4.0 EXPOSURE AND EFFECTS ASSESSMENT

In this section, the exposure and effects assessment is organized by assessment endpoint and conducted for each measurement endpoint. Exposure was evaluated by assessing the co-occurrence of the stressor (e.g., petroleum-related compounds) and the receptor associated with each measurement endpoint. To evaluate this co-occurrence, the distribution of petroleum-related compounds at NFD Point Molate is discussed in Section 4.1.

The sediment chemistry measurement endpoint (comparison of NFD Point Molate sampling location sum PAH concentrations to ambient threshold criteria) will not be discussed in the effects assessment because it is not a risk or effects-based criteria and, therefore, cannot be used to evaluate effects. In the effects assessment, only measurement endpoints representing effects will be reported.

4.1 DISTRIBUTION OF THE STRESSOR (TPH AND PETROLEUM-RELATED COMPOUNDS)

Due to the judgmental sampling design developed for NFD Point Molate, collected analytical data could not support a formal statistical evaluation to characterize the distribution of NFD Point Molate COPECs. The following description of the distribution of the stressor is focused on sediments and is based on non-statistical (qualitative) observations of the data. The distribution of tissue concentrations of COPECs is discussed in Section 4.4.

Sediment chemistry data were collected at intertidal and subtidal sampling locations at NFD Point Molate. Only data collected at intertidal sampling stations are discussed here as intertidal stations are being assessed for potential risk to the ecological resources represented by the NFD Point Molate selected assessment endpoints. Data collected from subtidal locations is discussed in Section 3.1.

For the purposes of the exposure assessment, the stressor is considered to be sum PAHs as they are determined to be the most toxic components of petroleum products. Sum PAHs detected at NFD Point Molate ranged from 0.428 mg/kg in the south cove (sampling station T5) to 4.753 mg/kg in the north cove (sampling station T11). On average, sum PAHs appeared to be higher in the north cove (2.628 mg/kg) than in the south cove (1.385 mg/kg). However, this trend could not be statistically evaluated. Based on the intertidal sediment chemistry results, there is evidence that: (1) the stressor (sum PAHs) occurs at all

NFD Point Molate intertidal sampling locations at similar levels, and (2) that the potential for exposure to the stressor exists at all NFD Point Molate sampling locations.

4.2 PROTECTION OF THE BENTHIC INVERTEBRATE COMMUNITY ASSOCIATED WITH NFD POINT MOLATE OFFSHORE SEDIMENTS

Measurement endpoints selected to measure potential effects of exposure to sediments collected from NFD Point Molate to the benthic invertebrate community included a 10-day bulk sediment bioassay with *Eohaustorius estuarius* (an infaunal amphipod) and a 7-day SWI bioassay using *Mysidopsis bahia* (mysid). The bulk sediment bioassays followed American Standard and Testing Methods (ASTM) ("Standard Guide for Conducting 10-d Static Sediment Toxicity Tests with Marine and Estuarine Amphipods" [1997]) and EPA guidelines ("Methods for Assessing the Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods" [1994]) guidelines (Appendix G). The Offshore ERA Work Plan (TtEMI, 1998) proposed performing a benthic community analysis to further evaluate potential risk at sites where bioassays revealed significant toxicity. Benthic samples were collected from NFD Point Molate, however, benthic analysis was not required due to the lack of toxicity in bioassays.

4.2.1 Assessment of Exposure

In general, the offshore invertebrate community in this area, as well as most offshore areas, has limited mobility and would be expected to spend its entire post-metamorphal life cycle in the offshore sediments. The organisms within this area may be exposed to sediment-associated chemicals through the ingestion of sediment, dermal contact with the sediment and pore water, respiration of the pore water, or all three mechanisms. The major exposure pathway for benthic infaunal species is ingestion of contaminated food in conjunction with uptake of water and sediments (see Figure 2-6).

Two organisms have been selected as surrogates to assess the potential risk that NFD Point Molate sediments may pose to the benthic community. These organisms are the amphipod *Eohaustorius estuarius* (*E. estuarius*) and the mysid *Mysidopsis bahia* (*M. bahia*). Additional details on the rationale for selection of these two species is presented in Section 2.7.2.

4.2.2 Effects Assessment

Effects are assessed based on measurement endpoint results. For the assessment endpoint, protection of the benthic invertebrate community associated with NFD Point Molate offshore sediments, an evaluation of the benthic infaunal community was proposed in the event that toxicity was observed. As discussed in the following section, toxicity was not observed and a benthic infaunal community analysis was not conducted. To assess effects to the benthic invertebrate, community bioassay results for the amphipod *E. estuarius*, and the mysid *M. bahia* are presented.

4.2.2.1 Results of the *E. estuarius* Bulk Sediment Bioassay

A detailed description of methods and results is provided in Appendix G. Average survival of *E. estuarius* in the control sediment was 98 percent. This value established the test organism health and the validity of the bioassay (Table 4-1). As shown in Table 4-1, average percent survival in sediments collected from the NFD Point Molate ranged from 69 to 94 percent. Reburial of amphipods in NFD Point Molate sediments ranged from 98.5 to 100 percent (Table 4-2).

4.2.2.2 Results of the *M. bahia* SWI Bioassay

Both survival and growth of *M. bahia* were monitored for seven days in SWI bioassays. Control sediment survival for mysids was 94 percent (adequate to determine the validity of the bioassay), while survival in the reference sediment averaged 86 percent over the seven-day period. In the sediments collected from NFD Point Molate, average percent survival of mysids ranged from 76 to 100 percent (Table 4-3). Average weight of mysids (milligrams-dry weight [mg-dw]) was also measured. Average dry weights of organisms exposed to the sediments collected from NFD Point Molate ranged from 0.21 to 0.29 mg (Table 4-4).

4.3 PROTECTION OF THE LARVAL FISH COMMUNITY ASSOCIATED WITH THE EELGRASS BEDS OFF NFD POINT MOLATE

The eelgrass beds at NFD Point Molate provide significant habitat for embryonic, larval and juvenile stages of several fish species. Therefore, to estimate potential risk to larval fish in the NFD Point Molate area, the topsmelt minnow (*Atherinopsis affinis*) has been selected as an appropriate surrogate. For this investigation, the topsmelt SWI bioassay was selected, as it is the only vertebrate development SWI bioassay that has been conducted (outside of pure research and development) in San Francisco Bay. The

topsmelt bioassay measured embryo hatchability as the embryo is thought to be the most sensitive life stage. Thus, protection of the embryo would indicate protection of other life stages as well.

4.3.1 Assessment of Exposure

Since fish intermittently use intertidal habitat during high tides and have a mobile life cycle, their exposure to contaminants in intertidal sediment is minimal. However, the eelgrass beds in the intertidal area at NFD Point Molate are potential habitat for fishes, especially in early life stages. The eelgrass beds at NFD Point Molate may serve as spawning habitat for the commercially important Pacific herring. It may also serve as nursery habitat and provide shelter and a forage base for juvenile fishes, such as flatfishes. The primary route of exposure for fish eggs, larvae, and juveniles would be through direct uptake of contaminants in sediments (see Figure 2-6).

4.3.2 Effects Assessment

Potential effects of NFD Point Molate sediments on fish populations associated with NFD Point Molate eelgrass beds were evaluated using the topsmelt minnow in 12-day SWI bioassays. The average sample location percent egg hatchability in sediments collected from NFD Point Molate ranged from 74 to 100 percent (Table 4-5).

4.4 PROTECTION OF THE SHOREBIRD COMMUNITY THAT UTILIZES THE INTERTIDAL HABITAT AS A FORAGING AREA AT NFD POINT MOLATE

Shorebirds and diving ducks were selected as the receptor groups to assess ecological risk at NFD Point Molate for this assessment endpoint because these trophic groups are most directly exposed to petroleum constituents (e.g., PAHs) through feeding on infaunal organisms such as Asian clams. Representative species were selected within the shorebird and diving duck groups based on their occurrence and relative abundance at NFD Point Molate during the late fall and early winter, as well as their foraging habits and food preferences. The western sandpiper (*Calidris mauri*) was selected as the representative shorebird, and the scaup (*Aythia spp.*) was selected as the representative diving duck. Natural history characteristics of these two proposed avian receptors are presented in Appendix H. The rationale for selection of these species as representative receptors is presented in Section 2.7.2.3.

4.4.1 Assessment of Exposure

The assessment of exposure for the bioaccumulation measurement endpoint and protection of the shorebird community that utilizes the intertidal habitat as a foraging area at NFD Point Molate is conducted by evaluating the co-occurrence of the stressor (e.g., petroleum-related compounds) in tissues and sediment, and the receptor (e.g., shorebirds at NFD Point Molate). Exposure is estimated by modeling sum PAH doses for each NFD Point Molate sampling station to the western sandpiper and scaup.

4.4.1.1 Distribution of COPECs in Clam Tissue

PAH concentrations measured in clam tissue were collected from all the intertidal sampling locations where shorebirds are expected to forage. Tissue was not collected from the pier area as shorebirds are not expected to forage in this region because of depth of the water column. Average PAH tissue concentrations were calculated for the north and south coves at NFD Point Molate. PAH concentrations in the north and south cove samples were similar indicating a relatively homogeneous distribution of PAHs in clam tissues at NFD Point Molate. Table 4-6 provides the sum PAH tissue data for NFD Point Molate sampling locations. Sum PAH tissue concentrations range from 0.142 to 0.313 mg/kg-dw for all NFD Point Molate sampling locations.

4.4.1.2 Exposure Model

Shorebirds are of biological importance at NFD Point Molate because they function as a predator of benthic invertebrates. The base prey of a shorebird consists of intertidal invertebrates, especially annelids, mollusks, and crustaceans. These invertebrates may bioaccumulate contaminants from sediments, the water column, and food. The primary route of exposure for shorebirds is through the ingestion of food. Secondary routes of exposure include incidental ingestion of sediments via activities such as preening. Estimates of exposure were based on knowledge of the spatial distribution of sediment and tissue concentrations (as collected during the 1998 field effort), and on the spatial and temporal characteristics of exposure to the selected shorebird. Exposure to PAHs was assessed and daily doses were derived for each sampling location. The basic components of the exposure model were: (1) temporal and spatial characterization of receptors and chemicals, (2) ingestion rates and diet composition, and (3) food chain exposure calculations.

A conservative estimate of exposure via ingestion of contaminated prey (measured clam body burdens) and incidental ingestion of sediments (a modeled dose) was calculated for the shorebird species using the following exposure model:

Dose Calculation

The equation used to calculate a daily dose is as follows:

$$Dose = \frac{\left[\left(IR_{prey} \times C_{prey}\right) + \left(IR_{sed} \times C_{sed}\right)\right] \times SUF}{BW}$$

where:

Dose =	estimated dose from ingestion (mg COPEC/kg body weight-day)
IR_{prey} =	amount of prey ingested per day (kg/day)
C_{prey} =	concentration of COPEC in prey (mg/kg)
IR_{sed} =	amount of sediment ingested (kg sediment per day)
C_{sed} =	concentration of COPEC in sediment (mg/kg)
SUF =	site use factor (unitless)
BW =	body weight (kg)

While every effort was made to identify site-specific information to estimate dose, such data is very limited. Therefore, in the absence of site-specific information, appropriate and conservative regional information, literature values, or allometric regression models were used in the exposure assessment. The following provides more detailed description of how the specific values were derived follows.

Western Sandpiper

Exposure parameters for the western sandpiper are shown in Table 4-7. The appropriate species-specific data was used when available or extrapolated using the spotted sandpiper when necessary (the spotted sandpiper is identified as a suitable surrogate species for the western sandpiper by the EPA [1993]). Natural history data used to develop exposure parameters can be found in Appendix H. A reasonable and conservative body weight for such a small bird was derived by averaging the mean weights reported in the literature regardless of the annual life cycle stage (e.g., migrating, breeding, wintering). Table H-1 in Appendix H presents body weights used to derive the mean weight. The body weight reported in grams was changed to kilograms. Ingestion rates for this species were not available in the literature. Therefore, the average body weight was incorporated into Nagy's (1987) allometric equation for food ingestion rates for all birds (IR {g/day} = [0.648 x body weight {g}]$^{0.651}$) and used to derive a daily ingestion rate.

This ingestion rate, which was generated in grams per day, was converted to kilograms per day. The incidental soil ingestion rate for western sandpiper (18 percent of the diet) was taken directly from the literature (Beyer et al., 1994). To ensure conservatism, the western sandpiper's diet was assumed to consist of 100 percent Asian clams from the site. The use of bivalves to monitor environmental concentrations of PAHs is considered to be conservative as bivalves are limited in their ability to metabolize these compounds and, therefore, are representative of maximum biocentration. This is the principle behind Mussel Watch Programs which provide an indication of water quality at steady-state conditions in a given locality. In the risk assessment paradigm, clam tissue burdens are representative of the "worst-case" scenario of contaminant exposure. It follows then, that if the calculated risk from these accumulated burdens (either to the clam or to potential consumers) is found to be minimal, there should be no excess risk to sensitive in situ populations. As a result, the worst case is conservative and hence protective.

The greatest level of conservativism Is likely associated with the estimate of the SUF. The SUF is therefore considered to be the most conservative input to the dose calculation. The assumption was made that the western sandpiper forages only at the site (i.e., 100 percent of the year). This is highly conservative based on the fact that the western sandpiper is a migratory bird and is known to spend several months migrating to and from and nesting within its breeding territory in the Pacific Northwest. While conservatism is necessary because of inherent uncertainties associated with the avian dose calculation, these conservative assumptions likely result in an overestimation of the actual dose.

Scaup

Exposure parameters for the scaup are summarized in Table 4-7. It was assumed that if scaup were being exposed to petroleum contaminants, the smaller individuals would potentially be at greater risk than the larger individuals. Additionally, reproductive impairments due to exposure would likely manifest themselves more in female individuals. Therefore, the average body weight for the female lesser scaup (the smaller of the two sexually dimorphic scaup species) regardless of annual life cycle was used as a conservative body weight. The body weight reported in grams was changed to kilograms. Ingestion rates in the literature were only available for juveniles less than 12 weeks old. Therefore, an ingestion rate was calculated using the average adult female body weight and Nagy's (1987) allometric equation for food ingestion rates for all birds. This equation generated a rate in grams per day, which was converted to kilograms per day. The scaup's diet was assumed to consist 100 percent of Asian clams. However, the scaup is omnivorous and consumes varying amounts of vegetation in addition to several other invertebrate classes. Thus, the dietary assumption is very conservative. An incidental soil ingestion rate

was derived using the highest value available in the literature for similar ducks (i.e., 11 percent of the diet for the wood duck) (Beyer et al., 1994). Like the western sandpiper, the scaup is a migratory species. Therefore, for reasons discussed previously, the assumption of a SUF of 1 is highly conservative. This, in conjunction with the other conservative assumptions, is likely to result in an over-estimation of the actual dose. Detailed data used to develop these exposure parameters can be found in Appendix H.

Calculated Doses

Doses in mg/kg/day were calculated for the two receptors based on exposure parameters shown in Table 4-7 for each NFD Point Molate sampling location (Table 4-8). Because the western sandpiper has a lower body weight than the scaup, the constituent concentrations in tissue and sediment yield a higher ingestion quantity per kilogram of body weight. Additionally, the sediment ingestion rate for the western sandpiper is higher than that of the scaup. For the scaup, calculated doses ranged from 0.018 to 0.046 mg/kg/day at the 10 sites where tissue data were collected. Doses for the western sandpiper were slightly higher and ranged from 0.064 to 0.216 mg/kg/day. A dose summary by sampling station can be found in Table 4-6.

4.4.1.3 Effects Assessment

In general, the effects assessment for shorebirds was based on the development of appropriate avian TRVs for TPH followed the Navy protocol for developing TRVs (EFA West, 1998) as follows:

- A broad literature search was conducted, focusing on adverse effects to birds through ingestion of TPH and TPH constituents.
- Identification and retrieval of the most relevant and highest quality studies.
- Review of studies and development of a toxicity spreadsheet that incorporates all the important parameters from the studies to develop toxicity doses (e.g., body weights, ingestion rates, toxicity endpoints etc.).
- Development of TPH constituent-specific doses from whole product toxicity doses cited in the literature.
- Development of a figure that summarizes NELs and ELs for high quality studies.
- Evaluation of whether sufficient high quality studies exist to develop a TRV.

A discussion of how these steps were implemented is presented in greater detail in Appendix D.

Both observational and experimental studies have shown that petroleum products are toxic to birds in three ways:

1. External oiling of birds can result in physical alteration of the structure of feathers which, in turn, causes matting and loss of insulating and water-repelling properties. Death owing to various combinations of heat loss, starvation and drowning frequently follows.

2. Exposure of eggs to oil during incubation can cause high mortality of embryos.

3. Ingestion of oil (which occurs during preening, from contamination of food or drinking water, or incidental soil/sediment ingestion) permits constituents of TPH to act as systemic poisons, causing a variety of physiological and pathological alterations.

As discussed previously, the most likely 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 or through the incidental ingestion of TPH-contaminated sediment.

To evaluate the potential for adverse effects to shorebirds through this ingestion of contaminated prey or sediment, the development of TRVs is required. Therefore, the focus of the TRV derivation task for TPH at NFD Point Molate is through the ingestion route of exposure.

Chronically ingested petroleum in sufficient quantities can invoke a variety of physiological effects in avian receptors. The effects range from systemic changes such as increased liver weight and enzyme activity, to reproductive failures such as reduced or absent oviposition, eggshell thinning, and decreased egg hatchability (Hartung, 1993). Behavioral abnormalities such as nest abandonment and failure to incubate as a result of oil exposure have also been documented (Leighton, 1993). The type and degree of effects appear to be linked to the petroleum product in question, but one general conclusion can be drawn: the ingestion of oil causes stress and has been shown to induce physiological responses.

Mortality was not considered an appropriate endpoint for TRV development since detrimental effects on populations and ecosystems can occur at chemical concentrations much lower than those causing mortality. Also, the high degree of uncertainty involved in estimating a NOAEL from a lethal dose or concentration reduces the usability and certainty of the converted data. Therefore, toxicological data having mortality as an endpoint were used only as a point of reference to insure that the criteria used to determine negative findings (i.e., no potential risk) fell below any concentration from any study at which mortality occurred. Toxicological endpoints related to reproduction and development were preferred since they best reflect population impacts. The lowest EL for the data set was approximately 0.5 mg/kg-d. No adverse effects were observed at lower doses.

Figure 2-7 and Table D-2 (Appendix D) summarize the reproductive toxicity data reviewed. Although a substantial number of studies on whole-product reproductive toxicity to birds were identified and reviewed, constituent-specific data were lacking. Thus, a high level of uncertainty was associated with the PAH composition of the different oils evaluated. Based on this inherent uncertainty, development of a formal TRV was deemed inappropriate. Therefore, a qualitative approach was followed. The development of the qualitative approach used is described in detail in Appendix D. The development of finding and magnitude criteria used to evaluate the bioaccumulation measurement endpoint is discussed in detail in Section 2.8.3.4.

TABLE 4-1

BULK SEDIMENT: SURVIVAL RESULTS OF THE 10-DAY TOXICITY TEST WITH *EOHAUSTORIUS ESTUARIUS* NFD POINT MOLATE

Sample Station ID	% Survival					
	Rep A	Rep B	Rep C	Rep D	Rep E	Mean
Control	95	100	100	95	100	98
REF-BSB1	55	65	55	65	65	61
REF-BSB2	50	60	40	60	65	55
REF-BSB3	35	55	30	35	65	44
DL-1BSB1	90	85	100	85	100	92
T2-BSB1	90	85	100	85	100	92
T3-1BSB	65	90	90	65	85	79
T5-BSB1	100	90	95	90	95	94
T6-BSB1	90	85	65	60	75	74
T9-1BSB1	90	70	65	75	90	78
T9-2BSB1	75	70	70	75	55	69
T10-1BSB1	95	95	90	80	85	89
T11-BSB1	60	80	85	75	90	78
T11-ABSB1	95	85	90	80	85	87
P1-BSB1	100	70	60	70	60	72

TABLE 4-2

BULK SEDIMENT: REBURIAL RESULTS OF THE 10-DAY TOXICITY TEST WITH *EOHAUSTORIUS ESTUARIUS* NFD POINT MOLATE

Sample Station ID	% Reburial of Surviving Amphipods					
	Rep A	Rep B	Rep C	Rep D	Rep E	Mean
Control	100	100	100	100	100	100
REF-BSB1	90.9	100	100	100	100	98.2
REF-BSB2	100	100	100	100	100	100
REF-BSB3	100	100	100	85.7	100	97.1
DL-1BSB1	100	100	100	100	100	100
T2-BSB1	100	100	100	92.3	100	98.5
T3-1BSB	100	100	100	100	100	100
T5-BSB1	100	100	100	100	100	100
T6-BSB1	100	100	100	100	100	100
T9-1BSB1	100	100	92.9	100	100	98.6
T9-2BSB1	100	92.9	100	100	100	98.6
T10-1BSB1	100	100	100	100	100	100
T11-BSB1	100	100	100	100	100	100
T11-ABSB1	100	100	94.4	100	100	98.9
P1-BSB1	100	100	100	100	100	100

TABLE 4-3

SEDIMENT-WATER INTERFACE CORES: SURVIVAL RESULTS OF THE 7-DAY *MYSIDOPSIS BAHIA* TEST NFD POINT MOLATE

Sample Station ID	% Survival					
	Rep A	Rep B	Rep C	Rep D	Rep E	Mean
Control	90	80	100	100	100	94
REF-SWB	100	100	40	100	90	86
DL-1SWB	100	100	100	100	90	98
T2-SWB	100	90	100	100	100	98
T3-1SWB	100	100	90	100	90	96
T5-SWB	70	80	90	60	80	76
T6-SWB	80	90	70	100	90	86
T9-1SWB	100	100	80	60	80	84
T10-1SWB	90	90	90	50	80	80
T11-SWB	100	100	90	100	100	98
T11-ASWB	100	100	90	100	100	98
P1-SWB	100	100	70	90	70	86

TABLE 4-4

SEDIMENT-WATER INTERFACE CORES: GROWTH RESULTS OF THE 7-DAY *MYSIDOPSIS BAHIA* TEST NFD POINT MOLATE

Sample Station ID	Mean Individual Mysid Weight (mg, dry wt)					
	Rep A	Rep B	Rep C	Rep D	Rep E	Mean
Control	0.22	0.29	0.25	0.13	0.21	0.22
REF-SWB	0.25	0.23	0.21	0.22	0.25	0.23
DL-1SWB	0.18	0.26	0.27	0.24	0.30	0.25
T2-SWB	0.22	0.34	0.24	0.28	0.30	0.28
T3-1SWB	0.24	0.29	0.29	0.28	0.27	0.27
T5-SWB	0.22	0.24	0.27	0.32	0.24	0.26
T6-SWB	0.30	0.27	0.27	0.28	0.35	0.29
T9-1SWB	0.28	0.27	0.23	0.11	0.30	0.23
T10-1SWB	0.24	0.27	0.16	0.25	0.38	0.26
T11-SWB	0.20	0.22	0.26	0.20	0.22	0.22
T11-ASWB	0.21	0.19	0.31	0.21	0.28	0.24
P1-SWB	0.24	0.29	0.18	0.29	0.23	0.25

TABLE 4-5

SEDIMENT-WATER INTERFACE CORES: EGG HATCHABILITY RESULTS OF THE 12-DAY TOPSMELT (*ATHERINOPS AFFINIS*) EMBRYO TEST NFD POINT MOLATE

Sample Station ID	% Hatchability					
	Rep A	Rep B	Rep C	Rep D	Rep E	Mean
Control	100	100	100	100	90	98
REF-SWB	90	70	60	80	80	76
DL-1SWB	90	70	60	80	80	76
T2-SWB	80	90	90	70	100	86
T3-1SWB	70	80	90	100	90	86
T5-SWB	90	80	(1)	100	100	92.5
T6-SWB	90	(1)	100	80	90	90
T9-1SWB	80	80	70	70	70	74
T10-1SWB	100	100	100	100	90	98
T11-SWB	90	100	100	80	90	92
T11-ASWB	100	100	100	100	100	100
P1-SWB	100	100	90	80	90	92

(1) Replicate was excluded from the analyses due to fungus covering the eggs.

TABLE 4-6

SUM PAH CONCENTRATIONS AND DOSE CALCULATIONS FOR THE WESTERN SANDPIPER AND SCAUP AT NFD POINT MOLATE

Station	Matrix	Sum PAH[a] mg/kg-dw	Scaup Dose[b] mg/kg/day	Sandpiper Dose[b] mg/kg/day
T11A	Tissue	0.178		
	Sed. T11A-1	2.614	0.031	0.138
	Sed. T11A-2	2.839	0.033	0.147
	Sed. T11A-3	2.388	0.030	0.129
T11-1	Tissue	0.159		
	Sediment	4.753	0.046	0.216
T10-1-1	Tissue	0.144		
	Sediment	4.343	0.042	0.197
T9-1	Tissue	0.167		
	Sed. T9-1-1	1.633	0.023	0.098
	Sed. T9-1-2	1.255	0.020	0.084
	Sed. T9-1-3	1.854	0.025	0.107
T9-2	Tissue	0.142		
	Sediment	2.653	0.029	0.132
DL-1-1	Tissue	0.157		
	Sediment	1.951	0.025	0.108
T6	Tissue	0.312		
	Sediment	0.722	0.026	0.094
T5	Tissue	0.226		
	Sed. T5-1	0.757	0.021	0.077
	Sed. T5-2	0.428	0.018	0.064
	Sed. T5-3	0.598	0.020	0.071
T3-1-1	Tissue	0.176		
	Sediment	1.396	0.022	0.091
T2	Tissue	0.292		
	Sed. T2-1	2.424	0.038	0.155
	Sed. T2-2	2.947	0.041	0.175
	Sed. T2-3	1.804	0.033	0.131

[a] Calculated using one-half the MDL for non-detected PAHs.
[B] Dose calculations based on tissue and sediment values at each station. For stations with replicate sediment values, a dose was calculated using each sediment value.

TABLE 4-7

EXPOSURE PARAMETERS FOR OFFSHORE AVIAN RECEPTORS AT NFD POINT MOLATE

Exposure Paramter	Units	Receptor Species	
		Western Sandpiper	***Scaup***
[1]Total Daily Feeding Ingestion Rate (FI)	kg/day	0.0051	0.0445
[2]Incidental Sediment Ingestion Rate (SI)	kg/day	0.00092	0.0049
Home/Foraging Range	km^2	17.2 + 2.5	0.89 + 0.06 SE
[3]Body Weight (BW)	kg	0.024	0.663

[1] Total daily ingestion rate was derived by using the body weight in Nagy's allometric equation (1987) for food ingestion rate for all birds as follows: $FI = 0.0582 \times BW\ (\text{in kg})^{0.651}$

[2] Incidental sediment ingestion rate was calculated by multiplying the percent sediment ingestion rate by the total daily ingestion rate.

[3] Body weight was derived for the western sandpiper by averaging means from three published studies of California birds (first three entries on Table H-1 in Appendix H). Body weight for the scaup was derived by taking the average female weight for the lesser scaup from a published study of California birds (twelfth entry on Table H-2 in Appendix H).

TABLE 4-8

INDIVIDUAL SAMPLE LOCATION DOSE CALCULATIONS

Dose Calculation Formula: $\frac{[(IR_p \times C_t) + (IR_s \times C_s)] \times SUF}{BW}$

Where:
IR_p = Ingestion rate of prey
C_t = Sum PAH concentration in tissue
IR_s =Incidental sediment ingestion rate
C_s = Sum PAH concentration in sediment
SUF = Site use factor
BW = Body weight

Scaup							
Sample Location	IR_p	C_t	Ir_s	C_s	SUF	BW	**Calculated Dose**
DL-1-1	0.0396	157.1	0.0049	1951.0	1	0.663	**0.025**
T10-1-1	0.0396	144.0	0.0049	4343.0	1	0.663	**0.042**
T11-1	0.0396	159.1	0.0049	4753.0	1	0.663	**0.046**
T11A-1	0.0396	178.1	0.0049	2614.0	1	0.663	**0.031**
T11A-2	0.0396	178.1	0.0049	2839.0	1	0.663	**0.033**
T11A-3	0.0396	178.1	0.0049	2388.0	1	0.663	**0.030**
T2-1	0.0396	292.0	0.0049	2424.0	1	0.663	**0.038**
T2-2	0.0396	292.0	0.0049	2947.0	1	0.663	**0.041**
T2-3	0.0396	292.0	0.0049	1804.0	1	0.663	**0.033**
T3-1-1	0.0396	175.8	0.0049	1396.3	1	0.663	**0.022**
T5-1	0.0396	226.0	0.0049	756.9	1	0.663	**0.021**
T5-2	0.0396	226.0	0.0049	428.3	1	0.663	**0.018**
T5-3	0.0396	226.0	0.0049	597.9	1	0.663	**0.020**
T6-1	0.0396	312.5	0.0049	722.0	1	0.663	**0.026**
T9-1-1	0.0396	167.1	0.0049	1633.0	1	0.663	**0.023**
T9-1-2	0.0396	167.1	0.0049	1255.0	1	0.663	**0.020**
T9-1-3	0.0396	167.1	0.0049	1854.0	1	0.663	**0.025**
T9-2	0.0396	141.8	0.0049	2653.0	1	0.663	**0.029**

Western Sandpiper							
Sample Location	IR_p	C_t	Ir_s	C_s	SUF	BW	**Calculated Dose**
DL-1-1	0.0042	157.1	0.00092	1951.0	1	0.026	**0.108**
T10-1-1	0.0042	144.0	0.00092	4343.0	1	0.026	**0.197**
T11-1	0.0042	159.1	0.00092	4753.0	1	0.026	**0.216**
T11A-1	0.0042	178.1	0.00092	2614.0	1	0.026	**0.138**
T11A-2	0.0042	178.1	0.00092	2839.0	1	0.026	**0.147**
T11A-3	0.0042	178.1	0.00092	2388.0	1	0.026	**0.129**
T2-1	0.0042	292.0	0.00092	2424.0	1	0.026	**0.155**
T2-2	0.0042	292.0	0.00092	2947.0	1	0.026	**0.175**
T2-3	0.0042	292.0	0.00092	1804.0	1	0.026	**0.131**
T3-1-1	0.0042	175.8	0.00092	1396.3	1	0.026	**0.091**
T5-1	0.0042	226.0	0.00092	756.9	1	0.026	**0.077**
T5-2	0.0042	226.0	0.00092	428.3	1	0.026	**0.064**
T5-3	0.0042	226.0	0.00092	597.9	1	0.026	**0.071**
T6-1	0.0042	312.5	0.00092	722.0	1	0.026	**0.094**
T9-1-1	0.0042	167.1	0.00092	1633.0	1	0.026	**0.098**
T9-1-2	0.0042	167.1	0.00092	1255.0	1	0.026	**0.084**
T9-1-3	0.0042	167.1	0.00092	1854.0	1	0.026	**0.107**
T9-2	0.0042	141.8	0.00092	2653.0	1	0.026	**0.132**