ENVIRONMENTAL SENSITIVITY INDEX — SAN FRANCISCO BAY AREA

SHORELINE TYPES

The shorelines of San Francisco Bay were classified during a low-altitude, fixed-wing aerial survey conducted in January 1986. Based on previous investigations of numerous oil spills, the shoreline types were ranked in order of increasing sensitivity (as appears below). Environments 9 and 10 are most sensitive and deserve priority protection in the event of an oil spill.

Sensitivity ↓

1. Exposed rocky shores and vertical seawalls
2. Exposed piers and rocky platforms
3. Fine-grained sand beaches
4. Medium- to coarse-grained sand beaches
5. Mixed sand, gravel, and fill beaches
6. Gravel beaches and exposed riprap
7. Exposed sandy tidal flats
8. Sheltered coastal structures and rocky shores
9. Sheltered tidal flats
10. Wetlands

BIOLOGICAL RESOURCES

The biological resources of the study area were determined from published literature and personal communications with California Fish and Game, San Francisco Regional Water Quality Control Board, and U.S. Fish and Wildlife Service.

The biological resources of the San Francisco Bay and San Pablo Bay area are abundant and diverse. The fish and wildlife indicated on the ESI maps were selected on the basis of commercial and recreational importance, special status under state or federal wildlife protection laws, or because they are especially sensitive to spilled oil. Sensitivity to spilled oil is based on literature describing effects from previous spills, the spatial and temporal distribution of the organism, and intrinsic physiological sensitivity to spilled oil.

The locations of biological resources is indicated by color-coded, round, wildlife symbols. Known concentrations of bird nesting sites, shellfish beds, fish spawning areas, and anadromous fish runs are shown as site-specific areas. The symbols indicate the seasons the species are present. On the bird symbols, breeding seasons are indicated by an asterisk.

The symbols used to indicate these resources are presented below:

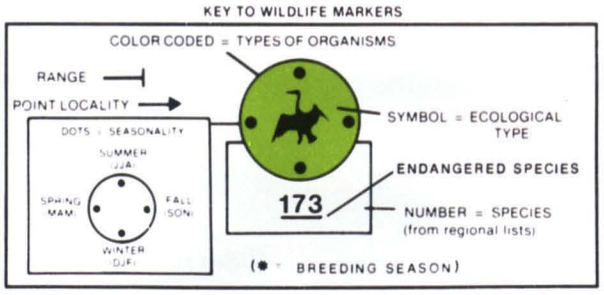
MAMMALS
- Seals
- Fur bearing aquatic mammals

BIRDS
- Raptors
- Diving birds
- Seabirds
- Shorebirds
- Wading birds
- Waterfowl

SHELLFISH
- Clams
- Crabs

FISH
- Anadromous fish
- Bottom fish
- Forage fish

KEY TO WILDLIFE MARKERS



SOCIOECONOMIC FEATURES

The following information is provided to highlight the areas having socioeconomic importance in order to aid or direct the response effort. Boat ramps are included to indicate access points.

- Parks and recreational areas
- Wildlife refuges, management areas, ecological reserves
- Boat ramps
- Marinas

SPILL-RESPONSE INFORMATION

Booms are the primary spill-response tools indicated on the maps. The positions of each are meant to be only approximate depending on the particular spill and weather conditions. They are placed to prevent oil from entering highly sensitive areas.

- Skimmer locations
- Boom locations

KEY TO SPECIES

BIRDS		
B	Shorebirds	
C	Waterfowl	
D	Diving birds	
E	Wading birds	
9	Brandt's cormorant	*Phalacrocorax penicillatus*
10	Pelagic cormorant	*Phalacrocorax pelagicus*
21	Canvasback	*Aythya valisineria*
25	Barrow's goldeneye	*Bucephala islandica*
37	Western gull	*Larus occidentalis*
43	Heermann's gull	*Larus heermanni*
47	Pigeon guillemot	*Cepphus columba*
53	Northern phalarope	*Phalaropus lobatus*
85	California least tern	*Sterna antillarum browni*
90	Black-crowned night heron	*Nycticorax nycticorax*
118	Brown pelican	*Pelecanus occidentalis*
125	Clapper rail	*Rallus longirostris*
136	Caspian tern	*Sterna caspia*
138	Forster's tern	*Sterna fosteri*
139	Snowy plover	*Charadrius alexandrinus*
141	American avocet	*Recurvirostra americana*
142	Black-necked stilt	*Himantopus mexicanus*
173	White pelican	*Pelecanus erythrorhynchos*
187	Virginia rail	*Rallus limicola*
204	California clapper rail	*Rallus longirostris obsoletus*
206	California black rail	*Laterallus jamaicensis coturniculus*
212	White-tailed kite	*Elanus leucuras*
FISH		
F	Bottomfish	
12	Starry flounder	*Platichthys stellatus*
43	White sturgeon	*Acipenser transmontanus*
44	Green sturgeon	*Acipenser medirostris*
66	Pacific herring	*Clupea harengus pallasi*
68	Chinook salmon (king)	*Oncorhynchus tshawytscha*
69	Coho salmon (silver)	*Oncorhynchus kisutch*
76	Rainbow trout (steelhead)	*Salmo gairdneri*
87	American shad	*Alosa sapidissima*
104	Striped bass	*Morone saxatilis*
MAMMALS		
2	Harbor seal	*Phoca vitulina*
8	River otter	*Lutra canadensis*
36	Beaver	*Caston canadensis*
41	Saltmarsh harvest mouse	*Reithrodontomys naviventris*
SHELLFISH		
14	Dungeness crab	*Cancer magister*
25	Soft-shell clam	*Mya arenaria*
29	Common Pacific littleneck clam	*Protothaca staminea*

PRIMARY REFERENCES

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Please reference as follows: Research Planning Institute, Inc.; 1986; Sensitivity of coastal environments and wildlife to spilled oil, San Francisco Bay area: an atlas of coastal resources: W. J. Sexton and J.A. Dahlin; RPI/ESI/86-3; Columbia, S.C.; 23 maps.

DESCRIPTION OF SHORELINE TYPES

EXPOSED ROCKY SHORES AND VERTICAL SEAWALLS — ESI = 1

- Exposed rocky shores are most common in the vicinity of the entrance to San Francisco Bay
- Exposed vertical seawalls are found throughout the study area
- They are exposed to high waves, strong currents, and/or frequent boat wakes

Predicted Oil Impact

- Oil will be held offshore by waves reflecting off the steep cliffs and seawalls
- Oil persistence will be short and will be a function of the wave energy during the spill; during high wave energy, oil will be removed in days
- Impacts to intertidal organisms are expected to be of short duration
- Marine birds and mammals using these rocky shores may be affected

Recommended Response Activity

- On very exposed shores, no cleanup is necessary
- On less exposed shores:
  - High-pressure spraying may be effective while oil is still liquid
  - Manual scraping of seawalls may be necessary for removal of tarry deposits
- Access is usually very difficult
- Cleanup of recreational areas may be necessary; high-pressure water spraying is effective while oil is still fresh

EXPOSED PIERS AND ROCKY PLATFORMS — ESI = 2

- Exposed pier structures are common in developed portions of the bay
- Exposed rocky platforms are not common in the study area
- The exposed pier structures are subject to strong tidal and river currents
- Pier structures may also provide habitat for barnacles, limpets, and mussels
- Rock platforms consist of wave-cut or low-lying bedrock

Predicted Oil Impact

- There may be a short-term oiling of the pile structures
- Persistence of oil is limited to days or weeks as a function of current and wave energies
- On rocky platforms, oil may be transported across the rock surface and accumulate along the high-tide line; fresh oil generally will not adhere to the intertidal surface
- Organisms may be killed, but recovery of populations can be rapid

Recommended Response Activity

- In most current/wave-exposed areas, cleanup is not necessary
- High recreational-use areas may be cleaned effectively using high-pressure water spraying if oil is still fresh
- Removal of organisms should be avoided
- If the pier structures are shown to be a source of oil, they may be cleaned to prevent reoiling of adjacent areas

FINE-GRAINED SAND BEACHES — ESI = 3

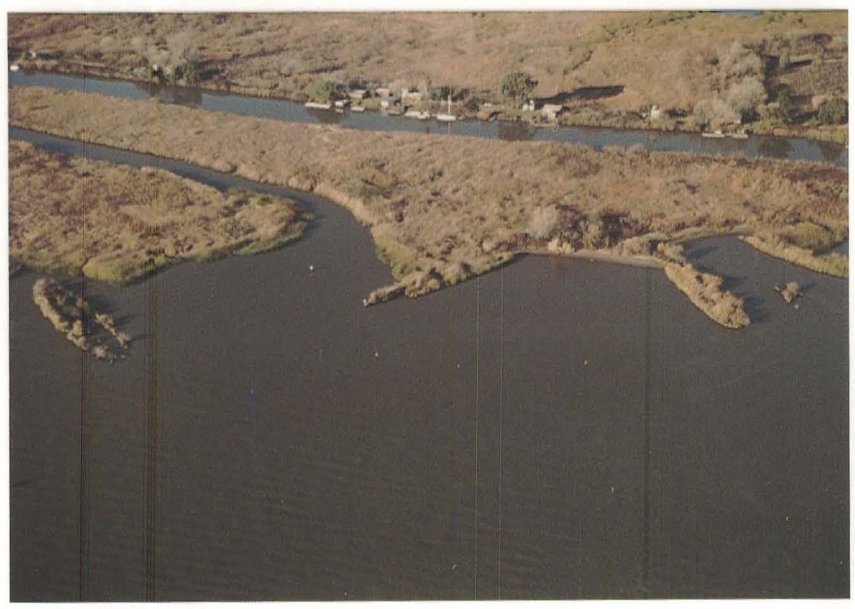
- Fine-grained sand beaches are the least common shoreline type in the study area
- These beaches are discontinuous and found associated with wetlands in more exposed settings only occurring in the vicinity of Sacramento and San Joaquin Rivers
- Fine-grained sand beaches are narrow and have gentle beach slopes, and beach infauna are scarce
- Wrack deposits are commonly found on the upper reaches of beach

Predicted Oil Impact

- During small spills, oil tends to be deposited at the high-tide line
- Large spills will cover the entire beach face
- Oil penetration into the beach sediments will be only a few centimeters, and burial by clean sand will be minimal

Recommended Response Activity

- Fine-grained sand beaches are among the easiest beach types to clean
- Oiled wrack and debris can be removed readily at any time; cleanup of oiled sediments should be conducted after most of the oil has come ashore to minimize potential for beach erosion
- Manual cleanup rather than use of heavy machinery is preferred



MEDIUM- TO COARSE-GRAINED SAND BEACHES ESI = 4

- Coarse-grained sand beaches are not very common throughout the study area
- Beaches typically are moderately wide with moderate slopes, and beach infauna are scarce
- These beaches are found most frequently in the vicinity of the bay entrance or exposed beach locations

Predicted Oil Impact

- During small spills, oil tends to be deposited at the high-tide line
- Large spills will cover the entire beach face
- Oil penetration into the sediments can be up to 25 cm
- Oil can be buried rapidly by clean sand to depths of up to 50 cm

Recommended Response Activity

- Cleanup should commence only after the majority of the oil has come onshore
- Cleanup should concentrate on oil removal from upper swash zones
- Sand removal should be minimal to avoid erosion problems
- Activity through the oiled sand should be limited to prevent grinding oil deeper into the beach
- Use of heavy equipment for oil/sand removal may result in the removal of excessive amounts of sand; manual cleanup may be more efficient

MIXED SAND, GRAVEL, AND FILL BEACHES ESI = 5

- These beaches are very common throughout the bay area
- They are composed of a mixture of medium- and coarse-grained sand, gravel of varying sizes, and fill (concrete, asphalt, bricks)
- In active beaches, organisms are scarce because of the mobility of the sediment
- In more stable beaches, moderate faunal species and diversity are present
- The large rocks and fill material also may provide habitat for barnacles, limpets, and crabs

Predicted Oil Impact

- Oil penetration may be high, with greatest penetration in coarse, well-sorted sediments (gravel) and coarse-grained fill material
- Under very heavy accumulations, oil may spread across the entire beach face with greatest concentrations along the high-tide swash zone
- Biota present may be killed by the oil, either by smothering or by lethal concentrations in the water

Recommended Response Activity

- Cleanup should commence only after the majority of oil has come ashore
- Oiled wrack and debris deposits should be removed
- Low-pressure spraying may be used effectively on gravel-rich beaches
- Removal of sediment should be limited
- Mechanical scraping and/or reworking of sediment is not recommended or effective
- Cleanup of the fill beaches would be difficult because of the irregular nature of the fill material

GRAVEL BEACHES AND EXPOSED RIPRAP ESI = 6

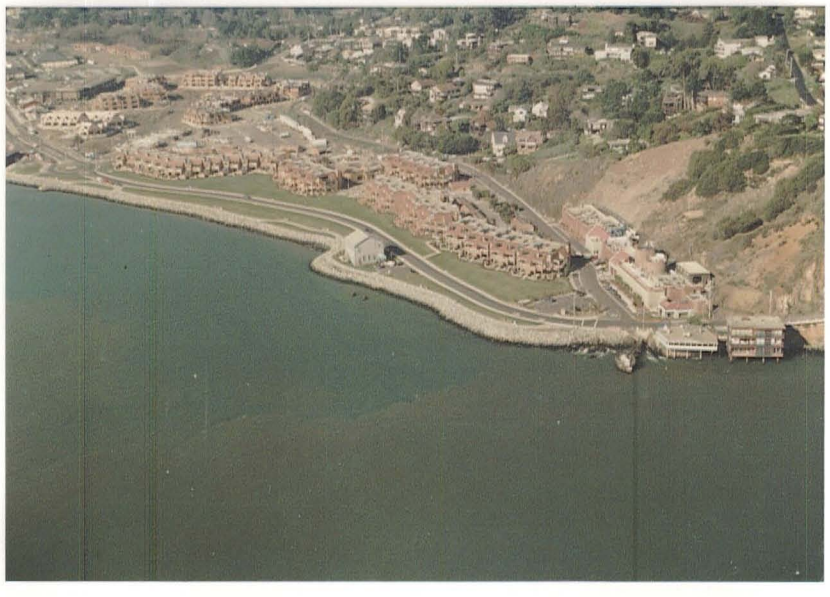
- This shoreline type is common throughout the study area
- Gravel beaches are commonly associated with headlands and frequently occur in areas with rocky shores
- Riprap structures generally are found in harbors and industrial sites
- Biomass is generally very low in high-energy (wave, current) areas; at calmer sites, faunal densities and species are high

Predicted Oil Impact

- Oil on gravel beaches would coat individual rocks and penetrate to several tens of centimeters into substrate
- Cavities in riprap structures may be completely filled
- Penetration would be greatest in areas of largest grain size and poorest sorting
- In exposed areas, waves will remove surface contamination
- If oil is left to harden in sheltered areas, an asphalt/gravel pavement may result
- In low-energy areas, buried oil will tend to seep out, generating sheens that can recontaminate the shoreline
- Resident fauna and flora may be killed by the oil

Recommended Response Activity

- On gravel beaches, heavily oiled wrack and debris should be removed
- There should be no permanent removal of sediments or riprap
- High-pressure spraying of oiled riprap and gravel may help in cleaning exposed surfaces but would have little effect on oil penetrated deeply into structures or gravel without extensive reworking
- In heavily oiled, sheltered areas, the sediments may have to be removed, cleaned, and replaced
- For small areas of impact, riprap units can be manually wiped or scraped to remove oil



EXPOSED SANDY TIDAL FLATS — ESI = 7

- Exposed sandy tidal flats are not very common throughout the study area
- They are composed of medium- to fine-grained sand mixed with some mud
- They are exposed to moderate wave energy, tidal currents, and/or river currents
- Species density may be high; clams and worms are most common

Predicted Oil Impact

- Most oil will be pushed across the flat as the tide rises
- Deposition of oil on the flat may occur on a falling tide if oil concentrations are heavy
- Penetration into water-saturated sediments will be limited
- Biological impacts to shellfish and birds may be severe

Recommended Response Activity

- Cleanup is generally not recommended
- Cleanup is very difficult (and possible only during low tides)
- The use of heavy machinery should be restricted to prevent mixing oil into the sediments and cannot be used in soft, muddier areas
- Cleanup should be concentrated on removing oil and oily debris along the high-tide line
- Shellfish should be monitored for lethal and sublethal effects

SHELTERED COASTAL STRUCTURES AND ROCKY SHORES — ESI = 8

- Sheltered coastal structures are commonly found in harbors and industrial sites
- They occur as long and short segments of various man-made structures (seawalls, docks, bulkheads, riprap revetments) in developed areas
- Sheltered rocky shores are not common in the study area and are found along rocky coasts
- These shoreline types provide habitats for limpets, mussels, barnacles, and other encrusting organisms

Predicted Oil Impact

- Oil will penetrate into the joints and voids of the structure
- Oil will coat the intertidal surfaces of solid structures and rocky shores
- Biota living on the structures and bedrock (barnacles, limpets, snails) would be impacted
- Oil may persist for weeks to months

Recommended Response Activity

- Low-pressure spraying of the structures and rocky shores may be required:
  - To remove oil
  - To prepare structures for recolonization of barnacles, mussels, etc.
  - For aesthetic reasons, in high-use recreational areas
  - To prevent the chronic leaching of oil from the structure

SHELTERED TIDAL FLATS — ESI = 9

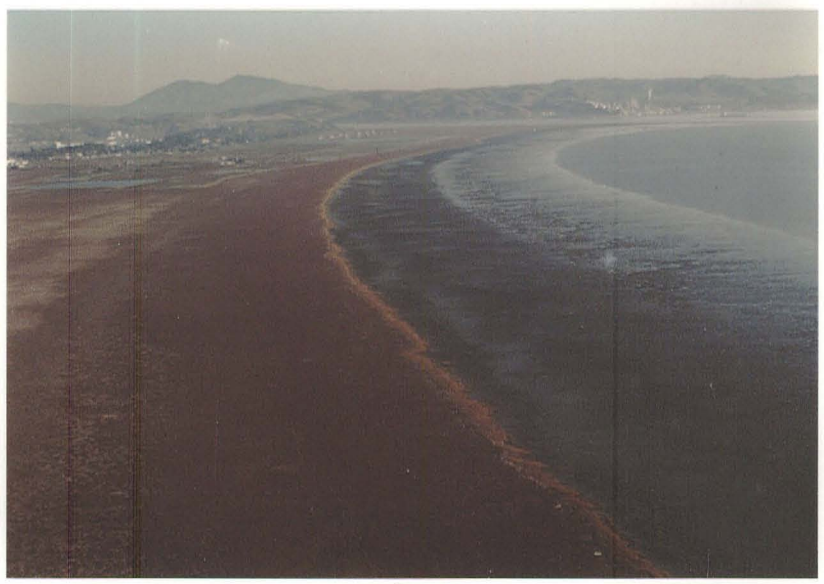
- Sheltered tidal flats are common throughout the study area
- They can be very wide, frequently up to 1 km across
- The largest sheltered tidal flats are found in San Pablo, Honker, and Grizzly Bays
- They are composed of very soft mud or sandy mud
- Although wave activity is low, these flats may be exposed to moderate tidal or river currents
- They may be used heavily by birds for feeding and as staging areas during migration

Predicted Oil Impact

- Oil is most likely to be transported across the tidal flat and deposited along the high-tide line
- Very heavy accumulations can cover much of the tidal-flat surface, but penetration will not occur into the water-saturated sediments of the flat
- In areas of high suspended sediments, sorption of oil can contaminate sediments that are eventually deposited on the flats
- When sediments are contaminated oil may persist for many years
- The common Pacific little neck and soft-shell clams will be severely impacted in areas of heavy oil accumulations

Recommended Response Activity

- These areas require high priority for protection during oil spills
- Cleanup of tidal flats is nearly impossible because of the soft substrate
- Cleanup is usually not even considered because of the likelihood of mixing oil deeper into the sediments during the cleanup effort
- If cleanup is necessary, it should be restricted to the upper reaches of the high-tide swash
- Passive cleanup efforts such as sorbent boom can be used to retain oil as it is removed naturally



WETLANDS ESI = 10

- Wetlands are common throughout the study area, though widely variable in extent as:
  - Small areas associated with streams entering bays
  - Moderate-sized marshes along the inside and at the head of major embayments
  - Extensive wetland areas along rivers
  - Expansive wetlands bordering the shoreline of upper and lower San Francisco Bay
- The moderate tidal range results in the presence of numerous tidal channels
- They are often fronted by tidal flats
- Marshes are heavily utilized by birds for nesting and feeding
- Numerous man-made dikes are commonly present in wetland areas

Predicted Oil Impact

- Small amounts of oil will contaminate the outer marsh fringe only; natural removal by wave and tidal energy can occur within months
- Large spills will cover more area and may persist for decades
- Spring tides can transport oil deep into the marsh, contaminating areas above normal tidal flushing
- Oil, particularly the heavy fuel oils, tends to adhere readily to marsh grasses

Recommended Response Activity

- Wetlands require the highest priority for shoreline protection
- Natural recovery is recommended when:
  - A small extent of marsh is affected
  - A small amount of oil impacts the marsh fringe
  - A small-to-moderate spill occurs during late fall or winter
  - There are no large concentrations of birds or mammals using the marsh
- The preferred cleanup method is a combination of low-pressure flushing, sorption, and vacuum pumping performed from boats
- Any cleanup activities should be supervised closely to avoid excessive disturbance of the marsh surface or roots
- Oiled wrack and other debris may be removed by hand