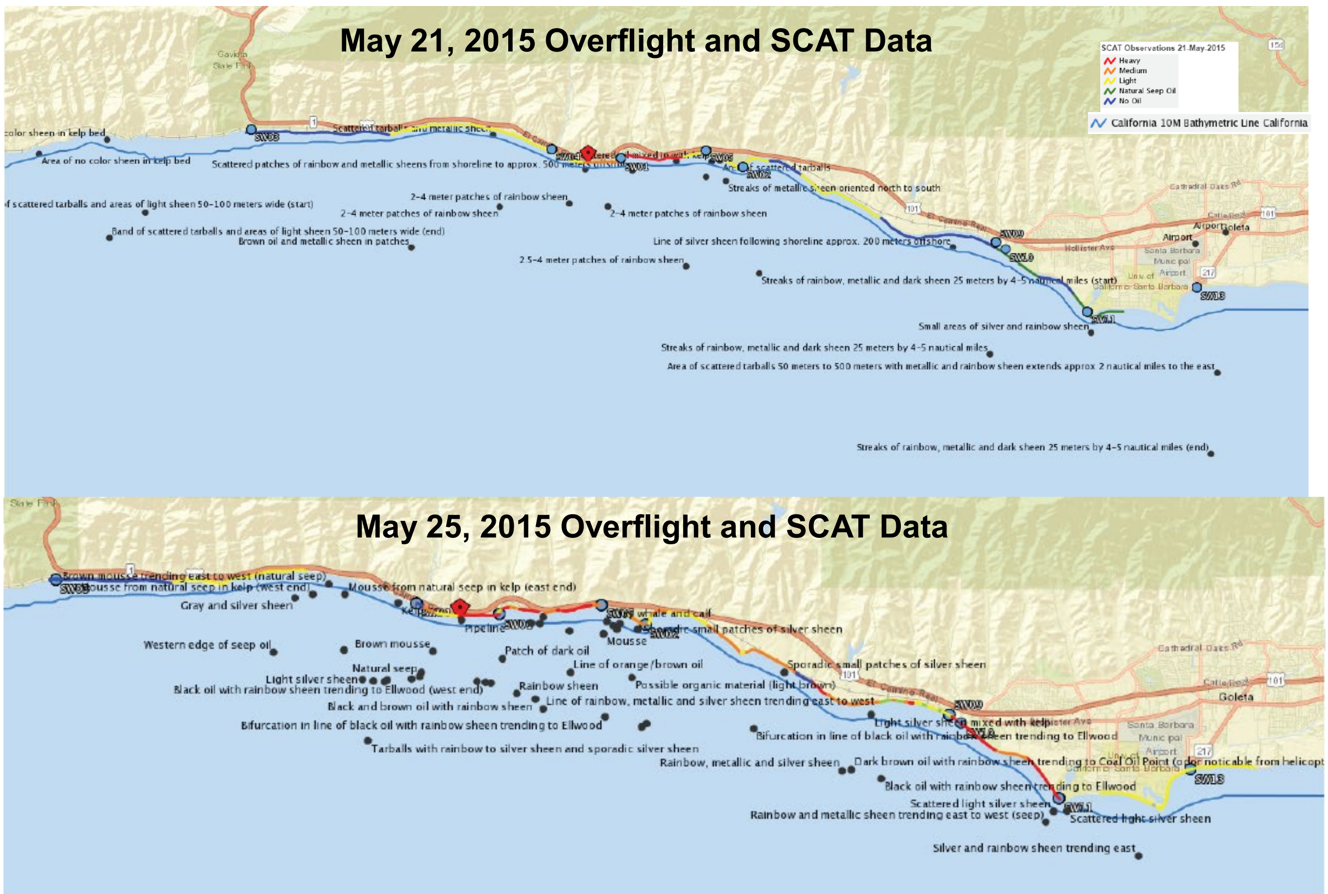


Figure 7. *Surface oil observations from overflights and SCAT data from May 21, 2015, (top) and May 25, 2015 (bottom).*

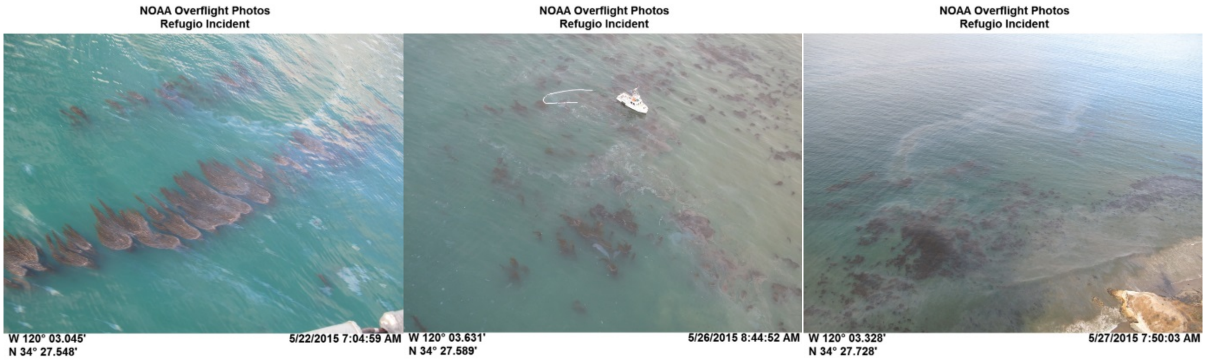


Figure 8. *Aerial photographs of oil in kelp canopy in Zone B from May 22 – 27, 2015.*

Figure 9. *Composite map of Zone B surface oil observations (May 21 – June 3, 2015) with a 0.5km buffer around each observation point*

In Santa Barbara, the giant kelp (*Macrocystis pyrifera*) is the foundational species of the subtidal rocky reef ecosystem (Miller et al. 2015). Attached to the rocks by holdfasts, the kelp fronds grow to the water surface, creating a forest that provides vertical habitat for one of the richest communities on earth (Foster and Schiel 1985, Schiel and Foster 2015). Hundreds of invertebrate and fish species use the fronds and holdfasts of giant kelp as a place to live, a refuge from predators, and an enhanced food supply in the form of plankton and small epiphytes that live on the fronds. Early life stages of many fish and invertebrate species live in the kelp canopy near the water surface as the fronds dampen currents and provide protection. At the Arroyo Quemado kelp forest, a Santa Barbara Coastal Long-Term Ecological Research site, common species include polychaetes, sea urchins, sea stars, spiny lobsters, kelp bass, rockfish, California sheephead and several other algal species (Schiel and Foster 2015). Additionally, seabirds and marine mammals frequently forage in the kelp forest.

During the January 1969 spill of over 70,000 barrels of crude oil into the Santa Barbara Channel from Platform A (Foster et al. 1971, Foster and Holmes 1977), offshore kelp beds received the first dose of incoming oil, and the kelp beds' floating fronds held large quantities of oil (Mitchell et al. 1970). The oil did not appear to stick to healthy fronds because of the species' mucus production but was seen adhering to patches of damaged tissue (Mitchell et al. 1970, Foster et al. 1971). A quantitative evaluation of the effects of the oil on the kelp canopy was not conducted for the 1969 spill.

However, laboratory studies have shown that kelp fronds exposed to crude oil become bleached (Antrim et al.1995). When significantly bleached, portions of the plant decayed in 3-4 days and then broke off. Plants with color loss were less slippery, indicating a loss of the mucus coating. Disruption of the mucus layer and subsequent drying lead to splitting and microbial decay of the tissue. Reduced photosynthesis accompanied the loss of photosynthetic pigments and disruption of cellular metabolism (Antrim et al. 1995). Thus, direct contact of the kelp canopy with oil may have reduced primary productivity. Since the kelp canopy can trap the oil, this may have increased the exposure duration for kelp and the fish and invertebrates associated with the canopy. This also may have resulted in increased mortality for the exposed organisms, including the more sensitive fish and invertebrate early life stages. Recent studies have shown that exposure to thin floating oil sheens are lethal to fish and invertebrate early life stages, and effects are potentiated with exposure to UV light (Morris et al., 2015).

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Changes in the Condition of Surfgrass (*Phyllospadix torreyi*) and Macroalgae Following the Refugio Oil Spill, Santa Barbara County

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Summary

The May 19, 2015 crude oil spill into the ocean from a pipeline rupture on the coastal terrace above the shoreline near Refugio State Beach, Santa Barbara County, California resulted in shores along the coast being oiled where surfgrass (*Phyllospadix torreyi*), a marine angiosperm aquatic seagrass grows abundantly in the low-intertidal and shallow-subtidal zone.

Two months after the spill, leaves of surfgrass in areas exposed to the spill shifted in color from being normal emerald green/light-green to yellow, brown, or black, and leaves became brittle and broke apart easily when pulled. Macroalgae occurring with the surfgrass also became discolored. The discoloration was from tissue damage involving the loss of functioning chlorophyll pigment essential in photosynthesis for growth and production. Intertidal and subtidal surveys ensued to further assess the magnitude and extent of the discoloration observed shortly following the spill.

Surfgrass habitat in the low-intertidal zone is only accessible for brief periods of time, even during the best low tides. Therefore, photographing quadrats of one quarter square meter in size (0.25 m^2) and analyzing the photos later for discoloration was chosen as the best method to collect data quickly on surfgrass condition for the study. Although eight sites were considered, five sites were chosen for repeated sampling. The five sites differed in oiling exposure, and were analyzed for the magnitude of the discoloration associated with the spill.

At each site, quadrats were placed and photographed along transects deployed between fixed GPS waypoints. In the lab, the color and coverage of surfgrass and macroalgae in each photographed quadrat was quantified using the point-contact sampling method where each sampling point (of a grid of 100 points) contacting surfgrass and macroalgae was recorded (scored) for presence and color condition.

Analysis of the August 2015 survey photographs revealed Corral Canyon had the highest proportion of discolored surfgrass and discolored macroalgae among the five sites sampled and analyzed; Corral Canyon was also among the most heavily oiled sites, based on shoreline cleanup assessment technique data (SCAT data). Approximately 82.0% of the surfgrass sampled at Corral Canyon was discolored. Macroalgae were less abundant but more discolored in proportion to all of the macroalgal species sampled; approximately 99.2% of the macroalgae sampled at Corral Canyon was discolored. As a result, the total coverage of discolored surfgrass and macroalgae combined was greatest at Corral Canyon (approximately 84.5% cover).

The amount of discoloration in surfgrass and in the macroalgae followed a gradient along the shore of oiling exposure corresponding to the SCAT data. Most discoloration was at Corral Canyon. There was less discoloration in surfgrass and in the macroalgae at three of the four other sites (Arroyo Hondo, Refugio West, Coal Oil Point), and essentially no discolored surfgrass or discolored macroalgae was observed at Mussel Shoals, an unoiled area but within the overall spill range based on the SCAT data.

The offshore distance of the discoloration in surfgrass and macroalgae was determined by snorkel, paddleboard, and SCUBA surveys. The maximum distance of the discoloration from shore was approximately 100 m (328 ft), and the maximum depth was generally between -2.1 m and -3.1 m (-7 and -10 ft) mean lower low water (MLLW). Approximately one year after the spill (June 2016) the continued monitoring found the discoloration in surfgrass and macroalgae was appreciably less than observed at the onset in summer 2015.

Introduction

On May 19, 2015, an underground pipeline conveying oil along the cliff bluff in Santa Barbara County, California near Refugio State Beach ruptured. An estimated 2,934 barrels (123,228 gallons) of heavy crude oil was released from the broken pipe (U.S. Dept. of Transportation 2016). A large volume subsequently reached the ocean. Surfgrass (*Phyllospadix torreyi*) was among the many marine species exposed to the spilled oil.

Phyllospadix torrreyi is a habitat-forming marine angiosperm that grows on wave exposed sand-swept rocky habitats in the low-intertidal/shallow-subtidal zone between the 0.0 and -3.1 m (0 ft and -10 ft) MLLW tide levels. It is abundant along the Santa Barbara County coastline growing as dense beds/meadows. Rhizomes hold the plants to rocky substrates, and the narrow leaves (blades) are uniformly emerald green/light green and can be up to 1.5 m (4.9 ft) long.

Macroalgal species occur within and next to surfgrass beds. These commonly include the feather boa kelp (*Egregia menziesii*), bladder chain kelp (*Sargassum muticum*), and the red macroalgae *Chondracanthus canaliculatus* and *Corallina vancouveriensis*, including many others. In addition, the red algae *Smithora naiadum* and *Melobesia mediocris* are macroalgal species that are exclusively epiphytic on surfgrass (Abbott and Hollenberg 1976).

Surfgrass beds also provide important nursery habitats, refuge, and foraging areas for many species of fishes (DeMartini 1981, Heck et al. 2003, Galst and Anderson 2008). These include topsmelt (*Antherinops affinis*), señoritas (*Oxyjulis californica*), blacksmith (*Girella nigricans*), and black surfperch (*Embiotoca jacksoni*), among many others. Additionally, surfgrass beds provide critical nursery habitat for juvenile California spiny lobsters (Engle 1979). Many other invertebrates are also abundant in surfgrass beds (Holbrook et al. 2000, Heck et al. 2003).

The first intertidal surveys in response to the Refugio oil spill were in May and June 2015, and were completed by marine biologists of the University of California, Santa Cruz and Tenera Environmental Services of San Luis Obispo, California. Surfgrass in the low-intertidal zone was observed with spots of oil on the leaves (**Figure 1**). However, no unusual discoloration in surfgrass was apparent during the initial surveys.

In early July 2015, nearly two months after the spill, visits to El Capitan and Corral Canyon found that intertidal surfgrass and species of macroalgae were unusually discolored (**Figure 1**). Surveys then followed to document the change suspected to be an impact from the spill and to document subsequent changes. The discoloration in the surfgrass and macroalgae was of similar nature to that found in prior oil spills; the January 1969 crude oil spill in the Santa Barbara Channel found surfgrass along the mainland shore that had been oiled turned brown and gradually disintegrated, and macroalgae in the affected surfgrass beds also became discolored (Foster et al. 1969, Mitchell et al. 1970, Nicholson and Cimberg 1971). Discoloration in surfgrass and macroalgae and subsequent abundance declines have occurred from other oil spills (Washington State Department of Ecology 1975, O'Brien and Dixon 1976, Clark et al. 1978, Floch and Diouris 1980, Antrim et al. 1995). The condition of surfgrass and macroalgae observed following the 2015 Refugio oil spill was therefore studied to assess the apparent impact from the spill, and the findings from the quantitative intertidal surveys and qualitative observations are described here.

Methods

Pull Tests

In July 2015 when surfgrass was first observed to be in a discolored condition, leaves were felt and held in hand. The leaves were found to be brittle and broke apart easily. This led to "pull tests" to evaluate tensile strengths. The pull tests consisted of reaching a hand into the surfgrass bed, closing the hand on a handful leaves, and gently pulling on the leaves. The leaf sections that broke off were measured to the nearest centimeter.

Whole Leaf Measurements

Whole leaves of surfgrass were collected and measured for length to the nearest centimeter. The whole leaves were collected by reaching indiscriminately at random locations into the surfgrass bed and feeling where a leaf was attached to the rhizome base and then breaking the leaf off at the rhizome base. The color of the breakage point of each leaf was also noted when measuring the leaf's length (green, yellow, or brown).

Figure 1. Examples of oil contact and surfgrass and macroalgae discoloration: a) oil on surfgrass; b) normal emerald green surfgrass; c) discolored surfgrass; and d) discolored feather boa kelp that is normally brown, not orange-red. Photos from east of Refugio State Beach on August 28, 2015.

Intertidal Quadrat Photo-Surveys and Laboratory Photo-Scoring

Data on the condition and abundance of intertidal surfgrass were collected by photographing quadrats (0.25 m^2; 2.7 ft^2) in the low-intertidal zone, the upper vertical range extent of surfgrass. This sampling was completed at eight sampling sites (**Figure 2**) in five surveys over the study period (**Table 1**). Photographing quadrats enabled data to be collected quickly as possible in the low-intertidal zone where there are only short time windows to sample during low tides.

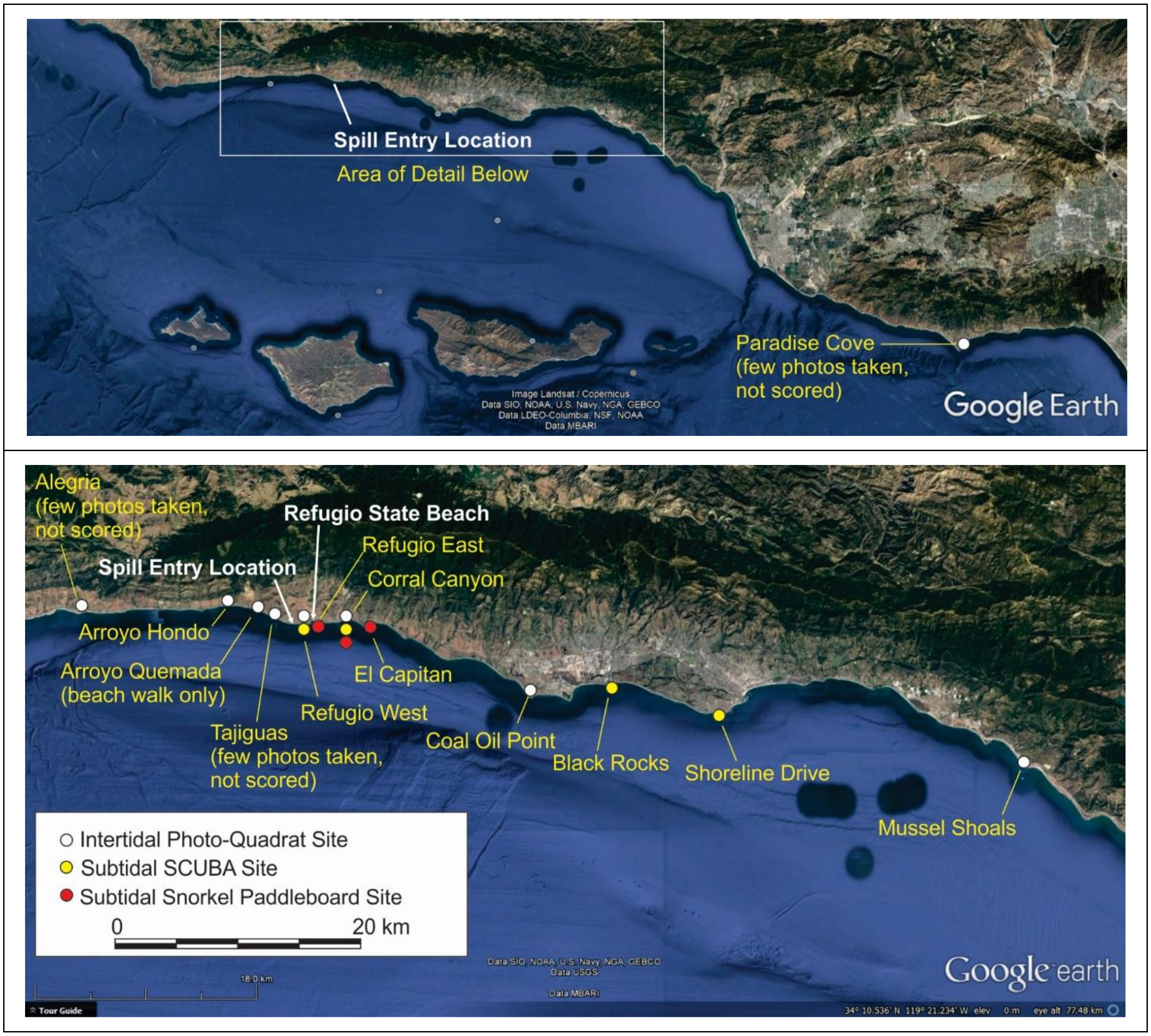


Figure 2. Sites sampled for surfgrass and macroalgae condition.

The sampling sites spanned much of the geographical range of the spill, and included sites that had heavy to no observed oil, based on SCAT data (**Figure 3**). However, due to limited tides sufficiently low to sample, the timing of the low tides, and swell constraints, including labor resources, not all of the intertidal sites could be sampled together in the same survey, and not all of the sites had equivalent large sample sizes. Sites that were sampled and analyzed are shown in **Table 1**, those being Arroyo Hondo, Refugio West, Corral Canyon, Coal Oil Point, and Mussel Shoals (**Figure 2**).

At each sampling site, multiple 10 m (33 ft) transects were deployed during extreme low tides in the accessible intertidal surfgrass zone between about the 0.0 m and -0.3 m (-1.0 ft) MLLW tide levels. Quadrats (0.25 m^2) were then spaced and photographed every 1–2 m (3.3–6.6 ft) along each transect. Most transects were oriented parallel-to-shore. Wave run-up and surf prevented sampling in lower intertidal zones. At three of the sites (Arroyo Hondo, Coal Oil Point, Mussel Shoals), surfgrass was also sampled along pre-existing transects established and sampled by MARINe (Multi-Agency Rocky Intertidal Network) (Engle 2008). Generally, the entire sampling area at each site was approximately 10 m wide (33 ft) perpendicular to shore by 50-100 m (164-328 ft) along the shore.

Table 1. Intertidal survey sites with numbers of transects and quadrat photographs taken at each site. Site locations are shown in Figure 2. The numbers of quadrats that were determined to have readable (scorable) data and the numbers of quadrats scored at each location are also shown.

Site Scored

	Alegria				Arroyo Hondo				Tajiguas				Refugio West				Corral Canyon				Coal Oil Point				Mussel Shoals				Paradise Cove			
	10 m Transects	Quads Photographed	Scorable Quads	Quad Scored	10 m Transects	Quads Photographed	Scorable Quads	Quadds Scored	10 m Transects	Quads Photographed	Scorable Quads	Quadds Scored	10 m Transects	Quads Photographed	Scorable Quads	Quads Scored	10 m Transects	Quads Photographed	Scorable Quads	Quads Scored	10 m Transects	Quads Photographed	Scorable Quads	Quads Scored	10 m Transects	Quads Photographed	Scorable Quads	Quads Scored	10 m Transects	Quads Photographed	Scorable Quads	Quads Scored
Initial Survey																																
Jul. 31, 2015																					9	89	89	45								
Aug. 1, 2015													7	72	59	35																
Aug. 2, 2015																	11	111	100	55												
Aug. 3, 2015																									8	79	70	42				
Aug. 15, 2015					5	29	29	29																								
Intermediate Surveys																																
Aug. 17, 2015									0	4	4	0																				
Aug. 29, 2015													5	52	47	0																
Aug. 30, 2015																	5	37	11	0												
Aug. 31, 2015																									5	36	27	0				
Sep. 1, 2015																													0	3	3	0
Oct. 25, 2015																					9	97	88	0								
Oct. 26, 2015	3	34	33	0					0	3	3	0																				
Oct. 27, 2015													5	55	47	0	1*	10	4	0												
Oct. 28, 2015																	9*	91	36	0												
Oct. 29, 2015																									8	80	75	0				
Oct. 30, 2015					4	19	18	0																								
Nov. 23, 2015					5	54	54	0																								
Nov. 24, 2015																	8*	80	37	0												
Jan. 21, 2016																	6	60	52	27												
Jan. 24, 2016																	9	100	85	29												
Jan. 25, 2016																									5	55	39	35				
Final Survey																																
May 23, 2016	0	16	15	0																												
May 24, 2016									0	4	4	0																				
Jun. 5, 2016													7	78	76	34																
Jun. 6, 2016																	17	175	173	50												
Jun. 7, 2016																					7	93	89	45								
Jun. 8, 2016																									8	81	81	40				
Jun. 9, 2016					5	38	38	28																								

* very marginal conditions

The transect origin and terminus latitude-longitude coordinates were recorded using a consumer-grade Garmin GPSmap 76C. The coordinates were used to re-deploy the transects in the same locations in subsequent surveys. Mostly, all transects at a site were able to be re-deployed for re-photographing quadrats when revisited each survey.

The photographs from the initial survey (August 2015) and final survey (June 2016) were analyzed because they had the largest number of photographs across the most sites (same five sites) within a few days or weeks of each other. Four of the five sites were oiled (Arroyo Hondo, Refugio West, Corral Canyon, and Coal Oil Point), of which Corral Canyon was among the most heavily oiled based on SCAT data (**Figure 3**). The fifth site, Mussel Shoals that was located furthest from the spill provided reference data from a site that was least exposed or not exposed to oil (**Figure 3**). Even though Corral Canyon and Mussel Shoals were the only sites sampled in the January 2016 survey (**Table 1**), the quadrat photographs from that survey were also included in the analysis, because surfgrass discoloration was most extensive at Corral Canyon (most oiled) and could be compared to Mussel Shoals (reference) over three versus two surveys.

In the laboratory, the quadrat photographs were first selected for clarity; those that were not in focus were eliminated. After this quality check, quadrat photographs were randomly selected and scored for each site and survey. Generally, 30-50 photo-quadrats were scored for each survey at each site (**Table 1**), which was approximately one-half of the scoreable quadrats at each site per survey.

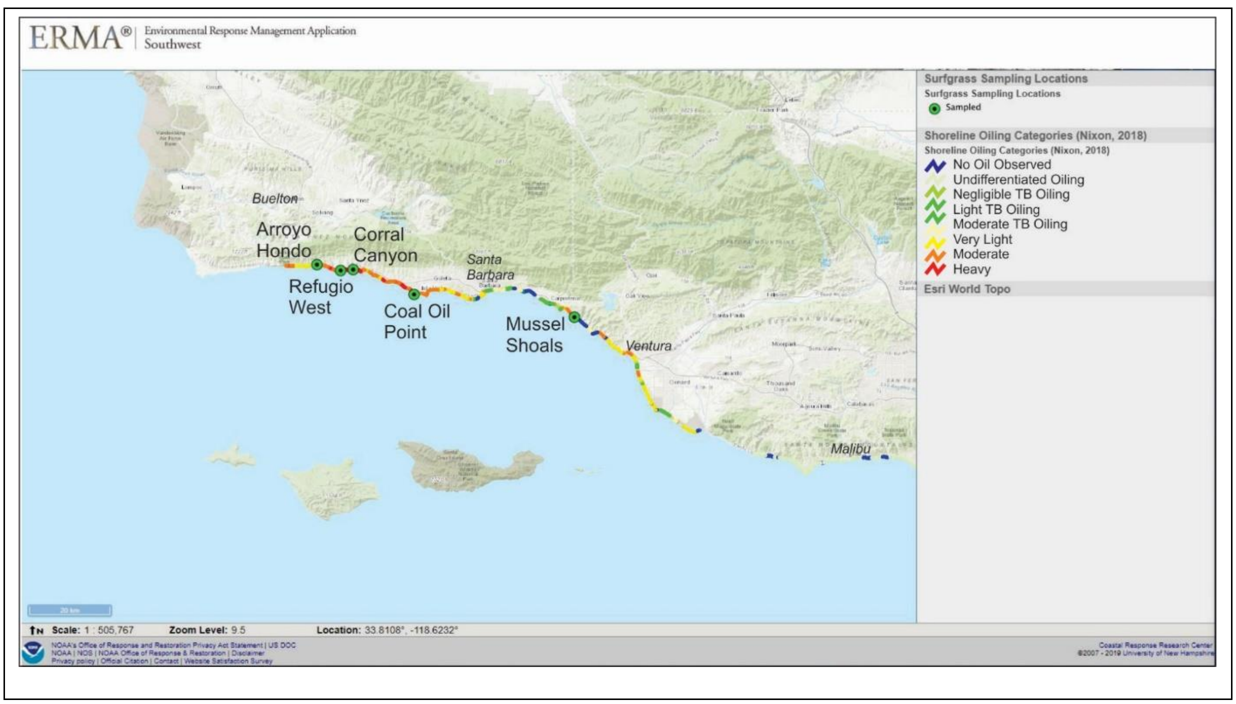


Figure 3. Oil exposure at intertidal surfgrass sampling sites based on SCAT maximum oiling data; Arroyo Hondo and Coal Oil Point moderately oiled, Mussel Shoals not oiled, and Refugio West and Corral Canyon heavily oiled. However, Corral Canyon was most heavily oiled in the low-intertidal, due to tide level and currents at the time of the spill. See *Discussion* section for explanation.

The MARINe point-contact sampling method was used in the laboratory to record (score) the photographs for species occurrences and color condition (Engle 2008, UCSC 2019). A grid of 100 evenly spaced points was superimposed over each photograph (using Adobe Photoshop™), and the species directly beneath each sampling point was scored for color. The scoring provided quantitative data on intertidal surfgrass and macroalgae color, condition, abundance, and proportions based on the contacts of the top-most layer in the photographs.

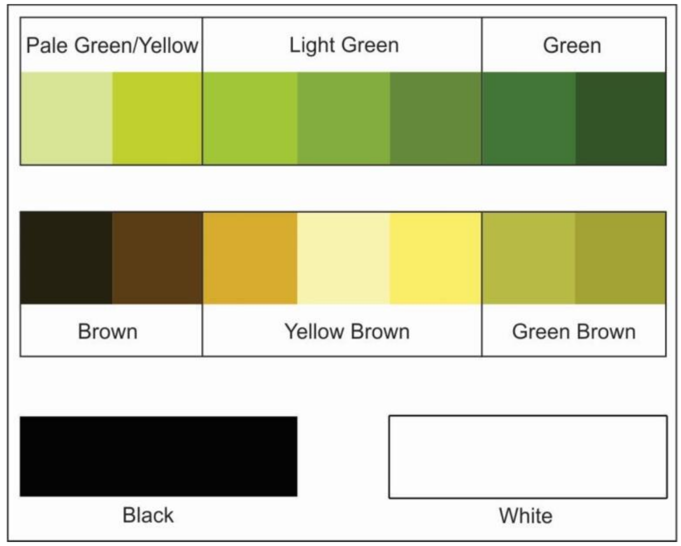


Figure 4. Color chart to score surfgrass leaf colors in the quadrat photographs.

A color chart was used to score colors consistently across the quadrat photographs (**Figure 4**). The Photoshop™ eyedropper tool was used to capture the range of surfgrass colors in photographs taken in the first survey in August 2015 at Mussel Shoals (reference site) and at Corral Canyon (a heavily oiled site). The range of colors was used to create a color library chart with each color being assigned a label/name. During the scoring, the color chart was viewed alongside the quadrat photograph on the computer monitor. The same computer and monitor were used in scoring all photographs. Green and light-green surfgrass leaves were scored and analyzed as normal color. All other surfgrass colors were considered unusual (discolored/injured tissues). The macroalgae were scored with fewer color categories than shown in **Figure 4**: “normal color”, “bleached”, or “discolored”. The color and condition categories are listed further in **Table 2**.

The abundance (percent cover) of each scored category in a quadrat was determined by the number of contacts out of the 100 points sampled. The total percent cover of surfgrass, for example, was the total number of contacts to surfgrass (regardless of color). The proportion of discolored surfgrass to all surfgrass in a quadrat was the number of point contacts scored as discolored surfgrass divided by the total points contacting surfgrass and multiplied by 100. Sample points scored as “unknown color” (from shadowing effects), and “epiphytes” (for surfgrass) were not included in the total points scored for discoloration. Algal species were scored for abundance and discoloration in the same manner.

Line-Point Contact Intertidal Field Measurements

The 10 m transects for placing and photographing the 0.25 m^2 quadrats were sampled in the field at every 10 cm (4 in.) interval (point) for the presence/absence of surfgrass and other species (line-point contact field sampling method). Five to 15 transects were sampled per site yielding contact data for 500 to 1,500 sample points per site for each survey.

Table 2. Taxa and condition categories scored in the quadrat photos.

Taxon	Condition
Phyllospadix torreyi	green light green yellow black brown yellow-rown green-brown unknown color *Smithora* on leaf *Melobesia*/white crust on leaf unid. filamentous macroalgae on leaf unid. gelatanous eggs? on leaf snagged drift macroalgae on leaf pink *Melobesia* on leaf unid. foliose macroalgae on leaf *Ulva* spp. on leaf limpet on leaf hydroid on leaf rhizome normal rhizome discolored rhizome with broken leaves
coralline crust macroalgae	normal bleached, discolored
non-coralline crust macroalgae	normal unknown color
articulated coralline macroalgae	normal bleached, discolored unknown color
Chondranthus canaliculatus	normal bleached, discolored
Chondracanthus spinosus	normal bleached, discolored unknown color
Colpomenia spp.	normal unknown color
Corallina vancouveriensis	normal bleached, discolored unknown color
Desmarestia ligulata	normal unknown color

Taxon	Condition
Egregia menziesii	normal bleached, discolored unknown color
Gastroclonium subarticulatum	normal bleached, discolored unknown color
Macrocystis pyrifera	normal
Mazzaella leptorhynchos	normal bleached, discolored
Prionitis spp.	unknown color
Sargassum muticum	normal bleached, discolored
Stephanocystis osmundacea/S. dioica	normal bleached, discolored unknown color
Ulva spp.	normal bleached, discolored unknown color
Zonaria farlowii	normal bleached, discolored
branched red macroalgae (unid.)	normal bleached, discolored unknown color
filamentous red macroalgae (unid.)	normal bleached, discolored unknown color
brown macroalgae (unid.)	normal bleached, discolored unknown color
foliose/fleshy red macroalgae (unid.)	unknown color normal bleached, discolored
anaerobic stain/bare substrate anemone bare bed rock bare boulder bare cobble barnacle encrusting invertebrate (unid.) mussel *Phragmatopoma californica* sand/gravel/pebble unid. sample point	

At each sample point, the occurrence of surfgrass (leaves) was recorded (scored) regardless of whether surfgrass was the top-most layer or was underneath layers of macroalgae. The latter situation was determined by brushing the macroalgae aside to confirm the presence/absence of surfgrass leaves underneath the sample point. In contrast, other species (taxa) underneath the overstory surfgrass and macroalgae layers, such as sea anemones, barnacles, and surfgrass rhizomes were not scored as a (secondary) layer in this sampling method, even if present. Also, the color and condition of the surfgrass and macroalgae were not scored for each point in this field sampling method. However, the appearance and condition of surfgrass and macroalgae was summarized for each transect and described in field notes and supplemented with overview panoramic photos to help document conditions.

Leaf Density and Biomass

The priority intertidal sampling during the limited low tide sampling windows was quadrat photography for assessing surfgrass and macroalgae condition, the line-point contact field sampling method for percent cover abundance and collecting surfgrass leaves for measuring leaf lengths. Leaf density and biomass data would have provided additional information to assess the health and condition of surfgrass, but these data were not collected.

Snorkel and Paddleboard Surveys

The offshore extent and depths of discolored surfgrass were initially determined at several sites in snorkel and paddleboard surveys at Refugio East, El Capitan, Corral Canyon (**Figure 2**). Refugio East was surveyed on August 28, 2015, followed by El Capitan on September 3, 2015 and Corral Canyon on September 4, 2015. The offshore (subtidal) outer boundaries of surfgrass beds were determined by deploying meter tapes from shore to offshore and using GPS to record locations. Depths were determined by lowering a weighted meter tape from the surface but was estimated in some cases. Depths were corrected to MLLW based on National Oceanic and Atmospheric Administration (NOAA) predicted tide heights and times for Gaviota Pier, the closest tide gauge to the sampling sites. Arroyo Quemada (**Figure 2**) was another site planned for noting the depths and distances of discolored surfgrass from shore, which was visited on September 3, 2015. However, waves were too large to enter the water so only beach walk observations were made.

SCUBA Surveys

Information from the snorkel and paddleboard surveys was used to plan and conduct SCUBA surveys to further assess the subtidal extents of the discolored/injured surfgrass. The SCUBA surveys were conducted from a dive boat on October 21, 2015. Locations were Refugio West, Corral Canyon, Black Rocks, and Shoreline Drive, sites across a geographic range of the spill (**Figure 2**).

The SCUBA surveys could not incorporate the same sampling methods used in the intertidal surveys, mainly because the work was underwater in the surf zone, a difficult place to sample. The observations were qualitative, and were made by a single two-person dive team at each site.

One transect was surveyed at each site. The anchor weight of the transect origin (marker buoy) was lowered to the seabed offshore of the surfgrass zone. Due to very clear water, the offshore boundary of surfgrass was visible from the dive boat in all areas surveyed. The origin marker coordinates were recorded using GPS. The divers then attached the end of a meter tape to the origin marker weight and spooled the tape out underwater on a compass heading directly towards shore to define the transect. The divers recorded distance intervals and color condition of surfgrass and macroalgae along each transect. All transects terminated in the low-intertidal zone of the shore that was confirmed by seeing macroalgae species that are strictly intertidal in occurrence (e.g., *Corallina vancouveriensis*). Depths were corrected for tidal height based on NOAA predicted tidal heights and times for Santa Barbara Harbor.

Results

Initial Observations of Discoloration in Surfgrass

On July 8, 2015, 53 days after the spill, El Capitan State Beach (**Figure 2**) was visited. Tar balls were observed on the rocky shore, and while dense surfgrass was present along the shore, many of the leaves were unusual in color and condition; leaves were yellowish-tan in color, brittle, and broke off easily when pulled. The discoloration observed from shore was present in plants at depths of approximately -1.2 m to -1.8 m (-4 ft to -6 ft) MLLW.

On July 10, 2015, the surfgrass bed at Corral Canyon (**Figure 2**) was observed by walking and wading along the shoreline. Oil was present along the shoreline underneath cobbles. Like El Capitan State Beach, surfgrass was noticeably discolored; the surfgrass was more tan than green, and leaves broke off easily when pulled. The discolored surfgrass was observed out to a depth of approximately -0.5 m (-1.5 ft) MLLW. Observations could not be made further offshore in deeper water due to waves and wave run-up on the shore preventing access.

On July 17, 2015, observations were made on a paddleboard along the shoreline west of Refugio State Beach up to the spill point (**Figure 2**). The surfgrass was not as uniformly discolored as the surfgrass at Corral Canyon. However, the surfgrass was unusually slimy in texture and tan in color in some areas.

Leaf Measurements

Leaf length measurements from the pull tests and measurements of whole leaves at Corral Canyon in the August 2015 survey found the leaf sections from the pull test (all leaf break point color categories combined) were nearly the same lengths of whole leaves (**Figure 5**); the leaves in the pull tests broke off n ear the rhizome bases. Similar results occurred in the January 2016 survey. Overall, whole leaves were shortest at Corral Canyon in the initial August 2015 survey compared to Mussel Shoals.

In contrast, whole leaves were longer at Mussel Shoals in the August 2015 survey, and pull tests found less leaf breakage (**Figure 5**). The summer (June 2016) survey found whole leaves at both Corral Canyon and Mussel Shoals had increased in length from the prior winter survey (January 2016), and there was no leaf breakage in pull tests.

Abundance: Line-Point Contact Field Sampling

The field transect line-point contact sampling method provided more complete data on surfgrass abundance and changes over time in cover than data from the quadrat photographs. This was because any surfgrass present at a field sampling point was scored regardless of whether the leaves were over or underneath an overstory layer of macroalgae. In contrast, the quadrat-photo method did not score surfgrass if underneath an overstory macroalgae layer.

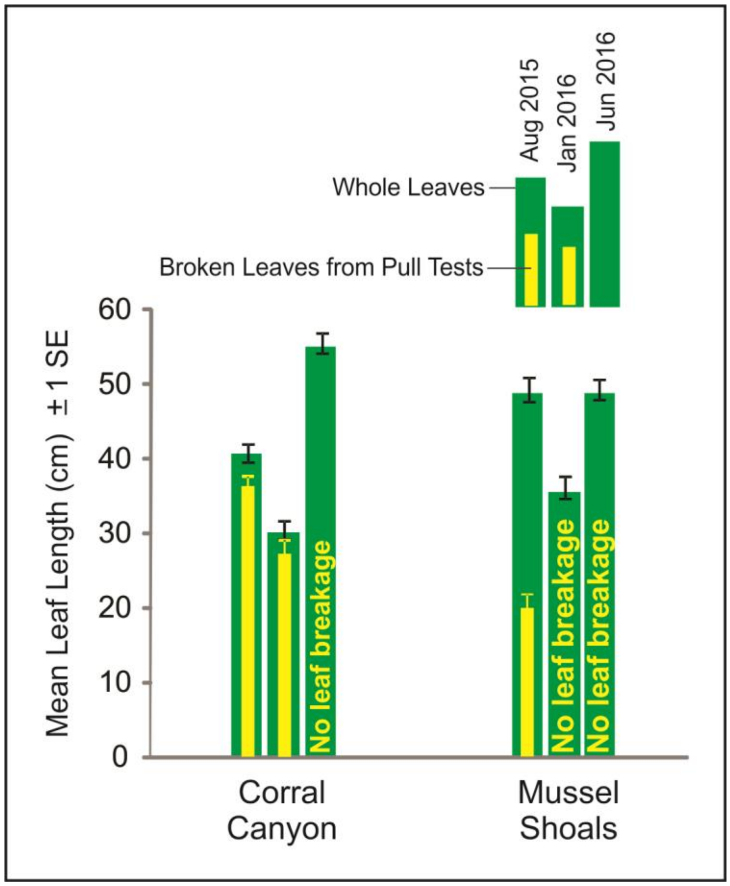


Figure 5. Surfgrass whole leaf lengths and lengths of leaves that broke off from pull tests.

Surfgrass was abundant at all of the sites in the initial survey completed in August 2015 and was most abundant at Corral Canyon (88.5% cover, **Figure 6**). Surfgrass then declined in cover from August 2015 to January 2016 and then increased by June 2016. However, the final abundance in June 2016 was lower than initially observed in 2015. Surfgrass was also less abundant in the final versus initial survey at Refugio West and Arroyo Hondo. In contrast, surfgrass was slightly more abundant in the final versus initial survey at Coal Oil Point and Mussel Shoals. Coal Oil Point was the farthest sampling site exposed to the spill, and Mussel Shoals, the reference site, was furthest from the spill.

Rhizomes bearing only leaf stubs (bare rhizomes) could be another indication of an oil spill effect, as discolored leaves broke apart more easily than normal emerald green leaves; all breakage could tend to leave rhizomes with only leaf stubs. Bare rhizomes were twice as common at Corral Canyon than at Mussel Shoals, but low in occurrence overall (less than 6.0% cover based on data from the quadrat photo and field line-point contact sampling methods). The estimate, however, is most likely an underestimate, as bare rhizomes were scored only if there was no overstory layer of macroalgae or surfgrass on top of the rhizomes at the sampling points. The qualitative field observations, however, further noted bare rhizomes were also black in color and peeling off rocks, a condition that was more extensive at Corral Canyon than at Mussel Shoals.

The field line-point contact sampling data also revealed that macroalgae were less abundant than surfgrass (**Figure 6**), although the abundance of macroalgae from this method were also likely underestimated, due to the algae often occurring underneath surfgrass and thus not scored. The method, however, detected increases in both surfgrass and in macroalgal abundance by the final June 2016 survey at Corral Canyon. Most of the increase in macroalgal abundance at Corral Canyon was from *Sargassum muticum*, a large naturalized non-native brown algal that was often scored in this method, due to being an overstory species.

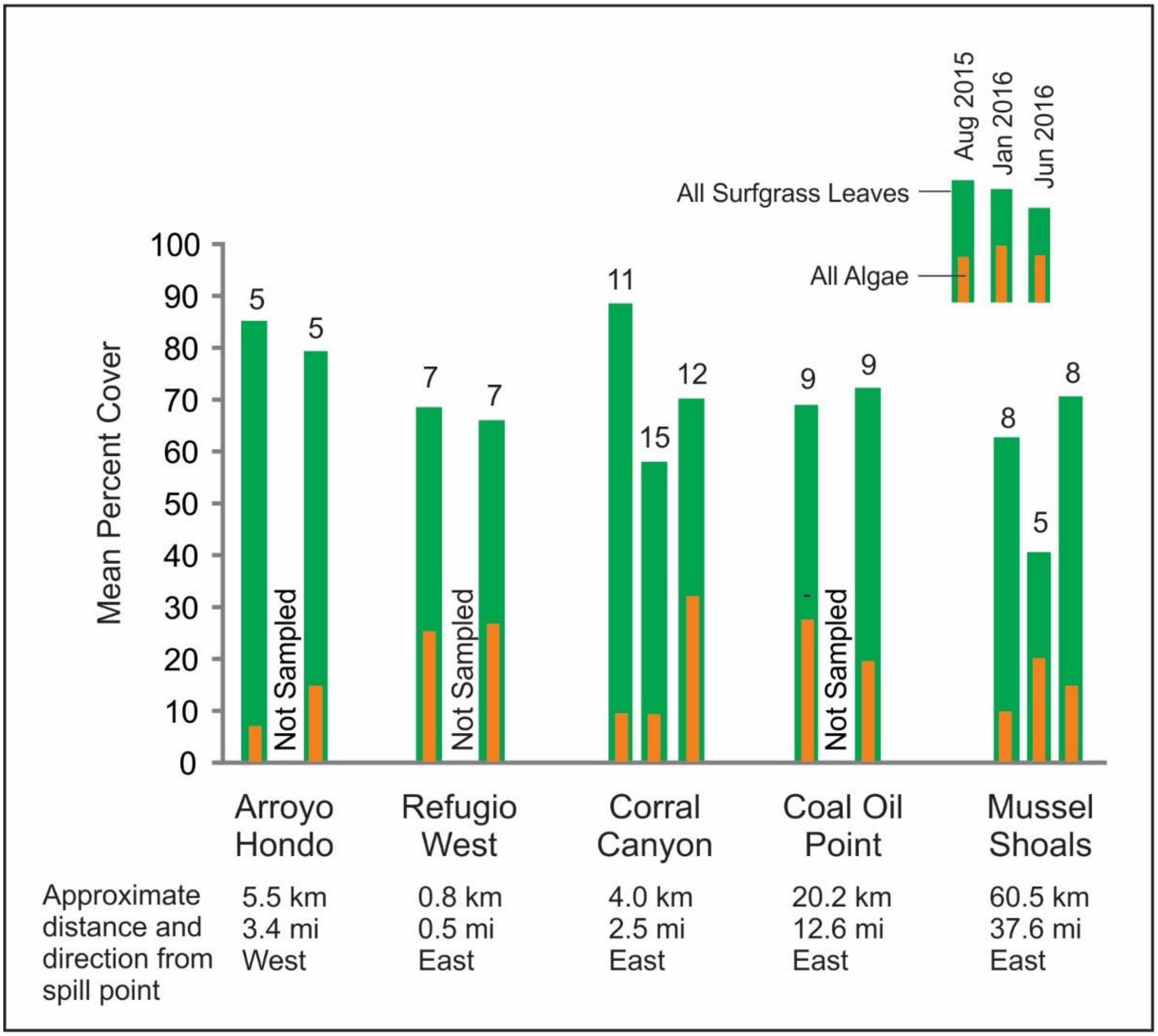


Figure 6. Percent cover changes by the line -point contact field sampling results for surfgrass and macroalgae (all colors and conditions combined for each taxon). The macroalgae do not include crustose species. The approximate distances of the sampling sites from the spill point are shown. Numbers above bars are the number of 10-m transects sampled.

Invertebrate data from the line-point contact sampling method are not included here, as invertebrates were typically the bottom-most layer and therefore not scored when there was an overstory layer present.

Discoloration: Photo-Quadrat Scoring

The largest proportion of surfgrass discoloration was observed at Corral Canyon (82.0%) during the (initial) August 2015 survey (**Table 3a**). This was followed by Coal Oil Point and Refugio West in the same survey where approximately half of the surfgrass leaves scored were discolored. At Arroyo Hondo, approximately one third of the leaves scored were discolored. Mussel Shoals had the smallest proportion of discolored leaves scored (less than 3%).

Macroalgal species were also discolored in the initial (August 2015) survey, and to a greater degree than surfgrass; nearly 100% of the macroalgae sampled was discolored at all sites, except at Mussel Shoals (**Table 3b**). Very little discoloration of the macroalgae (and surfgrass) was observed in the final survey in June 2016 at any of the sites (**Table 3a** and **3b**).

Table 3. Proportion of surfgrass discoloration to total cover at sites over time: a) surfgrass; b) algae.

	Arroyo Hondo	Refugio West	Corral Canyon	Coal Oil Point	Mussel Shoals
a) Surfgrass					
August 2015	37.4	46.2	82.0	54.3	2.2
January 2016	ns	ns	34.3	ns	19.7
June 2016	16.9	2.1	9.5	2.4	1.9
b) Algae					
August 2015	92.3	92.2	99.2	86.1	6.1
January 2016	ns	ns	2.0	ns	15.1
June 2016	1.9	0.8	0.2	11.2	0.0

ns: not sampled due to insufficient tides and labor resources

The combined coverage of discolored surfgrass and macroalgae scored as the top-most layer in the quadrat photographs was greatest in the August 2015 survey at all sites, and mostly at Corral Canyon at 84.5% cover (**Table 4**). This was followed by Refugio West, Coal Oil Point, and Arroyo Hondo. The least amount of discolored surfgrass and macroalgae was at Mussel Shoals. Nearly all of the discoloration in surfgrass and macroalgae had diminished by the final (June 2016) survey at all of the sites.

Table 4. Percent cover of top layer discoloration at sites over time, surfgrass and macroalgae combined.

	Arroyo Hondo	Refugio West	Corral Canyon	Coal Oil Point	Mussel Shoals
August 2015	35.3	61.2	84.5	52.0	3.4
January 2016	ns	ns	18.9	ns	12.5
June 2016	7.1	1.3	4.6	4.1	1.1

ns: not sampled due to insufficient tides and labor resources

Snorkel and Paddleboard Findings

Refugio East, Corral Canyon, and El Capitan (**Figure 2)** were surveyed in snorkel swims and from a paddleboard. The Refugio East site located at Refugio State Beach campground was searched in this manner on August 28, 2015 where an extensive subtidal surfgrass bed extended for hundreds of meters parallel-to-shore. A sand channel separated most of the surfgrass area from the deeper offshore kelp forest. The discoloration in surfgrass at Refugio East was observed in some areas as bands of discolored surfgrass leaves oriented parallel-to-shore alternating with bands of green leaves also oriented parallel-to-shore (**Figure 7a**). The discoloration was also observed to be near the distal ends of surfgrass leaves with leaves being more green closer the rhizome base (**Figure 7b**).

a)

b)

Figure 7. Discoloration in subtidal surfgrass appearing as: a) bands of non-green leaves alternating with bands of green leaves; and b) non-green leaf sections at the distal ends with green leaf sections closer to the rhizome base. Photos taken at Refugio East on August 28, 2015.

At Transect 1 at Refugio East (**Figure 8**), the outer depth boundary of surfgrass was -2.0 m (-6.5 ft) MLLW and was 88 m (289 ft) from shore. The depth at the outer boundary of surfgrass along Transect 2 was -1.8 (-5.8 ft) MLLW where it transitioned into a kelp forest. The outer depth boundaries of surfgrass at Transects 4 and 5 were -0.9 m (-2.8 ft) and -1.4 m (-4.5 ft) MLLW, respectively, with surfgrass occurring out to approximately 100 m (328 ft) from shore at both transects. Transect 3 (**Figure 8**) was not deployed due to breaking surf and was therefore not sampled; underwater visibility was also poor in that location.

Arroyo Quemada (**Figure 2**) was visited on September 3, 2015, but waves were too large to enter the water, and underwater visibility was poor. Paddleboard and snorkel surveys were not attempted, but beach walk observations found that drift surfgrass stranded along the high tide line on the shore was abundant. The leaves were yellowish-tan and brittle.

El Capitan State Beach cove (**Figure 2**) was also visited on September 3, 2015. Surfgrass did not occur in the intertidal zone along the sand beach but occurred on offshore emergent rocky outcroppings. In the subtidal zone, surfgrass was widespread, but not a solid bed. Snorkeling observations were able to be completed only outside the breaking surf zone. The depth reached was approximately -1.8 m (-6 ft) MLLW, which was approximately 50 m (164 ft) from shore. The surfgrass seen was pale with both light green and greenish-yellow leaves. Some patches were distinctly yellow/tan/brown. None of the surfgrass observed was bright emerald green. Discolored leaves were also brittle and broke apart easily when pulled by hand.

Corral Canyon (**Figure 2**) was surveyed on September 4, 2015, but surveys were hampered by strong southerly swells and waves. The outer extent of the bed was mapped using a GPS on a paddleboard and with a meter tape anchored at the 0.0 m MLLW tide level on the shore and deployed offshore. The surfgrass bed extended approximately 100 m from shore where depths were -1.5 m (-5 ft) to -2.1 m (-7 ft) MLLW. All of the surfgrass over this distance was pale, tan, black, and yellow-green. No surfgrass was bright emerald green.

Figure 8. Transects at Refugio East where surfgrass was observed in paddleboard and snorkel surveys on August 28, 2015.

SCUBA Findings

SCUBA surveys were completed on October 21, 2015, five months after the spill and approximately seven weeks after the snorkel and paddleboard surveys. Underwater visibility was 6-10 m (20-30 ft) at all four sites, and waves in the surf zone were 0.6–0.9 m (2-3 ft).

The findings from the SCUBA observations were similar to the earlier snorkel and paddleboard findings on depths, extent, and surfgrass discoloration (**Figures 9** and **10**). The maximum offshore depth of surfgrass was between -1.5 m to -3.1 m MLLW, and surfgrass extended offshore no greater than approximately 100 m at the sites surveyed.

At all four sites, yellow-green surfgrass was common at all of the depths and distances from shore surveyed, and discolored algae occurred with the discolored surfgrass. A quantitative assessment of the amount of discoloration in the algae and surfgrass (i.e., aerial coverage) was not completed, due to difficulties in sampling underwater in the surf zone; the purpose was to mainly confirm whether the discoloration occurred in the subtidal.

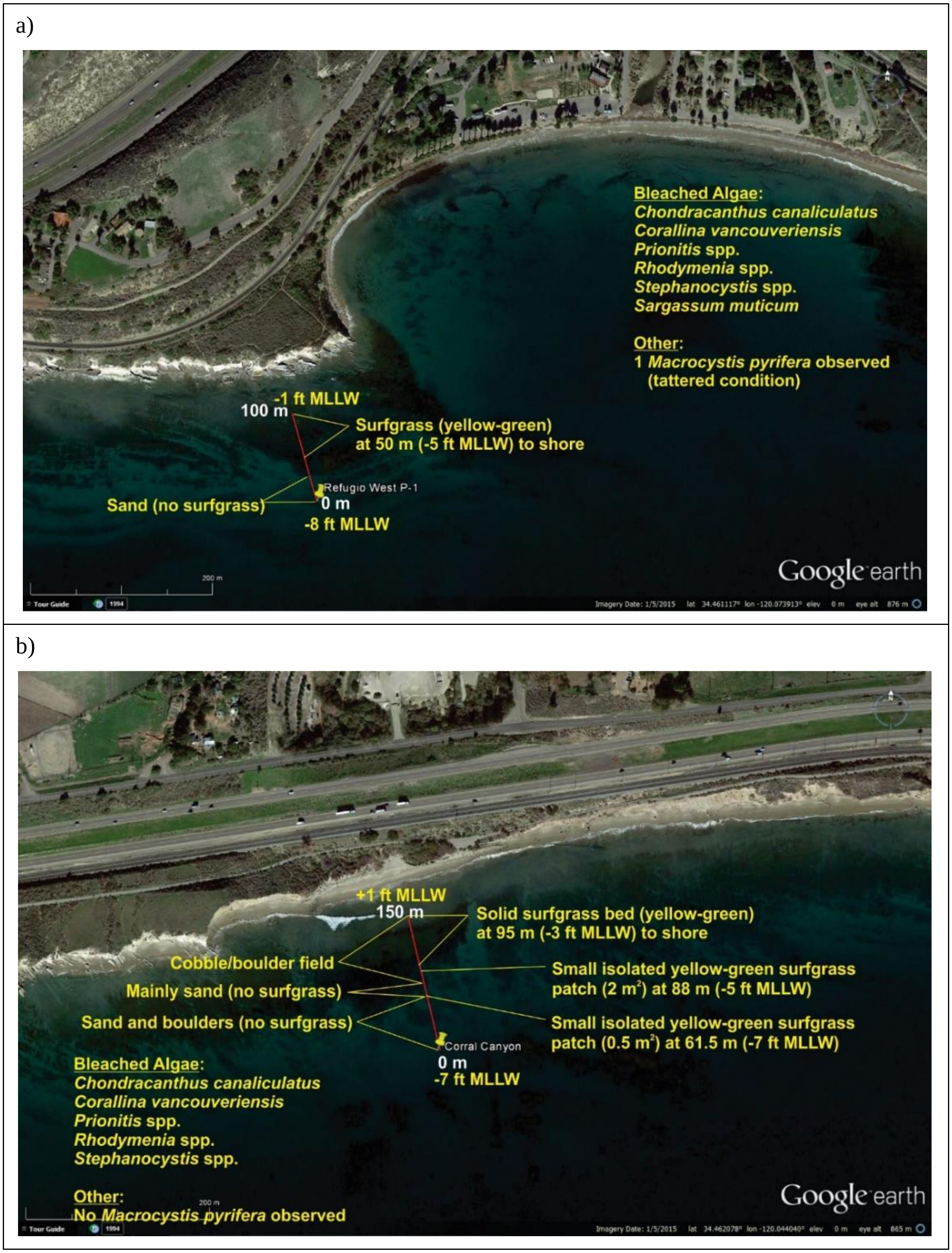
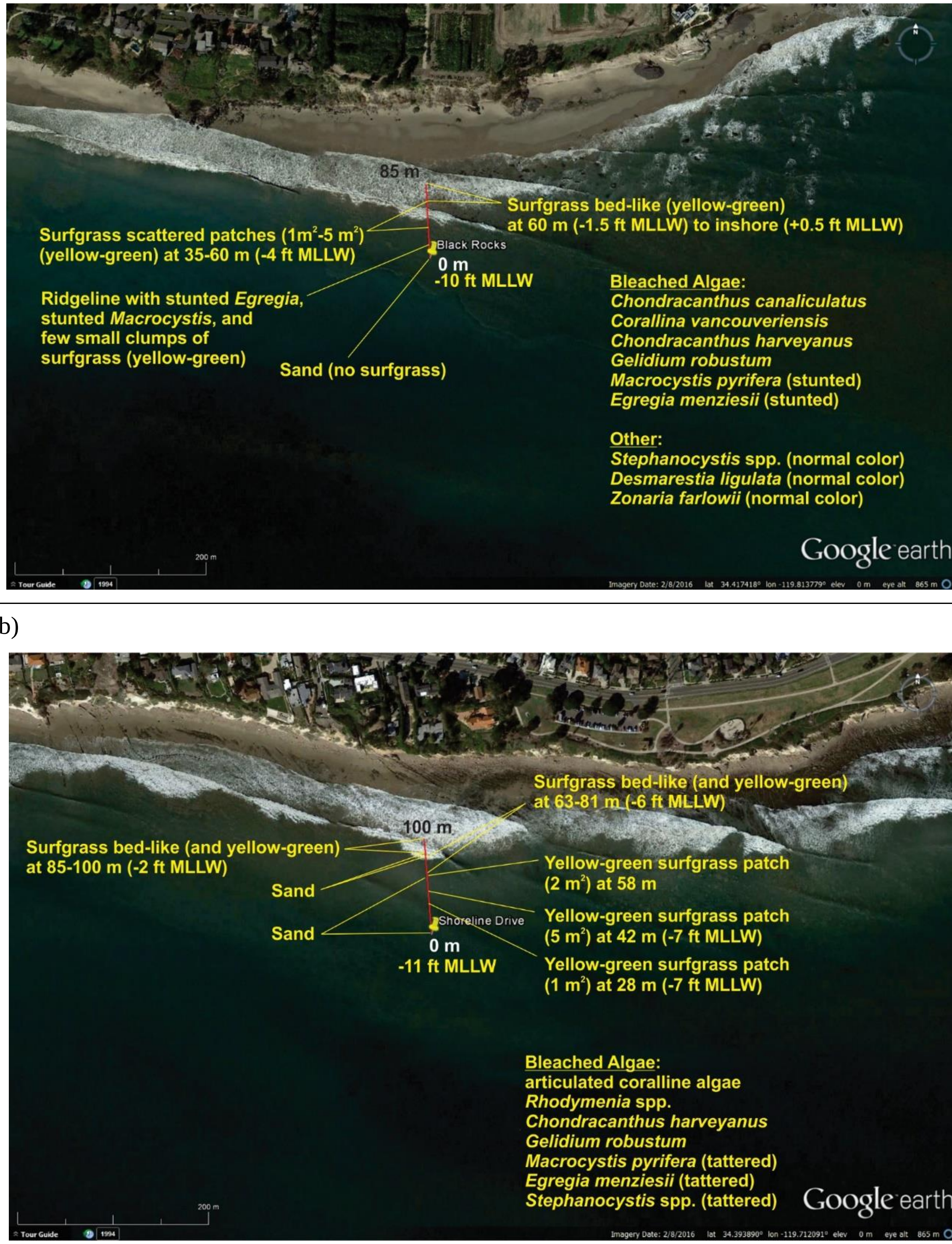


Figure 9. Subtidal (SCUBA) observations at: a) Refugio West; and b) Corral Canyon on October 21, 2015.

a)



b)

Figure 10. Subtidal (SCUBA) observations at: a) Black Rocks; and b) Shoreline Drive on October 21, 2015.

Discussion

Magnitude and Extent of Surgrass and Macroalgae Discoloration

The intertidal quadrat photo-surveys found the discoloration in surfgrass, expressed as the proportion of discolored (i.e., dead and dying) surfgrass compared to all the surfgrass sampled at a site, was greatest at Corral Canyon (82.0%) over the other sites sampled (**Table 3a**). Results for the macroalgae were similar with the greatest discoloration found at Corral Canyon (99.2%, **Table 3b**). Even though the immediate shore at Refugio State Beach Campground was highlighted in news media as a heavily oiled shore, which was closer to the spill point to the ocean (~0.8 km; ~0.5 mi) than Corral Canyon (~5 km; ~3 mi), surfgrass and macroalgae at the Corral Canyon sampling site were more affected by the spill than at the Refugio West sampling site that was immediately at the Refugio State Beach Campground. A possible explanation for the discrepancy is the tide level and currents at the time of the oil spill.

The spill occurred during a high tide when the ocean current and wind were in an eastward trajectory (downcoast). As a result, the Refugio West sampling site and Refugio State Beach Campground shores were contacted by the buoyant oil plume primarily in the upper intertidal zone on the day of the spill where the oil eventually dried as black bands coating the vertical rock (cliff) faces along the high splash zone of the high intertidal zone. The high tide condition thus limited the oiling exposure to the low-intertidal surfgrass occurring beneath the buoyant plume. As the oil plume continued to move east down the coastline, the tide level was dropping. Hours later, the oil plume reached Corral Canyon when the tide level was lower, which increased the exposure of the low-intertidal occurring surfgrass and macroalgae to the oil plume.

Using surfgrass discoloration/tissue damage as criteria to rank oiling exposure and injury, oiling exposure and injury was greatest at Corral Canyon, followed by Refugio West, Coal Oil Point, and Arroyo Hondo, and with Mussel Shoals being unoiled or least oiled. This is consistent with SCAT oil ranking data (**Figure 3**). This is also consistent with the first post-spill studies completed by the University of California, Santa Cruz, which included sites sampled in similar locations as in the present study and where oil scored in quadrats revealed the same gradient of oiling exposure; most oil was in quadrats sampled at Corral Canyon (Raimondi et al. 2019). Another hypothesis for why Corral Canyon in the present study was more affected by the spill than the other sites is that the low-intertidal zone of surfgrass at Corral Canyon is a habitat of boulders and cobbles rather than bench rock; oil tends to persist and remain entrapped in a liquid state in the open spaces between boulders and cobbles and can then re-suspend and re-oil the shore with the next incoming tide.

The upper-most elevation of the discoloration in surfgrass was found to be approximately 0.0 m MLLW, and the lowest elevation was found to be approximately -3.1 m MLLW underwater. This was also the full intertidal-subtidal vertical range of surfgrass in the areas surveyed. The maximum distance offshore of the surfgrass discoloration was approximately 100 m. Macroalgae co-occurring with the intertidal and subtidal surfgrass were also discolored in the same areas. The discoloration in surfgrass and in the macroalgae was appreciably less by the end of the study at all of the sites exposed to the oil spill.

Tensile Strength of Surfrass and Leaf Lengths

The surfgrass leaf measurements of whole leaves at Corral Canyon and Mussel Shoals provide evidence of an effect from the oil spill and then recovery. Whole leaves at Corral Canyon were appreciably shorter in the initial survey compared to the final survey (**Figure 5**). In contrast, whole leaf lengths at Mussel Shoals were nearly identical between the initial and final surveys. Without the oil spill, one hypothesis is whole leaf lengths at Corral Canyon should have been more similar to each other between the initial and final surveys, as found at Mussel Shoals. As such, one explanation why surfgrass leaves at Corral Canyon were considerably shorter in the initial survey compared to the final survey is that the discolored and weakened leaf sections had already broken off leaving mostly shorter leaves to be measured. No further leaf breakage from pull tests was evident in the final survey.

The initial decline in surfgrass leaf lengths at Mussel Shoals, the control/reference site where the decline was followed by an increase in leaf lengths, may also to help to explain some of the changes at Corral Canyon (**Figure 5**). The decline at Mussel Shoals from the initial survey (August 2015) to the mid-winter survey (January 2016) can be considered a natural change consisting of leaf growth slowing with the shorter day lengths and the leaves becoming shorter from winter storm waves eroding leaves. This may also explain all or part of the decline at Corral Canyon over the same time period. Leaf lengths and percent cover then increased at both Corral Canyon and Mussel Shoals (**Figure 6**). The increases at both sites represent positive growth responses to the returning spring/summer growth conditions.

Rhizome Condition

Bare rhizomes were only observed in the winter sample period (January 2016), and were sampled by the photo-quadrat and field line-point contact sampling methods at Corral Canyon and Mussel Shoals, the only sites sampled in the January 2016 survey. The occurrence of bare rhizomes at Mussel Shoals indicates bare rhizomes occur naturally, possibly related to winter storm waves and shorter day lengths causing leaf die-back and sloughing leaving bare rhizomes. On this basis, it is not possible to confirm whether all or a portion of the bare rhizome condition sampled at Corral Canyon was from the oil spill or from natural causes because bare rhizomes were also sampled at Mussel Shoals. However, other information suggests eelgrass rhizome condition was affected by the spill more than what the quantitative sampling revealed.

Bare rhizomes comprised less than 6% cover at both sites, as determined by the photo-quadrat and field line-point contact sampling methods, but were twice as common at Corral Canyon than Mussel Shoals. However, both sampling methods likely underestimated bare rhizome cover at both sites, due to rhizomes being the bottom-most layer in both sampling methods and therefore not scored if overstory species (surfgrass and macroalgae) were present.

In contrast, qualitative observations of general site conditions found that bare rhizomes, damaged/black rhizomes, and rhizomes partially pulled away from rocks were much more common at Corral Canyon than at Mussel Shoals. Without more quantitative data, however, it is not possible to describe the total amounts involved.

Discoloration and Oiling Exposure

The term "discoloration" in the present study describes the unusual condition of surfgrass leaves and macroalgae blades and branches occurring at the oiled sites in July-August 2015 after the oil spill. "Bleaching" is another term commonly used to describe the appearance of damaged tissues, but bleaching is from tissues becoming desiccated and changing to white in color. Natural tissue bleaching and desiccation generally occurs during extreme low tides when the intertidal zone is exposed to air, strong sunlight, and a consistent warm air breeze blowing across the intertidal zone (Scrosati and DeWreede 1998, Irving et al. 2004, Keough and Quinn 1998, Martone et al. 2010, Tenera Environmental, unpublished observations).

Bleaching along the central California coast tends to occur more often in winter than in the other seasons, associated with the timing of low tides and low tide levels. Winter is the season of the most extreme low tides that occur during daylight hours, which results in the low-intertidal zone becoming exposed to air and direct sunlight for longer hours than other seasons and to offshore winds that can be warm with low humidity. Extreme low tides also occur in spring and summer, but these low tides occur most often during night and early morning when the low-intertidal zone is not exposed as much to strong sunlight and warm air temperatures. Low tides also occur in fall, and can be during strong daylight, but the tide levels during the daylight hours are generally not as low in fall compared to winter. As such, the low-intertidal zone in fall is exposed less to warm air conditions than in winter. Thus, the timing when low tides occur and how low in elevation the tides reach largely explains why bleaching in intertidal surfgrass and macroalgae tends to occur more in winter than in any other season along the central California coast.

As such, and based on timing, the discoloration seen in surfgrass that was first observed in summer 2015 was not from exposure to direct sunlight and warm air temperatures, but rather the discoloration can be better explained as an impact from the oil spill; the discoloration did not occur suddenly at the time of the spill but instead was a delayed change. Supporting the assessment of being an oil impact is the discoloration also occurred in the subtidal, which is never exposed to direct sunlight and warm air temperatures, and essentially no discoloration was observed at Mussel Shoals, the reference/control site. The unusual color combined with the brittle condition of leaves further supports the determination that the tissue injury was caused by a harmful substance, not damage from sun exposure.

The observed discoloration and tissue injury could have also been due all or in part from natural oil seeps in the region, but no unusual discoloration was immediately apparent during the first post-spill surveys completed in May and June 2015 by University of California, Santa Cruz and Tenera Environmental biologists; no discoloration was noted because it was not observed. Additionally, the Coal Oil Point site with its high exposure to natural oil seeps (NOAA 2015) would have been the highest candidate site to observe such discoloration, but none was seen at Coal Oil Point during the May and June (first) surveys in 2015. Instead, the discoloration in surfgrass and macroalgae was first observed later in July 2015 at multiple locations contacted by the spill. The greatest discoloration occurred at Corral Canyon, one of the most heavily oiled sites from the spill. The timing of the discoloration would suggest an oiling dose higher than natural oil seeps is necessary to elicit a discoloration response in surfgrass.

The Refugio oil spill occurred during the 2014-2016 El Niño (Thompson 2015, Becker 2016). Accordingly, the El Niño event, rather than the oil spill, could explain the observed discoloration and tattered condition seen in surfgrass and in the macroalgae. If this was the case, one could expect the discoloration to be relatively uniform within and across sites. However, the magnitude of discoloration was not uniform within and across sites, but instead corresponded more closely to the amount of oiling exposure, in accordance with the SCAT data. In addition, an El Niño effect was not found in other local studies to cause changes outside the range of normal variation in species components of *Macrocystis pyrifera* (giant kelp) forests in the Santa Barbara Channel (Cohen 2016, Reed et.al. 2016). This would suggest the oil spill had a greater influence on the discoloration than a possible effect from the El Niño that occurred in the present study.

An additional observation supporting the hypothesis that oil contact caused the discoloration and injury to surfgrass was the discoloration was mostly at the distal ends of leaves in subtidal surfgrass (**Figure 7**). An explanation for this condition is surfgrass leaves wafting in the water column were contacted by the buoyant oil plume in the troughs of waves as waves passed by.

Other supportive evidence that the discoloration seen in the present study was from the oil spill is that similar observations have been made following other oil spills, in particular, the Santa Barbara oil spill that occurred in 1969 (Foster et al. 1969). Surfgrass with oil adhered to leaves from the spill turned yellow then brown (Nicholson and Cimberg 1971). In another study, discolored and burnt leaves of surfgrass (referred to as false eelgrass) resulted from a diesel fuel spill and exposure incident in Puget Sound, Washington that occurred in 1972 (Washington State Department of Ecology 1975). Also, other oil spills have been linked to causing marine algal tissues becoming discolored (O'Brien and Dixon 1976, Clark et al. 1978, Floch and Diouris 1980, Antrim et al. 1995). These past observations are consistent with the present observations of discoloration occurring in surfgrass and macroalgae as a response to the oil spill.

Conclusions

Surfgrass and macroalgae discoloration was observed in intertidal habitats following the Refugio oil spill. The discoloration from cell damage and loss of chlorophyll pigment necessary for primary production and growth represents a direct spill injury. Similar discoloration and injury associated with the spill was observed in subtidal eelgrass in snorkel, SCUBA, and paddleboard surveys. The magnitude of discoloration injury was consistent with oiling exposure. The study also provides evidence of recovery one year after the spill.

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The 2015 Refugio Beach Oil Spill: Field Assessment of Subtidal Exposure

Final Report
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Table of Contents

INTRODUCTION

On May 19, 2015, an underground pipeline (Line 901), owned and operated by Plains All American Pipeline, L.P., and Plains Pipeline, L.P., sustained a release of crude oil near Refugio State Beach in Santa Barbara County, California. Oil from the pipeline flowed down a culvert and entered the Pacific Ocean in the nearshore environment. *Phyllospadix spp*. (surfgrass), *Zostera marina* (eelgrass) and *Macrocystis pyrifera* (giant kelp) beds were observed to be oiled. Additionally, dead fish and invertebrates associated with these habitat types were observed on beaches in the spill affected area. The purpose of this study was to document exposure within the nearshore and offshore subtidal habitats adjacent to Refugio State Beach. Vegetation, invertebrate and sediment samples were collected from or near the seafloor and analyzed for polycyclic aromatic hydrocarbons (PAHs). A series of biomarkers was also measured to assist in fingerprinting the source of the oil, differentiating between Line 901 oil and oil from nearby seeps. This report summarizes the field collection methods and general results of the fingerprinting analysis.

METHODS

Field Sampling Procedures

On May 31, 2015, thirteen days after the spill, three sampling locations were selected near Refugio State Beach (Figure 1): K1, a kelp bed at a depth of approximately 15 ft (4.6 m); E2, an eelgrass bed at a depth of approximately 29-33 ft (10 m); and P1, a *Phyllospadix* or surfgrass bed at a depth of approximately 8-15 ft (2.4-4.6 m). The dive boat anchored at each location while a team of two divers swam to the bottom to collect vegetation and invertebrates. The divers collected specimens along a 30 meter transect from the boat to the shore, and the specimens were selected randomly. The invertebrate and algal/vegetation specimens were collected for tissue analysis and were reflective of the various habitats that were considered oiled (Table 1). These habitats included kelp beds, surfgrass beds, eelgrass beds and rocky reefs along with their associated invertebrates. The sampled material was placed in a mesh dive bag for transport to the boat. Grab sediment samples were collected from the top two centimeters of subtidal sediments using glass jars. On the boat, samples were photographed, taxonomically identified, labeled and transferred with gloved hands into a sample container. Vegetation, small invertebrate and sediment samples were collected in 250 ml wide-mouth, pre-cleaned glass jars with Teflon-lined lids. Larger invertebrate samples were wrapped in aluminum foil. Samples were placed in a cooler with ice on the boat and were then transported via FED-EX to Alpha Analytical Laboratory.

Figure 1. *May 31, 2015 sampling locations near Refugio State Beach*.

Chemical Analysis

Analytical chemistry methods are detailed in Stout (2016). Briefly, aliquots of some subtidal tissues were rinsed (exterior surfaces) with dichloromethane (DCM), and the rinsate was analyzed separately as an "oil". Tissues, rinsate and sediment extracts were analyzed for PAHs by GC/MS-SIM (USEPA Method 8270 mod). Results for these 50 individual PAHs and alkylated homologue groups were summed to estimate total PAHs ($TPAH_{50}$): naphthalene; naphthalenes, C1; naphthalenes, C2; naphthalenes, C3; naphthalenes, C4; acenaphthylene; acenaphthene; fluorene; fluorenes, C1; fluorenes, C2; fluorenes, C3; phenanthrene; anthracene; phenanthrene/anthracene, C1; phenanthrene/anthracene, C2; phenanthrene/anthracene, C3; phenanthrene/anthracene, C4; pyrene; benzo(b)fluorene; fluoranthene; fluoranthene/pyrenes, C1 -; fluoranthene/pyrenes, C2; fluoranthene/pyrenes, C3; fluoranthene/pyrenes, C4; benz[a]anthracene; chrysene; chrysenes, C1; chrysenes, C2; chrysenes, C3; chrysenes, C4; benzo(a)pyrene; benzo(e)pyrene; benzo(b)fluoranthene; benzo(k)fluoranthene; benzo(a)fluoranthene; benzo(g,h,i)perylene; indeno(1,2,3-c,d)pyrene; dibenz(a,h)anthracene; dibenzothiopene; dibenzothiophenes, C1; dibenzothiophenes, C2; dibenzothiophenes, C3; dibenzothiophenes, C4; biphenyl; dibenzofuran; naphthobenzothiophene; naphthobenzothiophene, C1; naphthobenzothiophene, C2; naphthobenzothiophene, C3; and naphthobenzothiophene, C4. When calculating $TPAH_{50}$, non-detects were assumed to be zero. Tissue results are reported on a wet weight basis and sediment on a dry weight basis. Fingerprinting methods are detailed in Stout (2016).

RESULTS and DISCUSSION

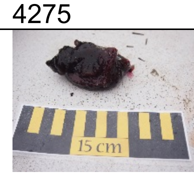
Field Observations and Sample Collection

At the K1 kelp bed site, oil sheen and globules were observed on the water surface (Figure 2). Eight algal samples of six different species and eight invertebrate samples of at least seven species were collected (Table 1). Initially, a known eelgrass bed was planned for sampling. However, a derrick barge was anchored directly over the bed (Figure 3), prohibiting access. Accordingly, a second eelgrass bed (E2) was selected where one eelgrass, two invertebrate and three sediment samples were collected (Table 1). At the P1 surfgrass site, seven invertebrate samples of at least six species, two surfgrass samples and one giant kelp sample were collected (Table 1).

Figure 2. *Surface oil sheen observed at the K1 site on May 31, 2015.*

Figure 3. *The DB San Diego anchored over an eelgrass bed*.

Table 1. Vegetation, invertebrate and sediment samples collected at the kelp bed (K1), eelgrass bed (E2) and surfgrass (P1) sites on May 31, 2015

Sample ID	**Species**	**Photo**
K1 – Kelp Bed Site		
RSBITED1001	*Panulirus interruptus* (California spiny lobster)	 4269
RSBVTED1002	*Pterygophera californica* (pom-pom kelp)	 4271
RSBVTED1003	*Egregia menziesii* (feather boa kelp)	 4272
RSBVTED1004	*Sargassum sp.*	 4273
RSBITED1005	*Strongylocentrotus franciscanus* (red sea urchin)	 4274
RSBITED1006	*Styleia montereyensis* (tunicates)	 4275
RSBITED1007	*Aplysia vaccaria* (sea hare)	 4276

Sample ID	Species	Photo
RSBITED1008	*Norrisia norrisii* (Norris top snail)	 4277
RSBITED1009	*Patiria miniata* (bat star)	 4278
RSBITED1010	Multiple snails (cowrie, wavy top snail, whelk snail)	 4279
RSBVTED1011	*Macrocystis pyrifera* (giant kelp)	 4280
RSBITED1012	*Styleia montereyensis* (tunicates)	 4282
RSBVTED1037	*Cystoseira sp.* (chain bladder kelp gas bladder)	 4283
RSBVTED1038	*Cystoseira sp.* (chain bladder kelp blade)	 4284
RSBVTED1039	*Sargassum sp*	 4285

Sample ID	Species	Photo
RSBVTED1040	*Eisenia arborea* (southern sea palm)	 4286
E2- Eelgrass Bed Site		
RSBITED1041	*Diopatra ornata* (ornate tube worm)	 4287
RSBVTED1042	*Zostera pacifica* (eelgrass)	 4288
RSBITED1043	*Kelletia kelletii* (Kellet's whelk)	 4289
RSBSED1007 RSBSED1008 RSBSED1009	Sediment from eelgrass bed – 29ft deep	No photos taken
P1 – Surfgrass Site		
RSBITED1044	*Panulirus interruptus* (CA spiny lobster)	 4296
RSBITED1045	*Norrisia norrisii* (Norris top snail)	 4297
RSBITED1046	*Crassadoma gigantea* (rock scallop)	 4298

Sample ID	Species	Photo
RSBITED1047	*Aplysia vaccaria* (sea hare)	 4299
RSBVTED1048	*Phyllospadix sp*. (surfgrass)	 4300
RSBVTED1049	*Phyllospadix sp*. (surfgrass)	 4301
RSBVTED1050	*Macrocystis pyrifera* (giant kelp)	 4302
RSBITED1051	*Strongylocentrotus franciscanus* (red sea urchin)	 4303
RSBITED1052	*Strongylocentrotus franciscanus* (red sea urchin)	 4303
RSBITED1053	Multiple snails (cowaries)	 4304

Tissue $TPAH_{50}$ and Fingerprinting Results

PAHs were detected in vegetation samples at all three locations and possible, probable and definitive matches to Line 901 oil were determined via fingerprinting (Table 2; Stout, 2016). There was good agreement between the forensic classification results obtained on the whole (unrinsed) tissue samples and on the rinsates, indicating that external oiling occurred (Stout, 2016). Tissues were classified as indeterminate, often due to low detectable hydrocarbons. $TPAH_{50}$ concentrations in vegetation samples were highest in the surfgrass samples.

Table 2. *Vegetation $TPAH_{50}$ and Fingerprinting Results*

Site	Sample ID	Vegetation Species	$TPAH_{50}$ (ug/kg ww)	Fingerprint (Stout 2016)	Rinsate Fingerprint
K1	RSBVTED1039	*Sargassum sp*	64	**Possible A**	**Possible A**
K1	RSBVTED1038	*Cystoseira sp.* Chain bladder kelp blade	32	**Match**	**Probable Match**
K1	RSBVTED1040	*Eisenia arborea* (southern sea palm)	26	**Possible A**	Indeterminate
K1	RSBVTED1003	*Egregia menziesii* (feather boa kelp)	20	Non-Match	Non-Match
K1	RSBVTED1011	*Macrocystis pyrifera* (giant kelp)	16	Indeterminate	Indeterminate
K1	RSBVTED1002	*Pterygophera californica* (pom-pom kelp)	4	Indeterminate	Indeterminate
K1	RSBVTED1037	*Cystoseira sp.* Chain bladder kelp	NA	NA	
K1	RSBVTED1004	*Sargassum sp.*	NA	NA	
E2	RSBVTED1042	*Zostera pacifica* (eelgrass)	74	**Probable Match**	**Probable Match**
P1	RSBVTED1048	*Phyllospadix sp*. (surfgrass)	181	**Probable Match**	**Match**
P1	RSBVTED1049	*Phyllospadix sp*. (surfgrass)	144	**Match**	**Probable Match**
P1	RSBVTED1050	*Macrocystis pyrifera* (giant kelp)	19	**Probable Match**	Indeterminate

NA = Not Analyzed

PAHs were detected in kelp (K1) and surfgrass (P1), and associated invertebrates, and were possibly or definitively matched to Line 901 oil (Table 3). Invertebrate samples from the eelgrass bed site were not analyzed. In the eelgrass bed, sediment concentrations were low and were not matched to Line 901 oil. The highest $TPAH_{50}$ concentration that was matched to Line 901 oil was measured in tunicate tissue at the kelp bed site. Tunicates attach to rocky reefs, are often fouled with algae, and are a filter feeder. $TPAH_{50}$ concentrations were highest in the sea hare, followed by the red sea urchin, and were possibly matched to Line 901 oil. Both of these mobile species feed on algae. Given that vegetation was oiled, diet was a potential oil exposure pathway. Overall, these data provide evidence for exposure of subtidal vegetation and invertebrates to Line 901 oil.

Table 3. Invertebrate and Sediment $TPAH_{50}$ and Fingerprinting Results Tissue PAH Concentrations

Site	Sample ID	Invertebrate Species and Sediment	$TPAH_{50}$ (ug/kg ww)*	Fingerprint (Stout 2016)
K1	RSBITED1012	*Styleia montereyensis* (tunicates)	448	**Match**
K1	RSBITED1005	*Strongylocentrotus franciscanus* (red sea urchin)	401	**Possible B**
K1	RSBITED1006	*Styleia montereyensis* (tunicates)	356	**Match**
K1	RSBITED1010	Multiple snails (cowrie, wavy top snail, whelk snail)	126	**Match**
K1	RSBITED1007	*Aplysia vaccaria* (sea hare)	93	**Possible B**
K1	RSBITED1001	*Panulirus interruptus* – gill tissue (CA spiny lobster)	47	Indeterminate
K1	RSBITED1009	*Patiria miniata* (bat star)	NA	NA
K1	RSBITED1008	*Norrisia norrisii* (Norris top snail)	NA	NA
E2	RSBSED1007 RSBSED1008 RSBSED1009	Sediment (ug/kg dw)	87 160 147	Non-match
E2	RSBITED1043	*Kelletia kelletii* (Kellet's whelk)	NA	NA
E2	RSBITED1041	*Diopatra ornata* (ornate tube worm)	NA	NA
P1	RSBITED1047	*Aplysia vaccaria* (sea hare)	2657	**Possible B**
P1	RSBITED1052	*Strongylocentrotus franciscanus* (red sea urchin)	525	**Possible B**
P1	RSBITED1051	*Strongylocentrotus franciscanus* (red sea urchin)	451	**Possible B**
P1	RSBITED1053	Multiple snails (cowaries)	130	**Match**
P1	RSBITED1044	*Panulirus interruptus* (CA spiny lobster)	NA	Rinsate Indeterminate
P1	RSBITED1045	*Norrisia norrisii* (Norris top snail)	NA	NA
P1	RSBITED1046	*Crassadoma gigantea* (rock scallop)	NA	NA

* sediment is ug/kg dw; NA = Not Analyzed

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The 2015 Refugio Beach Oil Spill: Polycyclic Aromatic Hydrocarbons in Nearshore Fish and Invertebrate Tissues

Final Report
November 2019

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Table of Contents

INTRODUCTION

On May 19, 2015, an underground pipeline (Line 901), owned and operated by Plains All American Pipeline, L.P., and Plains Pipeline, L.P., sustained a release of crude oil near Refugio State Beach in Santa Barbara County, California. Oil from the pipeline flowed down a culvert and entered the Pacific Ocean in the nearshore environment. As a result, the California Department of Fish and Wildlife (CDFW) implemented a fisheries closure, as recommended by the Office of Health Hazard Assessment (OEHHA). CDFW and OEHHA sampled fish and invertebrates to establish the degree and geographic extent of seafood contamination in the impacted area (OEHHA, 2015). The contaminants of concern for human health were the 8 polycyclic aromatic hydrocarbons that have the potential to cause cancer (cPAHs), reported as benzo(a)pyrene equivalents. The concentrations of benzo(a)pyrene equivalents found in finfish and invertebrate tissues were presented in the seafood consumption risk assessment report prepared by OEHHA (2015). However, in addition to the PAHs of human health concern, the fish and invertebrate tissues were analyzed for several other PAHs found in oil for a total of 45 PAHs ($TPAH_{45}$).

This report provides a summary of the $TPAH_{45}$ concentrations measured in the tissues. The natural resource trustees for resources affected by the Refugio[1] (Trustees) utilized this information to further evaluate fish and invertebrate exposure in the spill affected area.

METHODS

Field Sampling Procedures

Nearshore finfish and invertebrates were collected from June 10-19, 2015, approximately 3-4 weeks after the spill, from the three CDFW Commercial Fishing Blocks in the closure area (Figure 1 and Table 1; OEHHA, 2015). Details of the sampling and analysis methods are provided in OEHHA (2015).

Chemical Analysis

Skinless filets from fish and edible portions from invertebrates (e.g., crab, prawn and lobster body meat and sea urchin roe) were composited (Table 1), extracted and analyzed for PAHs, as detailed in OEHHA (2015). The gut contents of the sea cucumbers were rinsed out before tissues were composited. As indicated above, the extracts were analyzed for 45 individual PAHs and alkylated homologue groups. Results for these 45 individual PAHs and alkylated homologue groups were summed to estimate total PAHs ($TPAH_{45}$): naphthalene (N0); C1-naphthalenes as 1-methylnaphthalene (N1-1) and 2-methylnaphthalene (N1-2); C2-naphthalenes (N2); C3-naphthalenes (N3); C4-naphthalenes (N4); biphenyl (B); acenaphthylene (AY); acenaphthene (AE); fluorene (F0); C1-fluorenes (F1); C2-fluorenes (F2); C3-fluorenes (F3); phenanthrene (P0); anthracene (A0); C1-phenanthrene/anthracene (PA1); C2-

[1] The natural resource trustees for the Refugio Beach Oil Spill include the California Department of Fish and Wildlife, the U.S. Department of Commerce through the National Oceanic and Atmospheric Administration, the U.S. Department of the Interior through the Fish and Wildlife Service, the California Department of Parks and Recreation, the California State Lands Commission, and the Regents of the University of California.

phenanthrene/anthracene (PA2); C3-phenanthrene/anthracene (PA3); C4-phenanthrene/anthracene (PA4); dibenzothiopene (DBT0); C1-dibenzothiophenes (DBT1); C2-dibenzothiophenes (DBT2); C3-dibenzothiophenes (DBT3); pyrene (P); fluoranthene (FL0); C1-fluoranthene/pyrenes (FP1); C2-fluoranthene/pyrenes (FP2); C3-fluoranthene/pyrenes (FP3); C4-fluoranthene/pyrenes (FP4); benz[a]anthracene (BA0); chrysene (BC0); C1-chrysenes (BC1); C2-chrysenes (BC2); C3-chrysenes (BC3); C4-chrysenes (BC4); benzo(b)fluoranthene (BBF); benzo(k)fluoranthene (BJKF); benzo(e)pyrene (BEP); benzo(a)pyrene (BAP); perylene (PER); indeno(1,2,3-c,d)pyrene (ICDP); dibenz(a,h)anthracene (DA); C1-dibenz(a,h)anthracene (DA1); C2-dibenz(a,h)anthracene (DA2); C3-dibenz(a,h)anthracene (DA3); and benzo(g,h,i)perylene (GHI). When calculating $TPAH_{45}$, non-detects were assumed to be zero. Tissue results are reported on a dry weight basis. Moisture content ranged from 71 to 92 percent.

The Trustees also analyzed barred surfperch skinless filets collected on 23 May 2015 from Gaviota State Beach, Refugio State Beach and Campus Point (near Coal Oil Point) for the same 45 PAHs. Methods and results for this surfperch exposure assessment study are presented in Appendix G-3 of the DARP.

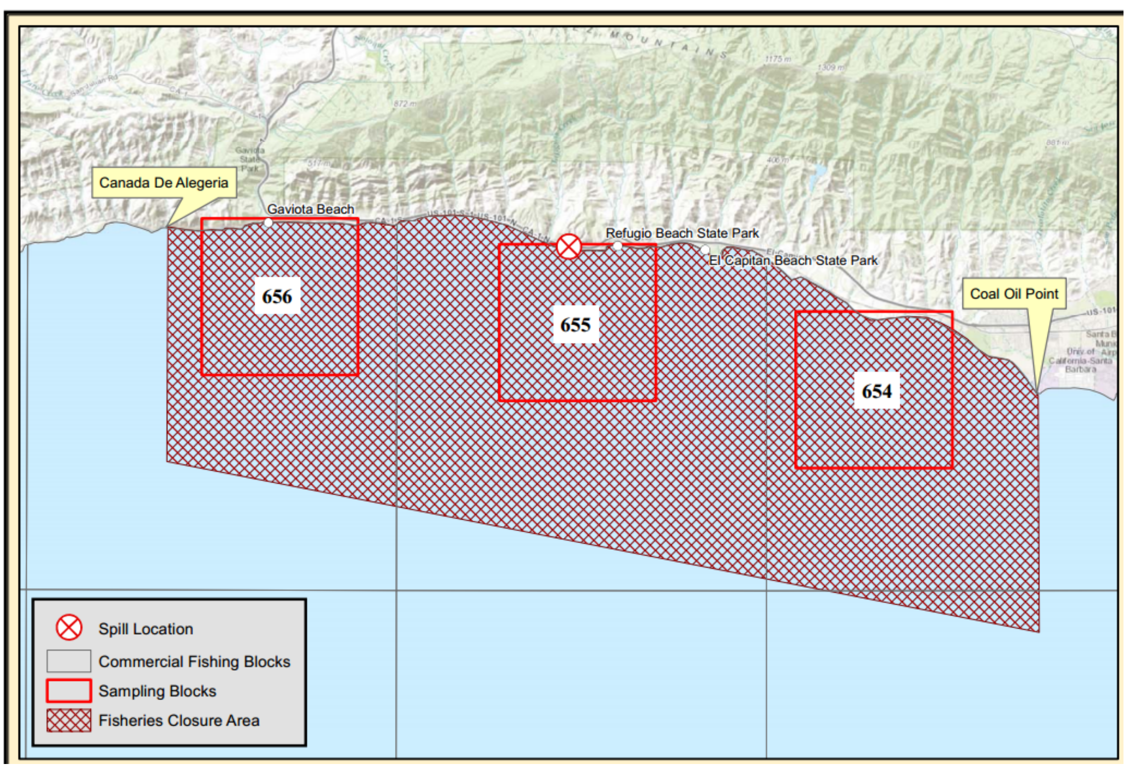

Figure 1. *Fishery closure area and sampling areas within the commercial fishing blocks (excerpted from Figure 1 of OEHHA, 2015).*

Table 1. *Number of fish and invertebrate individuals in composite samples collected from Fishing Blocks 654, 655 and 656 (excerpted from OEHHA, 2015). The 10 m depth column indicates whether a sampling location was inshore ("In") or further offshore, outside of the 10 m bathymetric line ("Out"), as depicted in Figure 2.*

Species	10 m Depth	654 – Coal Oil Pt	655 - Refugio	656- Gaviota
Invertebrates		**Number of Individuals per Composite –June 2015**		
CA Spiny Lobster *(Panulirus interruptus)*	In	**3**	**1**	**-**
Red Sea Urchin *(Strongylocentrotus franciscanus)*	In	**9**	**9**	**9**
Brown Rock Crab *(Cancer attennarius)*	In	**6**	**6**	**6**
Sheep Crab (Loxorhynchus grandis)	In	**9**	**9**	**6**
Warty Sea Cucumber (*Parastichopus parvimensis)*	In	**9**	**9**	**10**
Giant Red Cucumber (*Apostichopus californicus*)	Out	**8**	**12**	**-**
Ridgeback Prawn (Sicyonia ingentis)	Out	**12**	**11**	**-**
Yellow Rock Crab (Cancer anthonyi)	Out	**10**	**10**	**10**
Fish				
Barred Surfperch (*Amphistichus argenteus*)	In	**9**	**4**	**9**
Pacific Mackerel (*Scomber japonicas)*	In	**-**	**10**	**9**
Grass Rockfish *(Sebastes rastrelliger)*	In	**11**	**13**	**7**
Kelp Rockfish (Sebastes atrovirens)	In	**9**	**9**	**-**
Black and Yellow Rockfish *(Sebastes chrysomelas)*	In	**-**	**7**	**-**
Pacific Sanddab (deeper water) *(Citharichthys sordidus)*	Out	**9**	**11**	**12**
Pacific Sanddab (shallower water) *(Citharichthys sordidus)*	Out	**-**	**10**	**9**
Vermillion Rockfish (Sebastes miniatus)	Out	**8**	**9**	**9**
Bocaccio Rockfish *(Sebastes paucispinis)*	Out	**-**	**9**	**9**

\- Not sampled

RESULTS and DISCUSSION

Relative Tissue $TPAH_{45}$ Concentrations in Fishing Blocks and Depth Zones

Spatial and depth zone patterns of $TPAH_{45}$ concentrations in composited fish and invertebrate samples were evaluated. Fishing block 655 (labeled "Refugio") was closest to the oil release point, near Refugio State Beach, while Block 656 (labeled "Gaviota") was to the west in an area that included Gaviota State Beach and Block 654 (labeled "Coal Oil Point") was to the east in an area that included Coal Oil Point (Figure 2). There are active natural oil seeps offshore of Coal Oil Point (Lorenson, 2011).

The 10 m bathymetric line (Figure 2) is the approximate offshore extent of kelp forest and rocky reef habitat which provide critical habitat for fish and invertebrates. The Trustees determined that oil would mix throughout the water column to 10 meters depth through wave and tidal action. Accordingly, fish and invertebrates collected within the 10 m bathymetric line were likely to have experienced greater exposure to oil compared to fish and invertebrates collected farther offshore.

Figure 2. *Samples collected within the three fishing blocks in relationship to the 10 m bathymetric line. The red star is the approximate location of the oil release point.*

The highest $TPAH_{45}$ tissue concentrations were measured in the warty sea cucumber and red sea urchin composite samples near Refugio State Beach (Figure 3). Lower concentrations for these two species were measured in the fishing blocks to the west (Gaviota State Beach) and the east (Coal Oil Point). The giant red sea cucumber, collected outside of the 10 m bathymetric line in Fishing Block 655 (Figure 4), had $TPAH_{45}$ concentrations over ten times lower than the warty sea cucumber collected closer to shore in this block.

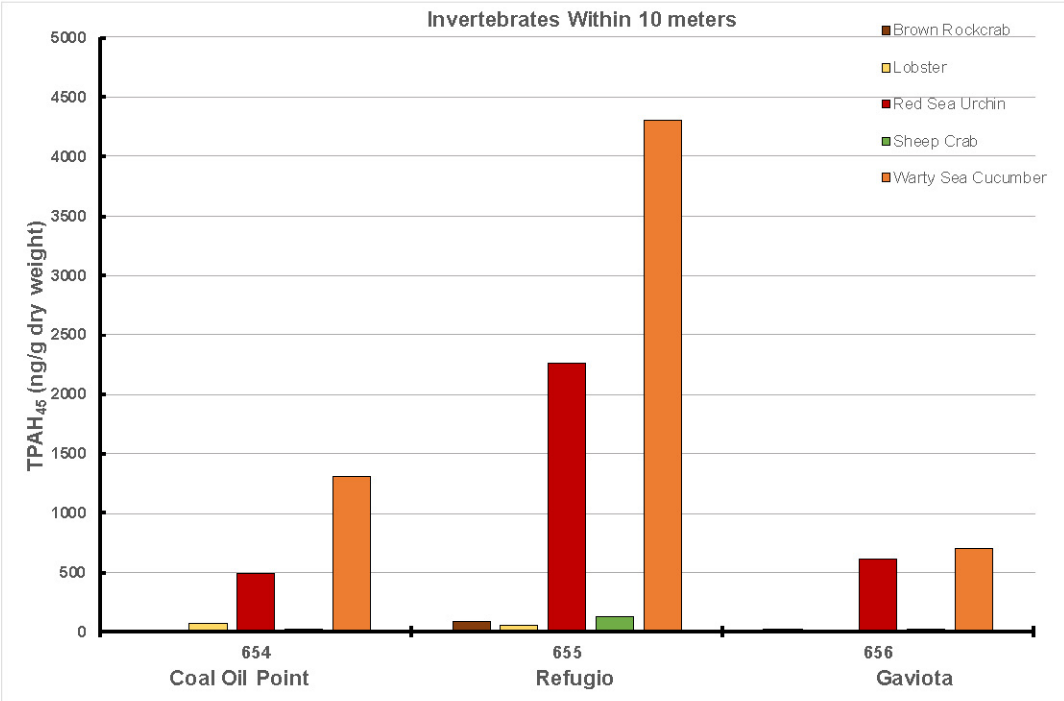

Figure 3. *Total polycyclic aromatic hydrocarbon concentrations ($TPAH_{45}$; ng/g dry weight) in invertebrates collected at or within the 10 m bathymetric line in Fishing Blocks 654, 655 and 656.*

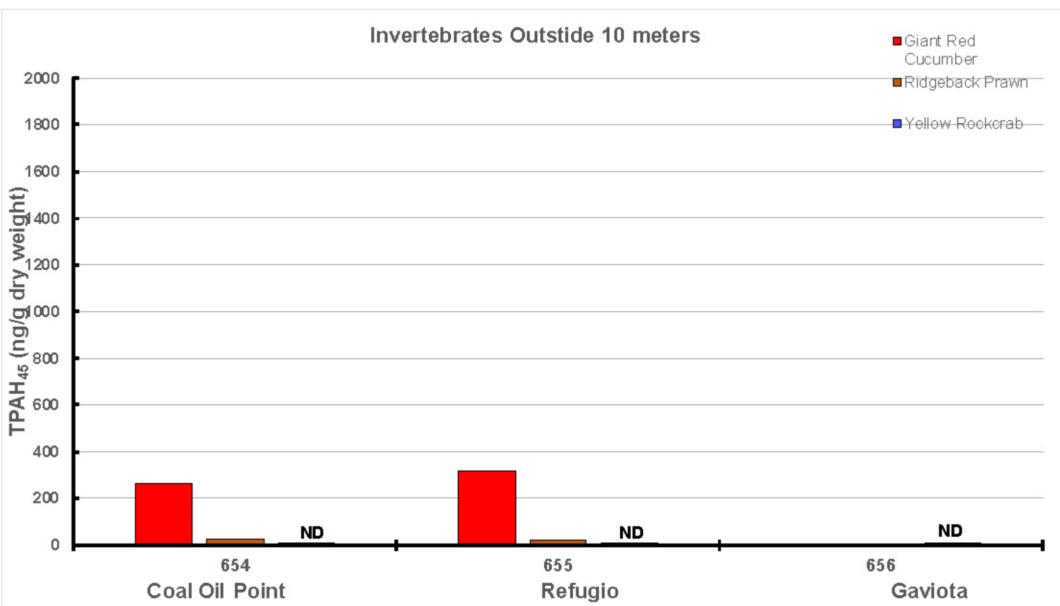

Figure 4. *Total polycyclic aromatic hydrocarbon concentrations ($TPAH_{45}$; ng/g dry weight) in invertebrates collected outside the 10 meter bathymetric line in Fishing Blocks 654, 655 and 656. ND = not detected.*

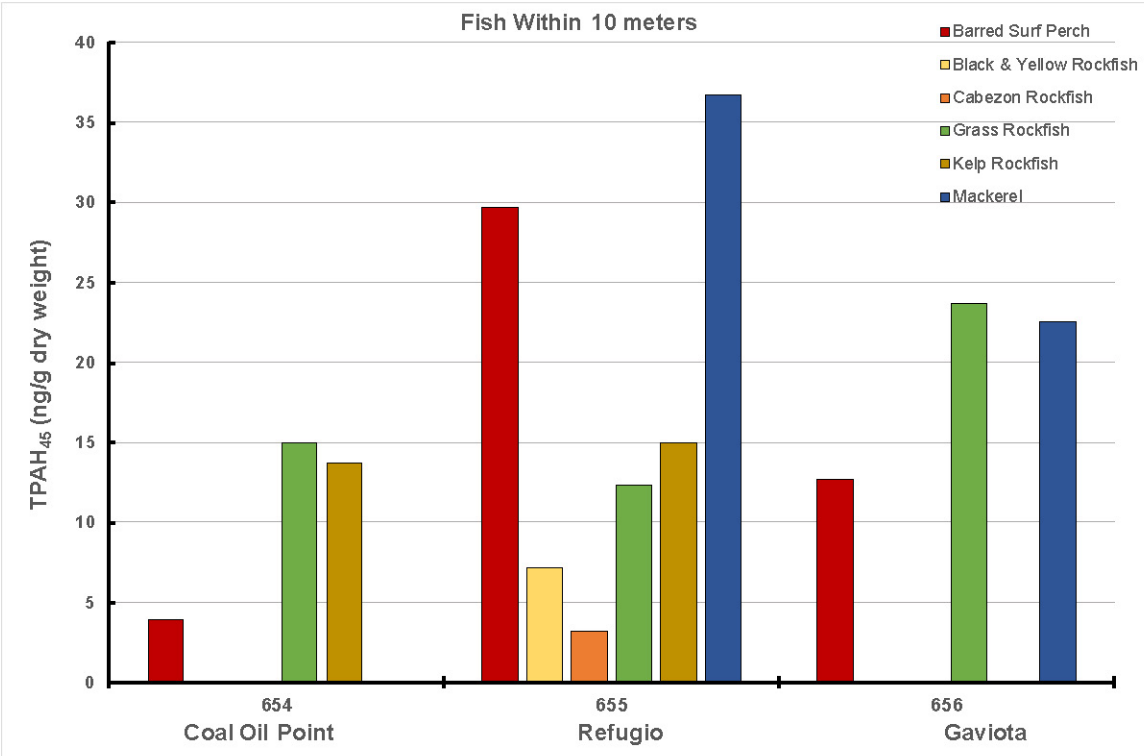

Figure 5. *Total polycyclic aromatic hydrocarbon concentrations ($TPAH_{45}$; ng/g dry weight) in fish collected at or within the 10 m bathymetric line in Fishing Blocks 654, 655 and 656.*

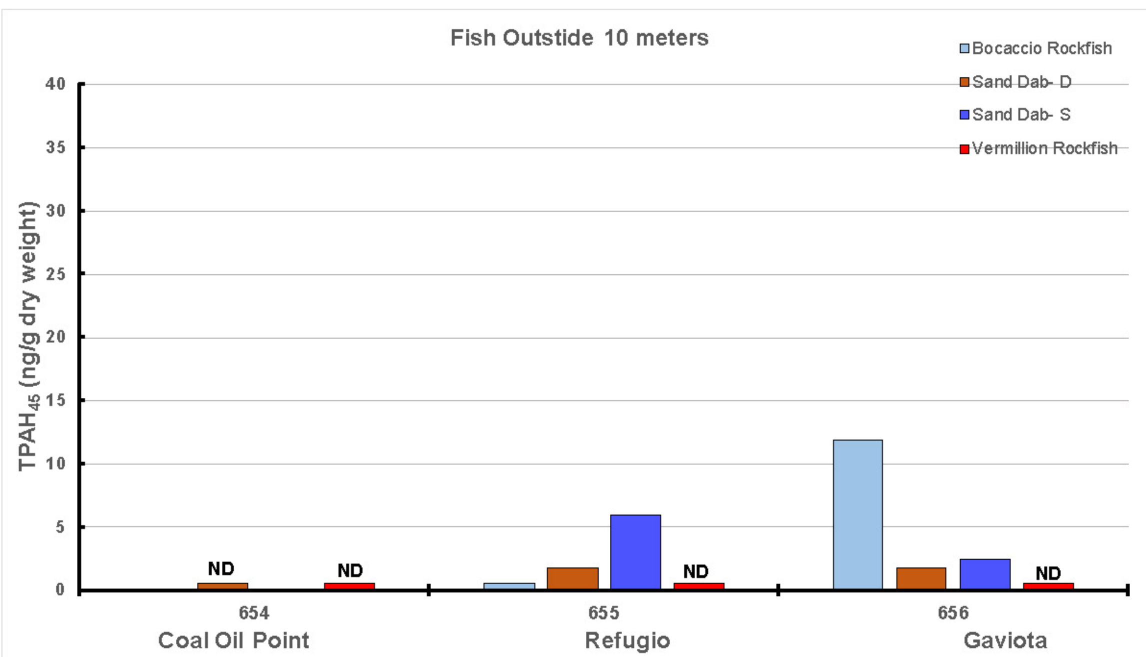

Figure 6. *Total polycyclic aromatic hydrocarbon concentrations ($TPAH_{45}$; ng/g dry weight) in fish collected outside the 10 m bathymetric line in Fishing Blocks 654, 655 and 656. ND = not detected.*

A similar spatial pattern was seen in fish where there were higher $TPAH_{45}$ concentrations in filets from fish collected within the 10 m bathymetric line (Figure 5), compared to filets from fish collected outside this depth zone (Figure 6). The highest $TPAH_{45}$ concentrations in fish were measured in mackerel and barred surfperch composite samples near Refugio State Beach (Figure 5), relative to the other fishing blocks. Surfperch filet concentrations from fish collected at Refugio State Beach approximately 22 days after the spill ($TPAH_{45}$ = 30 ng/g dry weight), were lower than surfperch filet composites from fish collected 4 days after the spill, from the same location (88 ng/g dry weight; Anulacion et al, 2019; see Appendix G-3 for study details). Since the tissue samples collected to evaluate seafood contamination in the impacted area were collected 3-4 weeks after the spill, $TPAH_{45}$ concentrations likely underestimated fish and invertebrate tissue concentrations that occurred immediately after the spill. Overall, results indicate exposures were higher within the 10 m depth zone and adjacent to the oil spill release site.

Comparison of Fish and Invertebrate PAH Concentrations

Fish filet $TPAH_{45}$ concentrations were generally lower than what were measured in invertebrate edible tissues (Figures 3-6). Fish have been reported to have greater ability to metabolize and eliminate PAHs, compared to invertebrates (Meador et al, 1995). Additionally, fish muscle tends to have lower PAH concentrations than other fish tissues, such as the liver (Meador et al., 1995; Ylitalo et al., 2012). Another factor potentially contributing to the difference is that some fish are more mobile than invertebrates and some may have been able to move away from the oil contaminated area, or may live and feed in habitats with less oil contamination (Graham et al, 2015; Law and Hellou, 1999). For example, the warty sea cucumber is an epibenthic detritivore that feeds on organic detritus and small organisms within the sediment, a potential depositional zone for the spilled oil (Leet et al., 2001). This feeding strategy may have contributed to the higher $TPAH_{45}$ concentrations in their tissues.

A wider array of PAHs were detected in invertebrate tissues (Figure 7) compared to fish tissues (Figure 8). In invertebrates, naphthalenes, phenanthrenes and dibenzothiophenes contributed the largest percentages to the $TPAH_{45}$ concentration, which is similar to other invertebrates analyzed following the Line 901 release (Stout, 2016). Elevated levels of naphthalenes and phenanthrenes in invertebrate tissues have been reported following other oil spills (Boehm et al, 2004; Rumney et al., 2011). Naphthalenes were the predominant PAHs detected in fish, which is consistent with other studies of fish contamination following oil spills (Incardona et al, 2011; Xia et al, 2012; Murawski et al., 2014).

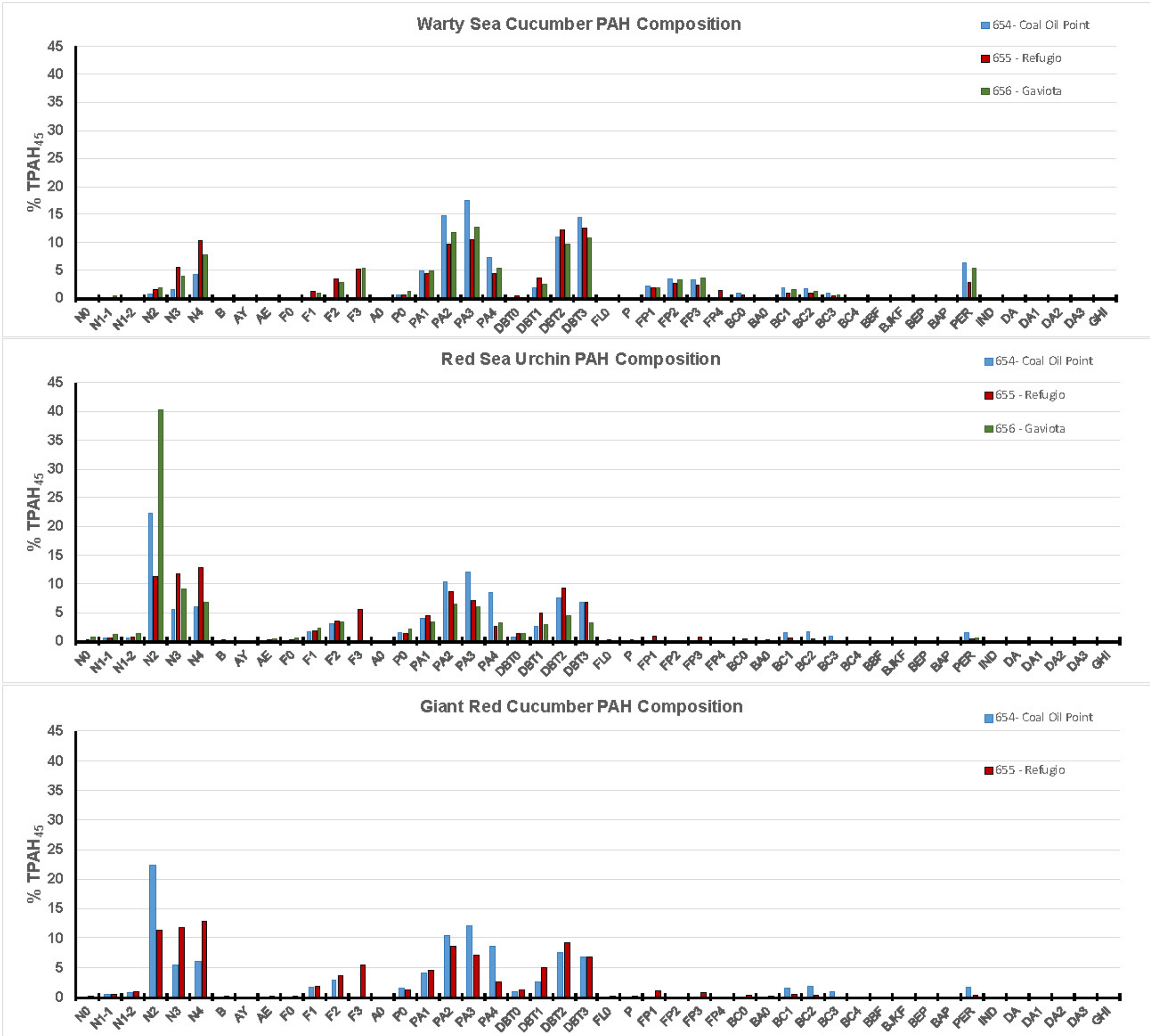

Figure 7. *Percent composition of polycyclic aromatic hydrocarbons (PAHs) in warty sea cucumber, red sea urchin and giant red sea cucumber in the three fishing blocks. See Methods for PAH abbreviations.*

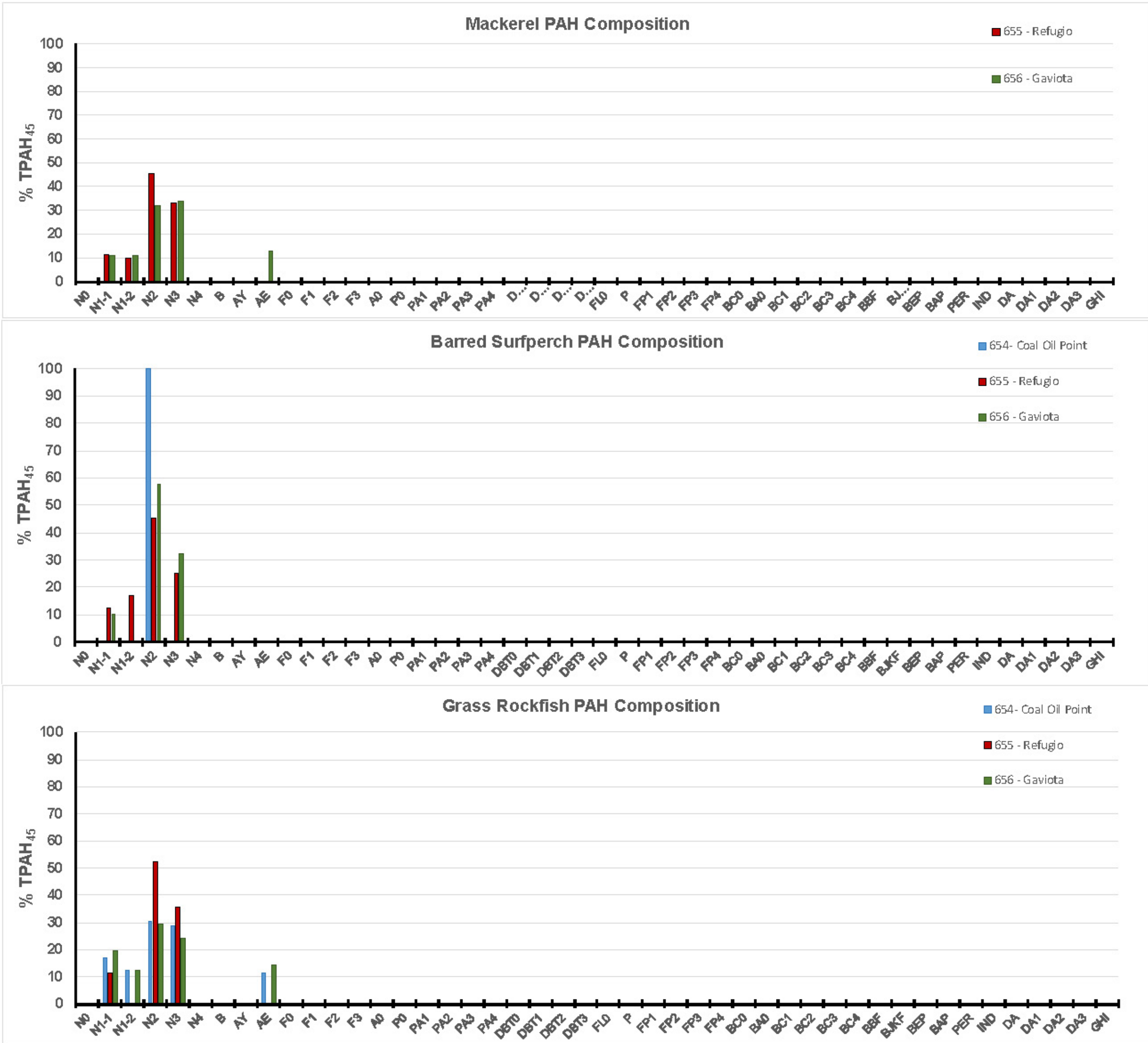

Figure 8. *Percent composition of polycyclic aromatic hydrocarbons in mackerel, barred surfperch and grass rockfish in the three fishing blocks. See Methods for PAH abbreviations.*

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Appendix H

Subtidal Injury Quantification and Habitat Equivalency Analysis

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Laurie Sullivan, M.S., NOAA Office of Response and Restoration

Summary:

This document supports the Damage Assessment and Restoration Plan (DARP) by describing the injury quantification and scaling metrics used for subtidal habitats for the Refugio Beach Oil Spill (RBOS) Natural Resources Damage Assessment (NRDA).

Introduction:

On May 19, 2015, Plains Line 901 pipeline ruptured and oil flowed into the ocean, ocean water was observed to be fouled, and oiled marine animals died and washed up on local beaches coincident in time and space with the spill (see Appendix G-1 of the RBOS DARP). Subsequent assessment studies documented Line 901 crude oil on the surface of marine vegetation (see Appendix G-6 of the RBOS DARP), uptake of petroleum hydrocarbons in fish and invertebrates (see Appendices G-3, G-4, G-6, G-7 of the RBOS DARP)), oil constituents at levels known to cause death to fish embryos and other marine life (see Appendices E, G-4 of the RBOS DARP) and die-off of marine vegetation critical to the function of nearshore subtidal habitats within 3 months after the spill (see Appendix G-5 of the RBOS DARP). The Trustees found no plausible alternative explanations for these injuries to marine resources apart from the spill.

For the purpose of defining exposure zones for the shoreline and subtidal NRDA claims, the Trustees identified four oiling zones, A-D (Figure 1), with Zone B identified as the zone with the heaviest oiling, A and C (to the immediate east and west of zone B) being of medium oiling, and Zone D to approximately Long Beach, California, to the southeast, being the lightest oiling category (Figure 1). For subtidal injury determination and quantification, the Trustees focused on the area offshore of Zone B (Figure 1), coinciding with most Trustee subtidal data collections and observed subtidal injuries.

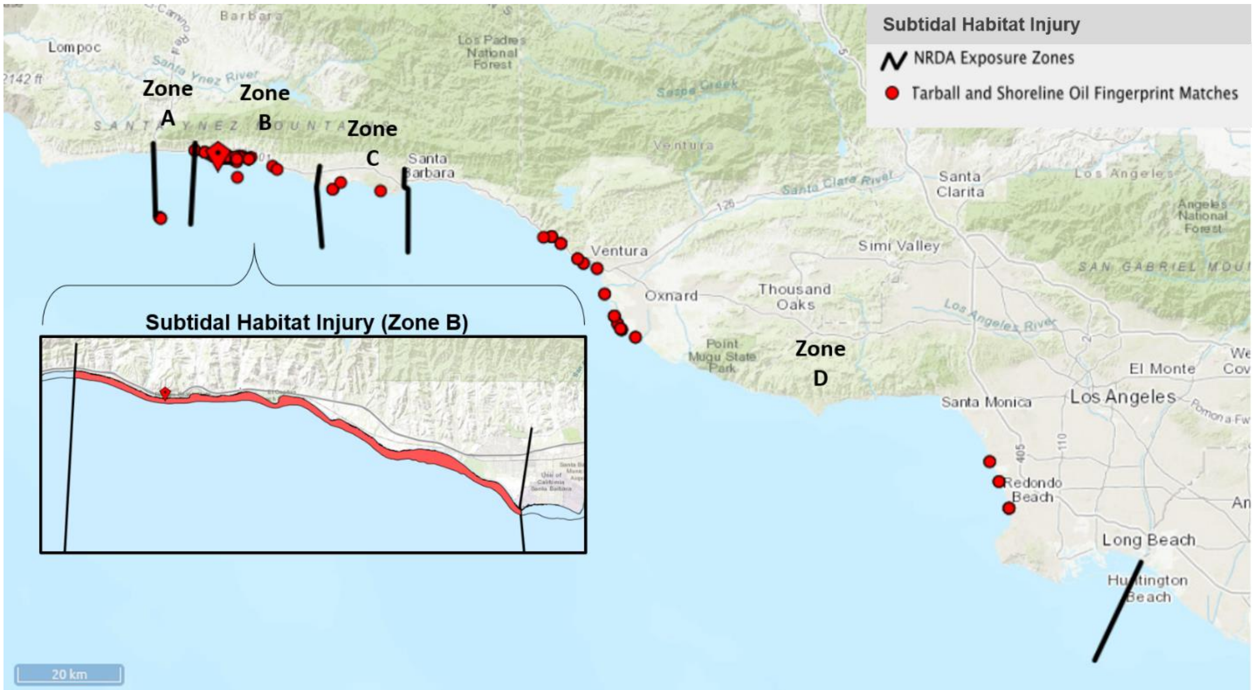

Figure 1 Habitat Exposure Zones (further described in the RBOS DARP) Defined for the Refugio Oil Spill NRDA showing beach tarball fingerprint matches. Zone B is the area of heaviest oiling. The Trustees quantified subtidal habitats injury from the shoreline to the 10 meter isobath offshore of Zone B.

Injury Determination

The Trustees calculated their subtidal injury claim from the shore to 10 m depth in Zone B. Although in Zone B, oil extended into the subtidal beyond the 10 m isobath, the 10 m isobath was selected because it approximates the offshore extent of the local kelp forest, an important foundational habitat. Ten meters is also the approximate depth to which the Trustees estimate oil mixed into the water column. Similarly, offshore surface and subtidal oil extended parallel to the shore east and west of Zone B, but the Trustees limited quantification to Zone B, where the majority of data collection occurred and where of observable subtidal impacts were located. The Trustee injury claims are based on a combination of empirical observations and consistency with an overall conceptual model that includes five main steps:

RELEASE & PATHWAYS: Spilled oil traveled from the ruptured pipeline across upland terrestrial areas, down a cliff face, across a beach, and into the ocean. Line 901 oil weathered to various degrees after it spilled and before it entered the ocean, but a substantial amount of the oil that flowed into the water was relatively unweathered and still contained lower molecular weight aromatic compounds. The inclusion of sediment and other debris into the oil as it traversed the terrain from the pipeline rupture to the ocean would have altered physical properties of the oil, which subsequently affected the buoyancy and distribution of oil in the nearshore environments.

MIXING & DILUTION: Spilled oil rapidly mixed in the ocean through physical forces of wind and waves in the turbulent surf zone. The oil-water mixture included relatively fresh crude oil, environmentally weathered oil, diluent (a mixture of lighter more volatile petroleum compounds), and other materials, such as oiled sediments and biological debris. Some of the oil dispersed in the water column re-surfaced, based on a lighter-than-water specific gravity, and aggregated into slicks that were moved by currents and winds to areas further away from the point of entry. Some of the oil containing debris lost buoyancy and sank to the bottom. Fractions of the oil that remained in the water column became dispersed or degraded. In general, the spilled oil became diluted and dispersed as it moved away from the initial point of entry to the ocean but maintained significantly elevated concentrations in the 0 – 3 m bathymetric zone throughout Zone B for more than a week after the spill based on the visible presence of oil droplets in the water.

EXPOSURE: Marine natural resources were exposed when oil flowed into and fouled various habitats, thereby affecting associated organisms. The Trustees treated the 0 – 3 m depth zone as a uniform exposure zone, weighted by habitat type. The Trustees determined injury separately in the offshore zone from 3 – 10 m bathymetric contours by habitat type: (1) water surface down to 2 m depth with variable short or extended exposures experiencing UV-enhanced phototoxicity; (2) mid-water column (from 2 to10 m depth) with fleeting exposures; and (3) benthic habitats (the seafloor communities) that extend roughly 1 m above the sea floor, with extended exposures to sunken oil due to entrapment or baffling of oil in 3 dimensional rock and vegetated habitat (Figure 2).

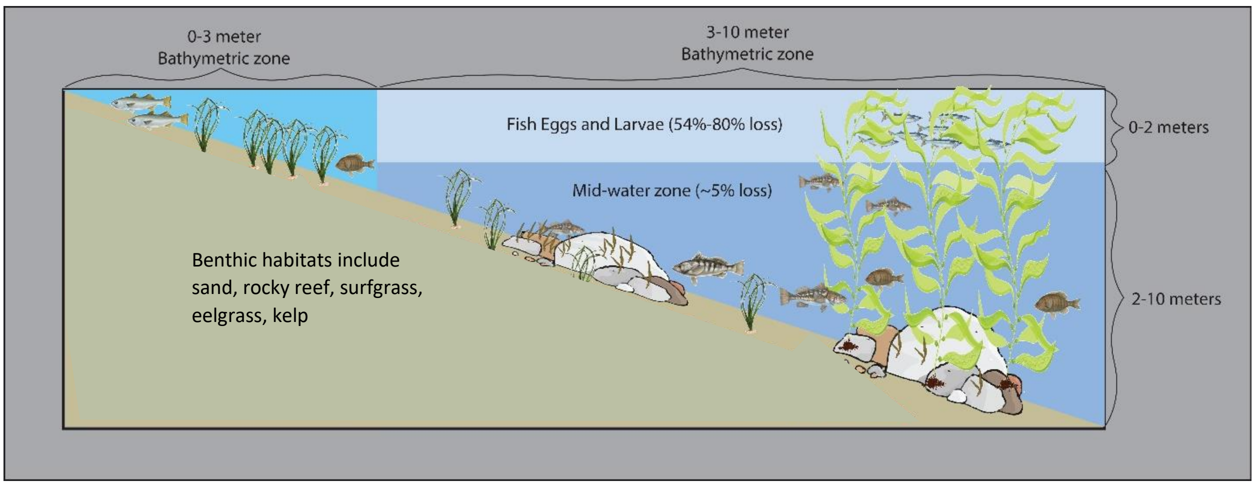

Figure 2 Description of subtidal habitats

INJURY DETERMINATION: Injuries to subtidal natural resources varied by the type, degree, and duration of exposure to spilled oil. Severity of an injury was based in part on the sensitivity of the life stage, as well as the species exposed. For example, fish early life stages, in general, have been shown through numerous published studies to be more sensitive than adult life stages to short-term, acute exposures of dissolved or dispersed oil (Pasparakis et al. 2019). However, all life stages may suffer mortality from short-term exposures if concentrations are high enough to cause physical fouling or various toxic responses. For the Line 901 oil spill, mortality was documented in mature fish and benthic invertebrates in the first few days of the spill, as well as to foundational habitat species such as surfgrass and kelps/algae over a period of 6 months. Trustees relied on the following evidence when determining the presence of injury:

1. Trustees observed an unusual and broad range of moribund and dead, oiled subtidal vertebrate and invertebrate animals washing ashore immediately after the spill (see Appendix G-1 of the

DARP). Acute mortality events like this have not been observed in past California oil spills in decades, setting a high level of concern for subtidal species.

2. Elevated PAH body burdens were measured in fish from areas closest to the release point; fishing closures occurred (even though this is a human loss, it underscores the fact that oil was in the water and contaminating fish) (Appendices G-3, G-6,G-7 of the DARP
3. Peer-reviewed studies from past oil spills support high mortality to ichthyoplankton (including early life stages of many fish species) in the upper 2 m surface water where slicks traverse (Appendix G-4 of the DARP).
4. Egg mortality and post-hatch mortality were observed in local fish species that spawn on the beach and occur in the shallow subtidal zone (see Appendix G-2 of the DARP).
5. Mortality to marine plant species (seagrasses and macroalgae) that comprise foundational subtidal habitat were documented up to three months after the spill (see Appendix G-5 of the DARP).

Injury Quantification

PERCENT SERVICE LOSS: One fundamental assumption in the Trustees' claim is that of a direct correlation between exposure levels and service loss. Since dose is a function of concentration and duration of exposure, decreasing either or both of these would likely lower the dose and reduce the toxic effect. Consequently, the service losses to subtidal benthic habitats claimed by the Trustees further offshore (i.e., 3-10 m bathymetric zone), except in the surface water zone, are lower than service losses claimed in the shallower nearshore zone (0-3 m bathymetric zone). The foundation of the Trustees' calculation of percent service loss to benthic habitats for the purposes of scaling was observed impacts to vegetation in the nearshore 0-3 m bathymetric zone. The Trustees conducted extensive surveys of the shallow subtidal surfgrass (*Phyllospadix torreyi*), and macroalgae (several species of both brown, green and red algae including *Egregia menziesii* and *Fucus distichus*) (see Appendix G-5 of the DARP). Observed injuries to these species were directly translated to a percent service loss for the entire associated benthic community. This direct relationship between injury and percent service loss is appropriate because this diverse community of surfgrass and algae is foundational to the ecological function of subtidal benthic habitat. It creates the habitat that supports a diverse community of benthic and demersal fish and invertebrates. Loss of foundational habitat is detrimental to every organism reliant upon it. Using this technique, the Trustees estimated a "base" percent service loss of 54% based on the area-weighted average across zone B of observed percent cover of impaired seagrass and algae (ranging from 35-88% loss) (see Appendix G-5 of the DARP). Percent service losses were calculated in different areas by adjusting for the type of habitat in that area (as described in "Exposure" above) and by distance from the shoreline.

The Trustees established percent service loss estimates for nearshore benthic, offshore surface layer, offshore mid-water layer, and offshore benthic habitats as follows (Figure 3):

> **NEARSHORE BENTHIC HABITATS:** The Trustees estimated 54% service loss to benthic habitats in the nearshore 0 – 3 m bathymetric zone, based on area-weighted averages of documented injuries to foundational species (see Appendix G-5 of the DARP). The injury is considered significant and persistent (i.e., > 1 year). For sand bottom habitats in this stratum the Trustees are claiming 10% of that loss, reflecting the lower productivity/services associated with sand

habitats compared to rocky reef, surfgrass or eelgrass habitats, resulting in a 5.4% loss for sand bottom habitats. Injury is estimated to decrease to 0 over five years post-spill.

OFFSHORE SURFACE LAYER: Published toxicity studies have shown high levels of mortality (>80%) to fish early life stages (typical of ichthyoplankton) exposed beneath crude oil surface slicks in the presence of environmentally relevant levels of UV light (i.e., photo-enhanced oil toxicity; Alloy et al. 2015; Alloy et al. 2016; Alloy et al. 2017; Morris et al. 2015). However, because of uncertainty across species and geographic areas the Trustees used a lower value of 54% loss, consistent with the loss calculated for the surf zone. This degree of loss would also apply to the kelp canopy community that occurs in the top 2 m of the water column. The injury is considered to be limited in duration.

OFFSHORE MID-WATER LAYER: The Trustees estimated 5% service loss to the mid-water column between the 3-10 m bathymetric contours to just above the bottom and the underlying foundational habitat. The injury percentage is based on an approximately 12 fold dilution of the total volume of water in the 0-3 m depth region mixing into the total volume of water in the adjacent 3-10 m depth region of Zone B. For purposes of simplification, the Trustees assume a direct inverse correlation between declining injury levels with increasing oil dilution. The Trustees used a volumetric approach to calculate loss in the midwater of the offshore areas (from 2m depth to just above the bottom from the outer edge of the "nearshore" zone to the 10 m isobath). In this method, the Trustees portray the water in the subtidal area of zone B in cross section as a triangle with side (a) representing the upper boundary of this layer at 2 m depth (horizontal) side (b) the water column (vertical), and side (c) representing the seafloor (hypotenuse)(Figure 3). The triangle representing the midwater area is divided up from the top black line of the triangle representing the top of the midwater layer, down to the side of the triangle representing the bottom of the seafloor. After dividing the water of the subtidal area into depth columns the Trustees then calculated the water column area for each depth interval down to a small triangle (red) representing the water column just above the seafloor. We then calculated the area of that triangle and added it to the water column area above it and multiplied it by the average distance of the contour interval to obtain the volume of the water for that total depth interval. The average distance of the contour interval was calculated by measuring the distance of 100 transects along each contour to the next sequential contour line and taking the average distance of those 100 transects. Lost services calculated for this area were 5% based on this method. Exposures in the mid-water layer are considered to be shorter term (i.e., days) but injuries to resources encountering this level of exposure could linger.

OFFSHORE BENTHIC HABITATS: The Trustees calculated losses to the offshore benthos based on areal dispersion of submerged oil across the benthic footprint of Zone B to the 10 m isobath. Sunken oil would not necessarily dilute out with the addition of more water but would persist for longer periods as small sediment-laden oil particles and droplets while spreading across the sea bottom by waves and currents. Sunken oil also has a high likelihood of being trapped or slowed in the bottom vegetation. The Trustees calculated losses using an area seafloor dispersion calculation. This method calculated the distance oil would travel along the seafloor from 0 to 3 m and 0 to 10 m by applying the Pythagorean Theorem. The seafloor distance is represented by the hypotenuse of a triangle that is created by the offshore distance and subsequent increase in depth associated with 1 m bathymetric contours (e.g., red triangle in

Figure 3). The two known sides of the triangle (distance offshore and change in depth) were used to complete the formula and calculate the distance along the bottom (calculated as a hypotenuse of a right triangle). The average distance from contour line to contour line ("a" in Figure 3) was calculated by measuring the distance of 100 transects along each contour to the next sequential contour line and taking the average distance of those 100 transects. The change in depth ("b" in Figure 3) was always one m as distance was between subsequent 1-m depth contours. In summary, these calculations resulted in an average seafloor distance of 76 m between the 0 and 3 m bathymetric contours, and 232 m between the 3 and 10m contours (Figure 2). Thus, seafloor dispersion would result in an approximately 4-fold decrease in exposure, so the 54% injury experienced in the 0-3 m zone would be reduced to an average of 13% in the 3-10 m zone. Injury to the benthic community, was similarly considered as decaying linearly with distance from the nearshore "baseline" injury of 54% to apply a 13% service loss across the 3-10 depth range for rocky reef, surfgrass, kelp and eelgrass habitats. For sand bottom habitats in this depth stratum the Trustees are claiming 10% of that loss, reflecting the lower productivity/services associated with sand habitats compared to rocky reef, surfgrass or eelgrass habitats, resulting in a 1.3% loss for sand bottom habitats. The injury is considered to decrease to 0 over 5 years post spill.

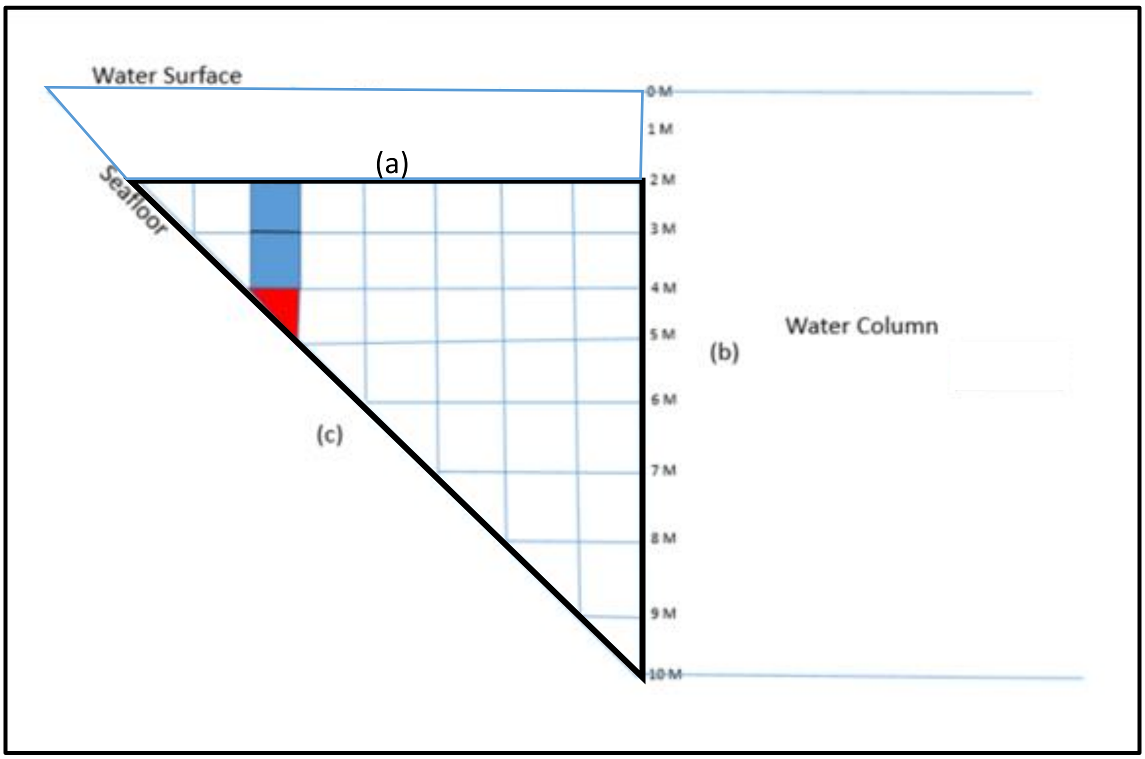

Figure 3 Subtidal quantification schematic diagram used to calculate volumetric dilution and areal dispersion factors. The red triangle shows the elements used to calculate the seafloor spreading distance with the Pythagorean Theorem.

Scaling Restoration Actions

The Trustees used Habitat Equivalency Analysis (HEA) to calculate injury Discount Service Acre years (DSAYs) for scaling compensatory restoration for the subtidal injury in the nearshore benthic habitats and the offshore benthic habitats. DSAYs were calculated based on the percent service loss for subtidal habitats based on the documented injury to vegetated habitat in surfgrass studies. In summary, the HEA calculations characterize a rapid initial loss that occurs in the first 6 months of the spill, followed by a relatively rapid recovery (88% recovered after a year, 94% after two years, and 100% after 5 years). Percent injury in the 0-3 m bathymetric zone was set at 54%, but adjusted for the relative productivity of different habitat types, thus a 5.4% injury was applied to open sand habitats, 54% was applied to rocky reef, kelp canopy, eelgrass or surfgrass habitats. The same approach was used for benthic habitats in the 3-10 m bathymetric zone, but a baseline injury of 13% was used, based on quantification discussed in the last section. This analysis resulted in a loss of 178.5 DSAYs in the 0-3 m bathymetric zone and 117.4 DSAYs in the 3-10 m bathymetric zone (Table 1). The Trustees did not identify specific, separate projects to benefit the offshore surface or midwater habitats because there are substantial benefits to water column species from restoration projects discussed below, which primarily restore benthic vegetated habitat.

Table 1. Summary of injury scaling for subtidal benthic habitats.

Depths	Habitat type	Base injury (%Loss)	Habitat factor	Final injury (% Loss)	Habitat acres	Discount Service Acre years (DSAY) for compensation
Nearshore Benthic Habitats (0-3 m isobath)	Rocky reef with kelp	54%	1.0	54%	3	1.6
	Rocky reef no kelp canopy	54%	1.0	54.%	208	124.7
	Eelgrass/Surfgrass	54%	1.0	54%	63	37.8
	Sand	54%	0.1	5.4%	240	14.4
Total (0-3 m)					**514**	**178.5**
Offshore Benthic Habitats (3-10 m isobath)	Rocky reef (kelp canopy	13%	1.0	13%	24	3.5
	Rocky reef (no canopy)	13%	1.0	13%	595	86.2
	Eelgrass/Surfgrass	13%	1.0	13%	98	14.1
	Sand	13%	0.1	1.3%	940	13.6
Total (3-10 m)					**1657**	**117.4**

The Trustees identified four categories of restoration activities (abalone restoration, eelgrass restoration, kelp restoration, and seawall removal) that would collectively compensate for approximately 47% of the losses to subtidal habitats caused by the release of Line 901 oil. These projects were selected and prioritized by their ability to enhance and restore subtidal habitats in the region affected by the spill. Projects within Zone B were heavily prioritized over projects that were in the region but outside Zone B. These projects are discussed below in order of priority.

ABALONE RESTORATION

In order to be successful, abalone restoration requires applying multiple approaches when possible (e.g., adult translocation and juvenile captive propagation and outplanting) and requires a multi-year program with repeated outplanting events. In addition, restoration in the marine environment requires the use of boats and divers, which elevates the cost above costs associated with implementing land-based restoration work. The Trustees proposed a 10-acre restoration project (5 acres within each of the Marine Reserves) that will be implemented over a 5-year period and subsequently monitored for an additional 5 years. To scale this project, the Trustees assumed a 50% service increase that would be realized at the end of the 5-year implementation period. This credit would be maintained for 20 years, at which point the credit would diminish due to uncertainties about how the population may fare beyond that timeframe. The project (including post-implementation monitoring) has an estimated DSAY value of 73.6.

EELGRASS RESTORATION: There are limited opportunities for coastal eelgrass restoration within Zone B. The Trustees propose restoration at a roughly 3-acre site where the habitat is likely to support eelgrass but is far enough from existing beds that natural recruitment is unlikely (Altstatt, personal communication). This work will create productive habitat services within Zone B. Previous restoration work with the species of eelgrass that frequents the coastal ocean (*Zostera pacifica*) suggests that full recovery of the eelgrass bed after project implementation is a relatively slow process that can take 7-10 years (Altstatt et al. 2014), so the Trustees propose a slow increase in credit over the course of approximately 15 years to a maximum of 70%, which will be realized for up to 20 years post-implementation and then decline for the same reasons that the credit of the abalone project declines after the same timeframe. This project has an estimated DSAY value of 27.

SAND-DWELLING KELP RESTORATION: While there are no opportunities for direct kelp forest restoration within Zone B, there are limited opportunities for kelp restoration offshore of Goleta Beach, which lies outside the southeastern border of Zone B. This project was initiated by a small group of dedicated citizen scientists who are attempting to restore the kelp forest that once existed in Goleta Bay. While there is no rocky reef habitat in the bay that typically supports kelp forests, it has been speculated that the kelp had once established itself on tube-forming worm colonies that frequent open sand habitats (e.g., colonies of the tube worms belonging to the genus *Diopatra*). The project aims to restore these “sand-dwelling” kelp plants by inserting small granite columns into the sediment, exposing the top 10-20 cm of the column to kelp recruitment. The ultimate goal of this project is that kelp holdfasts will spread beyond the area occupied by the granite column and form a kelp forest of sufficient density to support kelp canopy. This is currently a one-acre project that has shown some short-term success (i.e., kelp plants have recruited to a number of the granite columns), but the approach is still experimental in nature, and it is difficult for the Trustees to evaluate how the project will fare during storm events that could pull out the columns and associated kelp. The scope of this project is to expand the permits associated with the current one-acre project and to implement a systematic monitoring program. The Trustees are reluctant to propose a larger scale buildout of this project because the results are still preliminary, and the longer-term viability of the approach is unknown. This project has an estimated DSAY value of 6.8.

ELLWOOD SEAWALL: If the Ellwood Seawall removal project is selected as a shoreline project, the Trustees estimate that the removal of the seawall will have benefits to subtidal marine habitats that go beyond the benefits for sandy beach habitat (the primary goal of this project). These benefits include a presumed reduction in turbidity and scour in the offshore habitats resulting from the reduction in reflective wave energy that will occur after the seawall has been removed. These benefits have not been quantified in similar projects so the Trustees consider this project to have uncertainties regarding its benefits for subtidal habitat. In order to help quantify these benefits, the Trustees proposed that the current project budget be expanded to include long-term monitoring of subtidal habitats adjacent to the seawall removal site. The Trustees will require pre- and post-removal monitoring. The Trustees estimated a maximum credit of 30% applied to 20 acres of habitat that will be realized 5 years after the removal of the seawall, will persist for approximately 20 years, and will then decline due to uncertainties similar to those outlined above. The Trustees adjusted the habitat benefits based on acres of habitat type (e.g., 1/10 credit for open sand), so the project scaling is closely aligned with the injury scaling. The benefits to acreage of sandy habitat (Figure 2) within the project impact area were therefor scaled at 3%. The estimated DSAY value of this project is 35.

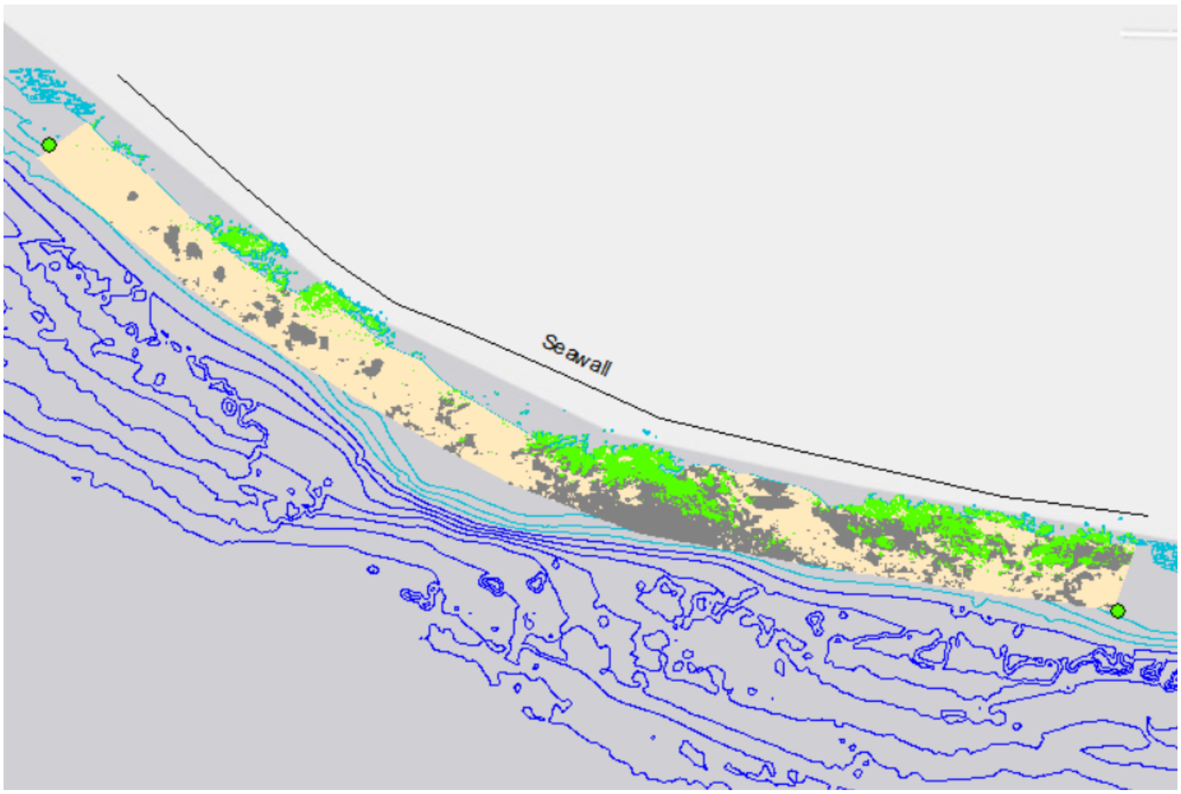

Figure 2. Map of habitats within the 20 acres of subtidal habitat adjacent to the seawall removal project. Rocky habitat (5.6 acres) indicated in grey, sand habitat (11.3 acres) indicated in beige, and seagrass habitat (3.6 acres) indicated in bright green.

REMAINING DSAYs: For remaining DSAYs, the Trustees will use remaining subtidal funds for projects as follows. The first option will be to scale up one or several of the restoration projects described above in the event that a larger scale project is feasible; the second option would be to fund projects that have strong nexus to the Line 901 oil spill that may come to light in the future; and the third option will be to provide funding for marine debris removal.

Marine Debris removal, particularly derelict fishing gear, can have limited benefits to marine habitats and can also reduce mortality of marine fish, birds, invertebrates and mammals along the Gaviota Coast. Marine debris removal is identified as a lower priority for a number of reasons. The degree of benefit that fishing gear removal has to each of these resources depends greatly on the location and habitat from which the gear is removed, and the nature of the items removed. While there are some opportunities to remove fishing gear from the greater southern California Bight, opportunities to remove gear from Zone B or along the Gaviota Coast have proven to be limited. Thus, direct benefits of gear removal to the benthic marine habitats that were injured by the spill are also limited. Benefits to the affected habitat of gear removal from other areas within Southern California are impossible to quantify, as they will vary greatly depending on the variables mentioned above.

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REFUGIO OIL SPILL BIRD INJURY ASSESSMENT

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April 15, 2020

Introduction

This report provides an estimate of total bird mortality from the Refugio Oil Spill that occurred on May 19, 2015, from an onshore pipeline that ruptured and released oil that flowed into the Pacific Ocean and throughout the Santa Barbara Channel. Oil spill response coordination began the same day the spill was reported, and wildlife reconnaissance, recovery, transport, and rehabilitation teams were deployed starting May 20, 2015, and worked continually until wildlife field operations for birds were demobilized on June 24, 2015. Wildlife operations covered shorelines and near-shore environments between Gaviota and Redondo/Manhattan Beach. These wildlife operations were led by the California Department of Fish and Wildlife Office of Spill Prevention and Response, and the Oiled Wildlife Care Network with support from other agencies and organizations (Figure 1 and Figure 3).

Birds are vulnerable to oil spills for a variety of reasons including fouling of feathers, damaging skin and eyes, or creating internal physiological harm following ingestion or inhalation (Helm et al. 2015). Bird fouling by oil compromises the ability of their feathers to keep them warm in the cold Pacific Ocean water. For a species that forages in the water, even a relatively small amount of oil (e.g., the size of a nickel) may result in death. Like a hole in a wetsuit, the oil destroys the feathers' ability to insulate the bird, thus allowing cold ocean water to spread against the bird's skin. Birds that contact oil typically die of hypothermia and starvation. With their rapid metabolism, birds that are oiled cannot consume enough food to keep them warm and to also maintain the daily energy requirements they need to survive (Oka and Okuyama 2000). They can also ingest toxic amounts of oil while preening, as they attempt to clean themselves (Fry et al. 1986). Finally, larger amounts of oil can smother birds, affecting their mobility and ability to survive.

Shortly after the spill began, the Natural Resource Trustees (Trustees) created a Bird Technical Working Group, comprised of representatives from the California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration, Bureau of Land Management[1], and University of California[2]. The group was responsible for developing and implementing the methodology for assessing injury to birds from the spill, and identifying and scaling appropriate restoration projects necessary to compensate for bird injuries.

Based on knowledge of the diversity of bird species and their use patterns within the spill zone, the Trustees sub-divided the injury assessment into three categories: 1) brown pelican injury; 2) western snowy plover injury; and 3) other bird injury. Brown pelicans were analyzed in a separate category due to the large numbers that were affected by the spill and because their body size allowed the Trustees to survey them in their breeding and non-breeding habitats to assess oiling rates and calculate injury in a way that was not feasible with other seabird species. Western snowy plovers were also analyzed in a separate category due to their status as "threatened" on the federal Endangered Species List, pursuant to the Endangered Species Act of 1973, as amended. All other birds were analyzed using methods that have been demonstrated to effectively characterize injury during past oil spills, and which are applicable to a broad range of species. The injury analysis relies on data collected by the Wildlife Branch of the spill response incident command and additional studies conducted specifically for the Natural Resource Damage Assessment (NRDA). A conceptual model of the bird injury assessment is shown in Figure 2.

Figure 1. Mike Harris of the California Department of Fish and Wildlife captures an oiled brown pelican during the response to the Refugio Beach oil spill. Photo Credit: Kenneth Song/Santa Barbara News-Press/ZUMA Wire

[1] Land manager of California Coastal National Monument
[2] Land manager of Coal Oil Point Reserve, UC Natural Reserve System

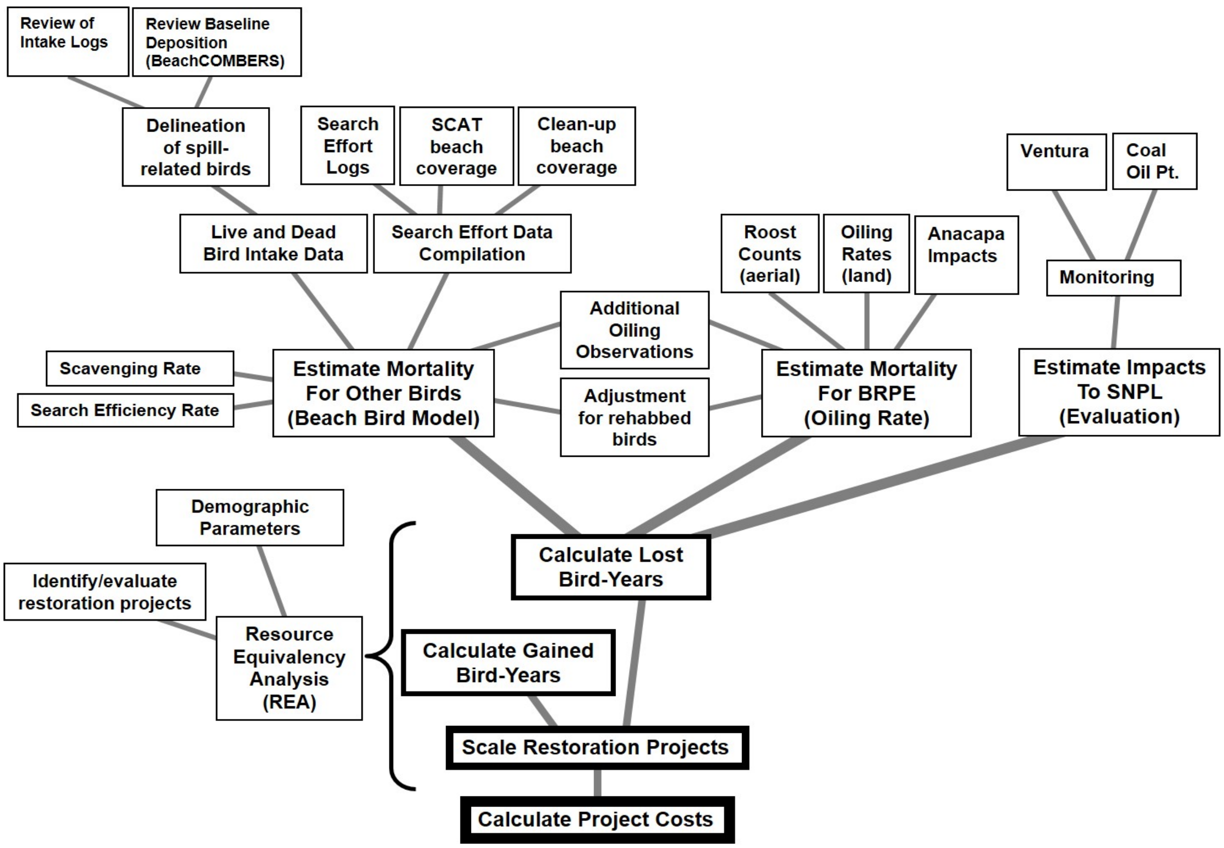

Figure 2. Conceptual model of the assessment of bird injury and restoration project scaling.

Data Collection and Studies

This section describes the data that was collected or analyzed by the Trustees in order to understand injury to birds from the spill. These data were generated by several efforts, including studies that were conducted by the spill response, data collected by the NRDA team, and studies that were not specifically developed for the spill response or the NRDA team but that provide relevant information for the understanding of injuries to birds from the spill.

Figure 3. Oiled western grebe captured along the Gaviota coast during the spill. Photo Credit: International Bird Rescue, 2015.

Wildlife Reconnaissance Aerial Surveys

On May 21, 2015, aerial surveys for pelagic birds were conducted roughly between Point Conception and the City of Goleta (Figure 4). The objective of these aerial surveys was to understand the general location and number of seabirds in the vicinity of the spill-affected area, in order to inform spill response activities. These surveys documented at least 13 unique pelagic bird species in groups ranging in size from a single individual to 120 individuals.

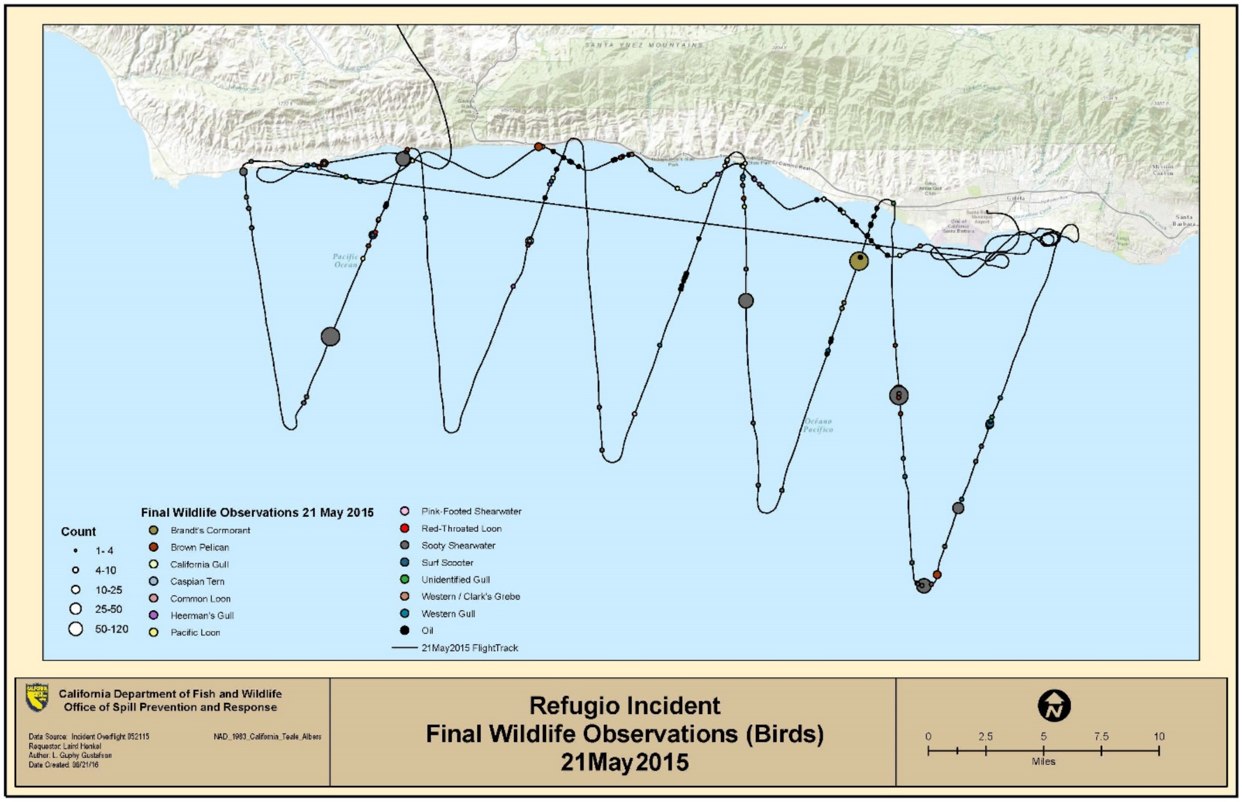

Figure 4. Observations of birds during overflights on May 21, 2015.

Live and Dead Bird Intake Data

Documentation of live and dead birds was collected as a normal part of the spill response. These data describe the collection of each bird, with such information as date, location, species, condition of bird, degree of oiling, etc. Locations of live and dead birds collected are shown in Figure 5, and details on the species collected are shown in Table 1.

During spill response operations all live distressed birds were taken to rehabilitation centers for further care. All dead birds encountered within the spill zone were collected. A total of 66 live birds and 203 dead bids comprised of at least 28 species were collected between May 20, 2015, and June 24, 2015 (OWCN 2015).

A portion of the live and dead birds collected during the spill may not have been injured or killed by the spill and/or response operations. The Trustees developed methods for analyzing the live and dead bird intake records to determine which animals were likely injured or killed by the spill and which were not. The details of this analysis are discussed below.

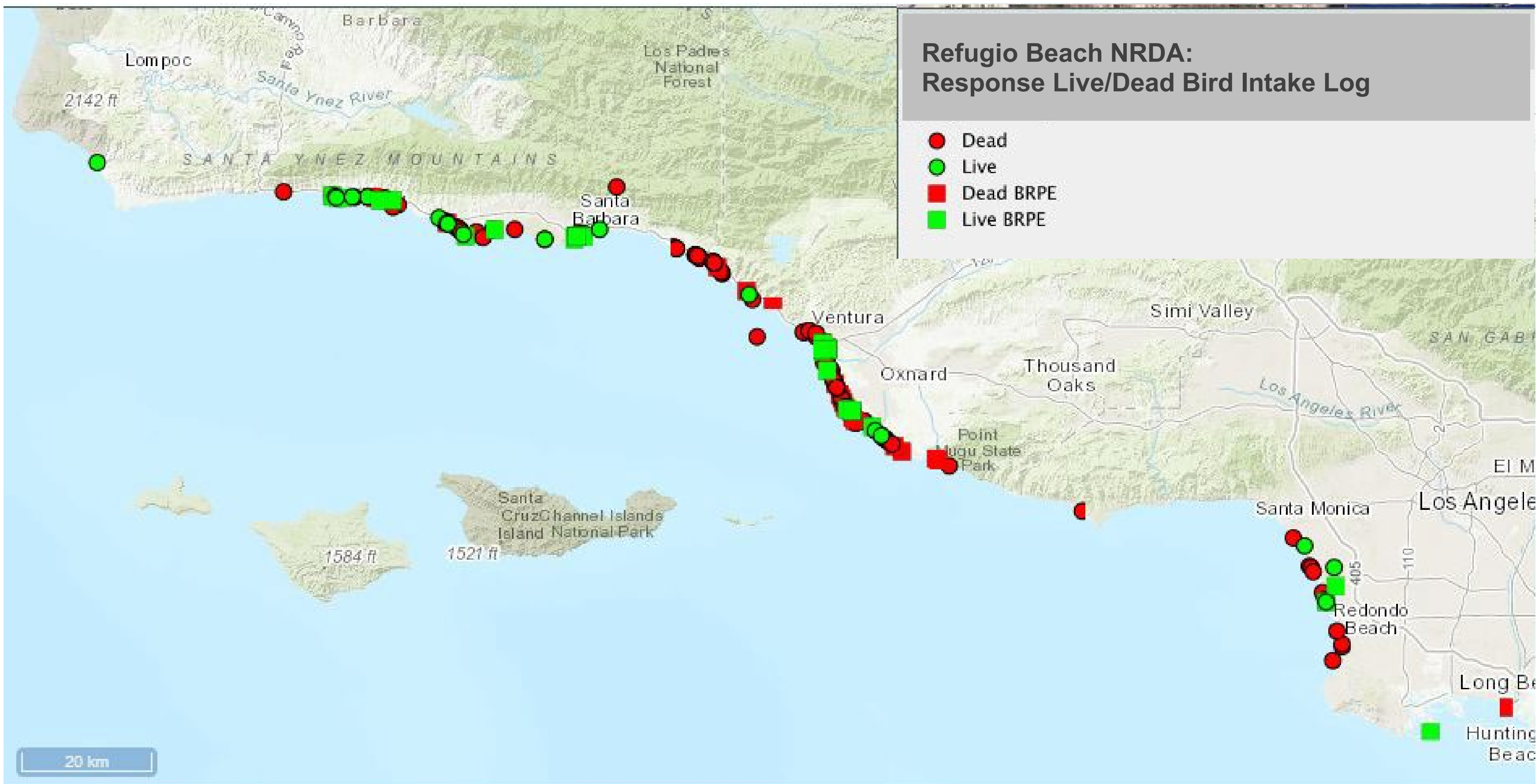

Figure 5. Location of live and dead birds recovered during wildlife operations segregated by brown pelicans (BRPE) and all other bird species. Two additional live pelicans were recovered from Newport Beach, outside the area represented in this map.

Table 1. All birds collected live and dead by species (or closest known taxon).

SPECIES	COLLECTED LIVE	COLLECTED DEAD	TOTAL
Black storm-petrel	0	1	1
Barn owl	0	1	1
Black skimmer	0	1	1
Brandt's cormorant	2	11	13
Masked/Nazca booby	0	1	1
Brown pelican	47	26	73
California gull	1	5	6
Cassin's auklet	0	1	1
Clark's grebe	0	2	2
Common loon	0	3	3
Common murre	5	33	38
Cormorant sp.	0	4	4
Double-crested cormorant	0	14	14
Domestic duck sp.	0	2	2
Eared grebe	0	1	1
Elegant tern	0	1	1
Forster's tern	0	1	1
Grebe sp.	0	3	3
Heermann's gull	0	3	3
Loon sp.	0	5	5
Mew gull	0	1	1
Northern fulmar	0	5	5
Pacific loon	6	17	23
Pelagic cormorant	0	2	2
Pigeon guillemot	0	1	1
Rhinoceros auklet	0	2	2
Rock pigeon (feral)	0	1	1
Red-throated loon	1	12	13
California scrub-jay	0	1	1
Shorebird sp.	0	1	1
Sooty shearwater	0	16	16
Surf scoter	1	2	3
Western grebe	1	8	9
Western gull	2	9	11
Unknown	0	6	6
TOTAL	66	203	269
TOTAL w/o brown pelican	19	177	196

Anacapa Island Brown Pelican Surveys

During the spill period, brown pelicans were nesting on Anacapa and Santa Barbara Islands, and were using the Santa Barbara Channel and mainland roosts for foraging, migrating, and resting. Surveys of brown pelicans at the Anacapa Island and Santa Barbara Island breeding colonies were conducted by the NRDA team to determine whether nesting brown pelicans were affected by oil from the spill. The surveys were conducted by boat and by ground, and are described further in the sections below.

Brown Pelican Roost Surveys

Due to their large size, pelicans can survive for many days after oiling. In order to assess the extent of oiling of brown pelicans, surveys of known pelican roost sites on the mainland from Morro Bay to Los Angeles were performed in the days immediately after the spill (Jaques et al. 2015). Surveys were conducted by the NRDA team by ground, boat, and air to determine the number and geographic distribution of pelicans and to observe the proportion of pelicans that showed signs of oiling.

Brown Pelican Rehabilitation Survival Studies

The Oiled Wildlife Care Network (OWCN) assisted with wildlife operations during the spill, including rehabilitation of oiled birds. In order to understand the survival rate of rehabilitated oiled wildlife, the OWCN and other collaborators tracked rehabilitated pelicans to determine their survival and distribution relative to birds that were not oiled and rehabilitated during the spill (Lamb et al. 2018). Prior to release, 12 oiled and rehabilitated pelicans were instrumented with solar-powered satellite GPS tracking devices, along with 8 control (unoiled) pelicans. All birds survived for at least 12 weeks. In the first 6 months after release, distance traveled and movements were similar between rehabilitated and control pelicans. Several individuals traveled >5000 km, migrating to northern California or central Oregon in late summer and early fall. In the spring, most birds traveled south, some as far as Baja California.

Mortality was documented among both rehabilitated and control birds; however, a majority of birds that stopped transmitting were never found. Lack of transmission could represent mortality, transmitter or battery failure, or transmitter loss. A major limitation of the study was unreliability of the technology. After 40 weeks of tracking, only 5 transmitters (3 rehabilitated and 2 control) were still transmitting. Field observations of color-banded birds documented at least five of the satellite transmitters that stopped transmitting did not do so because of mortality. Additional analysis is presented in Lamb et. al (2018) and Jaques et al. (2019).

Sandpiper Pier Cormorant Colony Surveys

Within the spill area, Brandt's cormorants nest on four platforms that were constructed offshore of Ellwood Beach in Santa Barbara County. Surveys were conducted by the NRDA team from the shore to assess the number and status of nests throughout the 2015 breeding season. The four nesting platforms were visited and photographed on May 22, May 28, and June 8, 2015. There were approximately 30 Brandt's cormorant (BRAC) nests on each platform.

In May, the nests were at a variety of stages; many had apparently incubating adults (the eggs were not visible from our vantage point) and some were feeding chicks. Between the May and June visits, we examined the photographs and identified 12 nests that: 1) had apparently incubating adults; and 2) were clearly visible (Figure 6). The 12 nests were surveyed for a final time on June 8, 2015, where chicks were observed in at least 8 of the nests. The status of the 12 nests on June 8, 2015 is described in Table 2. Based on these observations, the Trustees concluded that nests were not abandoned and chicks successfully hatched during the spill period. Adverse effects from exposure to oil were not visibly apparent during these surveys.

Figure 6. Cormorant nests on Platform 1 during a May 22, 2015 survey. Red circles indicate nests that were monitored during the May and June surveys. Photo Credit: NRDA team.

Table 2. Results of visual nest monitoring of 12 cormorant nets on June 8, 2015.

PLATFORM #	NEST #	OBSERVATION
1	1	Chick
1	2	2 chicks
1	3	Incubating but hunched up, possibly with little chick
1	4	2 chicks
2	1	Chick
2	2	Possibly giving up on incubating; adjusting nest
3	1	Chick
3	2	2 chicks
3	3	2 chicks
4	1	Incubating but hunched up, possibly with little chick
4	2	2 chicks
4	3	Incubating

Western Snowy Plover Studies

Western snowy plovers utilize several sandy beaches within Santa Barbara and Ventura Counties for nesting including Coal Oil Point Reserve, San Buenaventura State Beach, McGrath State Beach, Mandalay State Beach, Ormond Beach, Hollywood Beach, and Naval Base Ventura County at Point Mugu. Monitoring has generally been conducted at these sites since at least 2001, although not every site has continuous monitoring for each breeding season, and methods are somewhat varied between beaches. Some level of western snowy plover monitoring was conducted at each of these beaches during the 2015 nesting season (Coal Oil Point Reserve 2015, Hartley 2015, Barringer 2015, Frangis and Cox 2015). All nesting beaches are located in Ventura County, with the exception of Coal Oil Point Reserve in Santa Barbara County.

During the cleanup, staff of the University of California Natural Reserve worked closely with response staff assigned to cleanup Coal Oil Point to minimize injury to western snowy plovers by identifying safe access routes, monitoring the birds' behaviors to determine their response to increased activities on the beach, and to provide recommendations to cleanup workers to help achieve a balance between removing the oil from the beach and creating conditions for successful nesting in the 2015 breeding season. The spill-specific monitoring and adaptive cleanup process is described in Nielsen et al. (2017) and summarized in the western snowy plover injury analysis below.

Figure 7. Western snowy plover at Coal Oil Point during cleanup operations. Photo Credit: Jessica Nielsen, UCSB.

Baseline Beached Bird Studies

Information about the baseline rate of bird deposition on beaches throughout the spill zone is available from information collected through the Beach Coastal Ocean Mammal and Bird Education & Research Surveys (BeachCOMBERS) program. The program utilizes highly trained citizen scientists to conduct monthly beach surveys using a dedicated protocol for documenting the number and status of beached birds and mammals within each survey segment. Data collected include species identification, decomposition state, observations of carcass scavenging, observations of carcass oiling, and other factors. All carcasses encountered during a survey are marked to identify whether the carcass has been observed on previous surveys (a new mark is made each month). The goal of the BeachCOMBERS program is to establish long-term data on baseline bird and mammal stranding rates, so that when unusual mortality events occur (e.g., oil spills, domoic acid events, etc.), resource managers can understand and explore the magnitude and cause of the bird and/or mammal mortality. The spill occurred within the area monitored by the South Coast Chapter of BeachCOMBERS (Figure 8), which began collecting monthly data in January 2013.

Figure 8. Red areas show the location of BeachCOMBER segments within the spill zone, where data on baseline deposition of birds and mammals was collected prior to May 2015.

Brown Pelican Injury Analysis

Brown pelicans were the most numerous bird species to be found alive and dead during the spill period. Of the birds collected during the spill, 72% of the live birds (n=47), and 13% of the dead birds (n=26) were brown pelicans. Not all of the live and dead brown pelicans affected by the spill were captured or collected. Brown pelicans are capable of long-distance flights and oiled pelicans can survive for several days to weeks before becoming weak and either succumb to their exposure or become lethargic enough to be captured. To estimate the total number of brown pelicans injured by the spill, the Trustees applied the following methodology which will be discussed further in the sections below.

1) Determine brown pelican distribution during the spill;
2) Determine brown pelican oiling rate;
3) Calculate brown pelicans injured within the spill response zone;
4) Calculate brown pelicans injured outside the spill response zone (missed by the response);
5) Adjust for rehabilitated birds; and
6) Calculate total BRPE injured.

Brown pelican biology and distribution during the spill

The California brown pelican is a subspecies of brown pelican that ranges throughout the west coast of North America. It nests in Mexico and on the Channel Islands. The California brown pelican was delisted by the state of California in June 2009 and by the federal government in December 2009. Brown Pelicans typically forage in relatively shallow coastal waters, feeding almost entirely on surface-schooling fish caught by plunge diving. Brown pelicans are rarely found away from salt water and do not normally venture more than 32 kilometers (20 miles) out to sea. During the non-breeding season, brown pelicans roost communally on offshore rocks and structures such as piers and wharfs. Brown pelicans have wettable plumage, so they must have roost sites to dry after feeding or swimming (Jaques and Anderson 1987). Roost sites are also important for resting and preening. The essential characteristics of roosts include: nearness to adequate food supplies; presence of physical barriers to protect the bird from predation and disturbance; sufficient surface space for individuals to interact normally; and adequate protection from adverse environmental factors such as wind and surf (Jaques and Anderson 1987).

Brown pelicans on the Channel Islands

Anacapa Island, the second smallest of five Channel Islands, is home to the largest breeding colony of California brown pelicans in the United States. Brown pelicans create ground nests in dense colonies within the cliffs and canyons of the Channel Islands (Figure 9). The only other significant U.S. breeding colony is located on Santa Barbara Island, which is much further from the mainland and is unlikely to have been heavily impacted by the spill. A much larger number of pelicans breed in Baja California, Mexico. After breeding, many of these birds migrate north and make up the majority of pelicans along the U.S. west coast in summer and fall. During the oil spill, many of the Baja pelicans were already migrating north, due to a failed breeding season in Mexico, and were passing through the spill zone. Based on the results of a radio transmitter study of rehabilitated pelicans (funded by the OWCN and not through NRDA; see below), it appeared that pelicans from both Anacapa and Baja were impacted.

Reconnaissance level, boat-based surveys of the brown pelican nesting colony on Anacapa were conducted by Channel Islands National Park staff in June and July 2015 during the initial response effort (Larramendy et al. 2018). The surveys were conducted by boat to visually inspect brown pelicans that were visible from the water, and did not include direct, on-island, access. Visibly oiled pelicans were not observed on Anacapa Island during these surveys. Ground surveys provide a more comprehensive means of identifying oiled pelicans, but are highly disruptive to nesting and fledging activities, and were only scheduled after the end of the breeding season.

Ground surveys were conducted on September 20 and 21, 2015, on West Anacapa Island and Middle Anacapa Island, where a majority of the brown pelican nesting activity occurs (Larramendy et al. 2018). During these surveys, biologists inspected the remains of nests that were active during the spill period and the nests were marked and tallied per standard NPS methods. Surveys on day one focused on West Anacapa Island, where a majority of brown pelican nesting occurs; day two covered Middle Anacapa Island and East Anacapa Island. Hundreds of nests were inspected for oiling. Evidence of oiling was limited to one juvenile brown pelican carcass on Middle Anacapa Island, in which a small amount of weathered oil was found on several wing tips, and a few specks on the downy feathers around its shoulder (Figure 10). The survey team estimated the bird was about 6 weeks of age at the time of death, which is essentially full grown. Based on these efforts, the Trustees concluded that brown pelican nesting activities on the Channel Islands were not substantially affected by the Refugio Beach Oil Spill.

Figure 9. Brown pelicans nesting. Photo Credit: A. Yamagiwa 2017 as presented in Larramendy et al. 2018.

Figure 10. Brown pelican chick carcass identified on middle Anacapa Island during a September 2015 ground survey with oil observed on its feathers. Photo Credit: Chris Dunn, Padre Associates.

Determination of brown pelican oiling rate

Brown pelicans along the mainland coast between San Luis Obispo County and northern Los Angeles County were surveyed by ground on 11 days in May and June of 2015; and by air on May 27, 2015. Ground surveys allow for visual inspection of brown pelicans to identify visible oiling; however, for large roost sites it is not possible to accurately document the total number of individuals because only a portion are visible from ground-based vantage points. Similar to ground surveys, boat surveys were conducted of roost locations such as the jetties of the Ventura Harbor to visually inspect pelicans for oiled plumage in these locations that are not accessible by ground.

During each survey, the total number of pelicans visible and the number of individuals that showed visible oiling were documented. From those data, the percent of oiled individuals was calculated. For roosts where surveys were conducted from multiple vantage points observing the same population, the oiling rate ("percent oiled") was averaged over all observations for that location within a single day. For roost locations that were surveyed on multiple days, the day with the highest maximum oiling rate was selected as the maximum oiling rate ("Maximum % Oiled"). For example, the oiling rates at Santa Barbra Harbor were 6.4% on May 23, 8.2% on May 24, and 10.8% on May 25. For the Santa Barbara Harbor, 10.8% was used as the maximum oiling rate for that roost location. In general, oiling rates decreased with time and proximity to the spill.

The aerial survey of pelican roosts conducted on May 27, 2015 consisted of photographing brown pelicans at all roost sites and counting individuals from the aerial images (Jaques et al. 2015). Aerial surveys are ideal for documenting the total number of individuals at each roost by taking photographs and counting brown pelicans (which are easily distinguishable from other birds due to their body size) at each roost. A total of 6,862 brown pelicans, 90% of which were in adult plumage, were counted at 29 roost sites (Figure 11). The largest concentrations of pelicans were at Shell Beach and Pismo Beach to the north of the spill site and at Rincon Island and Ventura Harbor to the south (Jaques et al. 2015).

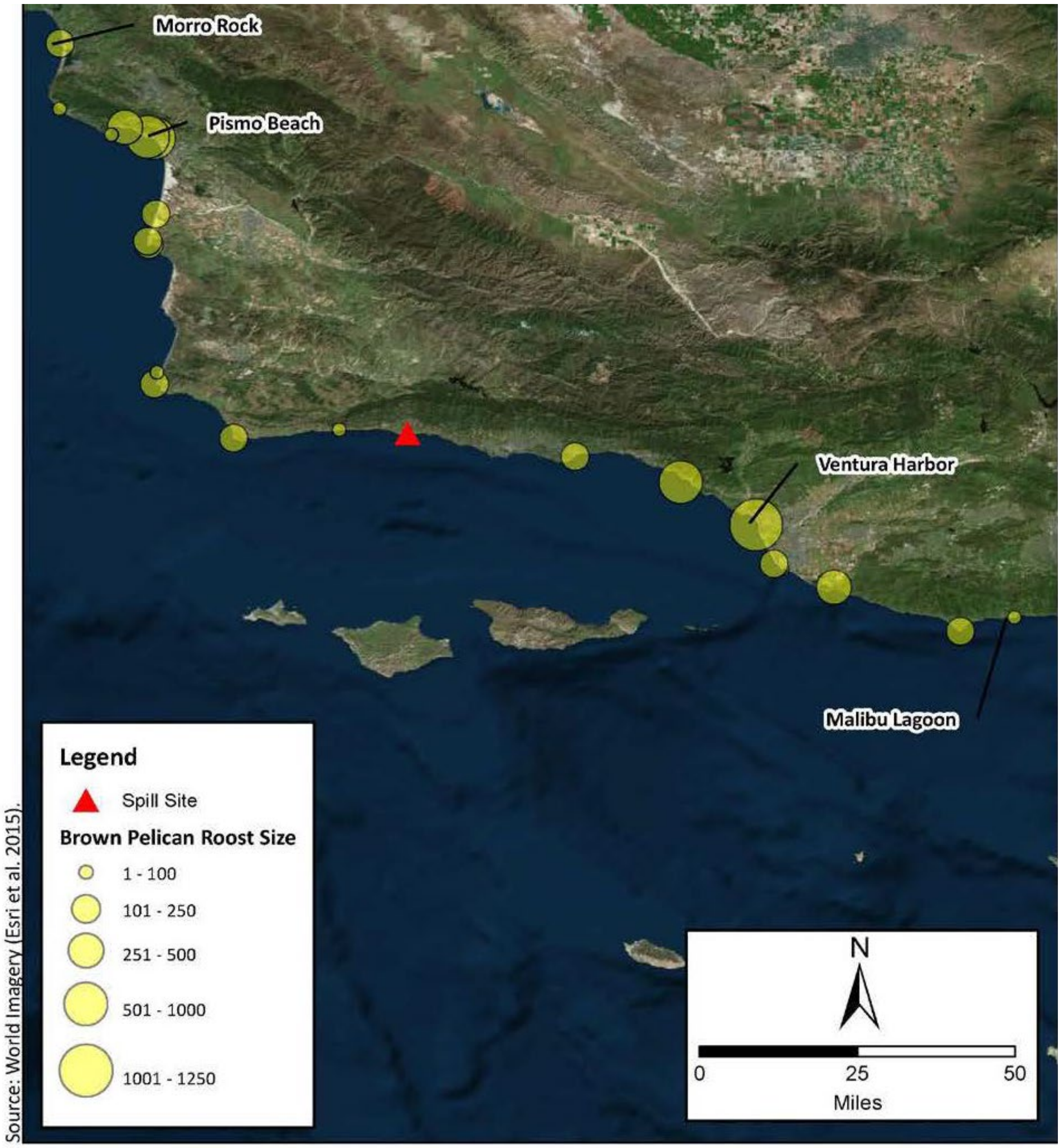

Figure 11. Results of aerial surveys of brown pelican roosts conducted on May 27, 2015. (Jaques et al. 2015)

Because no single survey method is able to detect both the proportion of oiled individuals at any given roost and the total number of individuals at the roost, the Trustees analyzed these datasets together to approximate the total estimated oiling at each roost site.

The Trustees used the maximum oiling rate ("percent oiled") at each roost site north of the spill zone and multiplied the oiling rate by the number of pelicans observed at each roost during the aerial survey (Table 3). Three substantial roost locations (Morro Bay, Santa Maria River/Point Sal, and Gaviota) were unable to be assessed for oiling rate because they were inaccessible by ground/boat or because the total number of observable pelicans was too low (n < 5) to provide a meaningful assessment. For these sites, the oiling rate was estimated by taking the average of the oiling rate at the roost site to the north and to the south. For Morro Bay, where no oiling rate was available to the north, the oiling rate was estimated to be half of the oiling rate calculated from the roost location to the south.

Table 3. Location and results of brown pelican surveys conducted between May 20 and June 9, 2015. Percentages (% oiled) represent the average oiling rate of brown pelicans at each roost site on each day. The number of brown pelicans at each roost site was documented by aerial surveys on May 27, 2015. The number of oiled pelicans was calculated by multiplying the maximum oiling rate (%) by the number of pelicans at each roost site.

	Morro Bay	Pismo/Shell Beach	S. Maria/ Pt. Sal	Vandenberg	Gaviota	S.B. Harbor	Rincon	Ventura/Oxnard	Malibu	
% oiled - 5/20/2015				**7.3%**						
% oiled - 5/23/2015		**5.9%**				6.4%				
% oiled - 5/24/2015						8.2%				
% oiled - 5/25/2015						**10.8%**	**1.9%**			
% oiled - 5/26/2015								**1.1%**	**2.0%**	
% oiled - 5/27/2015				2.9%						
% oiled - 5/28/2015								0.9%		
% oiled - 6/4/2015				0.0%						
% oiled - 6/8/2015								0.0%	0.0%	
% oiled - 6/9/2015						0.0%				
Max Oiling rate (%)	**3.0%**	**5.9%**	**6.6%**	**7.3%**	**9.0%**	**10.8%**	**1.9%**	**1.1%**	**2.0%**	**TOTAL**
# Pelicans at each Roost	**159**	**2681**	**794**	**381**	**59**	**139**	**748**	**1740**	**161**	**6,862**
# Oiled (calculated)	**5**	**159**	**53**	**28**	**5**	**15**	**14**	**20**	**3**	**302**

Brown pelican injuries within the spill response zone

Wildlife reconnaissance, recovery, transport and rehabilitation was conducted as part of the spill response operations. During the response, 47 brown pelicans were captured live and 26 were collected dead, for a total of 73 (OWCN 2015). The live birds were sent for rehabilitation, as described further below. Dead brown pelicans were collected and examined to determine carcass condition, extent and location of oiling, and extent of scavenging. One dead pelican was determined to have likely died prior to the spill because the decomposition state was considered to be too advanced at the time of collection to be spill related.

To determine how well observations of oiled pelicans at roost sites correlated with the number collected live and dead at each location, the Trustees compared the number of pelicans collected during the response with the number of oiled pelicans documented at roost sites within the response zone. For this analysis, the Trustees used the roost survey results (Table 3) and compared these to the number of brown pelicans collected by wildlife operations during the response. In the region of brown pelican roost sites south of the spill origin (Santa Barbara Harbor through Los Angeles), the response generally collected as many or more pelicans than were observed oiled during the roost surveys (Figure 12). From these data, the Trustees infer that the observation of oiled pelicans at roost sites is a conservative indicator of pelicans injured at that location.

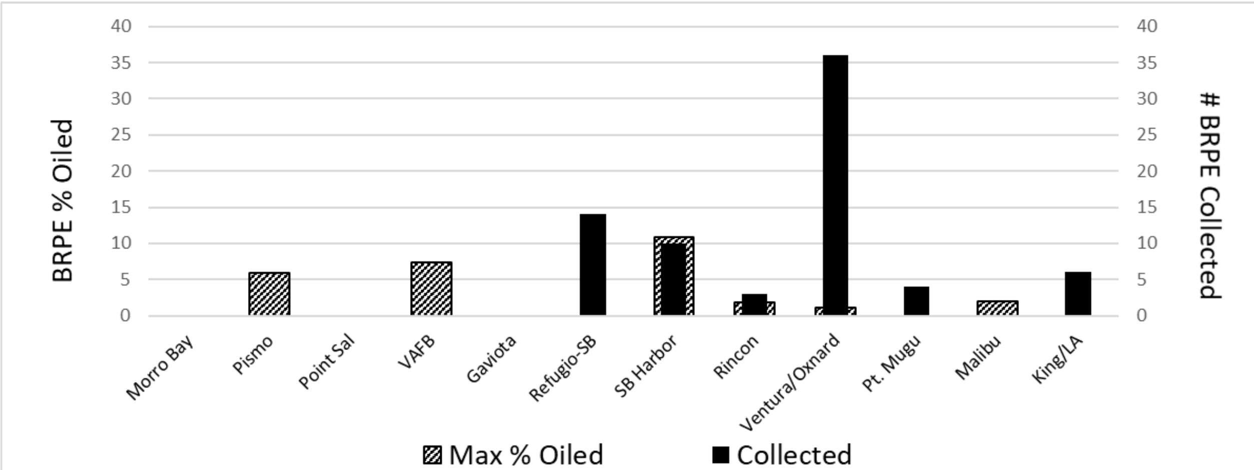

Figure 12. Brown pelicans collected live and dead at each location (black) and percent of brown pelicans observed oiled at each roost location (striped).

Brown Pelicans Missed by the Spill Response

During the time of the spill, brown pelicans within the spill zone were generally migrating north toward Oregon, Washington, and Canada, from breeding grounds in Mexico and on the Channel Islands, although movement patterns can be quite varied. This northward migration created the likelihood that brown pelicans may have been exposed to Refugio spill oil in the spill-affected area and carried it north, outside of the area that was surveyed for oil and oiled wildlife. No wildlife reconnaissance and recovery efforts were carried out by the response north of Gaviota; however the roost surveys indicated that oiled pelicans were found north of the spill response zone. When comparing the population distribution of brown pelicans at roost locations on May 27, 2015, to the location of collected birds throughout the spill response, it appears that more pelicans were present north of the spill zone, but response actions were only occurring to the south (Figure 13).

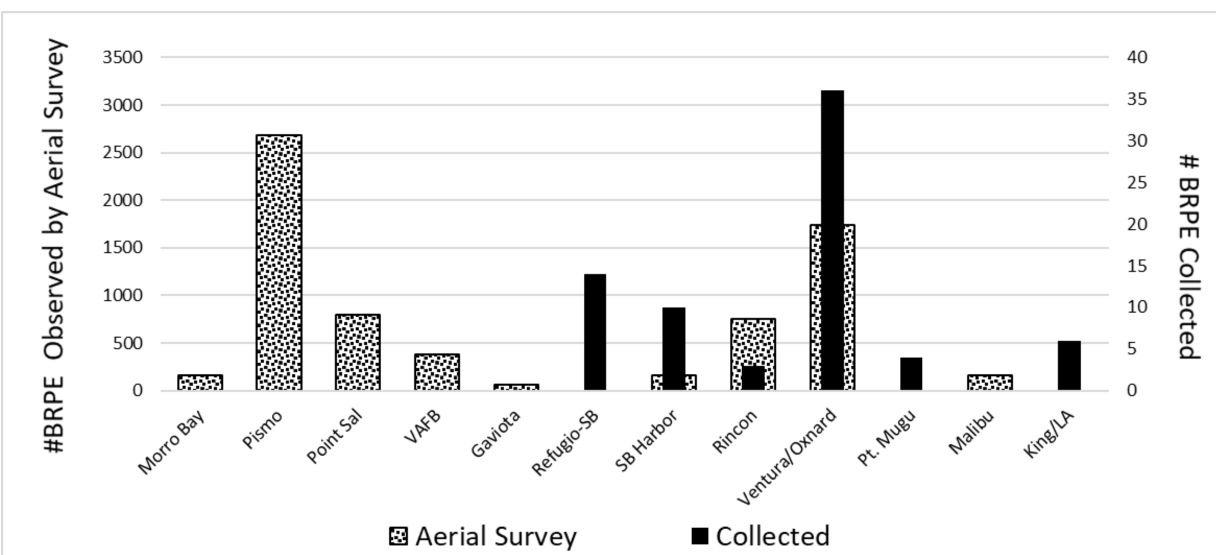

Figure 13. Brown pelicans observed at roost sites between Morro Bay and Malibu (speckled) compared with brown pelicans collected live and dead during the response (black).

These data suggest that a substantial number of brown pelicans affected by the spill were missed by the response. The Trustees estimated the number of injured brown pelicans that were affected by the spill, but traveled north outside the response area, by utilizing the observations of oiled pelicans at roosts north of the response area, and applying the ratio of observed oiled birds to collected birds observed throughout the spill response zone.

Based on the observation that oiled pelicans at roost sites is a conservative indicator of pelicans injured at that location, the Trustees developed a correction factor to determine the total number of injured birds using the roost survey data. To develop this correction factor, the Trustees compared the estimated number of oiled brown pelicans calculated at roost sites within the response area and compared that estimate with the total number of brown pelicans collected by the response at Santa Barbra Harbor or points south (Figure 14). This yielded a ratio of 58:52 (birds collected : birds estimated), resulting in an estimated 279 brown pelicans missed by the response.

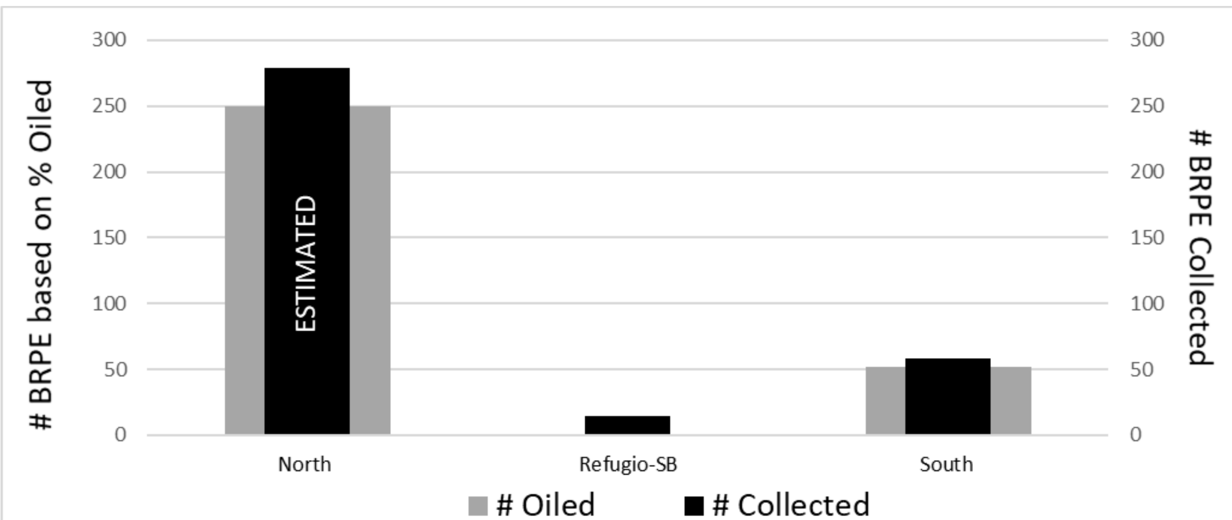

Figure 14. Estimated brown pelican injury north of the response area, based on the observed ratio between oiled birds at roosts within the response zone and the number of brown pelicans actually collected in those areas.

Rehabilitation Credit

During the spill response 47 brown pelicans were recovered and transported to rehabilitation centers for treatment. Of these 47 birds, 4 died in care and 43 were released. The post-release survival study was hampered by failure of some of the tracking equipment; however, field observations of color-banded birds, and results of the transmitter study indicated that all birds survived for at least 12 weeks, and some greater than one year (Lamb et al. 2018). Based on these findings, the Trustees are assuming that rehabilitated birds that were released survived 75% as well as wild birds that were unaffected by the spill, resulting in a rehabilitation credit of 32 birds as shown below.

Collected Live: 47
Rehabbed and released: 43
Survival Rate (assumed): 75% of natural survival rate
Rehabilitation Credit: 43 birds x 75% = **32** birds

Total Brown Pelican Injury
Based on the number of pelicans recovered live and collected dead during the response, the estimated number of pelicans injured by the spill but missed by the response, and the rehabilitation success of pelicans that were treated and released, the Trustees estimate that a total of 319 brown pelicans were injured by the Refugio Oil Spill.

Table 4. Total brown pelican injury from the Refugio oil spill.

Brown Pelicans injured within the spill response zone	72
Brown Pelicans missed by the spill response	+ 279
Rehabilitation credit	- 32
TOTAL Brown Pelican Injury	319

Western Snowy Plover Injury Analysis
When the spill occurred, federally threatened western snowy plovers were in the midst of their breeding season, with many chicks recently hatched and foraging on sandy beaches. Western snowy plovers are among very few species that nest directly on sandy beaches, which makes them vulnerable to conflicts with human activities. In the spill zone, there are several locations where plovers nest: Coal Oil Point Reserve (COPR) at University of California Santa Barbara, San Buenaventura State Beach, McGrath State Beach, Mandalay State Beach, Hollywood Beach, Ormond Beach, and Naval Base Ventura County at Point Mugu (Figure 15). All these locations are within "Recovery Unit 5" as outlined in the U.S. Fish and Wildlife Service's Western Snowy Plover Pacific Coast Population Recovery Plan (USFWS 2007). Population surveys are conducted each year during the same time period for each breeding location, creating a dataset of "summer window surveys" (USFWS 2018). The average population counted during the summer window surveys between 2014 and 2017 at each of these beaches is shown in Figure 15.

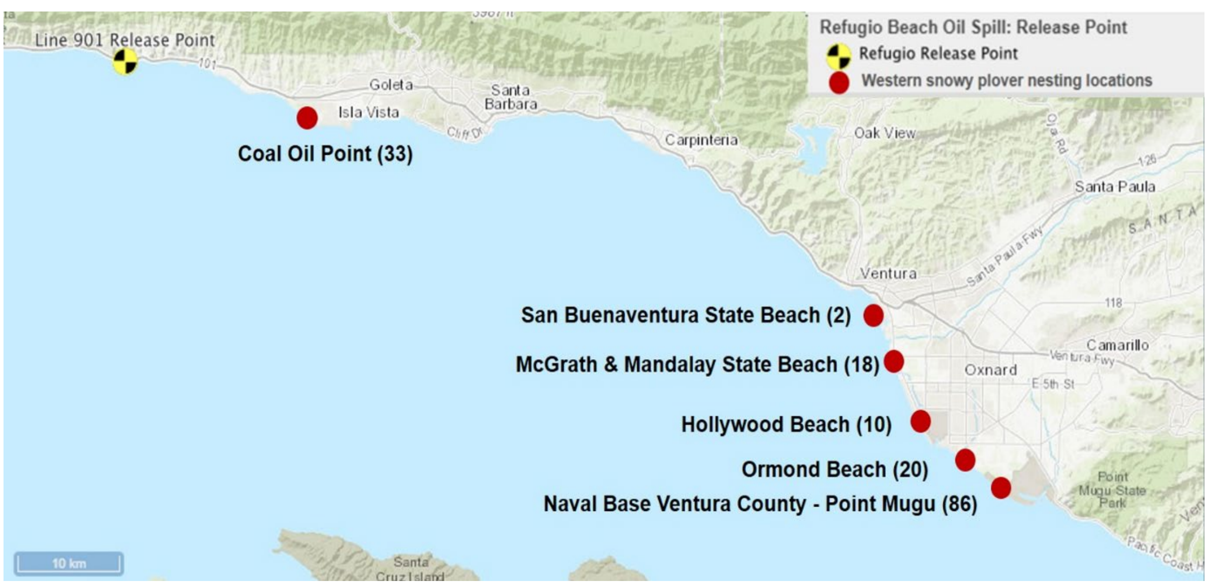

Figure 15. Refugio oil spill release location (yellow/black) relative to nesting western snowy plovers (red) with average number of adults counted during summer window surveys between 2014 and 2017 in parenthesis.

All of the beaches shown in Figure 15 received oiling and/or tar balls in varying degrees during the spill. The maximum amount of oil observed by Shoreline Cleanup Assessment Teams (SCAT) ranged from heavy at COPR to very light at Ormond. The presence of cleanup crews corresponded to the degree of oiling (Table 5).

Because western snowy plovers forage on invertebrates that live in the beach-cast wrack, resource managers sought to protect the plovers from four different impacts: 1) direct exposure to oil; 2) exposure via the ingestion of oiled prey; 3) the loss of wrack which serves as the primary habitat for their prey; and 4) disturbance by cleanup crews.

These goals led to tradeoffs between competing strategies. Cleanup crews removed oil from the beach, but also caused disturbance to both adult plovers and young chicks. Wrack removal reduced the risk of exposure to oil, but also eliminated the primary foraging habitat for shorebirds. Resource managers sought to balance these tradeoffs by intensive monitoring of the plovers and close communication with and education of cleanup crews. As COPR was exposed to the greatest oiling and most intense response activities of any plover breeding sites within the spill zone, it was also the most intensively studied to determine injury to plovers from oil exposure and response actions.

Table 5. Oiling and response activities at representative beaches that support nesting for western snowy plovers, showing a longer duration where cleanup crews were present at Coal Oil Point, compared to breeding sites in Ventura County where more limited cleaning was necessary.

Beach	SCAT max oiling	Cleanup crews present
Coal Oil Point Reserve	heavy	17 of 20 days May 24 – June 12
McGrath State Beach	light	6 of 9 days May 31 – June 8
Hollywood Beach	light	7 of 9 days May 31 – June 8
Ormond Beach	very light	3 of 4 days June 4 – June 7

Injury to plovers from response actions, wrack removal, and food web impacts at San Buenaventura, McGrath, Mandalay, Hollywood Beach, Ormond Beach, and Point Mugu are incorporated into the assessment of injury to sandy beach habitats described in other sections of the Damage Assessment and Restoration Plan (DARP). At these Ventura County nesting beaches, observations of direct exposure to oil were limited to Hollywood beach, but all nesting beaches were affected by some level of Refugio incident oil.

Effect of the spill on western snowy plover population size at COPR

A complete overview of the studies implemented to assess western snowy plover injury at COPR is presented by Nielsen et al. (2017) and is summarized in the sections below. Cleanup efforts started at COPR on May 24, 2015, after the staff at COPR determined that there was enough oil on the beach to warrant cleanup. To reduce the impact of the cleaning activities on the plovers, each crew was supervised by an observer, a biologist or a volunteer bird expert. Biological observers were assigned to monitor all plover nests during cleanup activities. The observers asked the crew to move away if the females incubating the nest left the nest for more than 5 minutes. After the female returned to the nest, the crew could come back, often with fewer workers, to avoid another disturbance.

To study whether the oil spill or cleanup efforts affected the population of plovers at COPR, all adults, chicks, and nests, were counted several times each week, during the entire breeding season in 2015. The beach at COPR is narrow, so the observers could easily count while walking along the wet sand and looking towards the upper beach where the nests and chicks rest. The COPR staff have counted the plover population 3 times a week every breeding season since 2000.

The population of adult western snowy plovers at COPR remained around 20 individuals throughout May, June, and July of 2015. It was not known if any died, but no dead western snowy plovers were found. Observers did not enter the fenced nesting area to avoid disturbing the nests and chicks. The long-term population data are shown in Figure 16 (COPR 2018).

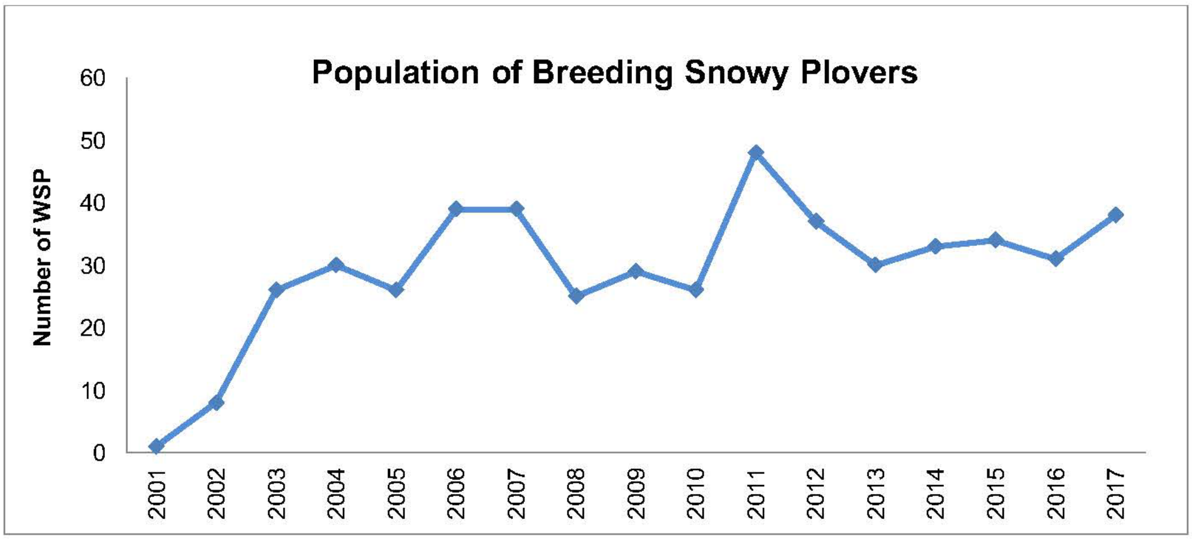

Figure 16. Population of breeding western snowy plovers at Coal Oil Point Reserve between 2001 and 2017.

Changes in western snowy plover behavior during cleanup activities at COPR During the last 3 cleanup days in June 2015, the COPR staff did not interfere with the cleanup efforts to study how those activities affected the western snowy plovers at the site. To study the effect of the cleaning crew on nesting behavior, the observers recorded the time that incubating western snowy plovers were on and off the nest, on days with or without crews, at approximately the same time of the day and under the same weather conditions. The nesting area of the COPR is marked every 5 meters with a post and number so the location of the crew could be recorded by looking at the closest beach marker.

The presence of the cleanup crew influenced the behavior of nesting parents. COPR staff investigated two metrics: (1) the number of times a parent fled their incubating nest and (2) once disturbed, the amount of time a parent remained off its nest. Western snowy plovers were twice as likely to leave their active nest during oil spill cleanup. The average number of nest disturbances per hour with a cleanup crew present (4.2 disturbances ± 0.66) was significantly higher (p-value = 0.0226) than during the period without a cleanup crew present (2.1 disturbances ± 0.33). Furthermore, nesting snowy plovers remained away from their nest nearly three times longer when the cleanup crew was present. During the oil spill cleanup, the length of time the western snowy plovers spent away from the nest (8.3 minutes ± 1.9) was significantly higher (p-value = 0.0321) than when the cleanup crew was absent (3.0 minutes ± 0.71). Western snowy plovers were approximately eight times less likely to feed when cleanup crews were present.

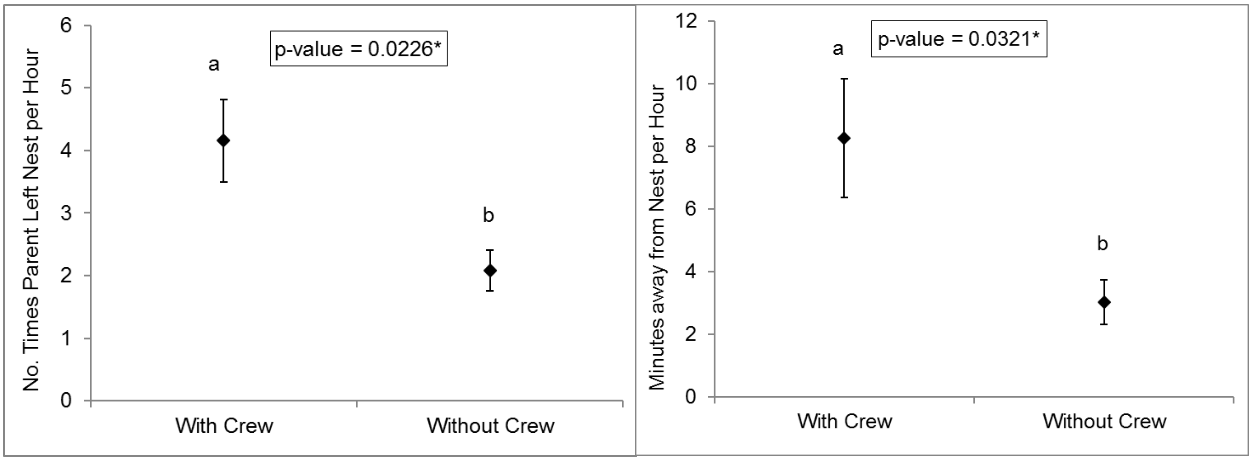

Figure 17. Number of times western snowy plover parents left the nest and total time away from nests with and without the presence of oil spill cleanup crews.

Effects of the spill on breeding success at COPR

In 2015, 62 western snowy plover nests were found at CORP and 34 of these nests hatched, resulting in a 55% hatching rate, which is above the long-term average (COPR 2015). From those 62 nests, 45 chicks fledged (Figure 18). The fledging rate (nests that fledged at least 1 chick, divided by the total number of nests that hatched at least 1 chick) was 78%, the highest it had been since 2009, as shown in Figure 19 (COPR 2015).

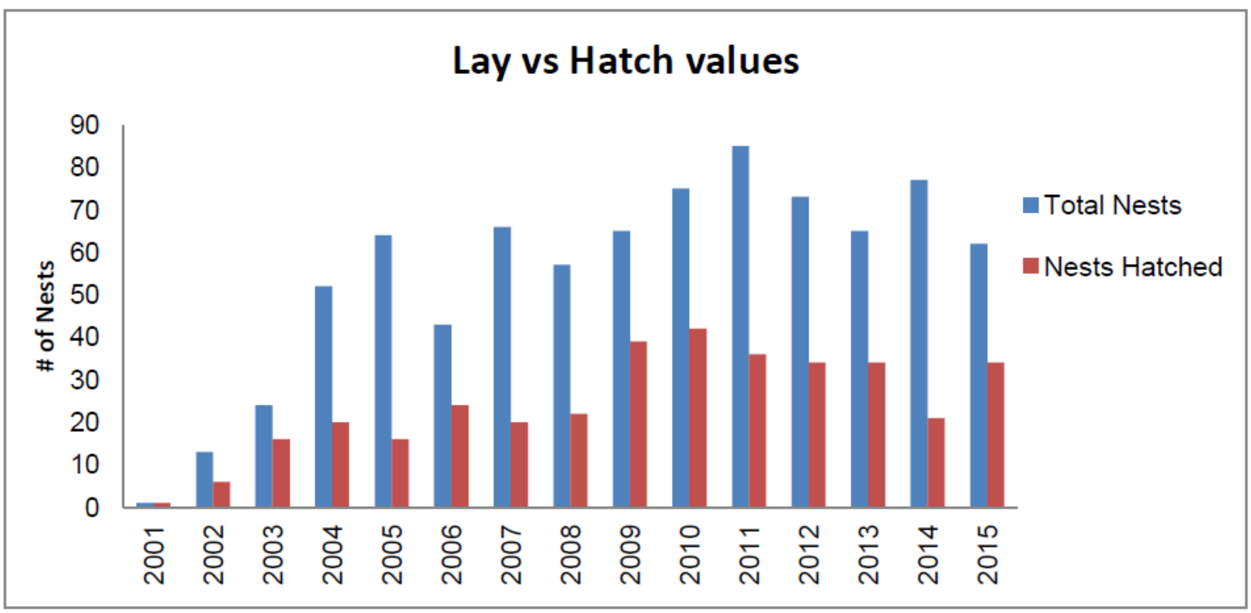

Figure 18. Nests laid (blue) compared with nests hatched (red) at Coal Oil Point between 2001 and 2015 (COPR 2015).

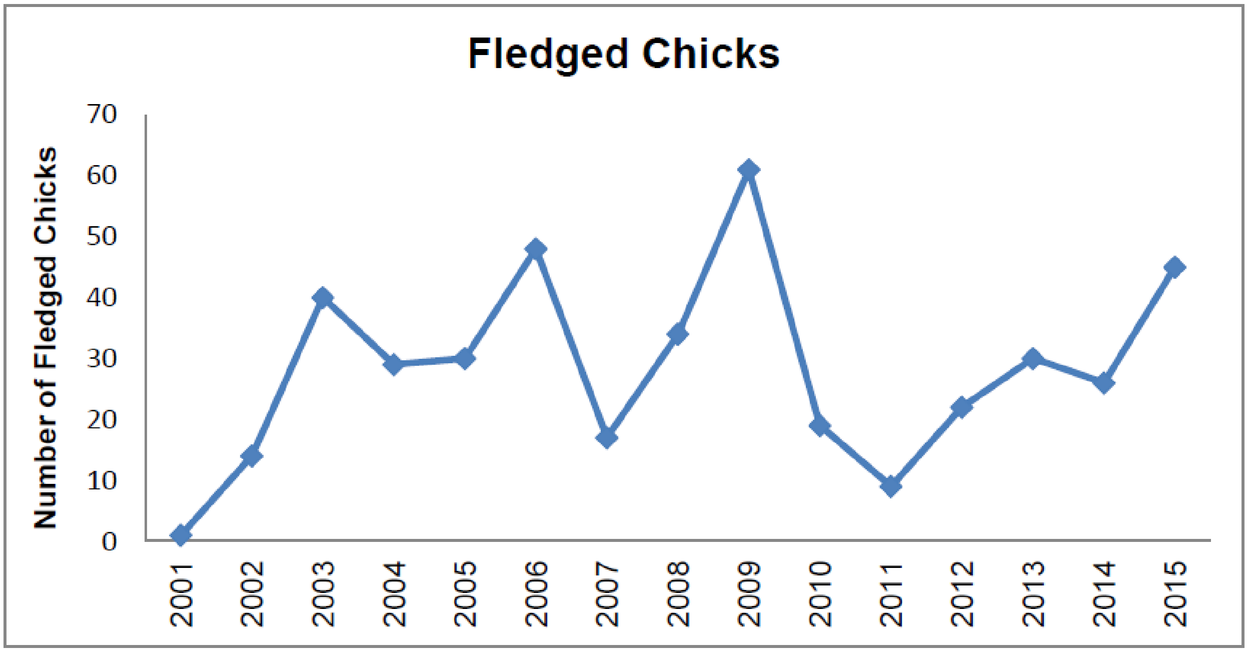

Figure 19. Number of chicks fledged from all nests each year at Coal Oil Point between 2001 and 2015 (COPR 2015).

Effects of the spill on body oiling at COPR

Unlike birds that dive in the water, western snowy plovers are exposed to oil while walking on the beach, bathing in shallow water, or foraging in and around kelp on the beach. To measure the amount of oiling on the western snowy plovers at COPR, each adult western snowy plover was photographed a total of 5 times during a 5-week period following the oil spill and again 2 months later (Figure 20). In the period following the oil spill through early June, the average percentage of western snowy plovers with oil on their body and bills was 37% and 41%, respectively. In late July, the percentage of western snowy plovers with oil on their body reduced to 4%, and percentage of western snowy plovers with oiled bills was 0% (Figure 21). This indicates that the occurrence of oil on the body and bills of western snowy plovers is likely attributed to the spill. The percentage of western snowy plovers with oil on their feet remained similar with 87% during the spill period and 76% in late July. As COPR is in close proximity to active oil seeps, the presence of weathered seep oil on COPR is common, and some level of oiling on plover feet is expected. Oil from the spill was fresh crude that was much less weathered and degraded when it arrived on COPR beaches, making it more “sticky” than weathered oil that typically washes up at COPR.

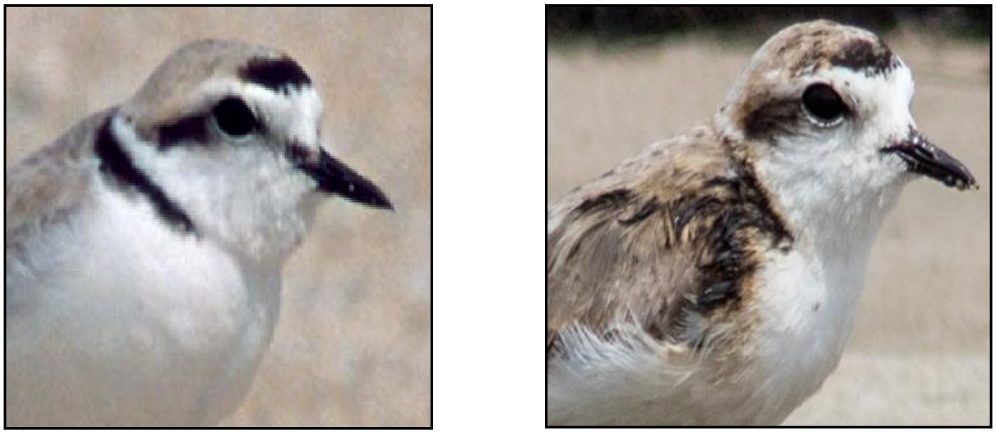

Figure 20. Sample photographs used for oiling analysis of western snowy plovers at Coal Oil Point. A clean plover is shown on the left, and an oiled plover is shown on the right. Photo credit: COPR 2015.

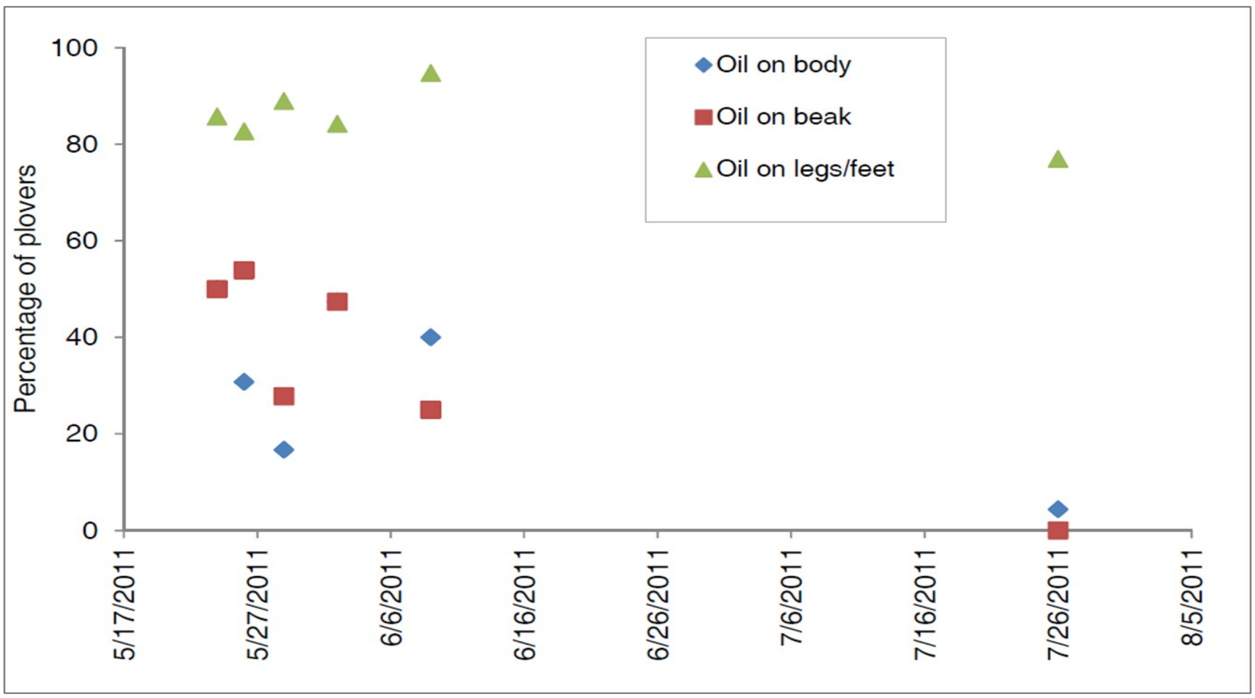

Figure 21. Results of photographic analysis of western snowy plover oiling on the body, beak, and feet/legs indicate that in the weeks immediately following the spill, over half of western snowy plovers at Coal Oil Point Reserve had oil on the beak and/or body, as compared with extremely low observations of oil on beak and/or body two months after the spill.

Risk of toxicity from oil ingestion

In order to understand whether the body and beak oiling document on western snowy plovers at COPR could cause harm to the birds, the Trustees conducted a screening level risk assessment using toxicity reference values identified in literature, and calculated oil exposure estimates by summing adult daily dietary and preening doses (Donohoe 2017). Fry et. al (1986) showed a negative relationship of external oiling of Santa Barbara crude oil on long-term fertility of wedge-tailed shearwaters, which were used as a surrogate for western snowy plovers in this analysis.

The results of this risk assessment indicated that the maximum calculated oil ingestion by western snowy plovers was over 8 times higher than levels that were documented to cause reproductive toxicity in shearwaters. Because over 70% of the season's nests had eggs that were already laid by the time oil reached the beach in 2015, it is unlikely that oil ingestion affected infertility in that year. Instead, the effects manifested a year later, which was the first time most birds had laid eggs since the spill. This delayed effect of oil ingestion on infertility rates has been documented in other birds (Fry et. al 1986). Because western snowy plovers at COPR are not banded, it was not possible to compare oiling on individuals to the fertility of those individuals in subsequent years. Despite the availability of fertility data for individual birds over time, a plausible connection between oil ingestion via preening and feeding and the increase in egg infertility in western snowy plovers at CORP the following breeding season was demonstrated.

Effects of the spill on western snowy plover fertility at COPR

Each year, western snowy plover eggs that don't hatch are opened by COPR staff to determine if the eggs were infertile (yolk intact), or had dead embryos. This procedure was continued during the oil spill response (2015) and subsequent years. The rate of infertile eggs fluctuates from year to year with an average of 2.13% infertility between 2001 and 2015 (n=1,785) (COPR 2018) (Figure 22). During the first breeding season after the oil spill, in 2016, the egg infertility rate increased to 9.56%, more than four times the average at COPR. In 2017, the egg infertility rate was higher than average at 3.95% but had decreased to a level more consistent with what had been observed prior to 2015 when the spill occurred. As described above, the increased levels of infertile eggs and dead embryos in the years following the spill may represent continued effects of the 2015 spill on plover reproduction.

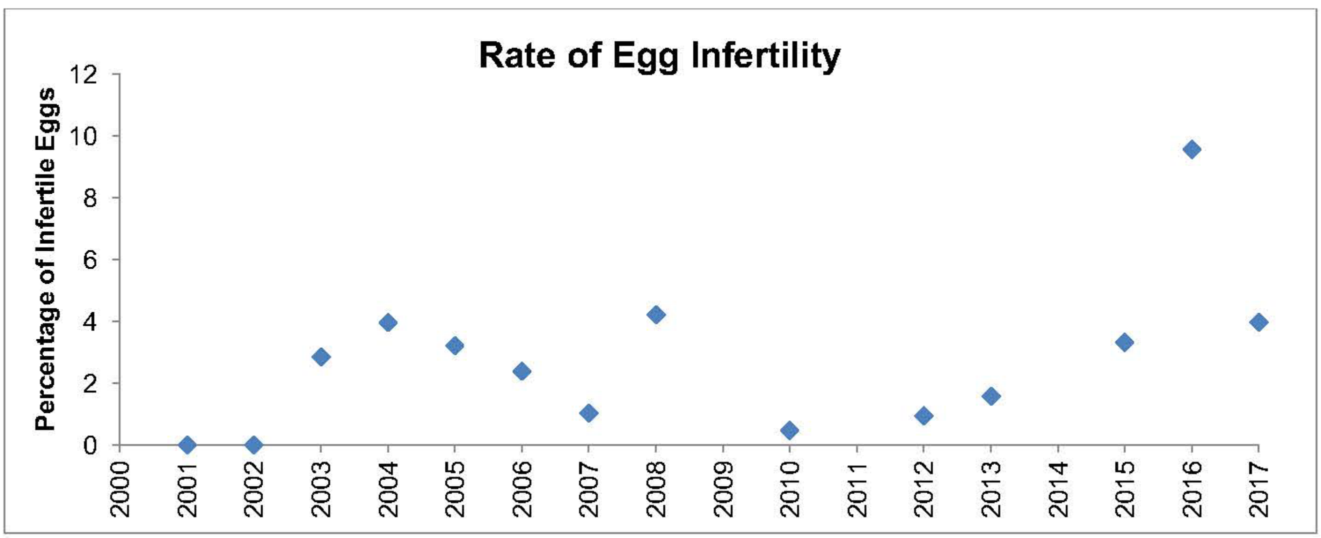

Figure 22. Percentage of infertile eggs by year (COPR 2018).

Effects of the Spill on Western Snowy Plovers at Other Locations

Western snowy plovers also nested in 2015 at San Buenaventura, McGrath, and Mandalay State Beaches in Ventura County (Frangis and Cox 2015), as well as Ormond Beach, Hollywood Beach, and Naval Base Ventura County, Point Mugu. One oiled western snowy plover was reported at Hollywood Beach (Barringer 2015). Farther south at Ormond Beach, no oiled western snowy plovers were observed, but the beach was oiled (Hartley 2015). At all of these Ventura County breeding sites where cleanup occurred, crews may have affected western snowy plover behavior resulting in minor decreases to reproductive success. Western snowy plovers also may have been oiled but not detected, and foraging habitat, including beach wrack, was affected by oil. These sources of injury to western snowy plovers are accounted for in the assessment of shoreline/sandy beach injury, presented in the DARP.

Estimate of western snowy plover injury

Western snowy plovers at COPR in Santa Barbara County, and various locations within Ventura County, were exposed to Line 901 oil during the Refugio oil spill. The spill occurred during the breeding season, and at the time of the spill many nests had been formed and eggs had been laid. COPR was exposed to heavy oiling and extensive response actions, and the Trustees determined that an assessment of injury to this population was warranted. All western snowy plover populations in Ventura County were exposed to some level of tarball oiling and disturbance from response actions. Due to the relatively low injury expected from this oiling and disturbance, these effects are captured as part of the shoreline habitat injury assessment which considers impacts to western snowy plover's prey base and disturbances to their habitat from response actions.

Response workers and land managers at COPR worked closely together to minimize impacts to western snowy plovers from oil spill cleanup actions. Managers documented oiling on western snowy plovers at COPR and disturbances to the birds from the presence of cleanup crews; however, no mortality was recorded and hatching and fledging rates met or exceeded long term averages. Therefore, no substantial injury at COPR was estimated in 2015, beyond impacts to food webs (through depressed beach invertebrate populations) and response impacts that are quantified as part of the shoreline injury assessment.

The year following the spill (2016), western snowy plover infertility substantially increased compared to the long term average, with a total of 12 infertile eggs, none of which contained embryos. Background infertility under normal conditions is around 2%, therefore, of the 12 infertile eggs, 2 would be expected to occur without the effects of the spill. The additional 10 infertile eggs cannot be explained by background infertility rates. These infertilities were likely caused by exposure of western snowy plover adults to oil during the 2015 breeding season. Adults were observed with oil on their plumage and beaks, which they preened and ingested. Adults were also observed foraging within oiled wrack, and their prey species (e.g., sandy beach invertebrates, such as sand crabs) were documented to have increased hydrocarbons in their tissue (see Section 5.1 of the DARP). In 2017, the infertility rate was reduced to a level that is within the range of normal variation. Based on typical hatching and fledging rates at COPR, the Trustees anticipate that of the 10 infertile eggs documented at COPR in 2016, 4 would have hatched and fledged. Therefore, we assert that at least 4 western snowy plovers at COPR were injured through reproductive injury from the Refugio oil spill. Additional injury to western snowy plovers may have occurred from direct oil exposure, prey reduction, and impacts from response operations. These effects to plovers from injuries to their habitat are captured in the shoreline injury analysis presented in Section 5.1 of the DARP.

Other Bird Species Injury

Bird species other than brown pelicans and western snowy plovers were also impacted by the spill, includingat least 28 species of seabirds, shorebirds, and landbirds. Table 1 lists all the birds by species collected alive and dead during the spill response.

After pelicans, impacts were spread among a variety of marine waterbirds and a few landbirds. Because the spill occurred during the nesting season for most North American birds, and most affected species do not nest locally, the impacts to them were largely limited to non-nesting individuals, such as sub-adults that were likely over-summering in the area. Had the spill occurred in winter, many more individuals from these species groups would have been impacted.

In order to estimate mortality for these species, the Trustees applied the following methodology, which will be explained further in the sections below.

1) Determine which of the collected birds were related to the spill:
    a. Identify species and numbers of birds collected;
    b. Identify number of visibly oiled and non-visibly oiled birds;
    c. Visibly oiled dead birds – adjust for baseline oiling from natural seeps;
    d. Non-visibly oiled dead birds – adjust for background deposition; and
2) Use the Beached Bird Model to identify how many birds were missed:
    a. Determine carcass persistence on beaches;
    b. Determine search effort;
    c. Determine search efficiency;
    d. Subtract rehabilitation credit; and
    e. Calculate total injury.

Determining which of the collected birds were related to the spill

A portion of the live and dead birds collected during the spill response may not have been impacted by the spill. The Trustees analyzed the live and dead bird intake records to determine which animals were likely injured or killed by the spill and which were not. The methodology is described below.

Live birds

All of the 66 birds recovered live and transported to rehabilitation centers were assumed to be spill-related. Of those, 47 were brown pelicans and so are not included in this analysis (see Brown Pelican Injury Analysis section above). Of the remaining 19 birds, one live Pacific loon captured at the end of the spill period (on June 14, 2015) had oil on it that was analyzed and found not to match Refugio incident oil. The bird was removed from the total. The Trustees assumed that no birds collected after June 14, 2015, were related to the spill. Thus, 18 birds, other than pelicans, were collected alive and attributed to the spill.

Dead birds

Of the 203 birds collected dead, 26 were pelicans and so are not included in this portion of the analysis (see Brown Pelican Injury Analysis section above). Additionally, two domestic ducks and one pigeon were removed from the total, as these non-native species are not protected under state and federal statutes. With these adjustments, the total number of dead birds used in this analysis was 174 birds. Of these, 85 were visibly oiled and 89 were not visibly oiled.

Dead birds- visibly oiled

Because natural oil seeps occur in the area (Henkel et al. 2014), a low number of oiled birds are regularly found. Thus, it is likely that some of the oiled birds collected during the spill response were oiled by natural oil seeps rather than the spill. Analyzing the petroleum fingerprint of oil from each bird carcass is both costly and possibly inconclusive, as results can be confounded by weathering and mixing of oil. To avoid this cost and ambiguity, the Trustees instead determined the background oiling rate of dead birds on impacted beaches using data from the BeachCOMBERS program. This rate was then applied to the oiled dead birds found during the spill response to determine the number of bird deaths assumed to be related to natural seeps rather than to the spill.

Eleven beaches within the spill zone are routinely surveyed as part of the BeachCOMBERS program, which counts and assesses bird carcasses for oiling status (among other factors) on a monthly basis. Historic oiling data (2013 to 2015) from birds identified on these eleven beaches for the months of May, June and July were analyzed to calculate a monthly average oiling rate for each beach. These months were selected because carcass deposition fluctuates during the year and these months are representative of the spill period.

Figure 23 illustrates the results, comparing the background number, per kilometer of beach, of dead oiled birds on the BeachCOMBER survey beaches with the number of dead oiled birds collected during the spill response on the same beaches. These data indicate that the number of oiled bird carcasses collected following the spill was significantly higher than the number observed in previous years, particularly on the west-facing beaches near Ventura, directly in the path of the oil. During the spill, an average of 0.83 oiled birds per kilometer were collected, compared with a historic average of 0.12 oiled birds per kilometer. This implies that 14% of the dead oiled birds collected were likely attributable to seep oil, and 86% were spill-related. Applying this background oiling rate to the 85 oiled dead birds (not including brown pelicans, the rock pigeon, or the two domestic ducks) collected during the response implies that 12 bird mortalities were likely not attributable to the Refugio incident and 73 were spill-related.

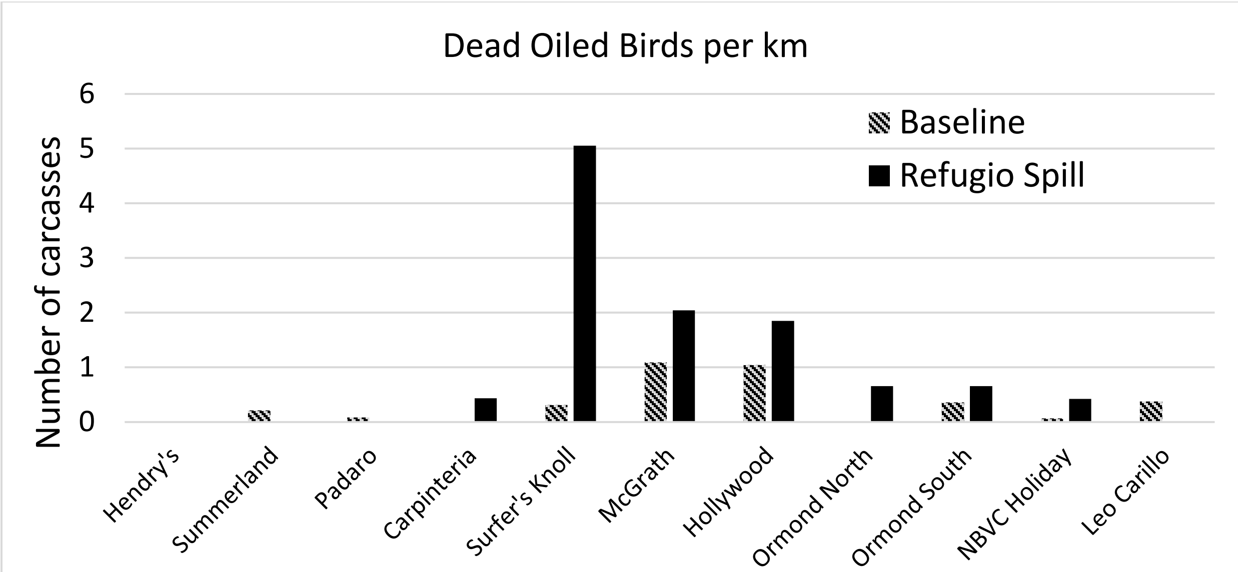

Figure 23. Dead oiled birds per kilometer collected during the response period (in black) compared with the baseline monthly average dead oiled birds per kilometer determined using data from the BeachCOMBERS program (in cross-hatch).

For purposes of the Beached Bird Model (described further below), rather than remove 12 of the birds from the list, without knowing which ones were actually seep-related mortalities, each of the 85 oiled dead birds were counted as 0.86 of a bird.

Dead birds- non-visibly oiled

Dead birds after an oil spill may not show any visible oil for a variety of reasons. The most common reason is that they are quickly scavenged, with the breast and belly feathers (where the oiling is most likely to occur) among the first feathers removed. As carcasses become old and desiccated, oiling becomes more difficult to detect. Nevertheless, it is common after an oil spill to see a spike in non-visibly oiled dead birds, suggesting they are related to the spill.

Of the 89 birds (not including brown pelicans, the rock pigeon, and domestic ducks) that were collected dead and not visibly oiled, the Trustees again relied on a comparison to baseline data from BeachCOMBERS survey beaches to detect a spill signal and estimate the difference between that spike and baseline numbers. Figure 24 shows the number of non-visibly oiled birds collected during the response compared with the average monthly number of non-visibly oiled birds calculated from the BeachCOMBERS data (i.e., baseline). Overall, following the Refugio oil spill, the number of non-visibly oiled birds collected was higher than the baseline number.

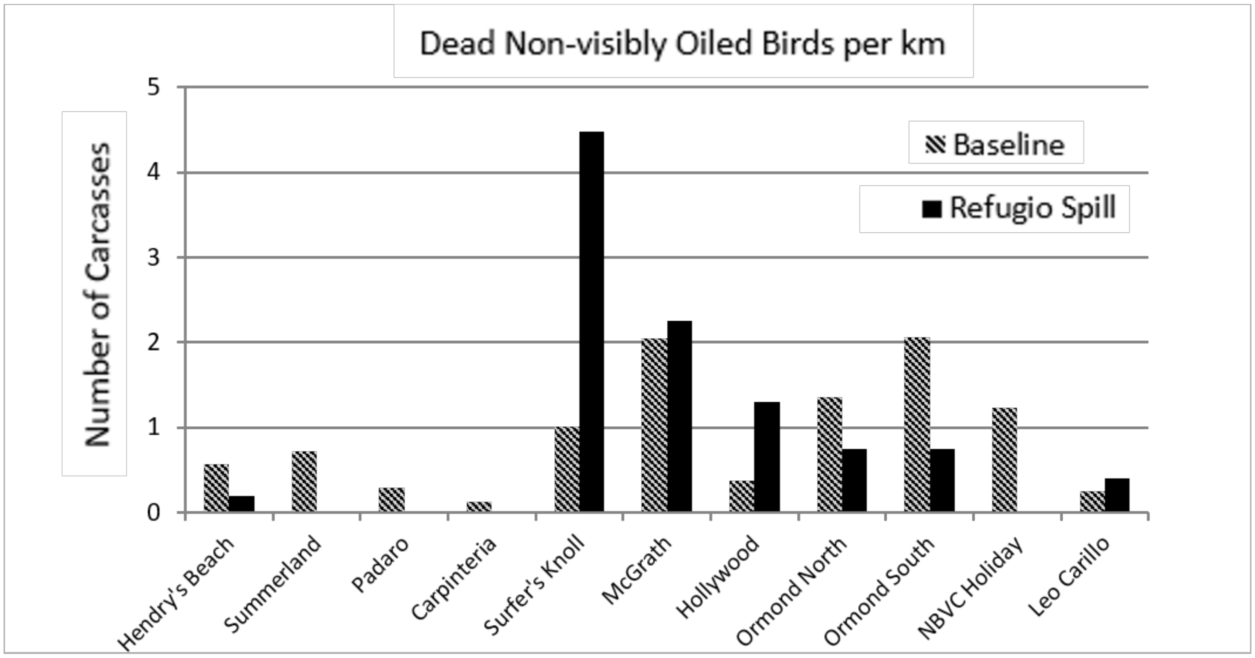

Figure 24. Dead non-visibly oiled birds per kilometer collected following the Refugio spill (black) compared with the baseline" monthly average calculated from the BeachCOMBERS data (cross-hatch).

To analyze these data further, the 89 non-visibly oiled dead birds were divided into three categories: fresh carcasses (n=23), decomposing carcasses (n=30), and fully desiccated carcasses ("mummies") (n=36). Carcass condition was recorded when dead birds were evaluated during intake. Historic BeachCOMBERS data also include these carcass delineations. Data from birds in each carcass category from the eleven beaches surveyed by BeachCOMBERS for the months of May, June and July were analyzed to calculate a monthly average deposition rate on each beach. These were compared to the analogous rates during the spill response period.

The results, tabulated in Table 6, show that fresh non-visibly oiled carcasses were found at nearly four times the rate that fresh carcasses are usually found, decomposing birds were found at about the same rate, and fewer mummified carcasses were found during the spill than would normally be expected. This implies that most of the fresh non-visibly oiled carcasses were likely due to the spill, some of the decomposing non-visibly oiled birds were likely due to the spill, and none of the mummies were likely due to the spill.

Table 6. Carcass condition of non-visibly oiled birds

	Baseline	Refugio Spill
Fresh	6%	22%
Decomposing	28%	26%
Mummified	53%	33%

These data were further analyzed to consider the fact that fresh and decomposing birds are disproportionately removed from beaches by scavengers, while mummies tend to persist for weeks. Taking this additional factor into account for purposes of the Beached Bird Model, the 23 fresh non-visibly oiled birds were counted as 0.70 of a bird. The 30 decomposing non-visibly oiled birds were counted as 0.37 of a bird. This method of applying an appropriate coefficient to each bird in these respective categories allows the model to weight fresh non-visibly oiled birds more heavily in the analysis and the non-visibly oiled birds less heavily, as appropriate due to the likelihood that each of these groups of birds should be attributed to the spill. All of the mummies were considered to pre-date the spill period and, thus, were removed from the injury calculations.

Total birds collected and attributed to the spill

All of the birds, not including brown pelicans, domestic ducks, and a rock pigeon, collected and attributed to the spill are shown in Table 7.

Table 7. All birds, not including pelicans, domestic ducks and a rock pigeon, collected and attributed to the spill.

	Total collected	Spill-related	Not-spill related	Total spill-related
Collected Live	19	95%	5%	18
Collected Dead				
Visibly oiled: spill-related	85	86%	14%	73
Not visibly oiled: fresh	23	70%	30%	16
Not visibly oiled: decomposing	30	37%	63%	11
Not visibly oiled: mummies	36	0%	100%	0
TOTAL	193			118

Calculating the number of birds missed

As with the brown pelican assessment above, it is very likely that the actual number of birds other than brown pelicans and western snowy plovers impacted by the spill exceeds the 118 enumerated above. Birds impacted by an oil spill may not be collected for a variety of reasons:

1. They may travel outside of the response area. As described above, this occurred with the large number of pelicans migrating north.
2. They may die at sea, sink, or be carried away by tides from beaches that were searched.
3. They may come ashore on inaccessible beaches that cannot be searched.
4. Once on the beach, they may be removed by other animals scavenging on the beach.
5. For carcasses that do make it to accessible beaches and are not removed by scavengers, searchers may miss them.

In this case, with the non-pelican species, it is difficult to assess the first two reasons. Some species, such as loons, were migrating north, but most non-pelican species may have been more acutely debilitated by the oil, limiting their dispersal distance. Because the spill was nearshore, substantial loss of birds at sea was unlikely. Given these caveats, we did not specifically apply any correction factors for these first two reasons for non-pelican bird species.

The remaining three factors, inaccessible beaches, carcass removal, and search efficiency, can be incorporated into a Beached Bird Model in order to estimate total mortality. The model is based on the number of birds recovered, the probability of a beached bird persisting over a given time interval, and the likelihood that searchers will detect a beached bird. Derivation of the basic equation is from Ford et al. (1996) and Page et al. (1990). This approach has been used for most major oil spill bird mortality events for several decades. Using a simplified example, if the probability of a bird being removed by a scavenger in the course of a day is 50 percent, and the probability of it being overlooked by a searcher is 50 percent, then the probability of it being recovered is 25 percent. This would imply that for every bird found, three more are missed. This would result in a "beached bird multiplier" of four. That is, one bird found implies that four birds died.

The Beached Bird Model requires estimating the following parameters in order to calculate the deposition rate of dead and dying birds:

1. Carcass persistence on beaches;
2. Searcher effort; and
3. Searchefficiency.

Carcass Persistence

Carcass persistence was calculated based on BeachCOMBER data. During BeachCOMBER surveys, bird carcasses are marked by clipping a toe each time the bird is encountered. Surveyors document the number of clipped toes on each bird to document how long the carcass has persisted on the beach (e.g., a carcass with no clipped toes has not been previously found, 1 clipped toe is at least 1 month old, etc.). BeachCOMBER data collected between 2013 and 2015 from beaches within southern Santa Barbara and Ventura Counties were analyzed to determine carcass persistence in the spill-affected area. These data suggest that if 100 birds were encountered on Day 0, 32.3 will still be there on Day 30, and 12.3 will still be there on Day 60. Figure 25 shows these data fitted with a logarithmic curve mimicking the curves derived from past studies whereby carcasses disappear more quickly after initial deposition.

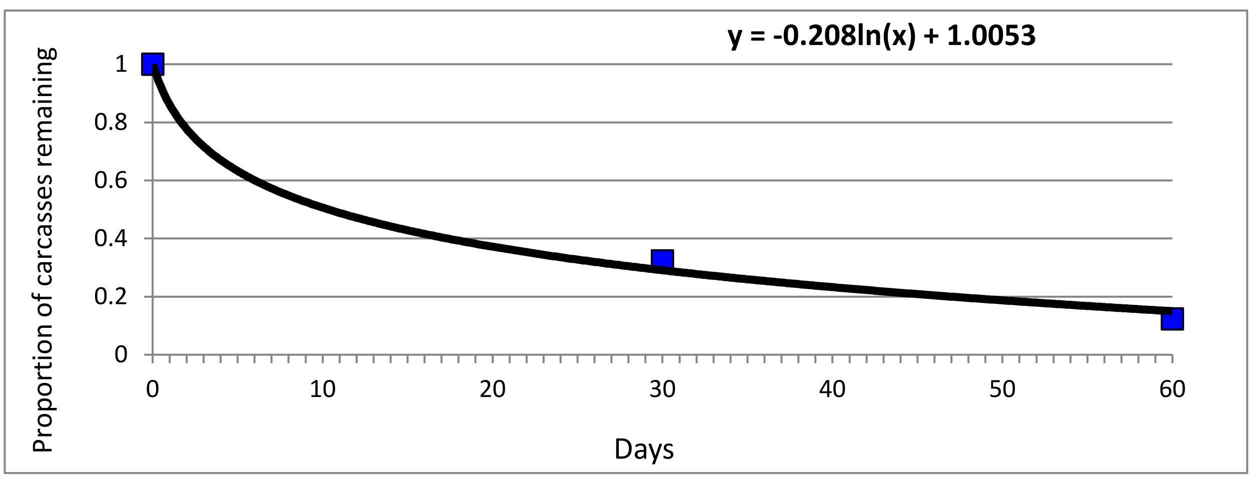

Figure 25. Carcass persistence based on BeachCOMBER data collected between 2013 and 2015 from beaches near the spill.

Because beaches are searched nearly daily during a spill response, the first week or two of the curve is the most relevant. Figure 26 shows estimated carcass persistence the first 1 to 14 days, and indicates that carcass persistence is about 60% after a week. This is similar to previous studies in northern California and Oregon.

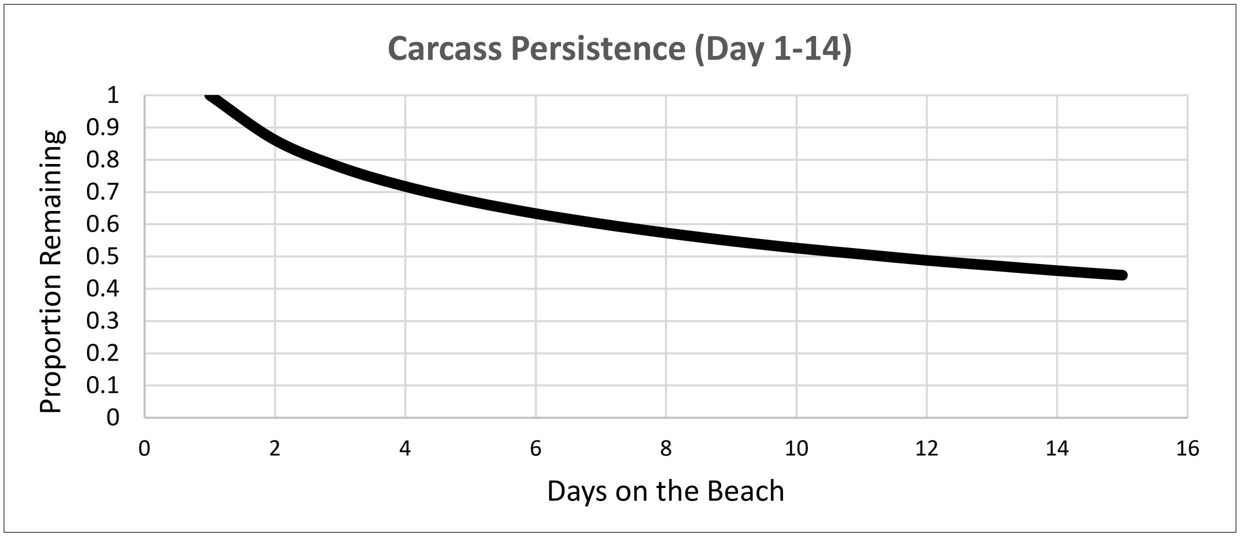

Figure 26. Calculation of carcass persistence in the first week of deposition.

Search Effort

The Beached Bird Model considers the proportion of beaches that were searched and unsearched. Search effort was calculated from the review of records throughout the spill of beach searches conducted by wildlife operations, cleanup crews, shoreline cleanup assessment technique (SCAT) teams, and other response activities. The results of this analysis are shown in Table 9 and were used in the Beached Bird Model. For beach segments that are never searched, the model simply averages the number from adjacent segments and applies that result to the unsearched segment. In this case, that factor was trivial, as nearly every beach between Gaviota and Point Mugu was accessible and searched. Many beaches were searched daily between May 20 and June 8.

Search Efficiency

It is surprisingly easy for searchers to miss beached birds. Debris or wrack-filled beaches are visually difficult environments, and birds can be hidden in small depressions, blend in with other debris, or be too far away to recognize. Studies of search efficiency have been conducted previously following other oil spills in California. For this case, the Trustees chose to adopt search efficiency parameters determined through studies conducted during the M/V Kure oil spill and the S.S. Jacob Luckenbach oil spill (Ford et al. 2006, Luckenbach Trustee Council 2006). The search efficiency values used in this case are shown in Table 8. Different values are used for large birds than for small birds because large birds are inherently more identifiable and are less likely to be missed by searchers than small birds.

Table 8. Search Efficiency

Large Birds	0.54
Small Birds	0.206

Table 9. Refugio Oil Spill Search Effort by Date and SCAT Segment. Segments are listed from North to South starting with SBIS-IS001 near Gaviota, and ending with South Bay near Santa Monica.

Wildlife Ops complete coverage	w ith SCAT	w ith Cleanup
Wildlife Ops partial coverage	w ith SCAT	w ith Cleanup
SCAT team only		
CleanUp team only (or w SCAT)		
DOES NOT INCLUDE NRDA ONLY TEAMS		

	0	1	0	2	7	2	0	1	0	0	1	13	3	0	1	0	1	9	10	0	2	2	0	1	0	2	0	0	0	10	2	1	0	0	0	3	0	0	10	0	18	4	2	10	5	2	15	14	16	15	3	8	2	0	11	4	1	0	0	2	0	1		13
	SBIS-IS-001	SBIS-IS-002	SBIS-IS-003	SBIS-IS-004	SBIS-IS-005A	SBIS-IS-005B	SBIS-IS-005C	SBJS-JS-001A	SBJS-JS-001B	SBJS-JS-001C	SBKS-KS-001A	SBKS-KS-001B	SBLS-LS-001	SBLS-LS-002	SBMS-MS-001	SBMS-MS-002	SBMS-MS-002E	SBNS-NS-001	SBNS-NS-002	SBNS-NS-003	SBOS-OS-001	SBPS-PS-001	SBPS-PS-002	SBQS-QS-001	SBQS-QS-002	SBQS-QS-003	SBQS-QS-004	SBQS-QS-005	SBRS-RS-001	SB Harbor	SBRS-RS-003	SBRS-RS-004	SBRS-RS-005	SBSS-SS-001	SBSS-SS-002	SBSS-SS-003	SBTS-TS-001	SBTS-TS-002	SBTS-TS-003	SBTS-TS-004	VNAS-AS-001	VNBS-BS-001	VNCS-CS-001	VNDS-DS-001	VNDS-DS-002	VNDS-DS-003	Ventura Harbor	VNES-ES-001	VNES-ES-002	VNES-ES-003	Channel I Harbo	VNFS-FS-001	VNFS-FS-003	VNGS-GS-001	VNGS-GS-002	VNHS-HS-001	VNHS-HS-002	VNHS-HS-003	VNHS-HS-004	VNHS-HS-007	VNHS-HS-008	VNIS-IS-001	VNIS-IS-002 to	SOUTH BAY
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Results of the Beached Bird Model

Based on the results of the Beached Bird Model (incorporating scavenging, search efficiency, and unsearched areas), the Trustees estimated that a total of 236 other birds were killed by the spill, not including brown pelicans and western snowy plovers.

Table 10. Summary of estimated mortality for "other birds" based on the results of the Beached Bird Model.

Bird Taxon	Total Birds Collected[1]	Total Estimated Mortality
Alcids	42	56
Loons	44	53
Procellarids/Boobies	23	35
Gulls/Terns/Skimmer	24	33
Cormorants	33	24
Grebes	15	21
Surf Scoter	3	6
Other/Unknown	9	8
TOTAL	**193**	**236**

[1]Not including pelicans, domestic ducks, a rock pigeon, and three rehabilitated and released birds. Note that a proportion of these carcasses were found to not be spill-related (see Table 7).

Rehabilitation Credit

Of the 18 non-pelican birds collected alive, only three were rehabilitated sufficiently to allow their release. All others died in care. These numbers are quite different from the corresponding figures for brown pelicans, for which 47 were collected alive and 43 released. The difference is largely because these non-pelican species were smaller and more sensitive to oiling than pelicans. The fate of the three released birds is unknown. Various post-release studies have produced a variety of results regarding the long-term survival of rehabbed and released birds. The results depend on species impacted and conditions in the field. For the purposes of this assessment, we will assume one of the three released birds survived and re-entered the breeding population (resulting in a rehabilitation credit of one bird).

Total Other Bird Injury

Applying the rehabilitation credit to the results of the Beached Bird Model results in a total of 235 birds injured by the spill (not including brown pelicans and western snowy plovers) as calculated below.

Total birds collected	193
Birds that were not related to the spill	-75
Estimated number of birds missed	+ 118
Rehabilitation credit	- 1
TOTAL Other Bird Injury	235

Summary of Bird Injury

Table 11. Total estimated bird mortality resulting from the Refugio Beach Oil Spill.

Bird Taxon	Total Estimated Mortality
Brown Pelicans	319
Western Snowy Plovers	4
Alcids	56
Loons	53
Procellarids/Boobies	35
Gulls/Terns/Skimmer	33
Cormorants	23
Grebes	21
Surf Scoter	6
Other/Unknown	8
TOTAL	**558**

Calculating Lost Bird Years

Lost bird-years were calculated several different ways, depending upon the species. Theoretically, lost bird-years are the difference between two different population trajectories: without the spill (baseline) and with the spill (injured). Without restoration, the two trajectories only converge (i.e., the injured population only recovers to baseline levels) if there is a natural compensating mechanism dependent upon population size (at least at the local, or colony, level). Thus, the calculation of lost bird-years must be consistent with a biological explanation of natural recovery over time (or lack thereof) (Zafonte and Hampton 2005).

The Single-Generation Stepwise Replacement Model was used to calculate lost bird-years. This approach is described below. For all bird-year calculations, a 3% discount rate is employed, consistent with common practice in natural resource damage assessments. The demographic parameters used in the bird Resource Equivalency Analysis are drawn from literature containing life history information for the species (see Injury Calculation section below).

Single-Generation Stepwise Replacement Model

The single-generation stepwise replacement approach to calculating lost bird-years assumes that each year after a spill the juvenile age class will be entirely replaced. That is, despite the fact that some breeding adults have been killed, the population produces the same number of juveniles post-spill as it did pre-spill. Biologically, this could occur if the population was at carrying capacity with respect to breeding opportunities (perhaps limited by available nesting habitat or food base during the nesting season). The loss of some adults would open up room for other adults (i.e. "floaters") to take over the vacant nesting opportunities and, thus, maintain the population's annual production of juveniles. Thus, the youngest age class impacted by the spill will fully recover to its pre-spill level after the next breeding season. The second-year age class will fully recover two years after the spill, as the recovered first-year birds grow older. Likewise, the third-year age class will fully recover after three years, and so on. Mathematically, this is equal to calculating the number of years lost by the killed birds, based on the life expectancy of each age class. Details regarding the demographic parameters used to calculate lost bird years are presented in the "Injury Calculation" section below.

This method roughly follows the same approach as used for calculating "direct loss" for birds with "extended" recovery times in the *North Cape* oil spill, and Luckenbach NRDA. Calculations are based upon the following assumptions:

> ***Assumption 1:*** Acute spill mortality is distributed proportionately across the various age classes of the injured population.
>
> ***Assumption 2:*** Rates of juvenile and adult survivorship are constant before and after the spill.
>
> ***Assumption 3:*** The pre-spill and fully recovered populations are roughly constant in size and stable in age-distribution, as determined by demographic characteristics of the species (specifically survivorship and fecundity).
>
> ***Assumption 4:*** There is a maximum age beyond which no birds live.
>
> ***Assumption 5:*** Surviving adult birds match the total reproductive output that the surviving and impacted birds would have had in the breeding seasons after the spill had the spill not occurred (i.e. the number of post-spill nests equals the number of baseline nests). This could occur because of non-breeding "floaters" in the area, reduced competition for high quality nesting sites, or decreased competition for foraging around the breeding area.

Figure 27 provides an example of how these assumptions combine to describe biological recovery in a hypothetical population with three one-year age classes. Year -1 depicts the population's pre-spill conditions. Year 0 shows population numbers prior to the first full year after the spill. The shaded area is the number of each age class killed, which is distributed proportionately between age classes (Assumption 1). The arrows describe how the recovered birds advance through each age class.

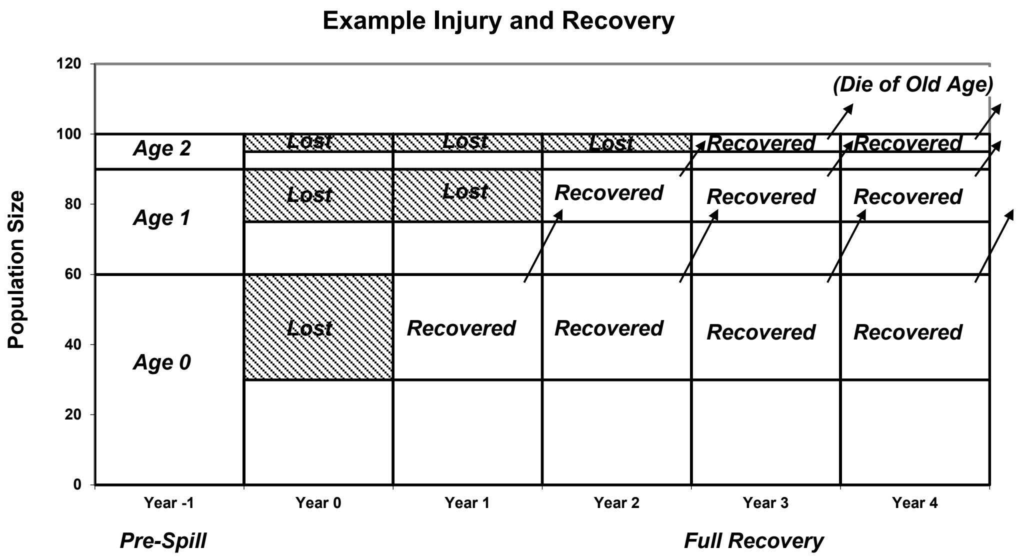

Figure 27. Example of recovery by age class over time

In Year 1, the number of fledglings replaces the losses to the first age class (Assumption 5). The age classes from Year 0 all face annual mortality with complete mortality for the third age class. This process continues in Year 2, with the recovered Age 0 juveniles from Year 1 facing mortality and growing one year older to reach Age 1. In Year 3, there is full recovery. These calculations do not include impacts to future generations of birds (i.e., "indirect loss" as considered by Sperduto et al. (1999, 2003).

Injury Calculation

As described earlier, the total estimated mortality for pelicans was 319, and the total for other seabirds was 235. Combined, these total 554 (not including the 4 western snowy plovers addressed elsewhere in the assessment).

To scale the size of the compensatory restoration projects to the size of the injury, the Trustees convert the total estimated mortality (554) into lost bird-years, using the single-generation stepwise replacement approach described above.

Because brown pelicans constitute the majority of the injury, and because the other seabirds have life-history parameters similar to pelicans on average, the Trustees used pelican life-history parameters to estimate lost bird-years. For brown pelican data, we relied upon Williams and Joanen (1974) and Anderson et al. (1996).

Brown Pelicans

- *Age of First Breeding:* 3 Years Old
- *Female Offspring per Female:* 0.33 (fecundity = 0.66)
- *Annual Survivorship (Age 3-4+):* 88%
- *Annual Survivorship (Age 2-3):* 80%
- *Annual Survivorship (Age 1-2):* 72%
- *Survivorship (From fledge to one year of age):* 64%
- *Maximum Age:* 34 Years

The result is that the bird-year multiplier, based on these life-history parameters for pelicans, is 6.28. This multiplier was then applied to the 554 estimated dead birds resulting in 3,479 discounted lost bird-years (554 x 6.28 = 3,479 discounted lost bird-years). The restoration projects proposed to compensate for these lost bird-years are scaled to create same the number of bird-years that were lost due to the spill.

Bird Injury Summary

In summary, the assessment of injury to birds from the Refugio oil spill was conducted by dividing all affected birds into three categories: brown pelicans, western snowy plovers, and all other birds. The assessment methods for each category were designed around the species' life-history strategy and feasible methods for quantifying injury. Based on the assessment, the Trustees estimated that approximately 319 brown pelicans, and 235 other birds were killed as a result of the Refugio Beach oil spill. Figure 28 shows the overall summary of estimated bird mortality by species group. Additionally, reproductive injuries to western snowy plovers at COPR resulted in the loss of at least 4 western snowy plovers, that would have hatched and fledged but for the spill.

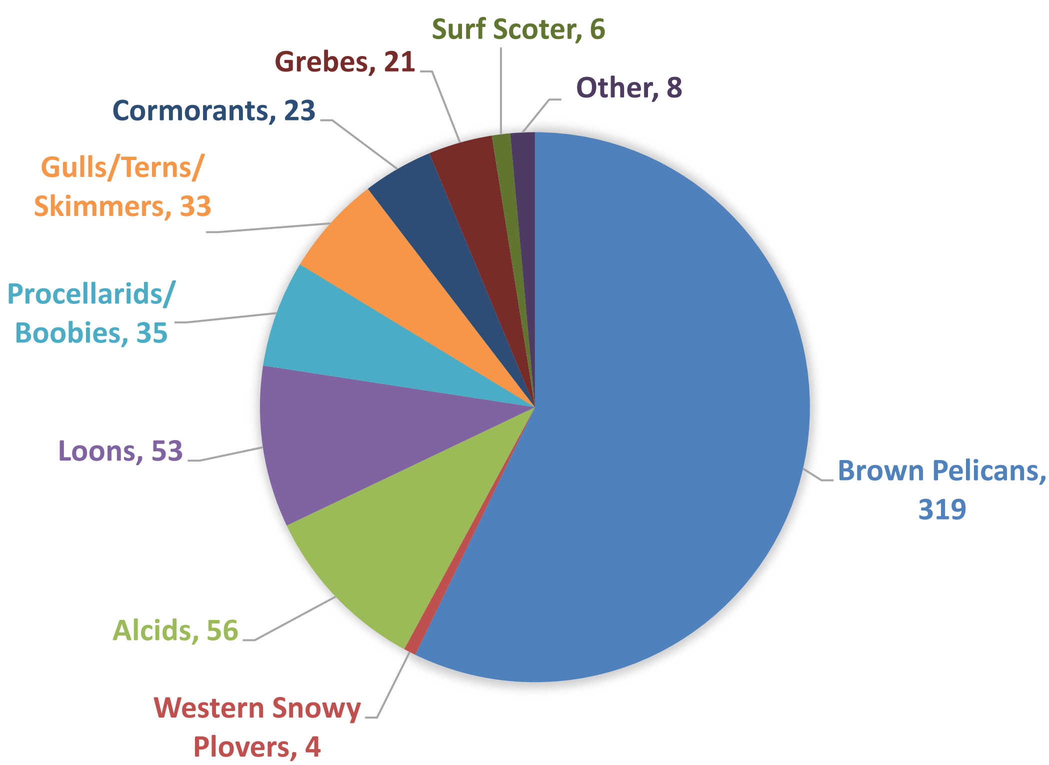

Figure 28. Estimated mortality of birds from the Refugio Beach oil spill (558 total) by species groups.

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Appendix J. 2015 Refugio Beach Oil Spill:
Marine Mammal Exposure, Injury and Restoration

Overview

Assessment of injury to marine mammals from the 19 May 2015 Refugio Beach Oil Spill (RBOS) included (1) a pre-assessment survey to identify the presence of cetacean and pinniped species within the spill zone in the weeks following the oil spill, and (2) analyses of post-spill stranding patterns as they relate to baseline conditions. This technical report includes a description of the data collected and methods used to assess injury to both pinnipeds and cetaceans.

1. Background

Most of the marine mammals known to occur off the California coast can be found in the Southern California Bight, and most of those are seen regularly in the Santa Barbara Channel (Barlow and Forney 2007, Barlow 2016, Carretta 2019).

Below is a brief overview of the cetaceans (whales, dolphins and porpoises) and pinnipeds (seals and sea lions) observed off the Santa Barbara and Ventura County coastlines shortly after the RBOS. The species presented are those that were sighted at-sea or observed stranded on the beach during the spill response period. A broader summary of each species can be found in National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS)'s Pacific Stock Assessment Report, which includes references to primary literature on the biology, abundance and distribution for each species (Carretta 2019).

The southern sea otter, an endangered species, is known to use the kelp beds of the Santa Barbara Channel and was a species of concern for effects from the RBOS spill. However, in an aerial survey conducted by the Incident Command on 21 May 2015, no sea otters were observed. There were also no reports of sea otters at other times during the oil spill response. Therefore, the Trustees did not consider sea otters further in the assessment.

a. Cetaceans observed following the Refugio Beach Oil Spill

Coastal bottlenose dolphin (*Tursiops truncatus*): The southern California coastal bottlenose dolphin population is less than 500 individuals and is typically found just outside of surf break less than 500 m from the beach and no farther than 1 km from shore (Carretta *et al.* 1998). These dolphins are nomadic, regularly traveling within a range that extends from Ensenada, Baja California, Mexico, in the south to Monterey Bay, California, in the north. This population has been studied since the early 1980s, and a 30-year photo-identification catalog is maintained by the NOAA NMFS, Southwest Fisheries Science Center (SWFSC) to document this population's movements and to estimate their abundance (Hwang *et al.* 2014, Weller *et al.* 2016).

Eastern North Pacific long-beaked common dolphins (*Delphinus delphis bairdii*[1]): This small dolphin species is a year-round resident of southern California's nearshore waters from within 1 km of shore to approximately 30 km offshore. Their range extends from approximately Monterey Bay to the southern tip of Baja California, Mexico, and the population off the California coast is estimated to be more than 100,000 (Carretta *et al.* 2011). Long-beaked common dolphins are routinely seen in the Santa Barbara Channel and are often sighted from Coal Oil Point (Smith 2017).

Gray whale (*Eschrichtius robustus*): Gray whales are seen off the southern California coast from approximately December through May, when most of the population of around 20,000 whales migrates between summer feeding grounds in the Arctic and winter breeding lagoons in Baja California, Mexico (Perryman and Lynn 2002, Weller *et al.* 2012). The migration has distinct phases for different sex and age classes. The last phase of the migration is made up of northbound adult females and their new calves. This last phase follows a near shore path just outside the surf zone off the California coast and typically concludes in late May (Poole 1984). As the migration ends, there are usually daily sightings of adult female and calf pairs passing by the Santa Barbara and Ventura County coastlines.

Humpback whale (*Megaptera novaeangliae*): Humpback whales feed off the California coast in the summer. Southern California is the southern limit of their summer feeding range, and these whales are most numerous here in the spring and summer (Campbell *et al.* 2014). Off Santa Barbara and Ventura Counties, humpback whales are often sighted feeding in the Santa Barbara Channel and around the northern Channel Islands (Campbell *et al.* 2014).

b. Pinnipeds observed following the Refugio Beach Oil Spill

California sea lion (*Zalophus californianus*): The Channel Islands contain the largest California sea lion rookeries in the United States, which serve as their primary breeding and pupping area. (Lowry *et al.* 2017). The primary breeding season is from May through July. Most pups are typically born in late June and weaned six to nine months later. California sea lions are found year-round in southern California, but all age and sex classes are only present at the same time during the breeding season; sub-adult and adult males migrate north, regularly as far north as British Columbia, Canada, during the non-breeding season. California sea lions are regularly sighted at-sea and hauled out on mainland beaches (Caretta 2019).

Pacific Harbor seal (*Phoca vitulina richardii*): This subspecies of harbor seal ranges from the Bering Sea to central Baja California. Harbor seals haul out to breed, pup, molt and rest. They have high site fidelity and are often known to use the same haul out site throughout their life (Lowry *et al.* 2008). Breeding and pupping occur during winter and spring; pupping dates vary latitudinally with later pupping dates occurring at rookeries farther north. There are haul outs in the Channel Islands and on mainland beaches in southern California, and there are several along the coast line of Santa Barbara and Ventura counties (Lowry *et al.* 2008).

[1] The taxonomy of common dolphins is under review at the time of writing of this report. *Delphinus capensis* was the species name ascribed to the long-beaked common dolphin in 1994, and the current subspecies designation is a recent revision by the Taxonomy Committee, Society of Marine Mammals (https://www.marinemammalscience.org/species-information/list-marine-mammal-species-subspecies/).

Northern elephant seal (*Mirounga angustirostris*): This species hauls out on Channel Islands and mainland beaches to breed, pup and molt (Caretta 2019). Breeding and pupping occur from December to March, and pups are weaned after 1 month. Molting takes place in spring (LeBeouf *et al* .1994).

c. Potential routes of exposure and toxicological effects

Both cetaceans and pinnipeds can be exposed to oil via inhalation, aspiration, ingestion of contaminated prey or water, and dermal exposure, especially through the eyes or other wounds and lesions. External oiling has been documented to cause lesions in harbor seals (Spraker et al. 1994). External oiling of fur (fur seals) or flippers (California sea lions or harbor seals) can also affect thermoregulation (Lipscomb *et al.* 1994; Odell 1974).

Exposure to oil can lead to damage to liver and kidneys and adrenal systems, suppression of the immune system and reproductive failure (Englehardt 1983). The *Exxon Valdez* oil spill affected killer whales (cetaceans), harbor seals and other pinnipeds, and sea otters, in some cases causing population level effects lasting decades (Loughlin 1992; Matkin et. al. 2008). More recent studies, undertaken for the *Deepwater Horizon* oil spill natural resource damage assessment (NRDA), discussed in a special edition of Endangered Species Research, document post-spill effects such as lung disease, impaired stress response, immune system impairment, reproductive failure and reduced survivorship (Wallace et. al. 2017 and associated papers).

2. Marine Mammal Studies and Data sources

For the RBOS NRDA, the Trustees first documented exposure by reviewing Incident Command overflights and conducting NRDA boat surveys along the Gaviota coast for several weeks after the spill to determine what species were likely present during the spill.

The Trustees considered the magnitude and duration of the spill, presence of other environmental stressors and a documented increase in strandings during the weeks after the oil spill and focused their assessment on acute mortality as the basis for injury determination and quantification.

a. Pre-assessment marine mammal surveys

The first phase of the marine mammal injury assessment consisted of surveys designed to (1) document the presence and count of cetacean and pinniped species following the oil spill and (2) conduct photo-id surveys in the response area for bottlenose dolphins. Scientists from NOAA NMFS's SWFSC conducted eleven days of land-based surveys at four locations around El Capitan State Beach from May 24, 2015, through June 7, 2015 (Figure 1).

Figure 1. Shore-based survey locations (Defran *et al.* 2017)

Sixty-six sightings of marine mammals were observed over the eleven shore-based survey days, including gray whales, bottlenose dolphins, long-beaked common dolphins, California sea lions, and harbor seals (Table 1).

Table 1. Daily summary of marine mammal sightings during shore-based surveys in 2015

Species	5/24	5/25	5/27	5/30	5/31	6/1	6/3	6/4	6/5	6/6	6/7	Total
Dolphin, Coastal Bottlenose	1	1	2	0	1	3	0	1	0	2	1	12
Dolphin, Long-beaked Common	0	0	0	2	0	0	0	0	0	0	0	2
Dolphin, Common, unidentified to species	0	0	0	0	0	0	0	0	0	0	1	1
Dolphin, unidentified to species	0	0	0	0	0	0	0	0	0	1	0	1
Pinniped, California Sea Lion	1	2	2	7	7	3	0	0	5	1	3	31
Pinniped, Harbor Seal	0	0	3	1	1	2	2	0	0	1	0	10
Pinniped, unidentified to species	0	0	1	0	0	0	0	0	0	0	0	1
Whale, Gray	0	0	1	2	0	0	1	0	0	0	0	4
Whale, Humpback	0	0	0	1	0	0	0	0	0	1	0	2
Whale, unidentified to species	0	0	0	0	0	0	0	1	1	0	0	2

Scientists from NOAA NMFS's SWFSC also conducted six days of boat-based surveys for the NRDA between June 2 and June 7, 2015, and reported 76 sighting events and over 1000 individual marine mammals (Table 2). Maps of tracklines and sightings are given in Appendix 1 of this technical report.

Table 2. Daily summary of marine mammal sightings (and average group size per sighting) during boat-based surveys in 2015

Species	6/2	6/3	6/4	6/5	6/6	6/7	Total sighting
Dolphin, Coastal Bottlenose	0	2 (5)	3 (3)	2 (6)	2 (7)	4 (4)	13
Dolphin, Long-beaked Common	1 (1050)	3 (42)	0	1 (70)	0	6 (205)	11
Dolphin, Common, unidentified to species	1 (41)	0	0	0	0	0	1
Pinniped, California Sea Lion	6 (7)	3 (7)	4 (1)	3(1)	8 (1)	5(7)	29
Pinniped, Harbor Seal	1 (1)	1 (1)	4 (1)	0	6 (1)	4 (2)	16
Whale, Gray	1 (2)	0	1 (2)	0	0	1 (2)	3
Whale, Humpback	0	1 (2)	0	2(1)	0	1 (14)	4

These surveys provided documentation of marine mammal species and numbers in the area affected by the oil spill (Defran *et al.* 2017).

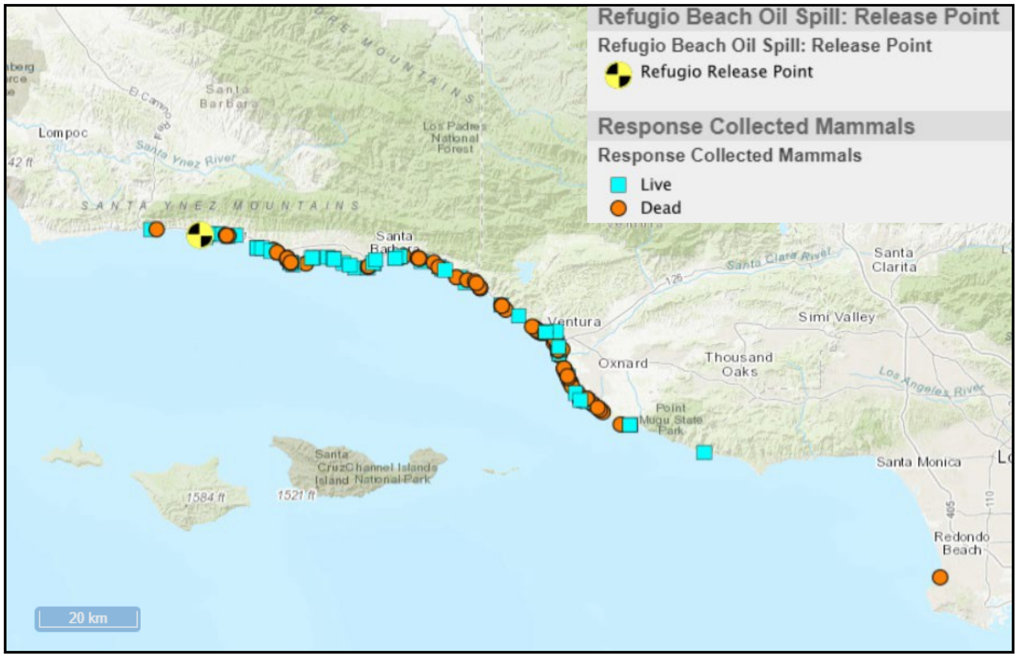
Analyses of the photo-identification data collected for bottlenose dolphins estimated that approximately 20% of the coastal bottlenose dolphin population was present during the survey period (Defran *et al.* 2017). However, no bottlenose dolphins stranded during the response period, and no further studies were initiated.

In summary, the Trustees observed over 100 sightings, comprising hundreds of individual pinnipeds (California sea lions and harbor seals), dolphins (coastal bottlenose dolphins and long-beaked common dolphins) and whales (humpback whales and gray whales) along the Gaviota Coast three weeks after the spill.

b. Wildlife Intake Logs

The Wildlife Branch of the Incident Command responded to live and dead marine mammal strandings following guidelines in Ziccardi *et al.* (2015). The Wildlife Branch was activated on May 19, 2015, and field activities ended on June 24, 2015. During the response, the Wildlife Branch screened stranding reports and primarily responded to those reports that noted animals with visible oiling. Reports of animals that were not visibly oiled were responded to by the California Marine Mammal Stranding Network (CAMMSN), discussed below. All activities were coordinated by the Wildlife Branch, which also maintained the intake logs (i.e., date and location of collection, species, sex, and age-stage class). Animals collected by the Wildlife Branch were transported to Sea World, San Diego, including both live animals for rehabilitation and dead animals for necropsy. The Trustees used the intake data as the basis for documenting mortality of marine mammals following the spill. Strandings associated with this incident took place mainly in Santa Barbara and Ventura Counties (Figure 2).

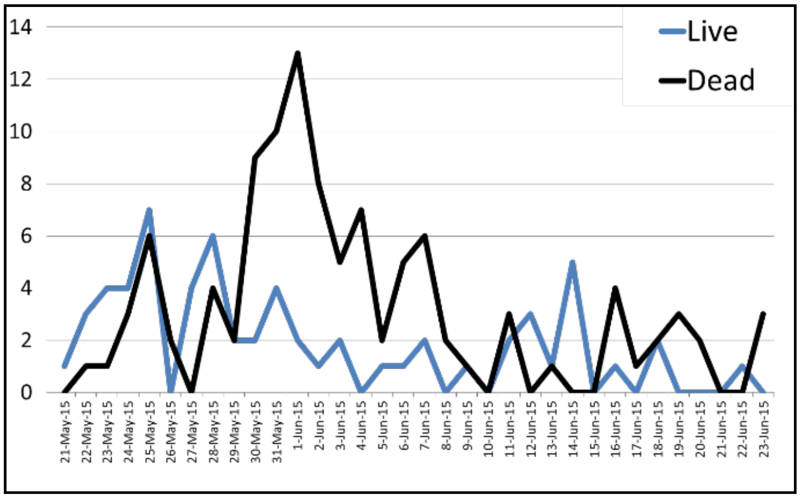
Figure 2 Wildlife Branch stranded mammal collections, live and dead following the RBOS



There were 106 dead and 62 live marine mammal strandings documented by the Wildlife Branch in the response area[2] (Figure 3, Appendix 1). Of the 62 collected alive, 24 were rehabilitated and released. Several were tagged to follow their movements. Subsequent stranding reports documented four of the released animals stranded dead in the months following their release. Of the 168 animals recorded there were 138 California sea lions, 15 long-beaked common dolphins, 9 northern elephant seals, and 2 harbor seals. The rest were unidentified species.

[2] These numbers differ from those reported by OSPR (2016) reflecting data quality check of records that occurred after the OSPR report. OSPR (2016) reported 99 dead and 63 live marine mammals.

Figure 3. Daily intake of stranded marine mammals by the Wildlife Branch



c. California Marine Mammal Stranding Network Reports

The California Marine Mammal Stranding Network (CAMMSN) has been well established in California for decades, and there is a long time series of data available to characterize spatiotemporal stranding patterns. General information on marine mammals strandings, rescue and rehabilitation, including data documentation, can be found in Geraci and Lounsbury (1993)

CAMMSN data were used in two ways: (1) to determine baseline strandings in Santa Barbara and Ventura Counties, and (2) to capture records of strandings in Santa Barbara and Ventura Counties in May – July 7, 2015, that were not recorded by the Wildlife Branch of the Incident Command, (for reasons described below), in order to have a complete stranding record for injury evaluation. Generally, the Trustees used CAMMSN data from 2000 through July 7, 2015, for baseline purposes. The year 2000 was selected because a Pacific Decadal Oscillation shift occurred about that time. This was a shift to a cool oceanographic regime (Chavez *et al.* 2003), which has been shown to influence strandings in the Southern California Bight (Danil *et al.* 2010). Although the RBOS Wildlife Branch ceased operation on June 24, 2015, the Trustees extended consideration of stranding data for another two weeks to July 7, 2015 because post oil spill strandings were elevated above the 2015 mean until the week of July 5, 2015.

However, for California sea lions the Trustees used only 2015 stranding data to determine baseline. A California sea lion Unusual Mortality Event (UME) was declared in January 2013 and was ongoing at the time of the RBOS. An early assessment of the UME revealed ecological factors, specifically limited prey availability, as the likely cause (McClatchie *et al.* 2016). In addition for 2015, there was an unprecedented number of pups stranding early in the year across the state (i.e., January through May). Peak strandings for pups are typically observed later in May and June coincident with weaning. Because of this anomaly, the Trustees believed that past years' stranding records would not serve as an appropriate baseline for comparison to 2015. For the purposes of NRDA, stranding patterns of California sea lion pups considered only the 2015 records to inform the likely expected stranding rates during the RBOS response period.

The 2015 CAMMSN records were also reviewed for strandings in Santa Barbara and Ventura Counties that occurred during the RBOS response period that were not handled by the Wildlife Branch. As noted in the previous section, during the response, the Wildlife Branch responded primarily to stranding reports that noted animals with visible oiling. Stranding reports of animals that were not visibly oiled were responded to by the CAMMSN. This protocol was necessary to ensure response to the large number of strandings that were occurring at this time. Furthermore, assembling all stranding records for this area was essential to compare stranding rates to baseline expectations.

The compiled data set of post-spill strandings was further reviewed to identify pre-spill strandings and other sources of mortality. The Trustees considered an advanced state of decomposition in the week to 10 days following the spill as evidence of a likely pre-spill stranding.

Table 3 provides the summary of all the strandings (live and dead) from May 19 through July 7, 2015, including both wildlife response and CAMMSN records.

Table 3. Total live and dead marine mammals strandings from May 19 through July 7, 2015 (Wildlife Branch and CAMMSN).

Species	**Total Recovered**	**Number of total reported oiled**
Dolphin, long-beaked common	22	3
Dolphin, bottlenose	1	0
Pinniped, California sea lion	221	79
Pinniped, northern elephant seal	9	7
Pinniped, harbor seal	2	2
Unidentified, marine mammals	9	1
Total	264	93

3. Assessment and Quantification

The Trustees used both Wildlife Branch intake logs and CAMMSN data to evaluate marine mammal strandings from May 19 to July 7, 2015, as compared to baseline (expected number of strandings had the spill not occurred), after accounting for likely pre-spill mortality and mortality due to fishing interactions (or other non-spill-related causes). Finally, a correction factor was applied to account for mammals that died and were scavenged or otherwise did not strand on the beach (and so, were not recovered). This section discusses the steps undertaken by the Trustees to calculate baseline, remove pre-spill and fishery interaction or other non-spill related deaths, and apply a correction factor to achieve final injury numbers.

California sea lions:

CAMMSN stranding response data and wildlife intake logs for all of 2015 in Santa Barbara and Ventura counties were used to estimate the expected, or baseline, number of strandings during the RBOS response period.

a. Calculate baseline

Baseline was estimated for live stranded sea lions using stranding records, because a more complete record of stranding data exists for live California sea lions in this area. For dead sea lions, the Trustees did not generate a separate, independent baseline. Rather, they assumed the proportion of expected live animals in the absence of a spill (baseline) compared to the number of observed live animals would be the same as the proportion of expected dead animals in the absence of a spill (baseline) compared to the number of observed dead animals. They calculated the ratio using the available data on live animal strandings and then applied that same ratio to dead animals. For example, if the estimated baseline number of live strandings was 3 and there were 12 observed, the ratio would be 3/12= 0.25. If there were 20 dead strandings, applying that same ratio would yield a dead animal stranding baseline of 5 (0.25 x 20 = 5). Therefore, out of 32 live and dead strandings, 8 would be considered baseline.

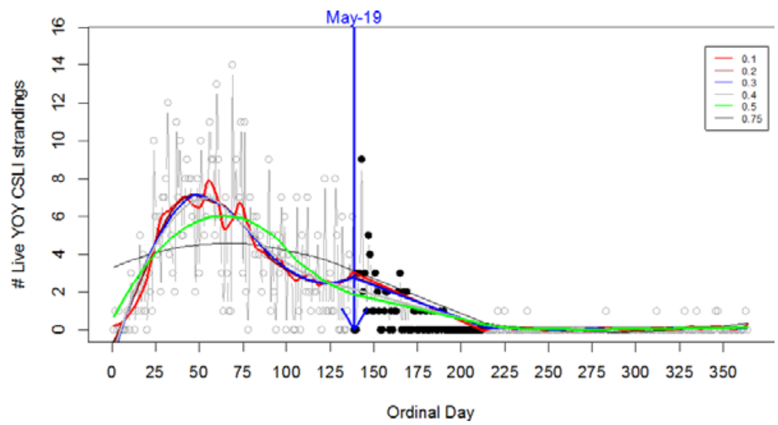
Three age class categories were considered for calculating baseline strandings for California sea lions. As noted above and described in detail below, due to unusual conditions in 2015, the Trustees considered only 2015 stranding data

- Young-of-the-Year (YOY): This category includes pups and yearlings. The Trustees estimated baseline (predicted strandings without a spill) by fitting a model to all 2015 data collected by the CAMMSN pre- and post-spill in 2015 (Figure 4). A nonparametric, locally weighted regression method was used to fit a smooth curve to the 2015 daily recovery data for live young-of-the-year (YOY) California sea lions in Santa Barbara and Ventura Counties using the LOESS function in the R statistical package.

- Adults: This category includes juveniles, sub-adults and adults (i.e., age 2+): Trustees calculated the average number of live California sea lions observed stranded weekly by the CAMMSN in 2015 to determine baseline.

- Unknown age class: The Trustees apportioned on the basis of observed YOY:Adult ratios.

Figure 4. Modeling to predict YOY baseline strandings. The open circles are recoveries made by members of the California Marine Mammal Stranding Network (CAMMSN), and the filled circles are recoveries made during the post-spill response period to July 7, 2015. All 2015 data were used to fit the model. Span settings influence the degree of smoothing and those ranging from 0.1 to 0.5 provided the best fit to the observed data and predicted strandings ranging from 59 to 63 for the post-spill period. Span = 0.75 is the default setting, and the legend shows the color coding for span settings.



b. Remove pre-spill strandings

According to the Marine Mammal Stranding Level A Report Examiners Manual, condition codes are recorded for each stranding as follows: Code 1 (alive); Code 2 (fresh dead); Code 3 (moderate decomposition); Code 4 (advanced decomposition), or Code 5 (mummified/skeletal) (NMFS 2020). For the purposes of the NRDA, all strandings were classified as pre-spill if they were Code 5. Code 4 animals found within ten days (before May 29, 2015) of the oil spill were also considered to be pre-spill. All identified pre-spill strandings were removed from the data set.

c. Remove mortalities attributable to other causes

All records were reviewed for other obvious, non-oil spill related causes of death. The most likely of these being fishery interactions. When field notes indicated stranding was likely attributable to fishery interactions, they were removed from consideration.

d. Calculate mortalities attributable to the RBOS

The Trustees estimated the number of strandings attributable to the spill by subtracting the calculated baseline strandings, pre-spill mortality, and strandings attributable to other causes, from the total number of live and dead California sea lions recovered. The results are summarized in Table 4.

Table 4. California sea lion strandings attributed to RBOS

Category	Number
Total recovered from 5/10 – 7/7/2015 (Live and dead)	221
Pre-spill	40
Fishery related	0
Baseline	87
Attributed to RBOS	94

Other species:

a. Calculate baseline

In the absence of a UME for other species at the time of the RBOS, and with lower numbers of strandings in general, the CAMMSN stranding data from 2000-2014 in Santa Barbara and Ventura Counties were used to estimate baseline post spill for long-beaked common dolphins, Northern elephant seals and Pacific harbor seals (Table 5).

Table 5. Baseline strandings for long-beaked common dolphins, northern elephant seals and harbor seals. The number of strandings expected during the 5 week response period (5/19-6/23/2015) was estimated from the average stranding rates previously observed during the same time period in prior years (i.e., 2000-2014.) Values are rounded to the nearest whole animal. Data sources: CAMMSN_2000-2014.xlsx. [YOY = Young-of-the-year].

	Dead expected			Live expected		
Species	YOY	Adult	Total	YOY	Adult	Total
Long-beaked common dolphin	0	2	2	0	0	0
Northern elephant seal	2	0	2	0	3	3
Harbor seal	0	0	0	1	0	1

Strandings of all species except California sea lions are relatively rare in the response area but with high inter-annual variability. For example, the long-beaked common dolphin has had several years where UMEs led to a high baseline. Further, a high percentage of northern elephant seals and harbor seals were oiled (Table 3). Therefore, each stranding record was reviewed to determine whether to omit the record from consideration as a potentially 'spill related' stranding.

b. Remove pre-spill strandings

As with California sea lions, for the purposes of the NRDA, all strandings were classified as pre-spill if they were Code 5. Code 4 animals found within ten days (before May 29, 2015) of the oil spill were also considered to be pre-spill. All identified pre-spill strandings were removed from the data set.

c. Remove mortalities attributable to other causes

All records were reviewed for other obvious, non-oil spill related causes of death, the most likely of these being fishery interactions. When field notes indicated stranding was likely attributable to fishery interactions or other causes, they were removed from consideration.

d. Calculate mortalities attributable to the RBOS

Taking into account the baseline calculations and removals due to pre-spill mortality and other causes, the Trustees estimated the number of strandings attributable to the spill. The results are summarized in Table 6.

Table 6. Summary of strandings other than California sea lions after accounting for pre-spill and other causes of mortality

Species	Dead	Live	Total Recovered	Pre-spill	Fishery related	Baseline	Spill related
Dolphin, long-beaked common	22	0	**22**	2	2	0	**18**
Dolphin, bottlenose	1	0	**1**	0	0	0	**1**
Pinniped, northern elephant seal	1	8	**9**	1	0	0	**8**
Pinniped, harbor seal	0	2	**2**	0	0	0	**2**
Unidentified, marine mammals	9	0	**9**	9	0	0	**0**

Numbers injured—Correction Factor

To estimate the number of marine mammals injured, a 'lost at-sea' correction factor was applied to account for the low probability of dead marine mammals washing ashore. Beached marine mammal carcass recoveries only represent a percentage of total impacts on populations due to incomplete detection and recovery. Carcasses may not be recovered as a stranding due to the natural processes of scavenging, drifting, sinking, decomposing and removal from beaches by wave action prior to reporting. (DeGange *et al.* 1994, Cox *et al.* 1998, Eguchi 2002, Williams *et al.* 2011, Peltier *et al.* 2012, Carretta *et al.* 2016).

The Carretta *et al.* (2016) study provides a likely 'best case scenario' for carcass recovery for marine mammals inhabiting the nearshore waters of Santa Barbara and Ventura Counties, based on the study of coastal bottlenose dolphins. For the study, the population is estimated to be ~500 individuals when corrected for unmarked dolphins. Animals range from Ensenada, Mexico to San Francisco, CA with the core of their range in the Southern California Bight (18% south of US/Mexico) and greater than 99% of sightings occur less than 500m from shore. Ninety of 91 strandings occurred in California, and 80 of the 90 were in the Southern California Bight. That is, 89% of the data used in the carcass recovery study were collected in the Southern California Bight, therefore relevant to the location of the marine mammal strandings related to the RBOS oil spill.

For the purposes of the NRDA, the recovery rate applied to the dead cetaceans was 0.25-- the published estimate for the coastal ecotype of the common bottlenose dolphins (Carretta *et al.* 2016). This recovery rate translates to a “lost at sea” correction factor of four. That is, the total number of injured cetaceans was estimated by multiplying the stranding total by four (the “lost at sea” correction factor for cetaceans). Half of the dead cetacean “lost at sea” factor was applied to dead pinnipeds to reflect the lower probability that a pinniped dying nearshore would come ashore, but acknowledging that no published estimate is available. No correction factor was applied to live stranded pinnipeds reflecting the uncertainty in our understanding of whether a sick and dying animal is more or less likely to come ashore; there are no known publications addressing this aspect of behavior. Also, no correction factor was applied to account for injured animals that moved out of the area, potentially underestimating injury. The final injury numbers are given in Table 7.

Table 7. Final marine mammal injury numbers, after lost-at-sea factor applied

Species	Dead	Live	Total spill related strandings	Lost-at-sea factor	Est. number injured
Dolphin, long-beaked	18		18	4	72
Dolphin, bottlenose	1		1	4	4
Pinniped, California sea lion	52	42	94	2	146
Pinniped, northern elephant seal		8	8		8
Pinniped, harbor seal		2	2		2

4. Other causes of mortality considered

Fishery bycatch

Stranded marine mammals with signs of fishery interaction are recognizable by experienced CAMMSN personnel. The typical signs are injuries associated with net or rope lacerations or missing appendages (see Byrd *et al.* 2014 and references therein). As noted, stranding records were reviewed, and any cases attributable to anthropogenic activities were removed from the post-spill stranding data set.

Ocean conditions and food availability

From 2013 to 2017, sea lion pups stranded in high numbers in southern California. The high stranding numbers and other factors led NMFS to declare an Unusual Mortality Event (UME) for sea lions in 2013 (NMFS 2019). Although the investigation into the UME is not complete as of the writing of this report, pups were emaciated and underweight indicating a lack of food for nursing mothers (NMFS 2019). Warm ocean conditions overall in southern California in 2013, the emergence of "the blob[3]" in 2014-15 and developing El Nino conditions in 2015 reduced plankton abundance nearshore, in turn contributing to the movement of sardines and other preferred prey fish offshore, thus reducing food availability for nursing mothers (Marine Mammal Center 2015). The year 2015 saw the greatest number of sea lion pup strandings of the 2013-2017 California sea lion UME. It was unusual for both the high number and early, (February-March) peak in strandings (NMFS 2019). Although these factors were considered during the injury assessment, the Trustees determined that the 2015 ocean conditions were sufficiently reflected in the baseline analysis for sea lions.

Domoic acid toxicosis

Another source of marine mammal mortality considered during the assessment was domoic acid (DA) toxicosis. In 1998 and again in 2000, NOAA NMFS declared UMEs for California sea lions. These two UMEs were largely attributed to DA toxicosis. DA is a neurotoxin produced by the alga, *Psuedonitschia* spp. which thrive in warmer waters. Later in 2002, DA was identified as the cause of a multi-species UME, which, in addition to sea lions, included long-beaked common dolphins. A 2006 review of multiple UMEs concluded that DA should no longer be considered an "unusual" cause of death in marine mammals (Gulland 2006). Beginning in 2007, DA outbreaks were no longer declared as UMEs, and DA is now frequently detected in stranded animals. Research on DA affecting California sea lions revealed that adult females are most susceptible and that the spatio-temporal patterns of DA outbreaks differ by year and species (Greig *et al.* 2005, Bejarano *et al.* 2008, Torres de la Riva *et al.* 2009, Bargu *et al.* 2010).

No publication characterizing DA in dolphins is currently available. However, the pre-2007 DA events affecting long-beaked common dolphins were dominated by adult males, suggesting they are the most susceptible age and sex class. In 2017, a significant DA event was evident in the southern California Bight, in which 94% of San Diego County strandings tested positive for DA, and 60% of those had acutely toxic levels of the neurotoxin present.

In summary, adults of all species are typically more susceptible to DA than juveniles, and adult female California sea lions are more likely to be affected than other age and sex classes. Behavioral symptoms, particularly seizures in live animals, are a key indicator of acute toxicity. DA can also be detected in urine and fecal samples; histology of the hippocampus will also reveal exposure (Buckmaster *et al.* 2014).

It is also well known that DA events typically follow El Nino events, and those environmental conditions in 2015 led to an unprecedented DA event that affected the United States coastline from central CA up to AK (McCabe *et al.* 2016). During 2015 in Santa Barbara County, water samples indicated high *Psuedonitzchia* counts at Stearns wharf (in Santa Barbara) in the spring and summer of 2015. And although fisheries were closed later in the summer, the Trustees are not aware of any obvious indicators of a DA outbreak among marine mammals recovered from the Gaviota Coast following the spill. Also the Trustees are not aware of any reports of DA toxicosis among the oiled and distressed animals in rehab from the spill. Samples from recovered dead and live marine mammals would likely have indicated whether the mammals were exposed

[3]In 2013 and lasting until 2016, a large mass of warm water persisted along the U.S. West coast, dubbed "The Blob," affecting ocean circulation and productivity. This is a separate phenomenon from El Nino weather patterns.

to DA, but unfortunately the Trustees were unable to obtain samples for analysis. Based on the forgoing, the Trustees did not subtract any animals from the injury estimate for potential DA toxicosis.

Saxitoxin toxicosis

Known to affect fish and shellfish, among marine mammals, saxitoxin poisoning has been implicated in the deaths of sea otters and Mediterranean monk seals. However, testing of California marine mammals rarely detects saxitoxin (NMFS, SWFSC, unpublished data) and is not considered a primary risk factor, so it was not considered further in this assessment.

Other disease or infections

Bacterial infections (e.g., *Leptospirosis*, *Clostridium* sp.) and other diseases have been identified among stranded California marine mammals (e.g., Greig *et al.* 2005, Danil *et al.* 2014). However, none of them are considered primary risk factors for dolphins, and no unusual cases were reported in 2015.

5. Restoration Equivalency

The Trustees calculated a loss of 156 pinnipeds and 76 cetaceans (Table 7) as a result of the RBOS oil spill. The two projects selected for scaling are:

Improving pinniped rehabilitation: This project would assist and enhance the existing stranding network organizations that respond to live strandings in Santa Barbara and Ventura Counties. The project will supplement and improve stranding response capabilities, rehabilitation capacities, and veterinary facilities. If implemented, this increase in capacity is expected to result in an increased number of animals treated per year. The trustees estimate that at least 150 additional pinnipeds will be treated over the estimated three to seven year timeframe of the project.

Cetacean Entanglement Response: Nearly all entangled marine mammals die, and these deaths are often long and painful. This project would support the existing Entanglement Response Network, allowing them to respond to more entangled cetaceans. In addition to physically disentangling animals (directly reducing mortality), increased reporting and documentation will help support the adoption of other conservation management measures. NRDA funding would provide support for additional boat time, specialized gear, and hands-on training and is expected to increase the number of animals that the Entanglement Response Network can respond to and document. For example, in 2015, 49 reports of entangled cetaceans were investigated and confirmed, and, of those 49, only 11 cetaceans were successfully disentangled. The proposed budget funds response activities for seven years, potentially saving an estimated 77 additional cetaceans, while also providing valuable information on fishing interactions and how they can be prevented.

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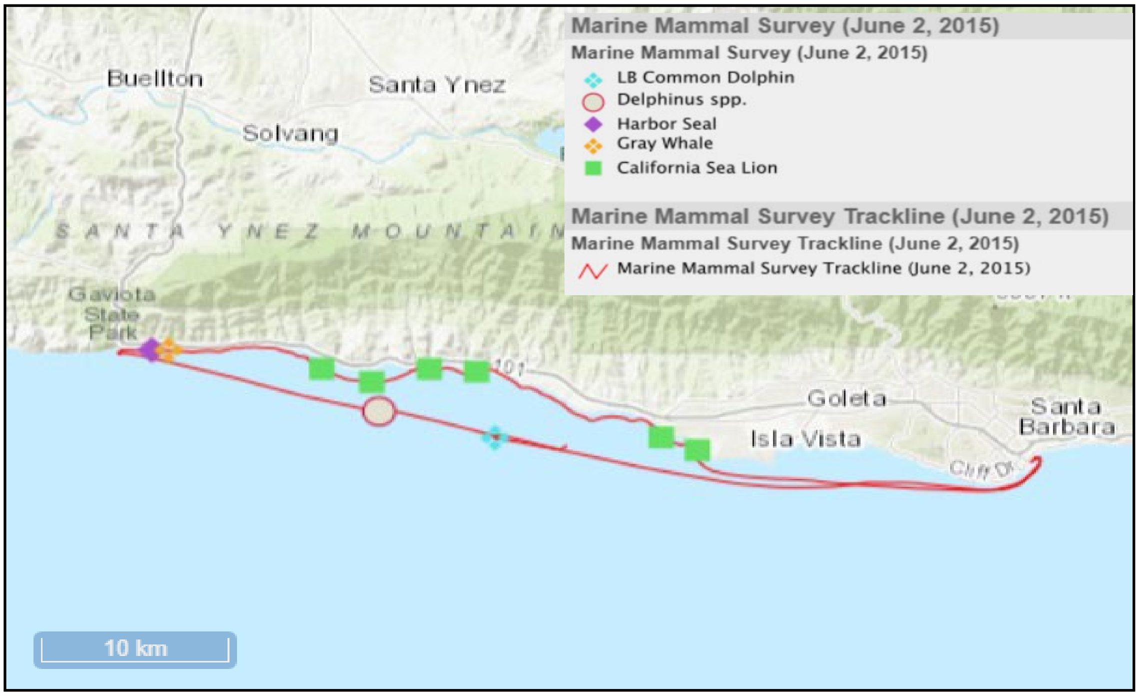
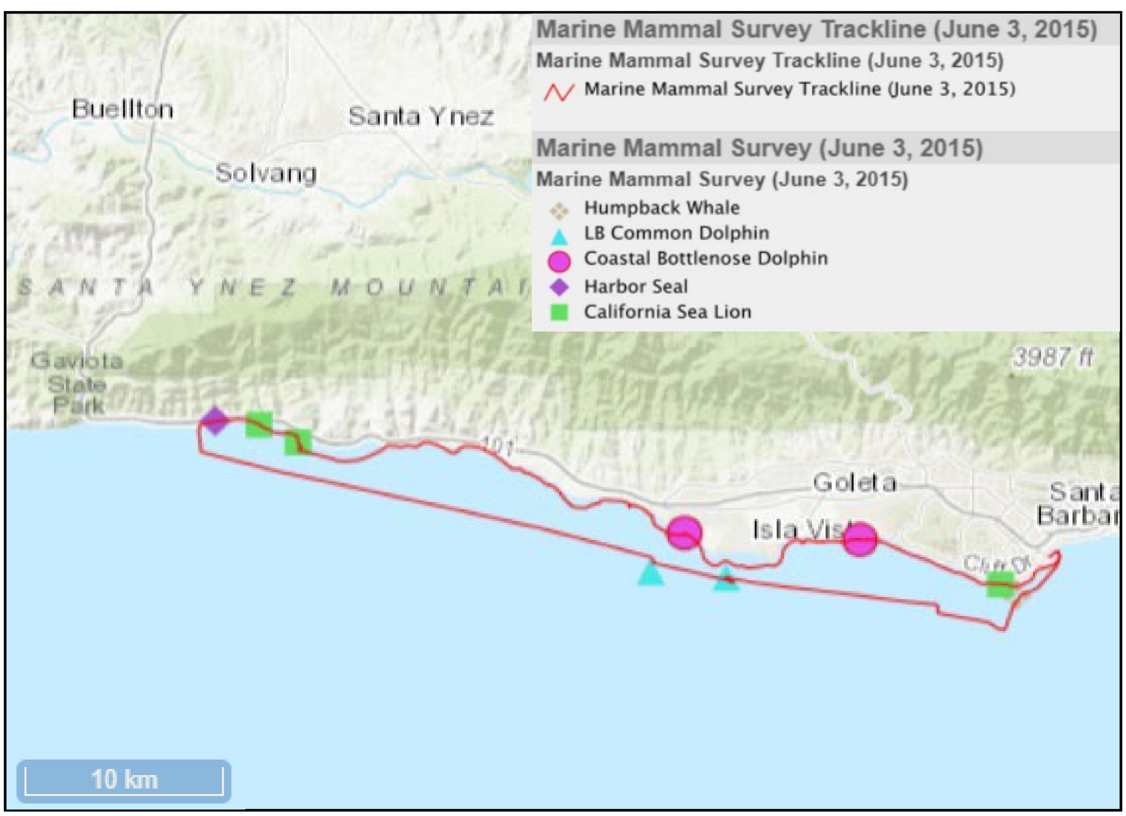
Appendix 1

Tracklines and sightings of marine mammals from surveys conducted as part of the NRDA preassessment, June 2-7, 2015. Data are available in the RBOS Administrative Record or in ERMA.

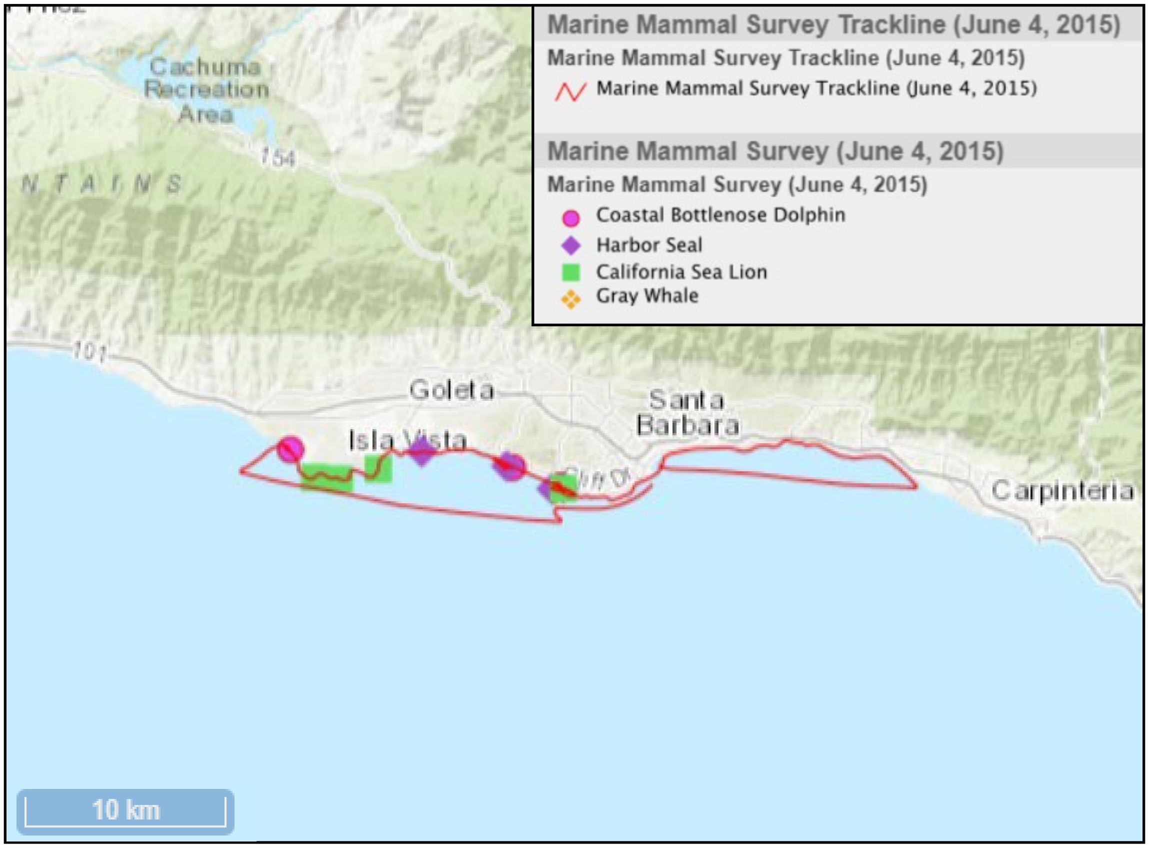
June 2, 2015



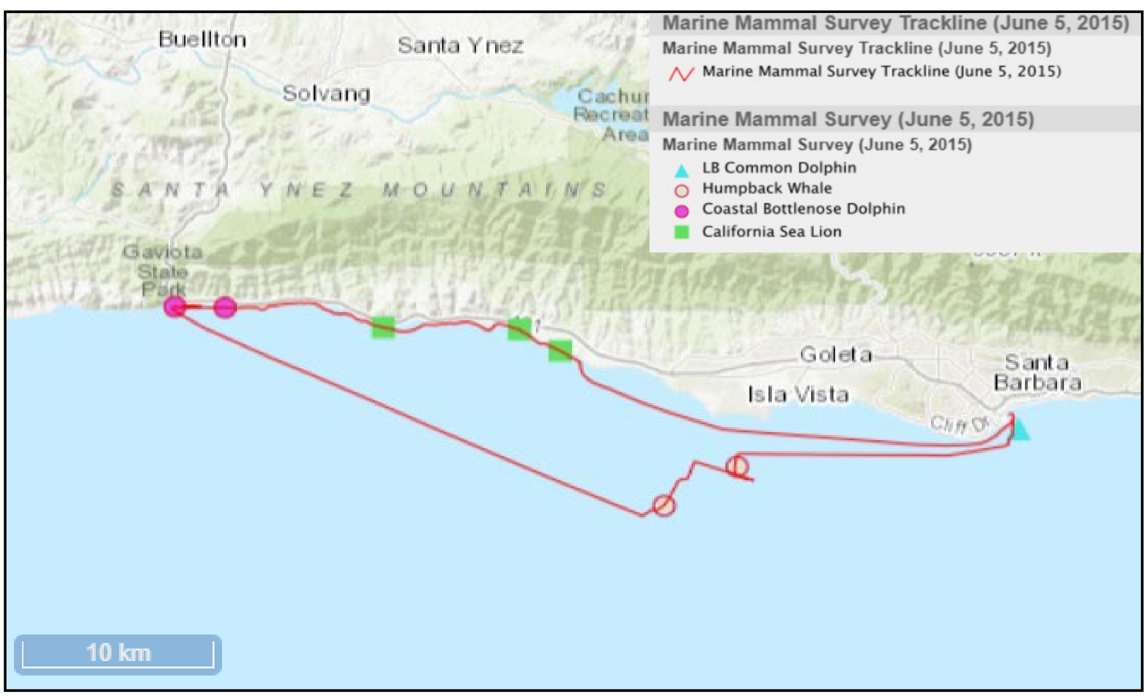
June 3, 2015



June 4, 2015

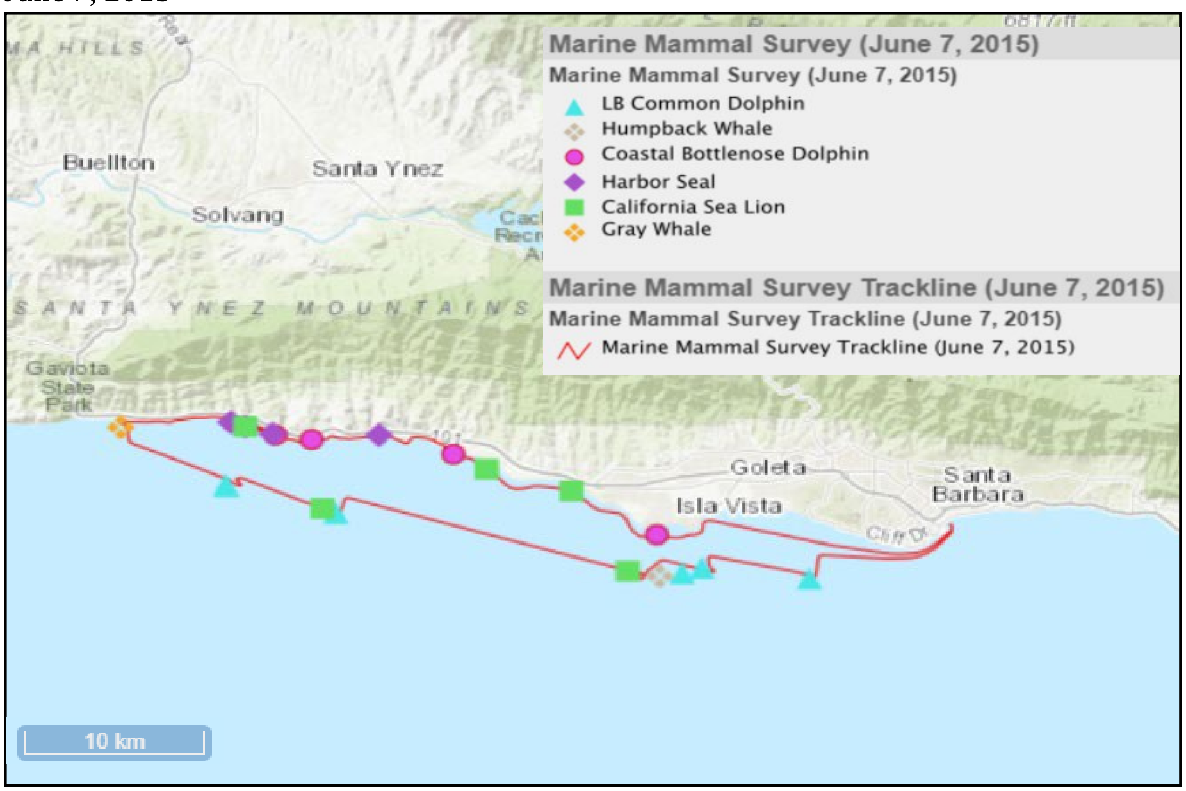


June 5, 2015



June 6, 2015

June 7, 2015



Appendix 2. Wildlife Branch intake logs for (a) dead and (b) live stranded marine mammals.

(a)

Cumulative Total	Daily Report #	Date	Field ID	Intake ID	Oiled Field	Oiled Intake	Oiled	Lat	Long	Species	Notes
1	5/22/2015-1	5/22/2015	FP1-D-05/22/2015-1	D-0001	blank	blank	N	blank	blank	CODO	Santa Barbara Harbor
2	5/23/2015-1	5/23/2015	WRM1-D-05/23/2015-1	D-0002	blank	1	Y	34 19 05	119 23 14	CODO	Faria Beach
3	5/24/2015-1	5/24/2015	WRM1-D-05/24/2015-1	D-0004	Y	Y	Y	34.42669	-119.90932	CSLI	Bacara Beach
4	5/24/2015-2	5/24/2015	WRM1-D-5/24/2015-2	D-0005	Y	Y	Y	34.42776	-119.9108	CSLI	Bacara Beach
5	5/24/2015-3	5/24/2015	WRM3-D-5/24/2015-1	D-0006	N	blank	N	34.1936	-119.235	CSLI	Rincon Pt.
6	5/25/2015-1	5/25/2015	WRM3-D-5/25/2015-1	D-0003	N	blank	N	38.21286	-122.12558	CODO	near Oxnard Beach
7	5/25/2015-3	5/25/2015	WRM115-D-5/25/2015-2	D-0007	N	blank	N	34.42	-119.62	CSLI	Miramar Beach
8		5/25/2015	WRM12-D-5/25/2015-1	D-0010	U	Y	Y	34.41672	-119.58891	CSLI	Loon Pt
9		5/25/2015	WRM3-D-5/25/2015-2	D-0092	U	cbd	CBD	34.20507	-119.25331	CODO	Oxnard Power Plant
10	5/25/2015-2	5/25/2015	WRM-D-5/25/2015-1	D-0008	N	Y	Y	34.406	-119.844	CSLI	Campus Pt. Beach
11		5/25/2015	WRM5/4-D-5/25/2015-2	D-0009	N	Y	Y	34.43232	-119.91868	CSLI	Haskell's/Bacara Beach
12		5/26/2015	WRM1-D-05/26/2015-1	D-0011	N	N	N	34.28342	-119.3204	CODO	Emma Wood
13	5/26/2015-1	5/26/2015	WRM7-D-5/26/2015-1	D-0012	Y <2%	Y	Y	34.45819	-120.02433	CSLI	El Capitan
14	5/28/2015-1	5/28/2015	WRM1-D-5/28/2015-1	D-0013	Y	Y	Y	34.38	-119.5	CSLI	Bates Beach
15	5/28/2015-2	5/28/2015	WRM17-D-5/28/2015-1	D-0015	Y	Y	Y	34.23191	-119.26501	CSLI	Surfers Knoll
16	5/28/2015-3	5/28/2015	WRM3-D-5/28/2015-1	D-0016	N	BLANK	N	34.4151	-119.58395	CSLI	Loon Point
17	5/28/2015-4	5/28/2015	WRM3-D-5/28/2015-2	D-0017	Unk	blank	N	34.4071	-119.8778	CSLI	Coal Oil Point
18		5/29/2015	WRM2-L-05/29/2015-1	D-0024	Y	Y	Y	34.2556	-119.277	CSLI	Terminus of Nathan Lane
19	5/29/2015-1	5/29/2015	WRM4-L-05/29/2015-1	D-0032	N	blank	N	34.39783	-119.70286	CSLI	Leadbetter Beach; animal that went to CIMWI, died there and then went to SWSD for necropsy?
20	5/30/2015-2	5/30/2015	WRM9-D-5/30/2015-1	D-0020	Y	Y	Y	34.23443	-119.2655	CSLI	Ventura Beach S. of Harbor
21	5/30/2015-3	5/30/2015	WRM9-D-5/30/2015-2	D-0021	N	N	N	34.23443	-119.2655	CSLI	Ventura Beaches
22	5/30/2015-4	5/30/2015	WRM9-D-5/30/2015-3	D-0022	Y	Y	Y	34.23085	-119.26465	CSLI	Ventura Beaches
23	5/30/2015-5	5/30/2015	WRM9-D-5/30/2015-4	D-0023	N	N	N	34.14588	-119.21612	CSLI	Silver Strand

Cumulative Total	Daily Report #	Date	Field ID	Intake ID	Oiled Field	Oiled Intake	Oiled	Lat	Long	Species	Notes
24	5/30/2015-1	5/30/2015	WRM7-D-5/30/2015-1	D-0025	U	N	N	34.39943	-119.70232	CSLI	Leadbetter Beach
25		5/30/2015	WRM9-D-5/30/2015-7	D-0030	Y	N	N	34.13066	-119.17595	CSLI	Port Hueneme
26		5/30/2015	WRM9-D-5/30/2015-8	D-0031	U	Y	Y	34.13881	-119.18924	CSLI	Port Hueneme
27		5/30/2015	WRM9-D-5/30/2015-6	D-0028	N	Y	Y	34.13045	-119.17585	CSLI	Port Hueneme
28		5/30/2015	WRM9-D-5/30/2015-5	D-0029	N	Y	Y	34.13715	-119.18632	CSLI	Port Hueneme
29	5/31/2015-1	5/31/2015	WRM2-D-5/31/2015-2	D-0026	U	CBD	CBD	34.27357	-119.30402	CETA	Ventura County Fairground
30	5/31/2015-10	5/31/2015	WRM2-D-5/31/2015-1	D-0027		N	N	34.27417	-119.29954	CSLI	Surfers Point Park
31	5/31/2015-4	5/31/2015	WRM3-D-5/31/2015-1	D-0033	N	blank	N	34.12517	-119.16836	CSLI	Port Hueneme
32	5/31/2015-5	5/31/2015	WRM3-D-5/31/2015-2	D-0034	N	blank	N	34.12285	-119.16505	CSLI	Port Hueneme
33	5/31/2015-6	5/31/2015	WRM3-D-5/31/2015-3	D-0035	Y 2%	Y	Y	34.1286	-119.17304	CSLI	Port Hueneme
34	5/31/2015-7	5/31/2015	WRM3-D-5/31/2015-4	D-0036	N	blank	N	34.13009	-119.17532	CSLI	Port Hueneme
35	5/31/2015-8	5/31/2015	WRM3-D-5/31/2015-5	D-0039	N	blank	N	34.14522	-119.21674	CSLI	Silver Strand
36	5/31/2015-2	5/31/2015	WRM2-D-5/31/2015-4	D-0040	U	blank	CBD	34.27816	-119.31464	CODO	Emma Wood State Beach
37	5/31/2015-9	5/31/2015	WRM1-D-5/31/2015-1	D-0037	Y 2%	blank	Y	34.40821	-119.55162	CSLI	Padaro Beach
38	5/31/2015-3	5/31/2015	WRM2-D-5/31/2015-3	D-0038	U	Y	Y	34.2719	-119.28491	CSLI	San Buenaventura
39	6/1/2015-12	6/1/2015	WRM3-D-6/1/2015-4	D-0041	N	CBD	CBD	34.27653	-119.31202	CSLI	Surfers Point
40	6/1/2015-2	6/1/2015	WRM3-D-6/1/2015-2	D-0042	N	CBD	CBD	34.46021	-120.02773	CSLI	El Capitan
41	6/1/2015-4	6/1/2015	WRM9-D-6/1/2015-1	D-0043	U	CBD	CBD	34.17688	-119.23786	MAMA	Ocean Beach
42	6/1/2015-8	6/1/2015	WRM9-D-6/1/2015-5	D-0044	N	N	N	34.19975	-119.25009	CSLI	Mandalay Co. Park
43	6/1/2015-5	6/1/2015	WRM9-D-6/1/2015-2	D-0047	N	N	N	34.17709	-119.23809	CSLI	Ocean Beach
44	6/1/2015-11	6/1/2015	WRM4-D-6/1/2015-2	D-0050	U	N	N	34.25538	-119.27101	CSLI	San Buenaventura
45	6/1/2015-13	6/1/2015	WRM3-D-6/1/2015-5	D-0051	N	N	N	34.27474	-119.30867	NESE	Surfers Point
46	6/1/2015-3	6/1/2015	WRM3-D-6/1/2015-3	D-0052	N	N	N	34.37469	-119.4749	CSLI	Rincon
47	6/1/2015-6	6/1/2015	WRM9-D-6/1/2015-3	D-0057	N	N	N	34.18745	-119.24387	CODO	Mandalay Beach
48	6/1/2015-1	6/1/2015	WRM4-D-6/1/2015-1	D-0058	Y 2%	Y	Y	34.0991449	-119.1240841	CODO	Point Mugu
49	6/1/2015-10	6/1/2015	WRM9-D-6/1/2015-7	D-0059	N	N	N	34.20519	-119.2534	CETA	Mandalay Power Plant
50	6/1/2015-7	6/1/2015	WRM9-D-6/1/2015-4	D-0053	N	Y	Y	34.19855	-119.24963	CSLI	Mandalay Co. Park
51	6/1/2015-9	6/1/2015	WRM9-D-6/1/2015-6	D-0060	N	Y	Y	34.20151	-119.2513	CSLI	Mandalay Bay
52	6/2/2015-5	6/2/2015	WRM2-D-6/2/2015-1	D-0045	U	N	N	34.27974	-119.31656	CSLI	Emma Woods

Cumulative Total	Daily Report #	Date	Field ID	Intake ID	Oiled Field	Oiled Intake	Oiled	Lat	Long	Species	Notes
53	6/2/2015-3	6/2/2015	WRM1-D-6/2/2015-2	D-0046	N	N	N	35.15982	-119.22227	CSLI	Kiddie Beach
54	6/2/2015-2	6/2/2015	WRM1-D-6/2/2015-1	D-0048	N	N	N	34.14624	-119.21631	CSLI	Silver Strand
55	6/2/2015-6	6/2/2015	WRM1-D-6/2/2015-3	D-0049	U	N	N	34.23754	-119.26647	MAMA	Spinnacer Point
56	6/2/2015-4	6/2/2015	WRM7-D-6/2/2015-1	D-0061	N	N	N	34.2795	-119.31644	CODO	Emma Woods
57	6/2/2015-8	6/2/2015	WRM4-D-6/2/2015-1	D-0063	N	N	N	34.41305	-119.88756	CSLI	Santa Barbara Harbor
58	6/2/2015-7	6/2/2015	WRM6-L-6/2/2015-1	D-0065	Y	Y	Y	34.307316	-119.87903	CSLI	Coal Oil Point
59	6/2/2015-1	6/2/2015	WRM3-D-6/2/2015-1	D-0056	N	Y	Y	34.27665	-119.31247	CODO	Surfers Point
60	6/3/2015-2	6/3/2015	WRM2-D-6/3/2015-2	D-0054	N	N	N	34.35934	-119.44569	MAMA	Mussel Shoals Beach
61	6/3/2015-1	6/3/2015	WRM2-D-6/3/2015-1	D-0062	N	CBD	CBD	34.35883	-119.44519	CSLI	Mussel Shoals Beach
62	6/3/2015-4	6/3/2015	WRM2-D-6/3/2015-3	D-0066	Y 2%	Y	Y	34.12691	-119.17101	CSLI	Ormond Beach
63	6/3/2015-5	6/3/2015	WRM2-D-6/3/2015-4	D-0067	N	N	N	34.17146	-119.23532	CODO	Hollywood Beach
64	6/3/2015-3	6/3/2015	WRM7-D-6/3/2015-1	D-0055	N	Y	Y	34.2572882	-119.2713985	MAMA	San Buenaventura
65	6/4/2015-7	6/4/2015	WRM2-D-6/4/2015-3	D-0068	N	N	N	34.41624	-119.8869	CSLI	Deverony
66	6/4/2015-2	6/4/2015	WRM-8-6/4/2015-1	D-0070	CBD	N	N	34.1485	-119.20156	CSLI	Port Hueneme
67	6/4/2015-3	6/4/2015	WRM-8-6/4/2015-2	D-0071	CBD	N	N	34.1485	-119.20156	CSLI	Port Hueneme
68	6/4/2015-6	6/4/2015	WRM2-D-6/4/2015-2	D-0072	N	N	N	34.41622	-119.88669	CSLI	Deverony
69	6/4/2015-5	6/4/2015	WRM2-D-6/4/2015-1	D-0073	N	N	N	34.45917	-120.02106	CSLI	El Capitan
70	6/4/2015-4	6/4/2015	WRM-8-D-6/4/2015-2	D-0074	CBD	Y	Y	34.1485	-119.20156	CSLI	Port Hueneme
71	6/4/2015-1	6/4/2015	WRM5-D-6/4/2015-1	D-0076	N	Y	Y	34.41593	-119.5859	CSLI	Loon Pt Beach
72		6/4/2015	WRM7-D-06/04/2015-1	D-0094	N		N	34.40082	-119.70087	CSLI	Leadbetter Beach
73	6/5/2015-1	6/5/2015	WRM3-D-6/5/2015-1	D-0069	N	N	N	34.19516	-119.24764	CSLI	Mandalay State Beach
74	6/5/2015-2	6/5/2015	WRM4-D-6/5/2015-1	D-0075	CBD	N	N	34.325347	-119.395871	CSLI	Faria Beach site 82
75	6/6/2015-1	6/6/2015	WRM2-D-6/6/2015-1	D-0077	N	Y	Y	34.36101	-119.4472	CSLI	Mussel Shoals Beach
76	6/6/2015-2	6/6/2015	WRM2-D-6/6/2015-2	D-0080	N	N	N	34.36863	-119.45403	CSLI	Mussel Shoals Beach
77	6/6/2015-3	6/6/2015	WRM2-D-6/6/2015-3	D-0079	N	N	N	34.37199	-119.45758	CSLI	Mussel Shoals Beach
78	6/6/2015-4	6/6/2015	WRM3-D-6/6/2015-1	D-0078	CBD	N	N	34.471167	-120.185733	CSLI	East Gaviota Canyon
79	6/6/2015-5	6/6/2015	WRM2-D-6/6/2015-4	D-0083	CBD	N	N	34.28586	-119.32653	CSLI	Emma Wood
80		6/7/2015	WRM2-D-6/7/2015-1	D-0081	N	N	N	34.20647	-119.25383	CSLI	McGrath State Beach
81		6/7/2015	WRM3-D-6/7/2015-3	D-0082	N	N	N	34.24002	-119.26634	PINN	Surfers Knoll

Cumulative Total	Daily Report #	Date	Field ID	Intake ID	Oiled Field	Oiled Intake	Oiled	Lat	Long	Species	Notes
82		6/7/2015	WRM3-D-6/7/2015-2	D-0084	Y 2%	Y	Y	34 24 273	119 26 716	CSLI	Surfers Knoll
83		6/7/2015		D-0085		N	N	34.24.251	119.25.775	PINN	Surfers Knoll
84		6/7/2015	WRM2-D-6/7/2015-2	D-0086	N	N	N	34.24122	-119.26749	CODO	Surfers Knoll
85		6/7/2015	WRM1-D-6/7/2015-3	D-0090	N	N	N	34.399154	-119.54042	CODO	Sand Point, Carpinteria
86		6/8/2015	WRM1-D-6/8/2015-1	D-0088	Y 2%	Y	Y	34.1877	-119.2379	CSLI	Mandalay State Beach
87		6/8/2015	WRM1-D-6/8/2015-2	D-0089	N	N	N	34.19151	-119.24577	CSLI	Mandalay State Beach
88		6/8/2015	WRM2-D-6/8/2015-1	D-0091	N		N	34.42754	-119.91028	PINN	Haskell Beach
89		6/11/2015	WRM6-D-6/11/2015-3	D-0093	Y <2%	y ,2%	Y	34.41617	-119.88666	CSLI	Elwood Beach
90		6/11/2015	WRM6-D-6/11/2015-1	D-0096	N	n	N	34.26123	-119.27424	CSLI	Pierpoint Beach
91		6/11/2015	WRM6-D-6/11/2015-2	D-0097	N	n	N	34.41626	-119.88677	CSLI	Elwood Beach
92		6/12/2015	WRM2-D-6/14/2015-1	D-0099	N	n	N	none	none	CSLI	Milpas St., Santa Barbara; admitted to CIMWI, died
93		6/13/2015	WRM4-D-06/13/2015-1	D-0095	Y 2-25%	Y 2-25%	Y	34.45954	-120.02574	CSLI	El Capitan State Beach
94		6/13/2015	WRM3-D-6/13/2015-1	D-0098	N	n	N	34.27483	-119.2971	CSLI	Surfers Point; left at beach
95		6/15/2015	WRM3-D-6/16/2015-1	D-0101		cbd	CBD	34.40822	-119.87891	csli	Coal Oil Point; yellow flipper tag 71V; Brand 195V; animal left in garbage bag by unknown person on unknown date
96		6/16/2015	WRM1-D-6/16/2015-1	D-0100		y <2%	Y	34.13105	-119.17661	CSLI	Port Hueneme
97		6/16/2015	WRM1-D-6/16/2015-2	none	N		N	34.13898	-119.1889	CSLI	Port Hueneme; no carcass recovered, only photos
98		6/16/2015	WRM1-D-6/16/2015-3	none	N		N	34.13792	-119.18733	CSLI	Port Hueneme; no carcass recovered, only photos
99		6/18/2015	WRM1-D-6/18/2015-1	none	N		N	34.23991	-119.26718	CSLI	Surfer's Knoll; left in place, photos only, no samples
100		6/18/2015	WRM2-D-6/18/2015-1	none	N		N	34.14125	-119.19447	CETA	Left in place, photos only, no samples
101		6/19/2015	WRM2-D-6/19/2015-1	D-102	Y <2%	n	Y	34.26117	-119.27426	CSLI	San Buenaventura
102		6/19/2015	WRM4-D-6/19/2015-1	none	N		N	34.41944	-119.6276	CSLI	Miramar Beach; Left in place, photos only, no samples
103		6/19/2015	WRM2-D-6/19/2015-3	none	CBD		CBD	34.14758	-119.21684	CSLI	Silver Strand; Left in place, photos only, no samples
104		6/20/2015	WRM4-D-6/20/2015-2	D-103	Y 2-25%	n	N	34.33139	-119.4014	CSLI	Rincon Beach
105		6/20/2015	WRM4-D-6/20/2015-2	none	N		N	34.1881	-119.24397	CSLI	Mandalay State Beach; Left in place, photos only, no samples
106		6/23/2015	WRM2-D-6/23/2015-1	D-104	Y <2%	y <2%	Y	34.46894	-120.11484	CSLI	Arroyo Quemado

(b)

Cumulative Total	Daily Report #	Date	Field ID	Intake ID	Oiled Field	Oiled Intake	Oiled Final	Lat	Long	Species	Notes	Disposition (D=Died, E=Euthanized, R=Released)	Notes 2	Necropsy Date	Gross Necropsy Findings of Note
24	28-May-15-1	5/28/2015	WRM15-L-5/28/2015-1	D-0014	Y <2%	Y <2	Y	34.41805	-119.79437	CSLI	Hope Ranch, died at FS	D	Died 5/28/15		
28	28-May-15-5	5/28/2015	SBMMC-15-508	D-0018	Y <2%	Y <2	Y			CSLI	Carpinteria - originally stranded on 5/23 or 5/24	D	Died 5/28/15		
29	28-May-15-6	5/28/2015	SBMMC-15-508P	D-0019	N	N	N			CSLI	born in rehab	D	Died 5/28/15		
41	3-Jun-15-1	6/3/2015	WRM7-L-6/3/2015-1	D-0064	Y 2%	Y	Y	34.143001	-119.1988465	CSLI	Point Hueneme Beach; recovered alive and DOA at MASH	D	Died 6/3/2015		
46	7-Jun-15-2	6/7/2015	WRM1-L-6/7/15-2	D-0087	N	N	N	34.414798	-119.779792	CSLI	Hope Ranch Beach	D	Died at CIMWI		
1	21-May-15-1	21-May	none	L-0001		Y	Y	34.460543	-120.079599	CSLI	1/2 mi N Refugio	D	Died 5/23	5/24/2015	Emaciation, aspiration (of gastric content), icterus
2	22-May-15-3	22-May	FP1-L-05/22/15-2	L-0002	Y	Y	Y	34.2536329	-119.2696329	CSLI	Ventura State Beach Marina	D	Died 6/1	6/1/2015	Gastric perforation and peritonitis; cerebral cyst
3	22-May-15-1	5/22/2015	FP1-L-05/22/15-1	L-0003	Y	2	Y	34.408367	-119.880149	CSLI	Coal Oil Point	R	Released 8/15/15		
4	22-May-15-2	5/22/2015	FP2-L-05/22/2015-1	L-0004	Y	2	Y	34.435884	-119.956307	NESE	Naples Point	R	Released 8/15/15		
5	23-May-15-1	5/23/2015	WRM2-L-5/23/2015-1	L-0005	Y	3	Y	34.46292	-120.0447	CSLI	El Capitan State Beach	R	Released 9/18/15		
6	23-May-15-2	5/23/2015	WRM3-L-5/23/2015-1	L-0006	Y	2	Y	34.435837	-119.956373	NESE	Naples Point	D	Died 6/4	6/4/2015	Nasal mites, generalized icterus, arterial nematodes (presumptive Otostrongylus sp).
7	23-May-15-3	5/23/2015	MMFS1-L-5/23/2015-1	L-0007	Y	2	Y	34.38	-119.49	CSLI	Carpinteria State Beach	R	Released 9/18/15		
8	23-May-15-4	5/23/2015		L-0008		blank	N	34.3270165	-119.3975374	CSLI	Feria Beach, Space 66; not on FS notes, not in daily count	R	released 7/30/15		
10	24-May-15-2	5/24/2015	WRM1-L-5/24/2015-1	L-0009	N	N	N	34.41585	-119.63892	CSLI	1323 Playa Pacifica Rd	D	Died 5/25	5/25/2015	Emaciation, gastric nematodiaisis, external oil
11	24-May-15-3	5/24/2015	MMFS1-L-5/24/2015-1	L-0010	Y	3	Y	34.45809	-120.02202	CSLI	El Capitan State Beach	R	Released 8/15/15		

Cumulative Total	Daily Report #	Date	Field ID	Intake ID	Oiled Field	Oiled Intake	Oiled Final	Lat	Long	Species	Notes	Disposition (D=Died, E=Euthanized, R=Released)	Notes 2	Necropsy Date	Gross Necropsy Findings of Note
17	25-May-15-5	5/25/2015	WRM11-L-5/25/2015-1	L-0011	N	1	Y	34.41954	-119.6285	CSLI	Miramar Beach	R	Released 8/7/15; found dead 9/1/15 on Camp Pendleton;		
16	25-May-15-4	5/25/2015	WRM8-L-5/25/2015-1	L-0012	Y <2%	1	Y	34.37	-119.479	NESE	Rincon Point		Still in Rehab as of 10/16		
14	25-May-15-2	5/25/2015	WRM12-L-5/25/2015-1	L-0013	N	1	Y	34.405934	-119.688143	CSLI	Santa Barbara breakwater	R	Released 9/16/15		
15	25-May-15-3	5/25/2015	n/a	L-0014	Y 15%	blank	Y	34.045308	-119.932887	CSLI	live CSL juv - Malibu -oiled	E	Euthanized 5/28	5/29/2015	Pulmonary nematodiasis, gastric ulcerations
9	24-May-15-1	5/24/2015	WRM2-L-5/24/2015-1	L-0015	Y	1	Y	34.47088	-120.19861	NESE	Mariposa Reina Rd	E	Euthanized 8/15/15		
12	24-May-15-4	5/24/2015	MMFS1-L-5/24/2015-2	L-0016	Y	1	Y	34.46232	-120.06538	NESE	Refugio	D	Died 6/3	6/3/2015	Icterus, pulmonary edema and hemorrhage, thoracic effusion, vascular nematodes (presumptive lungworms) noted
13	25-May-15-1	5/25/2015	WRM9-L-5/25/2015-1	L-0017	Y 30%	blank	Y	34.4563	-120.0735	CSLI	Refugio Point; SWSD intake log says collected on 5/24	D	Died 5/28	5/29/2015	Neoplasia (presumptive urogenital carcinoma)
19	25-May-15-7	5/25/2015	WRM1-L-5/25/2015-1	L-0018	N	1	Y	34.4042	-119.8735	CSLI	Coal Oil Point	R	Released 7/24/15		
18	25-May-15-6	5/25/2015	WRM5-L-5/25/2015-2	L-0019	Y	blank	Y	34.39757	-119.732222	NESE	Hendry's Beach	D	Died 5/29	5/29/2015	Icterus, cardiac enlargement (presumptive lung worm)
23	27-May-15-4	5/27/2015	WRM2-L-5/27/2015-1	L-0020	Y 2%	1	Y	34.43534	-119.944501	CSLI	Los Paradiso	D	Died 6/11	6/11/2015	Emaciated, flipper swelling, lymph node enlargement /abscess
20	27-May-15-1	5/27/2015	WRM1-L-5/27/2015-1	L-0021	Y 30%	4	Y	34.4	-119.54	CSLI	Sand Point	R	Released 9/18/15	-	-
22	27-May-15-3	5/27/2015	WRM10-L-5/27/2015-1	L-0022	Y 3%	3	Y	Unk	Unk	CSLI	Elwood Pier	R	Released 9/16/15		
21	27-May-15-2	5/27/2015	WRM1-L-5/27/2015-2	L-0023	Y 15%	4	Y	34.41	-119.58	CSLI	Loon Point	D	Died 6/1	6/1/2015	Emaciation, ascites/peritonitis, duodenal perforation
27	28-May-15-4	5/28/2015	WRM3-L-5/28/2015-1	L-0024	Y 2%	1	Y	34.242	-119.5241	CSLI	Coal Oil Point	D	Died 6/21/15	6/21/2015	Pulmonary edema, gastric nematodes
26	28-May-15-3	5/28/2015	WRM5-L-5/28/2015-1	L-0025	Y <2%	0	N	34.45987	-120.00529	CSLI	El Capitan Ranch	R	Released 9/16/15		
25	28-May-15-2	5/28/2015	WRM11-L-5/28/2015-1	L-0026	Y <2%	1	Y	34.43	-119.925	CSLI	Ellwood	R	Released 7/17/15		

Cumulative Total	Daily Report #	Date	Field ID	Intake ID	Oiled Field	Oiled Intake	Oiled Final	Lat	Long	Species	Notes	Disposition (D=Died, E=Euthanized, R=Released)	Notes 2	Necropsy Date	Gross Necropsy Findings of Note
30	29-May-15-1	5/29/2015	WRM5-L-5/29/2015-1	L-0027	Y <2%	1	Y	unk	unk	CSLI	El Capitan Beach Ranch	R	Released 7/17/15		
31	29-May-15-2	5/29/2015	WRM10-L-5/29/2015-1	L-0028	Y	2	Y	unk	unk	CSLI	Santa Barbara Harbor Patrol	D	Died 6/5	6/5/2015	Emaciation, multiple skin abrasions, nasal, pulmonary, gastric and enteric parasites
32	30-May-15-1	5/30/2015	WRM7-L-5/30/2015-2	L-0029	Y	2	Y	34.098	-119.1033	CSLI	Family Beach (Pt. Mugu)	D	Died 6/14	6/14/2015	Emaciated, mild ascites, skin abrasions
33	30-May-15-2	5/30/2015	WRM10-L-5/30/2015-1	L-0030	Y 8%	2	Y	34.27521	-119.29765	CSLI	Ventura Pier	D	Died 6/3	6/3/2015	Thin, nasal ascariasis, Lymph node enlargement, cutaneous ulcer/wound at the left mandible
34	31-May-15-1	5/31/2015	WRM9-L-5/31/2015-3	L-0031	Y	1	Y	34.39599	-119.53393	CSLI	Sandyland Beach	R	Released 7/17/15		
35	31-May-15-2	5/31/2015	WRM9-L-5/31/2015-2	L-0032	Y	1	Y	34.4073	-119.87899	CSLI	Coal Oil Point	E	Euthanized 6/3	6/3/2015	Emaciated, skin ulcerations, purulent ascites
36	31-May-15-3	5/31/2015	WRM5-L-5/31/2015-1	L-0033	Y <2%	1	Y	34.1905	-119.2437	CSLI	1073 Mandalay Beach	D	Died 6/4	6/4/2015	Emaciated, thoracic and pericardial effusion, icterus, hydrocephalus
37	31-May-15-4	5/31/2015	WRM9-L-5/31/2015-1	L-0034	Y	2	Y	34.46199	-120.04829	CSLI	Venadito Beach/Canyon	R	Released 8/15/15; Recovered Dead in LA County 10/1/15		
38	1-Jun-15-1	6/1/2015	WRM3-L-6/1/2015/1	L-0035	N	1	Y	34.40707	-119.7588	CSLI	Hendry's Beach	D	Died 6/4	6/4/2015	Gastric perforation and peritonitis
39	1-Jun-15-2	6/1/2015	WRM7-L-6/1/2015-1	L-0036	Y <2%	1	Y	34.098216	-119.10353	CSLI	Point Mugu (Navy Base)	D	Died 6/15	6/15/2015	Emaciated, lungworms
40	2-Jun-15-1	6/2/2015	WRM1-L-6/2/2015-1	L-0037	Y 2-5%	1	Y	34.23454	-119.26536	CSLI	Spinnaker Estuary	R	Released 8/7/15		
42	3-Jun-15-2	6/3/2015	WRM1-L-6/3/2015-1	L-0038	Y <2%	2	Y	34.417145	-119.827264	CSLI	Goleta Beach	D	Died 6/13	6/13/2015	Cardiac fibrosis/cardiomyopathy, endocardiosis, lymph node enlargement
43	5-Jun-15-1	6/5/2015	WRM2-L-6/5/2015-1	L-0039	Y <2%	blank	Y	34.27564	-119.28963	CSLI	Ventura Pier	R	Released 9/16/15		
44	6-Jun-15-1	6/6/2015	WRM5-L-6/6/2015-1	L-0040	Y 2-25%	2	Y	34.41534	-119.7819	HASE	Hope Ranch	D	Died 6/7/15	6/7/2015	Complex mandibular fracture, flipper wound
45	7-Jun-15-1	6/7/2015	WRM1-L-6/7/15-1	L-0041	N		N	34.403058	-119.743971	CSLI	Hendry's Beach	R	Released 9/16/15; initially thought potential fracture hind end		

Cumulative Total	Daily Report #	Date	Field ID	Intake ID	Oiled Field	Oiled Intake	Oiled Final	Lat	Long	Species	Notes	Disposition (D=Died, E=Euthanized, R=Released)	Notes 2	Necropsy Date	Gross Necropsy Findings of Note
47	9-Jun-15-1	6/9/2015	CIMWI15-30022-297	L-0042	N	0	N	34.05.879	-119.06.200	CSLI	Family Beach	D	Died at CIMWI	6/11/2015	Emaciated, skin abrasions
48	11-Jun-15-1	6/11/2015	WRM-3-L-6/11/15-1	L-0043	Y	1	Y	34.40732	-119.69083	CSLI	Santa Barbara Harbor	E	Euthanized at Field Stabilization 6/11	6/13/2015	HI- bullet recovered
49	11-Jun-15-2	6/11/2015	WRM4-L-6/11/15-1	L-0044	N		N			CSLI	Channel Islands Harbor	D	Died at CIMWI	6/13/2015	Emaciated
50	12-Jun-15-1	6/12/2015	WRM2-L-6/12/15-1	L-0045	Y		Y	34.2763	-119.2713	CSLI	Hanover St.	R	Released 7/24/15		
51	13-Jun-15-1	6/13/2015	WRM1-L-6/13/15-1	L-0046	Y <2%	1	Y	34.2753	-119.2957	CSLI	San Buenaventura	R	Released 7/24/15		
52	14-Jun-15-1	6/14/2015	WRM3-L-6/14/15-1	L-0047	Y <2%		Y	34.2472	-119.2661	CSLI	Ventura West Marina	D	Died 6/14/15 en route	6/15/2015	No significant gross findings
53	13-Jun-15-2	6/13/2015	WRM2-L-6/13/15-1	L-0048	N		N	34.159131	-119.22731	CSLI	Hollywood Beach at San Clemente	D	Died 6/14/15 at CIMWI	6/15/2015	Emaciated, gastric ulcers
54	14-Jun-15-2	6/14/2015	WRM1-L-6/14/15-1	L-0049	Y <2%		Y	34.41341	-119.68456	CSLI	East Beach	E	Euthanized 6/18/15	6/19/2015	Tracheal occluding foreign body
55	14-Jun-15-3	6/14/2015	WRM1-L-6/14/15-2	L-0050	Y <2%		Y	34.4166	-119.8311	CSLI	Goleta Beach	R	Released 8/24/15		
56	14-Jun-15-4	6/14/2015	WRM2-L-6/14/2015-1	L-0051	Y <2%	1	Y	34.416	119.6401	CSLI	Coral Casino	R	Released 8/24/15		
57	14-Jun-15-5	6/14/2015	WRM2-L-6/14/2015-2	L-0052	CBD	1	Y	34.3064984	-119.3575098	CSLI	Rincon Parkway	E	Euthanized 6/16/15	6/17/2015	Clinical seizures, gastrointestinal metazoan parasites
58	15-Jun-15-1	6/16/2015	WRM3-L-6/16/2015-1	L-0053		1	Y	34.46298	-1120.06896	CSLI	Refugio State Beach	D	Died 6/17/15	6/17/2015	Myocardial pallor/cardiomyopathy, gastrointestinal parasitism, unilateral renal abiotrophy
59	15-Jun-15-2	6/16/2015	WRM2-L-6/16/15-2	L-0054		0	Y			CSLI	Ormond Beach	D	Died 6/19/15	6/20/2015	No significant gross findings beyond the oil noted
60	18-Jun-15-1	6/18/2015	WRM3-L-6/18/15-2	L-0055		0	Y	34.39354	-119.52585	CSLI	Carpinteria at unden	D	Died 6/19/15	6/20/2015	Mottled lungs
61	22-Jun-15-1	6/22/2015	WRM2-L-6/22/2015	L-0056		1	Y	34.1454	-119.21645	CSLI	Silver Strand	D	Died 6/23/15	6/23/2015	Myositis left front limb, thoracic effusion (pyothorax), necrotizing hepatitis
62		6/6/2015		L-1001		4	Y			HASE	LA County	D			

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Recreational Camping Damages Due to the Refugio Beach Oil Spill

September 14, 2018

prepared for:

Refugio Beach Oil Spill Natural Resource Damage Assessment

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TABLE OF CONTENTS

CHAPTER 1 | INTRODUCTION

On May 19, 2015 an underground pipeline ruptured just west of Refugio State Beach in Santa Barbara County, California, spilling over 120,000 gallons of crude oil into the soil and onto the ground (hereafter referred to as "the spill").[1] A significant portion of the oil flowed down a nearby ravine and into the Pacific Ocean. After reaching the ocean, the oil spread primarily southward and eastward. Oil washed up on shore around Refugio and El Capitan State Beaches (Exhibit 1.1), resulting in the closure of those sites. In the weeks following the spill, oil and/or tarballs washed ashore in numerous locations along the coastlines of Santa Barbara, Ventura, and Los Angeles Counties.

EXHIBIT 1.1. OVERVIEW OF ASSESSMENT AREA

[1] The United States Department of Transportation's failure investigation for the spill indicates that, according to the pipeline owner, 2,934 barrels, or 123,228 gallons of oil were released (USDOT, 2016).

The spill occurred within the undeveloped portion of Santa Barbara County referred to as the "Gaviota Coast." The Gaviota Coast is widely recognized for its scenic beauty and outdoor recreation opportunities, and the area supports California State Park's mission of supporting health, inspiration, and education through the preservation of extraordinary biological diversity, protecting valued natural and cultural resources, and creating opportunities for high-quality outdoor recreation. In fact, in the early 2000s, the National Park Service (NPS) undertook a feasibility study to determine if the Gaviota Coast should be added to the National Park System (NPS, 2003).

Federal and state natural resource trustee agencies ("Trustees"), in coordination with Plains All America Pipeline (the pipeline owner and operator), conducted a Natural Resource Damage Assessment (NRDA) to assess the impacts of the spill on natural resources. The Trustees for the natural resources injured by the spill include the United States Department of Commerce represented by the National Oceanic and Atmospheric Administration; the United States Department of the Interior represented by the United States Fish and Wildlife Service (USFWS) and the Bureau of Land Management (BLM); the California Department of Fish and Wildlife; the California Department of Parks and Recreation; the California State Lands Commission; and the Regents of the University of California.

As part of the NRDA, the Trustees assessed the impacts of the spill on recreational users of the coastal and marine environment. Recreational users were potentially impacted due to the direct oiling of natural resources and the reasonable expectation of oiling, shoreline and fishing closures, advisories, and cleanup activities. This report documents the impact of the spill on recreational camping. Economic losses to campers are based on the economic concept of consumer surplus (USDOI, 1987). An individual's consumer surplus from a camping trip represents the difference between (1) the maximum amount that the individual would be willing to pay for the trip and (2) the amount that the individual actually paid for the trip (in gasoline, supplies, reservation fees, etc.). Thus, consumer surplus is a measure of the net value of a trip, after all expenses have been paid. Camping damages estimated in this report are measured as the aggregate decline in value across all impacted individuals.

We estimated camping damages in four steps:

1) Estimate the number of lost camping nights;
2) Estimate the economic value associated with a camping night;
3) Multiply the number of lost nights by the value per night; and
4) Adjust losses to present value.

Chapter 2 provides a description of camping opportunities in the assessment area and summarizes the spill impacts on these opportunities. Chapter 3 describes our quantification of lost camping nights. Chapter 4 explains our method for estimating the value per camping night and presents total damages.

CHAPTER 2 | OVERVIEW OF SPILL IMPACTS TO CAMPING

This chapter provides an overview of coastal camping opportunities in Santa Barbara and Ventura Counties. It then describes how camping in these counties may have been impacted by the spill. While oil also washed ashore in Los Angeles County, camping impacts in Los Angeles County were deemed negligible based on the absence of impacts in Ventura County (see Chapter 3) and conversations with resource managers.

2.1 CAMPING RESOURCES IN ASSESSMENT AREA

Santa Barbara and Ventura Counties provide a limited number of coastal camping opportunities (Exhibits 2.1 and 2.2). In Santa Barbara County, Jalama Beach County Park is the only coastal campground located north of Point Conception. Three state campgrounds lie between Point Conception and Goleta along the Gaviota Coast: Gaviota State Park, Refugio State Beach, and El Capitan State Beach.[2] Finally, Carpinteria State Beach is located in eastern Santa Barbara County.

In Ventura County, three county campgrounds are located along Highway 101 between Rincon Point and Ventura: Hobson Beach County Park, Rincon Parkway, and Faria Beach County Park. Emma Wood State Beach is located just north of Ventura. McGrath State Beach is located just south of the mouth of the Santa Clara River, and was closed for reasons unrelated to the spill from August 2014 to September 2017.[3] Finally, Point Mugu Beach Recreational Vehicle (RV) Park and Point Mugu State Park are located along Highway 101 south of Oxnard.

With limited camping opportunities along the coast in this region, several of these campgrounds are fully booked in late spring and summer. For example, Refugio and El Capitan State Beaches are completely full on most weekend nights in May and June, and are full or nearly full every night of the week in July and August. Further, visitors to these two parks typically need to reserve campsites three to four months in advance for summer visits.

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[2] Two private campgrounds are located a short walk from El Capitan State Beach north of Highway 101, El Capitan Canyon and Ocean Mesa. Impacts to patrons of these two campgrounds are included in the shoreline use assessment since they use the spill area as day users rather than as campers (see Horsch et al., 2018).

[3] McGrath State Beach has been closed intermittently since September 2017 due to flooding.

EXHIBIT 2.1. SANTA BARBARA AND VENTURY COUNTY COASTAL CAMPING LOCATIONS

EXHIBIT 2.2. CAPACITY OF COASTAL CAMPING LOCATIONS

LOCATION	INDIVIDUAL CAMPSITES (TENT OR RV)	GROUP CAMPSITES
Jalama Beach County Park	107	0
Gaviota State Park	40	0
Refugio State Beach	68	3
El Capitan State Beach	137	5
Carpinteria State Beach	201	7
Hobson Beach County Park	31	0
Rincon Parkway	127 (RV only)	0
Faria Beach County Park	42	0
Emma Wood State Beach	91	5
McGrath State Beach	NA (Closed)	NA (Closed)
Point Mugu Beach RV Park	86	0
Point Mugu State Park	136	3

Sources:
California State Parks System (2016), Santa Barbara County Parks (2016), Hobson Beach Park (2016), Rincon Parkway (2016), Faria Beach Park (2016), Point Mugu RV Park (2016).

2.2 SPILL IMPACTS TO CAMPING

In Santa Barbara County, Refugio and El Capitan State Beaches (including their campgrounds) were both temporarily closed as a result of the spill. Refugio State Beach, located immediately east of the release point, was evacuated on May 19, 2015 and remained closed for 59 days, reopening on July 17, 2015 (Exhibit 2.3). El Capitan State Beach was evacuated on May 20, 2015 and remained closed for 37 days, reopening on June 26, 2015. In addition, a fisheries closure was established on May 19 for the immediately affected area around the release point (Exhibit 2.4). On May 21, the fisheries closure area was expanded to include the shoreline between Canada de Alegeria and Coal Oil Point, as well as all ocean waters within six miles of this shoreline. The fisheries closure remained in place through June 28 and potentially impacted campers at Gaviota State Beach (throughout the entire closure period) and at El Capitan State Beach (for a three-day period after El Capitan State Beach reopened).

In Ventura County, no campgrounds were closed as a result of the spill, but advisories related to the oil spill—instructing people to avoid contact with tar and oil—were posted on large, electronic highway signs along major coastal access routes throughout the county from May 30 to June 8 (Exhibit 2.3).

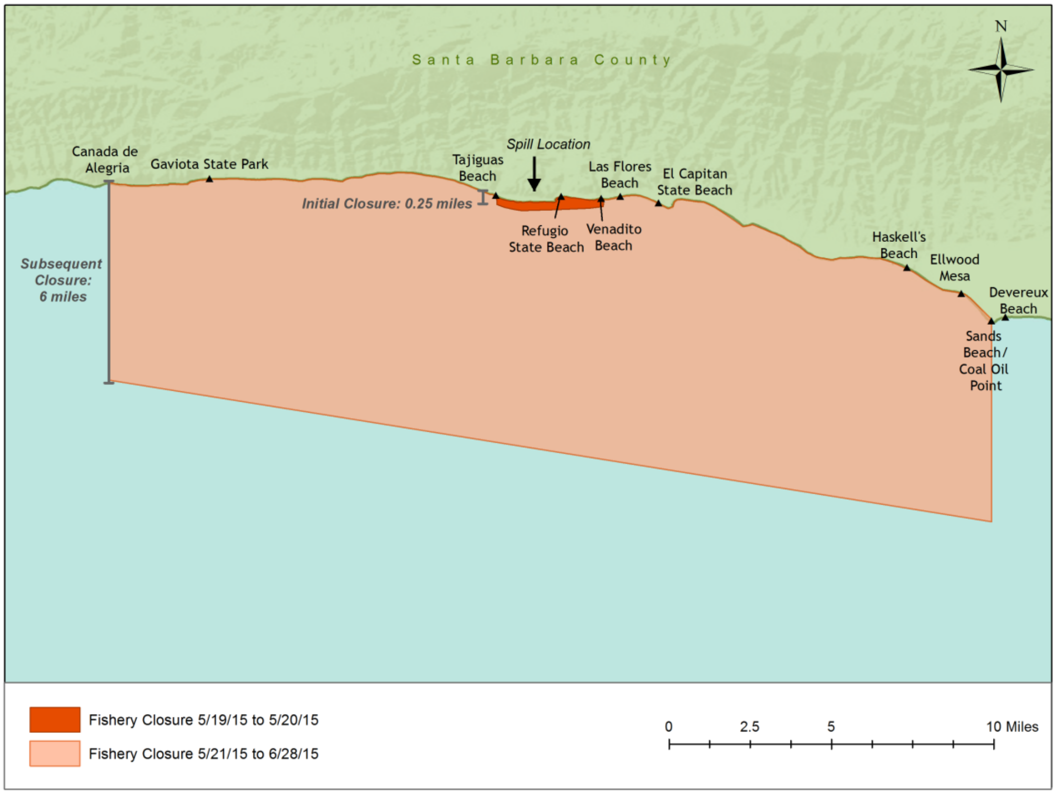
EXHIBIT 2.3. CAMPING-RELATED CLOSURES AND ADVISORIES

LOCATION	CLOSURE OR ADVISORY	BEGIN	END	DURATION
Refugio State Beach	Closure	May 19	July 16	59 days
El Capitan State Beach	Closure	May 20	June 25	37 days
Ocean fishing in vicinity of release point[a]	Closure	May 19	June 28	41 days
Beaches and campgrounds in Ventura County	Advisory	May 30	June 8	10 days

Notes:
[a] – The fisheries closure only included the area near the release point between May 19 and 20 (Exhibit 2.4). Between May 21 and June 28, it was expanded to include the area up to six miles offshore from Canada de Alegeria (western boundary) to Coal Oil Point (eastern boundary).

In addition to these advisories and closures, incident-related cleanup crews were present on numerous beaches in Santa Barbara and Ventura Counties in the weeks following the spill, ranging from Gaviota State Beach in the north to Port Hueneme Beach in the south. Oiling was heaviest and persisted longest in areas close to the release point (i.e., in the vicinity of Refugio and El Capitan State Beaches) and downcoast to Coal Oil Point. The oil spread primarily south and east from the release point, though some spread west to Gaviota State Park. Light to moderate oiling was observed at coastal locations throughout the rest of Santa Barbara County and much of Ventura County. During the weeks after the spill, media coverage of the event was pronounced throughout the South Coast region, and to a lesser extent nationally, on television, social media, and in newspapers.

EXHIBIT 2.4. FISHERIES CLOSURE AREA



CHAPTER 3 | NUMBER OF LOST CAMPING NIGHTS

This chapter describes the quantification of lost coastal camping nights in Santa Barbara and Ventura Counties. We begin with an overview of the available data and the methods used to estimate the number of lost camping nights. We then provide estimates for each site.

3.1 OVERVIEW OF DATA AND ANALYSIS APPROACH

The number of lost camping nights equals the reduction in camping relative to baseline, or the level of use that would have existed had the spill not occurred. At coastal campgrounds located in state parks, the number of occupied campsites is tracked on a daily basis. For these locations, the average number of occupied sites in years prior to the spill is compared to the actual number of occupied sites in 2015 to estimate the number of lost camping nights. For the remaining county and private campgrounds, visitation data are limited. To estimate lost camping nights at these sites, we rely on estimates from surrounding state parks and other relevant information, as described in the final section of this chapter.

For state park campgrounds, we obtained daily data on the number of occupied campsites for May through September for the five years prior to the spill (2010-2014) and for the spill year (2015).[4] We shifted the data series for each pre-spill year to match the days of the week in 2015, beginning with the Tuesday closest to May 19 (the spill date). For example, in 2014 the closest Tuesday to May 19 occurred on May 20, so the 2014 data series was shifted back by one day, such that May 20, 2014 was matched with May 19, 2015, and so on (Exhibit 3.1).

For every day in 2015, we calculate the deviation from baseline as the number of occupied campsites on that day in 2015 minus the average number of occupied campsites on the five matched days in 2010-2014:

(3.1) $$D_t = N_t^{2015} - (N_t^{2010} + N_t^{2011} + N_t^{2012} + N_t^{2013} + N_t^{2014})/5$$

[4] For Point Mugu State Park, we were unable to obtain data for August and September of 2010 and September of 2011-2014.

where:

D_t	=	Deviation on matched day *t*
N_t^y	=	Total number of occupied individual campsites on matched day *t* of year *y*.[5]

EXHIBIT 3.1. ILLUSTRATION OF APPROACH TO MATCHING DAYS

MATCHED DAY NUMBER	DAY OF WEEK	PRE-SPILL YEARS					SPILL YEAR
		2010	2011	2012	2013	2014	2015
1	Tuesday	5/18/2010	5/17/2011	5/22/2012	5/21/2013	5/20/2014	5/19/2015[a]
2	Wednesday	5/19/2010	5/18/2011	5/23/2012	5/22/2013	5/21/2014	5/20/2015
3	Thursday	5/20/2010	5/19/2011	5/24/2012	5/23/2013	5/22/2014	5/21/2015
4	Friday	5/21/2010	5/20/2011	5/25/2012	5/24/2013	5/23/2014	5/22/2015
5	Saturday	5/22/2010	5/21/2011	5/26/2012	5/25/2013	5/24/2014	5/23/2015
6	Sunday	5/23/2010	5/22/2011	5/27/2012	5/26/2013	5/25/2014	5/24/2015
7	Monday	5/24/2010	5/23/2011	5/28/2012	5/27/2013	5/26/2014	5/25/2015
8	Tuesday	5/25/2010	5/24/2011	5/29/2012	5/28/2013	5/27/2014	5/26/2015
9	Wednesday	5/26/2010	5/25/2011	5/30/2012	5/29/2013	5/28/2014	5/27/2015
Etc.							

Notes:
a –Day of the spill.

The daily deviations estimated using Equation 3.1 are summed over two-week periods, beginning with May 20, 2015, the first full day after the spill.[6] Aggregating by two-week periods smooths the results and ensures that major holidays fall within the same time blocks.

Our "matched days" approach to calculating lost camping nights is preferable to using a parametric model (i.e., modeling camping nights as a function of various factors) given that these campgrounds are at or near capacity throughout much of the summer. With the campgrounds at or near capacity, the impact of weather and other factors would be muted in a parametric model, and obtaining accurate predictions for 2015 would be challenging.[7]

[5] Group camping is excluded when calculating these deviations, but it is incorporated in our final estimate of lost camping nights.

[6] Since the closure at Refugio State Beach began on May 19, 2015, the first period for this site includes 15 rather than 14 days.

[7] Censored models were explored, but ultimately were not used due to estimation difficulties.

3.2 RESULTS FOR STATE PARKS AND BEACHES

Exhibit 3.2 presents the estimated percentage deviation from baseline for each site and two-week period. Spill impacts occur when the initial deviation at a site is negative and continue until the first period with a non-negative deviation or until the first full period after Labor Day.[8] We find a decline in camping associated with the spill for two weeks at Gaviota State Park, and through early September at Refugio and El Capitan State Beaches. We do not observe a spill-related decline in camping at any other site. While a modest decline was observed in the data for Carpinteria State Beach, conversations with resource managers indicate that this decline is likely due to a temporary reduction in the number of campsites available to visitors at Carpinteria State Beach in 2015. The highlighted periods in Exhibit 3.2 depict the sites and time periods with spill impacts.

EXHIBIT 3.2. PERCENTAGE DEVIATION BY SITE AND PERIOD[A]

Site	May		June		July		August		September		
Gaviota State Park		-16.1%	34.6%	10.3%	-20.9%	-6.4%	-9.0%	-9.0%	-10.2%	-2.8%	
Refugio State Beach[b]		-100.0%	-100.0%	-100.0%	-100.0%	-17.5%	-2.5%	-3.1%	-3.9%	-4.4%	
El Capitan State Beach		-100.0%	-100.0%	-66.3%	-4.5%	-0.3%	-0.7%	-3.1%	-7.3%	-1.4%	
Carpinteria State Beach		-3.3%	-7.5%	-5.1%	-5.8%	-6.7%	-5.1%	-4.5%	-8.1%	2.2%	
Emma Wood State Beach		13.8%	18.2%	11.9%	1.7%	-1.2%	0.8%	6.4%	12.5%	38.4%	
Point Mugu State Park		6.2%	-18.6%	-14.1%	-15.5%	-6.8%	1.5%	3.8%			

Notes:

[a] – Sites and time periods with a spill impact are highlighted.

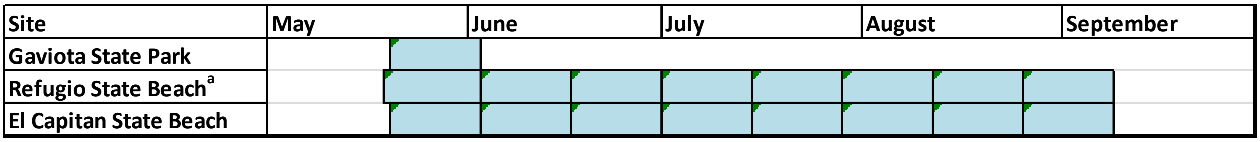
[b] - Since the closure at Refugio State Beach began on May 19, 2015, the first period for this site includes 15 rather than 14 days.

Estimates of baseline camping nights are presented in Exhibit 3.3 for sites and periods where a decline in use due to the spill was observed. These estimates were developed by multiplying our baseline estimates of occupied campsites by the average number of persons per occupied site (as estimated by the California Department of Parks and Recreation), then adding the average number of persons observed at group camping sites during the baseline period.

Lost camping nights are calculated by multiplying the percentage decline for a particular site and period (Exhibit 3.2) by the corresponding baseline nights (Exhibit 3.3). The lost camping night estimates are summarized in Exhibit 3.4. In total we estimate 49,188 lost camping nights, with the vast majority occurring at Refugio and El Capitan State Beaches.

[8] Any impacts after Labor Day were likely very small for two reasons: 1) the amount of baseline camping nights declines significantly after Labor Day, relative to the summer season, and 2) percentage declines were small relative to the summer season and diminishing.

EXHIBIT 3.3. BASELINE CAMPING NIGHTS BY SITE AND PERIOD



Notes:
[a] – Since the closure at Refugio State Beach began on May 19, 2015, the first period for this site includes 15 rather than 14 days.

EXHIBIT 3.4. SUMMARY OF LOST CAMPING NIGHTS

SITE	LOST CAMPING NIGHTS
Gaviota State Park	189
Refugio State Beach	23,009
El Capitan State Beach	25,989
Total	**49,188**

3.3 RESULTS FOR OTHER SITES

This section describes our assessment of impacts to camping at Jalama Beach County Park, Hobson Beach County Park, Rincon Parkway, Faria Beach County Park, and Point Mugu Beach RV Park.

For Jalama Beach County Park, we compared May-September occupancy rates in 2015 with May-September rates in pre-spill years. Based on this analysis, 2015 did not exhibit spill-related impacts. Although intra-month declines due to the spill may be masked in these monthly data, Jalama Beach County Park was relatively far from the spill.

Managers for Hobson Beach County Park, Rincon Parkway, Faria Beach County Park, and Point Mugu Beach RV Park reported that the spill did not have an impact on camping at their sites. While data were not available for these locations, these statements are consistent with results for surrounding sites (Carpinteria State Park and Emma Wood State Beach; Exhibit 3.2).

CHAPTER 4 | VALUE OF A CAMPING NIGHT AND SUMMARY OF DAMAGES

The value of a camping night was estimated using travel cost models for Refugio and El Capitan State Beaches. The analysis was implemented in three steps. First, we used campsite reservation data to estimate baseline demand functions. Second, we adjusted these baseline demand functions to reflect the impact of capacity constraints at the two sites. Third, we used these adjusted baseline demand functions to calculate the value of a camping trip. Each step of the analysis is described in detail below.

4.1 BASELINE DEMAND FUNCTIONS

We estimated baseline demand functions using single-site, zonal travel cost models for Refugio and El Capitan State Beaches. Single-site models were chosen over multiple-site models because data for multiple-site models were not available. In addition, the camping closures occurred during the peak camping season, when vacancies at substitute coastal campgrounds are scarce. Zonal travel cost models relate population trip rates (e.g., camping nights per person) to the cost of traveling to a recreation site, controlling for relevant demographic characteristics (Hellerstein 1992; Hellerstein and Mendelsohn 1993). The cost of traveling to the site is treated as a proxy for price, and the relationship between trip rate and price is used to derive baseline demand.

The unit of analysis for the zonal travel cost models was a zip code tabulation area (ZCTA), a geographic region defined by the U.S. Census Bureau that is largely consistent with U.S. Postal Service ZIP codes.[9] Our analysis focuses on the subset of ZCTAs within 500 driving miles of Refugio State Beach.[10]

For each ZCTA, we used reservation data provided by California State Parks to calculate the total number of reserved camping nights at Refugio and El Capitan State Beaches originating from the ZCTA. We then divided total reserved camping nights by the population of the ZCTA to produce a ZCTA-specific trip rate for each site. In calculating the total number of reserved camping nights, we focused on the 2015 closure dates during the five calendar years prior to the spill. That is, for Refugio State Beach, we focused on

[9] Approximately 2.7 percent of camping nights in the reservation data did not have a ZCTA match for the ZIP code provided, and were therefore excluded from the model. This is likely due to a combination of factors, including the use of P.O. boxes and ZIP code reporting errors.

[10] Five hundred miles was selected as a reasonable upper bound driving distance for the travel cost model. While some campers travel further than 500 miles to visit these sites, we do not know if visitors from these distant origins drive or fly to the site. Minor modifications to the distance cutoff had very little impact on the camping night value.

camping reservations between May 19 and July 16 during the 2010 to 2014 period, and for El Capitan State Beach we focused on camping reservations between May 20 and June 25 for the same five-year period.

The round-trip cost of driving to each site was calculated as the out-of-pocket cost per mile times the total number of miles traveled, plus the opportunity cost of time per hour times the total number of hours spent traveling, plus any tolls. Total miles, hours, and tolls associated with driving to each site were calculated using PC Miler, assuming all trips originate at the geographic centroid of each ZCTA.

The assumed out-of-pocket cost per vehicle mile was $0.418 for Refugio State Beach and $0.334 for El Capitan State Beach. These cost assumptions reflect weighted average out-of-pocket costs for standard vehicles, vehicles pulling trailers, and RVs, with weights determined by the percentage of reservations at each site using each type of transportation. We use $0.243, $0.456, and $0.763 to represent the out-of-pocket cost per vehicle mile for standard vehicles, vehicles pulling trailers, and RVs, respectively.[11] Out-of-pocket and toll costs were divided by 3.2 to reflect cost sharing among vehicle occupants.[12] The opportunity cost of time per hour was calculated as one-third the mean annual income of the ZCTA divided by 2,080 hours (52 weeks times 40 hours per week).[13]

We estimate the parameters of separate Poisson count models for each park. Letting y_i represent the park-specific trip rate associated with the ith ZCTA, the Poisson probability of observing y_i is given by

(4.1) $$P(y_i) = \frac{e^{-\mu_i}{\mu_i}^{y_i}}{y_i!},$$

where μ_i, the expected trip demand, is a function of travel cost (p_i), a set of demographic controls (z_i), and parameters to be estimated (γ and β):

(4.2) $$\mu_i(p_i, z_i) = \exp\,(\gamma p_i + z_i'\beta).$$

The demographic controls used in estimating the models are provided in Exhibit 4.1.

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[11] The per-mile cost for standard vehicles was calculated as the average operating cost (including gasoline, maintenance and depreciation) for small, medium, and large sedans based on the American Automobile Association's 2012 edition of "Your Driving Costs." The per-mile cost for vehicles pulling trailers was developed by adjusting the per-mile cost for standard vehicles using fuel efficiency calculations reported in Table 2 of Thomas, Huff, and West (2014). The per-mile cost for RVs was developed by adjusting the per-mile cost for standard vehicles to reflect a fuel efficiency ratio of approximately 3.14 (29.8 mpg for standard vehicles versus 9.5 mpg for RVs).

[12] California State Parks assumes an average of 3.2 persons per day use vehicle at these sites.

[13] One-third of hourly household income is often used by economists to represent the opportunity cost of time in travel cost models (e.g., Parsons et al., 2009).

EXHIBIT 4.1. DEMOGRAPHIC VARIABLES

VARIABLE DESCRIPTION
Median age
% of population living in Census-designated urban areas
% of adults with a high school diploma or less
% of adults with a 4-year college degree
% of adults unemployed
% white
% male
% of households with members less than 18
Mean household size
Source: 2012 American Community Survey (ACS) five-year averages.

These demographic variables are identical to those used in the Deepwater Horizon infield valuation model (von Haefen, 2015).

4.2 ADJUSTMENTS TO BASELINE DEMAND TO REFLECT CAPACITY CONSTRAINTS

The campgrounds at Refugio and El Capitan State Beaches are frequently filled to capacity during the summer months, even on many weekdays (Exhibit 4.2). As a result, not everyone who would like to camp at these sites can secure a reservation. All else equal, individuals who have a higher willingness to pay to camp at these locations are more likely to exert the effort required to secure a reservation. For this reason, we would underestimate campers' true willingness to pay by calculating the value per camping night using the baseline demand curves described in the previous section. We therefore adjust the baseline demand curves to reflect this capacity constraint prior to calculating a camping night value.

Specifically, we shift each demand curve outward to reflect demand at each site in the absence of the capacity constraint. As day use visits at the two sites are relatively unrestricted, we use information on variation in day use visitation during the baseline years (2010 to 2014) to predict unrestricted demand for camping. We assume that without the capacity constraint, the percentage increase in camping between the pre-closure period and the closure period would mirror the percentage increase in day use between the same two time periods. We specify May 1 to 18 as the pre-closure period for Refugio, and we specify May 1 to 19 as the pre-closure period for El Capitan.

Let d_1 and c_1 represent observed total day use and camping, respectively, during the pre-closure period from 2010 to 2014, and let d_2 and c_2 represent observed total day use and camping, respectively, during the closure period from 2010 to 2014. The percentage increase in camping (δ) without the capacity constraint is estimated as the ratio of day use to camping in the closure period to the ratio of day use to camping in the pre-closure period:

(4.3) $$\hat{\delta} = \frac{\left({d_2}/{c_2}\right)}{\left({d_1}/{c_1}\right)}$$

This percentage increase is estimated separately for weekdays and weekends at each park. A park-specific weighted average percentage increase is then calculated, where the weights are equal to the proportion of use occurring on each type of day.[14] The overall estimated percentage increase in camping demand is 50.0 percent for Refugio and 27.8 percent for El Capitan.

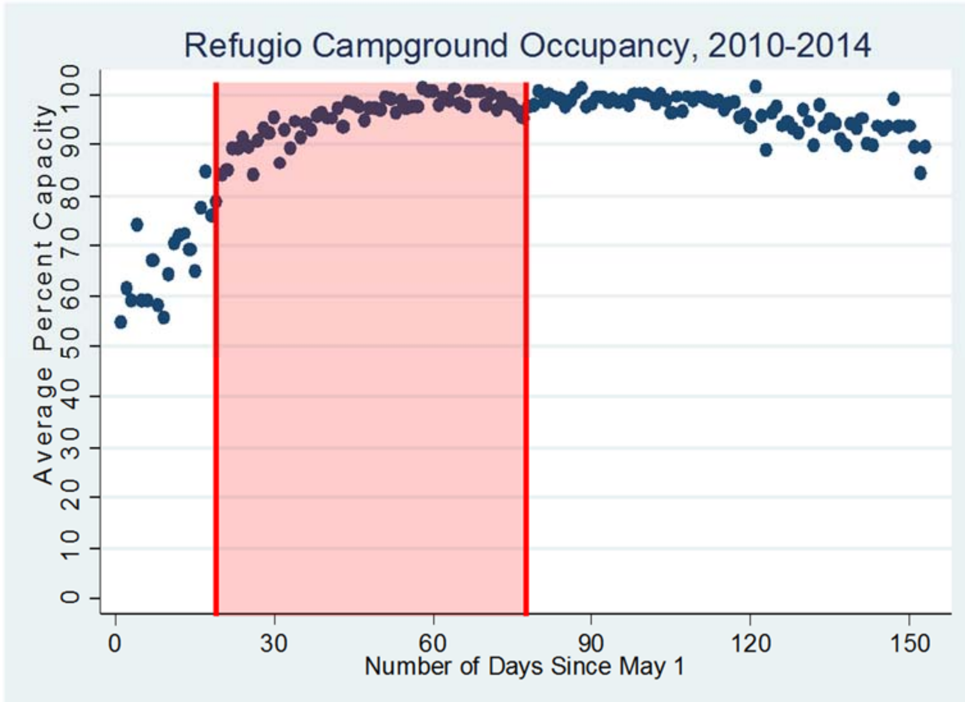
Given these estimated increases, the unrestricted camping demand at each site is given by:

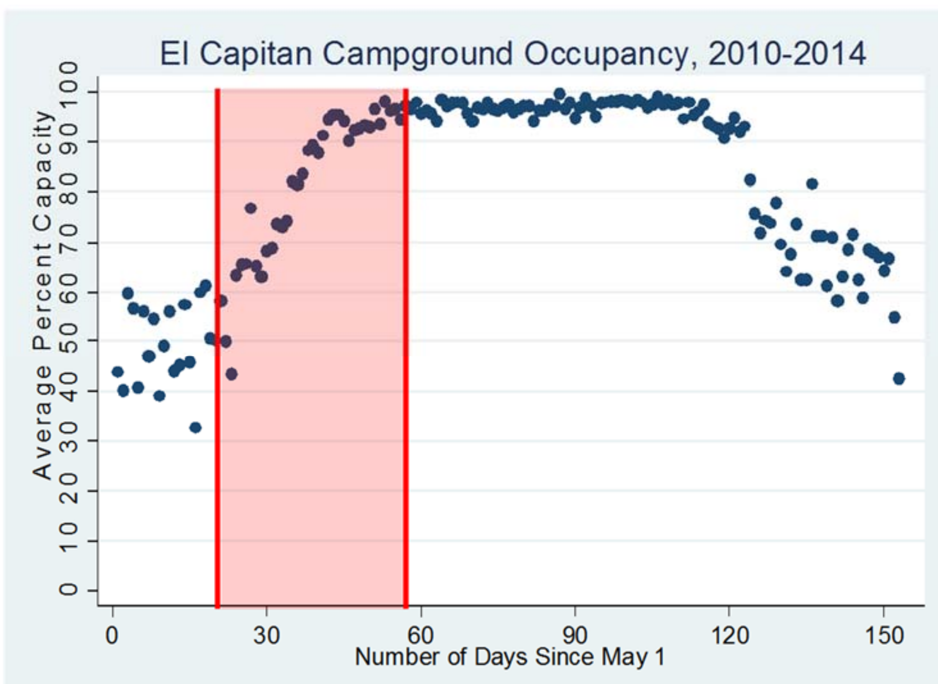
(4.4) $$\tilde{\mu}_i(p_i, z_i) = \hat{\delta}\exp\left(\hat{\gamma}p_i + z_i'\hat{\beta}\right),$$

where $\hat{\gamma}$ and $\hat{\beta}$ are the estimated parameters from Equation 4.2. This is the shifted camping demand curve from Equation 4.2 that would result if demand were allowed to increase to $\hat{\delta}$ times current levels.

[14] Camping at El Capitan does not appear to be capacity constrained on weekdays during the closure period, so the weekday adjustment ratio was 1.0 for El Capitan.

EXHIBIT 4.2. OCCUPANCY RATES AT REFUGIO AND EL CAPITAN STATE BEACHES (2015 CLOSURE PERIODS HIGHLIGHTED)





4.3 VALUE PER CAMPING NIGHT

We use the unrestricted camping demand curves for each park to calculate the value of a camping night. Specifically, for each ZCTA, we calculate the total consumer surplus as the area under the unrestricted demand curve (Equation 4.4) above the price, up to the number of camping trips predicted with the capacity constraint imposed. We then sum consumer surplus across all ZCTAs and divide by the total number of predicted trips to estimate the value per camping night.

Let $\tilde{p}_i(\mu_i, z_i)$ represent the unrestricted inverse demand curve for the ith ZCTA. The camping night value for each park is calculated as:

$$(4.5) \qquad V = \frac{\sum_{i=1}^{n} \int_0^{\mu_i(p_i, z_i)} (\tilde{p}_i(x_i, z_i) - p_i) dx}{\sum_{i=1}^{n} \mu_i(p_i, z_i)}$$

The estimated camping value for Refugio State Beach is $22.99 per night and $30.45 per night for El Capitan State Beach (both in 2012 dollars). We calculate an overall camping night value as the weighted average of the values for the two parks, with weights equal to the number of lost camping nights at each location. The weighted average camping night value is $26.94. We adjust this estimate to July 2018 dollars using the consumer price index (CPI) (Bureau of Labor Statistics, 2018) to obtain an estimated value per camping night of $29.57.

4.4 SUMMARY OF DAMAGES

We combine our estimate of lost camping nights (49,188) with the estimated value per night ($29.57) to calculate damages.[15] Present value damages as of July 2018 are calculated using monthly discounting at an annual rate of three percent (NOAA, 1999). To implement monthly discounting, we assign the two-week loss periods (Exhibit 3.2) to the month that includes the majority of the period. Exhibit 4.3 presents the distribution of losses by month.

EXHIBIT 4.3. TEMPORAL DISTRIBUTION OF CAMPING LOSSES

MAY	JUNE	JULY	AUGUST	SEPTEMBER
25%	57%	15%	1%	2%

Our estimate of camping damages as of July 2018 is $1,593,571.

[15] Some camping nights that occurred after the spill may have been diminished. However, we do not have sufficient data to estimate the number of diminished camping nights. Therefore, diminished camping use impacts are excluded from our damages estimate.

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Recreational Shoreline Use Damages Due to the Refugio Beach Oil Spill

September 14, 2018

prepared for:

Refugio Beach Oil Spill Natural Resource Damage Assessment

prepared by:

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TABLE OF CONTENTS

CHAPTER 1 | INTRODUCTION

On May 19, 2015 an underground pipeline ruptured just west of Refugio State Beach in Santa Barbara County, California, spilling over 120,000 gallons of crude oil into the soil and onto the ground (hereafter referred to as "the spill").[1] A significant portion of the oil flowed down a nearby ravine and into the Pacific Ocean. After reaching the ocean, the oil spread primarily southward and eastward. Oil washed up on shore around Refugio and El Capitan State Beaches (Exhibit 1.1). In the weeks following the spill, oil and/or tarballs washed ashore in numerous locations along the coastlines of Santa Barbara, Ventura, and Los Angeles Counties.

EXHIBIT 1.1. OVERVIEW OF ASSESSMENT AREA

[1] The United States Department of Transportation's failure investigation for the spill indicates that, according to the pipeline owner, 2,934 barrels, or 123,228 gallons of oil were released (USDOT, 2016).

The spill occurred within the undeveloped portion of Santa Barbara County referred to as the "Gaviota Coast." The Gaviota Coast is widely recognized for its scenic beauty and outdoor recreation opportunities, and the area supports California State Park's mission of supporting health, inspiration, and education through the preservation of extraordinary biological diversity, protecting valued natural and cultural resources, and creating opportunities for high-quality outdoor recreation. In fact, in the early 2000s, the National Park Service (NPS) undertook a feasibility study to determine if the Gaviota Coast should be added to the National Park System (NPS, 2003).

Federal and state natural resource trustee agencies ("Trustees"), in coordination with Plains All America Pipeline (the pipeline owner and operator), conducted a Natural Resource Damage Assessment (NRDA) to assess the impacts of the spill on natural resources. The Trustees for the natural resources injured by the spill include the United States Department of Commerce represented by the National Oceanic and Atmospheric Administration; the United States Department of the Interior represented by the United States Fish and Wildlife Service (USFWS) and the Bureau of Land Management (BLM); the California Department of Fish and Wildlife; the California Department of Parks and Recreation; the California State Lands Commission; and the Regents of the University of California.

As part of the NRDA, the Trustees assessed the impacts of the spill on recreational users of the coastal and marine environment. Recreational users were potentially impacted due to the direct oiling of natural resources and the reasonable expectation of oiling, shoreline and fishing closures, advisories, and cleanup activities. This report documents the impact of the spill on recreational shoreline use, including activities such as sunbathing, strolling, exercising, wildlife viewing, swimming, surfing, shore-based fishing, and nonmotorized boating (e.g., canoeing, kayaking, stand-up paddle boarding) originating from beaches or other informal boating access points.[2]

Economic losses to shoreline users are based on the economic concept of consumer surplus (USDOI, 1987). An individual's consumer surplus from a shoreline trip represents the difference between (1) the maximum amount that the individual would be willing to pay for the trip and (2) the amount that the individual actually paid for the trip (in gasoline, supplies, etc.). Thus, consumer surplus is a measure of the net value of a trip, after all expenses have been paid. Shoreline damages estimated in this report are measured as the aggregate decline in value across all impacted individuals.

We estimated shoreline damages in Santa Barbara and Ventura Counties in four steps:

1) Estimate the number of lost shoreline days;
2) Estimate the economic value per lost shoreline day;
3) Multiply the number of lost days by the value per lost day; and

[2] The boating and offshore use assessment (Horsch et al., 2018) includes impacts to nonmotorized boating originating from boat launches and marinas.

4) Adjust losses to present value.

We used a conceptually similar approach for Los Angeles County, but an existing recreation model simplified the process and allowed us to estimate shoreline damages directly. Specifically, the quantification of lost shoreline days and the associated lost economic value are calculated within the model, and the output is simply lost value.

Chapter 2 provides a description of shoreline use opportunities in the assessment area and summarizes the spill impacts on these opportunities. Chapter 3 describes our quantification of lost shoreline days in Santa Barbara and Ventura Counties. Chapter 4 consists of three sections. The first section describes our method for estimating the value per lost shoreline day in Santa Barbara and Ventura Counties. The second section presents our approach for estimating losses in Los Angeles County. The final section of Chapter 4 summarizes our total damages estimate.

CHAPTER 2 | OVERVIEW OF SPILL IMPACTS TO SHORELINE USE

This chapter provides an overview of recreational shoreline use opportunities in Santa Barbara, Ventura, and Los Angeles Counties. It then describes how shoreline use in these areas may have been impacted by the spill.

2.1 SHORELINE USE RESOURCES IN ASSESSMENT AREA

The stretch of coastline from Point Conception in Santa Barbara County to Long Beach in Los Angeles County provides numerous recreation opportunities at sandy beaches and other coastal access points. Much of this coastline is accessible to the public in the form of city, county, and state parks, and via other informal access points. Collectively, the beaches in these areas receive millions of annual visits (Chen et al., 2015).

Exhibit 2.1 displays several shoreline use locations in Santa Barbara County. From north to south along the Gaviota Coast, formal access exists at Gaviota State Park, Refugio State Beach, and El Capitan State Beach. Numerous “pocket beaches” along Highway 101 can be accessed by trails leading down from roadside pulloffs. Around the University of California-Santa Barbara (UCSB) in Isla Vista, access points include Haskell’s Beach, Sands Beach, Devereux Beach, and Campus Point Beach. The Goleta area includes Goleta Beach and Arroyo Burro Beach County Parks. The Santa Barbara waterfront includes Leadbetter, West, and East Beaches. East of the Santa Barbara waterfront are several small beaches and Carpinteria State Beach.

EXHIBIT 2.1. SELECTED SHORELINE USE LOCATIONS IN SANTA BARBARA COUNTY

Exhibits 2.2 and 2.3 display several shoreline use locations in Ventura and Los Angeles Counties. Hobson Beach and Faria Beach Parks are located in northwestern Ventura County. The coast along Ventura and Oxnard has numerous access points, including Emma Wood State Beach, San Buenaventura State Beach, Hollywood Beach, Silver Strand Beach, and Port Hueneme Beach Park. Point Mugu State Park is located in southern Ventura County. The Malibu coastline in Los Angeles County includes Leo Carillo State Park, Zuma Beach, Point Dume State Beach, Malibu Lagoon State Beach, Topanga Beach, and other sites. The coastline of south Santa Monica Bay is nearly one continuous stretch of beach, and includes Santa Monica State Beach, Dockweiler State Beach, Manhattan Beach, Hermosa Beach, and Redondo Beach. Finally, Long Beach is located in southeastern Los Angeles County.

EXHIBIT 2.2. SELECTED SHORELINE USE LOCATIONS IN VENTURA COUNTY

EXHIBIT 2.3. SELECTED SHORELINE USE LOCATIONS IN LOS ANGELES COUNTY

2.2 SPILL IMPACTS TO SHORELINE USE

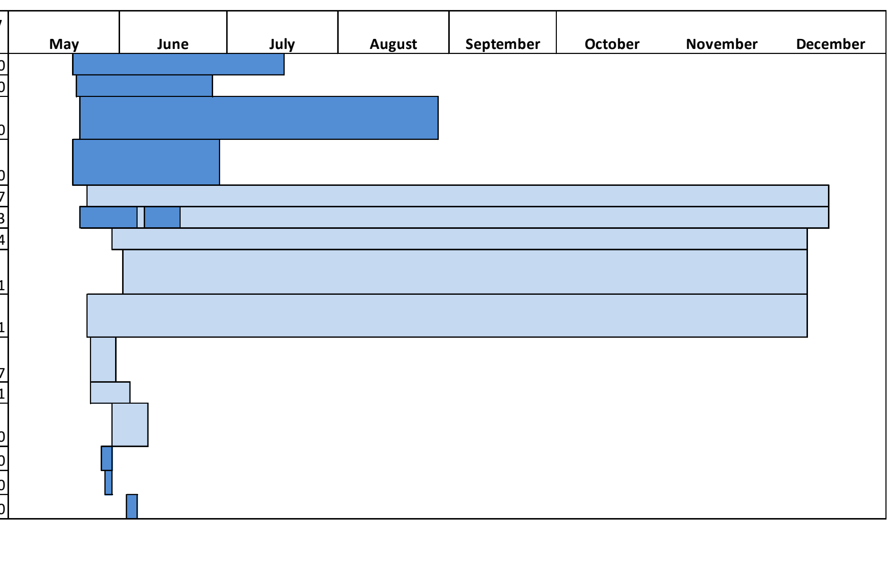
In Santa Barbara County, several beaches were temporarily closed as a result of the spill, including Refugio State Beach, El Capitan State Beach, three pocket beaches (Tajiguas, Venadito, and Las Flores Beaches), and Sands Beach. Refugio State Beach, located immediately east of the release point, was evacuated on May 19, 2015 and remained closed for 59 days, reopening on July 17, 2015 (Exhibits 2.4 and 2.5). El Capitan State Beach was evacuated on May 20 and remained closed for 37 days, reopening on June 26. The three pocket beaches were closed for 100 days from May 21 to August 28. Sands Beach, located in Isla Vista near UCSB was closed for 26 days from May 21 to June 5 and from June 8 to 17. In addition, a fisheries closure was established on May 19 for the immediately affected area around the release point (Exhibit 2.6). On May 21, the fisheries closure area was expanded to include the shoreline between Canada de Alegeria and Coal Oil Point, as well as all ocean waters within six miles of this shoreline. The fisheries closure remained in place through June 28.

Advisory signs instructing people to avoid contact with tar and oil were posted at numerous locations in Santa Barbara and Ventura Counties. These advisories were posted as early as May 23 and removed as late as December 15, depending on the location. Near Isla Vista and Goleta, advisories were present for about 200 days. Along the Santa Barbara waterfront, advisories were posted for as long as 11 days, starting on May 24. In Ventura County, advisories were posted on large, electronic highway signs along major coastal access routes throughout the county from May 30 to June 8.

In Los Angeles County, four beaches were briefly closed seaward of the lifeguard towers (including the water). Manhattan Beach was closed over three days (May 27 to 29), nearby Hermosa and Redondo Beaches were closed over two days (May 28 to 29), and Long Beach was closed over three days (June 3 to 5).

EXHIBIT 2.4. SHORELINE USE-RELATED CLOSURES AND ADVISORIES

Site	Closure Days	Advisory Days
Refugio State Beach	59	0
El Capitan State Beach	37	0
Tajiguas, Venadito, and Las Flores Beaches	100	0
Ocean Fishing in Vicinity of Release Point[a]	41	0
Haskell's Beach	0	207
Sands Beach	26	183
Devereux Beach	0	194
Isla Vista (excluding Campus Point Beaches)	0	191
Goleta Beach and Arroyo Burro Beach County Parks	0	201
Leadbetter and West Beaches	0	7
East Beach	0	11
Beaches and campgrounds in Ventura County	0	10
Manhattan Beach[b]	3	0
Hermosa and Redondo Beaches[b]	2	0
Long Beach[c]	3	0



Notes:

[a] – The fisheries closure only included the area near the release point between May 19 and 20 (Exhibit 2.6). Between May 21 and June 28, it was expanded to include the area up to six miles offshore from Canada de Alegeria (western boundary) to Coal Oil Point (eastern boundary).

[b] – Manhattan Beach was closed the afternoon of May 27. Hermosa and Redondo Beaches were added to the closure area on May 28, and all three beaches were closed through the evening of May 29.

c – Closure in place from late evening on June 3 to early morning on June 5. Closure included area between 1st Place and 72nd Place.

EXHIBIT 2.5. LOCATIONS OF ADVISORIES AND CLOSURES

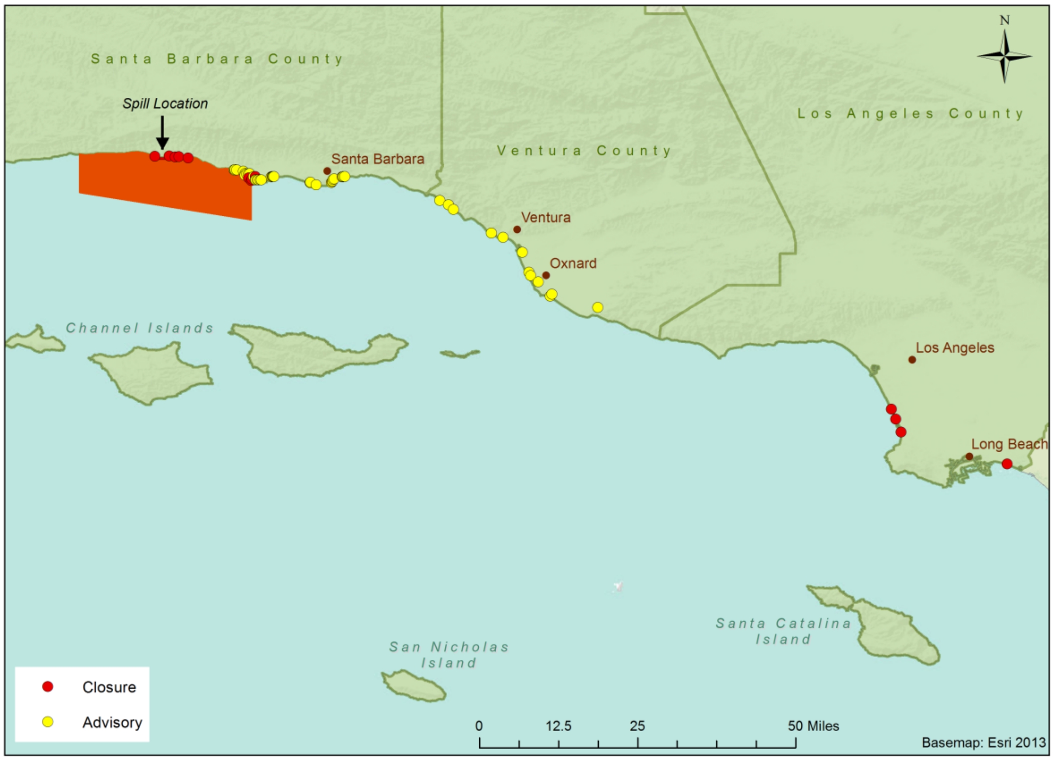
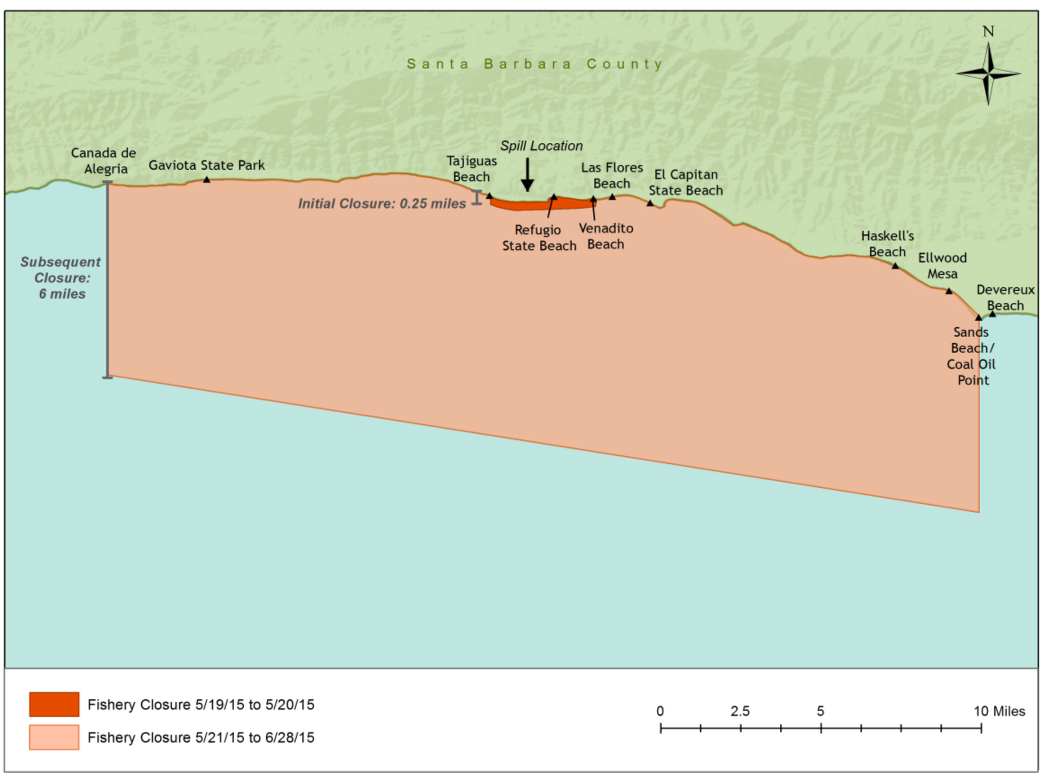


EXHIBIT 2.6. FISHERIES CLOSURE AREA



In addition to these advisories and closures, incident-related cleanup crews were present on several beaches in the weeks following the spill, ranging from Gaviota State Beach in the north to Long Beach in the south. Oiling was heaviest and persisted longest in areas close to the release point (i.e., in the vicinity of Refugio and El Capitan State Beaches) and downcoast to Coal Oil Point. The oil spread primarily south and east from the release point, though some spread west to Gaviota State Park. Light to moderate oiling was observed at coastal locations throughout the rest of Santa Barbara County and much of Ventura County. Oil and tarballs also washed ashore at some locations in Los Angeles County. During the weeks after the spill, media coverage of the event was pronounced throughout the South Coast region, and to a lesser extent nationally, on television, social media, and in newspapers.

CHAPTER 3 | NUMBER OF LOST SHORELINE RECREATION DAYS IN SANTA BARBARA AND VENTURA COUNTIES

This chapter describes the quantification of lost shoreline days in Santa Barbara and Ventura Counties. We begin with an overview of the available data and the methods, and then describe how these methods are implemented. The final section summarizes our estimate of lost shoreline days.

3.1 OVERVIEW OF DATA AND ANALYSIS APPROACH

The number of lost shoreline days equals the reduction in shoreline use relative to baseline, or the conditions that would have existed had the spill not occurred. We calculated lost days for each site in three steps:

1) Calculate the percentage reduction in use;
2) Estimate baseline use; and
3) Multiply the percentage reduction in use by baseline use.

PERCENTAGE REDUCTION IN USE

For a subset of coastal sites in Santa Barbara and Ventura Counties, we have daily data over multiple months on site attendance, vehicle traffic, or parking fees for 2015 and at least one other year. These sources constitute the best available information for quantifying the percentage reduction in use due to the spill, and are described in the following bullets.

- **State Parks Day Use Data**: The California Department of Parks and Recreation tracks the number of day use vehicles (separate from camping) entering each state park in the assessment area on a daily basis. We obtained data for 2010-2015 for most parks.
- **UCSB Coal Oil Point Reserve Spot Counts**: The Coal Oil Point Reserve at UCSB conducts spot counts of beach and water users at Sands Beach. A spot count (or "instantaneous count") provides a snapshot of the number of visitors at a specific time of day. For example, a spot count conducted at 3:30 pm might take a few minutes and result in a count of 15 users. Data are collected nearly every day, and several counts are usually conducted on each data collection day. We obtained data for 2010-2015.
- **County of Santa Barbara Vehicle Counter Data**: The County of Santa Barbara used automated counters to track daily vehicle traffic at Goleta Beach and Arroyo Burro Beach County Parks during the summer in 2015 and 2016.

- **Santa Barbara City Parking Data**: The City of Santa Barbara collects parking fees for coastal lots using a mixture of parking attendants and self-pay machines. We obtained daily data on the number of vehicles that paid for parking at lots along the Santa Barbara waterfront from 2010-2015. The lots include Leadbetter Lot, Palm Park Lot, and Cabrillo East and West Lots.[3]

Using these data, we constructed site-specific models of visitation as a function of weather, day of week, holidays, month, and other factors (Section 3.2). The models were used to predict visitation in 2015 at each site as if the spill had not occurred. Predicted visitation was compared to actual use to estimate the percentage reduction in use.

For a few sites around Coal Oil Point, we have limited data for a short period after the spill in 2015 and for the same time period in 2016. Specifically, the Trustees conducted spot counts multiple times per day in late May and early June in 2015 and 2016 at Haskell's Beach, Sands Beach, Devereux Beach, and Campus Point Beach. Using these data, we estimate the percentage reduction in use by comparing estimates of total use across years (Section 3.3).[4]

We do not have reliable data for estimating changes in visitation at other sites in Santa Barbara and Ventura Counties. Therefore, we estimate the percentage reduction in use for these sites by extrapolating results from surrounding areas (Section 3.3).

BASELINE USE

For all sites, we rely on visitation data collected outside of the spill period to develop estimates of baseline use. We estimate baseline for Refugio and El Capitan State Beaches, the three adjacent pocket beaches, and Goleta and Arroyo Burro Beach County Parks using the data sources described above combined with supplemental visitation data collected by the Trustees in early June 2016 (Section 3.4). Specifically, supplemental visitation data were collected at Tajiguas Beach, Venadito Beach, Las Flores Beach, El Capitan State Beach (walk-in day use only), Goleta Beach County Park, and Arroyo Burro Beach County Park.[5] Together, these data allow us to develop comprehensive estimates of baseline use at each of these sites.

For other sites, the data used to estimate the percentage reduction in use cannot also be used to develop comprehensive estimates of baseline use. For example, parking sales data from Santa Barbara Waterfront only provide a partial picture of baseline visitation because they exclude walk-in use. Instead, we estimate baseline visitation using information from an offsite survey conducted by the South Coast Marine Protected Areas

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[3] The locations of these lots can be found on the City of Santa Barbara's website: http://www.santabarbaraca.gov/gov/depts/waterfront/parking/parking_lots.asp.

[4] The primary source of information for estimating percentage reduction in use at Sands Beach is the daily data model based on the UCSB Coal Oil Point Reserve spot counts (Section 3.2). However, we considered the Trustee spot counts in our analysis (Section 3.3).

[5] Data were also collected at Santa Barbara City coastal parking lots in early June 2016, however, these data were used to characterize the type of visitation (recreational vs. non-recreational) rather than to estimate total baseline use.

(MPA) Baseline Program (Section 3.4). The South Coast MPA Baseline Program used a general-population online survey in 2012-2013 of Southern California residents to estimate the amount and types of visitation at locations throughout the South Coast region (i.e., from Point Conception in Santa Barbara County to the California/Mexico border; Chen et al., 2015). This work was part of a long term effort to understand visitation trends in and around MPAs along the South Coast. This data source is referred to as "the MPA Baseline survey" elsewhere in this chapter.

3.2 PERCENTAGE REDUCTION IN USE FOR SITES WITH DAILY DATA MODELS

This section describes the site-specific models used to estimate the percentage reduction in use at Gaviota State Park, Refugio and El Capitan State Beaches, Sands Beach (including Coal Oil Point), Goleta and Arroyo Burro Beach County Parks, Santa Barbara Waterfront (Leadbetter Beach, West Beach, and East Beach), Carpinteria State Beach, San Buenaventura State Beach, and Point Mugu State Park (see Exhibits 2.1 and 2.2).[6] We first describe model development and then present the results.

METHOD

As discussed in Section 3.1, we compiled daily data for several sites on attendance, parking sales, or vehicle traffic for 2015 and at least one other year. These data were used to estimate site-specific models of daily visitation in non-spill years (Exhibit 3.1). The models are then used to predict visitation in 2015 at each site as if the spill had not occurred. We compared predicted and actual visitation in 2015 to estimate the percentage reduction in use for these sites.

EXHIBIT 3.1. VISITATION DATA USED TO ESTIMATE DAILY DATA MODELS

SITE	VISITATION DATA USED TO ESTIMATE MODEL
State Parks	Day use data from May to September 2010-2014[a,b]
Sands Beach (including Coal Oil Point)	Spot counts of beach users from May to July 2010-2014
Goleta and Arroyo Burro Beach County Parks	Vehicle traffic counts from late May to late July 2016
Santa Barbara Waterfront Beaches	Parking fee data from May to September 2010-2014[c]

Notes:
[a] – Day use data are collected at the main lot and pier lot at San Buenaventura State Beach. Data from the main lot have not been collected consistently over time due to differences in how special events are handled, and were therefore excluded from our analysis. We were unable to obtain data for the pier lot prior to June 2011. Pre-spill data from May 2015 are included in the San Buenaventura pier lot model as described later in this section.
[b] – For Point Mugu State Park, we were unable to obtain data for August and September of 2010 and September of 2011-2014.
[c] – For Palm Park Lot, pre-2014 data are excluded because parking fees were collected differently than in 2014 and 2015.

[6] While day use data are collected at Emma Wood State Beach, they have not been collected consistently over time due to funding constraints. Our estimate of the percentage reduction in use for this site is included in Section 3.3.

The data listed in Exhibit 3.1 were used to estimate site-specific Poisson count models of visitation, where the number of recreators or vehicles at a site is modeled as a function of weather, day of week, holidays, month, and other site-specific controls.

Letting y_t represent the count of visitors or vehicles observed on day t, the Poisson regression model specifies the probability of observing y_t as follows:[7]

$$(3.1) \qquad P(y_t) = \frac{e^{-\mu_t} \mu_t^{y_t}}{y_t!}.$$

where μ_t is the expected count of visitors or vehicles and is a function of explanatory variables (x_t) and coefficients (β). As is standard for a Poisson regression, μ_t is specified as a log-linear function (Cameron and Trivedi, 1998):

$$(3.2) \qquad \mu_t = \exp\,(x_t' \beta).$$

The model is estimated by selecting the coefficients β that maximize the following likelihood function:

$$(3.3) \qquad L = \prod_{t=1}^{T} P(y_t)$$

The explanatory variables listed in Exhibit 3.2 were included in x_t:

EXHIBIT 3.2. EXPLANATORY VARIABLES INCLUDED IN DAILY DATA MODELS

VARIABLE	DESCRIPTION
DAY_t^d	1 if the count occurred on the dth day of the week and did not occur on a holiday or holiday weekend, as defined below (= 0 otherwise), (d = 2, 3, 4, 5, 6, 7).
$MONTH_t^m$	1 if the count occurred during mth month of the year (= 0 otherwise), (m = 5, 6, 7, 8 for sites with May through September data; highest available month omitted).
JUN_EARLY_t	1 if the count occurred between June 1 and 15 (= 0 otherwise).
MEM_t	1 if the count occurred on Memorial Day weekend (Saturday, Sunday, or Monday) (= 0 otherwise).
$4TH_t$	1 if the count occurred on Fourth of July or the holiday weekend (= 0 otherwise).[8]
$LABOR_t$	1 if the count occurred on Labor Day weekend (Saturday, Sunday, or Monday) (= 0 otherwise).

[7] On many days, multiple spot counts were conducted at UCSB Coal Oil Point Reserve. For this site, y_t represents the count of visits observed at day-time t.

[8] For years when Fourth of July falls on a Tuesday, Wednesday, or Thursday, this variable equals one for that day only. For years when Fourth of July falls on a Monday or a Friday, this variable equals one for the holiday itself and both adjacent weekend days. For years when Fourth of July falls on a Saturday or Sunday, this variable equals one for both weekend days.

VARIABLE	DESCRIPTION
$TEMP_t^{a-b}$	1 if the high temperature at the nearest weather station on day *t* was greater than *a* and less than or equal to *b* (= 0 otherwise), (*a-b* = 65-70, 70-75, 75-80, 80-85, 85-90, 90-100).[9]
PPT_t	1 if there was at least 0.1 inches of precipitation reported at the nearest weather station during the most recent 24-hour period (= 0 otherwise).
$WIND_t$	Average daily wind speed on day *t* at the nearest weather station.
$YEAR\_2014\_15_t$	1 if the count occurred in 2014 (or 2015 for predictions) (= 0 otherwise). This variable was only included in the models for Gaviota State Park and Refugio State Beach. Sand was scoured from the beaches at these sites during a spring 2014 storm.
$YEAR\_2015_t$	1 if the count occurred in 2015 (= 0 otherwise). This variable was only included in the pier lot model for San Buenaventura State Beach where a transition from attendant-based parking in 2011-2014 was made to self-pay parking in early summer 2015.
$TIME_t^{a-b}$	1 if the spot count collection time on day *t* was greater than *a* and less than or equal to *b* (= 0 otherwise), (*a-b* = 9:00-12:00, 12:00-15:00, 15:00-21:00). These variables were only included in the model for Sands Beach.
$UCSB\_SPRING_t$	1 if the UCSB spring semester was in session (= 0 otherwise). This variable was only included in the model for Sands Beach.
$SBCC_t$	1 if Santa Barbara City College was in session (= 0 otherwise). This variable was only included in the model for Leadbetter Beach.

The estimated models are used to predict the number of recreators or vehicles, μ_t, from (3.2), that would have been at each site in 2015 had the spill not occurred. Specifically, the estimated model coefficients, $\hat{\beta}$, are combined with site- and time-specific factors, x_t, to generate daily predictions (or day-time predictions at Sands Beach) of recreators or vehicles. The resulting predictions control for weather, day of week, holidays, month, and other relevant site-specific factors that are in the model.

The model predictions, μ_t from (3.2), are grouped by two-week periods to smooth the results, and compared with actual 2015 counts associated with the same time periods. The percentage deviation in counts for a time period (D) is then calculated as the actual counts for the period ($Y = \sum y_t$) minus predicted counts for the period ($\hat{Y} = \sum \mu_t$) divided by those predicted counts:

(3.4) $$D = \frac{Y - \hat{Y}}{\hat{Y}}$$

[9] No temperature exceeded 100 degrees in the data. All weather data are from stations monitored by the National Centers for Environmental Information (formerly the National Climatic Data Center).

An additional adjustment is required for sites where the data represent a mixture of visitation for recreation and other purposes – namely, the vehicle traffic counts at Goleta and Arroyo Burro Beach County Parks and the parking fee data from coastal lots along the Santa Barbara Waterfront. Since the estimated deviations at these sites represent changes in *overall* use, they may understate percentage changes in *recreational* visitation, as we would not expect non-recreational visitation to be affected by the spill. Surveys conducted by the Trustees at these sites in early June 2016 are used to estimate the percentage of visitation associated with recreation at each site. The estimated deviations are divided by these percentages to estimate changes in recreational use.

RESULTS

Exhibit 3.3 presents the percentage deviation in use for sites with daily data for each two-week period. Spill impacts occur when the initial deviation at a site is negative and continue until the first two-week period with a non-negative deviation. The highlighted periods in Exhibit 3.3 depict the sites and time periods with spill impacts. Our analysis shows a decline in day use associated with the spill for 16 weeks at Refugio State Beach; for six weeks at El Capitan State Beach; for four weeks at Sands Beach, Goleta Beach County Park, and Arroyo Burro Beach County Park; for 12 weeks at Leadbetter Beach; and for two weeks at Carpinteria State Beach, San Buenaventura State Beach, and Point Mugu State Park. We do not observe a decline in day use at Gaviota State Park, West Beach, or East Beach.

EXHIBIT 3.3. PERCENTAGE DEVIATION BY SITE AND PERIOD, MODELED SITES[A]

Site	May	June		July			August		September
Gaviota State Park	14.3%	39.8%	20.0%	19.8%	14.3%	29.3%	14.6%	4.0%	34.5%
Refugio State Beach[b]	-100.0%	-100.0%	-100.0%	-100.0%	-24.3%	-16.8%	-14.6%	-2.9%	28.4%
El Capitan State Beach	-100.0%	-100.0%	-61.9%	2.2%	8.8%	5.6%	2.2%	9.2%	39.1%
Sands Beach	-35.8%	-53.1%	10.9%	26.8%	-11.3%				
Goleta Beach County Park	-2.9%	-3.1%	3.7%	-6.3%	-6.5%				
Arroyo Burro Beach County Park	-0.4%	-5.3%	5.1%	0.1%	-2.7%				
Leadbetter Beach	-31.2%	-5.1%	-21.3%	-1.0%	-18.3%	-4.5%	13.5%	20.0%	18.8%
Palm Park Lot (West/East Beach)	1.3%	-6.5%	30.3%	21.0%	12.9%	32.4%	-2.6%	-21.7%	-45.7%
Cabrillo Lots (East Beach)	26.1%	21.8%	49.7%	19.0%	33.5%	78.3%	30.2%	55.5%	29.3%
Carpinteria State Beach	-9.8%	12.3%	24.9%	2.0%	-0.5%	31.8%	-2.8%	-9.9%	16.7%
San Buenaventura State Beach	-10.6%	13.3%	28.1%	56.1%	19.5%	81.1%	97.2%	56.0%	-1.4%
Point Mugu State Park	-2.0%	5.4%	11.8%	10.8%	28.4%	24.0%	-35.4%		

Notes:
a – Sites and time periods with a spill impact are highlighted.
b – Since the closure at Refugio State Beach began on May 19, 2015, the first period for this site includes 15 rather than 14 days.

3.3 PERCENTAGE REDUCTION IN USE FOR OTHER SITES

Santa Barbara and Ventura Counties include additional coastal recreation sites beyond those included in Exhibit 3.3. We describe our approach for estimating the percentage reduction in use at these sites in the sections below.

POCKET BEACHES

Tajiguas, Venadito, and Las Flores Beaches are small pocket beaches adjacent to Refugio and El Capitan State Beaches. As shown in Exhibit 2.4, these beaches were closed between May 21 and August 28, 2015, resulting in a 100 percent reduction in use during this period.

COAL OIL POINT AREA

The Trustees conducted spot counts twice per day for 10 days at Haskell's Beach, Sands Beach, Devereux Beach, and Campus Point Beach in late May and early June in 2015 and 2016 (5/29/15 to 6/7/15 and 6/3/16 to 6/12/16). The 2015 data collection times were replicated in 2016 to aid in year-over-year comparisons. Because of the small samples, we compared site-level sums across years rather than constructing daily models with multiple explanatory variables. No adjustments were made for weather or other factors, which were relatively constant across years.

We observe a decline in 2015 use relative to 2016 for Haskell's and Sands Beaches (34 and 32 percent, respectively) similar to the percentage reduction in use reported in Exhibit 3.3 for Sands Beach. Given these results, we adapt the percentage reduction in use for Sands Beach from Exhibit 3.3 for the stretch of coastline between Haskell's and Sands Beaches. We do not find a decline in use for Devereux or Campus Point Beaches.

EXTRAPOLATION APPROACH FOR OTHER SITES

Visitation data were available for some other sites in Santa Barbara and Ventura Counties, but were examined and determined to be unsuitable for estimating changes in visitation due to limited temporal resolution or other factors. We therefore calculated the percentage reduction in use for all other coastal sites in the two counties by extrapolating from percentage reductions estimated at nearby sites. Specifically, the percentage decline for each two-week period was estimated as the average of the percentage declines at the nearest upcoast and downcoast sites with adequate data.[10] This extrapolation approach is consistent with levels of oiling, advisories and closures, and site characteristics, which are spatially correlated.

Exhibit 3.4 summarizes the estimated percentage reduction in use by site and two-week period. The exhibit incorporates results presented in Section 3.3 and estimates for segments of coast where we use the extrapolation approach.[11]

[10] In cases where the duration of decline differs for the two boundary sites, a value of zero percent is used in the average calculation for the site with no estimated decline. For example, sites between Arroyo Burro Breach County Park and Leadbetter Beach are assigned the average percentage reduction in use of those two sites. Since the spill decline at Arroyo Burro lasted four weeks and the decline at Leadbetter lasted 12 weeks, the two-week averages are computed using a zero percent decline at Arroyo Burro for weeks five to 12.

[11] The Trustees do not claim for any spill-related losses for the segments of coast between Gaviota State Park and Tajiguas Beach and between Point Mugu State Park and the Los Angeles County line due to uncertainty about the applicability of the approach for these two segments. Baseline recreational use in these areas is expected to be low compared to the surrounding sites.

EXHIBIT 3.4. PERCENTAGE REDUCTION IN USE BY SITE AND PERIOD, SUMMARY

Site	May		June		July		August	September		
1. Gaviota State Park		No impact quantified								
2. Pocket Beaches[a]		-100.0%	-100.0%	-100.0%	-100.0%	-100.0%	-100.0%	-100.0%	-22.4%	
3. Refugio State Beach[b]		-100.0%	-100.0%	-100.0%	-100.0%	-24.3%	-16.8%	-14.6%	-2.9%	
4. El Capitan State Beach		-100.0%	-100.0%	-61.9%						
5. Haskell's Beach		-35.8%	-53.1%							
Sites between 5 and 6		-35.8%	-53.1%							
6. Sands Beach		-35.8%	-53.1%							
7. Deveruex and Campus Point Beaches		No impact quantified								
8. Goleta Beach County Park		-2.9%	-3.1%							
Sites between 8 and 9		-1.7%	-4.2%							
9. Arroyo Burro Beach County Park		-0.4%	-5.3%							
Sites between 9 and 10		-15.8%	-5.2%	-10.6%	-0.5%	-9.2%	-2.2%			
10. Leadbetter Beach		-31.2%	-5.1%	-21.3%	-1.0%	-18.3%	-4.5%			
11. West and East Beaches		No impact quantified								
Sites between 11 and 12		-4.9%								
12. Carpinteria State Beach		-9.8%								
Sites between 12 and 13		-10.2%								
13. San Buenaventura State Beach		-10.6%								
Sites between 13 and 14		-6.3%								
14. Point Mugu State Park		-2.0%								

Notes:

[a] – Since the closure at the pocket beaches began on May 21, 2015, the first period for this site includes 13 rather than 14 days. The percentage reduction in use for the final two-week period was calculated using the fraction of baseline use occurring up until the end of the closure on August 28 (described further in Section 3.4).

[b] – Since the closure at Refugio State Beach began on May 19, 2015, the first period for this site includes 15 rather than 14 days.

3.4 BASELINE USE

This section describes our approach for estimating baseline use levels at impacted sites. Baseline use represents the level of recreation use that would have existed had the spill not occurred. We multiply these baseline use estimates by our site-specific estimates of the percentage reduction in use to calculate lost days due to the spill.

For some sites, we are able to develop comprehensive estimates of baseline use from available onsite data. These sites include Refugio and El Capitan State Beaches, the pocket beaches, and Goleta and Arroyo Burro Beach County Parks. For the remaining sites, we rely on information from the MPA Baseline survey (Chen et al., 2015).

REFUGIO AND EL CAPITAN STATE BEACHES, THE POCKET BEACHES, AND GOLETA AND ARROYO BURRO BEACH COUNTY PARKS

Below, we describe the source data and method for estimating baseline use at each site with comprehensive onsite data.

- Refugio State Beach: The Refugio day use data include counts of the number of vehicles paying a daily fee or using a State Parks Annual Pass. The California Department of Parks and Recreation has data on the average number of individuals per vehicle that we use to convert vehicle counts to estimates of visitation. Since walk-in visitation at this site is uncommon, we use the vehicle day use data to estimate baseline use.[12] We multiplied the model predictions for 2015 (described in Section 3.2) by the average number of individuals per vehicle to estimate baseline use in each two-week period.

- El Capitan State Beach: The El Capitan day use data include all visitors entering in vehicles, but exclude visitors entering by foot or bicycles (hereafter, "walk-in" use). The primary sources of walk-in use are the two private campgrounds on the north side of Highway 101: El Capitan Canyon and Ocean Mesa. Interval counts of walk-in users were conducted at El Capitan State Beach on a sample of days and times between June 1 and 14, 2016. Interval counts enumerate all visitors departing from (or arriving to) a site during a time period. Interviews were also conducted to identify visitors leaving for the last time and to determine the purpose of visits (i.e., to distinguish recreators from non-recreators). These data were used to estimate recreation walk-in use for the entire two-week period. We calculated the ratio of walk-in use to camping use at El Capitan State Beach during the data collection period in 2016.[13] This ratio was applied to predicted baseline camping use for each two-week period in 2015 to estimate baseline walk-in use during the same periods.[14] We estimated baseline vehicle use using the same method described above for Refugio State Beach. Estimates of walk-in and vehicle use were combined to estimate total baseline use.
- Pocket beaches: Interval counts and interviews were conducted at Tajiguas Beach on the same sample of days as El Capitan State Beach between June 1 and 14, 2016. These data were used to estimate recreation use for the entire two-week period. Spot counts of parked vehicles were also conducted several times a day at Tajiguas, Venadito, and Las Flores Beaches on days when interval counts were conducted at Tajiguas. These data were used to estimate use at Venadito and Las Flores Beaches relative to Tajiguas Beach. Finally, we calculated the ratio of pocket beach visitation to day use at Refugio and El Capitan State Beaches during the data collection period in 2016. This ratio was applied to predicted baseline use at the two state parks for each two-week period in 2015 to estimate baseline use at the pocket beaches during the same periods.
- Goleta and Arroyo Beach County Parks: Interval counts of vehicles and pedestrians were conducted at entrances to these sites on a sample of days and times between June 1 and 14, 2016. Interviews were conducted to identify visitors leaving the site for the last time and to determine the purpose of visits (i.e., to distinguish recreators from non-recreators). The interval count data were

[12] Some visitors may arrive by foot via the Aniso Trail, which connects El Capitan and Refugio State Beaches. However, these visitors would likely have accessed the trail from El Capitan or one of the pocket beaches and would therefore be included in the estimates for those sites.

[13] We use camping use because walk-in users come primarily from the two private campgrounds and we expect El Capitan State Beach camping use to be correlated with camping at those campgrounds.

[14] Our approach for estimating baseline camping use in 2015 is described in Leggett et al. (2018).

combined with data from automated vehicle counters at the site entrances to estimate the ratio of recreators to counted vehicles. These site-specific ratios were applied to predicted traffic counts for each two-week period in 2015 (described in Section 3.2) to estimate baseline recreation use during the same periods.

OTHER SITES

We rely on information from the MPA Baseline survey to develop estimates of baseline use at all other sites. The MPA Baseline data were generated through a general-population online survey of Southern California residents, conducted in 2012-2013 to estimate the amount and types of visitation at locations throughout the South Coast region (Chen et al., 2015). The survey collected data over four independent quarterly waves from 4,492 residents of 10 South Coast counties: San Luis Obispo, Kern, San Bernardino, Santa Barbara, Ventura, Los Angeles, Orange, Riverside, San Deigo, and Imperial. As part of the survey, respondents were asked to place markers on a map to indicate the location of their most recent trip to the South Coast. The survey contractor (Knowledge Networks) developed weights that allow the sample data to be aggregated to the population of adult residents of the 10 counties. We used the survey data, sampling weights, and marked trip locations to estimate annual trips to sites along the South Coast. The number of annual trips to the *j*th site is estimated as:

(3.5) $$Trips_j = \sum_{i=1}^{n} \frac{t_i w_i r_i d_{ij}}{k_i},$$

where:

t_i	= number of coastal trips taken by respondent *i* over last 12 months.
w_i	= survey weight associated with respondent *i*.
r_i	= 1 if the primary purpose of respondent *i*'s most recent coastal trip was non-camping recreation (=0 otherwise).
d_{ij}	= 1 if respondent *i* visited site *j* on most recent coastal trip (=0 otherwise).
k_i	= number of sites visited on respondent *i*'s most recent coastal trip.

As a final step, the annual MPA baseline trip estimates were allocated to the two-week periods used in analysis (see Exhibit 3.4). This allocation was implemented using the daily onsite visitation data available for Goleta and Arroyo Burro Beach County Parks, Leadbetter Beach, Carpinteria State Beach, San Buenaventura State Beach, and Point Mugu State Park (i.e., based on the fraction of annual use occurring within a two-week period). For sites in between, we use the average proportion of use in a period from the two boundary sites.

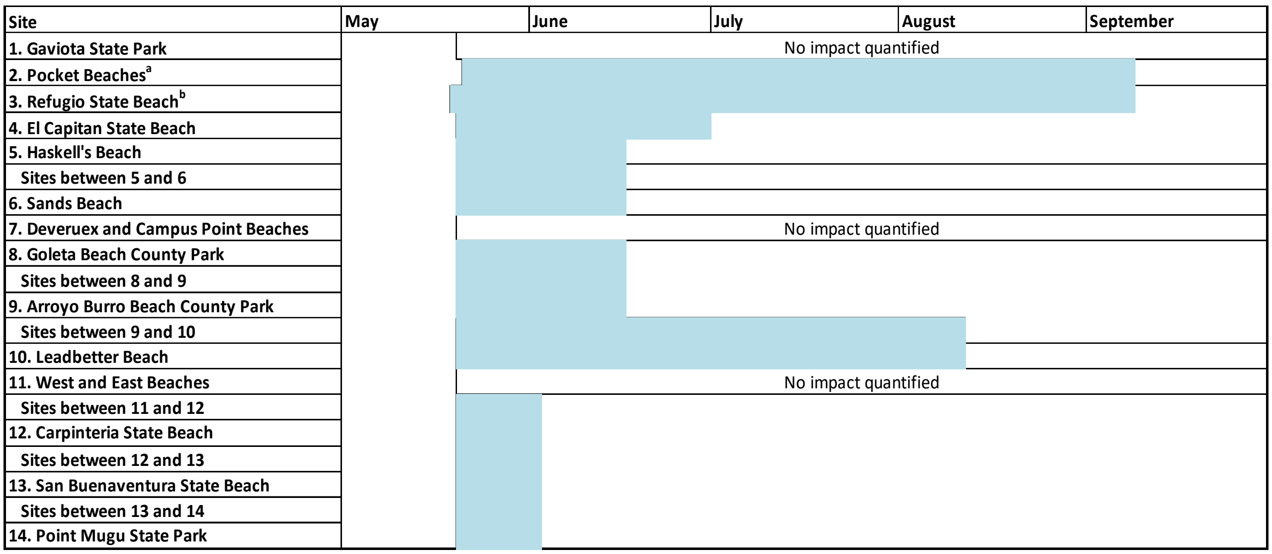
For validation purposes, the MPA Baseline trip estimates were compared to onsite trip estimates for a subset of sites in the Goleta area where comprehensive onsite visitation estimates were available (Gaviota State Park, Refugio State Beach, El Capitan State

Beach, Goleta County Park, and Arroyo Burro County Park). The aggregate difference in estimated trips for these sites was less than five percent.

ESTIMATES OF BASELINE USE

Exhibit 3.5 summarizes baseline use estimates by site and two-week period. Estimates are only provided for sites and time periods that had reductions in shoreline use in Santa Barbara and Ventura Counties (Exhibit 3.4).

EXHIBIT 3.5. BASELINE DAYS BY SITE AND PERIOD



Notes:
[a] – Since the closure at the pocket beaches began on May 21, 2015, the first period for this site includes 13 rather than 14 days.
[b] – Since the closure at Refugio State Beach began on May 19, 2015, the first period for this site includes 15 rather than 14 days.

3.5 SUMMARY OF LOST DAYS IN SANTA BARBARA AND VENTURA COUNTIES

Lost days in Santa Barbara and Ventura Counties are calculated by multiplying the percentage reduction in use for a particular site and period (Exhibit 3.4) by the corresponding baseline use estimate (Exhibit 3.5). Exhibit 3.6 summarizes our estimates of lost days by site. In total we estimate 89,380 lost days in these two counties: 72,073 in Santa Barbara County and 17,307 in Ventura County.

EXHIBIT 3.6. SUMMARY OF LOST DAYS IN SANTA BARBARA AND VENTURA COUNTIES

SITE	LOST DAYS
1. Gaviota State Park	No impact quantified
2. Pocket Beaches	2,644
3. Refugio State Beach	18,338
4. El Capitan State Beach	12,768
5. Haskell's Beach	4,036
Sites between 5 and 6	8,099
6. Sands Beach	1,632
7. Devereux Beach and Campus Point Beach	No impact quantified
8. Goleta Beach County Park	2,298
Sites between 8 and 9	82
9. Arroyo Burro Beach County Park	1,482
Sites between 9 and 10	4,799
10. Leadbetter Beach	13,890
11. West and East Beaches	No impact quantified
Sites between 11 and 12	874
12. Carpinteria State Beach	632
Sites between 12 and 13	5,256
13. San Buenaventura State Beach	3,428
Sites between 13 and 14	9,001
14. Point Mugu State Park	121
Total	**89,380**

Notes:
The totals differ slightly from the product of the estimates in Exhibits 3.4 and 3.5 due to rounding.

CHAPTER 4 | VALUATION AND SUMMARY OF DAMAGES

This chapter describes our valuation approach and summary of damages. The first section describes our method for estimating the value per lost day in Santa Barbara and Ventura Counties. The second section presents our approach for estimating losses in Los Angeles County. The final section summarizes our total damages estimate.

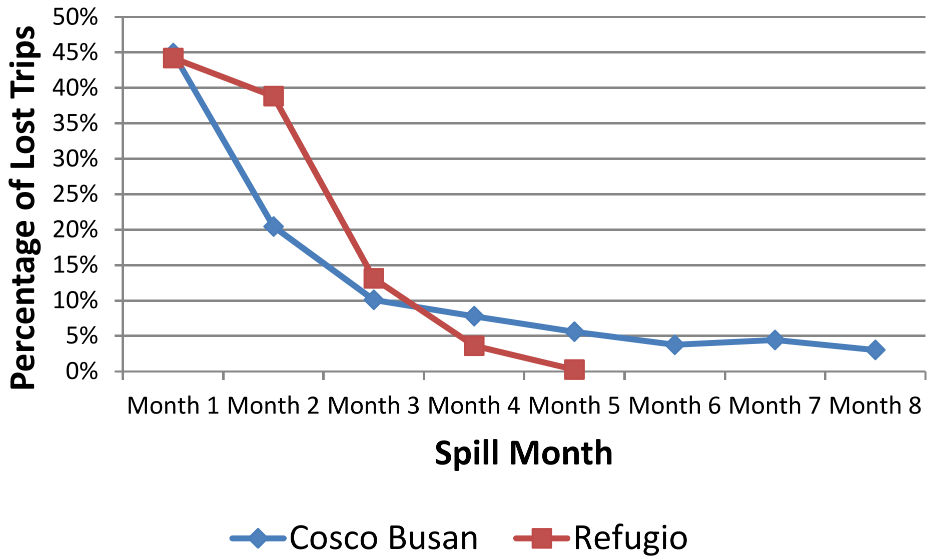
4.1 VALUE PER LOST DAY IN SANTA BARBARA AND VENTURA COUNTIES

We estimated the value per lost day in Santa Barbara and Ventura Counties using benefits transfer. Benefits transfer is the process of adapting trip or day values from existing literature to fit the conditions associated with the site, activity, and incident of interest. The methodology has been used to assess recreational use damages for several past oil spills (Chapman and Hanemann, 2001; Curry and Scherer, 2010; Leggett and Curry, 2010). We reviewed literature that estimates the value of shoreline use for the benefits transfer. Based on our review, we selected a value from English (2010), which was estimated using a travel cost model for the *Cosco Busan* oil spill damage assessment. The *Cosco Busan* oil spill occurred when a container ship struck the Bay Bridge in November 2007, spilling 53,569 gallons of oil into San Francisco Bay and the Pacific Ocean.

We considered other California beach valuation studies for the benefits transfer, including Hanemann et al. (2004), Lew and Larson (2008), and Leggett et al. (2014). However, these studies do not provide value estimates reflecting the mixture of impacts observed in Santa Barbara and Ventura Counties during the Refugio Beach oil spill, namely, closures, advisories, and other impacts from oiling and spill response. The value from English (2010) represents this mixture of spill impacts. Specifically, recreators affected by the *Cosco Busan* and Refugio Beach oil spills may have derived less enjoyment from their trips to sites affected by the spill (diminished trips); selected alternative, less desirable locations (substitute trips); or pursued alternative activities (lost trips). The approach used by English (2010) generates a value per lost trip that incorporates these three behavioral responses to a spill.

Further, the two spills are similar with respect to the availability of substitute sites, the types of affected shoreline recreation activities, and the recovery pattern of recreation impacts. Exhibit 4.1 compares the percentage of total lost trips by month for the *Cosco Busan* and Refugio Beach oil spills, which are broadly similar.

EXHIBIT 4.1. TIMING OF LOST SHORELINE TRIPS, COSCO BUSAN AND REFUGIO BEACH OIL SPILLS



The travel cost model developed by English (2010) relies on a telephone survey of San Francisco Bay Area residents conducted in the summer of 2008. The survey collected information about the number and characteristics of single-day shoreline recreation trips to coastal sites in the Bay Area. Respondents were asked to provide the number of trips they typically take to these beaches and the number of trips that were diverted (i.e., lost) in the months following the *Cosco Busan* spill. They were also asked to report the destination, activity, mode of transportation, and group size for several recent shoreline recreation trips (i.e., during a time period when spill impacts had largely dissipated). The data on recent trips were used to develop a multiple-site travel cost model for shoreline recreation in the Bay Area.[15] This baseline model was adjusted to represent reported changes in trip-taking behavior following the spill. Changes in welfare between the baseline and adjusted models were used to estimate the value per lost trip due to the spill.

English (2010) reports an average value per lost trip of $18.25 in 2007 dollars. This average reflects losses over a period of 8 months (Exhibit 4.1), where the estimated value per lost trip was highest in the months immediately after the spill—due to numerous closures, advisories, and other impacts—and lowest in later months when most beaches had reopened and other impacts had dissipated (see Table J.5 in English (2010)).[16] This

[15] The travel cost variable included in the model incorporates round-trip out-of-pocket costs such as gasoline and depreciation, and the opportunity cost of time associated with traveling to the site. Out-of-pocket costs were calculated using a rate of 21 cents per vehicle mile (or 8.4 cents per miles per passenger). The opportunity cost of time was calculated as one-third of a respondent's hourly household income.

[16] The average value of $18.25 is a weighted average of lost values by month using the corresponding lost trips as the weights.

decline in the value per lost trip reflects the increasing availability of non-impacted substitute sites over time, as the impact of the spill diminished.

We adjusted the average value estimate from English (2010) to July 2018 dollars using the consumer price index (CPI) (Bureau of Labor Statistics, 2018). Our estimate of the value per lost day in Santa Barbara and Ventura Counties is $21.45.

4.2 LOST VALUE DUE TO IMPACTS IN LOS ANGELES COUNTY

Our quantification of impacts in Los Angeles County focuses on the closures in South Santa Monica Bay and Long Beach (Exhibit 2.4). We obtained data for other areas of the county (i.e., outside South Santa Monica Bay and Long Beach) that remained open during the spill, including parking sales data at Zuma Beach and Point Dume State Beach, lifeguard counts of beach visitation, as well as counts of visitation in and around marine protected areas off the coast of Malibu and Palos Verdes. The data for these other areas were not indicative of a reduction in recreation use as a result of the spill.[17]

We estimated shoreline use damages due to the beach closures in Los Angeles County using the Southern California Beach Recreation Valuation Model (Hanemann et al., 2004; Hanemann, Pendleton, and Mohn, 2005; Leeworthy et al., 2007). This random utility travel cost model can be used to assess the economic impacts of changes in water quality and beach closures in Southern California. One of the primary motivations for developing the model was to support the estimation of recreational use losses for damage assessments. It relies on panel data from telephone surveys of residents of four Southern California counties, which were conducted in 1999-2000.[18] The surveys collected information about the number and characteristics of shoreline recreation trips to 53 beaches, with a specific focus on beaches in Los Angeles and Orange Counties. The model directly estimates the total lost value from a reduction in water quality or beach closure(s) by predicting changes in the amount and location of beach use (e.g., recreators substituting to other sites or to other types of activities) and estimating the total decline in value associated with this change in use.[19]

Our approach for estimating lost value in Los Angeles County proceeds differently from our approach for Santa Barbara and Ventura Counties. For those two counties, we separately estimated the number of lost days and the value per lost day, and then multiplied the two estimates. We considered available data sources for Los Angeles County to estimate lost trips associated with the beach closures in South Santa Monica Bay and Long Beach, namely lifeguard counts of visitation. However, we consider the

[17] In some cases these sources were limited in temporal resolution or suffered from other data quality issues. However, they represent the best-available information. Further, our conclusions based on these data were corroborated by conversations with local resource managers.

[18] Residents of Los Angeles, Orange, Riverside, and San Bernardino Counties were surveyed.

[19] The travel cost variable included in the model incorporates round-trip out-of-pocket costs such as gasoline and maintenance and the opportunity cost of time associated with traveling to the site. Out-of-pocket costs were calculated using a rate of 14.5 cents per mile per vehicle. The opportunity cost of time was calculated as 50 percent of a respondent's hourly income times the travel time.

model from Hanemann et al. (2004) to be the best available information. The Hanemann et al. (2004) model quantifies lost shoreline days and the associated lost economic value within the model, and the output is simply lost value.

The model can be used to estimate the total lost value associated with a range of scenarios, including single and multi-site closures. Further, closures at the site level can be specified as encompassing one or more of the following three beach areas: water, sand, and pavement (e.g., paved bike path running along the beach). Lastly, the duration and timing of the closures can be specified as the number of days within a given month. We used the model to estimate the total lost value associated with the Los Angeles County beach closures summarized in Exhibit 2.4. Specifically, we used the model to evaluate the scenarios described in the bullets below.

- **South Santa Monica Bay**: a one day water-only closure in May for Manhattan Beach and a two day water-only closure in May for Manhattan, Hermosa, and Redondo Beaches.
- **Long Beach**: a three day water-only closure in June for Long Beach (between 1st Place and 72nd Place).[20]

The actual closures in South Santa Monica Bay and Long Beach included the section of beach seaward of the lifeguard towers and all of the water. Our decision to close the water only may underestimate damages. However, a partial beach closure cannot be specified in the available modeling tool.

We make three adjustments to the model results. First, the model only estimates losses associated with single-day trips, which represent 92.9 percent of annual person days from the four surveyed counties (see Table 5 in Leeworthy et al., 2007). Therefore, the loss estimate is divided by 92.9 percent to incorporate losses associated with multiple-day trips. Second, the loss estimate is increased by 15 percent to account for population growth in the four surveyed counties since the survey year (2000) (U.S. Census Bureau 2018, 2000). Finally, we adjust the estimates to July 2018 dollars using the consumer price index (CPI) (Bureau of Labor Statistics, 2018).

Our undiscounted damages estimate for the Los Angeles County beach closures is $537,568. The estimates for the South Santa Monica Bay and Long Beach closures are $445,125 and $92,444, respectively. These represent lower bound estimates of damages since they do not incorporate impacts to recreators who live outside the four surveyed counties, and do not consider the beach closures between the water and lifeguard towers.

4.3 SUMMARY OF DAMAGES

We combine our estimate of lost shoreline days (89,380) in Santa Barbara and Ventura Counties with the estimated value per day ($21.45) to calculate damages for these two counties. Present value damages as of July 2018 are calculated using monthly discounting

[20] The Southern California Beach Recreation Valuation Model includes two sites for Long Beach between 1st Place and 72nd Place: Long Beach and Belmont Shore. Both sites are closed to evaluate the Long Beach closure scenario.

at an annual rate of three percent (NOAA, 1999). To implement monthly discounting, we assign the two-week loss periods (Exhibit 3.4) to the month that includes the majority of the period. Exhibit 4.2 presents the distribution of losses by month for Santa Barbara and Ventura Counties.

EXHIBIT 4.2. TEMPORAL DISTRIBUTION OF SHORELINE USE LOSSES, SANTA BARBARA AND VENTURA COUNTIES

MAY	JUNE	JULY	AUGUST	SEPTEMBER
44%	39%	13%	4%	<1%

Present value damages for Los Angeles County are calculated using the same monthly discounting approach. Based on the date of closures, South Santa Monica Bay losses are assigned to May and Long Beach losses are assigned to June. Exhibit 4.3 presents shoreline use damages by county and in total. Our total estimate of damages associated with impacts to shoreline use as of July 2018 is $2,691,534.

EXHIBIT 4.3. SUMMARY OF SHORELINE USE DAMAGES

COUNTY	DISCOUNTED DAMAGES (2018 DOLLARS)
Santa Barbara County	$1,693,790
Ventura County	$407,677
Los Angeles County	$590,067
Total	**$2,691,534**

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Recreational Boating and Offshore Use Damages Due to the Refugio Beach Oil Spill

September 14, 2018

prepared for:

Refugio Beach Oil Spill Natural Resource Damage Assessment

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INTRODUCTION

On May 19, 2015 an underground pipeline ruptured just west of Refugio State Beach in Santa Barbara County, California, spilling over 120,000 gallons of crude oil into the soil and onto the ground (hereafter referred to as "the spill").[1] A significant portion of the oil flowed down a nearby ravine and into the Pacific Ocean. After reaching the ocean, the oil spread primarily southward and eastward. Oil washed up on shore at and around Refugio and El Capitan State Beaches (Exhibit 1). In the weeks following the spill, oil and/or tarballs washed ashore in numerous locations along the coastlines of Santa Barbara, Ventura, and Los Angeles Counties.

The spill occurred within the undeveloped portion of Santa Barbara County referred to as the "Gaviota Coast." The Gaviota Coast is widely recognized for its scenic beauty and outdoor recreation opportunities, and the area supports California State Park's mission of supporting health, inspiration, and education through the preservation of extraordinary biological diversity, protecting valued natural and cultural resources, and creating opportunities for high-quality outdoor recreation. In fact, in the early 2000s, the National Park Service (NPS) undertook a feasibility study to determine if the Gaviota Coast should be added to the National Park System (NPS, 2003).

EXHIBIT 1. OVERVIEW OF ASSESSMENT AREA

[1] The United States Department of Transportation's failure investigation for the spill indicates that, according to the pipeline owner, 2,934 barrels, or 123,228 gallons of oil were released (USDOT, 2016).

Federal and state natural resource trustee agencies ("Trustees"), in coordination with Plains All America Pipeline (the pipeline owner and operator), conducted a Natural Resource Damage Assessment (NRDA) to assess the impacts of the spill on natural resources. The Trustees for the natural resources injured by the spill include the United States Department of Commerce represented by the National Oceanic and Atmospheric Administration; the United States Department of the Interior represented by the United States Fish and Wildlife Service (USFWS) and the Bureau of Land Management (BLM); the California Department of Fish and Wildlife; the California Department of Parks and Recreation; the California State Lands Commission; and the Regents of the University of California.

As part of the NRDA, the Trustees assessed the impacts of the spill on recreational users of the coastal and marine environment. Recreational users were potentially impacted due to the direct oiling of natural resources and the reasonable expectation of oiling, shoreline and fishing closures, advisories, and cleanup activities. This report documents the impact of the spill on recreational boating and offshore uses, including motorboating, sailboating, nonmotorized boating, and use of Channel Islands National Park (accessible by park concessionaire boats and planes or private boat).[2]

Economic losses to recreational boaters and offshore users are based on the economic concept of consumer surplus (USDOI, 1987). An individual's consumer surplus from a boating or offshore trip represents the difference between (1) the maximum amount that the individual would be willing to pay for the trip and (2) the amount that the individual actually paid for the trip (in gasoline, supplies, reservation fees, etc.). Thus, consumer surplus is a measure of the net value of a trip, after all expenses have been paid. Boating and offshore use damages estimated in this report are measured as the aggregate decline in value across all impacted individuals.

We estimated damages in four steps:

1) Estimate the number of lost boating and offshore days;
2) Estimate the economic value associated with a boating and offshore day;
3) Multiply the number of lost days by the value per day; and
4) Adjust losses to present value.

The remainder of this report provides a general overview of spill impacts on boating and offshore uses, and then we summarize the methods and results for each of these four steps

IMPACTS TO BOATING AND OFFSHORE USES

Santa Barbara, Ventura, and Los Angeles Counties have a limited number of developed boating access points (Exhibit 2). In Santa Barbara County, the primary boating access point is Santa Barbara Harbor, which contains a large marina and a public boat launch. Goleta Beach County Park is the only other access point in the county, but is more

[2] Nonmotorized boating includes canoeing, kayaking, stand-up paddle boarding, and other similar activities. This report assesses nonmotorized boating originating from boat launches and marinas. A separate shoreline use assessment assesses impacts to nonmotorized boating originating from beaches and other shoreline access points (see Horsch et al., 2018).

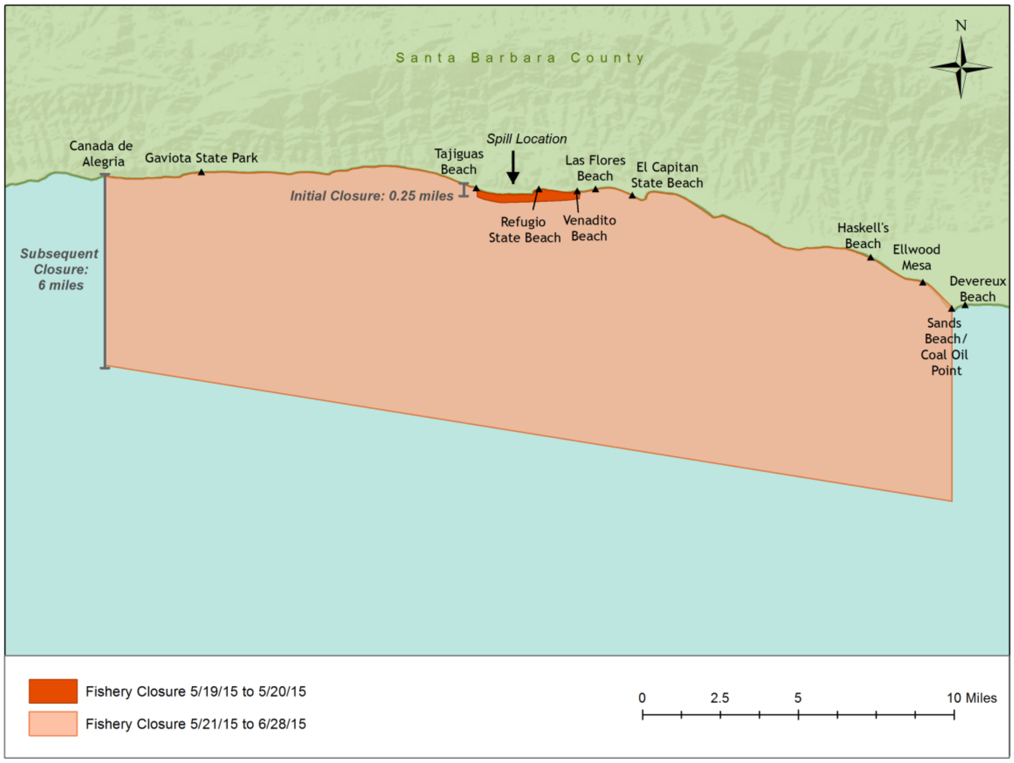
limited, with a hoist launch on the park's pier. Use of this launch is limited by the amount of time it takes to launch a boat and the need for specialized equipment. Ventura County has two large harbors (Ventura Harbor and Channel Islands Harbor), while Santa Monica Bay in Los Angeles County has access at Marina Del Ray and King Harbor Marina.

As described above, boating and offshore uses were potentially impacted due to the direct oiling of natural resources and the reasonable expectation of oiling, shoreline and fishing closures, advisories, and cleanup activities. Shortly after the spill, Refugio and El Capitan State Beaches were evacuated and closed, along with nearby pocket beaches. The closures at these locations lasted for 59 days, 37 days, and 100 days, respectively. On the day of the spill, a fisheries closure was established for the immediately affected area around the release point (Exhibit 3). On May 21, the fisheries closure area was expanded to include the shoreline between Canada de Alegeria and Coal Oil Point, as well as all ocean waters within six miles of this shoreline. The fisheries closure remained in place through June 28.

In the weeks following the spill, advisories were posted in numerous locations in Santa Barbara and Ventura Counties, and temporary beach closures were instituted around Coal Oil Point, in the southern area of Santa Monica Bay, and in Long Beach. Numerous response vessels operated in the spill area, attempting to contain and remove the oil. Cleanup personnel were dispatched to coastal areas of all three impacted counties. Media coverage of the spill was pronounced throughout the South Coast region, and to a lesser extent nationally, on television, social media, and in newspapers.

EXHIBIT 2. BOATING AND OFFSHORE USE LOCATIONS IN ASSESSMENT AREA

EXHIBIT 3. FISHERIES CLOSURE AREA



ESTIMATE OF LOST DAYS

The number of lost boating and offshore days equals the reduction in use relative to baseline, or the level of use that would have existed had the spill not occurred. We considered several data sources to estimate the number of lost days (discussed below). Only one data source was indicative of impacts to boating and offshore uses: phone interviews conducted with water- and shore-oriented recreation businesses in the assessment area during late summer and early fall of 2015. These interviews were conducted to collect information about trip cancelations, diminished outings, and other impacts to their customers due to the spill.[3]

Interviews were attempted with 96 businesses, some of which support boating and offshore uses, including fishing, kayaking/canoeing, sailing, stand-up paddle boarding, surfing, whale watching, and other boat charters. We successfully reached 67 of the businesses contacted. Eighteen of these businesses reported a combined total of 2,379 boating and offshore trips canceled or relocated due to the spill. Most of these businesses were located in Santa Barbara Harbor, though a few businesses were in Ventura Harbor and one was in King Harbor Marina. Since most of the affected trips last a day or less, we estimate 2,379 lost days from these interviews.

[3] Our quantification of lost days includes impacts to public recreational use (i.e., customers of water- and shore-oriented recreation businesses), but our loss estimate does not include private claims for impacts to commercial fishing or recreation-based concessionaires.

Our estimate of lost days constitutes a lower-bound for a couple reasons. First, some businesses that reported impacts did not provide an estimate of affected trips. Second, some businesses refused to participate or could not be reached, and customers of these businesses may have been impacted by the spill.

We considered other available data to evaluate impacts to boating and offshore uses. These data sources, listed below, provided limited information and were not relied upon for developing our damages estimate.

- **Santa Barbara Harbor boat launch trailer parking sales**: daily boat trailer parking sales data were obtained for 2010-2013 and quarterly data for 2014-2016 (daily data were not available for the latter time period).
- **California Recreational Fisheries Survey (CRFS) estimates and Commercial Passenger Fishing Vessels (CPFV) log summaries**: estimates of monthly angler days for boat-based fishing were obtained for District 2 (Santa Barbara and Ventura Counties) from May through September, 2010 to 2015. Separate estimates were provided for private/rental boat fishing and fishing from commercial passenger vessels. Site-specific estimates of private/rental boat fishing were obtained for Santa Barbara Harbor, Ventura Harbor, and Channel Islands Harbor. Further, monthly recreational fishing passenger days were obtained for CPFVs returning to the port of Santa Barbara from May through September, 2010-2015.
- **Santa Barbara Harbor fuel dock sales**: Santa Barbara harbor fuel dock sales data were obtained for the 2010-2015 period. For each year, three separate fuel sales totals were obtained: (1) May and June combined, (2) May 19–31, and (3) June 1–30.[4] The data include total gallons sold, total revenue, and gallons sold to response boats in 2015.
- **Channel Islands National Park attendance data**: monthly visitation data for Channel Islands National Park for recent years were downloaded from the NPS Visitor Use Statistics web portal (https://irma.nps.gov/Stats/).

ESTIMATE OF VALUE PER DAY

We estimated the value per boating and offshore day using benefits transfer. Benefits transfer is the process of adapting trip or day values from existing literature to fit the conditions associated with the site, activity, and incident of interest. The methodology has been used to assess recreational use damages for several past oil spills (Chapman and Hanemann, 2001; Curry and Scherer, 2010; Leggett and Curry, 2010). We reviewed literature that estimates the value of boating and offshore use for the benefits transfer. Based on our review, we selected an estimate from a 2013 study conducted by researchers at the University of California-Santa Barbara on the value of recreational boating in the Channel Islands National Marine Sanctuary (Gornik et al., 2013).

[4] Only the combined May/June total was available for 2010.

The authors use a random-utility travel cost model to estimate the value of single-day trips to 31 sites around Anacapa, Santa Cruz, and Santa Rosa Islands for four activity categories: non-consumptive underwater (e.g., snorkeling, free diving, scuba diving), surface non-consumptive (e.g., dinghy, kayaking, mammal or bird watching), consumptive (e.g., hook and line fishing, spearfishing, and lobster diving), and land-based (e.g., going to the beach, tidepooling, and hiking). The model was estimated using data from an intercept survey conducted in 2006/2007 near Santa Cruz Island.[5]

We adapt the average value of the three water activities for use in the benefits transfer because these are the types of activities represented in our estimate of lost days.[6] We adjust this estimate to July 2018 dollars using the consumer price index (CPI) (Bureau of Labor Statistics, 2018). Our estimate of the value per day is $59.01.

SUMMARY OF DAMAGES

We combine our estimate of lost boating and offshore days (2,379) with the estimated value per day ($59.01) to calculate damages. Present value damages as of July 2018 are calculated using monthly discounting at an annual rate of three percent (NOAA, 1999). Since the business interviews did not provide information about the timing of lost days, we allocate lost days to specific months for the purpose of discounting using the temporal distribution of shoreline losses (see Horsch et al., 2018). This distribution is presented in Exhibit 4.

EXHIBIT 4. TEMPORAL DISTRIBUTION OF BOATING AND OFFSHORE USE LOSSES

MAY	JUNE	JULY	AUGUST	SEPTEMBER
44%	39%	13%	4%	<1%

Our estimate of boating and offshore use damages as of July 2018 is $153,867.

[5] The travel cost variable used in the model incorporates round-trip out-of-pocket costs such as gasoline and maintenance (including on-land and on-water expenses) and the opportunity cost of time associated with traveling to the site. On-land costs were calculated using a rate of 21.28 cents per mile for all boaters. On-water costs were calculated using boater-specific fuel costs per mile, which were based on the boat type and size. The opportunity cost of time was calculated as 50 percent of a boater's hourly wage rate.

[6] The three values are $53.21 (underwater non-consumptive use), $53.69 (surface water non-consumptive use), and $34.72 (consumptive use) (2006 dollars). These values come from Table 4 in Gornik et al. (2013).

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Appendix N Summary of Proposed Restoration Projects

The Trustees identified potential NRDA restoration projects through internal discussion, input from local experts, and received through public input. The Trustees reviewed these projects for consistency with NRDA restoration criteria, as described in Section 4.2 of the Refugio Beach Oil Spill Damage Assessment and Restoration Plan. The following tables summarize the projects received, and the outcome of the Trustee review.

Table 1(a) Projects Meeting NRDA Criteria—Shoreline Habitats

Project ID	Project Name	Project Description	NRDA Criteria Evaluation
SHORE-1	Ellwood Seawall Removal	Restore sandy beach and mixed shoreline ecosystems and dynamics by removing a wooden seawall at Ellwood Beach that is currently constraining natural functioning condition of the sandy beach ecosystem as well as lateral access along the shoreline at high tide.	PREFERRED. Directly improves sandy beach habitat that was impacted by the spill.
SHORE-2	Ventura County Dunes Restoration	Remove invasive dune species, protect sensitive bird populations, and enhance public access routes.	PREFERRED. Improves sandy beach habitat, including habitats for western snowy plovers in Ventura County.
SHORE-3	Santa Monica Beach Restoration Pilot Project	Restoration of a highly impacted beach system in Santa Monica by stopping beach grooming and restoring a diverse, endemic-rich, coastal plant and wildlife community.	PREFERRED. This project compensates for shoreline injuries that occurred in Los Angeles County.
SHORE-4	Black Abalone Restoration and Relocation	Transplant black abalone into specific locations within rocky intertidal habitat to enhance the overall health of the rocky intertidal ecosystem by returning this important grazer to the community.	PREFERRED. This project benefits the endangered black abalone while also improving the overall health of rocky intertidal habitats as they are a foundational species.
SHORE-5	Surfer's Point Phase II	Realignment of infrastructure near the Ventura River to allow for coastal retreat and restoration of sandy beach and dune habitat.	2nd TIER PROJECT. Relatively high cost project for the amount of sandy beach restoration that would be achieved.
SHORE-6	Matilija Dam Removal	Remove Matilija Dam to restore natural sediment and water flow to the Ventura River and nearshore environment.	2nd TIER PROJECT. Relatively high cost project compared to other preferred projects. Time to achieve benefits unclear.
SHORE-7	Gaviota Creek Watershed Restoration	Activities may include replacing the existing road that bisects the creek's lower floodplain and acts as a levy during high flows, protecting land within the Gaviota Creek watershed, relocating the existing campground that encroaches on the Gaviota Creek estuary.	2nd TIER PROJECT. Benefits to shoreline habitats through increased sediment transport are uncertain. Time to provide benefits is relatively long when compared to other preferred projects.

Project ID	Project Name	Project Description	NRDA Criteria Evaluation
SHORE-8	El Capitan State Park Concrete Removal Project/Bike Path and Rip Rap Removal	Remnants of a road and associated rip rap on the beach immediately west of a failed bike path section would be removed to allow for sandy beach restoration at the site.	2nd TIER PROJECT. May not be feasible, as a portion of the riprap is protecting pipeline infrastructure.
SHORE-9	Santa Barbara County Seawall Removals	Remove seawalls along the Santa Barbara County shoreline that are impacting the sandy beach ecosystem (Does not include the Ellwood Seawall)	2nd TIER PROJECT. Preliminary review of structures indicate that they may be necessary for railroad infrastructure.
SHORE-10	Coastal Hazards Removal, Goleta Beaches from hazards removal, Arroyo Hondo to Coal Oil Point	Focusing on Goleta beaches between Arroyo Hondo and Coal Oil Point (not including Ellwood Seawall), this project includes removal of hazards such as iron material protruding from the shoreline surface.	2nd TIER PROJECT. Ecological benefits to shoreline habitat are uncertain. Primary benefit may be to recreation.
SHORE-11	Coal Oil Point Research and Education	Research and education at Coal Oil Point preserve.	2nd TIER PROJECT. No direct, physical benefits to shoreline habitats.
SHORE-12	Devereux Slough	Ongoing project within the UC Reserve System that is restoring Devereux Slough by removing a golf course and restoring estuarine and upland and vegetation.	2nd TIER PROJECT. Estuaries were not impacted by the spill and are not a top priority for restoration.
SHORE-13	Funding a Quick Reaction Cleanup Crew for Tar found on Beaches	Funding a quick reaction cleanup crew for tar found on beaches	2nd TIER PROJECT. Would only apply to naturally occurring seep oil. Anthropogenic spills are already required to be cleaned up under other legal authorities. Relatively high cost compared to other preferred projects, and benefits to shoreline habitat are unclear.
SHORE-14	Remove unnecessary sediment basins	Remove unnecessary sediment basins along the Gaviota coast to improve sediment transport for beach nourishment.	2nd TIER PROJECT. Feasibility uncertain in fire-affected areas.

Project ID	Project Name	Project Description	NRDA Criteria Evaluation
SHORE-15	Refugio and Gaviota Coast Human Impact Mitigation	Installation of restrooms and trash receptacles at informal costal access locations to reduce human waste and impacts on the shoreline.	2nd TIER PROJECT. Benefits to shoreline habitats uncertain. Primary benefit may be to recreation.
SHORE-16	Other Dune Restoration Projects	Dune restoration in locations other than Ventura County (i.e., Vandenberg AFB, etc.)	2nd TIER PROJECT. Benefits are less closely linked to affected habitat areas than other preferred projects.
SHORE-17	Coal Oil Point Pilings and Debris Removal	Remove creosote pilings that have broken from the Ellwood Seawall and deposited in COPR, including around the Devereux Slough and sandy beach at Coal Oil Point. May be conducted as a part of the Ellwood Seawall project.	2nd TIER PROJECT. Potential environmental impacts from disturbance to Devereux Sough during implementation are anticipated to be greater than those for other preferred projects
SHORE-18	Classroom education and outreach	Students from local schools would learn about the ecology of rocky intertidal habitats, including hands-on implementation of rocky intertidal monitoring. Students would also be engaged in docent programs to share their knowledge of rocky intertidal habitats with the public at popular tidepool areas.	2nd TIER PROJECT. Benefits would be less direct, as they would rely on an overall change in behavior and attitudes by users of rocky intertidal areas.
SHORE-19	Refugio and El Capitan rocky intertidal docent program	Development and implementation of a docent program at rocky intertidal sites at Refugio and El Capitan State Beaches to educate and oversee visitors and contact law enforcement personnel, if needed.	2nd TIER PROJECT. Benefits would be less direct, as they would rely on an overall change in behavior and attitudes by users of rocky intertidal areas.
SHORE-20	Increase substrates for rocky intertidal species	The creation of new shoreline habitat or modification of existing habitat to increase substrate for rocky intertidal species. Examples include wrapping pier pilings, or creating “living walls” at hardened shoreline structures such as breakwaters.	2nd TIER PROJECT. No viable locations or methods were identified as of the drafting of this plan, but the concept may be viable in the future.

Project ID	Project Name	Project Description	NRDA Criteria Evaluation
SHORE-21	Cessation of beach grooming	Cessation of beach grooming along beaches in Los Angeles and Ventura Counties.	2nd TIER PROJECT. No specific locations identified as of the drafting of this plan. There is a need for a project proponent and partnerships that do not currently exist.
SHORE-22	Rindge Dam Removal	The removal of the Rindge Dam and/or dams upstream.	2nd TIER PROJECT. This has a very high cost associated with the project (estimates over $100 million) and is too early in the planning and environmental review phase to be properly evaluated at the time this restoration plan was prepared.

Table 1(b) Projects Meeting NRDA Criteria—Subtidal and Fish Habitats

Project ID	Project Name	Project Description	NRDA Criteria Evaluation
SubT-1	Abalone Restoration	Transplant abalone from donor sites and cultivated populations to a target population within MPAs, in order to bolster the abalone population within MPAs that serve an important ecological role as benthic grazers.	PREFERRED. Site-specific direct benefits to subtidal habitats that were impacted by the spill.
SubT-2	Coastal Eelgrass Restoration	Eelgrass restoration in Refugio Bay	PREFERRED. Site-specific, In-kind, subtidal restoration.
SubT-3	Sand-Dwelling Kelp Restoration Project	Funding for this project would extend monitoring of the existing pilot project to assess long-term benefits of the project, and viability of the restoration design.	PREFERRED. Benefit to benthic resources impacted by the spill are less certain than for other preferred projects. However, the cost of the project is extremely low and would help quantify benefits that have the potential to be substantial.

Project ID	Project Name	Project Description	NRDA Criteria Evaluation
SubT-4	Ellwood Seawall Removal	Removing the Ellwood seawall primarily benefits sandy beach ecosystems, but subtidal habitats adjacent to the seawall are also projected to improve. For that reason, the subtidal monitoring portion of this project is categorized as a subtidal activity and funded proportionally.	PREFERRED. This is a sandy-beach project that will be primarily funded as a shoreline activity; however, it has collateral benefits to subtidal habitats and additional cost of subtidal monitoring is extremely low cost compared to other subtidal projects.
SubT-5	Net and Trap Removal (marine debris)	Removal of derelict fishing gear, with an emphasis on nets. The biggest accumulation of this gear is around the Channel Islands and in Southern California.	2nd TIER PROJECT. This project has limited tangible benefits to subtidal habitats in areas where injury was documented. To be effective, the project would likely focus on habitats outside of the injured area.
SubT-6	Artificial Reef	Construction of an artificial reef adjacent to Bird Island.	2nd TIER PROJECT. This project has relatively high cost project compared to other preferred projects. There is also uncertainty in project efficacy.
SubT-7	*Undaria* Removal at Anacapa Island	Remove *Undaria* infestation around Anacapa Island.	2nd TIER PROJECT. This project has relatively high cost project compared to other preferred projects and may not achieve lasting benefits to subtidal habitats. Benefits occur outside of the area affected by the spill.
SubT-8	Marine Protected Area Management and Stewardship Program	Monitoring to support adaptive management and agency enforcement of MPA regulations; support for MPA biological monitoring; clean-up of marine debris; and education and outreach to promote awareness, compliance, and stewardship of MPAs.	2nd TIER PROJECT. Does not meet threshold criteria, on its own, because it represents monitoring only. Aspects of this project may be incorporated into the red abalone restoration project.

Project ID	Project Name	Project Description	NRDA Criteria Evaluation
SubT-9	Grunion Habitat Restoration and Education	Protections for spawning grunion, including education and outreach to raise public awareness and engagement in Grunion protection.	2nd TIER PROJECT. This project would primarily benefit shoreline habitats, not subtidal habitats. Project would provide less benefit to shoreline habitats compared to other preferred shoreline projects.
SubT-10	West Goleta Slough, Carpinteria, and Devereux Slough Restoration Projects	These projects involve enhancing habitats within estuaries that may provide nursery habitat for subtidal species.	2nd TIER PROJECT. This project does not directly benefit impacted resources, as estuaries were not impacted by the spill.
SubT-11	Kelp Restoration in Santa Barbara Channel Area	Restoration of kelp will lend to protection of shoreline habitats from storms, provide habitat for prey of marine mammals and birds, provide additional habitat for fish, provide wrack for sandy beach, and could also have recreational value as kelp beds are attractive for recreational diving.	2nd TIER PROJECT. Unclear project description (i.e., focal species, location, etc.)
SubT-12	Sargassum Removal	Removal of invasive algae, *Sargassum* sp.	2nd TIER Project. Feasibility is uncertain.
SubT-13	Lobster Restoration (Multiple Methods)	This project includes: continuing Sea Grant at-sea sampling program; conducting a tag-recapture study; conducting an aging study; purchasing GPS units for permit holders; funding additional CDFW personnel to conduct a mail and/or phone survey of fishermen to assess the impact of trap limit on their practice; funding for a trap puller to pull commercial lobster and crab traps for the CDFW vessel Iris Lord; funding for CDFW trap loss reporting; funding for trap tag program and processing of trap loss reporting; a dockside sampling study to determine size/sex distributions and educate the public; funding of improvements to port Wi-Fi system to facilitate submission of electronic logbooks; and an electronic or other tool that will aid enforcement in keeping track of lobster tags.	2nd TIER PROJECT. Lobster-specific restoration is less preferred than habitat restoration that will benefit lobsters as well as many other subtidal species.

Project ID	Project Name	Project Description	NRDA Criteria Evaluation
SubT-14	Boater Outreach to Reduce Spread of Invasive Algae	Educate boaters about reducing the spread of invasive algae, by sending materials with boater registration, and developing other educational opportunities.	2nd TIER PROJECT. Any physical benefits to subtidal habitats would be indirect and dependent on behavior and attitude changes. These types of benefits are difficult to quantify.
SubT-15	Gaviota Creek fish barrier removal	Remove numerous fish barriers along the Gaviota Creek watershed.	2nd TIER PROJECT. The removal of steelhead barriers is focused on one species that was not documented to be injured by the spill.

Table 1(c) Projects Meeting NRDA Criteria—Birds

Project ID	Project Name	Project Description	NRDA Criteria Evaluation
BIRD-1	BRPE Colony Enhancement on Anacapa Island	Enhance brown pelican breeding habitat on Anacapa Island by removing invasive plants or taking other actions to improve breeding attempts and success.	PREFERRED. Conducting restoration in nesting habitat provides more benefits to brown pelicans than restoration focused on dispersed non-breeding habitat areas.
BIRD-2	Prevention of injury to seabirds related to recreational fishing	This project would use outreach to raise public awareness and educate anglers about ways to reduce their chances of hooking birds and what to do if one is hooked. The project may include: 1) physical improvements to facilities associated with sport and commercial fisheries to reduce plumage contamination, entanglement and other injuries; 2) outreach to fishermen to provide them resources and information for assisting entangled wildlife; and 3) assistance for vessel operators to minimize wildlife interactions during fishing operations. This program could be implemented through the Seabird Protection Network, or by a separate entity.	PREFERRED. Addresses a major source of injury to a variety of seabirds impacted by the Refugio spill.

Project ID	Project Name	Project Description	NRDA Criteria Evaluation
BIRD-3	Coal Oil Point Western Snowy Plover Protection	This may include: predator control; upgraded signage and fences; outreach to reduce disturbances at COPR; leashes to lend; and eradicate iceplant over nesting habitat on Ellwood Beach.	PREFERRED. Benefits the population of western snowy plovers that were directly impacted by the spill.
BIRD-4	Brown Pelican Restoration at Alcatraz Island	Restore habitat and use social attraction to try to establish breeding at Alcatraz Island.	2nd TIER PROJECT. Alcatraz Island is far outside of spill zone, and would benefit a small number of birds.
BIRD-5	Brown Pelican Restoration on San Clemente Island	BRPE have nested on San Clemente Island in the recent past (a first for that island) and could probably benefit from identifying the area used by BRPE and possibly establishing an exclusion zone from cats, fox, and rats. This action would most likely benefit other seabirds as well.	2nd TIER PROJECT. Would create fewer benefits to BRPE than a similar project where nesting densities are greater.
BIRD-6	Santa Barbara Island Revegetation	Continue re-vegetation to promote suitable brown pelican nesting habitat on Santa Barbra Island.	2nd TIER PROJECT. This project would create fewer benefits than BIRD-1 due to the lower number of pelicans that breed on Santa Barbara Island. This project is also more costly than BIRD-1, and may have feasibility due to pier outage at SB Island.
BIRD-7	Western Snowy Plover Predator Control	Provide funding for predator control in recovery unit 5 (inclusive of the spill zone) and/or 4 (north of the spill zone).	2nd TIER PROJECT. Priority for snowy plover restoration is where injury was documented (i.e., at Coal Oil Point Reserve).
BIRD-8	Raven Exclusion Devices For Nesting Ashy-Storm Petrel on Channel Islands	Provide enhanced protection for nesting Ashy-storm petrels being preyed upon by common ravens.	2nd TIER PROJECT. The impact of the spill on this species was low compared to other seabirds.
BIRD-9	Western Snowy Plover Monitoring and Habitat Protection at McGrath, Mandalay,	This project would include monitoring and protecting western snowy plovers and California least terns on State Parks, through installation of symbolic fencing, signage, docent programs, predator control, and other measures necessary to monitor and protect nesting shorebirds.	2nd TIER PROJECT. Some aspects of this project would be partially addressed by dune restoration projects proposed in the Shoreline section.

Project ID	Project Name	Project Description	NRDA Criteria Evaluation
	San Buenaventura		
BIRD-10	Dune Restoration	Restoration of sand dune habitat that supports western snowy plover and California least tern breeding.	2nd TIER PROJECT. Dune restoration is a preferred project that is proposed for implementation for "shoreline" restoration.
BIRD-11	Seabird Protection Network at Channel Islands	Implement actions identified by the Channel Islands chapter of the Seabird Protection Network. These actions focus on reducing human disturbances to seabirds at the Channel Islands.	2nd TIER PROJECT. Anthropogenic threats to seabirds are greater along the mainland shore. This project will not provide as great a benefit to seabirds as BIRD-2.
BIRD-12	Andre Clark Bird Refuge Proposal	The restoration project is designed to improve water quality and habitat for both bird and aquatic species, and to allow the bird refuge to function as nursing habitat for ocean going fish species.	2nd TIER Project. Unclear benefits for the bird species impacted by the spill, as the existing refuge habitat functions for seabird roosting.
BIRD-13	Protection of Nesting Grebes	Western and Clark's grebes have historically nested at Cachuma Lake in Santa Barbara County and Lake Casitas in Ventura County. This project would improve nesting success of grebes at these lakes.	2nd TIER Project. No specific project has been proposed for lakes in Santa Barbara or Ventura Counties, and would require further development. This project may be combined with BIRD-2.
BIRD-14	Artificial nest habitat creation at Anacapa, Santa Barbara, and/or San Clemente Island	Create artificial nest habitat to improve nesting success of Scripps's murrelets at Anacapa, Santa Barbara, and/or San Clemente Islands.	2nd TIER Project. There was no evidence of injury to Scripp's murrelets and other alcids by the spill and the damages were not quantified.

Project ID	Project Name	Project Description	NRDA Criteria Evaluation
BIRD-15	Restore and increase artificial nest habitat at San Miguel Island	Increase the number of nesting boxes and improve older auklet boxes at San Miguel Island.	2nd TIER Project. There was no evidence of injury to Scripp's murrelets and other alcids by the spill and the damages were not quantified.
BIRD-16	Restore native habitat at Anacapa Island	Restore native habitat for nesting seabirds at Anacapa Island. Work can be done through removing invasives and outplanting with native plants grown on the island.	2nd TIER Project. There was no evidence of injury to Scripp's murrelets and other alcids by the spill and the damages were not quantified.
BIRD-17	Establishment of bird and marine mammal rescue and rehabilitation facility	Facilitate the establishment of a bird and marine mammal rescue and rehabilitation facility in Ventura County.	2nd TIER Project. Establishing a new Ventura County mammal and/or bird rescue and rehabilitation facility exceeds the resources that could be provided through NRDA settlement funds.

Table 1(d) Projects Meeting NRDA Criteria—Marine Mammals

Project ID	Description	Project Description	NRDA Criteria Evaluation
MAMM-1	Pinniped Rehabilitation Survival Improvement	Increase survival rates for live stranded pinnipeds recovered in Santa Barbara and Ventura Counties by increasing capacity at rehabilitation facilities.	PREFERRED. Increased rehabilitation capacity directly benefits survival of pinnipeds that strand live due to disease, fishing interactions, vessel strikes, and other conditions.
MAMM-2	Cetacean Entanglement Response	Expand capacity for entanglement response to Increase survival rates of cetaceans entangled in fishing gear by staging gear in additional locations for quick response to reports of entangled whales in the Santa Barbara Channel.	PREFERRED. Increased response capacity directly benefits survival in cetaceans that become entangled in fishing gear.

Project ID	Description	Project Description	NRDA Criteria Evaluation
MAMM-3	Reduce Sea Lion Entanglement Mortality on San Miguel Island	Remove fishing gear from entangled pinnipeds on San Miguel Island, thus directly benefitting pinnipeds by reducing direct mortality. Evaluates the effects of different fisheries on the population for future management (3 year project).	2nd TIER PROJECT. Benefits pinnipeds by reducing mortality due to fishing gear. Additional benefits to pinnipeds and small cetaceans (dolphins) in future years through fisheries management.
MAMM-4	Mitigating Entanglement Risk for pinnipeds	Improves response capabilities on the mainland to respond to entangled pinnipeds from Santa Barbara county to Orange County.	2nd TIER PROJECT. Benefits pinnipeds from southern California and reduces mortality due to entanglement in fishing gear. The project was not preferred because it is not clear how success would be measured, and it would be implementing new, unproven technology.
MAMM-5	Mammal Haul-Out and Rookery Restoration	Purchase conservation easements at Carpinteria Beach to provide further buffers for harbor seal rookery, or identify additional areas that that could be protected and serve as rookery habitat. Includes public information campaign to reduce human disturbance to marine mammals at rookeries.	2nd TIER PROJECT. Carpinteria rookery is already protected under the MMPA. Additional benefits from this project are possible, but not quantifiable. Additional potential rookery locations are not identified.
MAMM-6	Mitigation of Cetacean Ship Strikes	This project would monitor the ship strike rate of large cetaceans as part of a voluntary speed reduction program in the Santa Barbara ship channel.	2nd TIER PROJECT. Not clear how ship speed reduction is monitored and implemented; feasibility and quantification uncertain at this time. This may be considered as a pilot project.
MAMM-7	Remove Derelict Fishing Gear	Remove sub-surface fishing gear and other marine debris.	2nd TIER PROJECT. While derelict nets may occasionally trap marine mammals, they have not been identified as a significant problem along the Gaviota coast. The benefits to marine mammals along the Gaviota coast is not readily quantifiable.

Project ID	Description	Project Description	NRDA Criteria Evaluation
MAMM-8	Bottlenose Dolphin Protection Area	Improve habitat for the coastal population of bottlenose dolphin through reduction of microbial and chemical contamination, and anthropogenic noise.	2nd TIER PROJECT. No known location to implement this project where substantial benefits to dolphins could be achieved. Benefits would be difficult to quantify if a suitable area were identified.

Table 2 Projects Not Meeting NRDA Criteria--Excluded From Further Consideration

Project ID	Project Name	Project Description	NRDA Criteria Evaluation
EX-1	Gaviota Marine Terminal Transfer To California State Parks For Inclusion In Gaviota State Park	Significant increase in available public recreational use and protection of additional coastal habitat. Also a number of known archaeological sites.	EXCLUDED. State Parks is familiar with this project and has concerns about liabilities that come with it. An alternative use would be to use that site to move the Caltrans rest stop.
EX-2	Provide Funding To Stewardship Groups Along Coast	Provide support for stewardship groups for projects, activities, etc.	EXCLUDED. Too vague and does not specifically target affected resource classes.
EX-3	Eel Grass Baseline Monitoring	There is a need to better understand the extent of eelgrass habitat along the open coast of Southern California so that mitigation of project impacts can be more informed. This would involve work to fill in gaps in existing information.	EXCLUDED. No tangible benefits, only studies. Does not meet threshold criteria.
EX-4	Subtidal Biological Surveys	Partnering with scientists from UC Santa Barbara to conduct subtidal biological surveys in and around the MPAs in the Santa Barbara Channel to quantify how fish and other marine species are benefiting from the protected status of these areas;	EXCLUDED. No tangible benefits only studies. Does not meet threshold criteria. Aspects may be incorporated into the abalone restoration project.
EX-5	Carpinteria Creek Mouth Habitat Restoration Project	The Carpinteria Creek Mouth restoration project is located at Carpinteria State Beach, on State Parks property. The goal of the project is to increase the habitat and ecological value of the Carpinteria Creek estuary by removing non-native flora and the planting of native flora along the banks. The project has also allowed volunteers and visitors of the Carpinteria State Beach to learn about habitat restoration and the importance of the Carpinteria Creek Watershed.	EXCLUDED. Project completed.
EX-6	Goleta Wave Buoy	The California State funding for the CDIP Goleta Wave Buoy will be expiring in 2016. Since knowledge of wave data are critical for any restoration project, continued funding of this buoy would be beneficial towards restoration work.	EXCLUDED. No tangible benefits, only studies. Does not meet threshold criteria

Project ID	Project Name	Project Description	NRDA Criteria Evaluation
EX-7	Kelp Monitoring	Kelp forest monitoring at the Channel Islands.	EXCLUDED. No tangible benefits, only studies. Does not meet threshold criteria
EX-8	Sea star Wasting Citizen Science Monitoring	Monitoring of sea star wasting.	EXCLUDED. No tangible benefits, only studies. Does not meet threshold criteria
EX-9	San Ysidro Creek And Romero Creek Fish Passage Enhancement and Goleta Slough Project	Enhance fish passage in narrow concrete walled or lined channels that would better allow steelhead to migrate upstream.	EXCLUDED. Terrestrial fish habitat was not impacted, and steelhead were not demonstrated to be specifically injured by the spill. Does not meet threshold criteria
EX-10	Arroyo Honda Stream Corridor Restoration	Providing habitat for wildlife, a sanctuary for nature lovers, and invaluable experience for those who are learning while working at the Land Trust owned and operated Arroyo Hondo Preserve, located between Refugio and Gaviota State Beaches. Interns and volunteers are helping with the removal of invasive species and the re-introduction of native plants throughout the stream corridor over the course of three years.	EXCLUDED. Does not target the affected resource classes.
EX-11	Santa Barbara Shores And Sperling Preserve Native Grassland Restoration At Ellwood Mesa	Project can be found at the following web link: http://goleta.granicus.com/MetaViewer.php?view_id=2&clip_id=165&meta_id=13684	EXCLUDED. Does not target the affected resource classes.
EX-12	Refugio Beach Cove Bluff Restoration	Overhanging slopes along the west end of Refugio Beach are a safety hazard, and will lead to loss of large palm trees. Construct tree wells utilizing locally quarried sandstone, and backfill eroded slope with native soil. Although non-native, these trees may provide nesting habitat for orioles and perching habitat for other birds.	EXCLUDED. Parks has evaluated this and preliminarily determined that it is not something they would like to pursue.
EX-13	Transplant Palm Trees On Refugio	Save the iconic palm trees at Refugio State Beach.	EXCLUDED. State Parks has evaluated this and preliminarily determined that it is not feasible at this time.

Project ID	Project Name	Project Description	NRDA Criteria Evaluation
EX-14	Refugio Beach Campground Lawn Replacement With Native Plants and Xeriscape	Improve aesthetics, water usage, bird and pollinator habitat (and watching), school education purposes, and exemplify pre-historic uses of this cove.	EXCLUDED. There is a septic leach field at the location of the lawn, so it makes sense to keep it there.
EX-15	RBOS Data Room	Create a "data room" to house information about flora and fauna in the area, as well as research conducted as part of or after the spill, to better facilitate restoration and other activities.	EXCLUDED. No tangible benefits to injured resources.
EX-16	Refugio Creek Mouth Restoration	Remove invasive non-native flora and install native flora along the banks at the mouth of Refugio Creek on State Parks property.	EXCLUDED. Project completed.
EX-17	Diesel Storage Tank Replacement	Replace existing single wall underground diesel storage tank, to decrease potential risks of a beach and/or intertidal diesel oil spill.	EXCLUDED. Capital improvement project.
EX-18	Haskell's Beach Emergency Access Improvements	The project includes improvements to a current dirt road to improve emergency responder access to Haskell's Beach. The road improvements include the creation of a turnaround for emergency vehicles just off the beach, which can serve as a staging area for emergency activities, as well as the creation of an access point directly on to the beach for emergency vehicles.	EXCLUDED. Capital improvement project.
EX-19	Quick Reaction Cleanup Crew for Tar on Beaches	For the most part the cleanup on the shore was pretty good in easy-to-access areas, but was not necessarily as good in the more remote pocket beaches. Also, there is a layer of oil that was covered by sand shortly after the spill and is periodically exposed by sand removal due to tidal and seasonal changes. A quick reaction cleanup crew could respond to these stretches of oily rock and sand as they become exposed.	EXCLUDED. Duplicative of responsibilities under oil spill response agencies. Removing seep oil from beaches would have a high cost and uncertain benefits to resources because seep oil has lower toxicity than fresh oil.
EX-20	Online Atlas of Western Snowy Plover Populations for Oil Spill Response	Create an online atlas of Western Snowy Plover population data.	EXCLUDED. No tangible benefits to injured resources.

Table 3 Human Use Projects – No Human Use Projects Considered at This Time

Project ID	Project Name	Project Description
EX-HU-1	Gaviota Creek Watershed Restoration	Restoration of the Gaviota Creek watershed involves removal of steelhead migration barriers, a restoration of the Gaviota Creek estuary, improving the access road to the Gaviota State Park, and other steps to protect the watershed from development and water diversion which could impact the creek. Implementation would improve wildlife habitat for anadromous species of the Southern Steelhead and Tidewater Goby (both Federally endangered), as well as other sensitive and endangered species. It will also reduce flood damage to Gaviota State Park, and protect future watershed health.
EX-HU-2	Gaviota Pier Repair	Improve recreational and sport fishing access, as well as enhance fish habitat around piers.
EX-HU-3	El Capitan Entry Road/Trail Realignment	Includes replacement of large culvert on entry road with free span bridge, modernizing road to better accommodate large RVs, and realignment of the pedestrian trail next to the roadway.
EX-HU-4	Upgrade/Enhances Day Use Beach Access On the Gaviota Coast	Upgrade landscape, infrastructure (including universal accessibility), beach access, day use, amenities, and campgrounds.
EX-HU-5	Land Acquisition for a Campground Near Gaviota	Expand camping recreation opportunities along the Gaviota coast.
EX-HU-6	Relocate and Reopen McGrath State Park	Relocate McGrath Campground to contiguous state-owned property to allow restoration of the estuary resources, which are currently degraded by the presence of the campground.
EX-HU-7	Refugio At-Sea Visitation for Special Needs	Boat trips to educate special needs people and their caregivers about the area, the incident, the impacts, the closure, the NRDA process, and the future of the area.
EX-HU-8	Refugio Recreational Angling Loss Makeup	Fishing trips to give back lost opportunities to the recreational fishing communities. As part of the project, fishing gear may be purchased to help make up for loss of business during the closure.
EX-HU-9	Multilingual Beach Access Signage at Railroad Crossings (Tajiguas, Vista Point)	Add multilingual railroad crossing signage to the vista point train trestle and the curved section of track at Tajiguas next to the parking areas to increase awareness of the tracks and safety of visitors to the area.

Project ID	Project Name	Project Description
EX-HU-10	Sportfish Contamination Information and Awareness (Gaviota Coast)	Provide access to lab testing of samples of fish and invertebrates from the spill zone to determine if they are safe to eat. Include samples collected by the public sport fishermen who fish in the area.
EX-HU-11	Sustainable Stewardship Program for Visitors of Santa Barbara and Ventura County Beaches	This project will be a coordinated effort to compile expertise from many resource managers to be delivered by an entity that controls visitor access/use of various areas of the coast. The goal would be to create a stewardship ethic in visitors of coastal resources so that human use has less of an impact on the resources and users may get more enjoyment out of trips by recognizing the unique resources that exist there.
EX-HU-12	Demolition of Restrooms at El Capitan	Remove these facilities that are no longer in use.
EX-HU-13	Goleta Beach Park Restoration	Goleta Beach Park recently was approved for a Coastal Permit for its existing rock revetment on the west end of the Park for twenty years, which will support wildlife, recreational use, and landward asset protections. However, there are approximately 950 linear feet of unprotected park which requires the same protection for marine life and recreational use. Projects may include, geotextile bags (or tubes) buried cobble stones, and landscaped (marine vegetation) sand dunes, with canary palms placed landward for final protection. This project would then provide a more universal protection buffer against future oil spills or the ravages of winter storms for habitat and recreational use.
EX-HU-14	Gaviota Land Conservation	There could be three different options for this project. One option could be outright buying conservation land to be used by the public. A second option could be purchasing the development rights of ranches throughout the Gaviota coast. And the third option could be developing conservation easements throughout the Gaviota coast. All three options would achieve the same goals. The public would gain the preservation of a pristine southern California coastline and continue to benefit from the recreational opportunities along this coastline. It would provide space for endangered and threatened plants and animals to live. Water quality would be maintained throughout the creek watersheds making sure beaches and rocky reef habitats are not degraded and polluted. A wildlife corridor will remain from the Los Padres National Forest to the coast.
EX-HU-15	Franklin Trail Extension	This project is looking to raise additional funds to pay for the environmental studies, review by the U.S. Forest Service, and the reconstruction of the historic Franklin Trail through the Los Padres National Forest, to be extended to the mountain crest overlooking south Santa Barbara county.

Project ID	Project Name	Project Description
EX-HU-16	Ellwood Beach Access Points Project	This project proposes to remove approximately 15 cubic yards of the existing aging asphalt along the Beach Access Point E, and to reduce the steepness of the grade at this location by creating a curvilinear trail. In order to address long-term erosion impacts, the proposed project would establish two bioswales to capture runoff along segments of the trail. Runoff captured in these bioswales would be directing into two drainpipes that would outlet on the beach. At Access Point F, the existing 275-foot beach access trail is narrow and steep. The project proposes to construct approximately 100 steps over the beach access trail. A gravel infiltration trench with buried pipe and filter sleeve would be established on the eastern side of the trail.
EX-HU-17	Ellwood Trails and Restoration Project	The proposed Ellwood Mesa Coastal Trails and Habitat Restoration Project would improve approximately 1.2 miles of existing coastal trails on the Ellwood Mesa. This could include improvements to 1.56 miles of existing trails, as well as drainage improvements to direct surface flows off of trails and improvements in the trail head surface. Improvements to three drainage crossings would also be made. In addition, approximately 0.54 mile of trail would be realigned around sensitive areas in conformance with the City of Goleta General Plan and Coastal Land Use Plan. The proposed project would include approximately 13 acres of total habitat restoration, including the removal of non-native species, and increases in the coverage of native coastal scrub, wetland, and grassland vegetation. There is also interest in building a foot path off Coronado Drive to cross into the Butterfly Grove.
EX-HU-18	Santa Barbara Coast Habitats Documentary	The project is a series of BBC-quality movies about the coastal habitats, including beach, intertidal, subtidal, sand flats, and kelp forest. The movies would describe the habitat, the natural history of important species, and conservation issues. Restoration in this case will be achieved through education, including by improving support and respect to these habitats.
EX-HU-19	Haskell's Beach Public Access Improvements	This project includes improvements to two public beach access points at Haskell's Beach. The first access point would be improved so as to mitigate erosion and safety concerns. A second access point would also be established south of the current access point.

Project ID	Project Name	Project Description
EX-HU-20	Santa Barbara County Gaviota Coast Plan Projects	Possible projects include:- Acquire near shore bluff top easements for the California Coastal Trail from the Bacara Hotel to El Capitan State Beach, and develop and open the California Coastal Trail throughout this reach. The County has acquired Offers to Dedicate (OTDs) for the development of several segments of the California Coastal Trail between the Bacara Hotel and El Capitan State Beach. Funding is needed to develop and complete the trails along the OTDs to open the California Coastal Trail throughout this reach.- Work with California State Parks and the California Coastal Commission to reopen the closed segment of the existing Class I bikeway that links El Capitan and Refugio State Beaches. Funding is needed to develop and implement a feasible longer term solution to repair and then maintain the damaged Refugio State Beach to El Capitan State Beach bike path. - Work with California State Parks to develop and open a three-mile-long bluff top segment of the California Coastal Trail, south of U. S. Highway 101, from Gaviota State Park east to the Gaviota Marine Terminal. Funding is needed to develop this segment.- Other potential options include a variety of acquisitions, easements, habitat restoration, and planning activities in the area.
EX-HU-21	Santa Barbara County Beachfront Improvements	Goleta beachfront improvements will include picnic areas, day use areas, turf, irrigation, and access stairs to the beach. Arroyo Burro beachfront improvements will include day use areas and benches. Goleta Pier improvements will include replacement of 2,000 deck boards, replacement of side rails, to improve lighting, benches, and a fish cleaning station.
EX-HU-22	Marine Protected Area Management and Stewardship Program	Promotion of MPA-centered recreation and eco-tourism in the Santa Barbara Channel; monitoring to support adaptive management and agency enforcement of MPA regulations; support for MPA biological monitoring; clean-up of marine debris; and education and outreach to promote awareness, compliance, and stewardship of MPAs.
EX-HU-23	Refugio and Gaviota Coast Human Impact Mitigation and Protection Program (Tajiguas, Mariposa Reina South, and Vista)	Tajiguas, Mariposa Reina south, and Vista point were closed to fishing and diving during the spill. Installment of bathrooms and trash bins in these areas will help decrease pollution and increase the overall condition of these highly-trafficked areas.

Project ID	Project Name	Project Description
EX-HU-24	Coastal Hazards Removal, Goleta Beaches Extending From Arroyo Hondo To Coal Oil Point (Note Includes Removal Of Ellwood Seawall)	These are permitted oil field related debris removal projects that have been completed periodically as funding is available. A number of sites including the Ellwood sea wall would provide significant habitat improvements including hazards to public uses.
EX-HU-25	Ventura Harbor Wetlands Ecological Reserve Wetland Restoration	Restoration and enhancement of the Ventura Harbor Wetlands Ecological Reserve. The dominant non-native plants will be removed. Once the non-native plants have been removed, live oak, valley oak, sycamore, toyon, willow and other smaller, native shrubs will be planted, which will enhance the habitat value of this site.
EX-HU-26	Coil Oil Point Research and Education	Funds for an endowment for an education coordinator, undergraduate internships for naturalist guides at the COP Nature Center, graduate student research awards to conduct research at COPR, and equipment for laboratory and monitoring.
EX-HU-27	Carpinteria Harbor Seal Rookery Protection Enhancement, and Visitor Education and Facility Enhancement	Enhanced protection could include adjacent bluff top property acquisition/easements, improved public beach exits, and signage east and west of the sanctuary as well as off-site education programs, including Carpinteria State Park and Venoco contractors. Restoration may include increasing habitat through extension of beach closure dates, measures to decrease disturbances, and dedicated measures in the event of Venoco Oil Co. pipeline or materials spills. Protection measures to diminish human disturbances of the seals could include improved bluff top and beach access at the east and west ends of the sanctuary, improved local and State Park education, improved monitoring of disturbances, improved education of Venoco Oil and Venoco lessees/contractor employees regarding measures to reduce disturbances, planning protocols to reduce injury in the event of a spill/explosion, improved educational signage, improvements to screening of the bluff top visitor viewing area, and improved onsite and offsite educational programs and materials. The proposed project will contribute to recreation through enhancing the visitor experience by providing increased seal protection/more seals, a more pleasant and safe viewing area, and increased visitor education on and off site.
EX-HU-28	Fish Reef	This project would include facilitating permitting by the necessary agencies and funding from Plains All American to work with Fish Reef Project to construct a 5-acre reef made up of quarry rock and reef balls, some of which should have smaller holes in order to protect a brood stock of abalone and other species of concern. This 5-acre reef zone, placed where recreational fishing can occur and at a depth where kelp will grow, will compensate the recreational angling community for lost/damaged capacity of affected natural reefs.

Project ID	Project Name	Project Description
EX-HU-29	Add project around cultural access per comment that was submitted	This project will construct and improve the Coastal Trail, develop culturally-appropriate interpretive programs to honor the Chumash peoples, and/or memorialize and dedicate the informal pathways that the community uses to access and enjoy the Gaviota Coast

APPENDIX O. Response to Public Comments on the Draft Damage Assessment and Restoration Plan/Environmental Assessment (DARP/EA)

The Trustees received over 45 comment letters on the Draft Refugio Beach Oil Spill DARP/EA that are summarized and responded to below. Original comment letters are available for download from the Administrative Record for the case at www……..

Comments of Support:

S Comment 1: The Trustees received several comments that indicated full support of the draft plan. Comments of Support included: • Support for the California brown pelican restoration and western snowy plover restoration proposed projects. • Support for of restoration projects for marine mammals. • Support for SHORE-1, SubT-4, SubT-2, BIRD-1, BIRD-3, and BIRD-7 Projects. • Hopes that all projects will be implemented.
S Comment 2: One commenter expressed their opinion that the Trustees presented an excellent assessment and restoration plan.
S Comment 3: Multiple comments were received specifically supporting restoration projects for marine mammals.
S Comment 4: Several commenters expressed support for the shoreline restoration projects and were highly supportive of the Ellwood Seawall Removal Project.
S Comment 5: One commenter expressed strong support for the sand dwelling kelp forest restoration project.
S Comment 6: Two commenters were supportive of SHORE-3 project and would like to help with implementation in "Zone D".
S Comment 7: A comment expressed support of the Draft DARP/EA, indicated that they provided support during development of the DARP/EA, and plan to continue to provide support in the implementation phase.
S Comment 8: A comment indicated support for removal of pilings at COPR (2nd tier) PROJECT.
S Comment 9: One commenter requested maximum funding possible to Channel Islands Marine and Wildlife Institute (CIMWI).
Response: The Trustees are thankful for the letters of support on the DARP/EA.

General Comments:

G Comment 1: The commenter requested a public comment period extension of 45 days due to COVID-19.
Response: The Trustees appreciate that the COVID-19 pandemic has created any number of hardships. Nevertheless, we received only one request to extend the 45-day comment period, and the requester did not suggest that they were unable to comment sufficiently on behalf of her organization. The comment period will remain at 45-days to ensure that the plan is finalized in early 2021.

G Comment 2: The commenter is concerned that the amount of the NRDA damages was included in the Plains Consent Decree before the public comment process was completed.
Response: Settlements for natural resource damages are often based upon estimates of what appropriate restoration may cost, and it is common for natural resource settlements to occur prior to completion of the public process and the Trustees completing a Final DARP/EA. A noteworthy example of this is the M/V Cosco Busan oil spill in San Francisco Bay, where the DARP/EA was finalized after the consent decree was entered. The OPA regulations allow the Trustees to settle claims for natural resource damages "… at any time, provided that the settlement is adequate in the judgment of the trustees to satisfy the goals of the OPA and is fair, reasonable, and in the public interest." (15 CFR § 990.25). In this case, the Trustees have concluded that the settlement achieves the goals of OPA to make the public and the environment whole, is a fair and reasonable result, and advances the public interest. The Trustees have provided a sufficient basis to support this conclusion through development of their Draft DARP/EA, as required by OPA. 33 U.S.C. § 2706. In developing their Draft DARP/EA, the Trustees followed requirements set forth in OPA to assess the injured natural resources and conduct restoration planning. Following OPA regulations, the Trustees determined whether the Refugio Beach incident injured natural resources or impaired their services (15 CFR § 990.51) and quantified the degree and the spatial and temporal extent of those injuries and loss of services (15 CFR § 990.52). This process of injury determination and quantification is described in detail in Chapter 5. The Trustees used a variety of standard scientific approaches, appropriate to the nature of the resource and injury being studied. Chapter 5 of the Draft DARP/EA also contains the Trustees' development and evaluation of alternatives for comprehensive restoration planning (15 CFR §§ 990.53-54). As a result of this process, the Trustees determined that the restoration projects identified in the Draft DARP/EA were appropriate to compensate the public for losses to the injured resources. After nearly five years of intensive field work, study, data analysis, and planning, the Trustees published the Draft DARP/EA satisfied that the plan would achieve the Trustees' restoration goals and that the settlement amounts included in the consent decree were appropriate. Now, having carefully considered the public's comments on the Draft DARP/EA, the Trustees still believe that to be true.

G Comment 3: The commenter requests that the Trustees stop referring to these incidents and blowouts by the places they occur and start giving them back to the companies that have caused them. They state that this incident is the Plains All American Oil Spill at Refugio.
Response: The Trustees appreciate this comment.

G Comment 4: The commenter requests that the Trustees keep an open mind and work with the community to ensure a final plan that meets the needs of the community and restores the environment.
Response: The Trustees place a high priority on public participation in the restoration planning process, before, during, and after the public's review of the Draft DARP/EA. In the summer of 2015, shortly after the spill, the Trustees began a robust outreach process. The Trustees held a public meeting in June 2015 and began publishing periodic newsletters to keep the public informed, starting in July 2015. However, the public outreach went beyond providing informational materials. Throughout the process, the Trustees also sought restoration concepts from experts, academics, local governments, and the general public. This is evidenced by the extensive list of both Tier 1 and Tier 2 projects that the Trustees' considered. In fact, few of the restoration projects included in the Draft DARP/EA were purely Trustee-driven; most were proposed by interested members of local communities throughout the spill area. The Trustees have also carefully considered the public comments submitted on the Draft DARP/EA. While the Trustees have not made any major changes to the preferred alternatives from the Draft DARP/EA, this is due, in part, to the fact that the preferred alternatives were already largely community-driven. Communication and coordination with local communities will also continue even after the publication of this Final DARP/EA. Most notably, the selection of projects to compensate for lost human use will be an ongoing process – one that will be driven largely by the needs of local communities. State Parks will consider public comments on the DARP/EA as well as input from Santa Barbara County and other local governmental and non-government organizations prior to selecting projects on State Parks' properties to compensate for recreation losses occurring from Gaviota to El Capitan. With regard to projects downcoast of El Capitan State Beach, the State Trustees will solicit grant proposals from Santa Barbara County, Ventura County, Los Angeles County, County and City Park Districts, as well as other local public entities and non-profits. The Trustees will provide funding through the South Coast Shoreline Parks and Outdoor Recreation Grants Program, but the project proposals will originate from local agencies and park districts as well as non-profits within the most spill-affected communities.

G Comment 5: The commenter states that the volume of oil spilled was greater than the amount considered by the Trustees in the DARP/EA.
Response: The Trustees understand that Dr. Igor Mezic, co-founder of AIMdyn, Inc. and a Professor at the University of California, Santa Barbara, performed a study for private litigants that suggests the volume of oil spilled exceeds the 123,000 gallon estimate referenced in the Draft DARP/EA. The Trustees relied upon the total spill volume (i.e., the amount that left the pipeline) referenced in the Pipeline and Hazardous Materials Safety Agency's Failure Investigation Report and various other response documents. We then estimated the amount of oil that in turn would have entered the ocean. Spill volume estimates were primarily considered by the Trustees in the assessment process as a means to "cross check" whether the spill volume was consistent with the Trustees' determination of the geographic extent of oiling and degree of impacts. However, the Trustees ultimately based their injury assessment on observations and data collected in the field, as well as laboratory studies. For

example, the Trustees considered field observations of oil collected by oil spill responders conducting SCAT surveys. The Trustees also conducted a robust forensics study to determine the origin (or "fingerprint") of a large number of oil and tissue samples found in the environment in various locations.

The Trustees do not believe that either their estimate of the amount of oil entering the ocean, or the estimates of Dr. Mezic are necessarily inconsistent with the injuries that were quantified in the assessment process. The resulting natural resource damages are based upon the cost to restore the quantified injuries to resources and the value of lost human use, not spill volume.

G Comment 6: The commenter stated that information about oil at the Channel Islands and in the Sanctuary is unclear throughout the DARP/EA.

Response: The Trustees appreciate this comment. Oil at the Channel Islands is discussed in Section 1.1.2, Figure 4, and Section 2.2.5 in the Draft DARP/EA. The Trustees have made revisions to Sections 1.1.2 and 2.2.5 for clarification.

G Comment 7: The commenter believes that the sunken oil assessment may have been too late.

Response: Bringing in equipment and divers certified to dive in oil-contaminated water for purposes of an assessment takes time. The Trustees initiated the sunken oil assessment as soon as it was feasible and safe to deploy. Submerged oil can move in and out of the area quickly, depending on tides and currents, making the certainty of "catching" the submerged oil a challenge. The two subtidal assessments were undertaken within 2 weeks of the spill—one conducted by the Response between 11 and 13 days after the spill, and one conducted by the Trustees 13 days after the spill (DARP/EA Section 5.2.1). However, the Trustees still found evidence of oil in sediments and tissue 13 days later. The quantification the Trustees used for the assessment (based on algal and surfgrass damage) was sufficient and we are confident that the injuries are adequately compensated.

G Comment 8: The commenter expressed concern over the lack of long-term analysis to assess the injury and damage of Refugio Beach Oil Spill. Several sections of the comment letter mention that no analyses were conducted beyond two years after the spill.

Response: The Trustees collected anniversary chemical and biological survey data for 1-2 years after the spill. The chemical data strongly suggested that exposure to Line 901 oil was greatly attenuated or no longer detectable within those media. The biological survey data suggested that recovery of beach hoppers was not complete; however the data showed recovery was occurring, and that recovery would likely be complete within 4-years, as estimated by Dr. Jenifer Dugan (UC Santa Barbara). Given this and other information, the Trustees felt there was enough justification to focus the assessment on restoration planning and achieving an out-of-court settlement with the responsible party, rather than pursuing additional biological injury and recovery data. As stated in Section 4 of the DARP/EA, while there is some uncertainty inherent in the assessment of impacts from oil spills, and while collecting more information may increase the precision of the estimate of the impacts, the Trustees believe that the type and scale of potential restoration actions would not substantially change as a result of more studies. Therefore, the Trustees sought to balance the desire for more information with the reality that further research would be costly and would delay the implementation of the restoration projects.

G Comment 9: The commenter states that the DARP/EA must be revised to include performance criteria in order to ensure adequate restoration as required by NRDA regulations.

Response: The Trustees agree that performance criteria and monitoring are critical to ensuring the selected restoration is adequate. Monitoring results also provide much-needed information to the Trustees in the unfortunate event of another oil spill. Accordingly, the Trustees included in the Draft DARP/EA a discussion of performance criteria for each preferred project. The Trustees also understand the desire for additional details on performance criteria. Accordingly, the Trustees have revised the performance criteria and monitoring discussions in the Final DARP/EA for each preferred project, adding as much detail as is practical at this point in the planning process.

However, many of the projects included in this plan are still relatively early in the planning process and are, therefore, not yet ready for the development of highly detailed monitoring plans or performance criteria. As the projects get more fully developed, the Trustees will work in coordination with project implementers to create more detailed monitoring plans and performance criteria.

G Comment 10: The commenter stated that active and ongoing Chumash partnership should be enlisted.

Response: The Trustees agree and will continue to reach out and invite Chumash collaboration throughout the restoration planning and implementation process.

G Comment 11: The commenter requests that Chumash continue to be involved throughout implementation of projects.

Response: The Trustees have appreciated our communication with the Chumash to date and welcome continued collaboration into the future.

G Comment 12: The commenter expressed that not all tribes are represented in the Draft DARP/EA and encourages better communication.

Response: The Trustees appreciate the commenter providing a list of tribes beyond those listed by the Native American Heritage Commission. We have updated the Final DARP/EA to reflect this information. We anticipate continued coordination with tribes throughout the implementation of this plan to ensure that restoration is conducted in a way that is protective of sacred sites and is respectful of cultural keystone species that have significance beyond their role in the ecosystem.

G Comment 13: The commenter states that access paths were created during the oil spill response, and while many have grown over, some remain and are being used for beach access through culturally-sensitive sites. The vulnerability of these sensitive sites can be reduced by blocking off and revegetating the access trails.

Response: The Unified Command as well as Santa Barbara County's Emergency Coastal Development Permit required archaeological and Native American monitoring during cleanup, repair, and habitat restoration activities in order to minimize impacts to cultural resources. Native American monitoring was coordinated by Owl Clan Consultants and carried out by a consortium composed of Owl Clan staff, the federally recognized Santa Ynez Band of Chumash Indians, the Coastal Band of the Chumash Nation, the Barbareño/Ventureño Band of Mission Indians, and the Barbareño Chumash Band. The Trustees followed up with personnel involved in the response and were informed that the majority of the access path improvements made by response personnel were made to pre-existing volunteer trails used by the public prior to the spill. The access paths were restored to pre-spill conditions following the response. A number of the pre-existing volunteer trails remain open. The Trustees will follow up with the commenter to obtain further information regarding the location of the paths they are concerned about and to confirm whether the paths of concern were pre-existing volunteer trails.

G Comment 14: Oil Spill Response capacity-building projects should have been included in the Draft DARP/EA but were absent. The commenter also expressed the need for cultural resource monitor HAZWOPER training.
Response: Funds secured through the Natural Resource Damage Assessment must be spent on restoration projects that have tangible benefits to the natural resources that were injured by the spill. While oil spill response capacity-building is a necessary component of spill preparedness, it falls outside the scope and purpose of Natural Resource Damage Assessment authorities. The California Department of Fish and Wildlife, Office of Spill Prevention and Response, U.S. Coast Guard, and The Environmental Protection Agency lead spill preparedness through Area Committees that are open to all, and are an appropriate forum for spill response capacity-building. Butch Willoughby, with the U.S. Coast Guard, welcomes members of the local indigenous community to attend and take part in their Area Contingency Plan meetings. He can be reached by email at Robert.M.Willoughby@uscg.mil. OSPR typically holds open several seats at their internal HAZWOPER trainings that can be made available free of charge to members of the tribal community. Due to the ongoing Covid-19 pandemic, future training sessions have not been scheduled at this time. Members of the indigenous community who would like to find future dates of OSPR HAZWOPER trainings can contact Jeff Westervelt by email at jeff.westervelt@wildlife.ca.gov.

G Comment 15: The commenter expressed the opinion that Chumash people should not just be considered an interest group and that indigenous peoples have the right to free, prior, and informed consent. In addition, they have the right to conserve and protect their traditional resources. The commenter also stated that cultural resources are not synonymous with archeological resources. Cultural resources include land-based, water-based, and living natural resources, as well as cultural landscapes and sacred places.
Response: The Trustees appreciate this comment and reviewed the DARP/EA to ensure our wording aligns with these values.

G Comment 16: The commenter submitted references about Chumash culture for inclusion in the DARP/EA.
Response: The Trustees welcome and appreciate these additional resources. We have incorporated the following references into the Final DARP/EA and they will be added to our administrative record: • Tribal Marine Protected Areas, Protecting Maritime Ways and Cultural Practices. 2004 • Chumash Ecosystem Services Assessment – CINMS Condition Report • Traditional and Local Knowledge, A vision for the Sea Grant Network, 2018.

G Comment 17: It was stated that wetland habitats were not assessed for damage after the spill. The commenter requested that the Trustees include justification in restoration plan if wetlands were not impacted by the spill.
Response: The Trustees did not assess wetlands for damages because the Trustees saw no evidence of wetlands oiling in the two weeks following the spill, and cleanup activities did not adversely affect wetlands. Section 2.3.6 of the DARP/EA addresses this point.

G Comment 18: The commenter requests enough funding to ensure projects are successful. The compensation should be 10x damage costs to address uncertainty.

Response: The Trustees agree that there is uncertainty in the costs associated with completing each of the restoration projects identified in the Draft Damage Assessment Restoration Plan. When necessary, cost contingencies were built into the cost estimate for each project. For example, the Trustees hired an engineering firm to develop construction cost escalation factors and a cost estimate for the removal of the Ellwood Seawall. The Trustees believe that contingency factors built into restoration project costs will provide an adequate level of certainty in being able to implement the projects in size and scope as identified in the plan.

G Comment 19: The commenter requests additional information on length of funding per project and if there is adequate funding to ensure long-term success.

Response: The length of funding per project is variable depending on the project and project scaling, i.e., the number of years needed for a project to compensate for the associated injuries. All projects have been budgeted to include a contingency that can be allocated to adjust for unanticipated issues that arise.

G Comment 20: The commenter has concerns with the consistency in monitoring post-spill and used Figure 14 (page 68) as an example; only one beach was monitored in August 2015. This was concerning to the commenter because this beach had the highest levels of Polycyclic Aromatic Hydrocarbons (PAHs). The commenter states that based on this figure, it appears that the majority of impacts may have been missed by the sampling regime.

Response: The NRDA team's sampling program was designed to assess broad-scale spatial and temporal patterns in macroinvertebrate fauna and contaminants over more than 50 km of shoreline. The team collected samples that were intended to yield time integrated measures of PAHs, including tissue from lower shore and upper shore elements of the food web and from intertidal pore water across the spill-affected area. These measures correlated well with SCAT estimates of oiling, which supported their use in further analyses. The example beach location that is the focus of this comment, shown in Figure 14, is Corral Canyon, a small beach located east of the site at Las Flores but west of the site at El Capitan. This location returned the highest pore water total PAH concentrations of any location sampled during this spill event. The responders and Trustees became aware of this location later than the commencement of the planned surveys of the other nearby sites following a surfer's complaint about its disproportionately significant and persistent oiling status. The oiling status of the originally sampled sites was more apparent to spill responders and NRDA teams shortly after the spill, and these sites were more frequently and easily accessed during and post-spill. As soon as the Trustees were alerted to the oiling status at Corral Canyon, we arranged a special sampling effort to collect data from it in August 2015. The Trustees then made the decision to continue to sample that site in the two following sampling events. While the pore water chemistry results reflect the later start of the sampling at this site, this was a function of becoming aware of the condition of this site later than other locations rather than any intentional omission. The post-spill sampling design decisions were made rapidly, based on the most current information available regarding fate and transport of oil and general oiling status of sites. While the peak concentrations of hydrocarbons may not have been captured in this dataset, the Trustees do not believe that this resulted in the majority of the impacts being missed and wish to point out that multiple datasets and lines of evidence were factored into the injury assessment.

G Comment 21: The commenter requests justification for how the percentage of injury was calculated for shoreline habitats and suggests there is a lack of consistency in the injury assessment data.

Response: SCAT derived data, which quantified oiling levels in shoreline Zones A, C, and D combined with acreage, were used to estimate injury based on the approximate proportionality of oiling compared to Zone B, given that less data and fewer types of data were collected in those zones. The concept was that lesser oiling led to lesser injury, both from exposure and from clean-up operations. The Trustees view this as the most consistent approach with the data and evidence available. Lower injury levels reduce the ability to detect injury using field data that have high inherent variability (*e.g.*, talitrid population measures). Reduced ability to detect injury in field data affects the utility and cost-effectiveness of collecting additional field data to conduct direct comparisons of Zones A, C, and D measurements to other sites, including control sites. The value 0.034 is the fraction of discounted service-acre years in Zone D compared to Zone B; (0.05 dSAY/Acre in Zone D) / (1.47 dSAY/Acre in Zone B) = 0.034. That calculated value follows from the 5% injury in one year assigned to Zone D.

G Comment 22: The commenter requests additional justification to link injuries assessed to the proposed restoration projects and for the Trustees to provide information on location of projects in terms of zones and injuries assessed for each zone
Response: The Trustees appreciate this comment. We have reviewed the DARP/EA and revised the bird and marine mammal appendices to include additional quantification information linking injuries to the preferred projects. In addition, the Final DARP/EA has been revised to include maps that identify the location of all preferred projects.

G Comment 23: The commenter stated that second-tier restoration projects described as "out of kind" or not appropriate for the impact should be removed from the document.
Response: The Trustees agree that there are plentiful opportunities for in-kind restoration and projects that provide out-of-kind benefits to the resources that were impacted by the spill are not preferred. We reviewed the three second-tier projects that were described as providing benefits that were "out of kind" with the injury caused by the oil spill. In each case, we identified some nexus between the restoration project and the injury, and therefore retained each in the text, but with expanded descriptions to clarify the nexus of the restoration to the injury.

G Comment 24: The commenter states they are optimistic that the preferred restoration projects in the Draft DARP/EA will be beneficial to the resources injured by the Refugio Oil Spill, but are concerned that the assessment may underestimate the damages. They are therefore also concerned that the scale of the selected restoration projects may be inadequate.
Response: The Trustees followed requirements set forth in OPA to assess the injured natural resources and conduct restoration planning in developing the Draft DARP/EA. Following OPA regulations, the Trustees determined whether the Refugio Beach incident injured natural resources or impaired their services (15 CFR § 990.51) and quantified the degree and the spatial and temporal extent of those injuries and loss of services (15 CFR § 990.52) The Trustees used a variety of standard scientific approaches, appropriate to the nature of the resource and injury being studied. This process of injury determination and quantification is described in detail in Chapter 5. In the Final DARP/EA the Trustees have provided further detail regarding restoration scaling. The Trustees believe that the preferred projects described in the Draft and Final DARP/EA achieve the goals of OPA to make the public and the environment whole, is a fair and reasonable result, and advances the public interest.

Responsible Party Comments:

RP Comment 1: The commenter provided background info on spill, participation, and NRDA process.
Response: The Trustees welcome and appreciate this comment.

RP Comment 2: The commenter stated that the Draft DARP/EA reflects only the Trustees' conclusions and determinations; Plains disagreed with several of the methods and findings of the Trustees.
Response: The Trustees acknowledge the comment.

RP Comment 3: The commenter stated that Plains' experts believe the Trustees somewhat overstated the spill's impact but agrees with the restoration projects in the Draft DARP/EA.
Response: The Trustees appreciate the support of the projects in the Draft DARP/EA.

Shoreline Habitats:

SH Comment 1: The commenter is concerned with the lack of impacts assessed for rocky intertidal habitats beyond Zone B.
Response: As part of our overall Injury assessment to rocky intertidal communities, the Trustees engaged researchers involved with the Multi-Agency Rocky Intertidal Network (MARINe), a consortium of research groups working together to collect compatible data that are entered into a centralized database. Their studies included sites well downcoast of Zone B, allowing the Trustees to leverage monitoring of already established, long-term community and population grids along much of the California coast to provide information as a control. Additional sampling sites were established very soon after the spill, within the primary known spill footprint, and were photographed following MARINEe RAPID assessment protocols developed specifically for oil spills. The summary of findings may be found here in the Raimondi et al. 2019 report: (https://pub-data.diver.orr.noaa.gov/admin-record/6104/Refugio%20Rocky%20intertidal%20report%20Final%209-5-2019.pdf). The photographs taken at sites directly in the heaviest oiling zone were examined for species composition, percent cover within a quadrat, and overall diversity of the community of organisms, in an attempt to detect community and population level impacts that could be attributable to oiling. When assessing impacts from an acute event such as an oil spill, particularly one that impacts a broad area, the Trustees are faced with situating these study sites across a variety of, potentially extremely diverse locations. However, we attempted to select sampling locations within areas we understood to be most likely to exhibit impacts from the oiling, with the ability to then extrapolate against locations with similar oiling throughout the spill zone(s). Thus, the quadrats were placed across a variety of locations with the most likelihood of exhibiting oil induced effects. Based on the findings from the Raimondi et al. 2019 report, we found that there were impacts to intertidal species resulting from the Refugio Beach Oil Spill at sites proximate to the spill location. Most common and long-lived sessile and mobile indicator species showed reduced cover in oiled sites, verses non-oiled sites. However, there were few quantifiable changes to rocky intertidal communities in the quadrat grids further from the spill location. The Trustees cannot assert that absolutely no injury occurred to some rocky intertidal flora and fauna outside of the Zone B. However, given the results of the studies that we conducted, and the burden of proof of injury we bear in NRDA, we determined that the most significant proportion of the injury to these habitats occurred within Zone B.

SH Comment 2: The commenter is concerned with project location choices for Rocky Intertidal and Shoreline Projects.
Response: The Trustees screened projects against criteria to designate them as preferred or non-preferred, as well as prioritizing projects that would be implemented within the spill affected area. It is our intention to select the best in-kind projects proximate to the injured habitats to compensate for the natural resources that were injured. Habitat restoration is generally best accomplished closer to, rather than farther from, the site of impact. We must, however, also consider the other qualities of the projects when making funding choices. So exact matching to the number of habitat equivalency units (i.e., dSAYs) within any given municipality or a given geopolitical boundary is often not possible and involves trade-offs to other aspects and qualities of the projects. These qualities include how in-kind the projects are, how likely to succeed they are, how durable the benefits are, or other important characteristics.

SH Comment 3: The commenter expressed concern with the data presented in the beach hopper analysis. Their specific comments are as follows:

> "Figure 15 (page 69) presents 2017 TPAH levels in beach hoppers that are not negative. A known negative reference or control value is needed here for direct comparison. Additionally, we are concerned that too low of a value was chosen for the value of enhancement for ultraviolet (UV) toxicity. The toxicity enhancement due to UV is stated as a range from 2-1000 (page 69), however 10 was chosen as the value of enhancement. There is no justification for this decision and we are concerned that it is not adequately protective. We recommend using the highest number (1000) to be most protective and precautionary. Finally, regarding Figure 16 (page 70), we request that additional reference sites outside of the spill zone are needed for direct comparison. We appreciate that there are data pre-spill and that there is a clear impact of the spill on talitrid amphipod abundance. However, the Zone D site is still in the spill zone and its very high abundance post-spill indicates that the post-spill data for all sites should have potentially been much higher than the pre-spill data. A host of other environmental conditions could be at play here and the addition of sites that were not impacted by oil could help tease apart true impacts."

Response: The Trustees sought out uncontaminated reference sites for these surveys, but the size of the spill and the timing of the spread made the selection of reference sites more complex. Goleta beach was originally selected, but the site became oiled within the week. The team then selected Carpinteria as the reference site, but the spilled oil reached that location and, eventually reached locations beyond it to the east. The team also considered that there are many known oil seeps in the spill-affected area. Upon further deliberation by the Trustee team, all of the areas shown on the referenced graph, and for which we had tissue samples, were also thought to experience some level of PAH-influence from seep sources. The team concluded that making comparisons in concentrations over time was appropriate, since completely PAH-free area(s) would have been challenging to locate in this region. The Trustees-did not expect negative concentrations to be present at reference sites in this region. The change in chemical results over time at each location became increasingly informative and the results demonstrated what appeared to be a meaningful decrease in PAH concentrations in years 2016 and 2017.

The ultraviolet light (UV) factors used in the analysis supported conclusions of injury, demonstrated by other lines of evidence. First, the UV factor was only applied to the megalopae stage sand crabs, as they are relatively translucent, which is necessary for phototoxicity to occur. Second, the Trustees did not need to use a factor greater than 10 since at this level the results demonstrated toxicity thresholds were exceeded, when compared to measured water values. That result, combined with the apparent reality that we did not capture the maximum water concentrations in all locations with our data set, was enough to conclude that the water values were toxic to life forms that were exposed to the contaminated water. A decision was made to utilize a factor of 10 following the scientific literature review on phototoxicity of PAHs.

The cooperatively designed sampling program aimed to characterize large scale patterns of exposure and injury while the spill was hitting the shoreline, encompassing a variety of shore types. Additional sampling followed to provide information on the early stages of recovery. After PAH concentration results were available (tissue and pore water), it was clear that there were generally good correlations between SCAT assessments and NRDA sampling results. This finding provided higher confidence in using early systematic oiling data for exposure estimates and in underscoring the importance of elucidating the potential clean-up associated injuries. The Trustees recognize that the Carpinteria site

shown in Figure 16 of the Draft DARP/EA, did receive some oiling, but realize that oiling occurred as far away as Los Angeles County beaches. Beaches in those densely urbanized and populated areas are mechanically groomed for human recreational uses and have highly altered wrack-associated biological resources that are notably lacking in beach hoppers (talitrids). This is largely because the wrack is removed in the beach grooming process. So, selecting distant sites that are so biologically different from the Gaviota Coast beaches, would not have provided useful reference sites. The injury was clear to the Trustees, upon examination of these data, especially at the three sites where we had pre-spill data on beach hopper abundance. We decided that there was limited technical benefit to pursuing reference data at much more distant beaches from the primary impacts that occurred on the Gaviota Coast. It is not clear to the Trustees that comparing to the beach hoppers at that site would have increased the injury, and there were notable non-oil related impacts that needed to be factored in as well.

SH Comment 4: The commenter states that shoreline restoration projects are appropriate and they particularly support Ellwood seawall removal and dune projects. They recommend cessation of beach grooming near dune restoration sites as a no cost project component.
Response: The Trustees appreciate the support of the shoreline projects. Cessation of beach grooming has been added as a second-tier project. However, cessation of beach grooming is not a zero cost alternative. Implementing the project would take time and effort to plan, changing management practices, and addressing public comments and input. In addition, few managed beach areas are likely to stop mechanical grooming without addressing issues associated with changes in those practices (analysis of the impacts from changes, public process, management plans, permitting, trash mitigation, liability issues, etc.).
SH Comment 5: The commenter is supportive of Black Abalone Restoration and Relocation Project, but does not think it's a priority without additional justification since the project is too experimental.
Response: The Trustees appreciate the support for the black abalone restoration project. This project is specifically designed to compensate for impacts to rocky intertidal habitat within the spill zone. Black abalone restoration has been identified by experts in the field of intertidal ecology to be a feasible mechanism for enhancing ecosystem function of rocky intertidal habitats. While Black abalone translocation is not commonplace, it has been largely successful in small trials near the spill zone. In addition, the implementers bring a wealth of knowledge and experience gained from these trials and over 20 years of assessing black abalone populations in California and Mexico. Because this project has shown success in trials undertaken by the project implementers, provides direct benefits to rocky intertidal habitats, and is important to the recovery of an endangered species, the project remains the Trustees' preferred alternative.

Subtidal and Fish Habitats:

SF Comment 1: Fish and invertebrate mortality observations lacked survey design and consistency.
Response: The Trustees appreciate this comment and agree. This is why we did not rely on mortality observations for quantification of injury.

SF Comment 2: The commenter agrees with the use of Grunion as an indicator species, but the assessment lacks an analysis of loss of recruitment beyond hatching.
Response: The Trustees agree that we did not analyze the loss of recruitment as a follow-on to hatching success. The scope and breadth of NRDA studies vary depending on the type of oil spilled, the duration of the spill and the ecosystems and species affected. The Trustees do not attempt to assess and quantify injuries for every resource group for every spill to make separate claims. Instead, restoration projects are selected that can have multiple benefits. In the case of grunion, the improvements to sand beach habitat, particularly with the removal of the Ellwood seawall is expected to open up spawning habitat for grunion.

SF Comment 3: The commenter is concerned that surfgrass and algae surveys were only conducted in Zone B.
Response: Large areas of surfgrass and algae are only present where rocky bottoms are present, and most of this coast is sandy bottom, so there are limited areas available for selection. Surfgrass and algae sample surveys were performed where oil was observed and in selected reference areas. Exposure zones were drawn after sampling was completed and were selected on the basis of relative oiling levels on the shoreline.

SF Comment 4: The Southern California Distinct Population Segment (DPS) of steelhead (Gaviota to Los Angeles County) were probably affected by the spill (both directly and indirectly). Their inclusion in the DARP/EA should be reconsidered.
Response: The Trustees examined the coastal lagoons of the Gaviota Coast (the most impacted area) in the week or two following the spill. None of the lagoons were oiled, and either the Unified Command had placed protective booms to protect those areas or they or were closed off to ocean access at the time. Therefore, the Trustees did not further assess the coastal lagoons or uplands. We agree that there may have been a potential route of exposure to steelhead, but quantification of offshore injuries within the broad area used by steelhead in the timeframe that Refugio oil was present in the environment was not possible. It is possible that steelhead could have encountered oil from the spill, but there was no evidence of mortality.

SF Comment 5: The commenter requests assistance with the series of barriers to steelhead migration in Gaviota Creek.
Response: The Trustees agree that watershed-wide restoration of Gaviota Creek, including the removal of steelhead migration barriers is an important project that would benefit multiple resources. The removal of steelhead barriers is focused on one species that was not documented to be injured by the spill, therefore it did not rise to the level of a "preferred" project. Furthermore, the commencement of watershed-wide restoration is contingent on the relocation of the access road to Gaviota State Beach and Hollister Ranch, and removal of the current road that comprises a substantial impediment in the watershed. The scale of this project exceeds the resources that could be provided through NRDA settlement funds; however, the Trustees have included this as a second-tier project.

SF Comment 6: The commenter is concerned about impacts on donor sites for the Red Abalone Restoration Project.
Response: The Trustees will work closely with the CDFW Marine Region, along with other experts in the field of abalone biology, to assess potential donor sites. If reasonable donor sites do not meet criteria established by CDFW, the project will be limited to outplanting cultured juvenile abalone. This will result in fewer immediate benefits of establishing adult abalone on the restoration site, but the long-term success of the project will be similar with or without the translocation.

SF Comment 7: The commenter requested that the Trustees explore other opportunities for kelp restoration in the location that kelp was injured.
Response: The Trustees will consult with a variety of kelp forest scientists and restoration professionals to determine if there are additional options for kelp forest restoration in the region affected by the spill.

SF Comment 8: The commenter is concerned with funding for the Sand-Dwelling Kelp Restoration Project and requests information on why additional funding is needed. The commenter also recommends investigating rocky reef kelp restoration projects in Zones A, C, and D.
Response: The sand dwelling kelp project is a pilot project that has shown promise, but requires additional monitoring and permitting to evaluate the viability of the project. Funding for this project is currently limited to a feasibility assessment via monitoring and permit acquisition. We will consider other locations as we develop the project for kelp restoration if determined to be feasible and warranted. We are not considering adding restoration projects that involve the construction of reef habitat.

SF Comment 9: The commenter is supportive of the Goleta Bay sand-dwelling kelp restoration project and would like to be funded to implement the project.
Response: The Trustees thank you for your comment. We will be evaluating potential project implementers through a competitive process.

SF Comment 10: The commenter is supportive of developing a Marine Protected Area (MPA) Management and Stewardship Program as a possible alternate restoration project. They propose that this project could include cleanup of marine debris within MPAs, removal of invasive kelps, and education and outreach to promote awareness, compliance, and stewardship of MPAs.
Response: The MPAs in the spill region are already managed as a statewide network through an established MPA Management Program. Therefore, the Trustees do not see a need to develop a separate MPA Management and Stewardship program. The MPA Management Program is a collaboration between the California Department of Fish and Wildlife, the Ocean Protection Council, the Fish and Game Commission, and the MPA Statewide Leadership Team. This partnership-based approach ensures MPAs are adaptively managed and informed by engaged partnerships. CDFW is the lead managing agency and enforces regulations set by the Fish and Game Commission. The Ocean Protection Council is the policy lead for the MPAs and implementation of MPA activities. The MPA Statewide Leadership Team ensures communication and collaboration among entities having significant authority, mandates, or interests that relate to California's MPA network. The Leadership Team includes numerous state and federal agencies with jurisdiction or management interests. It also includes four Tribal Representative seats as well as key partners outside of government, including nonprofits, members of the fishing community, tribal representatives, local governments, scientists and others. The MPA Leadership Team has developed "The California Collaborative Approach: Marine

Protected Area Partnership Plan" and a Work Plan to guide the partnership-based MPA Management Program. Several project proponents hope to target MPAs for restoration that will significantly enhance ecosystem function in the reserves and provide for significant monitoring inside and outside the reserves.

Birds:

B Comment 1: The commenter questioned if oil spill effects on fish prey species of the federally endangered nesting California least tern were assessed.
Response: The assessment of subtidal and fish habitat presented in Section 5.2 analyzed effects on fish from the oil spill. The data collected through this assessment suggest that the area of greatest injury was closest to the release location, in Zone B. Although specific studies weren't conducted that focused on California least tern prey species, it is likely that fish such as northern anchovy and young rockfishes were impacted by the spill, particularly in Zone B. California least terns forage for prey close to their nesting colonies and fly further from nesting grounds when prey is scarce. No nesting colonies occur within Zone B. Nesting colonies do occur within Zone D; however, this area was primarily affected by sporadic tarballs that do not pose a substantial risk to California least tern prey species.

B Comment 2: The commenter expressed concerns with the timing of data collection on bird impacts. The draft restoration plan provides the dates of May 20 – June 24 for collection of dead birds. Other sections of the draft plan state that impacts were seen for many months post-spill. The commenter is also concerned that impacts were missed for brown pelicans because breeding sites were not assessed until September. The commenter states that these potential missed impacts need to be added to the injury analysis.
Response: Surveillance and reporting of injured and dead birds along the coastline were conducted throughout the spill response between May 20, 2015 and June 24, 2015, and transitioned to surveillance through existing stranding networks from June 25, 2015, and beyond. The Trustees continued to monitor reports of dead birds beyond June 25, 2015, to determine if there were indications of additional animals affected by the oil spill. Ultimately, we determined that the period of May 20, 2015, to June 24, 2015, was the appropriate time period to determine the number of spill-affected birds that should be considered for the beached bird model. This model extrapolates the number of birds missed from parameters relevant to the number of birds found during the response period. Regarding our assessment of brown pelican breeding sites. Initial surveys were conducted at Anacapa Island breeding colonies starting on June 4. Surveys were conducted by boat, per standard protocols, and no oiled pelicans were observed. On-island surveys were conducted in September 2015 to search for dead oiled pelicans that may have been missed by earlier visual inspections. These surveys did not yield evidence that breeding activities at the Channel Islands were impacted by the oil spill.

B Comment 3: The commenter does not support the rehabilitation credit given to birds that were collected alive and rehabilitated and released. The birds should be included in the injury analysis as they experienced injury, and resources were used to rehabilitate them.
Response: All birds that were captured live or collected dead during the response period were considered in the analysis of injury. Birds that were rehabilitated and released were not removed from the analysis; rather, we ran the Beached Bird Model with all birds collected to understand the total number of birds affected by the spill. Based on the results of post-rehabilitation survival studies, we then provided "rehabilitation credit" that considered a likely survival rate of the birds that were rehabilitated (i.e., birds that were rehabilitated and released are not likely to have the same life expectancy as unaffected birds, and this is accounted for through a proportional rehabilitation credit). As noted in the comment, resources were used to rehabilitate birds that were injured by the spill. In the Natural Resource Damage Assessment framework, bird rehabilitation efforts are considered to be

"primary restoration" or efforts that directly reduce the impacts of the oil spill. The restoration outlined in the DARP/EA is compensatory restoration that makes the public whole for injury that occurred from the spill that could not be avoided or reduced through primary restoration. It would not be appropriate to completely discount the efforts of bird rehabilitation by providing no credit for birds that were rehabilitated.

B Comment 4: The commenter expressed concerns with the western snowy plover impact analysis. They do not support capturing impacts to western snowy plover populations in Ventura County as part of the shoreline habitat injury assessment (Draft DARP/EA page 118). The shoreline assessment only examined acres and time to recovery, a different metric than is used for birds in terms of impacts from death and breeding. The commenter requests more information about how this was conducted if the impacts will be included in the shoreline assessment.

Response: As part of the bird injury assessment, monitoring data from all western snowy plover breeding areas were analyzed for evidence of injury due to oil exposure or cleanup activities. There was no observed mortality of western snowy plovers due to the spill. No evidence of injury was found at any western snowy plover breeding sites, except for the breeding area at Coal Oil Point Reserve, where oiled plovers were observed in 2015 and an increase in egg infertility was identified in 2016. The Trustees conducted a screening level risk assessment and determined that it was plausible for the level of oil exposure to western snowy plovers at Coal Oil Point Reserve to have caused reproductive harm to birds attempting to breed the following year. Due to its close proximity to the spill origin, Coal Oil Point received far greater levels of oiling than any other beach that supports western snowy plover breeding, which are at least 36 miles straight-line distance downcoast. While many plovers at Coal Oil Point were documented to have oil on their bodies or beaks in 2015, only one plover at a Ventura County beach was observed to be lightly oiled. The low level of oiling at breeding sites and the extremely limited observations of oil exposure to western snowy plovers at these sites supports the conclusion that direct injury to western snowy plovers through mortality or reproductive injury other than at Coal Oil Point is unlikely.

The Trustees acknowledge that cleanup activities on beaches that support western snowy plover breeding likely caused a decrease in wrack that supports prey species for western snowy plovers. This impact of cleanup activities, including wrack removal on the sandy beach environment, is quantified through the shoreline habitat assessment. Quantifying the impacts to plover prey species at Ventura County beaches separately from the shoreline injury quantification would represent double-counting of the injury since many of the restoration projects proposed to restore the sandy beach environment also provide benefits to western snowy plovers.

B Comment 5: The commenters are concerned with the lack of long-term analysis. Coal Oil Point Reserve was the only location examined a year after the spill for impacts on Western Snowy Plover breeding. The commenter states that other breeding sites should have been examined as well and that all 10 infertile eggs at Coal Oil Point Reserve in 2016 should count as injuries, not just four.

Response: Each western snowy plover breeding location within the spill area is monitored annually. Monitoring data in the years after the spill provided no indication of lasting plover injury due to the spill, other than the reproductive injury to birds at Coal Oil Point in 2016. We acknowledge the commenters preference for a precautionary approach to quantifying injury, but it is inappropriate to ignore the biological baseline data of fledgling rates at Coal Oil Point when calculating injury.

B Comment 6: The commenter has concerns with the justification for the Brown Pelican Colony Protection at Anacapa Island. The commenter wants to know how close the Cape ivy is now to pelican breeding sites and what the impacts are on pelicans. The commenter says that it needs to be shown that this project will have a positive impact and doing nothing will have negative impacts on pelicans. They are concerned with the use of herbicide being applied by helicopter and recommend only hand application to ensure that impacts are limited to non-target species. They also want to know what happens if the Cape ivy is not gone or controlled after six years.
Response: Cape ivy is an invasive plant that originated from South Africa and was introduced to the United States in the late 1800s. The plant grows tenaciously in wetlands and streams, smothering native plants and often dominating the understory. The current infestation that is proposed for treatment is relatively small and is located in Summit Canyon, along the canyon's bluffs and near the canyon mouth. If left untreated, Cape ivy will expand and dominate the canyon that currently supports a high density of brown pelican breeding activity. This project will protect the integrity of the breeding habitat by preventing the spread of Cape ivy by eradicating the source population, thereby removing this threat to brown pelican breeding habitat. Treatment will occur outside of the breeding window for pelicans. No aerial application is proposed for treatment of the Cape ivy. The herbicide application will be done by hand. Due to rugged access up west Anacapa, helicopter operations were included in order to move materials (water, supplies etc.) and facilitate support for ground crews to spray by hand with backpack sprayers. The infestation should be eradicated within the proposed project timeframe of approximately 6 years. The scope includes follow-up treatment which is advisable given the nature and biology of the plant and literature regarding eradication timelines. The project will eradicate Cape ivy from the canyon. Monitoring and re-treatment will be conducted until this goal is met.

B Comment 7: The commenter is concerned with the lack of detailed information for specific techniques and quantitative goals in the western snowy plover management at Coal Oil Point Reserve. They state that this project does not take into account possible impacts at other locations.
Response: As discussed in previous comments, the Trustees did not find evidence of injuries at other snowy plover breeding areas. Management actions will be adapted to the needs of the population at the time the project is implemented and may include predator control, upgraded signage and fences, outreach to reduce disturbances, leashes to lend for pets, and eradication of iceplant in areas of nesting habitat on Ellwood Beach. The effectiveness of the management will be determined through monitoring of the plover population, nesting rate, fledgling success, and threats from humans and predators.

B Comment 8: The commenter raised questions of how the beach bird model was applied to determine injury in this case. The commenter stated that the Bird Beach Model should have examined all five criteria of why birds might not be collected for all species of birds. They suggested that the Bird Beach Model should be applied to all impacted birds, even non-native and domestic birds as well as rehabilitated birds, so that impacts are not being underestimated for the bird injury and damage assessment.
Response: The DARP/EA lists five reasons why birds might not be collected by response teams and states that for non- pelican species reasons one and two, travel outside of response area and death at sea/sinking respectively, were difficult to assess. The Beach Bird Model incorporates the remaining three reasons and applies correction factors. For non-pelican species, it was difficult to determine an appropriate correction factor for birds traveling outside of the response area following oiling. The

Trustees believe that loons and other non-pelican species migrating north were more likely to have been acutely debilitated following oiling, limiting their ability to disburse, therefore a correction factor was not applied. Similarly, because the spill occurred near shore, the Trustees do not believe that a substantial number of oiled birds were lost at sea. Therefore the Trustees did not feel that it was necessary to apply a correction factor for birds lost at sea. The Beached Bird Model did not include two domestic ducks and one rock pigeon that were recovered because domesticated species are not protected by natural resource authorities of any of the Trustee Agencies. The beached bird model did include all impacted wild birds, including rehabilitated birds. The Footnote in Table 11 of the Draft DARP/EA was revised to clarify that the Beached Bird Model did consider birds collected live in order to extrapolate the total number of birds that were injured by the spill based on the total number that were collected. Rehabilitation credit was provided for birds that were later released, but only after those affected birds were considered in the model. This means that a multiplier developed through the beached bird model was applied to all impacted wild birds, including rehabilitated birds, to extrapolate the total number of birds injured by the spill. After the beached bird model analysis was complete, rehabilitation credit was applied for the birds that were successfully rehabilitated and released.

B Comment 9: The commenter requests that the Trustees reconsider their assessment of potential impacts to Scripps's murrelet and provide documentation if a detailed assessment occurred.

Response: The Trustees agree that there may have been a potential route of exposure to alcids, but quantification of offshore injuries within the broad area used by alcids in the timeframe that Refugio oil was present in the environment was not possible. We therefore analyzed the species that were oiled and captured live, or collected dead during thorough beach searches. A Beached Bird Model was used to extrapolate how many birds were missed, based on the birds that were found. We have updated the text of Section 2.3 of the Final DARP/EA to remove Scripps's murrelets from the list of species that were not impacted. It is possible that Scripps's murrelets could have encountered oil from the spill, but there was no evidence of mortality.

B Comment 10: The commenter states that the Trustees should consider that the three preferred bird restoration projects will not likely result in restoration of murrelets or other alcid species. The commenter also states that Trustees should consider that many of the Trustee agencies on the Refugio Beach Oil Spill Trustee Council have supported restoration projects at Anacapa and Santa Barbara islands to restore Scripps's murrelet populations, and there are several restoration projects for alcids that are ready to be implemented.

Proposed projects that would benefit Scripps's murrelets and/or Cassin's auklet:

- Artificial nest habitat creation at Anacapa, Santa Barbara, or San Clemente Island
- Restore and increase artificial nest habitat at San Miguel Island
- Restore native habitat at Anacapa Island.

Response: The Trustees thank you for identifying these potential projects. While it is possible that Scripp's murrelets and other alcids were injured by the spill, there was no evidence of mortality and the damages were not quantified. Because the projects have an unknown nexus to injury, we will add them to our list of second-tier projects.

B Comment 11: The commenter recommended consulting with the Fish Contamination Education Collaborative for effective ways to target the angling community as part of the project to prevent injury to seabirds from recreational fishing.

Response: The Trustees thank you for this comment. We will keep this comment in mind during the implementation of the DARP/EA.

Marine Mammals:

MM Comment 1: The commenter was concerned that stranding data was only collected for Ventura and Santa Barbara Counties, but not Los Angeles County.
Response: Stranding data are collected for all counties by the Marine Mammal Stranding network member agencies and organizations on an ongoing basis. The Trustees only used stranding data for the mainland Ventura and Santa Barbara Counties for our injury quantification for marine mammals. While this may have left out some animals that ranged further afield, we also included animals that may have entered the area and stranded for reasons unrelated to oiling. Further, the surrounding counties did not have elevated strandings following the spill, so we would not have been able to detect a change above baseline. Regarding the selection of end dates, the wildlife response ended in late June after no animals were found oiled with oil matching Line 901. The Trustees extended our consideration for two weeks after the end of the wildlife response. There were no elevated strandings above baseline after the first week of July.

MM Comment 2: The commenter stated that the marine mammal injury and damage assessment does not contain analysis on toxicity or nonlethal impacts.
Response: Although large oil spills such as Exxon Valdez and the Deepwater Horizon pursued longer term studies and found sublethal and longer-term effects to marine mammals, the Trustees did not think that level of effort was warranted for this spill, nor is it required under the Oil Pollution Act. The Trustees generally want to get to restoration expeditiously. Focusing on acute injury allows us to do that. Pursuing toxicity studies on mammals require multiple years of data collection to detect any potential change. In addition, identifying spill-related injuries would be complicated by the ongoing low-level exposure to natural oil seeps, and other environmental factors such as reduced prey availability or algal blooms. The restoration projects selected as part of this more acute mortality assessment will improve marine mammal health and survivorship beginning in the first year of funding.

MM Comment 3: The commenter believes that the assessment was too conservative. As an example, whales were not assessed.
Response: The Trustees agree that gray whales may have been exposed to Line 901 oil. However, the Trustees are obligated to base our claims on injuries, not just exposure. The Trustees did not collect any data indicating that whales were injured by the spill. For example, there were no records indicating that whales stranded following the spill. Regardless, the Cetacean Entanglement Response project will benefit all cetaceans including large whales, such as gray whales.

MM Comment 4: The commenter believes that the marine mammal lost at sea factor was inappropriately used. The commenter wants the Trustees to apply the same factor for pinnipeds that was used for dolphins.
Response: The "lost at sea" factor is discussed in Appendix J of the Draft DARP/EA. It is based on a bottlenose dolphin study which included a significant amount of data from the southern California Bight. There are no equivalent studies for long-beaked common dolphin or for pinnipeds in the area, which is why the Trustees primarily relied on the Caretta study. The Trustees applied a lower "lost at sea" factor to pinnipeds in the area (half the cetacean "lost at sea" factor) based on the opinion of marine mammal experts that dying pinnipeds would be more likely to come to shore. The Trustees

believe it was appropriate to rely on marine mammal experts to determine which “lost at sea” factor to apply.

Human Uses:

HU Comment 1: Commenter would like natural steps created down to the beach after the existing steps end, at Camino Majorca/Del Playa in Isla Vista in order to reduce erosion. The commenter also would like bike racks at Coal Oil Point.
Response: The Trustees plan to solicit recreational-use project proposals via the South Coast Shoreline Parks and Outdoor Recreation Grants Program as detailed in the DARP/EA. Under this program, the Refugio Beach Oil Spill Trustees, through the National Fish and Wildlife Foundation, would solicit human recreational project grant proposals. At this time, the Final DARP/EA only identifies wildlife and habitat-related projects being considered by the Trustees.

HU Comment 2: A commenter expressed concerns that post-spill data from one year after the spill was used to serve as baseline data for Human Uses. They are concerned because spill impacts could have still been occurring and stated that appropriate reference sites outside of the spill area need to be used if appropriate and adequate pre-spill data are not available.
Response: "Baseline data" for human uses were primarily applied in two manners. The first was as an input to quantify percentage reductions in use due to the spill. This involved comparing indicators of human use collected during the spill (e.g., car counts, user counts) to predictions of those indicators had the spill not occurred (i.e., baseline). The second was to build estimates of total use for sections of shoreline. This involved deriving an absolute estimate of the potentially affected use in an area (e.g., in "user days"). In most cases, total lost use was calculated by combining these two elements: percentage reduction in use multiplied by total baseline use. For most of the assessment area, the site-specific baseline data used to quantify the percentage reduction in use due to the spill were collected prior to the spill (see Sections 3.1 and 3.3 of Appendix M; Section 3.1 of Appendix L). For Goleta Beach and Arroyo Burro Beach County Parks, as well as a few sites around Coal Oil Point, pre-spill data were not available, so 2016 "baseline" data were used to estimate spill impacts in 2015. The resulting estimates (i.e., percentage decline in use) are consistent with adjacent sites where pre-spill data were used. Further, the site-specific models used to estimate percentage reductions in use indicated that spill impacts had likely subsided by the late summer/early fall of 2015, though it is possible that low level impacts continued to persist at the limited sites where post-spill data were used to estimate spill impacts. For most of the assessment area, estimates of the absolute levels of baseline use were derived from pre-spill site-specific data or from the South Coast Marine Protected Area (MPA) Baseline Program, which conducted its surveys in 2012-2013. Data collected in 2016 at Refugio and El Capitan State Beaches and the adjacent pocket beaches provided "relative use" information that was used to supplement the model predictions of baseline use that relied on pre-spill data (see Sections 3.1 and 3.4 of Appendix L). For example, baseline use at the pocket beaches (i.e., Tajiguas, Venadito, and Las Flores Beaches) was calculated by estimating the ratio of pocket beach visitation to day use at Refugio and El Capitan State Beaches in 2016 and applying the ratio to predicted baseline use in 2015 using the pre-spill data. For Goleta Beach and Arroyo Burro Beach County Parks, baseline use was estimated using 2016 data. Had baseline use been estimated using the MPA Baseline Program information, which was collected prior to the spill, the estimates would have been similar. When annual trip estimates derived from the MPA Baseline survey were compared to annual onsite trip estimates derived using information collected in the 2016 surveys at Goleta Beach and Arroyo Burro Beach County Parks, the aggregate

difference in estimated trips was approximately 10 percent (with estimates derived using the 2016 data being slightly higher).

HU Comment 3: The commenter questions why $3.9 million was collected for compensation when there was $4.5 million in estimated lost value?
Response: The Trustees will recover about 87% of the lost use damages they estimated through the settlement process. However, the Trustees believe the amount recovered through the settlement is adequate based on the following considerations: the amount is within the range of values the Trustees deem plausible given the uncertainties in some of the data and the Trustees' burden of proof; the Trustees' desire to reach a settlement and commence restoration more quickly; and the inherent risks involved in litigation if a settlement was not reached.

HU Comment 4: The commenter wants to know how the $3.9 million allocation for Recreational Restoration Projects can be increased to provide more robust compensation of the loss of recreational uses directly on the Gaviota Coast. They state that the funds are misdirected.
Response: The Settlement amount is fixed. Most of the $3.9 million recovered for lost use will be spent on human-use related projects along the Gaviota Coast, based on the distribution of assessed impacts and corresponding estimates of lost value. Approximately 61.32% of the human use settlement amount is targeted for restoration along the Gaviota Coast. The remaining 38.68% of the human use settlement amount is targeted for recreation projects down coast from Coal Oil Point, across a much longer stretch of affected coastline. If more restoration funds are directed to the Gaviota Coast, less will be available for use elsewhere. State Parks will administer 53.4% of the funds allocated for human-use related projects to compensate for recreational losses up coast from and including El Capitan State Beach, where the bulk of the loss was attributable to human use impacts at Gaviota State Park, Refugio State Beach and El Capitan State Beach (State Parks properties). The University of California Natural Reserve will administer 0.67% of the human use funds, to benefit the research, education, and outreach missions of the University of California at Coal Oil Point Reserve. The State Trustees will oversee the remaining 46% of the human use funds to be allocated through a competitive grants program administered by the National Fish and Wildlife Foundation (NFWF). The grant program will fund projects to compensate for recreational losses suffered down coast of El Capitan. Approximately 16% of these funds will be targeted to fund projects between El Capitan and Coal Oil Point. After the Final DARP/EA is released, NFWF will solicit project ideas through a "Request for Proposals" (RFP) process. Grants will be awarded for projects that enhance the recreational use and enjoyment of fishing, boating, other water-based, and other shoreline recreation from southern Santa Barbara County (Goleta) to Los Angeles County (Long Beach). Local and regional park districts, and non-governmental organizations will be invited to apply. The Trustees encourage nonprofits, local agencies and park districts to submit grant proposals.

HU Comment 5: Several commenters stated that the funds for the recreation restoration projects are inadequate.
Response: The Trustees believe the amount recovered through the settlement is equitable and will compensate the public for the loss of use resulting from the spill. This belief is based on the following considerations:

- The amount is within a range of values the Trustees deem possible given the uncertainties in some of the data we collected;
- It can be difficult to assess human use baseline on affected shorelines for specific ranges of dates, i.e., what the human use would have been had the spill not occurred; and
- It is difficult to assess small declines in use following a spill, and many of the beaches that remained open had relatively small percentage reductions in beach use.

Additionally, the Trustees' were willing to accept a modest reduction (less than 13%) to reach a settlement and commence restoration more quickly. There are inherent risks involved in litigation if a settlement was not reached. Basically, there is no guarantee that we would get the full $4.47 million if we litigated and there would be a significant delay and cost involved.

HU Comment 6: The commenter is concerned that human-use damages are weighed more heavily than other damages in the DARP/EA.

Response: Under the Oil Pollution Act and State Law, the Trustees are authorized to pursue damages to pay for restoration to compensate for natural resource injuries and to compensate the public for the loss of use of natural resources resulting from an oil spill. The Trustees follow Oil Pollution Act (OPA) guidance when pursuing oil spill natural resource damages. The magnitude of human use losses were determined independently from restoration costs, and the appropriate compensation estimated for each. In this case, human use loss damages were estimated to be $4.47 million and the Trustees settled the lost human use portion of their claim for $3.9 million.

HU Comment 7: The commenter is concerned that the limited recreation funds are being spent away from Gaviota Coast and is concerned about exclusion of informal public use from the damage assessment.

Response: Most of the $3.9 million will be spent for projects that will benefit human uses along the Gaviota Coast, based on the distribution of assessed impacts and corresponding estimates of lost value. Approximately 61.32% of the human use settlement amount is targeted for restoration along the Gaviota Coast. The 38.68% of the settlement that is targeted for restoration outside the Gaviota Coast covers a much larger area, including shoreline in Ventura County, Los Angeles County, and other sections of Santa Barbara County. If more restoration funds are directed to the Gaviota Coast, less will be available for these other areas.

While the Gaviota Coast was the most heavily impacted region with respect to human uses (both in terms of intensity of impacts and total lost value), the Gaviota Coast is also being allocated the majority of the restoration funds. In general, the Trustees believe that it is important to distribute compensation, to the extent practical, to all the areas that were affected and to the extent those areas were affected. The less affected regions are being allocated less restoration funds. Moving funds away from impacted areas that have been allocated less restoration funds, simply because those areas were "less affected," would be undercompensating those areas. This would not be equitable. In addition, the Trustees did not exclude informal use. Please see the Trustees' response to comment HU Comment 9.

HU Comment 8: The commenter stated that additional funding should be directed to the Gaviota Coast because funding spent on State Parks units along the Gaviota Coast will not benefit local users and/or disadvantaged communities who often avoid accessing through State Parks units because of the access fees.

Response: State Parks will administer 53.4% of the funds allocated for human-use related projects to compensate for recreational losses up coast from, and including, El Capitan State Beach where the vast bulk of the loss was attributable to human use impacts at Gaviota State Park, Refugio State Beach and El Capitan State Beach (State Parks properties).

State Parks do serve disadvantaged communities along the Gaviota Coast and elsewhere. Some specific examples include, but are not limited to, informal recreational access where walk-in and bike-in visitors can access developed day use facilities at Gaviota State Park, Refugio State Beach, and El Capitan State Beach free of any admission charge. In addition, free parking is available in Gaviota State Park at the Beach to Backcountry trailhead and the Las Cruces trailhead. Two dollar ($2.00) parking is also available at the Hot Springs parking lot. When open, Gaviota Pier provides visitors with a place to fish that does not require a sport fishing license. Free parking is available at Bill Wallace trailhead in El Capitan SB. Finally, there are several informal parking areas along Hwy 101 where visitors can park and access Gaviota State Park, Refugio State Beach, and El Capitan State Beach without paying any day use fee.

As a Trustee and protector and preserver of coastal lands and access, State Parks is very interested in maximizing the ability of all communities to access and enjoy the Gaviota Coast. State Parks is open to hearing project ideas but will not conduct a competitive project selection process for implementation on State Park property. Project ideas can be submitted in writing to Refugio Restoration, 2493 Portola Road Suite B, Ventura, CA 93003, or RefugioRestoration@fws.gov.

HU Comment 9: The commenter stated that informal public use of the Gaviota Coast is considerable and are concerned that informal use may have been overlooked if only formal use was counted. They also stated that the majority of informal recreational users are low income and disadvantaged communities, so this exclusion has a disproportional impact on disadvantaged communities.

Response: The commenter is correct that the 76-mile Gaviota Coast from Coal Oil Point in Isla Vista to Point Sal at the northern boundary of Vandenberg Air Force Base provides recreational use opportunities at formal access points (e.g., Gaviota State Park, Refugio State Beach, and El Capitan State Beach) as well as informal access points. The human use assessment addressed informal use along the Gaviota Coast in two ways. First, recreation use data were collected in 2016 at Tajiguas, Venadito, and Las Flores Beaches, which are small, informal pocket beaches adjacent to Refugio and El Capitan State Beaches. These data were used to estimate baseline use at these locations (see Section 3.4 of Appendix L). Second, informal use along other sections of the Gaviota Coast—including between El Capitan State Beach and Haskell's Beach—was covered by the South Coast MPA Baseline Program data (see Section 3.1 of Appendix L), which relied on trip destinations reported by a sample of Southern California residents. Relying on data from sampled residents meant that that the Trustee analysis used a sample of trips to systematically cover informal access points. Since none of the spill areas were excluded from the survey conducted by the MPA Baseline Program, the entire coast can be examined using this dataset. However, as the geographic resolution gets finer and the number of baseline trips gets smaller, fewer trips by the sample of residents are expected within a given section of coast and the proportional variability of the resulting estimate can get large. As a result, the estimates of baseline use across the spill are only reliable over larger areas where sampling errors average out. This is one reason why lost value estimates are provided regionally in the Draft DARP/EA. The Trustees have updated row headers for Tables 23 and 24 in the Final DARP/EA to ensure that it is clear that the loss estimates and restoration targets cover the entire coast. For additional information, please see the Trustees' response to HU Comment 10.

HU Comment 10: The commenter stated that the Shoreline Use Impact Analysis failed to recognize or properly account for impacts to human uses along sections of the Gaviota Coast where informal use occurs, most notably a five mile long stretch between El Capitan State Park and Haskell's Beach. They pointed to Exhibit 2.1 in Appendix L as a demonstration of the omission of this area, which includes areas known by locals as Las Varas Ranch, Dos Pueblos Ranch, Naples (aka Santa Barbara Ranch), Paradiso (aka Seals, Deadman's), and Eagle Canyon (aka Driftwoods).
Response: The Gaviota Coast includes a mixture of formal and informal access points. Site-specific data were compiled for eight sites along the Gaviota Coast between Gaviota State Park and Coal Oil Point for the human use assessment, which are shown in Exhibit 2.1 of Appendix L: Gaviota State Park, Tajiguas Beach, Refugio State Beach, Venadito Beach, Las Flores Beach, El Capitan State Beach, Haskell's Beach, and Sands Beach (including Coal Oil point). Data for the state parks and beaches (Gaviota State Park, Refugio State Beach, and El Capitan State Beach) were available from the California Department of Parks and Recreation. Data at the three pocket beaches (Tajiguas Beach, Venadito Beach, Las Flores Beach) were collected through a targeted data collection effort in 2016. Data at Haskell's Beach and Sands Beach were collected through targeted data collection efforts in late May and early June 2015 and 2016. Further, data for Sands Beach (including Coal Oil Point) were available for years prior to the spill from the University of California–Santa Barbara. Exhibit 2.1 in Appendix L is titled "Selected Shoreline Use Locations…" because it does not include all access points in Santa Barbara County, including along the Gaviota Coast. However, all access points were included in the assessment and no part of the Gaviota Coast was ignored in the assessment. Informal use along the Gaviota Coast—including between El Capitan State Beach and Haskell's Beach—was covered by the South Coast MPA Baseline Program data (see Section 3.1 of Appendix L) which relied on trip destinations reported by a sample of Southern California residents. More broadly, the MPA Baseline data systematically covered use at informal access points throughout the assessment area where comprehensive site-specific data were not available and targeted onsite data collection efforts were impractical. Given that the MPA Baseline data relied on a sample of users, recreation use estimates for small areas of coast have larger errors than for broader areas of coast. The results of the assessment are aggregated across larger sections of coast to reduce this uncertainty (Table 24 of the DARP/EA).

HU Comment 11: The commenter states that settlement funds should be directed to secure the preservation of coastal lands, construct and improve the Coastal Trail, develop culturally-appropriate interpretive programs to honor the Chumash peoples, and memorialize and dedicate the informal pathways that the community uses to access and enjoy the Gaviota Coast.
Response: The Trustees appreciate the suggested projects. Preservation of coastal lands has been added as a second-tier project. Specific human use projects have not been selected for funding yet. The DARP/EA outlines how much and where specific monies should be spent on enhancing human uses along the Santa Barbara, Ventura, and Los Angeles County coastlines. Nevertheless, we welcome public input on potential human use projects to be implemented by State Parks and through the South Coast Shoreline Recreational Use Grants Program as described in the DARP/EA. The South Coast Recreational Use Grants Program, administered by the National Fish and Wildlife Foundation (NFWF), will solicit project ideas through a "Request for Proposals" (RFP) process. Grants will be awarded to projects that enhance the recreational use and enjoyment of fishing, boating, other water-based, and other shoreline recreation from southern Santa Barbara County (Goleta) to Los Angeles County (Long Beach). Local, state, and federal agencies, local and regional park districts, and non-governmental organizations will be invited to apply. The Trustees will also solicit public input

on project concepts considered for funding. Human use projects funded through State Parks will be coordinated with Santa Barbara County Building and Planning officials and other governmental and non-governmental organizations, as appropriate. State Parks will take into consideration the recreational projects identified in Appendix N, and public comments. The public will be provided an additional opportunity to provide input through the environmental planning and permitting process.

It should be noted that many of the informal pathways along the Gaviota Coast within State Parks ownership cannot be formalized because they cross Union Pacific Rail Road tracks at grade where there is no access easement in place. However, consistent with the suggestion by the commenter, State Parks is primarily considering repairs to the coastal trail segment between Refugio State Beach and El Capitan State Beach to compensate for lost human use along the designated portion of the Gaviota Coast. The development and approval of this project will be done through the CEQA public process, in which the commenter as well as other members of the public are welcome to participate.

HU Comment 12: The commenter states that compensation for local non-camping coastal uses on the Gaviota Coast are not addressed in current Tier 1 projects.

Response: The commenter is correct that specific projects to compensate for lost human use are not included in current TIER 1 projects. Instead, the DARP/EA outlines how much and where specific monies should be spent on enhancing human uses along the Santa Barbara, Ventura, and Los Angeles County coastlines and describes how appropriate projects will be identified and selected. State Parks will administer approximately $2.08 Million for projects on State Parks' properties to compensate for recreation losses from Gaviota to El Capitan. State Parks will consider public comments on the DARP/EA as well as input from Santa Barbara County, other local governmental, and non-government organizations prior to selecting projects. The public will have additional opportunities to provide input during the California Environmental Quality Act (CEQA) process following project selection. The State Trustees will administer approximately $1.79 Million through the South Coast Shoreline Parks and Outdoor Recreation Grants Program for projects to compensate for recreation losses that occurred downcoast of El Capitan State Beach. The Trustees plan to solicit grant proposals as detailed in the Restoration Plan. At this time, the Final DARP/EA only identifies wildlife and habitat-related projects being considered by the Trustees.

HU Comment 13: The commenter states that Human Use Projects Gaviota Pier Repair (EX-HU-2) and Refugio and Gaviota Human Impact Mitigation and Protection Program (EX-HU-23) should be Tier 1 projects.

Response: The Trustees appreciate your support for EX-HU-2 and EX-HU-23. Specific human use projects have not been selected for funding yet. Instead, the DARP/EA outlines how much and where specific monies should be spent on enhancing human uses along the Santa Barbara, Ventura, and Los Angeles County coastlines and describes how appropriate projects will be identified and selected. Please see HU Comment 12 for information on how human use projects will be administered. At this time, the Final DARP/EA only identifies wildlife and habitat-related projects being considered by the Trustees.

HU Comment 14: The commenter provided list of projects to be considered under the South Coast Shoreline Parks and Outdoor Recreation Grants Program and requests increased funding allocated to the Grants Program.

Response: The Trustees plan to solicit grant proposals for recreational-use projects via the South Coast Shoreline Parks and Outdoor Recreation Grants Program after the Final DARP/EA is completed.

Santa Barbara County, Ventura County, Los Angeles County, County and City Park Districts, as well as other local public entities and non-profits will be invited to submit grant proposals for shoreline recreational projects downcoast of El Capitan State Beach. Unless there is a conflict-of-interest, the Counties will be provided an opportunity to comment on projects the Trustees consider, following a Request-for-Proposal process to be initiated by the State Trustees. The Trustees are constrained in the amount of funding available to the Grants Program as detailed in the plan.

HU Comment 15: The commenter suggests the Trustees need to compensate local users that are geographically close to the spill location and were the most impacted.

Response: The Trustees agree. It is a goal of the Trustees to select projects spanning the geographic extent of the spill and to allocate funds according to the relative magnitude of the spill impacts. The distribution of damages is based upon the estimated distribution of lost value resulting from the spill. Accordingly, 61.32% of the estimated lost value covered in the human use assessment was concentrated on the Gaviota Coast. Accordingly, the human use restoration process targets 61.32% of the restoration funding to the Gaviota Coast. The remaining 38.68% of the damages for lost human use will go for projects along the Ventura and Los Angeles County coasts, and other areas in Santa Barbara County.

HU Comment 16: The commenter requests that the Trustees consider the project "Goleta Beach Park Restoration" (EX-HU-13).

Response: The Trustees have included the project in Appendix N, Table 3 “Human Use Projects – No human use projects considered at this time,” along with the Trustees’ evaluation.

This project was submitted as a human use project. The Trustees plan to solicit grant proposals for recreational-use projects covering the Goleta Beach area via the South Coast Shoreline Parks and Outdoor Recreation Grants Program after the Final DARP/EA is completed. Santa Barbara County, Ventura County, Los Angeles County, County and City Park Districts, as well as other local public entities and non-profits will be invited to submit grant proposals for shoreline recreational projects downcoast of El Capitan State Beach. The Trustees will provide the funding for projects through the South Coast Shoreline Parks and Outdoor Recreation Grants Program as described in the DARP/EA.

Since this project would increase coastal resilience and ecosystem services, the Trustees considered this project for sandy beach restoration. Because the project costs are relatively high compared to other preferred projects for sandy beach restoration, this project has been designated as a second-tier project.

HU Comment 17: The commenter notes that beach advisories south of Coal Oil Point and along Ventura County’s coastline impacted beach use. The commenter indicates this should be clearly stated in the DARP/EA.

Response: The commenter is correct that beach advisories south of Coal Oil Point Reserve in Santa Barbara and Ventura Counties impacted beach use. This information is in the DARP/EA: “Spill impacts on recreation were less severe south of Coal Oil Point Reserve. Although spill-related oiling, advisories, and significant media coverage of the incident occurred, no closures were identified along the remaining sections of the Santa Barbara and Ventura County coastlines.” (p. 143 of the Draft DARP/EA). The locations of the advisories, including those south of Coal Oil Point Reserve, are shown in Figure 37 of the Draft DARP/EA on page 144.

Advisories and closures were documented to provide context for the human use assessment, but advisories were not used to directly estimate spill impacts. Trustees estimated changes in recreation use attributable to the spill, a behavioral response informed by individual perceptions of the spill, advisories and closures, the presence of cleanup crews, media coverage, and other factors. The assessment identified areas of human use impacts using site-specific models of recreation visitation data and the results of these models correlated to areas covered by closures and advisories. However, changes in use specifically due to closures and advisories were not estimated separately because that was not necessary for the assessment.

HU Comment 18: The commenter stated that Point Mugu State Park and Gaviota State Park were not considered for human use projects.

Response: While Point Mugu experienced decreased camping visitation in June and July of 2015 (Appendix K, Exhibit 3-2, pg. 3-3), this was not attributed to the spill. Additionally, while Gaviota State Park experienced decreased camping visitation in July, August, and September of 2015 (Appendix K, Exhibit 3-2, pg. 3-3), this was not attributed to the spill. The reason for this determination is documented in Section 3.2 of Appendix K: "Spill impacts occur when the initial deviation at a site is negative and continues until the first period with a non-negative deviation or until the first full period after Labor Day." Since the initial deviations for Point Mugu in Exhibit 3.2 were not negative, subsequent negative deviations in June and July were not attributed to the spill. Since the initial deviation for Gaviota State Park in Exhibit 3.2 was negative, but the subsequent two deviations in June 2015 were not, subsequent negative deviations in July, August, and September were not attributed to the spill.

The human use assessment used statistical models to predict average visitation in 2015 but for the spill. Since actual visitation could be above or below the predicted mean even without the spill, it was important to have a systematic and consistent decision rule for identifying losses throughout the spill area. This ensured that the analysis was data-driven, and it produced results that were consistent with oiling, closures, advisories, and cleanup activities. This approach resulted in determining that camping spill impacts were limited to Gaviota State Park, Refugio State Beach, and El Capitan State Beach. The determination at Point Mugu was consistent with parks closer to the spill, including Hobson Beach County Park, Rincon Parkway, Faria Beach County Park, and Point Mugu Beach RV Park, where site managers reported that the spill did not have an impact on camping at their sites (Section 3.3 of Appendix K). The same data-driven approach was applied in assessing impacts to shoreline use (Section 3.2 of Appendix L) and identified impacts that were generally greater in magnitude and longer lasting in areas closer to the spill.

HU Comment 19: The commenter stated that there was no attempt to integrate the recreational resource elements from the National Park Service Feasibility Study into the DARP/EA.

Response: The human use assessment considered the NPS Feasibility Study and cited it in Appendices K, L, and M to document that the Gaviota Coast is widely recognized for its scenic beauty and outdoor recreation opportunities by providing extraordinary biological diversity, natural and cultural resources. The Recreational Resources section of the NPS Feasibility Study highlights the publicly-accessible areas included in the human use assessment: "Public access from Gaviota State Park east to Coal Oil Point consists of Gaviota State Park, Refugio State Beach, El Capitan State Beach, Haskell's Beach/Bacara Resort, beach access at Sandpiper Golf Course, and the Coal Oil Point Reserve. Generally, the beaches in this area enjoy greater usage with the milder ocean temperatures and meteorological conditions than the beaches north of Point Conception. On U.S. Highway 101, between Gaviota State Park and Refugio State Beach, there are vehicle pull-off areas from which State beaches may be accessed" (p. 39). The following page of the NPS Feasibility Study (p. 40) states that privately managed recreational areas also provide opportunities for public enjoyment.

All of the access points identified in the NPS Feasibility Study were covered by the human use assessment either by site-specific data (e.g., State Parks day use and camping data) or the South Coast MPA Baseline Program data (see Appendix L Section 3.1 of the DARP/EA), which relied on trip destinations reported by a sample of Southern California residents. The MPA Baseline data systematically covered use at informal access points throughout the assessment area, including along the Gaviota Coast, where comprehensive site-specific data were not available and targeted onsite data collection efforts were impractical due to the number of access points. While the NPS Feasibility Study offers some aggregate estimates of recreation use across state and county parks along the Gaviota Coast (p. 40, 145), the human use assessment instead used more recent disaggregated data for these individual parks, which were more relevant to determine impacts from the spill.

HU Comment 20: The commenter stated that the DARP/EA lacks any reference to the Santa Barbara County Gaviota Coast Plan even though it contains an extensive recreational analysis, including identification of existing and proposed recreational facilities, which would be applicable for documenting baseline conditions and considering restoration projects.

Response: With respect to documenting baseline conditions, Page 4-3 of the Gaviota Coast Plan states: "Dedicated public beach access locations along the entire 39-miles of coastline within the Plan Area are limited to four locations: El Capitan State Beach, Refugio State Beach, Gaviota State Park, and Jalama Beach County Park. The remainder of the coastline from Jalama to Gaviota State Park, and east of El Capitan State Beach is composed of large private land holdings and public access to the beach is currently not allowed except under privately managed access programs."

The human use assessment covered all of the listed dedicated public beach access locations and other informal access points using site-specific data (e.g., State Parks day use and camping data) or the South Coast MPA Baseline Program data (see Appendix L Section 3.1 of the DARP/EA), which relied on trip destinations reported by a sample of Southern California residents. The MPA Baseline data systematically covered use at informal access points throughout the assessment area, including along the Gaviota Coast, where comprehensive site-specific data were not available and targeted onsite data collection efforts were impractical.

With respect to restoration project selection, the Gaviota Coast Plan does have information relevant to the consideration of restoration projects. However, the DARP/EA does not select specific recreation projects related to human use restoration. The DARP/EA outlines how much and where specific monies should be spent on enhancing human uses along the Santa Barbara, Ventura, and Los Angeles County coastlines.

HU Comment 21: The commenter questioned why subsistence fishing was not included in the assessment of injuries to human uses.

Response: Subsistence fishing is an important part of fishing use, particularly on piers. Under the Oil Pollution Act as well as state law, damages for loss of subsistence fishing may be pursued separately as a third party claim by affected claimants. However, those involved in subsistence fishing may also have experienced consumer surplus losses due to the spill, which are recoverable by the Trustees.

These losses were captured by the Trustees' human use assessment. The data that were relied on in the Trustees' human use assessment did not distinguish between subsistence fishing and recreational fishing, and therefore, would have included subsistence fishing and applied an estimated value for consumer surplus loss to those uses.

Site-specific data were used to quantify the percentage reduction in use due to the spill (see Section 3.1 of Appendix L), including data covering piers proximate to the spill (e.g., Goleta County Park and the Santa Barbara Waterfront), as well as others further down the coast. Estimates of baseline use were derived from these site-specific data or the South Coast MPA Baseline Program (see Section 3.1 of Appendix L) to comprehensively cover the affected coastlines of Santa Barbara, Ventura, and Los Angeles Counties. These data sources include a range of users, including subsistence anglers.

HU Comment 22: The commenter offered support in helping Trustees reach out to the community during the Human Use grants program to identify human use restoration projects. They also encouraged multi-lingual outreach materials related to restoration and outreach to reach underrepresented communities. They suggested Trustees could add a requirement for grant proposals to describe how environmental justice and inclusion is taken into consideration in their approach to restoration.

Response: The Trustees appreciate commenter's offer of assistance and the important need to serve underrepresented communities. State Parks will administer approximately $2.08 Million for projects on State Parks' properties to compensate for recreation losses occurring from Gaviota to El Capitan. State Parks' properties currently serve disadvantaged communities along the Gaviota Coast and elsewhere. Some specific examples include but are not limited to informal recreational access where walk-in and bike-in visitors can access developed day use facilities at Gaviota State Park, Refugio State Beach, and El Capitan State Beach free of any admission charge. In addition, free parking is available in Gaviota State Park at the Beach to Backcountry trailhead and the Las Cruces trailhead. Two dollar ($2.00) parking is also available at the Hots Spring parking lot. Gaviota Pier (when open) provides visitors with a place to fish that does not require a sport fishing license. Free parking is available at Bill Wallace trailhead in El Capitan State Beach. Finally, there are several informal parking areas along Hwy 101 where visitors can park and access Gaviota State Park, Refugio State Beach, and El Capitan State Beach without paying any day use fee. State Parks is open to hearing project ideas but will not conduct a competitive project selection process for projects on State Parks' properties. State Parks will consider public comments on the DARP/EA as well as input from Santa Barbara County and other local governmental and non-government organizations prior to selecting projects.

With regard to projects downcoast of El Capitan State Beach, the State Trustees will solicit grant proposals from Counties (Santa Barbara, Ventura, and Los Angeles), County and local Park Districts, as well as other local public entities and non-profits. Grant proposals will not be solicited from individuals or for-profit companies. It is the goal of the Trustees to select a suite of projects spanning the geographic area of the spill that address the types of activities impacted by the spill. In addition to other requirements, the Trustees will request grant proposals to describe whether and to what extent the proposed project will provide recreational benefit to underserved communities affected by the spill.

Multi-resource Topics:

MR Comment 1: The commenter requested additional funding for programs at places like the Santa Barbara Wildlife Care Network that rescue and rehabilitate injured animals, including birds.
Response: The Trustees agree that support for rescue and rehabilitation of injured animals is an important and appropriate restoration measure to compensate for the effects of the oil spill. The projects BIRD-2 and MAMM-1 include funding for these activities.

MR Comment 2: The commenter is supportive of compensation to increase stranded animal rehabilitation but would like to see the establishment of a mammal and/or bird rescue/rehab facility in Ventura County.
Response: The Trustees appreciate the suggestion to focus bird restoration efforts on enhancing rescue and rehabilitation efforts in Ventura County. Rescue and rehabilitation facilities and personnel play an important role in preventing the death of birds that have been affected by fishing injuries and therefore is a valid component of project BIRD-2, Prevention of Injury to Seabirds Related to Recreational Fishing. The DARP/EA has been revised to specifically identify that enhancing the capacity for rescue and rehabilitation of seabirds is considered in the project BIRD-2. Establishing a new Ventura County mammal and/or bird rescue and rehabilitation facility exceeds the resources that could be provided through NRDA settlement funds; however, the Trustees have included this as a second-tier project

MR Comment 3: The commenter expressed concern about elevated erosion along bluffs with removal of the Ellwood Seawall and recommends using artificial reef balls slightly offshore to reduce wave energy.
Response: The Trustees share the concern that erosion and degradation of the seawall leads to unsafe conditions along the beach. However, the Ellwood Seawall was never a bluff seawall. The wall was the landward side of a raised road for historic oil works. The wall is disintegrating, falling apart, and collapsing from waves and the resulting scour. This creates unsafe conditions to beach users and snowy plovers downcoast, and exacerbates natural erosional processes. Even if the Trustees do not fund the project, the ocean will eventually degrade the seawall, plank by plank, until it is gone. At this time the Marine Region of the California Department of Fish and Wildlife does not support projects than introduce “fill” into the marine environment until a state-wide policy for such projects is completed and adopted.

MR Comment 4: The commenter stated that restoration plan needs to provide justification for why the Ellwood Seawall Project is being funded by this and not the entity who installed it.
Response: The entity(s) or companies that installed the road in the early 1900s are longer in existence. Our best information sources indicate that defunct oil production entities constructed the Ellwood Seawall (https://www.cityofgoleta.org/home/showdocument?id=15655). There is no party the Trustees, the city, county, or state can purse for cost recovery related to removing the seawall.

MR Comment 5: The commenter is supportive of the removal of the Matilija Dam as a possible alternate restoration project. They also request the removal of the Rindge Dam in Malibu Creek and other dams upstream to be considered as possible restoration projects.
Response: The Trustees thank you for this comment and will consider support for the Matilija Dam removal project. Based on the criteria for project selection, the Matilija Dam Removal Project is listed as a second-tier shoreline habitat project in the DARP/EA. The removal of Rindge Dam in Malibu Creek

and other dams upstream have also been added as second-tier shoreline habitat projects that may also have benefits to other resource categories.

Summary Revisions included in the Final DARP/EA:

Comment: Request additional justification to provide a link between injuries assessed and proposed restoration projects; provide information on location of projects in terms of zones and injuries assessed for each zone.
Revision: The bird and marine mammal appendices were revised to provide information to demonstrate the link between injuries and projects. Restoration summary maps were added to the Executive Summary.

Comment: DARP/EA must be revised to include performance criteria in order to ensure adequate restoration as required by NRDA regulations.
Revision: Trustees have reviewed the DARP/EA and updated performance criteria as needed in the DARP/EA. However, as specific projects are planned, more specific criteria will be developed.

Comment: The Trustees received multiple references about Chumash culture for inclusion in the DARP/EA.
Revision: The Trustees will incorporate and reference the following materials in the DARP/EA: • Tribal Marine Protected Areas, Protecting Maritime Ways and Cultural Practices. 2004 • Chumash Ecosystem Services Assessment – CINMS Condition Report • Traditional and Local Knowledge, A vision for the Sea Grant Network, 2018.

Comment: The commenter stated that information about oil at the Channel Islands and in the Sanctuary is unclear throughout the DARP/EA.
Revision: The Trustees appreciate this comment. Oil at the Channel Islands is discussed in Section 1.1.2, Figure 4, and Section 2.2.5 in the Draft DARP/EA. The Trustees have made revisions to Sections 1.1.2 and 2.2.5 for clarification.

Comment: The commenter stated that the DARP/EA lacks any reference to the Santa Barbara County Gaviota Coast Plan even though it contains an extensive recreational analysis, including identification of existing and proposed recreational facilities, which would be applicable for documenting baseline conditions and considering restoration projects.
Revision: DARP/EA Section 2.1.2 has been amended to reference the "Gaviota Coast Plan".

Comment: The commenter stated that second-tier restoration projects described as "out of kind" or not appropriate for impact should be removed from the document
Revision: The Trustees reviewed the three second-tier projects that were described as providing benefits that were "out of kind" with the injury caused by the oil spill. In each case, we identified some nexus of the restoration project to the injury, and therefore retained each in the text, but with expanded descriptions to clarify the nexus of the restoration to the injury.

Comment: The commenter states that shoreline restoration projects are appropriate and they particularly support Ellwood seawall removal and dune projects. They recommend cessation of beach grooming near dune restoration sites as a no cost project component.
Revision: Cessation of beach grooming has been added as a second-tier project. There is a need for a project proponent and partnerships that do not currently exist, and the project goal may come into conflict with some management goals of owner/manager entities.

Comment: The commenter requests assistance with the series of barriers to steelhead migration in Gaviota Creek.
Revision: The project has been included in the DARP/EA as a second-tier subtidal project.

Comment: The commenter states that the Trustees should consider that the three preferred bird restoration projects will not likely result in restoration to murrelets or other alcid species. The commenter also states that Trustees should consider that many of the Trustee agencies on the TC have supported restoration projects at Anacapa and Santa Barbara islands to restore Scripps's murrelet populations, and there are several restoration projects for alcids that are ready to be implemented Proposed projects that would benefit Scripps's murrelets and/or Cassin's auklet: • Artificial nest habitat creation at Anacapa, Santa Barbara, or San Clemente Island • Restore and increase artificial nest habitat at San Miguel Island • Restore native habitat at Anacapa Island.
Revision: The Trustees have included these projects in the DARP/EA as second-tier projects

Comment: The commenter requests that the Trustees reconsider their assessment of potential impacts to Scripps's murrelet and to provide documentation if a detailed assessment occurred.
Revision: The Trustees removed statements that Scripps's murrelets were not in the area from Section 2.3.

Comment: The commenter is supportive of compensation to increase stranded animal rehabilitation but would like to see the establishment of a mammal and/or bird rescue/rehab facility in Ventura County.
Revision: The Trustees have amended Section 5.3.6, project BIRD-2, to include expanding bird recovery, transport, and rehabilitation. The Trustees have added establishing a new Ventura County mammal and/or bird rescue and rehabilitation facility as a second-tier project.

Comment: The commenter stated that informal public use of the Gaviota Coast is considerable and are concerned that informal use may have been overlooked if only formal use was counted. They also stated that the majority of informal recreational users are low income and disadvantaged communities, so this exclusion has a disproportional impact on disadvantaged communities.
Revision: The row headings in Tables 23 and 24 were revised to reflect that there were no gaps in coastline coverage. Specifically, where Table 23 stated "Haskells to Ellwood", it was changed to "El Capitan to Ellwood". Where Table 24 stated "Haskells to Coal Oil Point", it was changed to "El Capitan to Coal Oil Point".

Comment: The commenter states that settlement funds should be directed to secure the preservation of coastal lands, construct and improve the Coastal Trail, develop culturally-appropriate interpretive programs to honor the Chumash peoples, and memorialize and dedicate the informal pathways that the community uses to access and enjoy the Gaviota Coast.
Revision: The Trustees have included these additional human-use projects in Table 3 in Appendix N.

Comment: The commenter is supportive of the removal of the Matilija Dam as a possible alternate restoration project. They also request the removal of the Rindge Dam in Malibu Creek and other dams upstream to be considered as possible restoration projects.

Revision: The Matilija Dam Removal Project will remain a second-tier project. Removal of Rindge Dam and other dams further upstream have been included in the DARP/EA as second-tier projects.