2.0 PROBLEM FORMULATION

The problem formulation phase of this ERA describes the goals and focus of the study. Information regarding the regional setting at NFD Point Molate, site characterization information, existing analytical data, and a description of the ecosystem potentially at risk were used to develop a conceptual site model for the offshore environment at NFD Point Molate. From this conceptual model, assessment and measurement endpoints were identified and a sampling approach was designed. Additional information on the location, history, geology, hydrogeology, topography, ecology, and other characteristics of NFD Point Molate are presented in the Offshore ERA Work Plan (TtEMI, 1998).

2.1 SITE LOCATION AND HISTORY

NFD Point Molate is located on the San Pablo Peninsula in Contra Costa County, approximately 1.5 miles north of the Richmond-San Rafael Bridge (Figure 2-1). The facility covers approximately 412 acres in the Potrero Hills along the northeastern shore of San Francisco Bay. NFD Point Molate is a former bulk fuel storage and transfer facility capable of storing more than 40 million gallons of fuel within 24 large capacity underground storage tanks (USTs). Jet petroleum fuel (JP-5), marine diesel fuel (F-76), and other fuels (including bunker fuel, gasoline, and aviation gasoline) have historically been stored at NFD Point Molate. Fuel was transferred at the facility by off-loading and on-loading ships and barges at the depot fuel pier and through the Santa Fe Pacific Pipeline Transfer Station. Fuel storage and transfer operations at the facility ceased in May 1995 as a result of the Base Realignment and Closure (BRAC) IV program. Operational closure of the facility occurred on September 30, 1998.

2.2 REGIONAL SETTING

NFD Point Molate is located in San Francisco Bay on the central coast of California. San Francisco Bay can be divided into two major circulatory systems: the South Bay and the North Bay. The North Bay is comprised of Suisun Bay, San Pablo Bay, and Central Bay. NFD Point Molate is located in the southeast portion of San Pablo Bay (Figure 2-1).

Tidal action greatly influences water exchange within the San Francisco Bay. During one tidal cycle, up to 24 percent of the Bay's water volume is exchanged. The tides are mixed semidiurnal, with two lows and two highs approximately every 24 hours. San Francisco Bay is an estuary receiving a significant amount of freshwater input, primarily from the Sacramento River, which affects currents

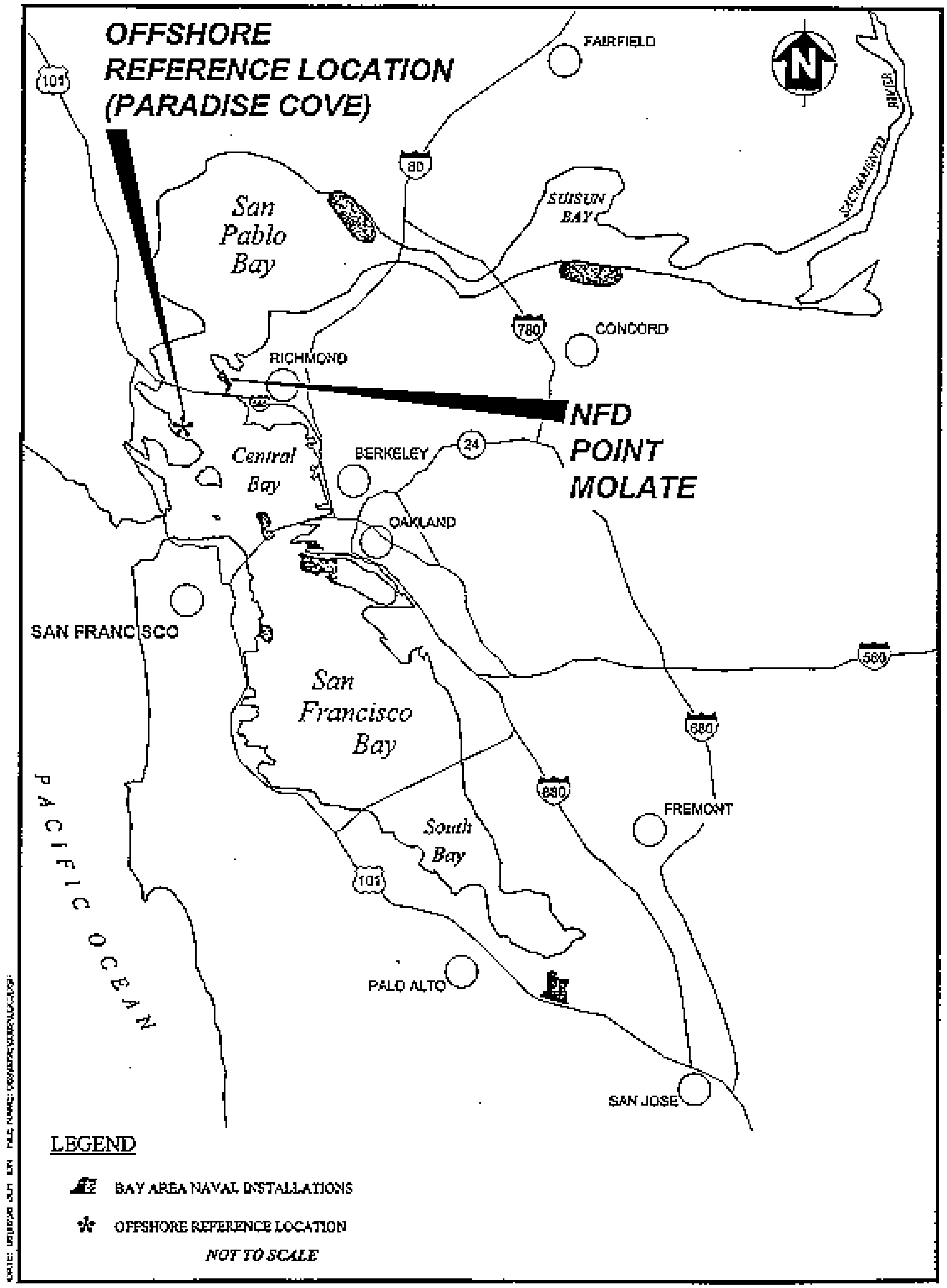

FIGURE 2-1

NFD POINT MOLATE FACILITY AND OFFSHORE REFERENCE LOCATION MAP

and water quality parameters such as salinity. Salinity ranges from less than 2 parts per thousand (ppt) during the winter in the eastern end of the San Pablo Bay to approximately 30 ppt and above in the Central Bay during summer (RWQCB, 1994). During the winter months, salinity can decrease to less than 18 ppt in the Central Bay.

San Francisco Bay provides habitats for diverse ecological communities including uplands, grasslands, wetlands, mudflats, shoals, and deep-water habitats. The Bay is one of the most important staging and wintering areas for migratory waterfowl and shorebird populations on the western coasts of North and South America. Nearly one million waterfowl and shorebirds utilize the San Francisco Bay's open water and wetland habitats**.** As waterfowl habitat has dwindled in other parts of the state, the Bay has become increasingly important for maintaining bird populations (SFEP, 1992). The Bay also supports numerous fish and benthic invertebrate species in a variety of aquatic habitats.

2.3 POTENTIAL CONTAMINANT SOURCES AND SELECTION OF CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN (COPECS)

The main source of contamination at NFD Point Molate was through fuel spills and leaks associated with the site’s use as a bulk fuel storage facility. Additional minor sources of contamination at the site may also include historical sandblasting and waste disposal activities; however, significant transport of these contaminants from the upland source areas to the near-shore sediments is unlikely. This conclusion is supported by previous metals analyses from near-shore sediments, which found that metal concentrations (with the exception of cadmium) fall within the values detected in the RWQCB’s Pilot Regional Monitoring Program (RMP) (RWQCB, 1994). While petroleum from NFD Point Molate is the main contaminant source of interest for the offshore ERA, petroleum and petroleum constituents detected in offshore sediments may also be attributable to other off-site industrial sources such as petroleum refineries, marinas, and other regional non-point source emissions.

In the past, near-shore sediments at NFD Point Molate may have been impacted by petroleum directly from spills or seeps during facility operations. Additionally, near-shore sediments may be impacted from upland sources via groundwater discharge and surface runoff during rain events. The steep topography at NFD Point Molate facilitates the flow of surface water and groundwater from higher elevations toward San Francisco Bay. During rainstorms, surface water flows down ravines into San Francisco Bay and San Pablo Bay. Stormwater outfalls, which may have contained fuels and fuel-contaminated water, also discharge directly into San Francisco Bay.

The presence of groundwater at NFD Point Molate is consistent along the near-shore areas that have little or no relief, and forms a highly variable water table that is, in some places, in hydraulic communication with San Francisco Bay. A true aquifer (i.e., a saturated permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients [Freeze and Cherry, 1979]), does not exist at NFD Point Molate. The presence of groundwater is directly related to seasonal infiltration, runoff from the hillsides, and hydraulic communication with the Bay. Some ravines that receive steady (but seasonally dependent) recharge also contain groundwater within unconsolidated material and, in some cases, within permeable horizons at the base of colluvium and fissile or fractured bedrock.

Constituents of potential ecological concern (COPECs) for the offshore ERA were selected based on knowledge of historical practices and releases at the site. Based on historic use, NFD Point Molate is not considered a significant source to the offshore sediments of pesticides, metals, polychlorinated biphenyls (PCBs), or other non-petroleum related volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs). Therefore, this offshore ERA focuses only on petroleum and petroleum-related constituents [e.g., total petroleum hydrocarbons [TPH] and polycyclic aromatic hydrocarbons (PAHs)]. PAHs will be evaluated as sum PAH. The one exception, T2 in the south cove, had potential for impact by pesticides stored on-site. At this location, tissue and sediment samples were evaluated for chlorinated pesticides as well as petroleum and petroleum-related constituents.

2.4 PREVIOUS INVESTIGATIONS OF OFFSHORE SEDIMENTS

Data collected from two previous investigations (1994 and 1995) were used to focus this investigation at NFD Point Molate to areas representing worst-case scenarios based on concentrations of COPECs detected in sediments. Information collected from these investigations included analytical data from site characterizations, environmental baseline study (EBS) sampling, and shoreline investigations. Offshore data included sediment chemistry data and whole sediment bioassay data. Previous sampling was conducted using targeted sampling approach based on historical spills, discharges, and practices.

In 1994, 76 sediment samples along 13 transects were collected as part of an investigation of the NFD Point Molate facility's entire shoreline (PRC Environmental Management, Inc. [PRC] 1994) (Plate 1). Samples from all sediment locations were analyzed for SVOCs, VOCs, and TPH extractables. Samples for a few select locations were analyzed for metals. In January 1995, sediment chemistry and whole sediment bioassays using the test organism *Eohaustorius estuarius* were conducted as part of the "January 1995 Fuel Seepage Response and Assessment" (PRC, 1995), an investigation of a fuel seep that was occurring adjacent to IR Site 3. The 1995-bioassay data are shown in Table 2-1. These bioassay data were not used to support the NFD Point Molate Offshore ERA as the investigation was conducted in a limited area and the resulting data were not co-located with other ERA data (e.g., additional bioassays, tissue data, sediment chemistry).

2.5 SITE CHARACTERIZATION

Site characterization involves the identification of site-specific factors and important resources that may influence or need to be considered by the ERA. The following sections review physical characteristics, ecological resources, potential contaminant sources, and existing data for NFD Point Molate.

2.5.1 Physical Description of NFD Point Molate

The physical description of the intertidal environment around NFD Point Molate is discussed in the following sections. This includes a description of the physical characteristics of the sediments within the intertidal area, and an oceanographic description of the offshore areas around Point Molate.

2.5.2 NFD Point Molate Sediments

Based on information provided in the U.S. Army Corps of Engineers (USCOE's) "Sediment Budget Report for San Francisco Bay" (1992), the offshore areas surrounding NFD Point Molate are believed to be composed of both erosional and depositional areas (Figure 2-2). The area north of the fuel pier at NFD Molate Point can be described as accretional proceeding to erosional near the northern offshore facility boundary. An erosional regime exists around the fuel pier itself offshore of Drum Lot 1. Directly south of this area is a depositional environment that extends into the subtidal regions to Castro Point, surrounding a near-shore erosional environment along the south shoreline. According to the USCOE report "Long-Term Management Strategy (LTMS) for the Placement of Dredged Material in the San Francisco Bay Region" (1979), areas surrounding NFD Point Molate cannot be described as predominantly accretional or erosional, rather, there appear to be areas of accretion and erosion. These areas are, however, only slightly accretional (0 to 1 foot) or slightly erosional (0 to 1 foot). The description of depositional and erosional environments provided above are based on data collected at only two points in time. Additionally, erosional and depositional patterns of SF Bay sediments are unknown between 1955 and 1990. If risk is indicated, a better study of erosional and accretional patterns in the area may be recommended for risk management purposes.

TABLE 2-1

JANUARY 1995 FUEL SEEPAGE RESPONSE AND ASSESSMENT BIOASSAY AND GRAIN SIZE RESULTS IN SEDIMENT NFD POINT MOLATE

Designation Sample	Grain Size (%)				Bioassay[1]		Total PAHs[2] (mg/kg)
	Gravel	Sand	Silt	Clay	% Survival	% Reburial	
T10-20	1.5	48.6	32.3	17.6	78.8*	100.0	5.9
T10-75	0.2	35.9	40.2	23.7	62.0*	98.9	4.4
T11A-10	0.3	37.4	32.7	29.7	68.0*	100.0	3.0
T11A-75	0.3	40.6	37.8	21.3	66.0*	100.0	2.3
T11A175	0.4	49.2	29.7	20.8	66.0*	100.0	2.1
T0A-200	0.4	31.3	45.1	23.2	69.0*	100.0	0.86
T0B-300	0.1	71.0	18.0	10.9	96.0	100.0	0.92
Control	--	--	--	--	98.0	100.0	--

Notes:

* Statistically different than control
(1) Results from MEC Analytical Systems, Inc.
Bioassay: 10-day solid phase using *Eohaustorius estuarius*
Test dates: January 21-31, 1995
Sample collection dates: January 14-15, 1995
(2) PAH: Polycyclic aromatic hydrocarbons; chemistry by PACE/ETC - Mid Pacific

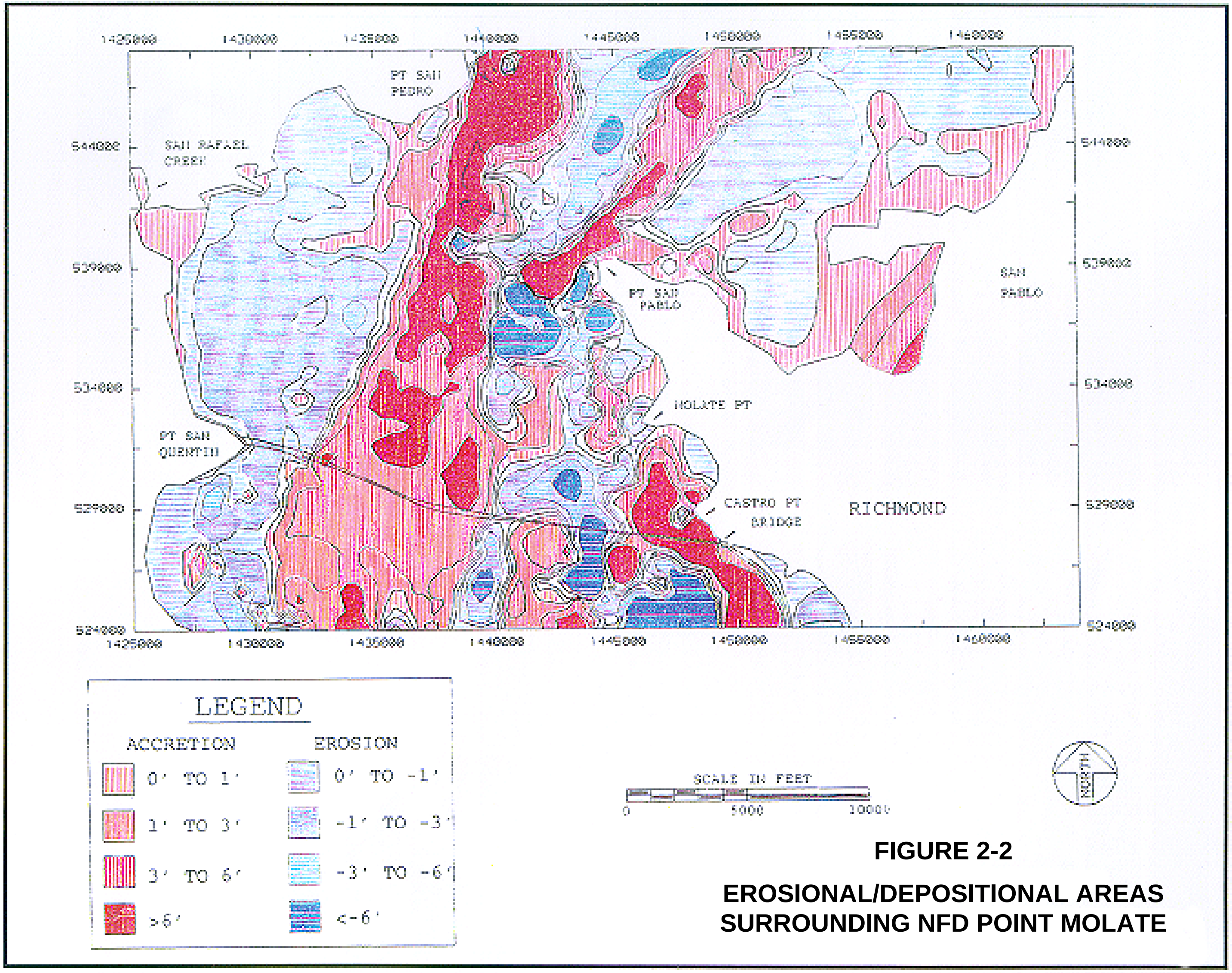

FIGURE 2-2

EROSIONAL/DEPOSITIONAL AREAS SURROUNDING NFD POINT MOLATE

2.5.2.1 Sediment Physical Parameters

Whole sediment samples collected as part of the 1998 field effort to compile data to support the offshore ERA at NFD Point Molate were analyzed for physical parameters including grain size, total organic carbon (TOC), pH, salinity, percent moisture, interstitial (pore water) salinity, sediment oxidation-reduction (redox) potential, and sediment oxygen demand (SOD) (sum of biochemical and chemical oxygen demand) at each site. This information was collected to characterize the site and potentially aid in interpreting bioassay results. In the event that toxicity is observed, physical sediment parameters can be calculated to assess confounding factors associated with toxicity test results and/or toxicity drivers. As discussed later, no toxicity was observed at NFD Point Molate sampling locations. The physical data discussed below was, therefore, not evaluated.

The grain size analysis measured the percent of total weight recovered for each grain size. The results were grouped into three categories: (1) fines (silt and clay components), (2) sand (very fine, fine, medium, coarse, and very coarse sands), and (3) gravel (fine and medium gravel). Fines measured in each sample are graphically summarized in Figure 2-3. For all but three sample stations (i.e., T5-1, T9-1-1, and DL-1-1), fines were the major component, with sands making up the remainder of the sample. The percent fines ranged from 18 to 94 percent. Intertidal sampling stations consisted of approximately 50 to 60 percent fines, except for stations T5-1, T9-1-1, and DL-1-1, which were 18, 37, and 30 percent, respectively, and station T11-1 that had 71 percent fines. Subtidal and reference station samples contained more than 75 percent fines, except for subtidal station P1-1, which had only 48 percent fines.

Results of the TOC analysis are graphically summarized in Figure 2-4. NFD Point Molate TOC concentrations in sediments ranged from 0.3 to 2.6 percent with average concentrations of 1.1 percent. No data trends or correlation between the grain size results and the TOC results were observed.

Results for percent moisture, pH, SOD, pore water salinity, and sediment redox potential are summarized in Table 2-2. Percent moisture was measured in all sediment samples analyzed for chemical parameters; the other physical properties were measured in one sediment sample from each station, but not in replicate samples. No obvious spatial trends are noted in the pH and pore water salinity values as the range of values for these parameters is very narrow among all samples. Qualitatively, SOD appears to be somewhat lower in the south cove area than in the north cove, pier area, and reference area. Sediment redox potential appears highly variable and does not appear related to levels of other physical or chemical

Figure 2-3
Percent Fines in Sediment
NFD Point Molate and Reference Area

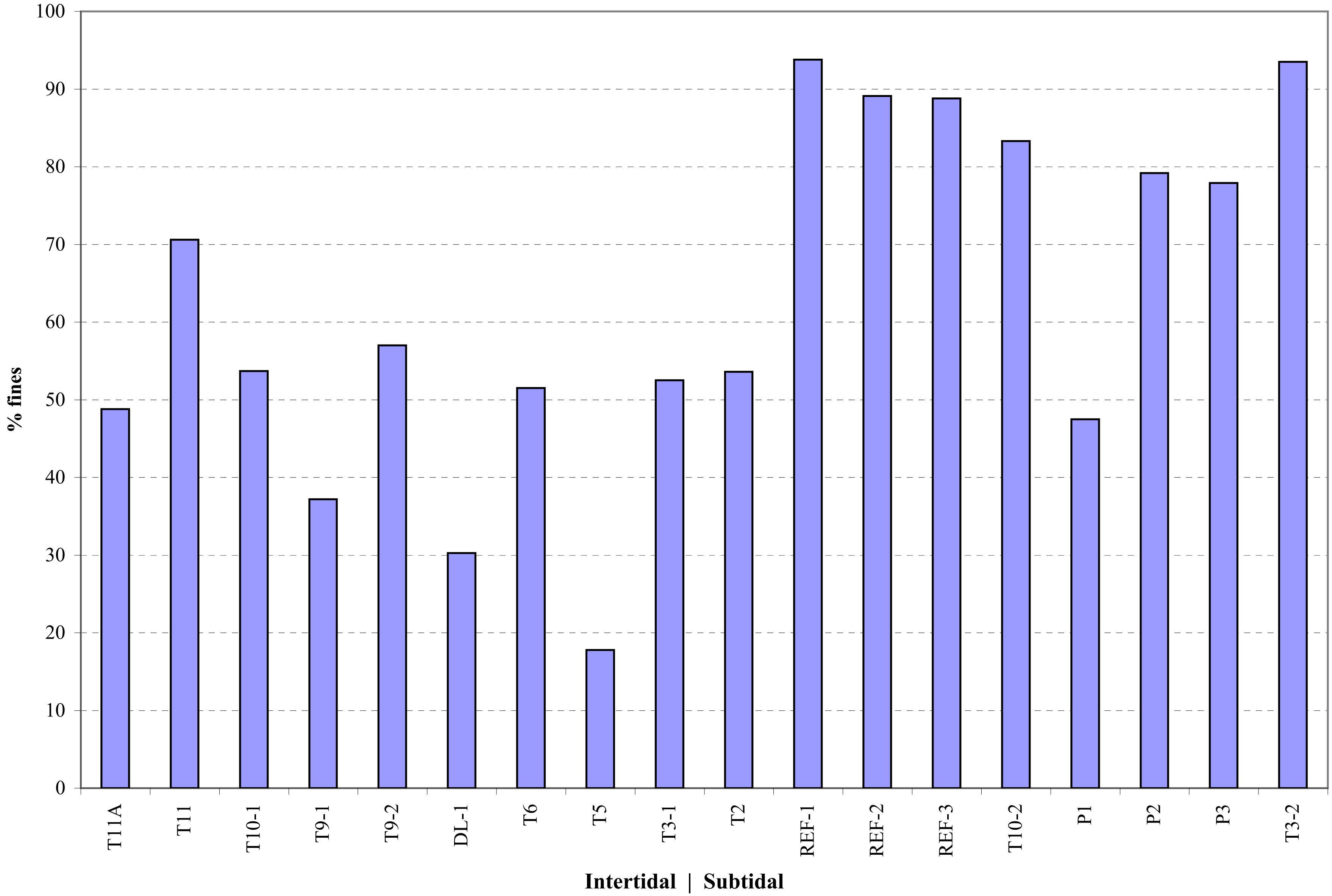

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Figure 2-4
Sediment Total Organic Carbon Values
at NFD Point Molate

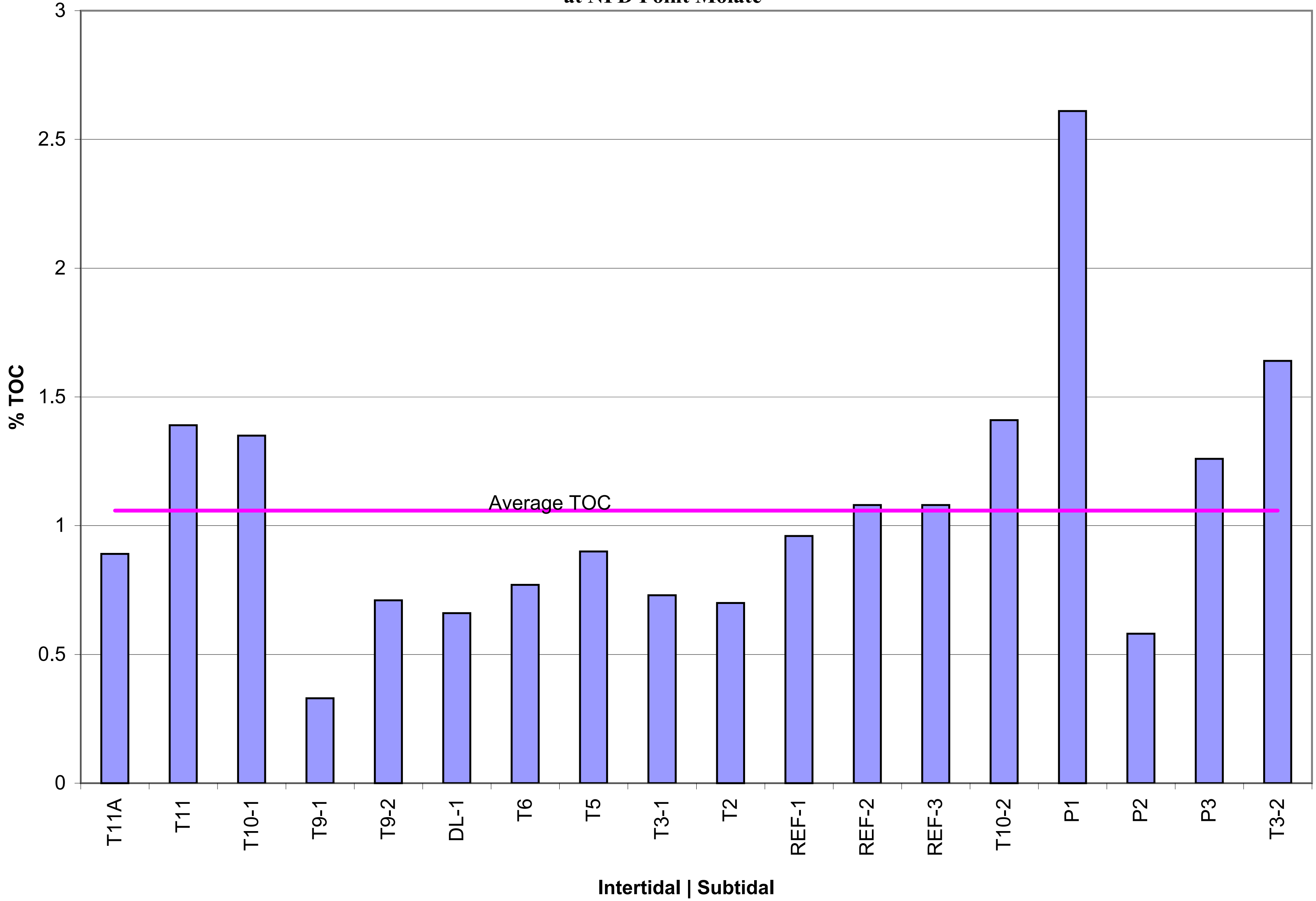

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TABLE 2-2

1998 SEDIMENT PHYSICAL PARAMETERS FOR NFD POINT MOLATE AND THE REFERENCE AREA

Area	Station	Sample ID	Moisture	pH	Sediment Oxygen Demand	Pore Water Salinity	Sediment Redox Potential
		Units	%	pH units	mg/kg	ppt	mV
Intertidal							
North cove	T11A	T11A-1	34.0	7.72	20570	23.6	-104.8
		T11A-2	35.0	NA	NA	NA	NA
		T11A-3	33.8	NA	NA	NA	NA
	T11	T11-1	43.9	7.63	41079	22.7	-156.5
	T10	T10-1-1	43.7	7.81	33900	22.6	-220.2
	T9-1	T9-1-1	34.6	7.65	18622	23	78.4
		T9-1-2	31.7	NA	NA	NA	NA
		T9-1-3	33.2	NA	NA	NA	NA
	T9-2	T9-2-1	43.4	NA	20283	23.7	-97.1
	DL-1	DL-1-1	30.5	7.69	22017	23.8	368.4
South cove	T6	T6-1	39.8	7.48	25707	24.3	-135.3
	T5	T5-1	26.7	7.77	11400	24.4	170.4
		T5-2	25.5	NA	NA	NA	NA
		T5-3	27.5	NA	NA	NA	NA
	T3-1	T3-1-1	54.0	7.29	28343	24.7	-54.1
	T2	T2-1	32.5	7.59	16223	24.6	107
		T2-2	32.7	NA	NA	NA	NA
		T2-3	29.9	NA	NA	NA	NA
Paradise Cove	Reference	REF-1	52.6	7.86	30338	25.3	-152.3
		REF-2	56.1	7.93	27788	25.7	-119.8
		REF-3	54.9	7.88	33452	25	-126
Subtidal							
North cove	T10-2	T10-2-1	54.6	7.78	31790	23.9	74.3
Pier	P1	P1-1	52.1	7.84	40278	24.1	-189
	P2	P2-1	48.0	7.82	27042	24.6	-135.9
	P3	P3-1	50.3	7.73	29004	24.8	-42.9
South cove	T3-2	T3-2-1	60.1	7.55	36550	25.3	-172.3

Note:

NA = Not analyzed

parameters measured in the samples. Generally, however, the sediment physical parameters are within the range of those measured in San Francisco Bay by the RMP (SFEI, 1995).

2.5.2.2 Description of Water Quality Parameters at NFD Point Molate

Selected water quality parameters were measured at each of the sampling stations during the 1998 site investigation. Salinity, dissolved oxygen, and water temperature in the vicinity of each station were measured and recorded on the field data sheets at the time the station was being sampled. A summary of these measurements is provided in Table 2-3. The intertidal, subtidal, and reference stations have been segregated in the table.

The salinity and temperature measurements collected at the intertidal, subtidal, and reference stations showed some general trends. The salinity at the intertidal stations ranged from 24 to 26 ppt, the subtidal stations ranged from 27 to 28 ppt, and the reference station was 30 ppt. The lowest water temperature was measured at the reference station at 14.7°C, and water temperature at the subtidal station ranged from 15.5 to 16.4°C. The higher water temperatures were measured at the intertidal stations which ranged from 15.5 to 20.4°C, with an average of temperature of 17.8°C. The dissolved oxygen measurement did not show any particular trend depending on station depth or location. Overall, the dissolved oxygen measurements ranged from 6.5 to 10 parts per million (ppm). The water quality parameters measured at NFD Point Molate are generally within the range of those measured in San Francisco Bay by the RMP (SFEI, 1995).

2.5.3 Description of Ecological Resources at NFD Point Molate

NFD Point Molate is comprised of terrestrial and aquatic environments with diverse species and complex interactions. The aquatic resources and habitat are described in the following sections.

2.5.3.1 Aquatic Habitat Resources

The predominant aquatic habitats occurring at NFD Point Molate are intertidal mudflats, eelgrass beds, and subtidal soft-bottom habitat. Rocky shoreline, which occurs in several areas, and a rip-rap shoreline by the fuel pier also provide additional intertidal habitat. Water depths surrounding NFD Point Molate exhibit a gradual slope from the shore to shelf break, with depths ranging from 1 to 18 feet. The shelf break runs north to south, generally parallel to the shore, and lies roughly 2,250 to 3,000 feet from shore. Intertidal areas vary seasonally but generally extend from 100 to 400 feet offshore (NOAA, 1993).

TABLE 2-3

SUMMARY OF WATER QUALITY MEASUREMENTS AT NFD POINT MOLATE

Station ID	Intertidal or Subtidal	Salinity (ppt)	Temperature (^oC)	Dissolved Oxygen (ppm)
DL-1	I	25	16.4	7.3
T9-1	I	24	16.7	7.3
T9-2	I	25	17.4	8.9
T10-1	I	24	19	6.5
T11	I	25	19.3	6.8
T11-A	I	25	20.4	7.4
T2	I	26	18.8	10
T3-1	I	26	15.5	8.3
T5	I	26	16.4	8.3
T6	I	26	17.7	9.8
T3-2	S	27	15.6	8.1
T10-2	S	28	15.5	8.2
P1	S	28	16.4	8.6
P2	S	27	15.8	8.4
P3	S	27	15.6	6.6
REF1	I	30	14.7	7.7
Average		26.2	17.0	8.0
Min		24	14.7	6.5
Max		30	20.4	10

The eelgrass beds located at NFD Point Molate are especially important intertidal habitat. Eelgrass beds provide significant nursery habitat for fish and invertebrates and can shelter as many as 20 fish and 1,000 invertebrates per square meter of substrate (NMFS, 1989). In San Francisco Bay, the eelgrass beds are known to provide one of the major spawning substrates for the Pacific herring (*Clupea harengus palasi*), an important commercial fishery (NMFS, 1989). Based on a 1987 National Marine Fisheries Service (NMFS) study on eelgrass beds in the San Francisco Bay, the eelgrass beds in the north and south coves of NFD Point Molate constitute the second largest mapped acreages of eelgrass beds in the Bay (approximately 38 out of a total of 316 acres in the Bay) (NMFS, 1989).

Because of the rich habitat, the offshore environment around NFD Point Molate is likely to support a number of benthic invertebrate and fish species. Benthic invertebrate species observed in the offshore environment include the introduced Asian clam (*Potamocorbula amurensis*) and possibly include mollusks (such as the bay mussel, *Mytilus edulis*), crustaceans (such as amphipods, copepods, shrimp, and the Dungeness crab, *Cancer magister*), annelids, gastropods, oligochaetes, and polychaetes. Fish likely to be present in these areas include striped bass (*Morone saxatilis*), American shad (*Alosa sapidissima*), Pacific herring (*Clupea harengus palasii*), brown smooth-hound shark (*Mustelus henlei*), big skate (*Raja binoculata*), and bat rays (*Myliobatis californicus*). A list of fish and invertebrates that are expected to occur at NFD Point Molate is provided in Appendix A (Table A-1).

Benthic invertebrate and fish communities present at NFD Point Molate make the aquatic environment surrounding the facility, and in particular the shoreline area of NFD Point Molate, suitable for numerous shorebird species. Bird surveys of the offshore area were conducted in November 1998 and January 1999 specifically to support the offshore ERA. A description of the methods used and a summary of results is included in Appendix A. A complete list of birds observed at NFD Point Molate during winter field surveys and species expected to be present is provided in Appendix A (Table A-2) (ENTRIX, 1999). In addition to the invertebrates, fish, and birds present in the intertidal areas around NFD Point Molate, harbor seals (*Phoca vitulina*) have also been observed swimming close to the fuel pier during the winter months.

The use of the intertidal area around NFD Point Molate by special status species is being determined and characterized by the Navy (e.g., Navy, 1994; 1998; Tetra Tech, Inc., 1997). Information has been collected for the ERA by maintaining detailed natural history logs during field surveys, conducting literature reviews, and collecting information from local scientists and organizations as listed below.

Government

- National Biological Survey
- Natural Diversity Database
- National Oceanic and Atmospheric Administration (NOAA)
- U.S. Fish and Wildlife Service (USFWS)
- California Department of Fish and Game (CDFG)
- Bay Conservation and Development Commission (BCDC)
- Golden Gate Parks and Recreation Department
- San Francisco Bay Estuary Project

Nonprofit Organizations

- California Native Plant Society (CNPS)
- Golden Gate Audubon Society
- Point Reyes Bird Observatory
- The Nature Conservancy
- Aquatic Habitat Institute
- Marine Mammal Center (MMC)

Academic Organizations

- Moss Landing Marine Laboratory
- California Academy of Sciences
- University of California, Berkeley - Museum of Vertebrate Zoology

There are no known resident special status species at NFD Point Molate. Several special status species, including the brown pelican, American peregrine falcon, California least tern, western snowy plover, delta smelt, and winter-run chinook salmon have been observed or are expected to occur at the site, but are not believed to depend on the area in any significant way (EFA West, 1996a, 1996b).

Based on a special status plant survey conducted in October 1997 (Tetra Tech, Inc. 1997), no state or federally protected plant species occur at NFD Point Molate. The marsh gumplant (*Grindelia stricta*) is present in scattered populations along the shoreline at NFD Point Molate and appears on the CNPS List 4 (Tetra Tech, Inc. 1997), but has no status as a state or federally protected species.

2.5.3.2 Food Web

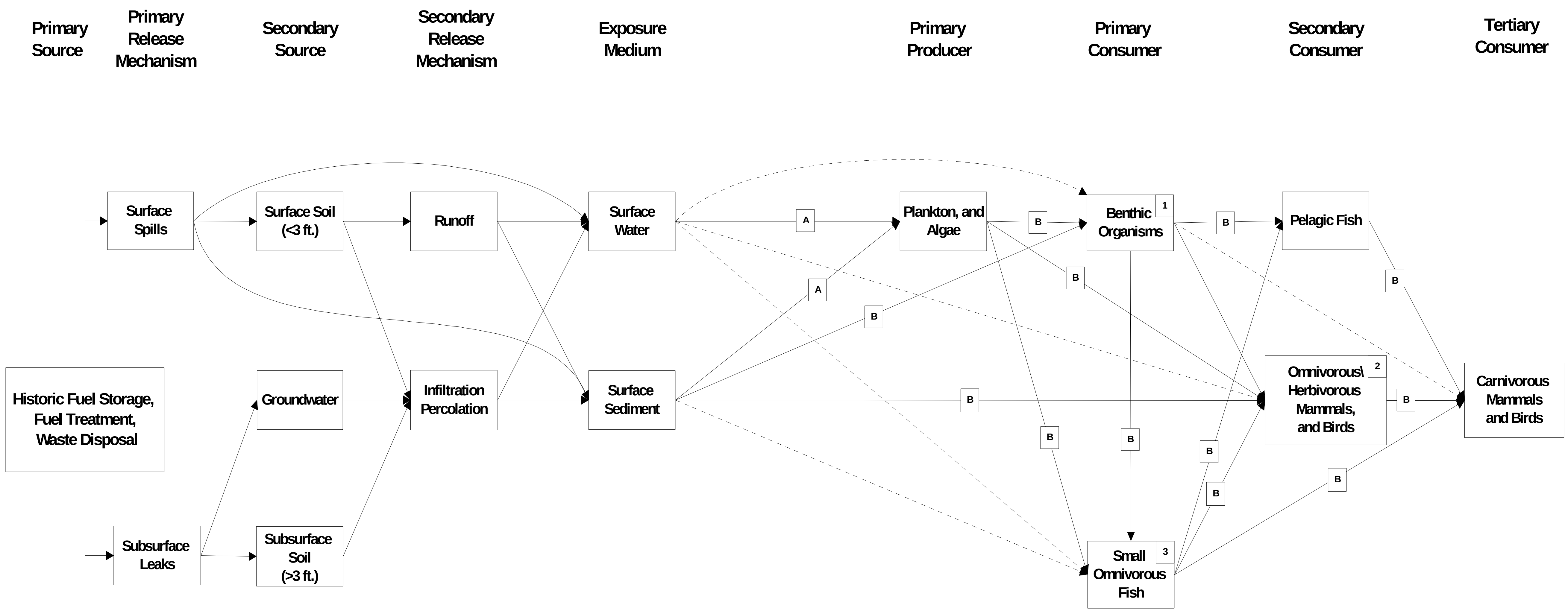
The following guilds were identified as important components of the offshore environment at NFD Point Molate: (1) shorebirds, (2) benthic invertebrates (such as clams, worms, and other invertebrates), and (3) near-shore fish communities. A stylized food web showing food chain interactions between guilds is presented in Figure 2-5.

The offshore habitats of NFD Point Molate support a complex food web. Nutrient-releasing decaying organic matter and primary producers, such as eelgrass, phytoplankton, and benthic algae, form the foundation of the aquatic food web. Primary consumers including zooplankton; mollusks such as clams, mussels, and other bivalves; crustaceans, such as amphipods, isopods, copepods, and decapods (crabs and shrimp); and annelids, such as oligochaetes and polychaetes are consumed by many bird species including shorebirds, gulls, diving ducks, and dabbling ducks. Additionally, these primary consumers form an integral prey base for fish.

Typical fish that prey on invertebrates are benthic fish, such as the speckled sanddab (*Citharichthys sigmaeus*) and the Pacific staghorn sculpin (*Leptocottus armatus*). Pelagic fish, such as the Pacific herring (*Clupea harengus palasii*) and the northern anchovy (*Engraulis mordax),* consume zooplankton. The benthic and pelagic fish, in turn, are consumed by piscivorous birds and fish. Top predators feeding in the aquatic environment at or near NFD Point Molate include cormorants and California halibut (*Paralichthys californicus).*

2.6 CONCEPTUAL SITE MODEL (CSM)

ERA methodology is based on establishing a CSM that identifies: (1) the site setting in an ecological context, (2) important site receptors, (3) ecological exposure pathways, and (4) potential pathways of chemical transport (EPA, 1992). The CSM can then be used to aid in the selection of assessment and measurement endpoints. The site setting has been discussed in the previous sections. The following sections will discuss potential site receptors and exposure scenarios, as well as potential chemical migration pathways. Figure 2-6 graphically represents the NFD Point Molate CSM described in the following sections.



Key :

Major Pathway - A complete exposure pathway with significant potential for contamination

Minor Pathway - A potentially complete pathway but relatively insignificant when compared to the major pathways considered. This pathway would not quantifiably affect the risk assessment.

1. (AE) Protection of the benthic community associated with NFD Point Molate offshore sediments.
   (ME) 1) Measure the toxicity of sediments to an infaunal amphipod using a bulk sediment bioassay protocol.
   2) Measure the toxicity at the sediment-water interface (SWI) to an epibenthic invertebrate.
   3) Potentailly determine the correlation between benthic species composition and abundance and constituent concentration at sampling locations.

2. (AE) Protection of the larval fish community associated with the eelgrass beds off NFD Point Molate.
   (ME) 1) Measure the toxicity at the SWI to fish embryos.

3. (AE) Protection of the shorebird community that utilizes the intertidal habitat of NFD Point Molate as a foraging area.
   (ME) 1) Compare the estimated site-specific doses (based on measured PAH body burdens in Asian clams) that could be ingested by foraging shorebirds to avian toxicity data associated with reproductive impairment in birds.

A. Exposure Route - Direct Uptake (i.e., dermal absorption or inhalation)

B. Exposure Route - Ingestion (i.e., direct consumption of prey items, water or sediment)

FIGURE 2-6

NFD POINT MOLATE OFFSHORE ERA CONCEPTUAL SITE MODEL

FINAL

2.6.1 Potential Site Receptors and Exposure Scenarios

Based on the aquatic food web schematic presented in Figure 2-5, four trophic levels are potentially exposed to COPECs found in offshore sediments at NFD Point Molate. These include:

- Primary producers: algae, phytoplankton and eelgrass
- Primary consumers: zooplankton, benthic invertebrates, and dabbling ducks
- Secondary consumers: carnivorous invertebrates, diving ducks and shorebirds; burrowing, demersal and pelagic fish
- Tertiary Consumers: piscivorous fish, birds, and mammals and carnivorous birds.

Table 2-4 summarizes potential exposure scenarios for site receptors.

As illustrated in Figure 2-5, the primary producers are exposed to COPECs through direct uptake in sediments and water. This exposure is likely to be insignificant because the primary mode of exposure to primary producers would be through the water column as holdfast or roots only secure the organism to the sediment and are not a means of uptake. The weathered character of the petroleum generally found at NFD Point Molate makes it likely that COPECs detected in sediments are not highly soluble and therefore would not significantly impact the water column. Additionally, NFD Point Molate's open location on the Bay makes it reasonable to assume that COPECs in the water column in the intertidal area of NFD Point Molate would be quickly diluted by currents and tidal action. Thus, no significant exposure to primary producers is expected. Primary producers were not evaluated further in the offshore ERA.

Primary consumers (primarily benthic invertebrates found in intertidal sediments at NFD Point Molate) are likely to be exposed to COPECs through ingestion and direct uptake of sediments. This exposure is potentially significant and warrants further evaluation in the offshore ERA. Primary consumers can also potentially be exposed through ingestion and direct uptake of surface water. However, as described above, exposure through the water column is unlikely to result in significant exposure. Thus, this pathway will not be evaluated further in the offshore ERA. Finally, primary consumers can be exposed through the food chain. However, since exposure to primary producers is unlikely to be significant, this pathway was not evaluated further. Therefore, the most likely exposure pathway to primary consumers is exposure through ingestion or direct uptake. This pathway is therefore recommended for further evaluation in the offshore ERA.

TABLE 2-4

POTENTIAL EXPOSURE SCENARIOS FOR SITE RECEPTORS

Potential Site Receptor Trophic Level	**Potential Site Receptor**	**Potential Exposure Route**	**Included in ERA**	**Excluded from ERA**	**Rationale for Inclusion (bold entries) or Exclusion (italic entries) from the ERA**
Primary producers	Algae, phytoplankton, eelgrass	Direct uptake from sediment and water		√	• *No uptake through roots.* • *Weathered products which are expected at Point Molate are typically insoluble, so uptake from the water column is negligible.* • *Any COPECs in the water column would be quickly diluted as a result of water exchange in the Bay.*
Primary Consumers	Zooplankton, benthic invertebrates, dabbling ducks	Ingestion and direct uptake of sediments, and surface water, and exposure through the food chain	√		• **Exposure through ingestion and direct uptake of sediments is potentially significant.** • *Because COPEC's are not expected to be highly soluble, exposure through uptake of surface water is negligible.* • *Because primary producers are not thought to uptake the COPECs, food chain exposure is unlikely.*
Secondary Consumers	Carnivorous invertebrates, diving ducks, shorebirds, burrowing, demersal or pelagic fish	Ingestion of sediments and surface water, food chain exposure, and direct contact	√		• **Exposure through ingestion of sediments is potentially significant.** • *Because COPEC's are not expected to be highly soluble, exposure through uptake of surface water is negligible.* • **Food chain exposure is potentially significant (assuming that COPECs bioaccumulate).** • *Exposure through direct contact is expected to be negligible because the insolubility of the COPECs make them unlikely to desorb from sediments.*
Tertiary Consumers	Piscivorous fish, birds and mammals, carnivorous birds	Ingestion of sediments, food chain exposure, direct contact with surface water.		√	• *The main food source of tertiary consumers in the offshore environment is vertebrates. Vertebrates readily metabolize PAHs (the main COPEC), thus exposure through the food chain is unlikely.* • *Exposure through direct contact is expected to be negligible because the insolubility of the COPECs make them unlikely to be present in significant concentrations in the water column.*

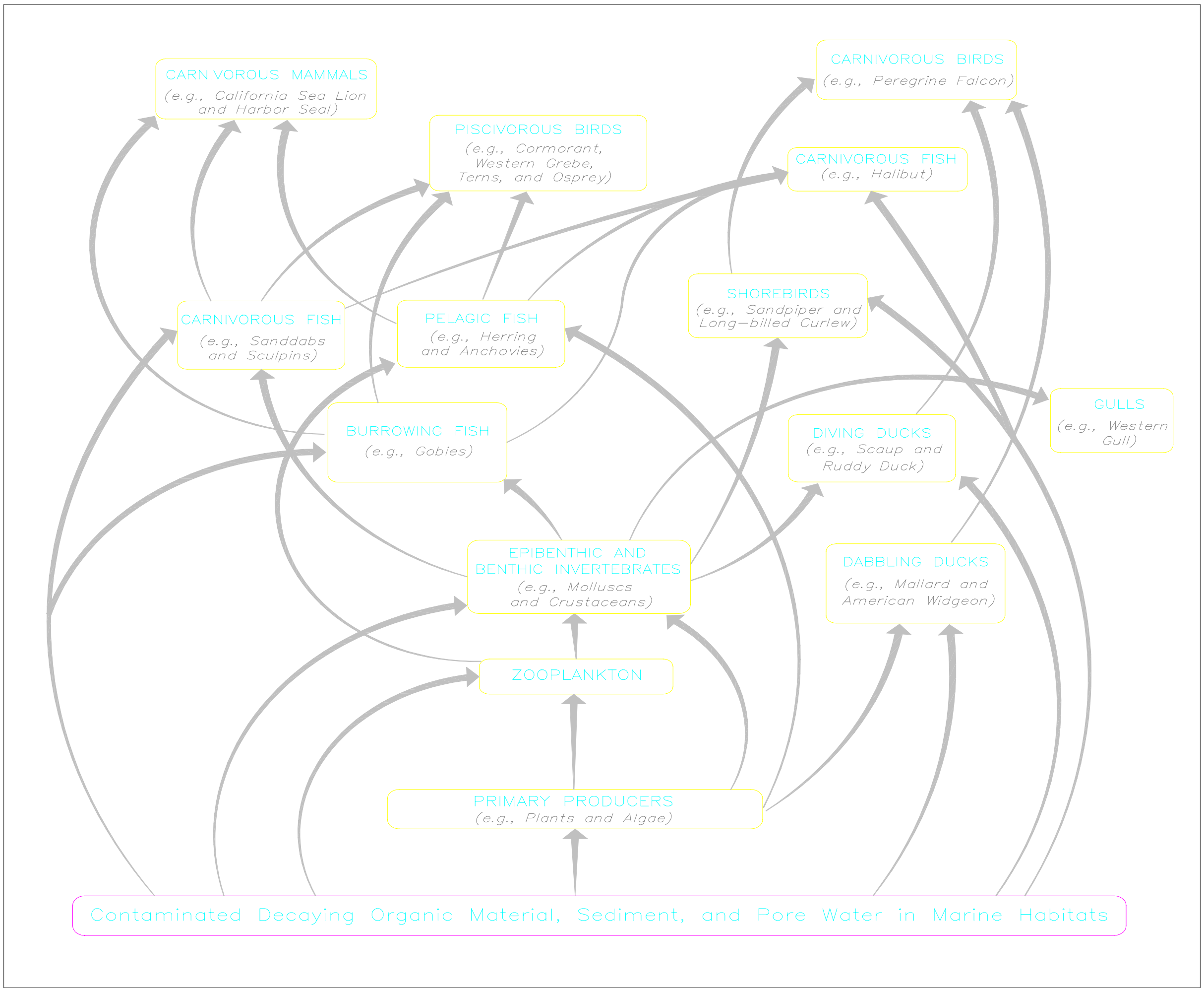


FIGURE 2-5

SIMPLIFIED AQUATIC FOOD WEB
WITH CONTAMINANT EXPOSURE AND FLOW PATTERNS

Secondary consumers (primarily invertebrate-feeding organisms such as shorebirds and diving ducks) are likely to be exposed to COPECs through ingestion of sediments. Additional significant exposure to secondary consumers could occur through the food chain. Because the main food source for secondary consumers are taxonomic groups that do not readily metabolize PAHs, the exposure to this trophic level through the food chain could be significant (assuming petroleum constituents bioaccumulate). While shorebirds may be exposed to petroleum-contaminated sediments as they wade through the intertidal, exposure via this route is likely to be *de minimus* due to: (1) the physical characteristics of weathered petroleum which would make it unlikely to readily desorb off of sediments (the petroleum in sediments at NFD Point Molate is not fresh product from an oil spill), and (2) the most significant route of chronic exposure to birds has been identified as ingestion of food items or incidental sediment ingestion through preening (Hartung, 1995; Leighton, 1995). Additionally, as discussed above, exposure through the water column is likely insignificant, and therefore will not be evaluated further in the offshore ERA. For secondary consumers, the pathway most likely to result in exposure, and recommended for further evaluation is incidental ingestion of sediments and contaminated biota.

Tertiary consumers (carnivorous and piscivorous fish, birds, and mammals) are most likely to be exposed to COPECs in the offshore area of NFD Point Molate through ingestion of contaminated biota. However, because vertebrates (their main food source) easily metabolize PAHs (the main constituent of concern in petroleum), exposure to this trophic group is likely to be much less than to lower trophic levels such as secondary consumers. Exposure of tertiary consumers to sediments is expected to be insignificant as they prey on vertebrates which are not in direct contact with the sediment. Additionally, as discussed above, exposure through the water column is also likely to be insignificant. Tertiary consumers are therefore not evaluated further in the offshore ERA.

2.6.2 Potential Migration Pathways

The focus of the NFD Point Molate ERA is the assessment of potentially contaminated sediments. Sediments can act as both a “sink” and a “source” for contaminants in the environment. The behavior of a compound in (or with) a sediment matrix depends on the physical/chemical properties of the compound and the sediment. For example, organic compounds (e.g., petroleum-related compounds) have a higher affinity to fine-grain sediments than to coarse-grain sediments, and to sediment containing higher proportions of organic matter than to sediments containing lower proportions of organic matter. Erosional environments are typically characterized by coarse-grain sediments having lower proportions of organic matter whereas depositional environments are typically characterized by fine-grain sediments having higher proportions of organic matter. Depositional sediments would, therefore, be expected to act as "sinks" and contain relatively higher concentrations of organic compounds when compared to erosional sediments. Because depositional sediments are not expected to be transported or eroded, organic compounds associated with these sediments are not expected to migrate.

Erosional sediments are likely to be transported or eroded, but are unlikely to contain significant concentrations of organic compounds as they are typically coarser and contain lower concentrations of organic matter. Additionally, most organic compounds are not likely to partition from sediment to the water column due to their hydrophobicity. Migration of sediment-bound organic constituents via the water is column is, therefore, not considered a significant migration pathway.

Organic compounds can be transferred to biota (e.g., filter and deposit feeding infaunal invertebrates) and be transported via the food chain. Migration of organic compounds spatially and through the food web is considered to be the primary migration pathway of organic compounds associated with sediments at NFD Point Molate.

2.7 NFD POINT MOLATE SELECTED ASSESSMENT ENDPOINTS (AEs) AND MEASUREMENT ENDPOINTS (MEs)

Ecological endpoints are explicit statements that identify desired environmental goals and provide a means for determining whether an unacceptable effect may occur. There are two types of ecological endpoints: (1) assessment endpoints (AEs), and (2) measurement endpoints (MEs)(Maughan, 1993; Suter, 1993; EPA, 1997).

2.7.1 Description and Rationale for Selection of AEs

AEs for the baseline ERA must be selected based on the ecosystems, communities, and species potentially present at a site. The selection of AEs depends on: (1) the contaminants present and their concentration; (2) mechanisms of toxicity of the contaminants to different groups of organisms; (3) ecologically relevant receptor groups that are potentially sensitive or highly exposed to the contaminant and attributes of their natural history; and (4) potentially complete exposure pathways.

Each AE is chosen to address a specific risk question (i.e., whether the site in question poses a risk to an identified environmental value). Defining AEs early in the process is fundamental because: (1) it focuses the ERA, (2) identifies essential data needs, and (3) helps direct the subsequent data analysis activities.

If AEs are noted to be adversely affected, this would indicate the need for remediation or other risk management actions.

As defined by the EPA (1997), AEs are formal expressions of the actual environmental values that are to be protected in the course of an ERA. AEs are defined based on technical considerations including the significance of exposure pathways, the presence of receptors, and COPECs biotic transfer pathways. An AE must be defined unambiguously so that it can be evaluated either through direct evaluation of the AE itself or through direct evaluation of MEs.

As discussed in the Offshore ERA Workplan (TtEMI, 1998), the CSM was reviewed and risk questions were identified. AEs were selected specifically to address the risk questions and MEs were selected to answer the questions. The following risk questions and associated AEs were identified:

- Do the sediments around NFD Point Molate pose a risk to the benthic invertebrate community associated with NFD Point Molate offshore sediments?
  AE - Protection of benthic invertebrate community associated with NFD Point Molate offshore sediments.

- Do the sediments around NFD Point Molate pose a risk to the larval fish community associated with the eelgrass beds off NFD Point Molate?
  AE - Protection of larval fish community associated with the eelgrass beds off NFD Point Molate.

- Do the sediments within the intertidal habitat around NFD Point Molate pose a risk to the shorebird community that utilizes the intertidal habitat of NFD Point as a foraging area?
  AE - Protection of shorebird community that utilizes the intertidal habitat of NFD Point Molate as a foraging area.

2.7.2 Description and Rationale for Selection of MEs

MEs may be used to predict effects to an AE if the AE is not directly measurable. MEs are measurable, quantitative expressions of an observed or measured effect that are related to the valued characteristic chosen as the AE (Suter, 1993; EPA, 1997). Frequently, MEs describe the results of toxicity tests (e.g., no observed adverse effect levels [NOAELs] or lowest observed adverse effect level [LOAELs]) that will be used to evaluate AEs; however, results from tissue analyses and field survey studies may also be used. A model may be used to describe the predictive relationship between the MEs and AEs.

The following sections summarize the MEs selected for each NFD Point Molate AE.

2.7.2.1 AE: Protection of the Benthic Invertebrate Community Associated With NFD Point Molate Offshore Sediments

ME: Measure the toxicity of sediments to an infaunal amphipod using a bulk sediment bioassay protocol.
Eohaustorius estuarius (*E. estuarius*) is a burrowing amphipod which is found in fine intertidal sediments from British Columbia to Central California (Hoffman et al., 1995). *E. estuarius* has been extensively used as a toxicity test species to evaluate potentially contaminated and reference sediments in the San Francisco Bay. *E. estuarius* has and continues to be used by the San Francisco Estuary Institute's Regional Monitoring Program for Trace Substances, and was one of the species used by the California State Water Resources Control Board (CWRCB) to develop the report "Evaluation and Use of Sediment Reference Sites and Toxicity Tests in San Francisco Bay"(CWRCB, 1998). *E. estuarius* was found to rank well with respect to test success rate, variability, tolerance to confounding factors such as grain size, and ability to distinguish between sediments from impacted and reference sites (CWRCB, 1998).

ME: Measure the toxicity at the Sediment-Water Interface (SWI) to an epibenthic invertebrate.
SWI bioassays apply toxicity test protocols that have traditionally been used in the evaluation of water column toxicity to evaluate the toxicity of solid phase samples at the SWI. The SWI is an ecologically important habitat and a primary site of exposure for epibenthic species (Anderson et al., 1996). This test system, which uses intact sediment samples to evaluate sediment toxicity, minimizes confounding factors arising from the manipulation of sediment and pore-water samples. SWI tests also minimize problems associated with salinity, variable sample dilution, ammonia and hydrogen sulfide, and increase the ecological relevance of embryo and larval tests (CWRCB, 1998).

The mysid was selected for the SWI bioassay based on its relevance to the identified assessment endpoint. *Mysidopsis bahia* (*M. bahia*) is a standard, water-column test species which has been used extensively in the evaluation of drilling muds and dredge sediments. *M. bahia* is generally recognized as one of the most sensitive water-column invertebrate test species having a growth and survival endpoint. The *M. bahia* SWI bioassay is an ecologically relevant test species as the organism spends a significant amount of time at the SWI and is believed to occur at NFD Point Molate.

ME: Potentially determine the correlation between benthic species composition and abundance and constituent concentrations at sampling locations.
Laboratory toxicity tests are not representative of exposure in the field. Therefore, a benthic community analysis is proposed as a separate line of evidence in the event bioassay results indicate toxicity of site sediments. (As discussed in the Offshore ERA Work Plan [TtEMI, 1998], this analysis will not be performed unless toxicity is observed). For this endpoint, benthos is collected, preserved, and archived

concurrently with the collection of sediment chemistry, tissue, and bioassay samples at each sampling location. If bioassays indicate significant toxicity, the archived samples are statistically evaluated to identify whether any correlations between sediment chemistry, bioassay results, and community structure exists.

ME: Measure and compare PAH concentrations to ambient threshold criteria to evaluate whether sediments at NFD Point Molate are potentially contaminated.

Sediment chemistry analytical results are often compared to effects range-low (ER-L) or effects range-median (ER-M) screening values. ER-Ls and ER-Ms are effects-based criteria reflecting toxicity data for a particular compound for a number of species. ER-Ls and ER-Ms are typically used as conservative screening values to preliminarily evaluate potential risk based on the likelihood of effects. When ER-Ls or ER-Ms are exceeded, site-specific toxicological investigations are conducted to directly evaluate the toxicity of a sediment. Because site-specific toxicological investigations are being conducted to evaluate risk, risk or effects-based screening criteria such as ER-Ls and ER-Ms are not appropriate for comparison. Therefore, to evaluate whether NFD Point Molate sediments are contaminated with petroleum-related compounds, a non-risk based criteria is alternatively proposed.

The Staff Report "Ambient Concentrations of Toxic Chemicals in Sediments" (RWQCB, 1998) presents an evaluation of ambient concentrations of chemical compounds found in subtidal sediments in the San Francisco Bay. In this report, ambient thresholds (or threshold concentrations) are proposed based on statistical analyses of chemical data collected at 36 stations in San Francisco Bay between August 1991 and August 1995. The thresholds are based on the 85th percentile of the population of ambient concentrations for each specific compound using an alpha level of 0.05 (or 95 percent confidence). The developed threshold concentrations represent compound-specific concentrations above which a sediment would be considered contaminated.

The RWQCB (1998) did not establish ambient thresholds for TPH. However, they did evaluate the distribution of PAHs in the Bay. PAHs have been hypothesized as being a significant contributor to the toxicity of crude and refined petroleum (Anderson, 1974). Therefore, evaluating the distribution of PAHs in sediments at NFD Point Molate was considered relevant in this analysis. The ambient data collected for PAHs indicate that two distinct statistical populations exist in San Francisco Bay based on sediment grain size. Threshold concentrations were generated for sediments with grain sizes less than 40 percent fines, and sediments having between 40 and 100 percent fines. A threshold concentration was developed for each of the 18 PAHs analyzed for NFD Point Molate, as well as sum PAHs based on 40 to 100 percent fines. The sum PAH ambient threshold concentrations for sediments is 3.390 parts per million (ppm) The proposed criteria are designed to serve as non-risk based criteria to determine if NFD Point Molate sediments should or should not be considered contaminated with PAHs relative to ambient conditions in San Francisco Bay. The findings associated with the analytical chemistry measurement endpoint are considered, along with the other measurement endpoints, to evaluate risk to the three assessment endpoints selected for the NFD Point Molate offshore ERA.

2.7.2.2 AE: Protection of the Larval Fish Community Associated With the Eelgrass Beds Near NFD Point Molate

ME: Measure the toxicity at the SWI to fish embryos.

The SWI test was chosen for the same reasons as discussed in Section 2.7.2.1. *Atherinopsis affinis (*topsmelt) was selected based on its relevance to the identified assessment endpoint (e.g., the presence of significant eelgrass beds at NFD Point Molate that may provide habitat for larval and juvenile smelt and other fish species). The topsmelt SWI bioassay has been selected as it is the only vertebrate development SWI bioassay that has been conducted (outside of pure research and development) in San Francisco Bay.

ME: Measure and compare PAH concentrations to ambient threshold criteria to evaluate whether sediments at NFD Point Molate are potentially contaminated.

A non-risk based criteria (e.g., ambient threshold criteria) was used to assess whether NFD Point Molate sediments can be considered contaminated with petroleum constituents (e.g., PAHs). For further rationale, see Section 2.7.2.1.

2.7.2.3 AE: Protection of the Shorebird Community That Uses the Intertidal Habitat as a Foraging Area at NFD Point Molate

ME: Compare the estimated site-specific doses (based on measured PAH body burdens in Asian clams) that could be ingested by foraging shorebirds to avian toxicity data associated with reproductive impairment in birds.

Both observational and experimental studies have shown that petroleum products are toxic to birds in various ways. The most relevant toxicological effects for the population-level assessment endpoint are reproductive effects that directly impact the fecundity and recruitment of shorebirds. The most common pathway for shorebird exposure to petroleum products in offshore sediments at NFD Point Molate is via the ingestion of prey organisms that have bioaccumulated petroleum-related hydrocarbons (e.g., PAHs) or through the incidental ingestion of TPH-contaminated sediment. Measurements of whole petroleum products are not useful in biological tissues (i.e., the volatile components [monoaromatics] do not tend to bioaccumulate and the aliphatic components are not easily tracked through the food web since they are generally incorporated into fatty acids in tissue). Thus, measurements must focus on petroleum constituents (i.e., PAH body burdens).

Wading birds and diving ducks have been selected as the trophic groups for which ecological risk will be evaluated to the shorebird assessment endpoint at NFD Point Molate. The term “shorebirds” is being used to describe a general category of birds, birds that live and/or feed near the shoreline. Both wading birds that probe the sediment for food and diving ducks that feed primarily on benthic invertebrates are being categorized as “shorebirds”. The assessment endpoint for shorebirds is evaluated using two avian receptors selected to represent the shorebird category, one wading bird and one diving duck. Based on site-specific constituents of concern, the preliminary food web, and the CSM developed for the offshore environment, it was determined that a conservative estimate of risk focused on those trophic categories most directly exposed to petroleum (e.g., to contaminated sediments and benthic invertebrates). PAHs are not readily metabolized by bivalves but are metabolized more easily by crustaceans, annelids, and vertebrates (Livingston, 1991). Trophic groups which feed primarily on bivalves, therefore, would have the most conservative estimate of exposure.

Representative species were selected within the shorebird and diving duck groups primarily based on: (1) the occurrence and relative abundance at NFD Point Molate during the November 1998 and January 1999 surveys, and (2) foraging habits and food preferences. Western sandpiper (*Calidris mauri*) was chosen as the representative shorebird. In addition to its abundance at the NFD Point Molate site, selection criteria for the western sandpiper also included its small body size, presumed high ingestion and metabolic rates, and incidental sediment ingestion rate associated with its probing-style feeding strategy. All of these parameters potentially result in high exposure. The scaup (*Aythia spp.*) was chosen as the representative diving duck because it occurs in very high numbers at the NFD Point Molate site during the winter months, and feeds mostly on benthic invertebrates, especially clams. The approach used to develop a toxicity-based criterion to evaluate calculated doses to selected avian receptors is described in Appendix D.

ME: Measure and compare PAH concentrations to ambient threshold criteria to evaluate whether sediments at NFD Point Molate are potentially contaminated.

A non-risk based criteria (e.g., ambient threshold criteria) was used to assess whether NFD Point Molate sediments can be considered contaminated with petroleum constituents (e.g., PAHs). For further rationale, see Section 2.7.2.1.

2.8 DEVELOPMENT OF A WOE APPROACH AT NFD POINT MOLATE

The use of multiple lines of evidence to evaluate ecological risk requires that an approach be developed to integrate potentially inconsistent findings in order to draw conclusions about risk. The need for a WOE approach to integrate the various types of data was expressed in the Offshore ERA Work Plan (TtEMI, 1998). At the time the Offshore ERA Work Plan was prepared, a WOE approach had not been identified or developed. The WOE approach has since been developed specifically to integrate and evaluate the four lines of evidence collected at NFD Point Molate**.** The developed WOE approach integrates environmental data (i.e., lines of evidence) to assess risk based on the association of assessment endpoints (i.e., those ecological resources selected for protection) and measurement endpoints (i.e., environmental measurements collected to evaluate risk to an assessment endpoint). This approach was developed through a series of technical agency meetings designed to solicit agency input and build consensus between the Navy and agencies. The WOE approach is described in detail in Appendix B, and consists of both generic components and project-specific components.

The objective of the generic components is to:

- Determine a numerical weight for each measurement endpoint based on endpoint strength and association with the assessment endpoint of interest.

The project-specific components are to:

- Determine the finding (positive or negative) and magnitude (high or low) for each measurement endpoint result. Positive findings indicate the potential for risk; negative findings do not indicate risk.
- Use the weight and finding for each measurement endpoint to evaluate risk at a given site.
- Present the approach and format for the WOE findings.

The proposed procedures for summarizing the WOE findings have been developed to allow the evaluation of:

- Sampling station risk with respect to the particular ecological resource(s) selected for protection (e.g. assessment endpoints).
- Co-occurrence among measurement endpoint findings associated with an assessment endpoint.
- Potential risk associated with each measurement endpoint at a sampling station.
- Overall potential risk at a sampling station.

- Relative risk between sampling stations.
- The evaluation of uncertainty.

The WOE evaluation is presented via a series of tables and figures that have been developed for the NFD Point Molate ERA (see Appendix B). During the problem formulation stage, measurement endpoint weights are calculated and criteria for determination of positive and negative findings are developed. These are described in more detail in the following sections.

2.8.1 Determination of Ranks and Weights for NFD Point Molate Measurement Endpoints

NFD Point Molate measurement endpoints were weighed and ranked with respect to the 10 attributes described in Appendix C. The ranks assigned and weights calculated for NFD Point Molate measurement endpoints are summarized in Table 2-5.

2.8.2 Criteria and Rationale for Determination of Positive and Negative Findings

During the problem formulation phase, criteria was used to evaluate positive (indicating risk) and negative (no risk) measurement endpoint results and to categorize responses as “high” or “low” magnitude. The following sections describe positive and negative findings and magnitude criteria for measurement endpoints listed below:

- Bulk Sediment Bioassay Findings
- Bulk Sediment Chemistry Findings
- SWI Bioassay Findings
- Bioaccumulation Findings

Findings and magnitude criteria for measurement endpoints selected for the offshore ERA at NFD Point Molate are summarized in Table 2-6. In the WOE approach, positive findings are an indication of potential risk, and negative findings represent no indication of risk.

2.8.2.1 Bulk Sediment Bioassay Findings

For the bulk sediment bioassays, the following criteria were proposed for negative findings. The reference envelope threshold, to assign a positive or negative finding to bulk sediment bioassay results, was defined as 68 percent (TtEMI, 1998). Mean percent survival for five test replicates at a given sampling location greater than 68 percent indicates a negative finding (no toxicity).

TABLE 2-5
MEASUREMENT ENDPOINT WEIGHT CALCULATIONS USING THE SCALED ATTRIBUTES PREPARED FOR THE WOE DETERMINATION

Sediment Toxicity		A1-Bulk Sediment Bioassay		A2-SWI (Topsmelt)		A3-SWI (Mysid)	
Attribute	Scaling Value	Rank	Score	Rank	Score	Rank	Score
Degree of Association	1.00	3	3	3	3	3	3
Stressor/Response	0.70	3	2.1	3	2.1	3	2.1
Utility of Measure	0.50	4	2	3	1.5	2	1
Quality of Data	0.80	5	4	5	4	5	4
Site Specificity	0.50	4	2	4	2	4	2
Sensitivity	0.50	3	1.5	2	1	2	1
Spatial Representativeness	0.40	4	1.6	4	1.6	4	1.6
Temporal Representativeness	0.20	4	0.8	3	0.6	4	0.8
Quantitative Measure	0.20	5	1	5	1	5	1
Standard Measure	0.20	5	1	2	0.4	2	0.4
Measurement Endpoint Weight			**3.80**		**3.44**		**3.38**

Sediment Chemistry, PAHs		C1-Chemistry Screening	
Attribute	Scaling Value	Rank	Score
Degree of Association	1.00	0	0
Stressor/Response	0.70	0	0
Utility of Measure	0.50	2	1
Quality of Data	0.80	5	4
Site Specificity	0.50	2	1
Sensitivity	0.50	0	0
Spatial Representativeness	0.40	1	0.4
Temporal Representativeness	0.20	3	0.6
Quantitative Measure	0.20	3	0.6
Standard Measure	0.20	4	0.8
Measurement Endpoint Weight			**1.68**

Bioaccumulation		Dose/TRV Comparison	
Attribute	Scaling Value	Rank	Score
Degree of Association	1.00	2	2
Stressor/Response	0.70	1	0.7
Utility of Measure	0.50	2	1
Quality of Data	0.80	5	4
Site Specificity	0.50	3	1.5
Sensitivity	0.50	3	1.5
Spatial Representativeness	0.40	3	1.2
Temporal Representativeness	0.20	3	0.6
Quantitative Measure	0.20	2	0.4
Standard Measure	0.20	3	0.6
Measurement Endpoint Weight			**2.70**

TABLE 2-6

SUMMARY OF FINDING AND MAGNITUDE CRITERIA FOR MEASUREMENT ENDPOINTS SELECTED FOR THE OFFSHORE ERA AT NFD POINT MOLATE

Endpoint	Finding	Magnitude	Proposed Criteria
Bulk Sediment Bioassay	Positive	High	<50% mean survival
	Positive	Low	50% < 68% mean survival
	Undetermined	--	--
	Negative	Low	68% - 80% mean survival
	Negative	High	>80% mean survival
Bulk Sediment Chemistry Finding	Positive	High	Sum PAH concentration at a sampling station is greater than or equal to 6,000 ppb.
	Positive	Low	Sum PAH concentration at a sampling station is greater than or equal to 3,390 ppb.
	Undetermined	--	--
	Negative	Low	Sum PAH concentration at a sampling station is less than 3,390 ppb.
	Negative	High	Sum PAH concentration at a sampling station is greater than or equal to 1,695 ppb.
Sediment Water Interface Bioassay	Positive	High	Significant difference between test sediment and reference sediment (t-test) and >40% (MSD) in mean survival.
	Positive	Low	Significant difference between test sediment and reference sediment (t-test) and >20% (MSD) in mean survival.
	Undetermined	--	--
	Negative	Low	Significant difference between test sediment and reference sediment (t-test) and <20% (MSD) in mean survival.
	Negative	High	No significant difference between test sediment and reference sediment (t-test).
Bioaccumulation Findings	Positive	High	Calculated sum PAH dose at a sampling station is greater than 9 mg/kg-d.
	Positive	Low	Calculated sum PAH dose at a sampling station is greater than 0.5 mg/kg-d and less than or equal to 9 mg/kg-d.
	Undetermined	--	The calculated sum PAH dose at a sampling station is greater than 0.03 mg/kg-d and less than or equal to 0.5 mg/kg-d.
	Negative	Low	The calculated sum PAH dose at a sampling station is greater than 0.003 mg/kg-d and less than or equal to 0.03 mg/kg-d.
	Negative	High	The calculated sum PAH dose at a sampling station is less than or equal to 0.003 mg/kg-d.

- ***High Magnitude Negative Findings*** **-** Survival of 80 percent is a laboratory control acceptability criteria (i.e., an expected repeatable result given optimal conditions achievable in a laboratory for the test species) and, therefore, indicates a high magnitude negative response (i.e. the test results could be used as laboratory control results).

- ***Low Magnitude Negative Findings*** **-** Low findings were categorized as low magnitude if 68 to 80 percent survival was observed for five test replicates at a given sampling location.

As described in the Offshore ERA Work Plan (TtEMI, 1998), a positive finding was indicated by less than 68 percent survival for five test replicates at a given sampling location.

- ***High Magnitude Positive Findings*** **-** Positive findings were categorized as high magnitude if 0 to 50 percent survival was observed. The 50 percent survival breakpoint was used as it is commonly employed in acute toxicity tests where LC_{50} values are estimated. The LC_{50} is defined as the median concentration of a chemical(s) resulting in 50 percent mortality of a test population within a specified period of exposure (e.g., 48 hour LC_{50}).

- ***Low Magnitude Positive Findings*** **-** Positive findings were categorized as low magnitude if 50 to 67 percent survival was observed.

2.8.2.2 Bulk Sediment Chemistry Findings

As discussed in Section 2.7.2.1, non-risk based criteria were developed for this measurement endpoint that were used to evaluate whether NFD Point Molate sediments are potentially contaminated with petroleum constituents (e.g., PAHs). The following criteria were developed to determine findings (positive and negative) and magnitude for this measurement endpoint.

- ***High Magnitude Negative Findings*** - A sum PAH concentration measured at a sampling station of less than 1.695 ppm is considered a high magnitude negative finding. This value (1.695 ppm) represents one-half the concentration considered ambient.

- ***Low Magnitude Negative Findings*** - A sum PAH concentration measured at a sampling station less than 3.390 ppm and more than 1.695 ppm is considered a low magnitude negative finding. Values less than 3.390 ppm are considered within the statistically defined upper-bound of ambient concentrations for sediments and represents "non-contaminated" conditions according to the RWQCB (1998).

- ***High Magnitude Positive Findings*** - The sum PAH concentration is greater than 6.0 ppm. This value (6.0 ppm) was the highest sediment concentration detected by the RWQCB (1998) in an ambient sampling station. Thus, values higher than results or a MSD of less than 20 percent was used, a low magnitude negative finding was indicated.

A positive response was defined as a statistically significant difference between the reference location bioassay results and test location bioassay results, and a MSD of greater than or equal to 20 percent (survival for the mysid bioassay or hatchability for the topsmelt bioassay) between the reference and test location results.

- ***High Magnitude Positive Findings*** **-** A positive high magnitude response for this test system was defined by a statistically significant difference between the reference location bioassay results and test location bioassay results, and a MSD of greater than or equal to 40 percent. MPSL calculated an MSD for the purple sea urchin bioassay of 40 percent. Whereas, 20 percent is a conservative MSD for SWI tests, 40 percent is a more realistic number in terms of predicting a biologically relevant response using this test system.

- ***Low Magnitude Positive Findings*** **-** A low magnitude positive finding was indicated by a statistically significant difference between the reference location bioassay results and test location bioassay results, and a MSD of greater than or equal to 20 percent (survival for the mysid bioassay or hatchability for the topsmelt bioassay) between the reference and test location results. The 20 percent MSD is conservative for the SWI test system as the MSD is a function of variability of the test system and SWI test systems have more inherent variability than the bulk sediment tests for which MSDs have traditionally been calculated.

2.8.2.4 Comparison of Site-Specific Doses and Avian Toxicity Data

In order to develop criteria to evaluate calculated sum PAH doses to avian receptors, avian toxicity data from the literature were reviewed. Development of a formal toxicity reference value (TRV) was not possible because available literature on avian toxicity to specific PAHs is sparse. In general, the development of the comparative toxicity values for avian species followed the existing Navy protocol for developing TRVs (EFA West, 1998). Specific details of the development process can be found in Appendix D. Figure 2-7 summarizes the toxicity data collected. Based on the data presented in Figure 2-7 (see discussion in Appendix D), it was determined that a formal TRV could not be developed, but that the data could be used to develop criteria defining qualitative finding categories (e.g., positive and negative findings) instead of hazard quotients (HQs). These criteria were developed to be highly conservative by making the most conservative assumptions about site use factors (SUFs), ingestion rates, and body weights when published data were lacking. The assumptions made and the associated uncertainty are discussed in detail in Section 6.4.2.

6.0 ppm have a higher probability of not being part of the whole ambient population and, therefore, representing contaminated sediments.

- ***Low Magnitude Positive Findings -*** The sum PAH concentration is greater than 3.390 ppm and less than 6.0 ppm. Concentrations greater than 3.390 ppm represent areas that exceed the upper-bound for ambient and are considered contaminated (RWQCB, 1998).

2.8.2.3 SWI Bioassay Findings

For the SWI bioassays, a negative response was defined in the Offshore ERA Work Plan (TtEMI, 1998) as *"no statistically significant difference between reference and NFD Point Molate sampling location mean survival and a minimum significant difference (MSD) of less than 20 percent mean survival."* Sufficient data do not exist to calculate a reference envelope for the two SWI test species (*M. bahia* and *A. affinis*). The MSD is an approach often used to compare site toxicity data with reference data. The MSD is a value that indicates the difference between reference and test site mean toxicity that will be considered statistically significant given the inherent level of replicate variation in reference tests (SFEI, 1996). MSDs have been calculated for many toxicity test protocols and may require 50 to 100 independent tests in order to have any biological relevance. SWI tests are very new and, in the case of the two species tested, still under development. Therefore, rigorously defined MSDs for these taxa are not available.

Alternatively, a value of 20 percent has been suggested as a general MSD for SWI tests. However, this value may be low considering that a MSD of 41 percent has been calculated by the Department of Fish and Game's (DFG's) Marine Pollution Studies Laboratory (MPSL) for the purple sea urchin larval development SWI bioassay. MSDs for SWI tests will be higher than MSDs other bioassay protocols that use homogenized sediments for replicate tests since the SWI protocol specifies the use of intact sediment cores for each replicate of the bioassay. Spatial variation among intact sediment samples may be expected to contribute a greater amount of variation to toxicity compared to tests using homogenized sediment. In lieu of rigorously determined values for the test species, a MSD of 20 percent will be used in conjunction with best professional judgment in interpreting the toxicity comparison tests.

- ***High Magnitude Negative Findings -*** If no statistically significant difference was found between the reference location bioassay results and test location bioassay results, a high magnitude negative finding was indicated. This finding was warranted as these results would indicate no difference between the test location and the reference location.

- ***Low Magnitude Negative Findings -*** If no statistically significant difference was found between the reference location bioassay results and test location bioassay

To use these data qualitatively, a sum PAH dose to the shorebirds was calculated. The dose concentrations of sum PAHs were calculated from the tissue data collected and analyzed at each of the intertidal stations at NFD Point Molate. The sum PAH dose concentration was then compared to the following criteria (see Figure 2-7):

- ***High Magnitude Negative Findings* -** The calculated sum PAH dose is less than or equal to 0.003 mg/kg-d. This value (0.003 mg/kg-d) represents a dose one order of magnitude below the lowest No Effect Level (NEL) and, therefore, represents a value below which no effects could be predicted with a high level of certainty.

- ***Low Magnitude Negative Findings* -** The calculated sum PAH dose at a sampling station is greater than 0.003 mg/kg-d and less than or equal to 0.03 mg/kg-d. This criterion corresponds to doses that represent a range from the lowest observed NEL (at 0.03 mg/kg-d) to one order of magnitude below the lowest observed NEL.

- ***Undetermined Finding* -** The calculated sum PAH dose is greater than 0.03 mg/kg-d and less than or equal to 0.5 mg/kg-d. In this dose range, it is unclear whether a dose clearly represents a positive or negative finding. While the limited toxicity data in this dose range indicate no effects, one study at the upper boundary of this region reported an effect level (EL). Therefore, due to the uncertainty associated with this dose range, a finding of undetermined risk is considered appropriate.

- ***Low Magnitude Positive Findings* -** The calculated sum PAH dose is greater than 0.5 mg/kg-d and less than or equal to 9 mg/kg-d. The lower boundary of this region (0.5 mg/kg-d) was identified as the threshold between undetermined findings and when adverse effects (i.e., positive findings) might begin. The area between 0.5 and 9 mg/kg-d represents both EL and NEL estimates with the low PAH estimate (see Appendix D for a full description).

- ***High Magnitude Positive Findings* -** The calculated sum PAH dose is greater than 9 mg/kg-d. The toxicity data in this range represents ELs and NELs developed with the high PAH estimate (see Appendix D). Since the probability of observing adverse effects increase with dose, doses higher than 9 mg/kg-d are considered to be associated with a high magnitude of positive findings.

2.9 SUMMARY OF 1998 DATA COLLECTION ACTIVITIES IN SUPPORT OF THE OFFSHORE ERA

Based on all the information discussed in this problem formulation section, a sampling approach was developed to collect information to evaluate the selected assessment and measurement endpoints for NFD Point Molate. This sampling approach was described in detail in the Offshore ERA Work Plan (1998) and in Appendix E.

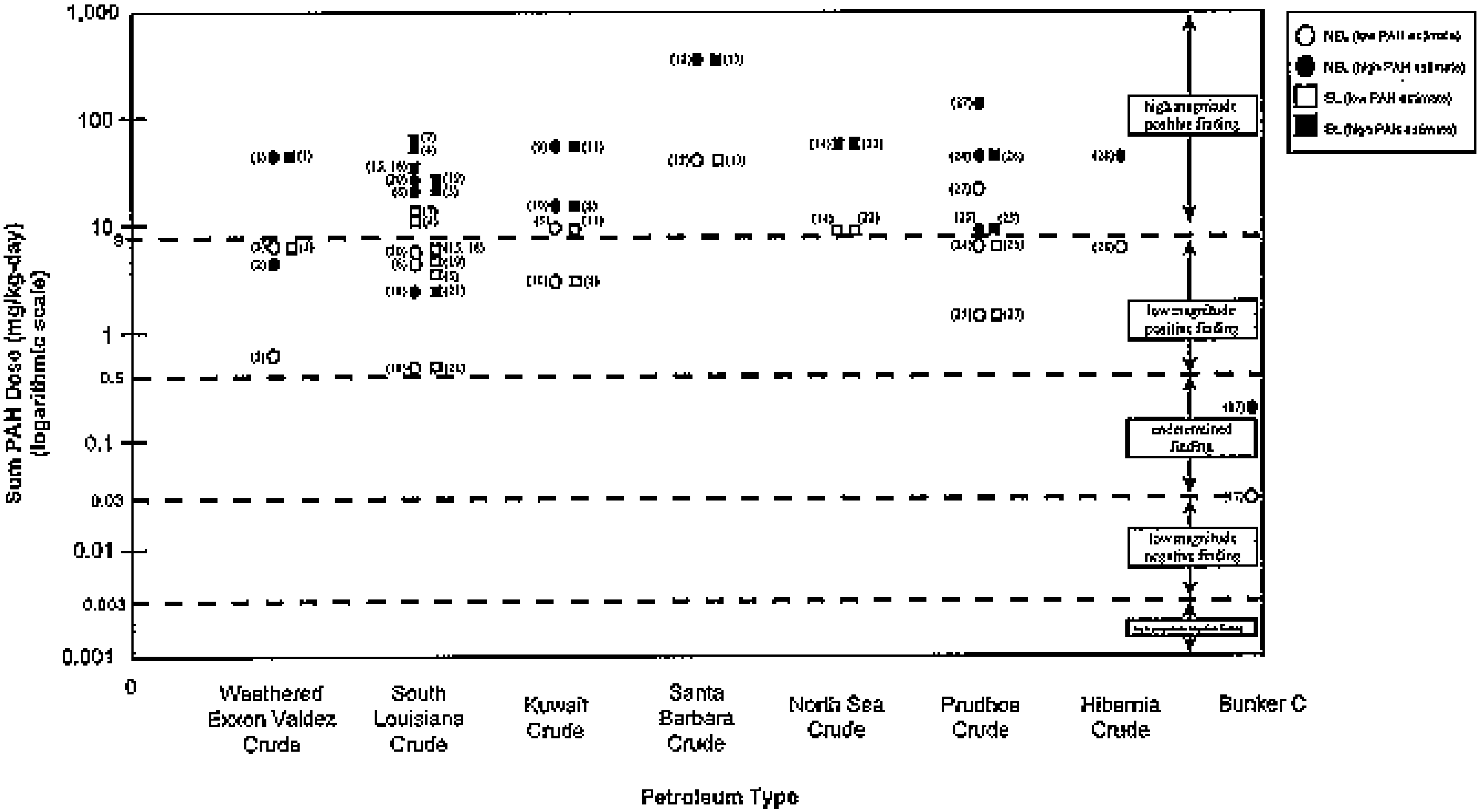


FIGURE 2-7

DOSE THRESHOLDS DEFINING FINDING AND MAGNITUDE CATEGORIES FOR THE BIOACCUMULATION MEASUREMENT ENDPOINT AT NFD POINT MOLATE

In summary, sediment sampling and analysis of sediments at NFD Point Molate collected in 1998 were focused on areas of previous sampling and followed an approach which targeted areas of known or possible contamination. Following previous sampling designs, the sampling approach was conducted to represent a "worst-case" scenario in terms of contamination and potential risk at NFD Point Molate. Locations sampled at NFD Point Molate (as described by the Offshore ERA Work Plan, TtEMI, 1998) are presented in Plate 2. A description of methods used to collect data to support the offshore ERA at NFD Point Molate is provided in Appendix E.

Data were collected with two main objectives: (1) to provide general site characterization information, and (2) to support the ERA. Site characterization data were collected at specific locations to provide information concerning the potential for petroleum contamination in subtidal areas and in deeper sediments in the intertidal. As these areas were not assessed for risk assessment purposes, the data collected at these sampling stations focused on TPH and PAH analyses. Sampling stations where site characterization data were collected included subtidal stations (P2, P3, T3-2, and T10-2), vertical cores collected at selected erosional and depositional intertidal sampling locations (T2, T3-1, T5, T6, T11 and Dl-1), and pesticide data collected at T2. Table 2-7 provides a summary of the types of data collected for characterization purposes as part of ERA data collection efforts at NFD Point Molate.

Risk assessment data were collected in the near-shore intertidal area at NFD Point Molate. The near-shore intertidal was selected for risk assessment data collection due to its close proximity to onshore NFD Point Molate sources; thus, it is likely to represent the highest exposure to aquatic receptors. All of the sampling stations sampled for risk assessment needs were within the intertidal zone except for P1. While P1 was nearshore (due to the rip-rap in this area), the habitat was subtidal. Because P1 was subtidal, intertidal shorebirds cannot utilize this area for foraging and tissue was not collected in this location. Bioassay data were collected at P1.

The risk assessment focused on COPECs associated with NFD Point Molate sources (e.g., petroleum and PAHs). Sediments were also analyzed for a full suite of chemicals, including metals, SVOCs, VOCs, PCBs, and organochlorine pesticides at bioassay locations to evaluate potential sediment toxicity drivers. Invertebrate tissue was collected and analyzed for PAHs at intertidal sample locations in order to evaluate bioaccumulation potential and to assess the potential risk to shorebirds that ingest invertebrates. At each location, benthos were collected, preserved, and archived for further evaluation if necessary. A more detailed description of the analyses that were conducted at each sampling location is presented in Table 2-7 and in Appendix E.

TABLE 2-7

SAMPLE LOCATIONS AND ANALYSES NFD POINT MOLATE OFFSHORE ERA

		Tissue Chemical Analysis	Bioassays			Benthic Fauna Analyses	Sediment – Chemistry Analyses							Sediment - Physical Analyses						Purpose
Sample Location	**Station ID**	**PAHs (8270 Mod)**	**SWI (Survival) A[(1)]**	**SWI (Survival) M[(2)]**	**Bulk Sediment (Development) F[(3)]**	**Benthic Community Indices[(4)]**	**Metals**	**TPH & PAHs[(5)] (8270 Mod)**	**VOCs (CLP)**	**SVOCs (CLP)**	**Pesticides & PCBs (CLP)**	**Ammonia**	**TOC**	**Grain Size**	**% Moisture**	**Redox Potential**	**SOD**	**pH**	**Interstitial Salinity**	**of Collection**
Paradise Cove	Ref.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	RA
Intertidal Point Molate	T2[(6)]	x [(7)]	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	RA, SC
	T3(1)[(6)]	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	RA, SC
	T5[(6)]	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	RA, SC
	T6[(6)]	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	RA, SC
	T9(1)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	RA
	T9(2)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	RA
	T10(1)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	RA
	T11[(6)]	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	RA, SC
	T11A	x	x	x	x	X	x	x	x	x	x	x	x	x	x	x	x	x	x	RA
	DL(1)[(6)]	x	x	x	x	X	x	x	x	x	x	x	x	x	x	x	x	x	x	RA, SC
Subtidal Point Molate	P1		x	x	x	X	x	x	x	x	x	x	x	x	x	x	x	x	x	RA
	P2					X		x					x	x	x	x	x	x	x	SC
	P3					X		x					x	x	x	x	x	x	x	SC
	T3(2)					x		x					x	x	x	x	x	x	x	SC
	T10(2)					x		x					x	x	x	x	x	x	x	SC

Notes:

[(1)] Sediment-water interface bioassay with *Mysidopsis bahia* (5 replicates analyzed per station; 6 collected)
[(2)] Sediment-water interface bioassay with *Athineropsis affinis* (5 replicates analyzed per station; 6 collected)
[(3)] Amphipod bulk sediment bioassay with *Eohaustorius estuarius*
[(4)] Five replicate benthos samples were collected at each station and archived
[(5)] Sediment samples were analyzed by the TPH Criteria Working Group Method (Gustafson, et al., 1997)
[(6)] Vertical cores were collected at these stations and analyzed for TPH and PAHs (EPA Method 8270 Mod.)
[(7)] Tissue collected at this station were analyzed for pesticides in addition to PAHs for site characterization purposes

x = Sample collected
RA = risk assessment
SC = site characterization

In order to evaluate the risk assessment data, a reference location was selected for comparison. As discussed in the Offshore ERA Work Plan (TtEMI, 1998), the following criteria were used to select an appropriate reference location: (1) toxicity and sediment concentrations reflective of ambient conditions in San Francisco Bay, and (2) sediment grain size and salinity similar to that at NFD Point Molate. Based on a review of the three reference locations used as part of the RWQCB program to develop ambient sediment concentrations within the Bay (RWQCB, 1998), Paradise Cove was selected as the most appropriate reference location for NFD Point Molate. Findings reported in the April 1998 report, "Evaluation and Use of Sediment Reference Sites and Toxicity Tests in San Francisco Bay" (CWRCB et al., 1998), indicate that Paradise Cove sediments exhibited little toxicity to amphipods and appear to have chemical concentrations representative of ambient conditions in San Francisco Bay. In support of the risk assessment, bulk sediment chemistry, bioassays, tissue, and benthos were collected at Paradise Cove. Sampling locations at Paradise Cove are presented in Figure 2-8.

Additionally, all surficial samples were analyzed for physical parameters such as grain size, TOC, pH, salinity, percent moisture, interstitial salinity, sediment redox potential, and SOD. All sediment samples (except vertical cores) were collected in the top 5.0 centimeters (cm). The depth of 5.0 cm was considered appropriate for this investigation because: (1) it encompasses the surficial sediment layer and most of the biologically active layer of species known to occur in the Bay, and (2) it is consistent with current RWQCB program methods and recent EPA guidance (EPA's "Contaminated Sediment Management Strategy"; EPA, 1998).