ENVIRONMENTAL SENSITIVITY INDEX–
MARIANA ISLANDS - VOL. 1 - GUAM

SHORELINE HABITATS

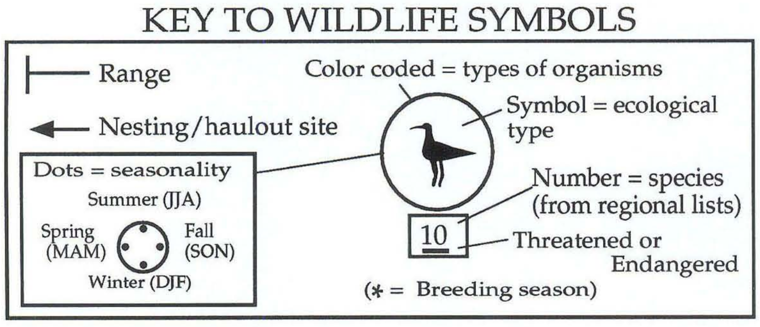
The shorelines of the island of Guam were classified with respect to their sensitivity to oil-spill impacts, according to the following ranking scheme. The primary source of information was an atlas of the reefs and beaches of the island prepared by the Marine Laboratory of the University of Guam[1].

ESI RANK	DESCRIPTION
1.	Exposed rocky shores and vertical, hard man-made structures
2.	Exposed wave-cut rock platforms
3.	Fine-grained sand beaches
4.	Medium- to coarse-grained sand beaches
5A.	Mixed sand and gravel beaches
5B.	Artificial fill containing a range of grain sizes and materials
6A.	Gravel beaches
6B.	Exposed riprap
7.	Exposed tidal flats
8.	Sheltered rocky shores
9.	Sheltered tidal flats
10A.	Mangroves
10B.	Other estuarine wetlands
	Unranked – Sheltered man-made structures

1 Randall, R.H. and Eldredge, L.G., 1976, Atlas of the reefs and beaches of Guam: Marine Laboratory, Univ. of Guam, 191 pp.

BIOLOGICAL RESOURCES

KEY TO WILDLIFE SYMBOLS



BIRDS

Wading birds
Shorebirds
Waterfowl
Terns
Pelagic birds
Terrestrial birds

FISH

Fish

SHELLFISH

Gastropods
Lobsters
Crabs

REPTILES/AMPHIBIANS

Sea turtles
Skinks

MAMMALS

Whales/Dolphins
Bats

BIOLOGICAL RESOURCES (Cont.)

CORAL REEF AREAS OF SPECIAL INTEREST

Coral densities

– Abundant corals
– Less abundant corals
– Widely scattered corals

SEAGRASSES

SPONGES

HUMAN-USE FEATURES

AQ AQUACULTURE

SUBSISTENCE FISHERIES

MANAGED AREAS

CULTURAL RESOURCES

WATER INTAKES

KEY TO SPECIES

BIRDS		
Shorebirds		
13	Lesser golden plover	*Pluvialis dominica*
14	Ruddy turnstone	*Arenaria interpres*
17	Black-bellied plover	*Pluvialis squatarola*
44	Mongolian plover	*Charadrius mongolus*
45	Tattlers	*Heteroscelus spp.*
46	Whimbrel	*Numenius phaeopu*
Terns		
19	Brown noddy	*Anous stolidus*
22	Black noddy	*Anous minutus*
38	White tern (Fairy)	*Gygis alba*
Pelagic birds		
34	Red-footed booby	*Sula sula*
35	Brown booby	*Sula leucogaster*
Wading birds		
43	Yellow bittern	*Ixobrychus sinensis*
**47	Common moorhen	*Gallinula chloropus*
48	Pacific reef heron	*Egretta sacra*
Waterfowl		
42	Migratory ducks (2 most common)	
	Northern pintail	*Anas acuta*
	Tufted duck	*Aythya fuligula*
Terrestrial birds		
**49	Mariana crow	*Corvus kubaryi*
**50	Micronesian starling	*Aplonis opaca*
FISH		
1	Butterflyfish	fam. Chaetodontidae
2	Surgeonfish	*Acanthurus spp.*
3	Damselfish	fam. Pomacentridae
4	Wrasse	*Thalassoma spp.*
5	Mullet	*Crenimugil crenilabis*
6	Hawaiian anchovy (nehu)	*Stolephorus purpurens*
8	Rabbitfish	*Siganus spp.*
11	Mackeral	*Selar crumenopthalmus*
12	Jack	fam. Carangidae
13	Goatfish	fam. Mullidae
14	Snapper	fam. Lethrinidae/Lutjanidae
15	Parrotfish (juvenile)	fam. Scaridae
SHELLFISH		
1	Spiny lobster	*Panulirus penicillatus, P. versicolor*
4	Hermit crab	*Coenobita spp.*
5	Coconut crab	*Birgus latro*
6	Top shell	*Trochus niloticus*
REPTILES/AMPHIBIANS		
**1	Green sea turtle	*Chelonia mydas*
**2	Hawksbill sea turtle	*Eretomochelys imbricata*
3	Tide pool skink	*Emoia atrocostata*

** Threatened or Endangered

ENVIRONMENTAL SENSITIVITY INDEX– MARIANA ISLANDS - VOL. 1 - GUAM

KEY TO SPECIES (Cont.)

MAMMALS

**1	Humpback whale	*Megaptera novaeangliae*
2	Pilot whale	*Globicephala macrorhynchus*
3	Bottlenosed dolphin	*Tursiops gillii*
5	Spinner dolphin	*Stenella longirostris*
7	Killer whale	*Orcinus orca*
8	False killer whale	*Pseudorca crassidens*
9	Streaker dolphin	*Stenella coeruleoalba*
**11	Marianas fruit bat	*Pteropus mariannus*

CORALS - Assemblage A

Common Fringing Reef Flat Coral Community (3 feet deep)

Acropora aspera
Porites lutea
Pocillopora damicornis
Psammocora contigua
Pavona decussata
Pavona divericata
Porites cylindrica
Porites annae
Porites australiensis

Common Lagoon Coral Community (3-20 feet)

Acropora formosa
Acropora aspera
Porites cylindrica
Porites (S.) rus
Porites lutea
Pocillopora damicornis
Millepora dichotoma
Montipora lobulata

Common Upper Reef Front Slope Coral Community (20 feet or less)

Goniastrea retiformis
Pocillopora setchelli
Porites lutea
Acropora monticulosa
Acropora irregularis
Acropora ocellata
Acropora smithi
Acropora cerealis
Acropora azurea
Favia mathaii
Favites abdita
Acanthastrea echinata
Galaxea fascicularis
Acropora digitifera
Acropora surculosa
Millepora platyphylla
Porites (S.) rus
Monitpora verrilli
Leptoria phrygia
Montastrea curta

Assemblage B

Acropora hebes

** Threatened or Endangered

MANAGED AREAS

NO.	NAME	ESI MAP
1	Rizal Beach	2
2	Old Agat Family Beach	2
3	Nimitz Beach	2
4	Umatac Bay	3
5	Merizo Pier Park	4
6	Cocos Island Dano Park	4
7	Salaglula Pool	5
8	Inarajan Bay Beach	5,6
9	Talofofo Beach	6
10	Ipan Beach	7
11	Tagachan Beach	7
12	Frank Perez (Gonga) Beach	7
13	Tanguisson Beach	14
14	Matapang Beach	14
15	Governor Joseph Flores Beach Park (Ypao)	14
16	East Agana Beach	15
17	Paseo de Susana Park and Padre Palomo Park	15
18	West Agana Beach	15
19	Adelup Park	15
20	Asan Memorial Beach	15
21	Tepungan Beach	15

KEY TO SUBSISTENCE FISHERIES

COMMON NAME	LOCAL NAME	GENUS AND SPECIES
FISH		
Species Assemblage C		
Rabbitfish	hiteng	*Siganus spp.*
Juvenile goatfish	ti'ao	fam. Mullidae
Jack	tarakitu	fam. Lutjanidae
Juvenile jacks	i'e'	fam. Lutjanidae
Mullet	laiguan	fam. Mugilidae
Surgeonfish	hamoktan	*Acanthurus spp.*
Rudderfish	guili	fam. Kyphosidae
Parrotfish	laggua	fam. Scaridae
Unicornfish	tataga'	*Naso unicornis*
Species Assemblage D - Offshore (>20 fathoms depth)		
Emperor fish, other	mafute' (lililuk)	fam. Lethrinidae
Snapper, other	kaka'ka' (tagafi)	fam. Lutjanidae
Grouper	gadao	fam. Serranidae
Jack	tarakitu	fam. Carangidae
Dolphinfish	botague'	*Coryphaena hippurus*
Wahoo	saoara'	*Acanthocybium solandri*
Yellowfin tuna	makuro'	*Thunnus albacares*
Skipjack	mamulen (terakitu)	*Katsuwonus pelamis*
Blue marlin	taghalar	*Makaira nigricans*
Bigeye scad	atulai	*Selar crumenopthalmus*
MOLLUSCS		
Species Assemblage E		
<u>Gastropods</u>		
Top shell	alileng	*Tectus pyramis*
Top shell	alileng	*Trochus niloticus*
Turban shells	alileng	*Turbo spp.*
Vase shell		*Vasum spp.*
Conch	do'gas	fam. Strombidae
Nerites	pedes	*Nerita spp.*
Species Assemblage F		
<u>Bivalves</u>		
Giant clam	hima	*Tridacna spp.*
Lucinid clam		*Codakia punctata*
Lucinid clam		*Codakia bella*
Venerid clam		*Gafrarium pectinatum*
	pa'gang	*Asaphis violascens*
Tellinids		*Quidnipagus palatum*
		Scutarcopagia scobinata
Species Assemblage G		
<u>Polyplacophora</u>		
Chiton	tagula	*Acanthopleura gemmata*
<u>Cephalopods</u>		
Octopii	gamson	*Octopus spp.*
CRUSTACEANS		
Species Assemblage H		
<u>Crabs</u>		
Seven-eleven crab	panglao oros	*Carpilius maculatus*
Blue swimming crab		*Thalamita spp.*
Crab		*Etisus splendens*
Mangrove crab	akmangao	*Scylla serrata*
Land crab	panglao tunas	*Cardisoma carnifex*
Coconut crab	ayuyu	*Birgus latro*
Species Assemblage I		
<u>Shrimp</u>		
Deepwater shrimp		*Heterocarpus ensifer*
Deepwater shrimp		*H. laevigatus*
Deepwater shrimp		*H. longirostris*
Species Assemblage J		
<u>Lobster</u>		
Spiny lobster		*Panulirus penicillatus*
Spiny lobster		*P. versicolor*
Species Assemblage K		
<u>Echinoderm</u>		
Short-spined sea urchin		*Tripneustes gratilla*
Edible sea urchin		*Echinometra mathaei*
Sea cucumber	balate'	*Holoturia atra*

SHORELINE HABITAT RANKINGS

The shoreline habitats of Guam were characterized from the descriptions of the beaches of Guam in Randall and Eldredge (1976) and ground-truthed by local resource personnel. Where appropriate, multiple habitats were delineated for each shoreline segment.

Prediction of the behavior and persistence of oil on intertidal habitats is based on an understanding of the dynamics of coastal environments, not just the substrate type and grain size. The vulnerability of a particular intertidal habitat is an integration of the following factors:

1. Shoreline type (substrate, grain size, tidal elevation, origin)
2. Exposure to wave and tidal energy
3. Biological productivity and sensitivity
4. Ease of cleanup

All of these factors are used to determine the relative sensitivity of shorelines. Key to the sensitivity ranking is an understanding of the relationships among: physical processes, substrate, shoreline type, product type, sediment transport, and product fate and effect. Thus, the intensity of energy expended on a shoreline by wave action directly affects the persistence of stranded oil. The need for shoreline cleanup activities is determined, in part, by the lack or slowness of natural processes in removal of oil stranded on the shoreline.

These concepts have been used in the development of the Environmental Sensitivity Index (ESI), which ranks shoreline environments as to their relative sensitivity to oil spills, potential biological injury, and ease of cleanup. Generally speaking, areas exposed to high levels of physical energy, such as wave action and currents, and low biological activity rank low on the scale, while sheltered areas with associated high biological activity have the highest ranking. These rankings follow a shoreline classification system that has been applied nationwide during the preparation of oil spill sensitivity maps. The list below includes the shoreline habitats delineated for Guam, presented in order of increasing sensitivity to spilled oil.

- 1. Exposed rocky shores and vertical, hard man-made structures (e.g., seawalls)
- 2. Exposed wave-cut rock platforms
- 3. Fine-grained sand beaches
- 4. Medium- to coarse-grained sand beaches
- 5A. Mixed sand and gravel beaches
- 5B. Artificial fill containing a range of grain sizes and materials
- 6A. Gravel beaches
- 6B. Exposed riprap
- 7. Exposed tidal flats
- 8. Sheltered rocky shores
- 9. Sheltered tidal flats
- 10A. Mangroves
- 10B. Other estuarine wetlands
- Unranked Sheltered man-made structures

SENSITIVE BIOLOGICAL RESOURCES

Depicted on the maps are the key biological resources of the coastal zone of Guam that are most likely at risk in the event of an oil spill. There are six major categories of biological resources included on the maps: birds, fish, shellfish, mammals, reptiles and amphibians, and coral reef areas of special interest. Additionally, the location of dense assemblages of seagrasses and sponges (commercially important species and habitats) have also been identified on the maps.

Distributions and seasonalities of selected oil-sensitive fish and wildlife are depicted on the ESI maps using a color- and alpha/numeric-coding system. A round colored symbol is used to indicate the animal group of the organisms depicted. In the center of each symbol is a black silhouette indicating the ecological type of the organism depicted. The symbols used are as follows:

Birds
- Wading birds
- Shorebirds
- Waterfowl
- Terns
- Pelagic birds
- Terrestrial birds

Fish
- Fish

Shellfish
- Gastropods
- Lobsters
- Crabs

Reptiles/Amphibians
- Sea Turtles
- Skinks

Mammals
- Whales/Dolphins
- Bats

Coral Reef Areas of Special Interest

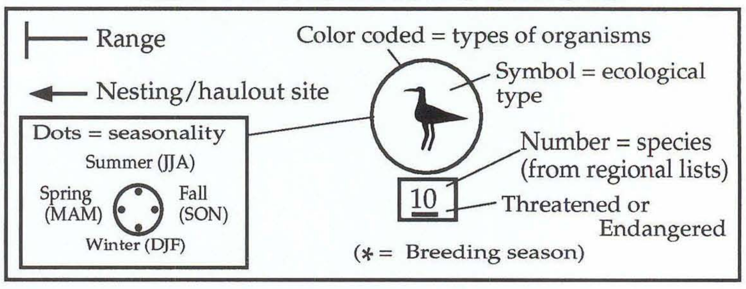
Seagrasses

Sponges

The seasonal presence and reproductive activity of fish and wildlife are indicated using a series of four dots or asterisks located on the perimeter of the colored symbol. Asterisks indicate periods of reproductive activity such as nesting for birds and spawning for fish. Arrows and bars are used to indicate specific, localized areas where oil-sensitive fish and wildlife tend to congregate, such as bird nesting sites and marine turtle nesting beaches. The locations indicated by the arrows and bars show the main concentration areas; those species indicated may also be relatively common in adjacent areas. Arrows point to specific sites, such as nesting colonies. Range bars are used to indicate the areal extent along the shoreline where the species occur. Those organisms that are wide-ranging and tend to be present over wide areas are indicated in small rectangular boxes, indicating their presence in nearshore or onshore areas.

Numbers or letters on each symbol indicate the species depicted. The species number refers to a species list. Species numbers which have been underlined indicate that the animal is either endangered or threatened and warrants special protection considerations.

KEY TO WILDLIFE SYMBOLS



Birds

The bird populations of Guam are divided into several species groupings based on behavior and genealogy including: wading birds, waterfowl, pelagic birds, shorebirds, terns, and terrestrial birds. The species table shows the listing of all birds and their grouping included on the maps. These species were included because of the potential for impact by an oil spill, or because they had a special protected status.

In general, shorebirds and terns are ubiquitously distributed throughout coastal Guam, however, only those areas that are special concentration areas (e.g., nesting sites) are depicted on the maps. Several terrestrial birds are also depicted on the maps. The Mariana crow (endangered) becomes highly disturbed and nesting behavior is interrupted by low flying helicopter and airplane traffic that often occurs during response operations. Thus, this species has been added to the maps and a no-fly zone (under 1,600 feet) has been developed for the northern end of Guam. Flying operations involving overflights or landings by fixed wing or helicopter aircraft are prohibited on Northwest Field except on the South runway (O6R/24L). Approaches/departures to the South runway at Northwest Field are restricted to straight in/straight out aligned on the runway centerline extended a minimum of 2 nautical miles from the runway threshold. Overflights of Northwest Field land areas North of the South runway (O6R/24L) below 1,600 feet mean sea level are prohibited. All flying operations (overflights, landings, etc.) in the vicinity of Northwest Field shall be coordinated with Airfield Management, 671/366-3212, who will request approval from the Environmental Management office (Natural Resources) at 671/366-2101 for endangered species clearance (Dept. of the Air Force, 1994).

The Micronesian starling (endangered) is found in large concentrations on Cocos Island, an area that could be impacted by an oil spill, thus endangering a major foraging area/habitat for this species. Cocos Island also supports Guam's largest nesting colony of white terns, black noddies, and Pacific reef herons. The common moorhen (endangered) is present in sensitive freshwater marshes close to the coast and is also susceptible to oil spills.

Fish

Fish distributions depicted on the maps are either important known nursery areas for many species of fish, or areas of particularly high fish concentrations. Species shown on the maps are important commercial, recreational, or subsistence fish or species that are an important part of the ecosystem. Information on fish seasonality and distribution was obtained from the Department of Agriculture, Division of Aquatic and Wildlife Resources.

Many of the commercial, recreational, and subsistence fishes of Guam are found associated with the topographically varied and dense, coral-populated portions of the reef flat environment. The composition of the fish community is influenced primarily by two environmental factors: wave action and topographic relief (Amesbury, 1978). The fish species of Guam have varied habitat needs.

The reef flat fishes produce large numbers of eggs during their lifetimes, and it is generally believed that there are many more marine young fish available to take up residence on the reef than the reef can support. The majority of the marine tropical fishes exhibit external fertilization coupled with pelagic (free-floating) gamete release. There are several species that exhibit parental care for their egg and larval offspring in the form of mouth-breeding and nest builders. The highest fertilized egg release occurs in the summer months of July and August (Amesbury, 1978). Therefore, a spill event occurring in these months when egg release is greatest could have extensive year-class impacts.

Shellfish

Shellfish of commercial, recreational, or subsistence importance are identified on the maps, with symbols for three species groups: gastropods, lobster, and crabs. The only gastropod shown is the commercially important top shell, which is harvested primarily within Apra Harbor. The spiny lobster is an important subsistence fishery. Lobsters are primarily harvested from the eastern shore of Guam, but are common to all reefs. Two species of terrestrial crabs, which use intertidal habitats for spawning or foraging, are shown on the maps.

The coconut crab (one of the two terrestrial crabs identified on the maps) does not inhabit a gastropod shell as an adult, unlike other terrestrial hermit crabs in its family. Throughout its dwindling range on Guam, "the coconut crab is considered a highly desirable food item among local populations" (Amesbury, 1980). Adult coconut crabs typically are found in coastal limestone forest habitats where they establish burrows for resting during the days and forage exclusively at night. The gravid females transport their eggs to the ocean for spontaneous hatching and release when brought into contact with seawater. Spawning occurs at night and appears to coincide with the new moon.

Reptiles, Nesting Turtle Beaches, and Amphibians

Two sea turtle species utilize several beaches in Guam for nesting: the green sea turtle (threatened) and the hawksbill sea turtle (endangered). These species typically nest in the spring and summer, although adults of both species are known to forage year-round in many areas around Guam.

Important aspects of the life histories of sea turtles, which spend part of their lives in coastal waters, are (Eckert, 1993):

- Sea turtles may nest every 1-4 years after reaching maturity (which is estimated to take 23 years).
- The female may lay anywhere from 1-6 clutches of about 40-140 eggs per season, depending on the species.
- The nests are normally located above the high-tide level.
- Incubation takes about 2-3 months.
- The greatest source of natural mortality of sea turtles is probably predation of hatchlings in the ocean.
- Loss of nesting habitat is an important factor in population reduction.
- There is strong nesting beach fidelity.

The most sensitive turtle life stages are the eggs when they are buried in the sand, the hatchlings as they dig their way out of the nest and enter the water, and young juveniles which are pelagic surface dwellers. Adults and juvenile sea turtles may experience skin irritation to surface lesions if directly coated by oil, primarily in skin folds. Additionally, juvenile sea turtles have been known to consume or take refuge under floating tar balls, coating their mouths and flippers as well as experiencing impacts from the direct consumption of the oil.

The greatest threat of oil spills on land is the toxic effects of direct contamination of eggs in the nest. However, it should be noted that, because the eggs are laid above the high-tide line, direct oiling is unlikely except during storms. Studies have shown that the number of unhatched eggs is much higher when fresh crude oil is on the sand surface during the last half to quarter of the incubation period. This effect is thought to be due to displacement of oxygen by the lighter oil fractions when the rate of oxygen consumption is at its peak. Many weathered crude oils are less toxic to turtle eggs than fresh crude oils.

Hatchling morphology is also affected by the amount of oil and time of oiling. Weights are lower and sizes are smaller when the eggs are exposed to a light dosage of oil mixed in the sand. Young turtles exposed to oil in water in tests have demonstrated disturbed diving and respiratory patterns, decreased blood glucose levels, reddening and sloughing off of the skin, and dysfunctioning of the salt glands.

The removal of eggs from nests along beaches is not recommended. The eggs should not be moved after 24 hours post-laying. The yolks and embryos settle to one side within 48 hours, thus any movement after that period usually results in decreased viability. Only experienced or trained personnel should attempt to move threatened eggs.

Nesting beaches should receive highest priority for cleanup if they are oiled prior to the nesting period. Rapid removal of oil from a beach with active nests may be attempted, particularly if the oil has not reached the nest sites. If hatchlings emerge while oil is coming onshore and slicks are still in nearshore waters, hatchlings can be captured and released in clean waters. Hatchlings usually emerge during night hours, so nests should be monitored to intercept hatchlings before they attempt to cross oiled beaches or swim into contaminated waters. Cleanup activities on nesting beaches should be monitored by experienced personnel so that the nests are not physically disturbed. Vehicle activity on nesting beaches should be minimized.

The tide pool skink is found in the intertidal zone along the east side of Cocos Island and thus could be susceptible to impacts by oil spills.

Mammals

There are essentially two mammal groups depicted on the Guam ESI maps: marine mammals (whales and dolphins) and terrestrial bats. The whale and dolphin populations can be present year-round in the offshore waters of Guam; however, only the spinner and bottlenose dolphins are present in any significant numbers. Spinner dolphins are frequent residents in nearshore waters and their more frequently sighted locations are shown on the maps with range bars. Marine mammals are seldom directly impacted by oil spills. In fact, during several spills, dolphins have been known to swim directly through surface sheens while others appear to actively avoid thicker slicks. Irritation to mucosal membranes of the eyes and nose may result from contact with oil. Response operations may also impact these species, driving some species away from their preferred feeding grounds and attracting the curiosity of others (primarily dolphins).

The Marianas fruit bat is an endangered terrestrial species which forages along the northern coastline of the island. There is an extensive colony located on Anderson Air Force Base; the exact location of the colony is not being shown to protect these mammals. They are shown on the maps to indicate the need to prevent disturbance by response (aircraft operations) and cleanup activities in the vicinity. During a spill response operation, specific information regarding the locations of these colonies can be provided by the Department of Agriculture, Division of Aquatic and Wildlife Resource.

Corals Reef Areas of Special Interest

Coral reefs are structures which are created and maintained by the establishment and growth of populations of hermatypic coral and coralline algae. The shoreline of Guam is bordered by fringing reefs of various widths. Most subtidal parts of the island are covered with a variety of corals, benthic algae, and other reef-associated organisms (Randall and Eldredge, 1976).

Randall and Eldredge (1976) divided the coastal reefs of Guam into three subzones for the purpose of coastal descriptions: the intertidal shoreline, the reef flat zone, and the reef margin. The intertidal shoreline, or that portion of the beach or rocky shore which is covered at high tide and exposed at low tide, may have various parts or all of the bordering fringing reef platform exposed during low tide. In this area, the common shallow water corals are most likely to be affected by oil spills.

The reef flat zone extends from the intertidal shoreline to the wave-washed reef margin. This zone is slightly elevated and at low tide, the outer reef flat is often exposed, while the inner reef flat remains submerged and is often referred to as the "moat". The coral growth on the reef flat zone is "more or less restricted to the low-tide moats or where holes and depressions retain water during low tide" (Randall and Eldredge, 1976). The reef margin consists of the shallow seaward edge of the reef-flat platform which is constantly awash during low tide.

Of the more than 255 species reported on Guam, 31 coral species in three water depth ranges (<20 feet) were identified as the most common shallow water corals by Dr. Richard Randall (University of Guam). For the ESI mapping effort, these 31 species have been identified as Assemblage A on all maps due to their ubiquitous nature. A single species, *Acropora hebes*, is identified as Assemblage B on the ESI maps because there is only one known location for this coral species along the Guam shoreline (ESI map

4). Additionally, a ranking scale of coral reef abundances along the coastline of Guam is depicted on the ESI maps. This scale is taken directly from Randall and Eldredge (1976) who characterized the coral formations in terms of their relative density: abundant corals, less abundant corals, and widely scattered corals. Sensitive coral reef areas are present around most of the Guam coast. Coral symbols on the ESI maps mark special coral reef areas that have been identified by local resource agencies. These areas are known for their high biodiversity and abundance.

Corals may be most vulnerable to oiling impacts during spawning, when they broadcast their larvae. The peak coral spawning period for Guam is 7-10 days after the summer (July) full moon (Dr. Robert Richmond, University of Guam), although gamete release may occur also 7-10 days after the June and August full moons.

Oil typically passes over subtidal reefs with no direct contamination. However, conditions in which floating oil could potentially coat living reef communities may occur when reef platforms are exposed at low tide, when certain reef-flats which are floored with bedrock have high coral heads growing on them, or when oil is trapped against the outer, seaward part of reef-flat platforms. Except in the event of very heavy oil concentrations, oil would be readily removed from these reef areas with the rising tide.

There is little documentation of long-term impacts to coral reefs from oil spills, except in the situations where the pollution was chronic, or in the rare instance where oiled sediments were transported to the bottom. The greatest impacts to the reef would result from spills of light refined products directly into the shallow waters overlying reefs and where high concentrations of water-soluble fractions persist. Also, large spills during the period of simultaneous spawning could affect the larvae of all coral species, regardless of water depth. Of equal or greater concern at most spills are the organisms that concentrate around the coral reef habitat, such as sponges, fish, and shellfish.

For most spills involving coral reef structures, no cleanup is recommended or necessary. Cleanup of the reef itself by natural processes is expected to be rapid. Sorbents and booms can be used to prevent oil from being transported over the reefs. The use of sorbents should be limited to those that can be contained and recovered. As an additional cleanup measure, oil should be removed from adjacent intertidal areas to prevent chronic exposure of the corals to oil leaching from these sites.

Seagrasses

Seagrasses in Guam are dominated by shoalgrass (*Halodule uninervis* and *Enhalus acoroides*). Their distribution is limited by water temperature, light penetration (thus turbidity and water depth), and salinity. Seagrasses play a very important role in shallow coastal marine environments, including: sediment stabilization; detritus production which provides a major basis of food chains, although the bulk of the biomass is in the sediments (in the rhizomes); substrate for a highly productive epiphytic community, with a total biomass which often approaches or exceeds that of the plants themselves; a directly utilized food source for a few organisms, namely turtles, who graze on seagrasses; habitat which is utilized by fish and shellfish as nursery areas; and key role in nutrient cycling, including nitrogen, phosphorous, and sulfur.

The seagrass beds portrayed on the ESI maps are those beds that are described as "abundant" in the Randall and Eldredge (1976) survey of Guam's reef system.

The greatest impacts from oiling occur on seagrasses that are intertidal, where the oil comes in direct contact with exposed blades. Oil readily adheres to exposed blades, particularly when the oil is heavy or weathered. Unless the sediments are also oiled, any oiled blades are quickly defoliated and the plants have the capacity to grow new leaves (the leaves grow from a relatively protected meristem). Recovery can occur within 6-12 months. Plant mortality has been observed at spills when the sediments were contaminated by oil, although such incidents have been rare.

The most sensitive components of the seagrass ecosystem are the epiphytic community and juvenile organisms using the grass beds as a nursery. These species and life stages can be highly sensitive to both the water-soluble and insoluble fractions of oil. The plants can uptake hydrocarbons from the water column and sediments, potentially lowering their tolerances to other stresses. During response actions, the oil should be prevented from entering shallow, sheltered areas where seagrass beds occur, where possible. Highest priority should be those beds which are known to provide nursery areas for commercially important species. However, there is little that can be done to protect seagrass beds which occur along exposed sections of shoreline.

Furthermore, extreme care should be taken not to disturb the sediments during cleanup operations in the vicinity of seagrasses, which could result in total loss of the seagrass bed. Cleanup efforts onshore should not result in the deposition of oiled sediments in the beds, e.g., from water flushing of intertidal substrates. Oiled wrack on adjacent beaches should be removed quickly, to prevent re-entry of oiled detritus into the nearshore environment. Removal of oiled blades should only be considered when it can be demonstrated that special species (such as endangered turtles) are at significant risk of injury from contact or grazing on the blades. Otherwise, the best strategy for oiled blades is to allow natural recovery; the oiled blades are sloughed off within days to weeks.

HUMAN-USE FEATURES

Human-use features of concern shown on the Guam ESI maps are the locations of local aquaculture sites, subsistence fisheries, recreational beaches, and cultural resources. One major concern for the aquaculture facility involves the water intake system which could potentially affect the harvested species.

Aquaculture Facilities

Aquaculture sites include water intakes at Taogam for the University of Guam (ESI map No. 7), the Guam Aquaculture Training and Development Center at Fadian Point (ESI map No. 8), and fish pens on rivers emptying into Ajayan, Agfayan, and Talofofo Bays (ESI map Nos. 5, 6, and 8).

Subsistence Fisheries

Subsistence fisheries play an important role in obtaining food for residents on the island of Guam, particularly in terms of protein foods. The primary subsistence fisheries target fish, shellfish, crustaceans, and echinoderms. These species are typically harvested from shallow-water reef areas, freshwater, and offshore fishing habitats. Various fishing methods are employed, utilizing time-honored techniques to modern-day technology, in the effort to obtain food. The major types of fishing done on Guam's reef flats are throw-net and surround-net fishing. Some species of fish are commonly harvested by spearfishing, and pole and line fishing.

Species sought in shallow-water reef areas include: rabbitfish, goatfish, jack, mullet, surgeonfish, rudderfish, parrotfish, unicorn-fish, turtles, shark, chitons, reef snails or top shells, conchs, nerites, cockles, tridachnids, octopii, lobster, and one land crab, as well as a wide variety of clams, mussels, and the short-spined sea urchin from seagrass meadows. Freshwater shrimp (*Macrobrachium*) are trapped in the streams near Ordot (Amesbury et al., 1986).

Offshore fishing efforts target larger fish species in water depths of 20 to nearly 120 fathoms. The species of importance to Guam's offshore subsistence fishery include: a snapper-like fish known as Mafute' and Lililuk, and various species of snapper, grouper, and jack using bottom fishing gear; dolphinfish, wahoo, tuna, and blue marlin by trolling; tuna and billfishes by longlining; bigeye scad from mackerel fishing; and the collection of three deep water shrimp species by trapping technologies (Amesbury et al., 1986).

Managed Areas

There are 21 managed recreational beaches and other facilities on the island of Guam. These sites have been indicated on the maps by an icon with a unique number associated with it. The names for each managed area are listed under the heading Managed Areas on the legend. For further information about these sites, contact the Government of Guam, Department of Parks and Recreation at 671/477-9620.

Cultural Resources

Archeological studies indicate settlement on the island of Guam occurred as much as 3,500 years ago. Excavations have confirmed that early settlement occurred in areas identified as "optimal" in environmental terms; that is, areas adjacent to expansive sections of the reef with easy access to the open ocean, suitable tracts of arable land, and freshwater sources. Over time, as these optimal areas were settled, movement into more marginal coastal areas occurred. Evidence of this settlement includes human remains, rock shelters, and overhangs containing midden deposits and pottery remanents. Megalithic structures, known as latte, are found on most of the islands in the Mariana archipelago. These structures, consisting of two parallel rows of stone pillars and capstones, served as foundations for residences starting about 800 years ago.

Other historic sites associated with coastal areas include Spanish period structures from the 1800's, evidenced by bridges, forts, and other sites. With the capture of Guam on 10 December 1941, Japan held the entire archipelago, creating a series of air and naval bases on many of the islands and an extensive series of defensive fortifications to defend the coasts from the U.S. forces.

The Guam Historical Preservation Office is responsible for protecting and monitoring activities potentially impacting these resources and has identified over three hundred cultural resources along the coast which are potentially at risk from an oil spill or associated response activities. In particular, Taotao Resort, the area from Ulomnia Beach through Matala on Map No. 6, has more than 200 individual sites identified. This area is considered extremely vulnerable to damage. In order to protect these resources, the exact location of individual sites is being withheld from the maps. Instead, a star (★) icon is placed within the vicinity of the resource(s). The Guam Historical Preservation Office should be contacted if one of these sites is likely to be impacted by a spill or the associated response activities. This office can be contacted at 671/477-7391.

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Shoreline Habitat Descriptions

EXPOSED ROCKY SHORES AND VERTICAL, HARD MAN-MADE STRUCTURES (e.g., SEAWALLS) ESI=1

DESCRIPTION

- Exposed rocky shores are very common, but exposed man-made features, such as seawalls, are rare
- Composed of vertical scarps of limestone or volcanic rocks
- Most common on exposed headlands with steep nearshore topography
- In places, the vertical scarps are buttressed at the base by large slump blocks
- May be nesting and roosting sites for marine birds

PREDICTED OIL BEHAVIOR

- Most commonly, oil would be held offshore by waves reflecting off the steep rock faces
- Deposited light, refined oils would be removed rapidly by wave action; heavier, sticky oils are likely to remain longer as a patchy band at or above the high-tide line
- Impacts to intertidal communities are expected to be of short duration; an exception would be where heavy concentrations of a light refined product (e.g., No. 2 fuel oil) came ashore very quickly

RESPONSE CONSIDERATIONS

- On very exposed shores, no cleanup is necessary (and may be dangerous)
- On less exposed shores:
  - Low-pressure spraying may be effective while oil is still liquid
  - Manual scraping of seawalls may be necessary for removal of tarry deposits

EXPOSED WAVE-CUT ROCK PLATFORMS ESI=2

DESCRIPTION

- Most common shoreline type on the islands
- Platforms are wavecut benches in limestone and volcanic rocks
- In some places, low-lying, pitted and pinnacled limestone merges into offshore reef-flat platforms
- Generally exposed to high wave action
- Rock surfaces irregular, with numerous tidal pools
- Habitat may support large populations of encrusting plants and animals

PREDICTED OIL BEHAVIOR

- Oil would not adhere to the rock platform, but rather be transported across the platform and accumulate along the high-tide line
- Oil can penetrate and persist in the beach sediments on the landward side of the platform, if present
- Tidal pool organisms may be killed, but recovery can be rapid
- Light, refined oils would tend to be removed rapidly by waves and evaporation
- Heavy oils and tar balls would tend to melt into crevices and depressions, especially on porous, irregular rock surfaces
- Persistence is limited to days or weeks, depending on the wave-energy level

RESPONSE CONSIDERATIONS

- Cleanup is not necessary in most areas
- High recreational-use areas may be cleaned effectively using high-pressure water spraying if oil is still fresh
- Removal of organisms should be avoided

FINE-GRAINED SAND BEACHES ESI=3

DESCRIPTION

- Very rare beach type because of the abundance of coarse shells and coral rubble
- Difficult to identify because of sparsity of sediment grain-size information

PREDICTED OIL BEHAVIOR

- Large oil accumulations would cover entire active beach face
- Light accumulations of oil would be deposited as oily swashes along the upper intertidal zone
- Oil would accumulate in any wrack that may be present
- Penetration of oil into the beach can be up to 10 cm; burial would be minimal
- Asphalt pavements can form under thick accumulations of oil; pavements would change the nature and stability of the substrate and thus its biological utilization
- Shorebirds resting/feeding on these beaches may be oiled
- Biological impacts include temporary declines in infaunal populations, which may also affect feeding shorebirds

RESPONSE CONSIDERATIONS

- Fine-grained sand beaches are the easiest beach type to clean
- Cleanup should commence after all oil has come ashore
- Removal of sand from the beach should be minimized to avoid erosion problems
- Access to the oiled area should be restricted to cleanup teams
- Manual cleanup, rather than use of road graders and front-end loaders, is advised to minimize volume of sand removed, depending on the size of the oiled area

MEDIUM- TO COARSE-GRAINED SAND BEACHES ESI=4

DESCRIPTION

- Present mostly in areas sheltered by barrier reefs or wide reef-flat platforms (e.g., Agana Bay)
- Moderate beach slopes
- Occur in areas with intermittent high waves
- Species density and diversity usually low

PREDICTED OIL BEHAVIOR

- Large amounts of oil can cover the entire beach face, although the oil would be lifted off the lower part of the beach with the rising tide
- Small accumulations would be deposited primarily as swash lines and in wrack deposits
- Large amounts of oil can accumulate in the berm runnel where it is unable to drain off the beach at low tide
- Oil penetration can be from 10 to 15 cm, with light oils penetrating deeper than heavy oils (up to 25 cm)
- Oil may become deeply buried (30-60 cm) under clean beach sediments
- Asphalt pavements can form where oil accumulates in the more sheltered areas; pavements would change nature and stability of the substrate and thus its biological utilization
- Organisms residing in the beach sediments are likely to be killed under moderate oiling concentrations; temporary declines in infaunal populations which could impact feeding shorebirds may occur with lighter oiling accumulations

RESPONSE CONSIDERATIONS

- Cleanup should commence only after the majority of oil has come onshore
- Cleanup may be difficult because of relatively soft sediments (e.g., vehicular access may be impaired)
- Cleanup should concentrate on oil and oily debris removal from the upper beach face
- Sand removal should be minimized to avoid erosional problems
- Traffic on the oiled beach should be limited to prevent mixing oil deeper into the beach sediments
- Use of heavy equipment for oiled sand removal may result in the removal of excessive amounts of sand; manual cleanup may be more efficient, depending on the size of the oiled area

MIXED SAND AND GRAVEL BEACHES ESI=5A

DESCRIPTION

- By far the most common beach type on the islands
- Usually composed of a variable mixture of carbonate sand, shells, coral rubble, and gravel composed of limestone and/or volcanic rock fragments
- Occurs in a wide variety of settings, but most common on exposed shorelines in shallow indentions adjacent to eroding headlands

PREDICTED OIL BEHAVIOR

- Oil penetration may be high (10's of cm), with greatest penetration in coarser, well-sorted sediments
- During large spills, oil may spread across the entire beach
- During small spills, oil would be deposited along and above the high-tide swash line
- Burial of oil may be very deep (more than 1 m) at the high-tide berm
- Oil can be stranded on low-tide terraces composed of gravel, particularly if the oil is weathered or emulsified
- Asphalt pavements are likely to form in more sheltered beaches where oil fills the voids between the sediments; once formed, these pavements are very stable and can persist for many years
- Any oil stranded above the high-tide line would be highly persistent
- Biota present may be killed by the oil, either by smothering or by lethal concentrations of dissolved components in the water column

RESPONSE CONSIDERATIONS

- Cleanup should commence only after the majority of oil has come ashore
- Oiled wrack and debris deposits should be removed manually
- Low-pressure spraying may be used effectively
- Removal of sediment should be limited
- Berm relocation is effective for promoting the natural removal of previously buried oil

ARTIFICIAL FILL CONTAINING A RANGE OF GRAIN-SIZE AND MATERIALS ESI=5B

DESCRIPTION

- Most of the developed ports and harbors have areas that have been modified by creating beaches, assorted break-waters, etc., by artificial placement of a variety of materials
- Usually has the consistency of mixed sand and gravel beaches, being composed of sand mixed with coral and rock debris

PREDICTED OIL BEHAVIOR

- Oil penetration may be high (10's of cm), with greatest penetration in coarser, well-sorted sediments
- During large spills, oil may spread across the entire beach
- During small spills, oil would be deposited along and above the high-tide swash line
- Burial of oil may be very deep at the high-tide line
- Asphalt pavements are likely to form in more sheltered beaches where oil fills the voids between the sediments; once formed, these pavements are very stable and can persist for many years
- Any oil stranded above the high-tide line would be highly persistent
- Biota present may be killed by the oil, either by smothering or by lethal concentrations of dissolved components in the water column

RESPONSE CONSIDERATIONS

- Cleanup should commence only after the majority of oil has impacted the beach
- Oiled wrack and debris deposits should be removed manually
- Low-pressure spraying may be used effectively
- Removal of sediment may be advisable if more fill is available to replace it

GRAVEL BEACHES ESI=6A

DESCRIPTION

- Relatively rare beach type, usually present adjacent to eroding headlands (e.g., near Facpi Point)
- Difficult to distinguish between this type and mixed sand and gravel beaches based on data sources

PREDICTED OIL BEHAVIOR

- Oil on gravel beaches would coat individual clasts
- High porosity and permeability would allow deep penetration to several tens of centimeters into substrate
- Penetration would be greatest in areas of largest grain size and best sorting
- In exposed areas, waves would remove surface contamination
- In low-energy areas, buried or penetrated oil would tend to seep out slowly, generating sheens that can recontaminate the shoreline
- There is a high potential for oil burial by accretional features
- If left to harden, thick accumulations of oil would likely form an asphalt/gravel pavement in sheltered areas

RESPONSE CONSIDERATIONS

- Oiled wrack and debris should be removed
- Removal of sediments is not recommended
- High-pressure spraying of oiled gravel may help in cleaning exposed surfaces, but would have little effect on oil that penetrated deeply into gravel
- Berm relocation is effective for promoting the natural removal of previously buried oil

EXPOSED RIPRAP ESI=6B

DESCRIPTION

- Only present in harbor entrances and along some developed areas where jetties and groins have been constructed
- It is likely that biomass is generally low in these high energy areas, and that faunal density and species diversity are high at more protected sites

PREDICTED OIL BEHAVIOR

- Oil would coat the surface as well as penetrate and completely fill the cavities in riprap structures
- In exposed areas, waves would remove surface contamination
- In low-energy areas, oil would tend to seep out of the oil-filled cavities slowly, generating sheens that can recontaminate the shoreline
- If oil is left to harden, an asphalt pavement may result
- Resident fauna and flora may be killed by the oil

RESPONSE CONSIDERATIONS

- There should be no removal of sediments or riprap
- High-pressure spraying of oiled riprap may help in cleaning exposed surfaces but would have little effect on oil that penetrated deeply into the riprap
- For small areas of impact, riprap units can be manually wiped or scraped to remove oil

EXPOSED TIDAL FLATS — ESI=7

DESCRIPTION

- Rare shoreline type in study area
- Present near river mouths in areas sheltered by barrier reefs or wide fringing reefs (e.g., Cocos Lagoon)
- Appears to be mixed sediment, containing a range of grain size and including some mud
- Exposed to moderate wave energy

PREDICTED OIL BEHAVIOR

- Most of the oil would concentrate along the high-tide line
- Most oil would be transported across the flat with the rising tide; seldom would oil adhere to the tidal flat or be buried
- During large spills, oil would cover the flat during low tide
- Oil does not penetrate the water-saturated sediments, except into burrows in the upper intertidal zone
- Biological impacts may be severe, primarily to infauna, thereby reducing food sources for birds and other predators

RESPONSE CONSIDERATIONS

- Cleanup is difficult; therefore these areas require priority protection
- Cleanup is possible only during low tides
- The use of heavy machinery should be avoided at all times
- Cleanup efforts should concentrate on removing oil and oily debris along the high-tide line
- Operations should be conducted from boats to minimize sediment disturbance

SHELTERED ROCKY SHORES — ESI=8

DESCRIPTION

- Very rare shoreline type
- Only occurs in Apra Harbor
- Occurs as vertical rock walls and boulder-strewn rocky ledges inside bays and coves

PREDICTED OIL BEHAVIOR

- Oil would coat the intertidal surfaces of rocky shores
- Oil would penetrate into the joints and voids of the rocks
- On vertical surfaces, the oil would form a distinct oil band along the high-tide line; the lower half of the rock face usually stays wet enough to prevent oil from adhering and remaining
- During large spills, oil can coat the entire intertidal zone
- Oil may persist for weeks to months; fresh oil and light refined products have high acute toxicities, which can affect attached organisms after even short exposures
- Biota living on the bedrock (e.g., urchins, crabs, snails) would be impacted

RESPONSE CONSIDERATIONS

- Cleanup is difficult; therefore, these areas require priority protection
- High- and low-pressure water spraying of the rocky surfaces may be required:
  - To remove oil
  - To prepare area for recolonization of epifauna
  - For aesthetic reasons, in high-use recreational areas
  - To prevent the chronic leaching of oil from the surface

SHELTERED TIDAL FLATS — ESI=9

DESCRIPTION

- Present only near the entrances of a few of the small estuarine systems on the Island of Guam
- Composed mostly of mud, but may contain sand and/or gravel

PREDICTED OIL BEHAVIOR

- Oil would most likely be transported across the tidal flat and deposited along the high-tide line
- Very large amounts of oil can cover much of the flat surface, but penetration would not occur into the water-saturated sediments of the flat, except possibly into burrows at the high-tide line
- Long-term contamination of muddy tidal-flat sediments is possible in areas of high suspended sediments through the sorption of the oil on these particulates
- Oil may persist for many years; natural removal is very slow
- Organisms living in and on the sediments will be impacted

RESPONSE CONSIDERATIONS

- These environments are high-priority areas necessitating the use of spill protection devices such as booms to prevent or minimize oil impact
- If cleanup is necessary, it should be restricted to the upper reaches of the high-tide line or conducted from boats
- Passive cleanup efforts such as deployment of sorbent boom can be used to retain oil as it is removed naturally, but they must be monitored and changed frequently to be effective
- Any cleanup should be supervised closely to minimize the mixing of oil into the sediment during the cleanup effort

MANGROVES — ESI=10A

DESCRIPTION

- By far the most sensitive habitat on the islands to oil-spill impacts
- Mangrove swamps are situated in two distinct areas: a 7 km section of Apra Harbor and a 5.5 km section of Cocos Lagoon
- The mangrove areas are protected from heavy surf action by either a large lagoon or a man-made harbor
- *Rizophora* and *Avicennia* spp. are the most common types

PREDICTED OIL BEHAVIOR

- As oil enters mangrove forests, their roots and associated epiphytic communities would be covered with a band of oil
- Degree of impact is oil-type dependent:
  - Light oils (gasoline, jet fuel, No. 2 fuel oil) would have acute, toxic impacts to both trees and intertidal biota
  - Crude oils/heavy refined products exhibit toxicity due to coating and sediment contamination
- Oiling of sediments would occur if large quantities of oil were washed ashore
- No. 2 fuel oil would have the greatest persistence; it can persist and remain toxic for many years if it penetrates burrows and prop root cavities
- Persistence would be long-term where oil accumulated
- Presence of a beach berm fronting the mangroves would normally limit the extent of oil impact to the seaward side of the berm, thus prevent oiling of forest interiors

RESPONSE CONSIDERATIONS

- These highly sensitive areas are very difficult to clean up, therefore they require the highest of priority protection
- Under most conditions, the best practice is to allow natural recovery, especially where natural cleaning can occur
- Placement of sorbent boom along the mangrove forest fringe may reduce the quantity of oil impacts significantly
- Booms should be deployed in an attempt to protect the most sheltered areas where greatest persistence is likely
- However, deployment of boom is seldom effective with light refined oils, because of the low viscosity of these products
- Thick accumulations of oil should be skimmed or flushed with low-pressure water flooding, as long as there is NO disturbance or mixing of oil into the substrate. If substrate mixing is likely or unavoidable, it is usually better to leave the oil to weather naturally
- Oily debris should be removed, taking care not to disturb the substrate
- Vegetation should never be cut or otherwise removed
- Sorbents can be used to wipe thick oil coating from prop roots in areas of firm substrate. Close supervision of cleanup is required

OTHER ESTUARINE WETLANDS ESI=10B

DESCRIPTION

- Nine of the river systems on Guam contain estuarine wetlands which, in some rivers, extend over 1 km inland
- Principal plants are the Nipa palm (*Nypa fruticans*), pago (*Hibiscus tiliaceus*), tangan-tangan (*Leucaena* sp.), bamboo, and miscellaneous grasses, among others
- Provide nesting habitat for the endangered common moorhen (*Gallinula chloropus*)
- Many have high density and diversity of plants, and they are important habitats for many animals

PREDICTED OIL BEHAVIOR

- Estuarine conditions allow the possibility for oil to be transported into these wetlands during flood tides
- Exact impacts of oil on many of these species is unknown, but wetlands are usually heavily impacted during oil spills
- Oil adheres readily to the vegetation
- The band of coating would vary widely, depending on the tidal stage at the time that the oil slicks are in the vegetation. There can be multiple oil bands
- Large slicks would persist through multiple tidal cycles and coat the entire plant from the high-tide line to the base
- Fresh crudes and heavy oils would tend to "slide" down the stem over time in warmer weather and pool on the sediments at the base of the plant
- Weathered oils do not "slide" as much; the oil stays on the vegetation
- If the vegetation is thick, oil contamination can be restricted to the outer fringing vegetation, with less penetration and oiling further inland
- Lighter, refined oils and fresh crudes can penetrate farther into the wetland, to the high-tide line
- Medium to heavy oils do not readily adhere to or penetrate the wet, muddy sediments, but they can pool on the surface and in burrows
- Light, refined oils can penetrate the top few cm of sediment and deeply into burrows and cracks (up to 100 cm)

RESPONSE CONSIDERATIONS

- These highly sensitive areas are very difficult to clean up, therefore they require the highest of priority protection
- Under most conditions, the best practice is to allow natural recovery, especially where natural cleaning is effective, such as along river channels exposed to wave and tidal energy
- Placement of sorbent boom along the vegetative fringe may reduce the quantity of oil impacting the area
- Deployment of boom is seldom effective with light refined oils because of the low viscosity of these products
- For other products, booms should be deployed in an attempt to protect the most sheltered areas where greatest persistence is likely
- Thick accumulations of oil should be skimmed or flushed with low-pressure water flooding, as long as there is NO disturbance or mixing of oil into the substrate. If substrate mixing is likely or unavoidable, it is better to leave the oil to weather naturally
- Oily debris should be removed, taking care not to disturb the substrate
- Live vegetation should not be cut or otherwise removed
- These activities should be closely supervised

SHELTERED MAN-MADE STRUCTURES UNRANKED

DESCRIPTION

- Common feature in harbors and other developed areas
- Difficult to categorize because of the variety of materials and construction used
- Most common in Apra Harbor

PREDICTED OIL BEHAVIOR

- Different degrees of penetration and persistence may be expected, depending upon material used
- On vertical, solid structures, oil would form a band at the high-tide line
- Oil can be trapped under piers and dock structures, where it is difficult to remove
- Biological impacts are usually minor on these artificial structures

RESPONSE CONSIDERATIONS

- There is little restriction on the type of cleanup that can be used on these structures, except for the use of toxic chemicals

CORAL REEFS UNRANKED

DESCRIPTION

- According to Randall and Eldredge (1976), "The shoreline of Guam is bordered by fringing reefs of various widths. A triangular barrier reef encloses a shallow lagoon at the southwestern corner of the island. A deep lagoon at Apra Harbor is enclosed by a submerged coral bank, a barrier reef and Cabras Island"
- Most of the reefs that surround the islands occur subtidally. The most abundant coral growth on the reef platform is usually restricted to low-tide moats or where holes and depressions retain water during low tide

PREDICTED OIL BEHAVIOR

- There are three locations where floating oil is apt to coat the living reefs of Guam:
  - Landward border of fringing reef platforms which are exposed at low tide
  - Certain reef-flats which are floored with bedrock and may have scattered coral growing on them, and
  - The outer, seaward part of reef-flat platforms that are usually slightly elevated and are consequently exposed at low tide and heavily washed by waves
- Except in the event of extremely large amounts of oil, any stranded oil would be readily removed from these reef areas with the rising tide. This is especially true of the outer reef platform
- There is little documentation of long-term impacts to coral reefs by oil spills, except in the situations where the pollution was chronic, or in the rare instance where the oil sank

RESPONSE CONSIDERATIONS

- No cleanup is recommended. Cleanup of the reef itself by natural processes is expected to be rapid
- Oil should be removed from adjacent intertidal areas to prevent chronic exposure of the corals to oil leaching from these sites