Cosco Busan Oil Spill

Draft
Damage Assessment and Restoration Plan/
Environmental Assessment

for public review and comment

September 19, 2011

Prepared by:
California Department of Fish and Game
California State Lands Commission
National Oceanic and Atmospheric Administration
United States Fish and Wildlife Service
National Park Service
Bureau of Land Management

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DRAFT

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FACT SHEET

Draft Damage Assessment and Restoration Plan / Environmental Assessment for the *Cosco Busan* Oil Spill

Trustee Agencies: California Department of Fish and Game, California State Lands Commission, National Oceanic and Atmospheric Administration, United States Fish and Wildlife Service, National Park Service, Bureau of Land Management.

Abstract: The Natural Resource Trustee Agencies (Trustees) present a description and quantification of the injuries as well as a proposal for restoration actions to compensate for the impacts of the *Cosco Busan* Oil Spill that occurred in San Francisco Bay on November 7, 2007. The spill affected wildlife (primarily birds and fish), habitat (primarily rocky intertidal, salt marsh, flats, sandy beach, and eelgrass beds), and human recreational activities. The Trustees have proposed 12 restoration projects to restore and compensate for the injured resources and created a process that is intended to identify numerous recreational use improvements. The projects are:

- Creation of grebe nesting habitat at Tule Lake National Wildlife Refuge;
- Creation of over-wintering duck and grebe habitat at the South Bay Salt Ponds;
- Creation of nesting and roosting habitat for cormorants, pelicans, and shorebirds at the Berkeley Pier;
- Creation of nesting habitat for seabirds at the Farallon Islands;
- Creation of a grant project to benefit Surf Scoters;
- Restoration of Marbled Murrelet nesting habitat through corvid management at Humboldt Redwoods and Grizzly Creek State Parks;
- Restoration of eelgrass at several sites inside the Bay, to benefit both eelgrass and herring;
- Restoration of sandy beach habitats at Muir Beach and Albany Beach;
- Restoration of salt marsh and mudflat habitats at Aramburu Island;
- Restoration of native oysters and rockweed at several sites inside the Bay, to benefit rocky intertidal communities;
- Creation of a process to fund a wide variety of human recreational use projects at impacted sites across the spill zone.

The Trustees also present their environmental assessment of the proposed projects under the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA).

Contact Person: Steve Hampton
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Copies: Copies of the Damage Assessment and Restoration Plan/Environment Assessment are available from Steve Hampton at the above address. Copies are also available online at http://www.dfg.ca.gov/ospr/Science/cosco_busan_spill.aspx

Public Meeting: The Trustees will hold two public meetings on October 19: 12 noon in the First Floor Auditorium in the Elihu M. Harris State Building, 1515 Clay Street, Oakland and 7pm at the Mill Valley Community Center, 180 El Camino Alto, Mill Valley. At these meetings, the Trustees will present a brief overview of the restoration plan and accept public comment.

Public Comments: Public comments may also be submitted to Steve Hampton (see contact above).

Executive Summary

On November 7, 2007, the freighter *Cosco Busan* struck the Bay Bridge as it attempted to depart San Francisco Bay. The accident created a gash in the hull of the vessel, causing it to spill approximately 58,000 gallons of oil into the Bay. Wind and currents took some of the oil outside of the Bay, where it impacted the outer coast from approximately Half Moon Bay to Point Reyes. Inside the Bay, the oil primarily impacted waters and shoreline within the central portion of the Bay, from Tiburon to San Francisco on the west side and from Richmond to Alameda on the east side.

The responsible parties are Regal Stone Limited, the owner of the vessel, Fleet Management Limited, the operator of the vessel, and John Cota, the pilot of the vessel.

The spill precipitated widespread beach closures, fishery closures (both commercial and recreational), and the cancellation of many activities associated with boating or use of the Bay waters. A large-scale response ensued, with clean-up crews active for several weeks. The response was organized through a Unified Command, which was made up of several federal and state agencies as well as the responsible parties. The latter was primarily represented by the O'Brien Group, a company employed to manage the oil spill response.

Portions of the response were completed as beaches were inspected and determined to have met cleanup criteria. The US Coast Guard officially declared the response to be complete on November 9, 2008, one year and two days after the spill. Most of the active response ended less than two months after the spill. Some clean-up continued at several beaches (e.g. Rodeo Beach, Albany Beach) into summer 2008, as they continued to have oiling episodes as buried or sunken oil was uncovered or washed up by wave action.

In addition to the response and clean-up effort, the natural resources Trustee agencies conducted a Natural Resource Damage Assessment (NRDA) to quantify the injuries and seek compensation in the form of restoration projects. In this case, the Trustees for the injured natural resources are the United States Fish and Wildlife Service (USFWS), the National Park Service (NPS), the Bureau of Land Management (BLM), the National Oceanic and Atmospheric Administration (NOAA), the California Department of Fish and Game (CDFG), the California State Lands Commission (CSLC) (the Trustees). As a designated Trustee, each of these agencies 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.

Damage Assessment and Restoration Plan (DARP)/Environmental Assessment (EA)
Under the OPA regulations, the Trustees have cooperatively prepared this Draft Damage Assessment and Restoration Plan (DARP) for public review and comment. This document describes the injuries resulting from the spill and the restoration projects intended to compensate the public for those injuries. This document is also an Environmental Assessment (EA) intended to satisfy the Federal Trustees' requirement to evaluate the environmental impacts of the proposed restoration projects under the National Environmental Policy Act (NEPA). This document is therefore called a DARP/EA. As full environmental review would be premature for some of the proposed

projects in the document, additional review may be required if the particular project is selected. This will be determined once detailed engineering design work or operational plans are developed for those projects.

What was injured?
The spill caused significant impacts to wildlife, habitats, and human recreational uses.

- Birds: 6,849 birds were estimated killed, representing 65 different species. The primary species impacted were diving ducks, grebes, cormorants, and murres. Special status species impacted included Marbled Murrelet and Snowy Plover.
- Fish: An estimated 14 to 29% of the winter 2007-8 herring spawn was lost due to widespread egg mortality in some areas of the Bay.
- Shoreline Habitats: 3,367 acres of shoreline habitat were impacted, and recovery is expected to vary from a few months to several years, depending upon the habitat type and degree of oiling.
- Human Uses: 1,079,900 user-days were lost, representing a wide variety of activities (recreational fishing, general beach use, surfing, etc.).

What restoration projects will compensate the public for these injuries?
The Trustees propose 12 restoration projects that are designed to address the various resources impacted by the spill, as well as a process to identify various recreational use projects. All of them 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. Where feasible restoration project alternatives existed within the spill area, those projects were given priority. Section 1.3 provides short summaries of the proposed preferred projects; section 4.2 lists the criteria used in project selection; and section 4.3 lists all projects considered (by resource category) and provides detailed information on the proposed preferred projects.

How will these projects be funded?
Under OPA, the responsible party (RP) 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 have settled this claim for natural resource damages with the RP. The following amounts are tentatively allocated to fund the projects described in this document:

- Birds: $5 million
- Fish/Eelgrass: $2.5 million
- Habitat: $4 million
- Recreational Use: $18.8 million

How do I comment on this restoration plan and environmental assessment?
Public review of this Draft DARP/EA is an integral component of the restoration planning process. A public review period is being held on this draft plan thru October 31, 2011. Written comments must be received by that date to be considered part of the official record. Comments should be sent to the attention of Steve Hampton by email

(shampton@ospr.dfg.ca.gov), fax (916-324-8829), or letter (California DFG-OSPR, 1700 K Street, Suite 250, Sacramento, CA 95814).

The Trustees will hold two public meetings on October 19:

- 12 noon in the First Floor Auditorium in the Elihu M. Harris State Building, 1515 Clay Street, Oakland; and
- 7pm at the Mill Valley Community Center, 180 El Camino Alto, Mill Valley.

At these meetings, the Trustees will present an overview of the DARP/EA and accept public comments.

Abbreviations

BCDC	Bay Conservation and Development Commission
BLM	Bureau of Land Management
CBNMS	Cordell Bank National Marine Sanctuary
CCSF	City and County of San Francisco
CDFG	California Department of Fish and Game
CESA	California Endangered Species Act
CEQ	Council on Environmental Quality
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
EBRPD	East Bay Regional Park District
EFH	Essential Fish Habitat
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ELER	Eden Landing Ecological Reserve
ESA	Endangered Species Act
ESI	Environmental Sensitivity Index
FLAT	Federal Lead Administrative Trustee
FONSI	Finding of No Significant Impact
FWCA	Fish and Wildlife Coordination Act
GGNRA	Golden Gate National Recreation Area
GFNMS	Gulf of the Farallones National Marine Sanctuary
HEA	Habitat Equivalency Analysis
IBA	Important Bird Area
IEc	Industrial Economics, Inc.
IFO	Intermediate Fuel Oil
LAT	Lead Administrative Trustee
MBNMS	Monterey Bay National Marine Sanctuary
MBTA	Migratory Bird Treaty Act
MMPA	Marine Mammal Protection Act
M/V	Motor Vessel
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
PAHs	Polycyclic aromatic hydrocarbons
PEMD	Polyethylene Membrane Devices
POP	Persistent Organic Pollutants
PRBO	PRBO Conservation Science (formerly Point Reyes Bird Observatory)
PSRPA	Park System Resource Protection Act
REA	Resource Equivalency Analysis
RFP	Request for Proposals
ROD	Record of Decision
RP	Responsible Party
SBSPRP	South Bay Salt Ponds Restoration Project
SCAT	Shoreline Cleanup and Assessment Team
SFEI	San Francisco Estuary Institute
USFWS	United States Fish and Wildlife Service
UV	ultraviolet light

Common and Scientific Names

Maritime Goldfield (*Lasthenia maritima*)
Pink Sand Verbena (*Abronia umbellata*)
Bull Kelp (*Nereocystis leutkeana*).
Giant Kelp (*Heterostichus rostratus*)
Southern Sea Palm Kelp (*Eisenia arborea*)
Eelgrass (*Zostera marina*)
European Beachgrass (*Ammophila arenaria*)
Rockweed (*Fucus gardneri*)
Widgeon Grass (*Ruppia maritima*)
Pickleweed (*Salicornia* sp.)
California Mussel (*Mytilus californianus*)
Ribbed Mussel (*Guekensia demissa*)
Olympia Oyster (*Ostrea lurida*)
Pink Abalone (*Haliotis corrugata*)
Red Abalone (*Haliotis rufescens)*
Black Abalone (*Haliotis cracherodii)*
Sand Dollar (*Clypeaster subdepressus*)
Inshore Squid (*Loligo opalescens*)
Dungeness Crab (*Metacarcinus magister*)
Bat Ray (*Myliobatis californica*)
Leopard Shark (*Trakis semifasciata*)
California Sardine (*Sardinops caeruleus*)
Northern Anchovy (*Engraulis mordax*)
Pacific Herring (*Clupea pallasii)*
Surf Smelt (*Hypomesus pretiosus*)
Jack Smelt *(Atherinopsis californiensis)*
California Grunion (*Leuresthes tenuis*)
Chinook Salmon (*Oncorhynchus tshawytscha*)
Coho Salmon (*Oncorhynchus kisutch*)
Steelhead (*Oncorhynchus mykiss*)
Inland Silverside (*Menidia beryllina*)
Sheepshead Minnow (*Cyprinodon variegatus*)
Tidepool Snailfish (*Liparis florae*)
Threespine Stickleback (*Gasterosteus aculeatus)*
Jack Mackerel (*Thyrsitops sp*.)
Sablefish (*Anoplopoma fimbria*)
Tidewater Goby (*Eucyclogobius newberryi*)
English Sole (*Parophrys vetulus*)
Petrale Sole (*Eopsetta jordani*)
Sand Sole (*Pegusa lascaris*)
Rockfish (*Sebastes sp.*)
Striped Bass (*Morone lineatus*)
Pacific Sanddab (*Citharichthys sordidus*)
Greenling (*Hexagrammos sp.*)
Lingcod (*Ophiodon elongatus*)
Monkeyface Prickleback (*Cebidichthys violaceous*)
Rock Gunnel (*Pholis gunnellus*)
Dwarf Surfperch (*Micrometrus minimus*)
Striped Surfperch (*Embiotoca lateralis*)

Tidepool Sculpin (*Oligocottus maculosus*)
Cabezon (*Scorpaenichthys marmoratus*)
Starry Flounder (*Platichthys stellatus*)
House Mouse (*Mus musculus*)
Common Raccoon (*Procyon lotor*)
Sea Otter (*Enhydra lutris*)
River Otter (*Lontra canadensis*)
Northern Fur Seal (*Callorhinus ursinus*)
Guadalupe Fur Seal (*Arctocephalus townsendi*)
Steller Sea Lion (*Eumetopias jubatus*)
California Sea Lion (*Zalophus californianus*)
Northern Elephant Seal (*Mirounga angustirostris*)
Harbor Seal (*Phoca vitulina*)
Harbor Porpoise (*Phocoena phocoena*)
Dall's Porpoise (*Phocoenoides dalli*)
Pac. White-sided Dolphin (*Lagenorhynchus obliquidens*)
Killer Whale (*Orcinus orca*)
Minke Whale (*Balaenoptera acutorostrata*)
Gray Whale (*Eschrichtius robustus*)
Blue Whale (*Balaenoptera musculus*)
Humpback Whale (*Megaptera novaeangliae*)
Greater White-fronted Goose (*Anser albifrons*)
Brant (*Branta bernicla*)
Canada Goose (*Branta Canadensis*)
Greater Scaup (*Aythya marila*)
Lesser Scaup (*Aythya affinis*)
Surf Scoter (*Melanitta perspicillata*)
White-winged Scoter (*Melanitta fusca*)
Long-tailed Duck (*Clangula hyemalis*)
Bufflehead (*Bucephala albeola*)
Red-breasted Merganser (*Mergus serrator*)
Ruddy Duck (*Oxyura jamaicensis*)
Red-throated Loon (*Gavia stellata*)
Pacific Loon (*Gavia pacifica*)
Common Loon (*Gavia immer*)
Pied-billed Grebe (*Podilymbus podiceps*)
Horned Grebe (*Podiceps auritus*)
Eared Grebe (*Podiceps nigricollis*)
Western Grebe (*Aechmorphorus occidentalis*)
Clark's Grebe (*Aechmorphorus clarkii*)
Short-tailed Albatross (*Phoebastria albatrus*)
Northern Fulmar (*Fulmarus glacialis*)
Ashy Storm-Petrel (*Oceanodroma homochroa*)
Brandt's Cormorant (*Phalacrocorax penicillatus*)
Double-crested Cormorant (*Phalacrocorax auritus*)
Pelagic Cormorant (*Phalacrocorax pelagicus*)
Brown Pelican (*Pelecanus occidentalis*)
Great Blue Heron (*Ardea herodias*)
Black-crowned NightHeron (*Nycticorax nycticorax*)
California Condor (*Gymnogyps californianus*)

Red-shouldered Hawk (*Buteo lineatus*)
Red-tailed Hawk (*Buteo jamaicensis*)
Peregrine Falcon (*Falco peregrinus*)
Clapper Rail (*Rallus longirostris*)
Common Moorhen (*Gallinula chloropus*)
American Coot (*Fulica americana*)
Black-bellied Plover (*Pluvialis squatarola*)
Snowy Plover (*Charadrius nivosus*)
Semipalmated Plover (*Charadrius semipalmatus*)
Killdeer (*Charadrius vociferous*)
Black Oystercatcher (*Haematopus bachmani*)
Black-necked Stilt (*Himantopus mexicanus*)
American Avocet (*Recurvirostra americana*)
Spotted Sandpiper (*Actitis macularius*)
Willet (*Tringa semipalmata*)
Whimbrel (*Numenius phaeopus*)
Long-billed Curlew (*Numenius americanus*)
Marbled Godwit (*Limosa fedoa*)
Black Turnstone (*Arenaria melanocephala*)
Sanderling (*Calidris alba*)
Western Sandpiper (*Calidris mauri*)
Least Sandpiper (*Calidris minutilla*)
Dunlin (*Calidris alpine*)

Red Phalarope (*Phalaropus fulicarius*)
Bonaparte’s Gull (*Larus philadelphia*)
Heermann's Gull (*Larus heermanni*)
Mew Gull (*Larus brachyrynchus*)
Western Gull (*Larus occidentalis*)
California Gull (*Larus californicus*)
Herring Gull (*Larus smithsonianus*)
Glaucous-winged Gull (*Larus glaucescens*)
Glaucous Gull (*Larus hyperboreus*)
Parasitic Jaeger (*Stercorarius parasiticus*)
Common Murre (*Uria aalge*)
Pigeon Guillemot (*Cepphas columba*)
Marbled Murrelet (*Brachyramphus marmoratus*)
Xantus's Murrelet (*Synthliboramphus hypoleucus*)
Ancient Murrelet (*Synthliboramphus antiquus*)
Cassin’s Auklet (*Ptychoramphus aleuticus*)
Rhinoceros Auklet (*Cerorhinca monocerata*)
Tufted Puffin (*Fratercula cirrhata*)
Steller’s Jay (*Cyanocitta stelleri*)
Common Raven (*Corvus corax*)
Fox Sparrow (*Passerella iliaca*)

Table of Contents

1.0 Introduction and Purpose

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

1. reimbursement for clean-up costs;
2. natural resource damages (including the costs of assessment);
3. fines and penalties under various laws;
4. third party claims (e.g. such as from commercial fisheries).

This document is only concerned with the second item, natural resource damages.

This draft 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[1] and resource services[2] injured by the release of oil from the *M/V Cosco Busan* oil spill occurring in San Francisco Bay on November 7, 2007. This document provides details regarding the injuries and their quantification, restoration planning, and the proposed restoration projects to address the injuries. 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 Draft 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.

The United States Fish and Wildlife Service (USFWS), the National Park Service (NPS), the Bureau of Land Management (BLM), the National Oceanic and Atmospheric Administration (NOAA), the California Department of Fish and Game (CDFG), and the California State Lands Commission (CSLC) are Trustees for 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 as a result of a discharge of oil. For purposes of coordination and compliance with OPA and NEPA, the USFWS and NOAA are designated as the joint lead federal Trustees.

The Trustees have prepared this Draft 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)

[1] 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.

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

intended to satisfy the Federal Trustees' requirement to evaluate the environmental impacts of the proposed restoration projects under NEPA. As full environmental review would be premature for some of the proposed projects in the document, additional review may be required if the particular project is selected. This will be determined once detailed engineering design work or operational plans are developed for those projects.

The Trustees seek comments on the proposed restoration alternatives and the environmental assessment presented in this DARP/EA. The Trustees will consider comments received during the public comment period before selecting the preferred projects and finalizing the document.

1.1 Overview of the Incident

On November 7, 2007, the freighter *Cosco Busan* struck the Bay Bridge as it attempted to depart San Francisco Bay. It was en route from the Port of Oakland to Pusan, South Korea. The accident created a gash in the hull of the vessel, causing it to spill approximately 58,000 gallons of Intermediate Fuel Oil (IFO-380) into the Bay. This is the bunker fuel that propels the 902-foot container ship. The accident happened at 8:30 am. Oil escaped from the vessel for approximately 53 minutes. After that, the vessel was shifted such that oil could no longer leak. The vessel turned around and anchored off San Francisco. It was repaired at the Port of Oakland and left the Bay on December 20, bound for South Korea and additional repairs. It has since been renamed the *Venezia*.

Wind and currents quickly took some of the oil outside of the Bay, where it impacted the outer coast from approximately Half Moon Bay to Limantour Beach at Point Reyes. Inside the Bay, the oil primarily impacted waters and shoreline within the central portion of the Bay, from Tiburon to San Francisco on the west side and from Richmond to Bay Farm Island and Alameda on the east side.

The movement of the oil was sporadic. Not all of the waters depicted in gray in Figure 1 were necessarily impacted, nor were all of the shorelines. This figure merely illustrates the general location and maximum extent of oil movement.

Clean-up operations recovered an estimated 22,991.5 gallons of oil, both from beaches and from on-water operations in the days immediately after the spill. Dispersants were not used during the response. The remaining 35,000 gallons of oil either remains on beaches where it is buried or cannot be removed, washed to sea, or evaporated. Small amounts may be sunken.

Figure 1: Spill Area

1.2 Summary of Natural Resource Injuries

The injuries from the oil spill can be divided into the following categories: birds; mammals; fish; shoreline habitats (including rocky intertidal, salt marsh, flats, and sandy beach habitat); eelgrass beds; and human recreational uses. The injuries to each category are summarized here and presented in greater detail in Chapter 4.

- Birds: 6,849 birds were estimated killed, representing 65 different species. The primary species impacted were diving ducks, grebes, cormorants, and murres. Special status species impacted included Marbled Murrelet and Snowy Plover.
- Mammals: No significant injuries.
- Fish: An estimated 14% to 29% of the winter 2007-8 herring spawn was lost due to widespread egg mortality in some areas of the Bay.

- Shoreline Habitats: 3,367 acres of shoreline habitat were impacted, and recovery is expected to vary from a few months to several years, depending upon the habitat type and degree of oiling.
- Human Uses: Approximately 1,079,900 user-days were lost, representing a wide variety of activities (recreational fishing, general beach use, surfing, etc.).

1.3 Summary of Preferred 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.

Restoration actions under OPA are termed primary or compensatory. Primary restoration is any action taken to accelerate the return of injured natural resources and services to their baseline condition-- the condition the resource would have been in were it not for the spill. Trustees may elect to rely on natural recovery rather than active restoration where feasible or cost-effective active restoration actions are not available, or where the injured resources will recover relatively quickly without human intervention.

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 over 25 restoration concepts and alternatives with the potential to provide primary and 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 4.2.2 presents OPA-based selection criteria developed by the Trustees for this spill. Based on the Trustees' evaluation, a total of 12 restoration projects have been proposed, plus the recreational use projects, which have yet to be delineated. These are summarized below and presented in detail in section 4.3.

It is the intent of the Trustees to address all injuries. However, rather than develop separate restoration projects for each wildlife species impacted, 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.

Figures 2 and 3 provide a conceptual guide to the injury categories and the restoration projects that would address each injury.

Figure 2: Matching Bird Injury Categories to Restoration Projects

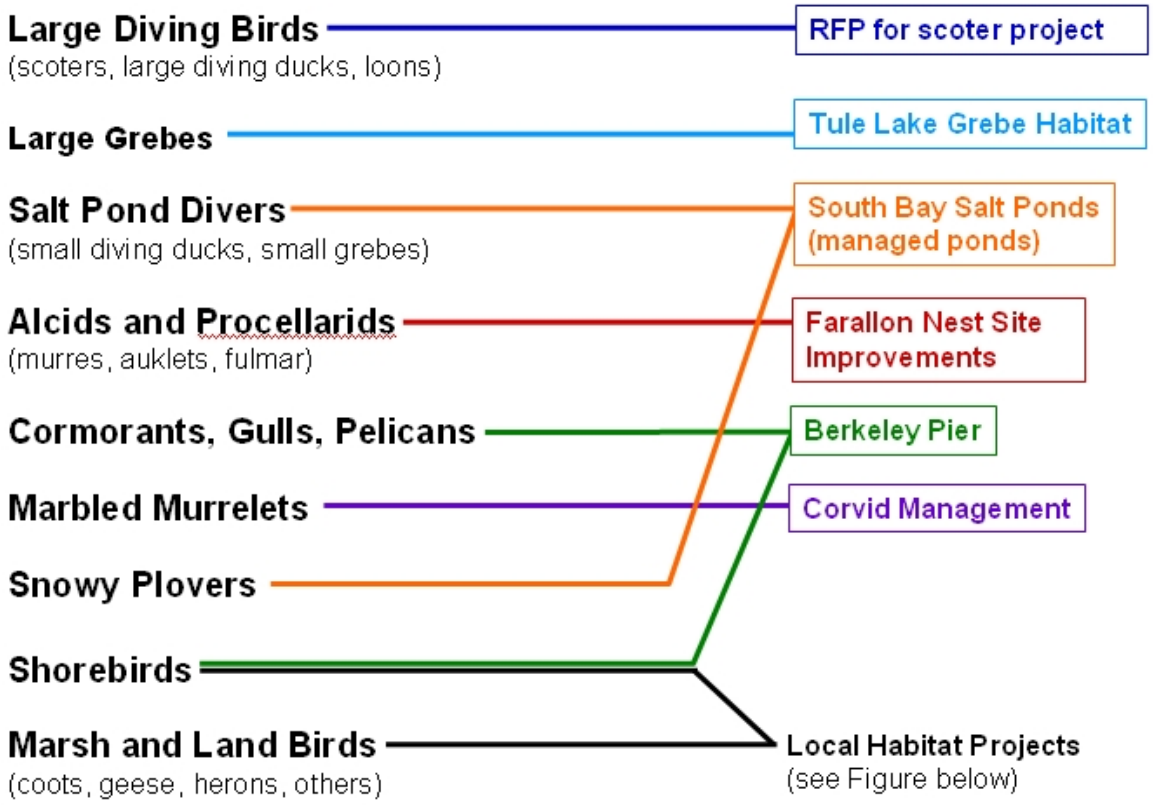
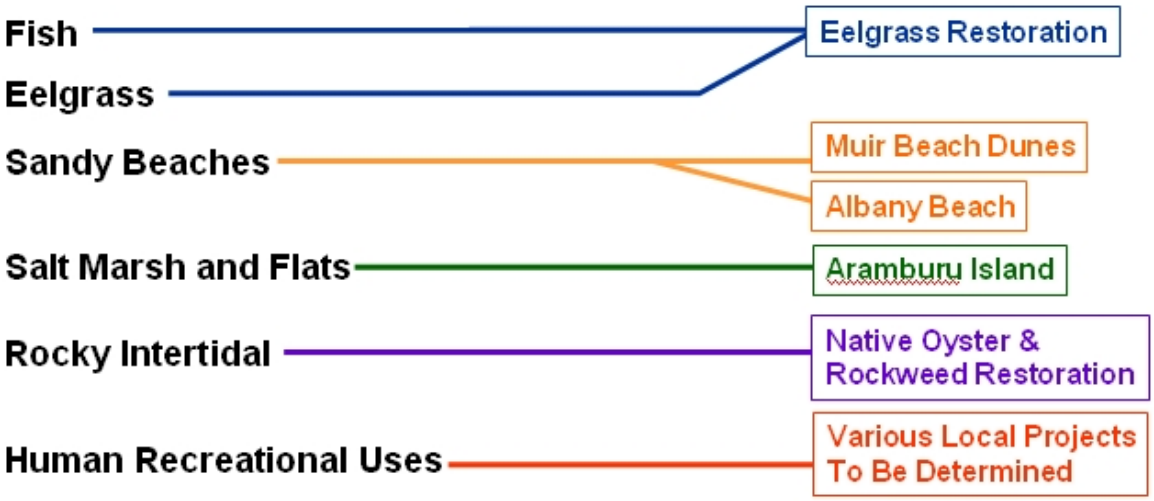


Figure 3: Matching Other Injury Categories to Restoration Projects



In accordance with OPA, all of the proposed projects have been "scaled" in size, such that the benefits of the restoration offset the injuries caused by the spill. Summaries of the proposed restoration projects are provided below. More details on the projects are provided in Chapter 4.

PROJECT: ***Request for Proposals for project benefiting Surf Scoters***
BENEFITS: scoters and other large diving ducks
This project will seek proposals and award a grant to one or more projects that will provide benefits to Surf Scoters, the bird species most impacted by the spill.

PROJECT: ***Tule Lake Grebe Habitat***
BENEFITS: Western/Clark's Grebes
This project will seek to create more suitable nesting habitat for Western and Clark's Grebes at Tule Lake National Wildlife Refuge. These species spend the winter in the Bay and along the outer coast. The project primarily involves the managing of water levels in Tule Lake's Upper Sump to create over 500 acres of new freshwater marsh, in which the birds would nest.

PROJECT: ***Winter Diving Duck Habitat at the South Bay Salt Ponds***
BENEFITS: small diving ducks and small grebes
This project compliments on-going efforts to restore the South Bay Salt Ponds by maintaining and managing habitat for wintering Lesser Scaup and Eared Grebes, among other species. The same ponds would be managed for Snowy Plover nesting during the summer.

PROJECT: ***Farallon Island Nest Site Improvements***
BENEFITS: Alcids and Procellarids
This project seeks to increase suitable nest sites for seabirds at Southeast Farallon Island. Specifically, it will replace up to 80 Rhinoceros Auklet and 450 Cassin's Auklet nest boxes, and create nest sites for up to 100 pairs of Ashy Storm-Petrels.

PROJECT: ***Berkeley Pier Enhancements***
BENEFITS: pelicans, cormorants, gulls, shorebirds
This project will enhance the dilapidated tip of the Berkeley Pier for cormorant and gull nesting and pelican roosting. It will also enhance another section nearer the base as a high tide roost site for shorebirds.

PROJECT: ***Marbled Murrelet Habitat Enhancement through Corvid Management***
BENEFITS: Marbled Murrelets
This project seeks to contribute to corvid management efforts at Humboldt Redwoods and Grizzly Creek State Parks. Corvids are ravens, crowns, and jays, which are present in high numbers around campgrounds and picnic areas, and in turn prey upon murrelet eggs and chicks. The project seeks to reduce corvid numbers in these areas through improved garbage management and extensive public outreach and education.

PROJECT: ***Eelgrass Restoration***
BENEFITS: eelgrass habitat, invertebrates, herring, and other bay fishes
This project will create or expand eelgrass beds at multiple locations inside the Bay. Eelgrass beds are a vital part of the Bay ecosystem, providing benefits to a variety of eelgrass-dependent organisms, as well as herring, which use eelgrass beds for spawning.

PROJECT: ***Muir Beach Dunes Restoration***
BENEFITS: sandy beach habitat
This project will enhance dune vegetation and habitat at Muir Beach by removing non-native vegetation, planting native vegetation, and re-routing pedestrian traffic. It is part of a larger effort to restore Redwood Creek, including the creek, wetlands, lagoon and sand dunes in the Muir Beach area.

PROJECT: ***Albany Beach***
BENEFITS: sandy beach habitat
This project will enhance and expand Albany Beach in the East Bay by removing non-native vegetation, planting native vegetation, and importing more sand, among other activities.

PROJECT: ***Aramburu Island Restoration***
BENEFITS: salt marsh and mud/sand flats
This project seeks to restore tidal marsh and shoreline habitat on Aramburu Island in Richardson Bay. Project elements include rehabilitation of tidal marsh and flats, improvements to upland grassland areas and creation of roost habitat for herons and egrets, and expansion of existing sand and gravel areas for shorebird roosting and to reduce wave erosion.

PROJECT: ***Native Oyster Restoration***
BENEFITS: rocky intertidal habitat
This project will create rocky intertidal habitat by installing hard substrates augmented with oyster shells in low intertidal areas. These provide a substrate for the attachment and development of native oyster community. The hard surfaces will also permit the establishment of algae and any nooks and crevices would harbor small fish and crabs, creating a diverse rocky intertidal community. There will be several project sites within the Central Bay.

PROJECT: ***Rockweed Restoration***
BENEFITS: rocky intertidal habitat
Rockweed habitat in the Central Bay will be created at mid-intertidal elevations using two techniques: seed bags and direct transplant. Some of the proposed sites for rockweed restoration include rocky intertidal habitats heavily damaged by hot water pressure washing. Once established, the rockweed habitat provides shelter for many invertebrates, particularly from desiccation during very low tides.

PROJECT: ***Recreational Use Projects***
BENEFITS: human recreational uses
There will be a suite of local projects to enhance recreational uses. The projects will be located in the East Bay, San Francisco Peninsula, and Marin County, proportional to the

levels of lost uses in each region. While this plan does not specify any particular project, it proposes a process, working with local governments and affected users, to select projects.

Under OPA, the responsible party (RP) 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 RP for $32.3 million. The following amounts are tentatively allocated to fund the projects described in this document:

- Birds: $5 million
- Fish/Eelgrass: $2.5 million
- Habitat: $4 million
- Recreational Use: $18.8 million

Another $2 million is allocated to cover administrative and oversight costs, but could be used to augment projects if available.

4.3.4.2 Sandy Beaches

Background

Beaches are an important resource along the Bay's shoreline, and the importance that these environments play towards providing habitat is critical. Beaches are typically dominated by very different species than those found in rocky shorelines or marsh habitats. The dominant fauna on sand beaches include amphipods and flies, coleopteran beetles, and isopods and mole crabs (*Emerita*) (see Appendix K). These invertebrates all present a vital food source for the multitude of marine and avian species found along this intertidal habitat. In addition, two species of concern, the California Least Tern and the Western Snowy Plover, typically require open, unvegetated or sparsely vegetated sand or gravel areas near open water (bars, flats, beaches) for foraging, roosting and nesting habitat (Thompson et al. 1997). Both the tern and plover utilize the sand beach environments within the San Francisco Bay and the outer coast.

In addition, the inland sand beaches within the San Francisco Bay provide a unique environment that helps to support a diminished high marsh and beach flora and fauna found specifically in these inland, protected environments. There are currently only about seven miles of interior beaches within San Francisco Bay. These beaches are mostly "pocket beaches" which have either regenerated in different locations or have been emplaced by humans. The shores of the Central Bay (Berkley, Albany, Richmond, San Francisco, etc.) are the main centers of beach locations and have seen the elimination of most of these beaches due to urbanization and emplacement of riprap shorelines.

Injury Assessment

Oil from the *Cosco Busan* spill washed over and stranded on the Bay Area beaches, smothering and fouling invertebrates and other fauna using the habitat, and rendering it impaired for use by fish, birds and other wildlife. The entire tidal zone is impacted by the oil, as it travels back and forth with individual waves throughout the tidal cycle, until it either washes back out to sea or is stranded on the shore by the receding tides. Interstitial and suspended detritus is a major food source for the masses of invertebrates living in the intertidal zone, and is easily fouled by adherence with oil particles. In addition, the beach wrack was often oiled and is generally removed as part of clean-up operations. This wrack is of prime importance as habitat to a variety of micro and macroinvertebrate species that are a critical food source for higher trophic level organisms, including shorebirds, fish and crabs.

The movement of sand on beaches along the coast of California is very dynamic and affects the final disposition of the oil. The beach cycle of erosion and deposition of sand on beaches of the West Coast is driven by the passage of storms, particularly in the winter. During storms, large, short-period waves suspend the sand and carry it offshore, creating a flat beach profile. Within days after a storm, smaller, long-period waves transport sand back onto the beach, building depositional berms at the high-tide level. (See Appendix K for more detailed information.) Any oil deposited on the beach will follow this same pattern of suspension, transport offshore, and re-deposition and burial on the beach. The next erosion event releases the oil again to be transported back and forth across the beach. Oil which permeates the surface sand and is buried by the processes described may result in chronic exposure to oil. Coarse sand and gravelly beaches are

particularly prone to burial of oil. For example, at Rodeo Beach on the outer Marin peninsula, so much oil was buried that surf washing by cleanup crews was still being conducted in late November (see Figure 16). Furthermore, buried oil continued to be encountered for several months, with reports of visitors (including children) getting oiled while digging in the sand on March 14, April 7, May 6, and June 9, 2008. Surfers reported oil on their surfboards and booties over the period June 2-11, 2008, and it is likely there were other unreported incidents. This oil would have continued to foul organisms which live in or pass through the intertidal zone for months after the initial incident.

The injury assessment for sandy beaches was based on field observations and the literature, which together describe how the habitat functions, how the oiling and clean-up affected it, and how it recovers. A summary of acres impacted and duration to recovery is shown in Table 4.

Area of Impact. The entire intertidal zone was determined to be impacted due to oil movement with the tides, the movement of motile organisms up and down with the tide for foraging, and the movement and mixing of the sand itself with waves and storm surges, particularly in the winter storm season.

Baseline Conditions. Information used to assess baseline sandy beach conditions included BeachWatch data on occurrence and abundance of beach wrack, and the collection and chemical analysis of biological samples outside of the spill zone.

Initial Injury. Fouling and removal of beach wrack, impacts to the associated invertebrate communities, and oil exposure to benthic invertebrate populations figured prominently in the injury to beaches. Treatment options for oiled wrack are limited. Oiling of wrack results in invertebrate mortality and contaminated forage for birds. The complete removal of wrack material from the beach removes a potential exposure mechanism, but has long term effects on forage options for birds due to reduced invertebrate community replenishment (Dugan et al. 2009, Beeler 2009). Both of these occurred in the aftermath of the *Cosco Busan* spill as oiled wrack was generally collected and removed from the more heavily oiled beaches, but remained in place on lighter oiled or unvisited stretches. In addition, PAH matches to *Cosco Busan* oil in mole crabs collected from oiled beaches were used to confirm oil exposure to these important prey items. These crustaceans migrate with the tides while feeding, and are at prime risk for being fouled by particulate oil in the splash zone.

Recovery. The recovery periods reflect the time to restore to pre-spill age class distributions of the most long-lived key species. Dominant species on sand beaches include amphipods and flies (<1 year life span), Coleopteran beetles (2 year life span), and isopods and mole crabs (2-3 year life span). Tarball stranding and re-oiling events along the outer coast sand beaches continued into June 2008, approximately 7 months after the spill.

Table 4: Summary of Sandy Beach Injury

Habitat/Category	Acres Injured	Time to full recovery (years)
Entire intertidal zone - Heavy	4.26	3
Entire intertidal zone - Moderate	5.43	3
Entire intertidal zone - Light	147.21	0.5
Entire intertidal zone -Very Light	491.30	0.5
Total	***648.20***	***0.5 - 3***

A total of 648.2 acres of sandy beach habitat was exposed to and injured by the oil spill. Appendix E provides additional information on the injury assessment and quantification of sandy beach habitat injuries.

Figure 16. Oiling across surf zone at Rodeo Beach.

Restoration Alternatives

Projects in this category will benefit sandy beach ecosystems and may also provide benefits to Snowy Plovers, endangered plants, and grunion spawning. The Trustees are proposing the following preferred projects to compensate for the injuries caused by the oil spill. The trustees also considered additional sandy beach restoration projects, but are not recommending them for further evaluation at this time.

PREFERRED PROJECTS	SUB-REGION	BENEFITS
Muir Beach dune enhancement	**Outer Coast**	**dune habitat**
Albany Beach restoration	**East Bay**	**dune and beach habitat**

Proposed Preferred Alternative

Muir Beach Dune Enhancement

The goal of this project is to enhance dune habitat at Muir Beach by installing protective fencing and diversifying the native plant assemblage. Fencing is needed to protect dunes from visitor trampling and encourage dunes to develop in a position in the landscape that is supported by natural processes (Aeolian sand supply).

Trampling has eliminated all but a trace of low foredune vegetation along the central segment of Muir Beach and has contributed to delivery of sand into Redwood Creek. Backdunes have been described as artificially overinflated due to excessive delivery of sand landward through the funnel shaped pedestrian pathway that bisects the dunes. Dune enhancement activities would include a number of actions to reduce the effects of trampling, including re-routing the existing pedestrian traffic.

The foredune zone would be re-vegetated incrementally in annual phases. Driftwood would be strategically placed in shallow pits to help trap sand. The locked-in driftwood would naturally accumulate sand while simultaneously serving to obstruct unauthorized foot traffic through the dunes. Native dune plants would be planted into the area to further accelerate dune development and diversify the plant assemblage. Non-native vegetation would be removed from the dunes. Fencing would be installed around the perimeter of the dunes to further deter trampling by humans and dogs.

This project includes the following specific tasks:

- The existing pedestrian access route through the dunes would be re-routed.
- Non-native vegetation would be removed from the dunes.
- Native dune plants would be planted to accelerate dune development and enhance the existing plant assemblage.
- Fencing would be installed to protect dunes from trampling

Affected Environment

The project is located at Muir Beach on the coast of Marin County, where Redwood Creek drains into the Pacific Ocean. The project area includes Muir Beach, an intermittent tidal lagoon at the beach, and the wetland and creek area extending from just downstream of Highway 1 to the beach. Wetlands and waters under the jurisdiction of the U.S. Army Corps of Engineers extend over most of the site, with about 26.5 acres of jurisdictional wetlands and about 2.6 acres of jurisdictional waters. The San Francisco Zen Center owns about 15 acres of the site over which the National Park Service has a conservation easement, and Marin County owns and manages the Pacific Way road and bridge which are included in the project area. The National Park Service (NPS) owns the beach as well as the remainder of the site.

Environmental Consequences (Beneficial and Adverse)

The proposed dune project is part of a much larger watershed restoration project that includes the restoration of Big Lagoon, Redwood Creek and associated wetlands. The description of dune restoration is based on actions proposed in the Final EIS/EIR titled

Wetland and Creek Restoration at Big Lagoon, Muir Beach Final EIS/EIR (http://parkplanning.nps.gov/document.cfm?parkID=303&projectId=12126&documentID=21520) and issued for public review and comment in December 2007. Dune enhancement would, in part, result from the natural lowering of the water table following excavation of the new creek channel to the tidal lagoon, combined with wind activity to develop dunes from newly dry and erodible sands. New fencing would be installed to allow reestablishment of foredunes, to the ocean-side of the existing back dune lobes. With establishment of native foredune vegetation, the foredunes are anticipated to capture fine sand, thereby reducing the sand washed or blown into the new channel. Overall, project actions will increase the extent and the quality of dune habitats at Muir Beach and reduce the transport of sand into the creek.

Under the preferred alternative, all actions would improve the potential for coastal dune formation and dune formation would not have significant adverse impacts. Vegetation restoration associated with dune creation would also not have significant adverse impacts on the environment and would have beneficial outcomes to the site, by reducing the transport of sand into Redwood Creek, diversifying the native plant assemblage, reducing invasive species, and providing habitat for rare dune species. In particular, the restoration plant palette for Muir Beach would include pink sand verbena, which is regionally scarce and comprised of small, unstable population sizes in this region.

Probability of Success

The probability of success is for this project is high, as established techniques will be used for the project.

Performance Criteria and Monitoring

A variety of monitoring elements for the dune restoration and other components of the Wetland and Creek Restoration at Big Lagoon, Muir Beach, Marin County are outlined in a post-implementation monitoring and assessment plan designed to evaluate project success relative to the original project objectives (Ward 2009).

Evaluation

Overall, the environmental impact analysis concluded that the selected action would have short-term impacts but that the overall benefits for natural resources were long-term.

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

Proposed Preferred Alternative

Albany Beach Restoration

The proposed project will enhance and expand Albany Beach, a highly visited and eroding beach within the Eastshore State Park, adjacent to Golden Gate Fields in the city of Albany (Figure 17).


Figure 17. Albany Beach showing beach shoreline slated for improvement by sand replenishment.

Coastal beach and dune complexes have been virtually eliminated along the East Bay shoreline, and along with them, the flora and fauna unique to these habitats. Many special-status plants historically occurred only in such areas, but are presently absent from the East Bay. The Albany Beach restoration effort will expand beach and dune habitat. It will be accomplished through removal of existing debris and non-native vegetation, importation of sand to expand the existing beach and adjacent dune complex, and replanting with native dune vegetation. (Figure 18). In addition, sand may also be placed off-shore to create new shallow subtidal habitat suitable for colonization by eelgrass.

This project includes the following specific tasks:

- Invasive vegetation removal and native dune vegetation re-planting to stabilize the upper beach and dunes, and to prevent wind erosion.
- Upland dune area expansion by use of imported sand, and protection from encroachment by humans.

Other elements of this project may include:

- Shallow subtidal habitat creation by importing sand to create a substrate suitable for colonization by eelgrass.
- Artificial substrate (asphalt and concrete rubble) removal and re-sloping of natural rocky shoreline along neck of Albany Bulb.

Affected Environment

This project is located at Albany Beach, on the east shore of the central San Francisco Bay. This beach is heavily used by the public. Albany Beach experienced heavy oiling during the spill event, which closed the beach for several weeks, as well as tarball re-oiling events into the summer of 2008.

Environmental Consequences (Beneficial and Adverse)

Under the preferred alternative, inland dune formation and native plant revegetation would not have significant adverse impacts. The dunes would be designed to expand onto a paved area currently used for parking. Dune and native plant revegetation design will be integrated to benefit wildlife function and physical sustainability of the dunes. This integrated approach will ensure that dunes also provide water quality benefits to the area. Soil disturbance from replacing non-native vegetation with native plants will not have significant adverse impacts on the environment. Successful re-establishment of native beach and dune plant communities on site will benefit dune stability and benefit species by providing high value habitat.

Probability of Success

The probability of success is high. The East Bay Regional Park District views this project as a high priority, and has made significant efforts in the development of site plans. In addition, established techniques for sand replenishment and native plant revegetation will be used for the project.

Figure 18. Dune habitat at Albany Beach showing extensive invasion of non-native vegetation.

Performance Criteria and Monitoring

The Albany Beach Project will be monitored by the project implementer to ensure completion of the project and restoration of beach and dune habitats including establishment of native vegetation.

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. They believe that this type and scale of project will effectively provide appropriate compensation for sandy beach habitat injured as a result of the spills and have therefore selected this project as a preferred alternative.

Other Restoration Projects Considered

The Trustees also considered the following projects but did not select them as preferred. All of the proposed projects would contribute towards restoring coastal dune habitat by removal of invasive plant species and sand replenishment measures, necessary to restore the resiliency of the dune systems to persist as a habitat and ecological feature within the seashore.

OTHER PROJECTS CONSIDERED	SUB-REGION	BENEFITS
Radio Beach expansion	East Bay	beach and dune habitat
Limantour Beach dune enhancement	Outer Coast	dune habitat, Snowy Plovers
Ocean Beach invasive plant removal and dune enhancement	Outer Coast	beach and dune habitat, Snowy Plovers

Radio Beach expansion. This project was similar in location and type of restoration to the Albany Beach project, but the oil exposure and subsequent injury at Albany Beach were more extensive than at Radio Beach. Also, the Albany Beach Restoration plan is already being developed by the East Bay Regional Park District and the project will likely be implemented and provide benefits sooner than a project at Radio Beach. Thus the Albany Beach Project is prioritized and selected as a preferred alternative.

Limantour Beach dune enhancement. Both this project and the Muir Beach dunes project benefit outer coast beaches within the spill zone. The oil exposure and subsequent injury at Muir Beach was more extensive than at Limantour Beach, and restoration at that beach was therefore prioritized and selected as a preferred alternative.

Ocean Beach invasive plant removal and dune enhancement. Both this project and the Muir Beach dunes project benefit outer coast beaches within the spill zone. The Muir Beach project was preferred over the Ocean Beach project because the Trustees felt that the overall ecological benefits from the restoration project would be greater at the Muir Beach site.

4.3.4.3 Marsh Wetlands and Tidal Flats

The Trustees evaluated restoration projects for marshes and tidal flats together and therefore these two habitat types are discussed together.

Marsh Background

Marshes and tidal flats impacted by the spill included significant areas of Bolinas Lagoon along the northern outer coast, and several areas inside central San Francisco Bay along the Richmond/Emeryville/Oakland shoreline.

Crustaceans and gastropods are the dominant epifauna in salt marshes. These species are motile and cross from marsh to tidal flats and channels to feed, increasing their exposure to the oiled marsh fringe as mentioned above. Salt marshes in the Bay are also home to a variety of birds which feed and live in the salt marshes. Of particular concern is the federally endangered California Clapper Rail, a year-round resident in marshes throughout the Bay Area that forages through the networks of small channels and sloughs at the vegetation edge. The Clapper Rail nests and overwinters in Central Bay salt marshes including Emeryville crescent and Stege marsh both oiled in the oil spill. Other marshes oiled in the spill include the marsh at Bolinas Lagoon and the marsh along Alameda (Elsie Rohmer Bird Sanctuary).

Marsh Injury Assessment

Due to their environmentally sensitive nature, spill responders are often specifically tasked with protecting marsh habitats from oiling, via the specific placement of deflection and containment booms. While much care was put on protecting these environments during the *Cosco Busan* spill, several locations were oiled to varying degrees. These locations include the Emeryville Crescent, Stege Marsh and Albany Marsh, and Bolinas Lagoon.

The basis for determining injury to the impacted marshes was based on field observations, previous scientific investigations on habitat functions, effect of oiling and clean-up actions on the habitat, and recovery. A summary of marsh acres impacted and duration to recovery is shown in Table 3.

Area of Impact. Areas included in this assessment were based on segments identified as marsh vegetation under the SCAT shoreline designation. The area impacted was considered to be the stranded oil band within the marsh habitats as described in the SCAT data.

Baseline Conditions. Information used to assess baseline conditions included historical ecological investigations conducted pre-spill, and PAH concentrations in bivalve tissues collected prior to the spill.

Initial Injury. Oil from the *Cosco Busan* affected a band of vegetation several meters wide, beginning at the outer fringe of the marshes, as well as channels leading into the marshes. This band of oiled vegetation impacted the fauna using the edges and channel borders of this habitat and the fauna which crosses the marsh edge interface for feeding and protection. The degree of oiling affected the

extent and types of impacts. Heavy and moderate oiling smothered flora and fauna, rendering it unsuitable for use by fish, invertebrates, and wildlife such as birds. Light and very light oiling adhered to vegetation and sediment surfaces, primarily impacting motile species which cross the oiled zones. Cleanup methods included clipping and removing oiled vegetation at two oiled locations. Data on PAH tissue concentrations and PAH patterns that matched the *Cosco Busan* oil signature in Ribbed Mussels was also evaluated.

Recovery. Oil in the salt marshes was bio-available to fauna from the initial spill and from at least one significant re-oiling event in January 2008 in east San Francisco Bay. The Trustees expect reduced recovery of affected fauna during the less reproductively active winter period, extending the duration of the injury. Recovery periods reflected the time required to reach pre-spill age class distributions of key long-lived species, including crustaceans and gastropods with life spans of more than five years.

Table 5: Summary of Impacted Marsh Acreages

Habitat/Category	Acres Injured	Time to full recovery (years)
Stranded Oil Band - Heavy	0.1	5
Stranded Oil Band - Moderate	0.6	3
Stranded Oil Band - Light	5.0	3
Stranded Oil Band -Very Light	12.4	1
Total	***18.1***	***1 - 5***

A total of 18.1 acres of marsh habitat was exposed to and injured by the oil spill. Appendix E provides additional details on the injury assessment and quantification of salt marsh habitat injuries.

Tidal Flats Background

Dominant species on tidal flats include mollusks (*Gemma, Nutricola, Venerupis, Cryptomya*), worms (annelids and polychaetes) and small crustaceans (amphipods and copepods; Brusati, 2004; Neira et al., 2005). Many of these species are filter feeders, making them susceptible to exposure to particulate oil and oil components suspended in the water column. Further, thousands of shorebirds daily utilize these flats during low tides as forage sites, as they probe into the sediments for the variety of invertebrates. In addition, benthic bacteria create significant biofilms along tidal flats, which have been found to account for up to half the total diet of Western Sandpipers (Kuwae et al. 2008). Oil products are likely to have a significant effect on the bacteria and microfauna existing on the surface of these sediments.

Tidal Flats Injury Assessment

The injury assessment for tidal flats was based on an understanding of the literature and field observations which describe how the habitat functions, how the oiling and clean-up affected it, and how it recovers. (See Appendix K for more information.) A summary of tidal flats acres impacted and duration to recovery is shown in Table 6.

Area of Impact. SCAT teams did not assess oiling within tidal flats due to accessibility issues and the limited likelihood of recoverable oil occurring there. Degree of tidal flat oiling was considered to be proportional to the degree of oiling of the adjacent shoreline (i.e., more oil would be moving across tidal flats next to more heavily oiled shorelines). Therefore, for the purposes of NRDA, tidal flats were categorized based on the SCAT oiling categories of the adjacent shoreline habitats. The size and locations of the tidal flat habitat segments were determined from the ESI maps.

Baseline Conditions. Information used to assess baseline conditions included life history information of the tidal flat biota and pre-existing PAH tissue concentrations in bivalves.

Initial Injury. Oil at the surface of the water and particulate and dissolved oil within the water column move across tidal flats with the tides. Although the entire tidal flat is likely exposed to oil, potential injury may be highest in the areas nearest the shoreline where oil temporarily strands and re-mobilizes, and where the flats are exposed most frequently during the tidal cycle. No cleanup actions were conducted within tidal flats. Information used to assess injury included direct observations of oil within the tidal flats both during the initial spill response, aerial overflight observations of oil on the water near shore, and PAH tissue concentrations and patterns that matched the *Cosco Busan* oil signature in bivalves within (clams collected from sediments) and adjacent to tidal flats (mussels, oysters and clams collected from rocky shores and marsh vegetation).

Recovery. The recovery times are based on the assumption that most of the affected species, particularly invertebrates, would have successfully reproduced during the next reproductive period.

Table 6: Summary of Impacted Tidal Flat Acreages

Habitat/Category	Acres Injured	Time to full recovery (years)
Adjacent to Heavy	4.18	1
Adjacent to Moderate	239.41	0.5
Adjacent to Light	227.43	0.17
Adjacent to Very Light	905.9	0.17
Total	***1376.9***	***0.17 - 1***

A total of 1376.9 acres of sandy beach habitat was exposed to and injured by the oil spill. Appendix E provides additional details on the injury assessment and quantification of tidal flat habitat injuries.

Restoration Alternatives

The Trustees are proposing the following project to compensate for the injuries to salt marsh and tidal flats.

PREFERRED PROJECT	BENEFITS
Aramburu Island restoration	**salt marsh habitat**

Proposed Preferred Alternative

Aramburu Island Restoration

This project seeks to restore tidal marsh and shoreline habitat on Aramburu Island in Richardson Bay. The island is currently owned by Marin County and managed as a nature preserve. Richardson Bay historically provided a rich assortment of ecological benefits to wildlife and human communities. In 1987, a channel was cut between the developed and undeveloped portions of the Richardson Bay peninsula, forming what is now the 17-acre Aramburu Island (Figure 19). The channel was cut to provide a buffer of open water between the wildlife that were using the island and the human community on Strawberry Point. In addition, a beach area was constructed on the north end of the island to provide additional harbor seal haul-out habitat. However, the island currently offers only marginal habitat for wildlife. The upland areas of the island are dominated by non-native plants, and the eastern shore of the island is subject to high wave energy that has caused a steep, wave-cut erosional shoreline to develop.

There are several distinct opportunities for enhancing the habitat. The island is located along the western border of the 900-acre Richardson Bay Audubon Sanctuary, which protects important habitats including mudflats, native oyster beds, and eelgrass beds that support fish and wintering waterbirds, among other species. The following four habitat types are available for restoration on Aramburu Island: 1) beach and sand flat areas, 2) tidal marsh, 3) coastal grassland, and 4) seasonal wetlands.

This project includes the following specific tasks:

1. Rehabilitate existing tidal marsh and grassland habitats, rehabilitate tidal flat and shoreline habitats, and establish gradual transition zones (ecotones) that support diverse native vegetation and optimum wildlife habitats for shorebirds, waterfowl, marine mammals, and native plant species and oysters.

2. Expand existing sand and gravel spit areas as shorebird roosting habitats and reduce wave erosion and shoreline retreat by replenishment of bay sand and gravel beach sediments.

3. Maintain varied topography on the island to facilitate gradual movement of wetland habitats.

4. Establish additional roost habitat for herons and egrets by placement of large woody debris and snags on the island.

Affected Environment

This project will be located on Aramburu Island, which is located in the central arm of Richardson Bay.

Environmental Consequences (Beneficial and Adverse)

The appropriate permits and clearances will be obtained once the project implementers have finalized the conceptual design for the project. This project has the potential to result in a few negative impacts. Beach and groin construction along the shoreline could

Figure 19. Aramburu Island, located within Richardson Bay.

temporarily increase suspended sediments and disturb substrate in the work area. Construction activities could impact nesting birds, which would be mitigated by constructing outside of nesting season (February through August). These potential impacts will be mitigated below the threshold of significance by adjusting construction schedules, establishing disturbance boundaries, and relocating species of concern.

Probability of Success

The probability of success is high. As the landowner, the County of Marin established the Aramburu Nature Preserve in 2005, and is managed by Marin County Parks. The Audubon Society has been steward of the adjacent Richardson Bay Audubon Sanctuary for 53 years, and plans to continue this stewardship into the future, as evidenced by the recent renewal of a 50-year lease on the portion of Sanctuary. Further, The Audubon Society is committed to achieving the goal of a restored and enhanced coastal habitat on Aramburu Island, and the County of Marin shares a commitment to this vision.

Performance Criteria and Monitoring

Audubon volunteers and staff members are currently involved in pre-restoration monitoring, including surveys of birds and plants on the island, fish use of the eelgrass and mudflat areas adjacent to the island, and native oyster densities along the margins of

the island and in the larger Richardson Bay area. Volunteers will continue to play a substantial role in monitoring post-restoration. The proposed monitoring plan can be found at http://www.tiburonaudubon.org/docs/aramburuEnhancementPlan20100420.pdf and includes separate performance targets for beach nourishment, salt marsh vegetation, coastal grasslands and seasonal wetlands.

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. They believe that this type and scale of project will effectively provide appropriate compensation for tidal flat and marsh habitats injured as a result of the spill and have therefore selected this project as a preferred alternative.

Other Restoration Projects Considered

The Trustees also considered the following projects but did not select them as preferred. All of the proposed projects would contribute towards restoring salt marsh and tidal flat habitat.

OTHER PROJECTS CONSIDERED	BENEFITS
Schoolhouse Creek daylighting project	stream mouth habitat
Invasive Spartina control	salt marsh habitat
Strawberry Creek enhancement	stream mouth habitat
Quartermaster Reach wetland restoration	stream mouth habitat
Bolinas Lagoon restoration	salt marsh habitat

Schoolhouse Creek daylighting project. The Schoolhouse Creek project site is located between the frontage road west of I-80 and the Berkeley North Basin. The restoration project would reconstruct the dynamics and structure of the historic local stream mouth morphology and habitat. However, the project is still in the very early development phase and cannot be implemented as soon as the other alternatives.

Invasive Spartina control project. The project is part of a long-term control program conducted by the State Coastal Conservancy. Although efforts are conducted bay wide, the vast majority of the affected environment occurs in the South Bay, outside of the spill zone.

Strawberry Creek enhancement. The proposed project will enhance the historic mouth of Strawberry Creek into San Francisco Bay, located on the south side of University Avenue, in Berkeley, CA. The project would call for removal of non native vegetation and inorganic debris from the banks of Strawberry Creek, and land restructuring. However, the project is still in the very early development phase and cannot be implemented as soon as the other alternatives.

Quartermaster Reach wetland restoration. The Quartermaster Reach project will restore an approximately 6 acre site in the northeastern portion of the Presidio. The project would daylight a stream, currently flowing underground in a storm drain which ultimately discharges to the Crissy Field Marsh. A diversity of

habitats will be restored including salt marsh, brackish marsh, dune swales, riparian forest, and upland scrub vegetation. However, the Aramburu Project will provide a greater degree of multiple resource and service benefits and will provide benefits sooner than the Quartermaster Reach project.

Bolinas Lagoon restoration. This project involves restoration of ecological functions of the lagoon, by way of large-scale invasive species removal from an island located near the mouth of the lagoon. The removal of non-native trees and other vegetation from the island, would allow the natural hydrologic processes to erode the island sediments, thereby providing better tidal flow into and out of the lagoon. This project has recently received grant funding for the first five years of the 10-year project. Funding is not currently needed but will be needed in years 6-10 to continue removal of non-native vegetation and greatly increase the likelihood of the success of this project.

4.3.4.4 Rocky Intertidal Habitat

Background

The rocky intertidal habitat within the area affected by the *Cosco Busan* spill includes a variety of natural and artificial rocky substrates, both within the San Francisco Bay and the outer coast. These habitat types include boulder fields, bedrock outcrop and benches, riprap, seawalls, and mixed cobble beaches. Along the open coast, many of the rocky intertidal environments are located in high energy environments especially along headland areas (e.g., Marin Headlands). Within the Bay, much of the rocky intertidal shoreline contains artificial substrates including rock riprap and seawalls, yet also are habitat to the native oyster, a species that occurs within the oiled area and is a species being restored by local groups. A wide variety of attached algae, invertebrates, and fish use rocky intertidal habitats. In terms of species diversity, hard substrates within San Francisco Bay support the greatest diversity of macroalgae (Silva 1979).

Injury Assessment

Impacts to rocky intertidal habitat were assessed through a number of field studies. Similar to the other shoreline habitats, the degree of oiling was classified based on descriptors used in the SCAT data. In additional to several field studies conducted after the oil spill, the Trustees also relied on other monitoring programs (e.g., through the Multi-Agency Rocky Intertidal Network and the National Park Service) that had pre-existing sample sites. In addition, the Trustees conducted analyses of pre- and post-spill photographs, field notes (e.g., from Jepson Herbarium at UC Berkeley), and species data from other projects (e.g., Moss Landing Laboratory Aquatic Invasives Study). Detailed information is available in Appendix F as well as in reports available in the administrative record (Raimondi et al. 2009, Zabin et al. 2009).

Area of Impact. Acres impacted were quantified using the 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.

By Region. Rocky intertidal habitat was separated into outer coast sites and sites within San Francisco Bay ("in-bay") because the composition of the intertidal communities differed between the two (Silva 1979, Raimondi et al. 2009). In addition, the duration of oil exposure and impacts differed between the two regions.

By Sub-Habitat Type. Injury was considered separately for rocky (Boulder, Bedrock, Seawall, and Mixed Cobble) and rip-rap shorelines, based on habitat structure and oiling. Most of the oil deposited in the mid, high and splash intertidal zones of rocky shores such that the degree of impacts and recovery differ between the stranded zone and the non-stranded, lower intertidal zone. For all non-rip-rap rocky intertidal habitats (both In-Bay and Outer Coast sites), the area of the oiled footprint (determined from the length of the segment multiplied by the oil band width recorded on the SCAT datasheet) was used as the stranded oil band area. The intertidal habitat below the stranded oil band was evaluated separately as the "rest of intertidal" zone. Rip-rap habitats were not separated into a stranded oil band and lower intertidal zone due to the three-dimensional nature of rip-rap and the oiling within the interstitial spaces. For rip-rap, oil dispersed within the crevices between rocks and in some areas, pooled oil was present and likely re-mobilized during tides and storm events, contributing to oiling throughout the intertidal zone.

Baseline Conditions. Limited pre-spill data are available that provide a quantitative description of rocky intertidal biota within the bay. Most of the pre-spill monitoring data are available for sites along the outer coast or are in-bay sites strongly influenced by marine conditions (e.g., Alcatraz) (Fong 2009). These sites are mapped at http://www.marine.gov/About/StudyArea.html#northerncalifornia. In-bay baseline data were available for native oyster monitoring sites maintained by UC Davis/Smithsonian.

Initial Injury. Injuries were a result of direct oil smothering/fouling of individuals, tissue necrosis and bleaching from oil contact (Figure 20), sublethal effects from exposure to petroleum, and trampling and physical cleaning of rocky intertidal habitats (Figures 21-22). Injury quantification was based on field survey data, PAH tissue concentrations in mussels, and supplemented with scientific literature. Sites that were cleaned with high pressure hot water or were subject to rock removal and replacement had different impacts and recoveries than sites without this "heavy" cleaning. The degree of impacts associated with manual cleaning varied according with the amount of oiling (e.g., sites with "moderate" oiling have more cleaning related impacts than "lightly" oiled).

Recovery. Recovery times from a UC Santa Cruz disturbance study were used to estimate recovery times for oil spill impacts. The recovery periods reflect the time needed for the affected areas to attain 100% of ecological services that would be present but for the oil spill. Recovery may be delayed by re-oiling events. The recovery time for this habitat was estimated based upon the recovery time of key intertidal assemblages (fucoid, barnacle, mussel, and mid-intertidal

red algae) following disturbance. Lower intertidal recovery trajectory were developed using relevant scientific literature for affected taxa.

Figure 20. Close-up of algae (*Gymnogongrus sp.*) with oiled portions (black base), normal tissue (brownish-red), and bleached (white) at Rodeo Beach-Bird Island (Fort Cronkhite, Marin Co.). (Photo: Darren Fong, January 17, 2008)

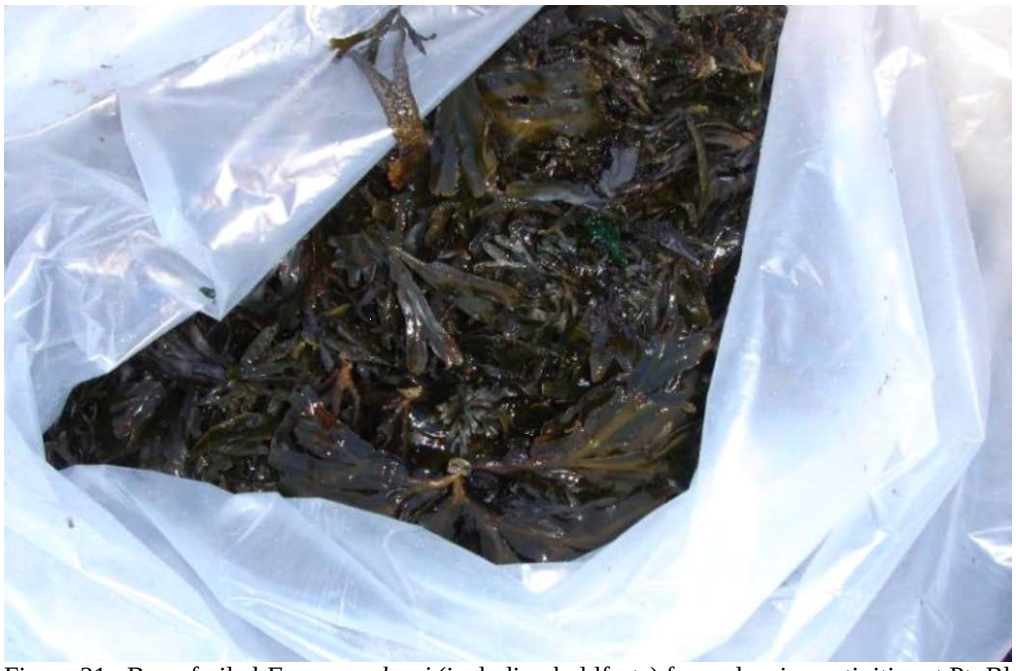


Figure 21. Bag of oiled *Fucus gardneri* (including holdfasts) from cleaning activities at Pt. Blunt, Angel Island. (Photo: Dan Richards, Nov 21, 2007)

Figure 22. Manual clean-up actions at Pt. Blunt, Angel Island (Photo: Dan Richards, Nov 21, 2007)

Table 7: Summary of Rocky Intertidal Injury (In-Bay)

Habitat/Category	Acres Injured	Time to full recovery (years)
Heavy clean-up (e.g. hot water rinse or rock replacement)	5.8	5.4
Riprap - Heavy	0.9	5.4
Riprap - Moderate	5.8	5.4
Riprap - Light	21.3	5
Riprap - Very Light	49.6	5
Stranded Oil Band - Heavy	0.5	5.4
Stranded Oil Band - Moderate	0.8	5.4
Stranded Oil Band - Light	4.4	5
Stranded Oil Band -Very Light	3.2	5
Rest of Intertidal - Heavy	1.1	4
Rest of Intertidal - Moderate	4.7	2
Rest of Intertidal - Light	29.4	1
Rest of Intertidal - Very Light	30.6	0.08
Bay Subtotal	**158.1**	**0.08 – 5.4**

Table 8: Summary of Rocky Intertidal Injury (Outer Coast)

Habitat/Category	Acres Injured	Time to full recovery (years)
Stranded Oil Band - Heavy	0.6	5.4
Stranded Oil Band - Moderate	0.9	5.4
Stranded Oil Band - Light	2.4	5
Stranded Oil Band - Very Light	18.3	5
Rest of Intertidal - Heavy	0.7	3
Rest of Intertidal - Moderate	3.7	1
Rest of Intertidal - Light	37.2	0.25
Rest of Intertidal - Very Light	162.5	0.08
Outer Coast Subtotal	**226.2**	**0.08 – 5.4**

A total of 384.3 acres of rocky intertidal habitat was exposed to and injured by the oil spill. Appendix F provides additional information on the injury assessment and quantification of rocky intertidal habitat injuries.

Restoration Alternatives

The Trustees are proposing the projects described below to compensate for injuries to rocky intertidal communities caused by the oil spill (Tables 7 and 8).

PREFERRED PROJECTS	BENEFITS
Native oyster restoration	**rocky intertidal habitat**
Rockweed restoration	**rocky intertidal habitat**

Proposed Preferred Alternative

Native oyster (*Ostrea lurida*) restoration and enhancement projects

The goal of this project is to provide suitable natural hard substrate to enhance oyster larvae settlement and recruitment. This project would compensate for the lost services to natural rock and rip rap intertidal habitats.

Oyster reefs are key marine habitats (Jackson et al. 2001), and create biological diversity (Posey et al 1999, Brietburg et al. 2000). Oysters are responsible for higher densities of macro invertebrate species for crabs and predatory fish species than unstructured mud (Summerson and Peterson 1984, Lenihan and Peterson 1998).

Macroinvertebrate density and species richness are positively correlated with structural complexity (Crowder and Cooper 1982, Diehl 1988, Diehl 1992). Enhanced habitat structure increases prey for crabs and predatory fish survival (Heck and Thoman 1981, Crowder and Cooper 1982, Schriver et al. 1995, Beukers and Jones 1997, Grabowski 2004). Oyster beds made of disarticulated shell (versus mud) increased resident fish, bivalve, and decapod crustacean populations (Plunket et al. 2005).

Naturally occurring populations of native oysters can be found throughout San Francisco Bay from Pt. Pinole to south of the Dumbarton Bridge on natural and artificial hard substrate. In the intertidal zone, oysters can be found in highest abundances (80 per m^2) in the Central Bay, but lower densities and scattered live individuals are found over a wider extent. Based on measurements of oyster densities around the Bay in 2006, Grosholz et al. (2007) estimated that there are 300,000 living oysters in the intertidal zone in San Francisco Bay.

Oysters require hard substrate for attachment. The increase in sediment in the Bay that has occurred as a result of human activities has likely resulted in the burial of smaller, naturally occurring substrates oysters once were able to use and necessitates the addition of larger substrate. Hard substrate also appears to be limited below the zero tide line in many locations where it is present in the intertidal zone.

Specifically, the project will involve the placement of cleaned and dried Pacific oyster shells in mesh bags on wooden pallets at various locations suitable for native oyster restoration within the Central Bay. Potential sites include Angel Island, Richardson Bay, San Rafael Shoreline from Marin Rod & Gun Club to south of canal area, Marin Islands, Point Isabel and Albany Dog Park, Berkeley Shorebird Park, Ashby Spit to Emeryville Crescent, San Leandro Marina and nearby shoreline.

Affected Environment

This project will be located at various locations within the Central Bay where predation is minimal and salinities are within the range for oyster recruitment and survival.

Environmental Consequences (Beneficial and Adverse)

While Olympia oysters do not make reefs, there is evidence that even small-scale physical structure increases biodiversity (Kimbro & Grosholz 2006). In Louisiana, as in San Francisco Bay, oysters are present in beds not reefs. Despite lacking this, oyster beds have been shown to be a valuable refuge and foraging habitat for fish and decapod crustaceans (Plunket et al 2005). The primary negative impacts include loss of soft substrate within these locations. This impact would be insignificant based on the size of the reefs relative to the area of soft substrate covered.

Probability of Success

Native oyster restoration using shell placed in mesh bags and stacked on wooden pallets have worked relatively well for recruiting and maintaining native oyster populations in the various locations in the bay. In addition, techniques to increase larval success by seeding cultch could also be employed.

Performance Criteria and Monitoring

The following table is used to guide restoration success of native oyster beds.

Table 9: Modified Matrix for Measuring Restoration Success

Goal	Measurements	Methodology	Timing
Increase/improve habitat for native oysters	Acreage or linear feet of hard substrate	Snorkeling/wading measurements of perimeter	During construction phase and immediately following construction phase, determine that substrate configuration is holding
Self-sustaining populations of native oysters	Oyster density	Counts of live oysters per unit area; compare to reference site	At least annually, for 3-5 years after construction.
	Size class structure	Measurements of oysters in above counts: compare to reference site	At least quarterly, for 3-5 years after construction.
	Recruitment	Number of spat on samples of material used for restoration; compare to reference site	At least annually, for 3-5 years after construction. If recruitment is low over 2-3 years, consider seeding

Source: Zabin et al. 2010.

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. They believe that this type and scale of project will effectively provide appropriate compensation for injured rocky intertidal habitat as a result of the spill and have therefore selected this project as a preferred alternative.

Proposed Preferred Alternative

Rockweed (*Fucus gardneri*) Restoration

The primary goal of this project is to increase the amount of vegetative cover of a key mid-high intertidal alga in areas that were directly impacted by the *Cosco Busan* oil spill.

During the *Cosco Busan* oil spill several rocky intertidal areas, such as at Berkeley Marina and Treasure Island, were directly impacted by clean-up activities. Some areas were heavily cleaned with hot water or had rocky intertidal habitat physically removed. Additionally, oiled *Fucus* was removed from rocky shorelines during cleanup efforts. This project is intended to increase the amount of rockweed within the Central Bay at several locations. These sites include riprap shorelines that were heavily cleaned with hot water. The primary goal of this project is to increase the amount of vegetative cover of a key mid-high intertidal alga in areas that were directly impacted by the spill.

This project includes the following specific tasks:

- Map existing distribution of *Fucus* within the Central Bay to determine viable donor sites
- Establish potential donor sites and the maximum percentage of algae that could be harvested for the two techniques (listed below).

- Create 2,000 lineal meters of new *Fucus* habitat through two techniques: (1) use of seed bags with fertile tips of Fucus blades in areas with filamentous algae and (2) use of transplanted *Fucus* (minimum 10-20 cm length, with holdfast intact) either individuals harvested from boulders or through transplant of cobbles with plants attached
- Monitoring of new *Fucus* establishment areas and control sites for five years over a 10-year monitoring period.

Affected Environment

This project will occur on pre-existing rocky shorelines with minimal to non-existent *Fucus* cover. Many of these shorelines are artificial riprap which has been cleaned using hot water during the spill. Donor sites will come from areas within Central Bay that have large and healthy stands of *Fucus*.

Environmental Consequences (Beneficial and Adverse)

Planting of riprap shorelines, particularly those that have been impacted by hotwash activities would increase the amount of algal cover in the mid-intertidal zone. The development of a *Fucus* canopy would benefit long-term establishment of understory species that need protection from desiccation. Adverse impacts could be associated with donor site impacts, should a high percentage of *Fucus* be removed from one site and transplanted at another. Such impacts would be minimized below the threshold of significance by only harvesting small numbers of *Fucus* from several sites with high abundance. This would be accomplished in preliminary tasks, by mapping the existing distribution of *Fucus* within the Central Bay to determine viable donor sites).

Probability of Success

The proposed "planting" activities have been tried with a similar species, *Silvetia compressa*, with good success with planted juveniles on a medium scale (100m x 20 m area; Whitaker 2009). Work in Alaska associated with the *Exxon Valdez* spill indicated that *Fucus* establishment in restoration plots associated with moist conditions provided either by adults or by artificial coconut fiber mats (Stekoll and Deysher 1996).

Performance Criteria and Monitoring

Various criteria measures may include assessments of: survivorship of transplanted adults relative to reference adults, recruitment of new individuals relative to reference areas, Fucus cover over time in transplant areas, recruitment of new individuals relative to reference areas, and expansion of Fucus cover over time in transplant areas.

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. They believe that this type and scale of project will effectively provide appropriate compensation for rocky intertidal habitat injured as a result of the spill and have therefore selected this project as a preferred alternative.

Other Restoration Projects Considered

The Trustees also considered the following project but did not select it as preferred.

OTHER PROJECTS CONSIDERED	BENEFITS
Albany Bulb rocky shoreline restoration	rocky intertidal habitat

Albany Bulb Rocky Shoreline Restoration

The Albany Bulb Rocky Shoreline Restoration project was considered as part of the larger Albany Beach restoration project (see project details described under Section 4.3.3.3). This project would restore and enhance rocky shoreline habitat via removal of artificial substrate and re-sloping of natural shoreline, providing improved habitat for invertebrates and fish. This component of the project is still in the early development phase but could be considered in the future.

4.3.4.5 Eelgrass Beds

Background

Areas vegetated by eelgrass and other seagrasses are recognized as important ecological communities in shallow bays and estuaries because of their multiple biological and physical values (reviewed in Kenworthy et al. 2006). Habitat provided by these submarine plants functions as an important structural environment for resident bay and estuarine species, offering a predation refuge, a food source and a nursery area for many commercially and recreational important finfish and shellfish species, including those that are resident within bays and estuaries, as well as oceanic species that enter estuaries to breed or spawn. Herring use eelgrass beds for spawning in San Francisco Bay.

Eelgrass is also major food source in near shore marine systems, contributing to the system at multiple trophic levels. Eelgrass provides the greatest amount of primary production of any near shore marine ecosystem, forming the base of detritus-based food webs and providing a food source for organisms that feed directly on eelgrass leaves, such as migrating waterfowl. Eelgrass is also a source of secondary production, supporting epiphytic plants, animals, and microbial organisms that in turn are grazed upon by other invertebrates, larval and juvenile fish, and birds.

In addition to habitat and resource attributes, eelgrass serves beneficial physical roles in bays and estuaries. Extant eelgrass meadows dampen wave and current action, trap suspended particulates, reduce erosion by stabilizing the sediment improving water clarity, cycle nutrients, and generate oxygen during daylight hours.

Injury Assessment

SCAT teams did not assess oiling within eelgrass beds due to accessibility and limited likelihood of recoverable oil occurring there. Degree of tidal flat oiling was considered by the Trustees to be proportional to the degree of oiling of the adjacent shoreline (e.g., more oil would be moving across eelgrass beds next to more heavily oiling shorelines). Therefore, for the purposes of NRDA, tidal flats were categorized based on the oiling categories of the adjacent shoreline habitats. The areas of eelgrass beds were determined from maps previously developed (Merkel and Associates 2005). The eel grass beds were divided into intertidal and subtidal areas based on the depth of the beds as provided by NOAA: intertidal (0-4 ft.) and subtidal (greater than 4 ft.). The intertidal beds were

assigned a degree of oiling equivalent to the most prominent maximum oiling observed on the closest adjacent shoreline to the intertidal bed. The subtidal beds were assigned an oiling one degree lighter than the oiling assigned to the adjacent intertidal beds.

The studies conducted investigating oiling effects on eelgrass beds showed that, while many eelgrass beds were exposed to oil, there is little evidence to suggest serious injuries to them. In the metrics quantified, the beds under study showed few changes that could be attributed directly to the oil.

Table 10: Summary of Acres of Eelgrass Beds Exposed to Oil

Eelgrass Beds (based on oiling category of adjacent shoreline)	**Acres**
Very lightly oiled	789
Lightly oiled	119
Moderately oiled	14.3
Heavily oiled	17.6
TOTAL	**939.9**

A total of 939.9 acres of eelgrass bed habitat was exposed to the oil spill.

In addition, clean-up operations resulted in impacts to the eelgrass bed at Keil Cove, Marin County. Impacts from vessel groundings on seagrass beds are not uncommon during oil spills. Groundings are when a vessel hits bottom, displacing sediments and uprooting seagrasses. Another injury feature, known as a "blowhole" is formed from the concentrated force of propeller wash, either from the grounded vessel attempting to power off the bank or the propeller wash of the salvage vessel pulling the grounded vessel off the bank. The depth and area of the blowholes also vary depending on the size of the vessel, extent of power used to remove the vessel, and type of seagrass bed substrate. Berms, another common seagrass injury feature, are produced from the sand, mud, coral fragments, and other substrates excavated during the creation of prop scars and blowholes that typically accumulate around the perimeter of the impact, thereby burying healthy seagrasses (Fonseca et al. 2002).

The injuries sustained to the eelgrass bed at Keil Cove are from a combination of prop scars and vessel grounding. In reviewing side scan and single beam images taken in November 2007 and April/May 2008, the images map multiple features that can be correlated with clean-up activities at the site. The vessel *Allied Mariner* was used to transport and haul away oiled rock and carry in new rock and clean-up equipment to the shoreline of Keil Cove. As the vessel moved in and out of the cove, several large scars (approximately 0.19 acres) were formed through an eelgrass bed that has persisted at this site for more than 85 years (Setchell 1927, 1929).

A complete survey of the site for eelgrass was conducted using sidescan sonar (Figure 23). A January 2008 survey revealed a large scar-like impression located at the east end of the cove and running perpendicular to the shore as well as two crescent shaped scars in the deeper bed. A fourth scar appeared in May after additional clean-up activities were being completed (Figure 23). These scars did not appear in the November 2007 scan.

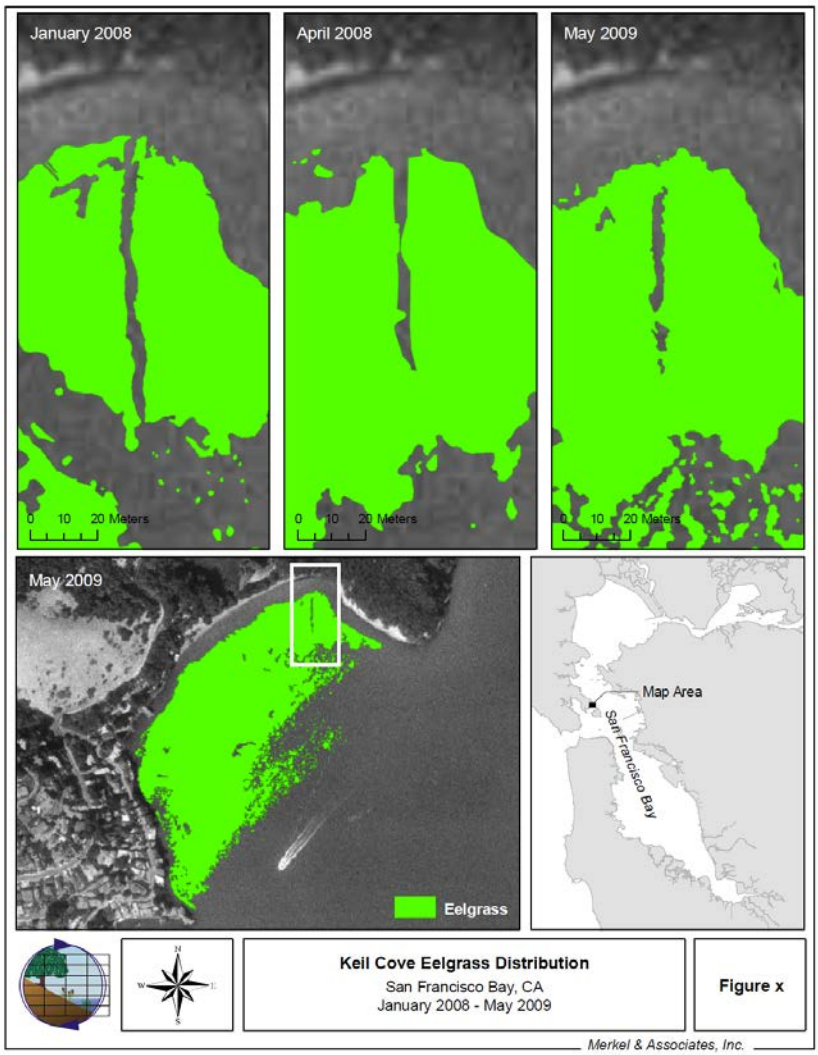


Figure 23. Side-scan sonar data were collected operating at 600 kHz scanning out 20 meters on both the starboard and port channels for a 40-meter wide swath. All data were projected in meters (NAD 83) in the Universal Transverse Mercator (UTM) system and plotted on a geo-rectified aerial image of the study area.

In discussions with seagrass restoration specialists, emergency restoration of the scar by filling and or transplanting was not recommended. Subsequent side scan sonar images revealed the scar maybe recovering on its own (Figure 23). Nevertheless, the scar will be monitored for the next three years.

Restoration Alternatives

Projects conducted under this category will benefit eelgrass habitat, herring and other fish spawn, and invertebrate communities.

PREFERRED PROJECT	**BENEFITS**
Eelgrass restoration in San Francisco Bay	Eelgrass, herring

8.0 Appendices

Appendix A: Resource Equivalency Analysis

Appendix B: Acute seabird and waterfowl mortality resulting from the *M/V Cosco Busan* oil spill, November 7, 2007 (Ford et al. 2009)

Appendix C: Shorebird Injury Assessment

Appendix D: Herring Injury Report (Incardona et al. 2011)

Appendix E: Habitat Equivalency Analysis (HEA) Details for Marsh, Flats, and Sand/Gravel Beaches

Appendix F: Rocky Intertidal Service Loss Report

Appendix G: Baseline Shoreline Use Estimates (IEc 2010a)

Appendix H: Recreational Fishing Damages (IEc 2010b)

Appendix I: Recreational Boating Damages (IEc 2010c)

Appendix J: Shoreline Use Damages (Stratus 2010)

Appendix K: Benthic Invertebrates on Beach and Tidal Flat Habitat (Peterson and Michel 2010)