Sensitivity of Coastal Environments to Spilled Oil: Southern California

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1. INTRODUCTION

The southern California bight, from Santa Barbara to the Mexico border, is valuable for recreation, for commercial and industrial development, and as a wildlife habitat. Careful planning for the multiple use of limited coastal resources is critical for ensuring their continued usefulness.

This report describes an Environmental Sensitivity Index (ESI) specifically designed to reflect the environments and marine habitats present in southern California. The ESI can be used for rapid evaluation of the hazard of an oil spill and for detailed prespill planning for effective spill responses.

1.1 The Need for Prespill Planning

The active development of offshore hydrocarbon resources in Santa Barbara Channel and the Gulf of Catalina continually presents the possibility of accidental oil spillage. (The blowout of an offshore oil well in the Santa Barbara Channel in 1969 remains the largest to occur in U.S. waters.) Additional risks of oil spillage are associated with tanker transport of Alaskan and foreign crude oils into southern California ports. The Bureau of Land Management (1979, Vol. 2) estimated that approximately ten spills of 1,000 barrels or more will occur between 1979 and 2000. Detailed prespill contingency plans for the area have been prepared by the oil industry, including the formation of oil spill cooperatives to respond to spills. Government agencies at the Federal, state and local level have also developed contingency plans to deal with spills should they occur. The ESI serves as an adjunct to each of these plans.

1.2 The Environmental Sensitivity Index

The Environmental Sensitivity Index comprises the following specific information needed for planning purposes and field response to decrease impacts associated with an oil spill:

> Geological data--ranking shoreline types in relation to potential spill damage and persistence.
>
> Biological data--delineating the location and range of major spill-sensitive marine species or groups.

Table 1.--Principal oil spills and references that serve as a basis for the Environmental Sensitivity Index

Oil spills	Date	Type and amount	Studies
WW II tankers, United States East Coast	Jan.-June '42	Various; 533,740 tons	Campbell et al. (1977)
Torrey Canyon, Scilly Isles, U.K.	Mar. '67	Arabian Gulf crude: 117,000 tons total; 18,000 tons onshore	Smith (1968)
Santa Barbara blowout	Jan. '69	California crude; 11,290 to 112,900 tons total; 4,509 tons onshore	Foster et al. (1971)
Arrow, Chedabucto Bay, Nova Scotia	Feb. '70	Bunker C; 18,220 tons total	Owens (1971); Vandermeulen and Gordon (1976)
Metula, Strait of Magellan, Chile	Aug. '74	Saudi Arabian crude; 53,000 tons total; 40,000 tons onshore	Blount (1978); Hann (1974)
Urquiola, La Coruña, Spain	May '78	Arabian Gulf crude; 110,000 tons total; 25,000-30,000 tons onshore	Gundlach and Hayes (1977); Gundlach et al. (1978)
Amoco Cadiz, Brittany, France	Mar. '78	Arabian Gulf crude; 223,000 tons total	Gundlach and Hayes (1978); Hayes et al. (1979)
Howard Star, Tampa Bay	Oct. '78	Crude and distillate approx. 140 tons	Getter et al. (1980a)
Peck Slip, Eastern Puerto Rico	Dec. '78	No. 6 oil; 1,500 tons	Getter et al. (1980b); Gundlach et al. (1979)
Ixtoc I, Gulf of Mexico	June '79 to Apr. '80	Crude oil; several hundred thousand tons	Getter et al. 1980c); Gundlach et al. (1981)
Burmah Agate, Texas	Nov. '79	Crude and refined product	Thebeau and Kana (1981)

Socioeconomic data--delineating the location of special-use areas.

Spill-response data--indicating primary methods of responding to an oil spill.

The index was applied to southern California through field study of the region and review of the literature. The kinds of information to be included in the index were determined from investigations of actual spills (table 1), including several of the largest spills in history (Amoco Cadiz, Metula, Urquiola). The concept was tested in Texas by the Federal response organization at the Ixtoc I and Burmah Agate spills during 1979.

Indexes have been compiled for other areas as well: Alaska, Puget Sound (Washington), Massachusetts, south Florida, and South Carolina (fig. 1). Development and application of the indexes have been reported by Gundlach et al. (1980 a and b), Hayes et al. (1980a), Getter et al. (1981), and Domeracki et al. (1981). The information included in the index for southern California has been recorded on 40 Geological Survey quadrangle maps and 7 National Ocean Survey navigation charts (fig. 2). The maps are available for review through NOAA's Office of Marine Pollution Assessment in Seattle, Washington. The maps are not intended to supplant local input to the spill response process, but to provide government and private response teams with an easily accessible summary of key areas needing immediate response or protection. The maps also provide a working mechanism to make possible combined Federal, state, and local participation in spill response planning activities.

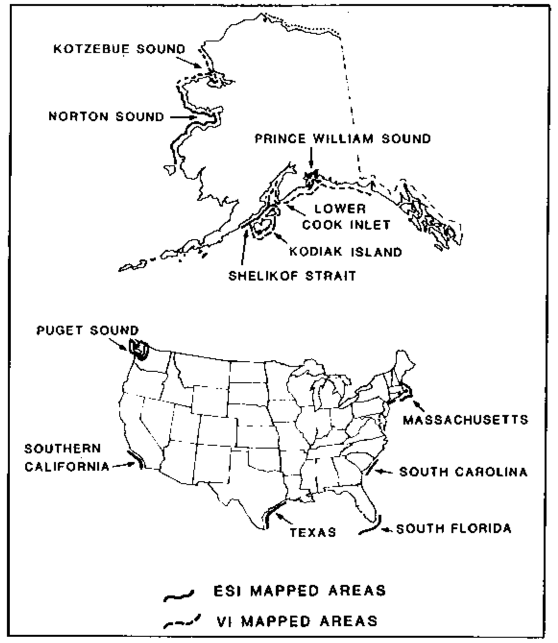

Figure 1.--Areas in Alaska and the lower 48 states that have been mapped according to the Vulnerability Index (VI) (Gundlach and Hayes, 1978b) or the Environmental Sensitivity Index (ESI) (Hayes et al., 1980a). The ESI includes the addition of critical biological and socioeconomic resources. The Beaufort Sea coastline was mapped by Nummedal and Ruby (1979) using a specially developed retention index.

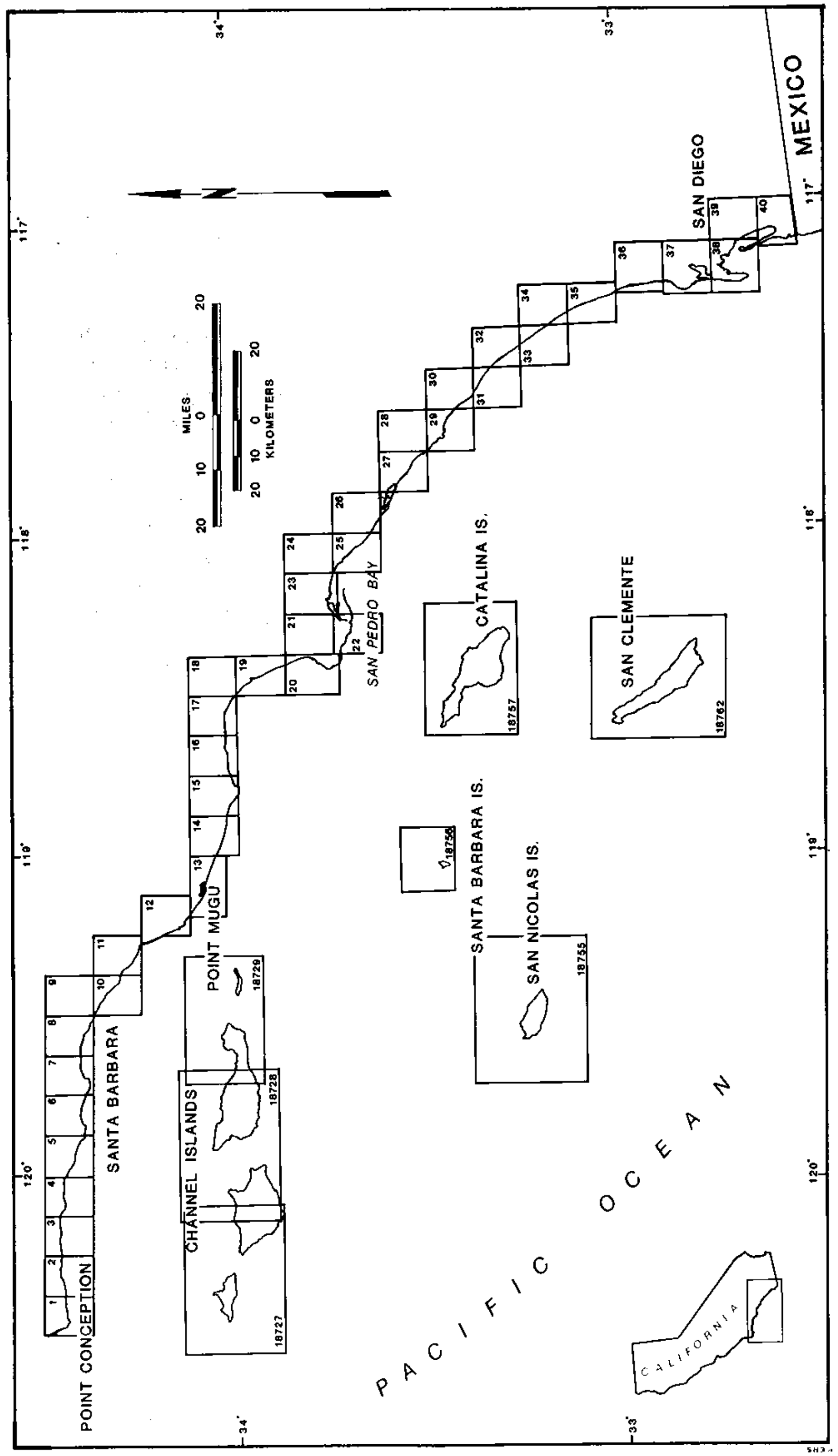

Figure 2.--Individual oil spill Environmental Sensivity Index maps of areas included in Southern California study. Numbers on continental maps refer to the ESI map series. Numbers on offshore island maps refer to NOS navigation chart numbers.

2. SOUTHERN CALIFORNIA PHYSICAL SETTING

The climate and physical oceanography of the southern California region have been documented by Dailey et al. (1974a). Most of the descriptions that follow have been extracted from their publication.

2.1 Climate

The coastal zone of the region is classified as semitropical, with cool dry summers and a winter rainy season. The development and movement of the Pacific Subtropical Anticyclone is the dominant weather factor. Mean January temperatures are in the mid-50°F range; mean August temperatures are in the upper 60°F range. The ocean has a strong moderating effect on both summer highs and winter lows.

2.2 Winds

The Pacific Anticyclone also dominates the region's wind patterns. Strong, consistent northwesterly winds dominate the summer pattern. Winter winds are also generally northwesterly, but are more variable because of wind shifts associated with high- and low-pressure system frontal passage. A summary of winds offshore the area is presented in fig. 3.

Very local wind patterns are created in the coastal zone when land or sea breezes develop. Onshore sea breezes dominate in summer; offshore land breezes dominate in winter.

2.3 Physical Oceanography

Winds occurring over a large area of the northern and southern Pacific Ocean can generate waves that reach the southern California coast. During winter and spring, waves generated in the north Pacific approach the coast from the west. In summer and fall, waves from the south Pacific predominate, approaching the coast from the south and southwest. Wave heights generally range from 1 to 2 meters.

Tides of the region are mixed semidiurnal, with two highs and two lows of different height each day. The range of tides is from 1 to 3 meters.

The alongshore or littoral currents from Santa Barbara to San Diego in the area are generally from north to south. From San Diego to the Mexico border the currents are from south to north (California Dept. of Navigation and Ocean Development, 1977). Shoreline sediment is supplied from river runoff and is lost through current transport down submarine canyons. Accretion and erosion of shoreline sediments are controlled by a number of factors including river flow volume and storm-produced waves. As a result of this cycle some beaches vary in composition from sand to gravel, depending on time of year and storm conditions.

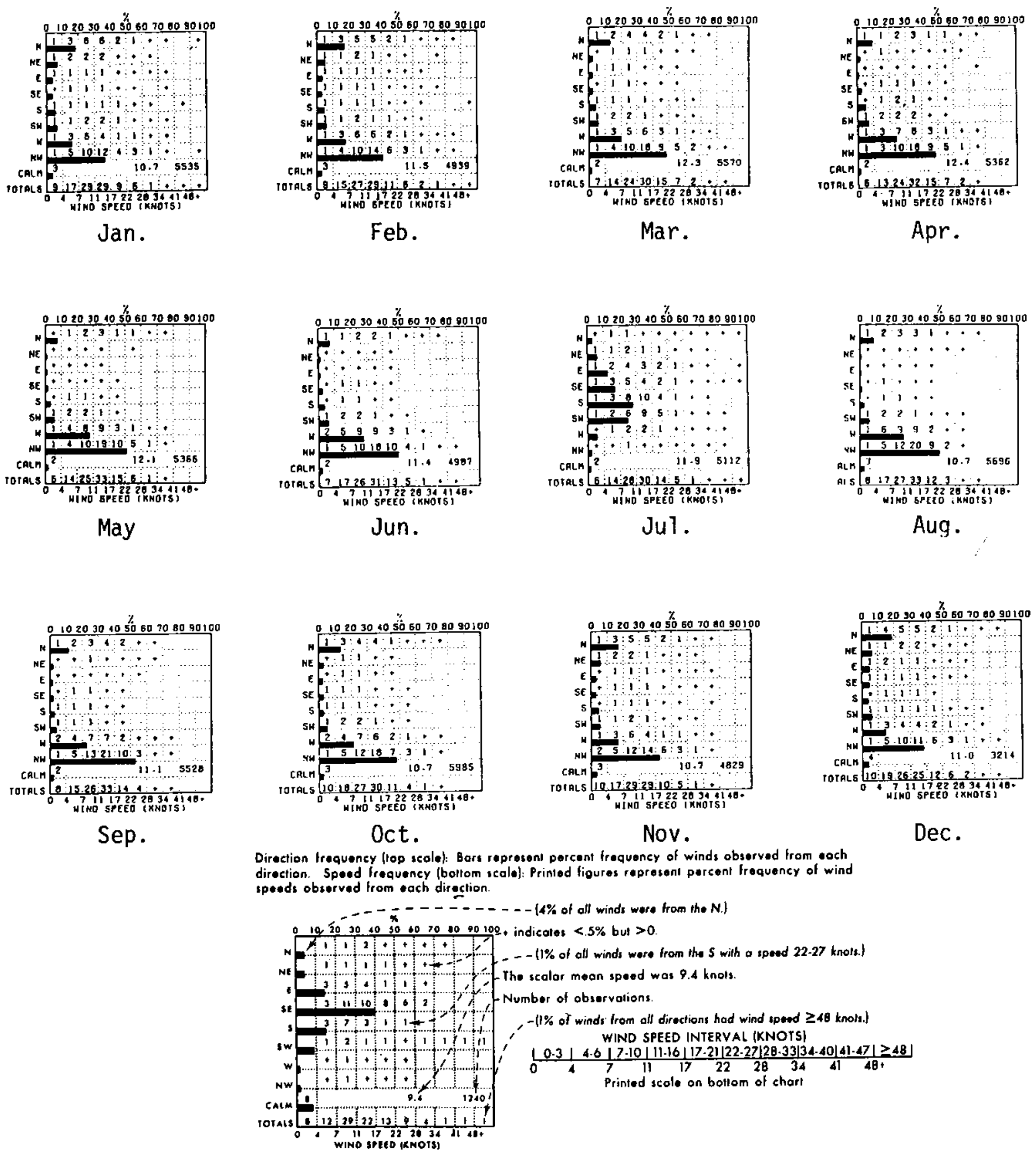

Figure 3.--Yearly winds for the area offshore Long Beach (U.S. Navy, 1977).

3. METHODOLOGY

3.1 Shoreline Characterization

Field work was undertaken from 27 November through 3 December 1981. The shoreline was classified primarily by low-altitude aerial survey with ground stations to verify observations and to determine the biology associated with each type. Fifteen stations were surveyed on the mainland. Because of limited resources, offshore areas were classified solely by aerial survey.

During the aerial survey, shoreline types were marked in colored ink on 1:24,000-scale USGS topographic maps. In addition, reference photographs were taken of most of the shoreline. All observed bird rookeries and seal haulout areas were marked on the maps for comparison with published data.

The ground survey included visual assessment of substrate characteristics (e.g., poorly sorted, coarse-grained sand) and a rapid determination of infauna, epiflora, and epifauna. Sieving was used to find infauna on soft-sediment beaches. Transects were run along rocky shores, and the fauna and attached algae were identified to genus or species level. Reference keys, primarily Dawson (1966), Hinton (1969), and Small (1974), were used for identification.

3.2 Biological Resources Evaluation

Important biological resources were identified from the extensive literature base that exists for southern California coastal environments. The primary information used in the mapping project came from Dailey et al. (1974a, b, c), Blunt (1980), Sowls et al. (1980), and California Coastal Commission (1980).

In addition, the National Park Service provided specific information for the Channel Islands National Park. Numerous other Federal, State, county, and private sources were also consulted. A complete list of sources is contained in Appendix I. In assembling the ESI maps, information sources were cross checked for each category of resources. If conflicts occurred, data were considered acceptable in these situations:

- Information from two or more sources agreed.
- Information was most recent or site specific.
- Information was from the agency with legal or trustee responsibility for a resource.

Finally draft copies of the maps were reviewed by representatives of local resource agencies and other knowledgeable persons for accuracy and to provide specific local knowledge that might otherwise be unattainable. A complete list of reviewers is contained in Appendix II.

3.3 Socioeconomic Information

Socioeconomic information is included on the ESI maps to highlight areas that have special uses, such as parks, or have been specially designated for unique values, such as ecological areas. This information is provided to assist response teams in evaluating measures for protection or cleanup. Public marinas are marked to indicate possible launch sites for small boats and boom equipment. Inner-harbor structures and dock areas are also indicated on the maps.

Primary sources of socioeconomic information were the same as those listed for biological resources.

3.4 Spill Response Information

During the low-altitude aerial survey, appropriate locations for open-water booms, harbor booms, mobile skimmers, and inlet closures were marked on the maps in consultation with USCG Petty Officer Don Gutknecht of the Pacific Strike Team. Locations were based on "best judgment" with respect to previous experience and observed wave, wind, and tidal conditions. Recommendations have been made only for mainland areas.

4. THE ENVIRONMENTAL SENSITIVITY INDEX SPECIFIC TO SOUTHERN CALIFORNIA

4.1 Geomorphic Information

Table 2 lists the shoreline types of southern California in order of increasing potential for long-term spill persistence and biological damage. A short discussion of each type is presented below.

Table 2.--ESI ranking of Southern California shoreline types

Rank	Shoreline types
1	Exposed rocky headlands and exposed seawalls.
2	Wave-cut platforms with or without thin sediment cover.
3	Fine-grained sand beaches.
4	Exposed medium- to coarse-grained sand beaches.
5	Sheltered sand beaches.
5a	Mixed sand, gravel, cobble, and boulder beaches.
6	Exposed, gravel/boulder beaches and exposed riprap structures.
7	Not present in study area (exposed tidal flats).
8	Sheltered gravel/boulder beaches and sheltered riprap structures.
9	Sheltered tidal flats.
10	Marshland.
Unranked.	Sheltered inner-harbor structures.

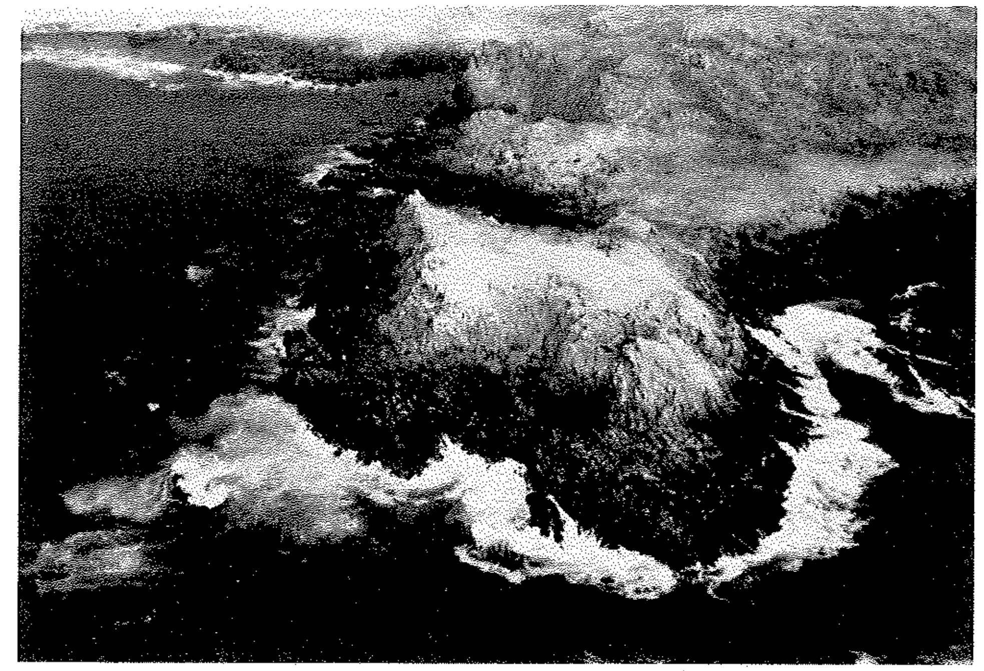

Figure 4.--Example of ESI=1, an exposed rocky shoreline on San Clemente Island. Oil impact along this high-energy shoreline would be short term.

(1) <u>Exposed Rocky Headlands</u>

Common on Palos Verdes Peninsula, Sunset Cliffs area, and offshore islands. Usually associated with ESI ranks 2 and 7.

Consist of sedimentary rocks (mostly Tertiary) exposed as steep headlands which are eroding more slowly than adjacent wave-cut platforms. Commonly, the intertidal zone has a rich epibiotic growth and displays a narrow (1-2 m) wave-cut terrace at the low-tide position. Sediment accumulations (gravels to boulders) are sometimes present at the base of the headland, owing to mass wasting processes associated with sea cliff retreat (e.g., the southeastern coast of San Clemente Island).

Along very steep shores, most oil would be held offshore by reflected waves and any oil deposited would be rapidly removed. On less steep shores, the upper intertidal and supralittoral zones would be most heavily oiled, and would take 6 to 9 months for natural removal.

Greatest exposure would be to upper intertidal, supralittoral, and tide pool organisms. Impact to fauna and flora would be low, owing to short-term persistence. Mortalities may be caused by smothering in cases of heavy oiling. Removal of grazers may cause temporary increased productivity of attached algae. Many bird species (alcids, gulls, terns) nest on offshore, exposed rocky headlands and spend much time in nearshore waters. These birds would be oiled as they attempt to land in waters becalmed by oil.

Cleanup of steep shores would not be necessary. On less steep shores, high-pressure spraying would be effective only while the oil remains liquid.

Figure 5.--Example of ESI=2, a wave-cut platform at Laguna Beach. For the most part oil would pass across the platform on an incoming tide, but could injure resident biota.

(2) Wave-Cut Platforms

Common at Sunset Cliffs, Palos Verdes Peninsula, Laguna Beach, Santa Barbara to Point Conception and the offshore islands. Commonly associated with ESI ranks 1, 3, 4, 6, and 7.

Consist of sedimentary bedrock headlands eroded back into a wide platform backed by a steep sea cliff. Rock platforms sometimes are formed by flat-lying resistant strata at sea level. These platforms usually have some epifloral growth, but epifaunal density varies greatly.

The richest epibiotic cover on this shoreline type is present in the Laguna Beach area and on Santa Barbara and San Nicholas Islands. Wave-cut platforms in high human-use areas (e.g., Point Fermin, Cabrino National Seashore) generally have sparse growth. Commonly these platforms have a thin covering of sediment, ranging in size from fine-grained sand (e.g., Santa Barbara to Point Conception) to boulder and cobble (e.g., Channel Islands). Where an unconsolidated sediment cover is present, the substrate is highly mobile and adversely affects colonization by organisms.

Short-term persistence of oil would occur along the upper intertidal sediments (thin sand veneer and gravel).

Oil remaining in the upper intertidal and supralittoral zones would smother barnacles and snails, and would retard recolonization in proportion to its persistence. Oil seeping into the cracks and crevices between rocks would impact "underrock" organisms. Though attached algae have a mucilaginous covering that provides some protection from oil, associated epifauna might be contaminated by the oil, causing die-off by mechanical (smothering) or physiological (ingestion or absorption) means.

High-pressure spraying of the rocks may be an effective method of cleanup. For thick oil accumulations, manual/mechanical cleanup is recommended with caution.

Figure 6.--Example of ESI=3, a fine-grained sand beach at Malaga Cove. The compact nature of the substrate inhibits oil penetration and aids cleanup.

(3) Exposed Fine-Grained Sand Beaches

Common from Port Hueneme to Point Conception. Usually associated with ESI ranks 2 and 4.

The sediment is highly reworked and sorted by wave action and accumulates in pockets between headlands and on long stretches of wave-cut platform. Epibiota are absent to rare; infauna are seasonally found in low to moderate densities and low diversity. Fine-grained sand beaches tend to have very flat profiles and are of variable width.

Large accumulations of oil would cover the entire beach face. Small accumulations would be deposited primarily along the high-tide swashlines. The compact sediments of this beach type prevent deep penetration of the oil, but oil may be buried to a maximum of 10-20 cm along the upper beach face.

Biological damage would be limited. Intertidal organisms would have short-term exposure because the oil would be deposited over the berm crest.

Cleanup should begin only after the majority of the oil has been deposited onshore. Cleanup should concentrate on removal of oil from the upper swash zone. Mechanical methods should be cautiously used; however, in general, fine-grained sand beaches are among the easiest to clean mechanically because of their hard, compact substrate. Removal of sand should be minimized.

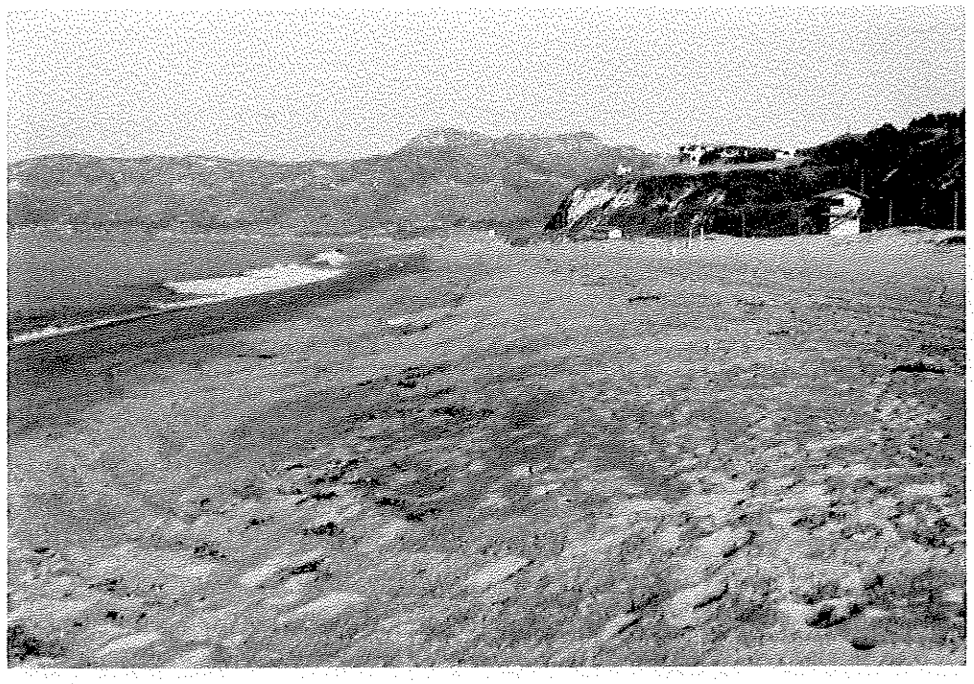

Figure 7.--Example of ESI=4, a coarse-grained sand beach at Zuma Beach. On coarse-grained sand beaches, cleanup is more difficult than on fine-grained beaches because oil penetrates deeper and more rapidly into the sediment.

(4) Exposed Coarse-Grained Sand Beaches

Common throughout the mainland coast. This sediment is rich in heavy minerals and is highly reworked by wave action. This beach type exhibits high berms, cusps, steep profiles, and variable width owing to seasonal variations in wave energy and cycles of erosion and deposition. Biota are not especially common (being somewhat less present than on ESI rank 3).

Large accumulations of oil would cover the entire beach face. Small accumulations would be deposited along the high-tide swashlines. Oil may be buried deeply along the berm and berm runnel.

Biological damages would be minimal. Where oil penetrates the substrate, some die-offs of infauna would be expected.

Cleanup should occur after a majority of the oil has been deposited onshore. Cleanup should concentrate at the upper swash zone. Mechanical methods should be used cautiously and sand removal kept to a minimum.

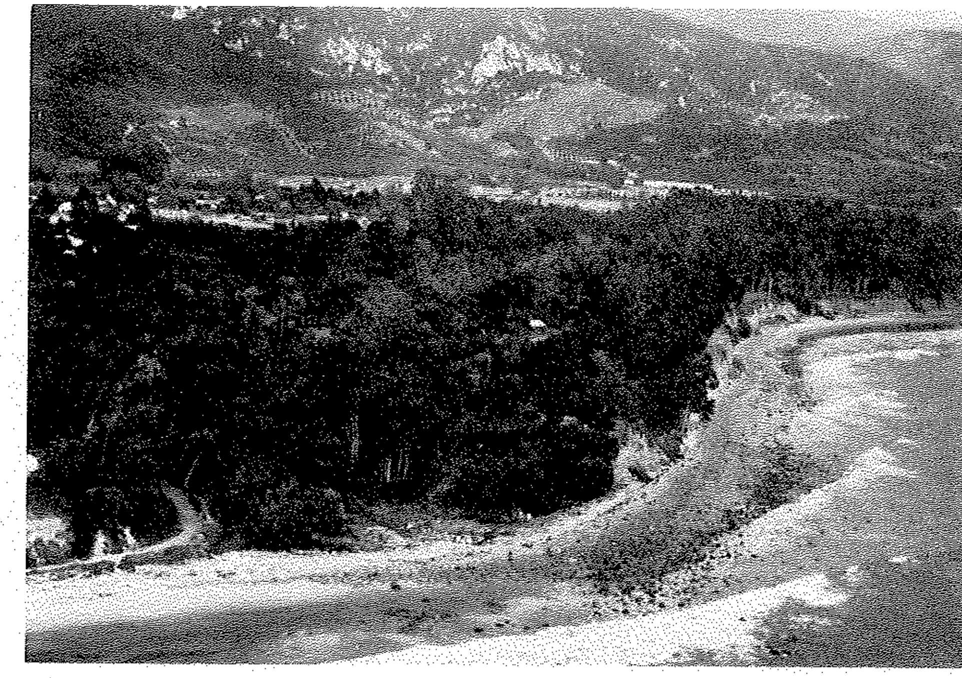

Figure 8.--Example ESI=5, an aerial view of an exposed, mixed sand and gravel beach near Santa Barbara. Oil would probably persist longer on this beach type than along shorelines of lower ranking.

(5) Exposed Mixed Sand and Gravel Beaches

Common near Oxnard and Ventura. This shoreline type is scattered throughout the area; it is usually present where there is a local source of coarse-grained material. Epibiotic growth is sometimes present on cobbles and boulders in areas of low to moderate substrate mobility (mainland coast), and is absent in areas of high wave energy (pocket beaches on the offshore islands).

Oil would be deposited primarily on the upper beach face and, during heavy accumulations, on the lower beach face. Burial may be deep along the berm. Long-term persistence of oil would be dependent on incoming wave energy. The lower the energy, the longer the persistence.

Biological damage would be minimal in highly mobile substrate. In low to moderate substrate mobility, damage would be moderate to high. Heavy oiling would smother epibiotic communities. Infauna would be affected by oil percolating through the coarse sediments.

Oil should be removed primarily from the upper swashlines. High-pressure spraying may be necessary. Under heavy accumulations, mechanical reworking of the sediment into the surf may be necessary. Sediment removal should be minimized.

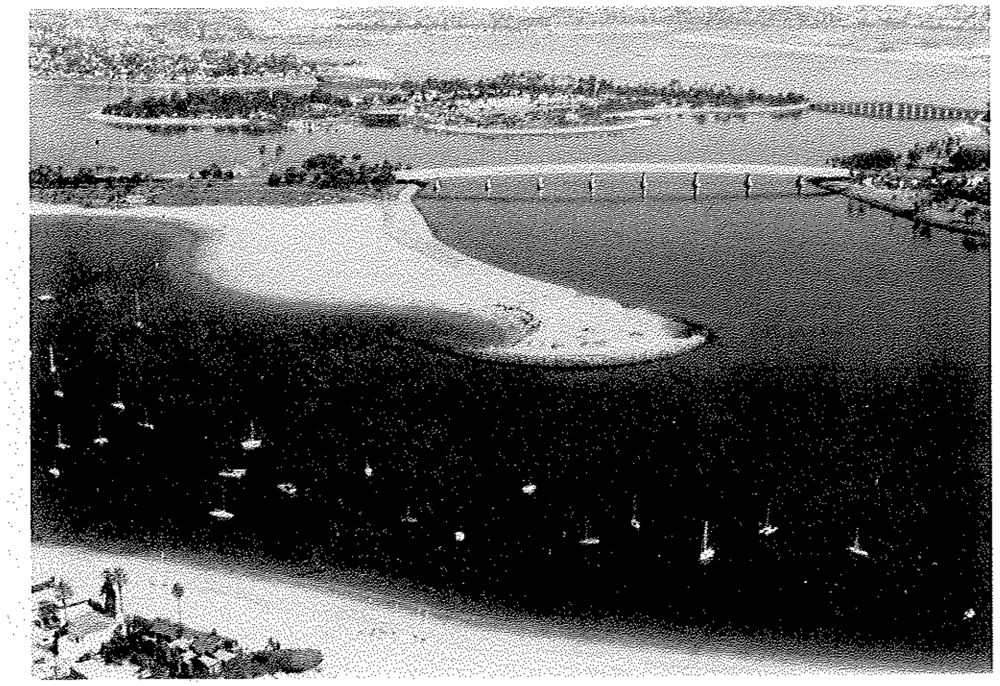

Figure 9.--Example of ESI=5a, sheltered sand beaches located in Mission Bay. Because of the sheltered nature of this environment, any stranded oil would persist for a long time. Cleanup would be necessary.

(5a) Sheltered Sand Beaches

Present in embayments (e.g., Mission Bay) and usually associated with ESI rank 8 and inner-harbor structures.

These beaches tend to be artificially developed areas near marinas, parks, and hotels. They are in very sheltered areas and exhibit little to no marine life. This shoreline type is also present behind sand spits and in coastal lagoons.

Large accumulations of oil would cover the entire beach face. The compact sediments of this beach type would prevent deep penetration of oil.

Biological damage would probably be low. Birds using these beaches for roosting may become contaminated.

Cleanup is necessary because of the sheltered nature of the habitat. Sand removal should be minimized.

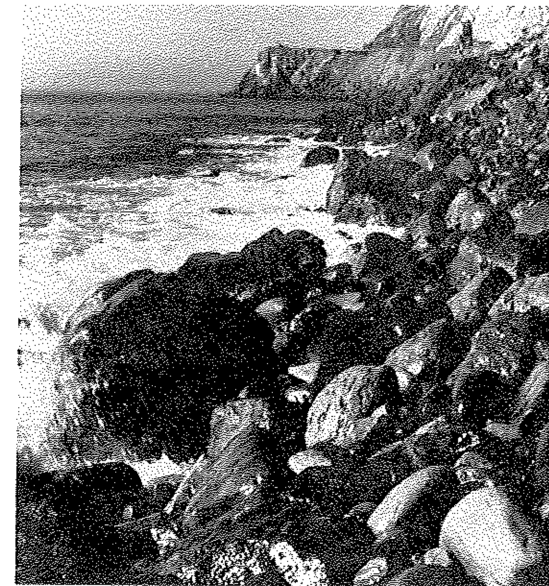

Figure 10.--Example of ESI=6, an exposed gravel/boulder beach located near Point Mugu. Oil can penetrate deeply into this very coarse-grained beach type.

Figure 11.--Example of ESI=6, an exposed riprap jetty located at Oxnard. This artificial shoreline acts similarly to exposed gravel/boulder beaches.

(6) Exposed Gravel/Boulder Beaches and Exposed Riprap

Exposed gravel/boulder beaches are present throughout the area and are usually associated with ESI ranks 1 and 2. They exhibit better sorting of coarse-grained material than ESI rank 5.

Occurrence is common in pockets between rocky headlands as a sediment veneer on wave-cut platforms and as tombolos (especially on the offshore islands).

Riprap is a very commonly used material for seawalls, harbor structures, groins (within both harbors and marinas), and along stretches of mainland coastline where coastal erosion is a problem.

Oil would be deposited primarily on the upper beach face and would percolate easily into the sediments. Burial would be exceptionally deep along the berm of the gravel beaches. Oil would percolate easily between the gravel and boulder elements of riprap. Heavy oils would adhere to the irregular surfaces of the boulders. The lighter oils would be removed by wave actions.

In areas of mobile substrate, biological activity is limited. On stable gravel beaches and riprap, epibiota living in the protected cracks and crevices may be impacted from oil that percolates down.

Cleanup for the gravel beaches may include high-pressure spraying and mechanical reworking of the sediment into the surf zone. Removal of the sediment should be restricted. High-pressure spraying may be required for oiled riprap.

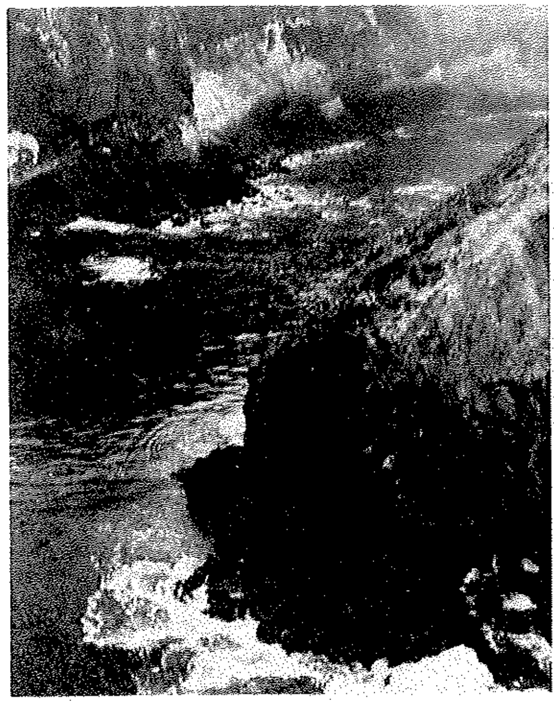

Figure 12.--Example of ESI=8, a sheltered cove located on Santa Barbara Island. Attached flora and fauna may be abundant. Oil may persist for several months depending on the degree of sheltering. This shoreline type is not common in the study area.

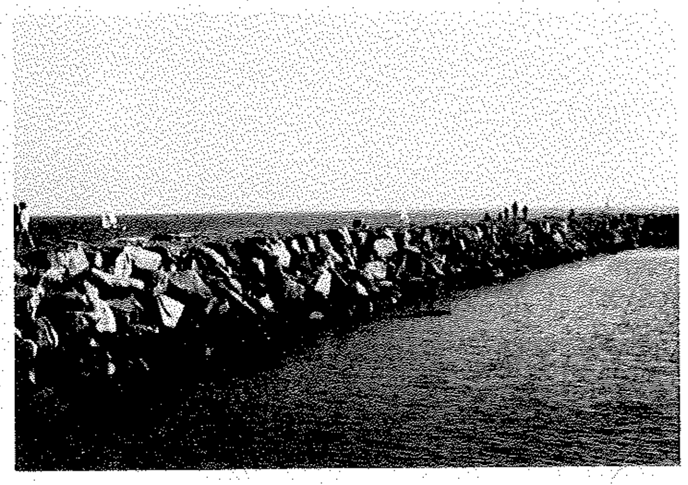

Figure 13.--Example of ESI=8, a sheltered riprap seawall along the interior of Dana Point Harbor. This shoreline type would show persistence of oil similar to that of sheltered rocky shorelines, although attached biota may be less.

(7) Exposed Tidal Flats (high biomass)

Not present in study area.

(8) Sheltered Rocky Shores and Sheltered Riprap

Sheltered rocky shores are not common to this area; sheltered riprap structures are found within harbors. Along the latter shoreline, epibiotic growth is generally poor to absent, owing to the foul harbor waters; however some areas do contain a fairly abundant cover.

Oil persistence for both would be long term (1-1½ years), especially between rocks and boulders. Oil would percolate down between the cracks and crevices of the riprap.

In areas of abundant cover, biological damage could be long term because of the long-term persistence of the oil.

High pressure spraying may be effective for cleanup, but caution should be taken in areas of high biomass.

Figure 14.--Example of ESI=9, a sheltered tidal flat at Soledad Valley. A marsh area surrounds the flat. Oil would persist for several years if stranded in the environment

(9) Sheltered Tidal Flats

Uncommon in the area, but present within small bays (esteros) and in some harbors. They are composed of mud or silty sand and are sheltered from major wave and tidal activity. Tidal flats are usually devoid of vegetation.

This shoreline type is always associated with a marsh. Sheltered tidal flats have a dense and diverse infaunal population and are important to birds.

Oil persistence would be long term (several years) because of lack of wave and tidal activity. Long-term oil incorporation into the sediments is common.

Extensive die-offs of infauna would be expected from smothering and ingestion. Recovery would be slow; oil persistence would be long term. Stressed clams move to the surface attracting birds and other scavengers that may become contaminated. Roosting birds would be susceptible to feather oiling.

Where sediment is compact, manual and mechanical cleanup may be effective for massive accumulations. Traffic over the flat should be limited.

Figure 15.--Example of ESI=10, an aerial view of a marsh located in Mugu Lagoon. Fine-grained sand spits form an entrance to the marsh system. Several tidal flats are also present. Oil would be most damaging if it reached this environment. Booms should be placed to prevent oil from entering.

(10) Marshes

Present in esteros, coastal lagoons behind mainland coast beaches, and at river mouths.

The salinity of the marsh water is highly variable (ranging from freshwater to seawater). Marsh areas are used by numerous types of birds. This shoreline type is rare on the offshore islands.

The primarily Spartina-dominated intertidal marsh areas are highly productive. This high productivity helps to support benthic communities and fish populations associated with marshes.

Long-term oil persistence (5-10 years) is common with heavy oil accumulations. Small quantities of oil are usually deposited along the marsh fringe. Large quantities may cover an entire marsh.

Long-term exposure to oil would damage marsh plants and affect epifauna and infauna.

Under light oiling the marsh should be allowed to recover naturally. Cutting of oiled fringing marsh plants or low-pressure spraying may be effective. Vehicles and cleanup crews should avoid activity on the marsh surface where possible.

Figure 16.--Example of inner-harbor structures at Oxnard. This category, unranked, includes area of high recreational importance as well as industrialized zones.

(Unranked) Inner-Harbor Structures

Includes bulkheads, piers and docks. This shoreline type is unranked because of very low associated biological activity. In commercial areas it has already been subjected to varying levels of pollution. Highly developed residential areas having boat moorings and seawalls are marked as having socioeconomic importance.

Typically these structures are found in a low-energy environment, dependent on seasonal storm activity. Barnacle communities may be attached to pilings or bulkheads.

4.2 Specific Biological Information

The ESI maps outline the location of critical biological resource areas with respect to oil spill impact. The locations of feeding and breeding grounds of certain important species are also indicated.

This section presents five major groups of wildlife: (1) marine mammals, (2) marine birds, (3) reptiles, (4) finfish, and (5) shellfish. Summaries are given for major species present along with information concerning species distribution and the effects of oiling.

4.2.1 Marine Mammals

Cetacean Species Common to Study Area† (Dailey et al., 1974b)

Species	Location	Time
+*California Gray Whale Eschrichtius gibbosus	Migration near shore; females/calves near islands	December-April migration south, then north
Common Dolphin Delphinus delphis	Throughout area	Year-round, summer calving
Pacific Striped Dolphin Lagenorhynchus obliquidens	Catalina Channel offshore waters	Year-round, spring-summer breeding
Dall porpoise Phocoenoides dalli	Throughout area 10-20 miles offshore	Year-round, abundant winter-spring
Killer Whale Orcinus orca	Catalina Channel, Channel Islands	Year-round, more abundant with gray whales

†All species are protected by All-Marine Mammal Protection Act of 1972
*Protected by Endangered Species Act of 1973
+Protected by Convention on International Trade in Endangered Species of Wild Fauna and Flora

Possible Impacts:

- Stress may occur through ingestion of oil-contaminated food, oil intake through blowholes, eye irritation, and skin absorption.

Pinnaped Species Common to Study Area† (OCZM, 197?)

Species	On Land	Pupping	Breeding	Nursing
Northern Fur Seal Callorhinus ursinus	May-November	Late May-mid-August	Late May-mid-August	Late May-November
Harbor Seal Phoca vitulina	Year round	March-April	April-May	March-May
Northern Sea Lion Eumetopias jubatus	May-Nov.	June	June	June-Nov.
California Sea Lion Zolophus californianus	Year round	June	June-July	June-Nov.
*Northern Elephant Seal Mirounga angustirostris	Year round	Late Dec.-late Feb.	January-mid-March	Late Dec.-mid-March
*Guadalupe Fur Seal Arctocephalus philippii	Year round	NA	NA	NA

†All species are protected by All-Marine Mammal Protection Act of 1972.
*Protected by Convention on International Trade in Endangered Species of Wild Fauna and Flora

Possible Impacts:

- Eye irritation (Geraci and Smith, 1976).
- Death of already stressed seals (e.g., emaciated, late molting, captive), from additional stress of oil contamination (Geraci and Smith, 1976).
- Thermoregulatory stress in preweaned pups, which have not yet developed insulating fat layers.
- Disturbance of feeding and reproductive activities by aircraft and cleanup activities.
- Ingestion of oil during nursing by young (BLM, 1979, Vol. 2)

4.2.2 Marine Coastal Birds

Bird Species Common to Study Area† (Dailey et al., 1974b)

Common Name	Species	Occurrence
Diving Birds		
Brown Pelican*	*Pelecanus occidentalis*	Year round; islands, mainland (coastal)
Double-Crested Cormorant	*Phalacrocorax auritus*	Year round; islands, mainland (coastal)
Brandt's Cormorant	*Phalacrocorax penicillatus*	Year round; islands, mainland (coastal)
Pelagic Cormorant	*Phalacrocorax pelagicus*	Year round; islands, mainland (coastal)
Waterfowl		
Red-Necked Grebe	*Podiceps grisegena*	Winter; coastal
Black Brant	*Branta nigricans*	Winter; coastal
Shorebirds/wading birds		
Black oystercatcher	*Haematopus bachmani*	Year round; island beaches
Snowy Plover	*Charadrius alexandrinus*	Year round; island, mainland beaches
American Avocet	*Recurvirostra americana*	Year round; island, mainland marshes
Belding Savannah Sparrow+	*Passerculus sandwichensis beldingi*	Year round; mainland beaches, marshes
Clapper Rail *+#	*Rallus longirostris*	Year round; mainland marshes
Black-Necked Stilt	*Himantopus mexicanus*	Year round; mainland marshes
Killdeer	*Charadrius vociferus*	Year round; island, mainland marshes
Gulls and Terns		
Western Gull	*Larus occidentalis*	Year round; islands, mainland (coastal)
Least Tern*	*Sterna albifrons*	Spring, summer; beaches, intertidal
Elegant Tern	*Sterna elegans*	Summer; beaches
Alcids, Petrels		
Cassin's Auklet	*Ptychoramphus aleuticus*	Year round; islands (coastal)
Pigeon Guillemot	*Cepphus columba*	Year round; islands (coastal)
Xantus' Murrelet	*Endomychura hypoleuca*	Year round; islands (coastal)
Ashy Storm Petrel	*Oceanodroma homochroa*	Summer; islands (coastal)

†All species are protected by Migratory Bird Treaty Act of 1918 and other migratory waterfowl regulations.
*Protected by Endangered Species Act of 1973
+A State endangered species
#California subspecies

Possible Impacts:

Diving Birds
- May dive or swim into oiled waters.
- Sometimes form large feeding flocks; these would be especially susceptible to mass oiling.

Waterfowl
- Coastal species would be especially vulnerable; Brant feed on seagrass flats in very shallow waters; may be oiled in water, or may be deprived of access to seagrass beds.
- Ducks dive for food and are found in coastal or offshore waters; contamination could result from swimming in oiled water; they may land in oil-calmed water for evening roost; they sometimes form large rafts which might result in massive oiling; they may dive through or surface in oiled water.

Shorebirds
- May feed or roost on oil-contaminated beaches.
- May ingest contaminated food.
- May ingest oil when preening contaminated feathers.

Gulls and Terns
- Form large colonies on isolated islands or high cliffs when nesting.
- May attempt to feed in oil-contaminated water.
- Oil on feathers can be transferred to eggs.
- May roost in oiled water or on contaminated beaches.
- May ingest oil when preening contaminated feathers.

Alcids
- Form large colonies, subject to mass oiling.
- If disturbed, will fly from nests into water.
- May attempt to land in oil-calmed water.
- Dive into water to escape danger.
- May feed in oiled water.

4.2.3 Reptiles

Common Name	Species	Occurrence
Green Sea Turtle*	Chelonia mydas	Year round

*Protected by Endangered Species Act of 1973 and by Convention on International Trade in Endangered Species of Wild Fauna and Flora

4.2.4 Finfish

Resident Finfish Populations*

Common Name	Species	Occurrence
Grunion	Leuresthes tenuis	Spring and summer
Pacific Herring	Clupea harengus pallasi	Winter and spring
Steelhead Trout	Salmo gairdneri	Winter and spring

Predicted impact:

Grunion
- Adults would be impacted during egg laying, which takes place on beach.
- Eggs on beach could be exposed to oiling.

Trout
- Susceptible to impact during migration.

Pacific Herring
- Adults would be impacted during egg laying, which takes place nearshore on intertidal kelps and rockweeds.
- Eggs attached to algaes would be sensitive to oiling.
- Larvae remaining in hatching area would also be sensitive to oiling.

Studies of oil effects on eggs, larvae, and adults have been well documented (Kuhnhold, 1972; Lachotowich et al., 1977; Rice et al., 1976; and others).

*Regulated by State of California, Fish and Game Code, secs.8210-8239 and 8550-8557.

4.2.5 Shellfish

Shellfish Species Common to Study Area* (Johnson and Snook, 1967)

Common Name	Species	Occurrence
Pismo Clam	Tivela stultorum	Year round
Butter (Washington) Clam	Saxidomus nuttallii	Year round
Gaper Clam	Schizothaerus nuttallii	Year round
Razor Clam	Siliqua sp.	Year round
Little-Neck Clam	Paphia staminea	Year round
Geoduck Clam	Panope generosa	Year round
Bean Clam	Donax gouldii	Year round
Jacknife Clam	Tagelus californianus	Year round
Spiny Cockle	Cardium quadragenarium	Year round
Rock Scallop	Hinnites giganteus	Year round
California Sea Mussel	Mytilus californianus	Year round
Red Abalone	Haliotis rufescens	Year round
Black Abalone	Haliotis cracherodii	Year round

*Harvest regulated by State of California, Fish and Game Code, secs. 8340-8346.

Predicted impacts:

- Oil on exposed sand during low tide would flow down burrows and perhaps be ingested by clams inhabiting tidal flats or beaches.

- Stressed clams would move to surface, becoming more exposed to oil and predation.

- Individuals in planktonic stages would be exposed to oil in the water column.

- Clams and mussels on rocky shores would be subject to physical damage.

4.2.6 Kelp Beds

The dominant species of southern California kelp beds is Macrocystis pyrifera. There are approximately 33 square miles of kelp beds in the study area, with island beds comprising 64% of the total area (Dailey et al., 1974b). These beds are mapped and regulated by the California Department of Fish and Game. Certain beds are leased to private concerns for commercial harvest (California Fish and Game Code, Title 14). In 1972 the total kelp harvest for California waters was 165,500 tons, with an approximate value of $2 million (Dailey et al., 1974b).

Important commercial and recreational finfish and shellfish are directly associated with kelp beds (Haaker and Wilson, 1975). Large, diverse infaunal and epifaunal invertebrate populations are also associated with kelp beds.

Adult kelp may be partially protected from oil damage by the mucilaginous covering on blades; kelp in reproductive stages that do not have this covering may be more susceptible to oil damage (Nelson-Smith, 1973).

4.2.7 Seagrass Beds

The shallow, subtidal areas of estuaries can support growth of eel grass, Zostera marina, in the study area. Zostera is a true grass with a sub-bottom root system. Grass beds provide food and cover for fish and invertebrates in estuaries (California Dept. of Fish and Game, 1973). Black Brant also use the grass for food.

Zostera lacks the protective mucilaginous coating of kelp; thus, it is more susceptible to short-term effects of oil impacts (Straughan, 1971; Diaz-Piferrer, 1962). If the sediments in which they root are not contaminated by oil, these plants are probably resistant to long-term damage from oil.

Within the study area, seagrasses are found in Anaheim, Mission, and San Diego Bays.

4.3 Areas of Special Use

4.3.1 Channel Islands National Park (Monument)

Anacapa, San Miguel, Santa Barbara, Santa Cruz, and Santa Rosa Islands are administered as a national park by the U.S. National Park Service. Access to some island areas is limited because of private ownership or the need to protect plants and animals from disturbance.

4.3.2 Channel Islands National Marine Sanctuary

The sanctuary includes the waters surrounding the islands of the Channel Islands National Park from 6 nautical miles seaward from the mean high-tide line. NOAA, the National Park Service, and California jointly administer the sanctuary. Activities include research, assessment, and monitoring of sanctuary resources and a variety of educational programs (OCZM, 197?).

4.3.3 Ecological Reserves and Marine Life Refuges

Reserves are designated by the California Fish and Game Commission. The reserves are established to "provide protection for rare or endangered wildlife, aquatic organisms and specialized terrestrial or aquatic habitat types" (State Ecological Reserve Regulations, Appendix C, p. 197). Reserves and refuges are administered by the California Department of Fish and Game.

4.3.4 Areas of Special Biological Significance (ASBS)

Fourteen ASBS have been designated within the study area by the California Water Resources Control Board. These areas are described "...as requiring protection of species or biological communities to the extent that alteration of natural water quality is undesirable" (California State Water Resources Control Board, 1976).

5. USE OF THE ENVIRONMENTAL SENSITIVITY INDEX

During a spill, the on-scene coordinator, whether Federal or private, must decide how to deploy finite equipment and human resources to protect shoreline areas from oil. The ESI is intended to assist the coordinator and government agencies in planning strategies for protection. By use of the shoreline ranking scheme as a guide, regions of potential impact can be evaluated as to the severity of damage likely to result from oiling.

Shoreline types are ranked on a scale of 1 to 10 to indicate the persistence of oil and potential for biological habitat damage. Types are color coded according to rank to allow rapid identification of differences. (The color key is on the maps). The most highly sensitive shoreline types--9 and 10--would have the highest priority for protection. Sheltered tidal flats and marshes receive this high ranking because of long oil persistence and high biological value. These shoreline types are widely scattered on the mainland and are usually associated with lagoons and embayments. Large areas of the mainland are of low to moderate sensitivity--1 to 5--and would be assigned lower priorities for protection.

The seasonal use of a shoreline by particular organisms such as birds or marine mammals can result in a wide variation in the total natural resource damage that results from an oil spill. The presence of these organisms in an area threatened by oil could alter priorities for protection that were based solely on a shoreline ranking. By incorporating this biological resource information with the shoreline ranking, the total threat to natural resources can be evaluated.

On the ESI maps biological resource information is noted by colored circles (fig. 17). The color of the circle identifies the type of organism present: yellow = marine mammal; green = bird; orange = shellfish; blue = fish; red = reptile. Biological groups are identified by symbols within the circles (table 3). Numbers in the circles refer to species or species groups listed in Appendix III. Dots in the circle indicate seasonality. This information allows the prediction of species' presence or absence during a specific time of the year. A red border indicates that the species is rare, threatened, or endangered. The location and range of species are indicated by the bars and arrows that extend from the circle. Special symbols identify the approximate perimeter of kelp beds and the extent of seagrass beds.

Areas of socioeconomic importance (major state and local parks and marinas) may support high-intensity recreational use, knowledge of which would be important to the on-scene coordinator. These areas are marked by a black decal on a white background. In addition to parks and beaches, other shoreline areas have been specially designated for scenic, wildlife, or other values. These areas include reserves, preserves, refuges, and ecological areas. They are marked by a brown circle and a star with a number keyed to the area's name and the agency with controlling authority (Appendix IV). Approximate boundaries are given for Areas of Special Biological Significance as designated by the State Water Resources Control Board.

The sum of this information--shoreline ranking, biological resources, socioeconomics--is the basis for decisions on protection priorities that constitute the strategy for response to a spill. Protection of resources is most often based on mechanical means: protection equipment such as booms and inlet closures, and removal equipment such as skimmers. Potential locations for the deployment of this equipment are marked on the maps to aid in planning deployment strategies. Areas where oil could wash completely over a beach during a storm are also marked. In some cases protection strategy may be based on chemical dispersants that remove oil from the water's surface before it reaches shore. In this case the damage to water column resources must be balanced against the shoreline resources protected.

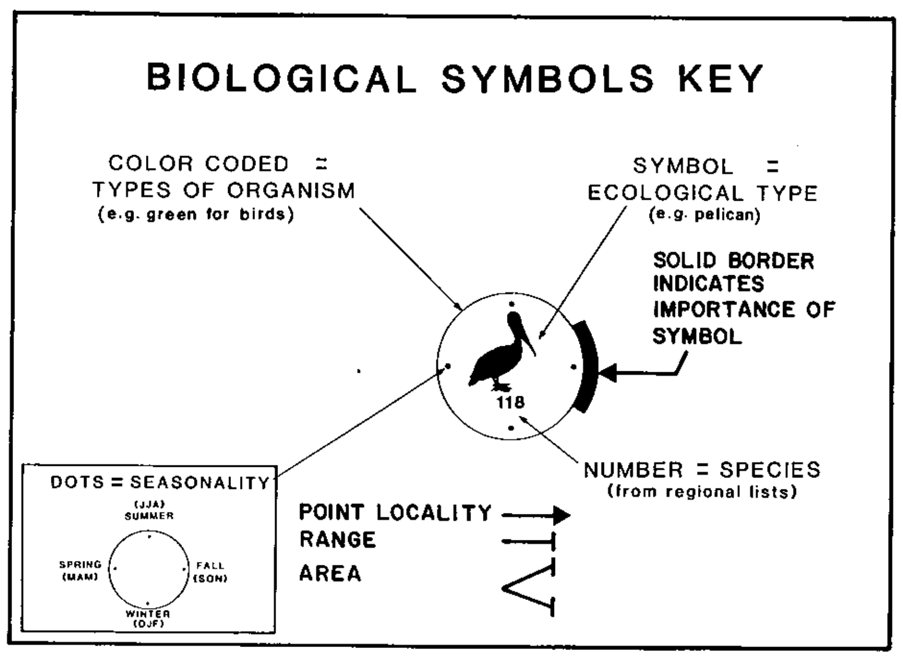

Figure 17.--Key to information provided on colored biological markers.

Table 3.--Symbols used on the Environmental Sensitivity Index maps to indicate dominant groups

Symbol	Occurrence
Resident Marine Mammals	
Seals or Sea Lions	Haulout grounds or pupping areas
Marine Birds	
Diving birds	Pelican or Cormorant feeding and roosting areas
Alcid or Petrels	Auklet, Guillemot, Murrelet, or Petrel rookeries
Waterfowl	Duck, Goose, or Brant forage areas
Shorebirds	Oystercatcher, Plover, Avocet, Sparrow, Rail, Stilt or Killdeer forage areas or rookeries
Gulls or Terns	Rookeries or forage areas
Fish	
Grunion or Herring	Spawning areas
Steelhead Trout	Spawning or nursery areas
Shellfish	
Clams	Clam, Scallop, or Mussel areas
Abalone	Abalone areas
Reptiles	
Turtle	Green Sea Turtle areas
Plants	
Kelp	Abundant brown algae beds
Seagrass	Subtidal eel grass beds
Socioeconomic Features	
Parks and beaches	Location
Marinas	Location
Areas of special biological significance	Boundaries
Protective Strategy Features	
Recommended boom	Location
Skimmers	Deployment
Closures	Location
Shoreline washover potential	Location

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Appendix III: Number Key to Biological Groups

Reptiles

14. Green Sea Turtles (*Chelonia mydas*)

Marine Mammals

1. Northern Sea Lion (*Eumetopias jubatus*)
2. Harbor Seal (*Phoca vitulina*)
3. Northern Fur Seal (*Callorhinus ursinus*)
22. California Sea Lion (*Zalophus californianus*)
23. Guadalupe Fur Seal (*Arctocephalus philippii*)
24. Northern Elephant Seal (*Mirounga angustirostris*)

Finfish

C. Anadromous Species
66. Pacific Herring (*Clupea harengus pallasi*)
74. Steelhead Trout (*Salmo gairdneri*)
106. Grunion (*Leuresthes tenuis*)

Marine Coastal Birds

A. Numerous Species
4. Red-Necked Grebe (*Podiceps grisegena*)
8. Double-Crested Cormorant (*Phalacrocorax auritus*)
9. Brandt's Cormorant (*Phalacrocorax penicillatus*)
10. Pelagic Cormorant (*Phalacrorax pelagicus*)
13. Black Brant (*Branta nigrican*)
37. Western Gull (*Larus occidentalis*)
47. Pigeon Guillemot (*Cepphus columba*)
49. Cassin's Auklet (*Ptychoramphus aleuticus*)
68. Black Oystercatcher (*Haematopus backmani*)
70. Killdeer (*Charadrius vociferus*)
86. Least Tern (*Sterna albifrons*)
118. Brown Pelican (*Pelecanus occidentalis*)
125. Clapper Rail (*Rallus longirostris*)
139. Snowy Plover (*Charadrius alexandrinus*)
140. Belding Savannah Sparrow (*Passerculus sandwichensis beldingi*)
141. American Avocet (*Recurvirostra americana*)
142. Black-Necked Stilt (*Himantopus mexicanus*)
143. Xantus' Murrelet (*Endomychura hypoleuca*)
144. Ashy Storm Petrel (*Oceanodroma homochroa*)
145. Elegant Tern (*Sterna elegans*)

Number Key to Biological Groups (continued)

Shellfish

A. Numerous Shellfish

18. Pismo Clam (*Tivela stultorum*)

21. Butter (Washington) Clam (*Saxidomus nuttallii*)

24. Gaper Clam (*Schizothaerus nuttallii*)

28. Razor Clam (*Siliqua sp.*)

29. Little-Neck Clam (*Paphia staminea*)

32. Geoduck Clam (*Panope generosa*)

35. Rock Scallop (*Hinnites giganteus*)

52. Bean Clam (*Donax gouldii*)

57. California Sea Mussel (*Mytilus californianus*)

60. Abalone species

61. Red Abalone (*Haliotis rufescens*)

62. Black Abalone (*Haliotis cracherodii*)

66. Jacknife Clam (*Tagelus californianus*)

67. Spiny Cockle (*Cardium quadragenarium*)

Appendix IV: Number Key to Preserves, Reserves, Refuges, and Ecological Areas

Area	Administering Agency
1. Andre Clark Bird Refuge	City of Santa Barbara
2. Santa Monica Mountains National Recreation Area	U.S. National Park Service
3. Abalone Cove Ecological Reserve	California Fish and Game
4. Portuguese Bend Significant Ecological Area	Los Angeles County
5. Point Fermin Marine Life Refuge	California Fish and Game
6. Seal Beach National Wildlife Refuge	U.S. Fish and Wildlife Service
7. Bolsa Chica Ecological Reserve	California Fish and Game
8. Upper Newport Bay State Ecological Reserve	California Fish and Game
9. Newport Beach Marine Life Refuge	California Fish and Game
10. Irvine Coast Marine Life Refuge	California Fish and Game
11. Laguna Beach Marine Life Refuge	California Fish and Game
12. Heisler Park Ecological Preserve	California Fish and Game
13. South Laguna Beach Marine Life Refuge	California Fish and Game
14. Niguel Marine Life Refuge	California Fish and Game
15. Dana Point Marine Life Refuge	California Fish and Game
16. Doneny Beach Marine Life Refuge	California Fish and Game
17. Buena Vista Lagoon Ecological Reserve	California Fish and Game
18. San Elijo Lagoon Ecological Reserve	California Fish and Game
19. Los Penasquitos Lagoon Natural Preserve	California Parks and Recreation
20. Torry Pines State Reserve	California Parks and Recreation
21. San Diego Marine Life Refuge	California Fish and Game
22. San Diego-La Jolla Ecological Reserve	California Fish and Game
23. Kendall-Frost State Ecological Reserve	California Fish and Game
24. Point Loma Ecological Reserve	California Fish and Game
25. Tijuana Slough National Wildlife Refuge	U.S. Fish and Wildlife Service
26. Border Field State Park Natural Preserve	California Parks and Recreation

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