REPORT ON THE SAFETY OF CONSUMING FISH AND SHELLFISH FROM AREAS IMPACTED BY THE T/V DUBAI STAR OIL SPILL IN SAN FRANCISCO BAY, CALIFORNIA

May 2010

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Executive Summary

On Friday, October 30, 2009, the tank vessel T/V Dubai Star spilled an estimated 400 to 800 gallons of Intermediate Fuel Oil (IFO) 380 bunker fuel into San Francisco Bay, California. The spill occurred during a bunkering (fueling) operation at Anchorage 9, south of the San Francisco-Oakland Bay Bridge. The California Department of Fish and Game (CDFG), Office of Spill Prevention and Response (OSPR) notified the Office of Environmental Health Hazard Assessment (OEHHA) of the spill, as required by state law (Fish and Game Code Section 5654). Over the course of the day, spill trajectory maps predicted likely shoreline oiling along the Alameda County coast. Because adequate information was not available to determine the potential threat to public health from fishing and shellfish harvesting in the spill-impacted area, OEHHA recommended to CDFG that fishing and shellfish harvesting be closed along the Alameda County shoreline between the San Francisco-Oakland Bay Bridge and the San Mateo Bridge, pending an investigation. OEHHA also advised that fishers avoid fishing in areas where there was a visible sheen on the water. Following OEHHA's recommendation, CDFG declared an immediate shoreline fisheries closure for this area.

Polycyclic aromatic hydrocarbons (PAHs) can become concentrated in bunker fuel and may pose major human health concerns following an oil spill. Our findings following the 2007 Cosco Busan oil spill in San Francisco Bay indicated that PAH levels in analyzed fish and crabs were not high enough to pose a human health concern. Thus, mussels were targeted following the Dubai Star oil spill because they were considered the species most likely to accumulate PAH compounds of human health concern as a result of this much smaller spill of the same oil product. Vanadium was also analyzed because of high vanadium levels in bunker fuel and the bioaccumulation potential of vanadium in mussels.

Fisheries closure samples were collected between November 5 and November 20, 2009. Samples collected before shoreline oiling (pre-oiling) and after fisheries closure sampling was concluded were also evaluated, as appropriate. Mussels were sampled at roughly weekly intervals to capture expected rates of bioaccumulation of PAH compounds in mussel tissues. Sampling results were used to modify the existing closure boundaries and guide successive sampling efforts.

For public health risk assessment, only the concentrations of the PAH benzo(a)pyrene (BaP) and its equivalents (BaP equivalents, or BaPE), several additional PAHs having known non-cancer hazards, and vanadium were considered. BaPE PAHs are considered the most valid measure of the cancer potency of the fuel. OEHHA had previously determined 44 ppb (wet weight) as a level of BaPE PAHs in fish or shellfish tissue that, when consumed, will not pose a significant human health risk. For a population of 10,000 people consuming fish or shellfish containing 44 ppb BaPEs at 8-ounces per week for 30 years, no more than one additional case of cancer would be expected. This risk level is provided as an example of a maximum acceptable risk level in U.S. EPA's Guidance for Assessing Chemical Contaminant Data for Use in Fish

Advisories (U.S. EPA, 2000). OEHHA determined that non-cancer hazards associated with PAHs and vanadium were not of human health concern.

Based on analyses of mussels collected within the closure boundaries between October 31 and November 13, 2009, OEHHA determined that consumption of mussels collected from most areas within the initial closure zone posed no ongoing significant oil-related health risk and the existing closure was lifted for those areas. Elevated BaPE levels in mussels collected from Crown Beach (15.5 ppb BaPE compared to 3.4 ppb BaPE pre-spill) and a timber near Ballena Bay Marina area (up to 164.1 ppb BaPE) required further monitoring. It was determined that mussels collected from the timber near Ballena Bay Marina on November 5 and 13, 2009, indicated the prevalence of non-oil derived PAHs that were unrelated to the oil spill, while those collected from submerged rocks near the timber on November 13 had BaPE concentrations similar to pre-oiled samples collected from the same approximate site two weeks before. Therefore, it was decided that the Ballena Bay Marina area should not remain closed pursuant to Fish and Game Code Section 5654 (the statute that provides for fisheries closure following marine oil spills). Instead, OEHHA issued a health advisory for the public to avoid mussel consumption along the south and east sides of Ballena Boulevard until further notice. Following receipt of November 20, 2009, results, the only remaining closed fishery (shellfish harvesting at Crown Beach) was re-opened on December 7, 2009. The health advisory for mussels remains in effect. Mussel samples collected on November 30 and December 1, 2009, confirmed the appropriateness of lifting the fisheries closure, as BePE concentrations in mussels appeared to have returned to pre-spill levels. The time course of sampling and results from this spill will be useful to inform sampling plans for future spill events.

It is important to note that there are other existing sport fish consumption advisories in the San Francisco Bay, issued previously based of findings of mercury and other contaminants in fish (see http://www.oehha.ca.gov/fish/general/sfbaydelta.html).

Introduction

On Friday, October 30, 2009, at approximately 6:50 am, the tank vessel T/V Dubai Star spilled an estimated 400 to 800 gallons of intermediate fuel oil (IFO) 380 bunker fuel into San Francisco Bay, California. The spill occurred during a bunkering (fueling) operation at Anchorage 9, south of the San Francisco-Oakland Bay Bridge. The California Department of Fish and Game (CDFG), Office of Spill Prevention and Response (OSPR) received notification of the spill at 7:40 am and subsequently informed the Office of Environmental Health Hazard Assessment (OEHHA), as required by state law (Fish and Game Code Section 5654; Appendix 1). The OSPR Seafood Safety Technical Specialist was deployed to Unified Command at Coast Guard Island in Alameda.

Over the course of the day, spill trajectory maps predicted likely shoreline oiling along the Alameda County coast (Figure 1). Because adequate information was not available to determine the potential threat to public health from fishing and shellfish harvesting in the spill-impacted area, OEHHA recommended to CDFG that fishing and shellfish harvesting be closed along the Alameda County shoreline between the San Francisco-Oakland Bay Bridge and the San Mateo Bridge, pending an investigation (Appendix 2). OEHHA also advised that fishers avoid fishing in areas where there was a visible sheen on the water. After receiving this recommendation from OEHHA, CDFG declared an immediate fisheries closure for this area at 5:30 pm (Appendix 3; see map).

OEHHA considers that fishing or shellfish harvesting from oiled shorelines or waters (i.e., those with a visible sheen) constitutes a potential public health threat. Thus, OEHHA recommended that oiled areas remain closed to fishing or shellfish harvesting until such time as any risk from direct contact could be evaluated and remediated, as necessary.

On November 4, 2009, OEHHA recommended that the area of fisheries closure be modified based on updated information on shoreline oiling (Figure 2; Appendix 4). The new area of closure included only the Alameda County shoreline along San Francisco Bay from Alameda Point (at the northwest corner of Alameda Naval Air Station) to the southern boundary of the Oakland Airport. It was further clarified that the closure did not apply to fishing from boats in the bay. CDFG responded with a new declaration on that date (Appendix 5; see map).

The purpose of this report is to describe the nature of the potential human health risk from consuming fish and shellfish in the impacted area, the process of collecting and analyzing seafood in the affected area, risk-based criteria for determining the safety of fish and shellfish consumption, the analytical chemistry results of the seafood sampling, and the conclusions regarding the safety of consuming fish and shellfish from the affected area. A timeline of activities/responses related to the Dubai Star oil spill is presented in Table 1. Portions of this report (e.g., contaminants of concern and the

development of risk-based criteria) have been reproduced from a similar report prepared following the Cosco Busan oil spill in 2007 (OEHHA, 2007).

Contaminants of Concern in Marine Life Following an Oil Spill

Several major oil spills, including bunker fuel, have occurred in U.S. waters in recent years, resulting in fishery closures because of actual or potential contamination (Yender et al., 2002). Physical and chemical characteristics of oil products vary significantly and, along with environmental and biological factors such as wind, water temperature, solar radiation, shoreline type, and species, influence the degree to which seafood may become contaminated (Yender et al., 2002).

Bunker fuel, as released from the T/V Dubai Star, refers to fuel used for ship propulsion and is comprised largely of residual fuel (heavier oils remaining after distillation) blended with lesser amounts of distillate fuel (OEHHA, 2004). These blends are also referred to as intermediate fuels. IFO 380 and 180 bunker fuels contain about 98% and 88% residual fuel, respectively (OEHHA, 2004). Residual fuels are highly viscous and contain significant levels of sulfur, nitrogen, metal oxides, and other impurities (U.S. EPA, 1998; 2003) as well as higher concentrations of monoaromatic compounds (benzene, toluene, ethylbenzene, and xylene, or BTEX) and polycyclic aromatic hydrocarbons (PAHs), especially higher molecular weight PAHs, than do other oil types (Yender et al., 2002). It is these higher molecular weight PAHs that are more likely to result in seafood contamination, particularly in species such as bivalve mollusks that are not mobile and do not rapidly metabolize these compounds as do finfish and some other shellfish (Yender et al., 2002; Meador et al. 1995). While not generally considered acutely toxic, several of these higher molecular weight PAHs are extremely potent carcinogens, most notably benzo[a]pyrene (BaP). For this reason, their occurrence in the environment has been the subject of considerable study and concern (Eisler, 2000).

Although PAHs are ubiquitous global pollutants and are derived from natural and anthropogenic sources, oils spills constitute the greatest source of PAHs in the aquatic environment (Eisler, 2000). PAHs are known to cause other acute or chronic health effects, but cancer is generally the health effect of concern when evaluating the risks of fish or shellfish consumption. For public health risk assessment, only the concentration of BaP and its equivalents (BaP equivalents, or BaPE), several other PAHs having non-cancer hazards and vanadium were considered (see discussion below). Total PAH levels are not useful for this purpose and are thus not reported. All BaPE concentrations are reported in wet weight.

Identifying Contaminants Levels in Fish and Shellfish following the Dubai Star Oil Spill

On Monday, November 2, 2009, OEHHA and OSPR staff held a telephone conference to discuss Shoreline Cleanup Assessment Team (SCAT) reports on shoreline oiling and initial sampling activities conducted by National Resource Damage Assessment (NRDA) teams. On Tuesday, November 3, OEHHA and OSPR staff convened a Seafood Safety

Technical Advisory Group (SSTAG) to develop and implement a sampling and analysis plan to support a risk assessment on the safety of seafood consumption in the impacted area.

Project Organization and Responsibility

Task	*Name(s)*	*Agency*
Project Lead	Susan Klasing	OEHHA
SSTAG Sampling Coordinator	Susan Klasing	OEHHA
Field Sampling Lead	Ellen Faurot-Daniels	DFG/OSPR
Analytical Laboratory Contact	Dave Crane	DFG/OSPR

SSTAG also met by telephone conference on November 9, November 16, November 19, November 25, December 3, December 21, and December 22, 2009, to discuss sampling plans and results, when available.

Sampling Goals

Fish and shellfish are exposed to a variety of PAHs following oil spills, and can become contaminated from this exposure. Following the *Cosco Busan* oil spill, PAH levels in analyzed fish and crabs were not high enough to pose a human health concern. Thus, mussels were targeted following the Dubai Star oil spill because they were considered the species most likely to accumulate PAH compounds of human health concern as a result of this much smaller spill of the same oil product. Edible-sized crabs, which typically accumulate PAH levels intermediate to mussels and finfish, would also have been collected if mussel PAH concentrations were found to be high.

The goal of the sampling effort was to collect mussel samples from multiple sites in the area impacted by the oil spill and analyze those samples for PAHs, specifically those PAHs that are the chemicals of concern for seafood consumption following an oil spill. As noted, only those PAH compounds with known adverse human health effects were considered. Additionally, samples were analyzed for vanadium because of high vanadium levels in bunker fuel and the bioaccumulation potential of vanadium in mussels.

Limited research has provided insight into the bioaccumulation and depuration rates of PAH compounds in mussels. Pruell et al. (1986), for example, measured levels of several PAH compounds in mussels exposed to contaminated sediment in the laboratory at 3, 10, 20, and 40 days during a 40-day exposure period. Of those time periods, most five- and six-ring PAHs were found at the highest concentration in mussels following 20 days of laboratory exposure and had begun to depurate by 40 days. Mussel levels of PAHs of human health concern were thus expected to peak somewhere between 10 and 40 days following the Dubai Star spill. Based on the Pruell study and the results of approximately weekly serial sampling following the Dubai Star spill, fisheries closure sampling was concluded after three weeks.

Sample Locations and Schedule

Sampling teams consisted of representatives from OEHHA, OSPR, National Oceanic and Atmospheric Administration (NOAA), and U.S. Fish and Wildlife Service (USFWS). Sampling was conducted to meet fisheries closure and/or NRDA goals. A total of 22 composite mussel (*Mytilus*) samples, comprised of 470 individual mussels, were collected between October 30 and November 20, 2008, and shipped to the TDI-Brooks International analytical laboratory in College Station, Texas, for PAH analysis. Additionally, five clam (*Venerupis*) composites, comprised of 166 individual clams, were collected by NRDA teams and are reported here for comparison purposes. Collected crabs were considered too small for human consumption and are thus not included in this report. A summary of samples collected, sites, dates, species, individuals per composite, sample identification numbers, and sample location coordinates are reported in Table 2. Week 0 samples were those collected on October 30 (the date of the spill), October 31 and November 2, 2009 (NRDA). Week 1 and 2 samples were collected on November 5 and 6, 2009. Week 2 and 3 samples were collected on November 13 and 20, 2009, respectively, and Week 4 (NRDA) samples were collected on November 30 and December 1, 2009. A map of sampling locations is presented in Figure 3.

Since the oil did not immediately strand on the shoreline, pre-oiling samples were collected, where possible, from areas within the projected spill trajectory. These samples were used to help establish background PAH concentrations for biota in the area. On the day of the spill (October 30), mussels were collected from Alameda Point, Ballena Bay Marina (adjacent to Ballena Boulevard), Robert Crown Memorial State Beach (Crown Beach), and Harbor Bay Isle (also known as Bay Farm Island), and clams were collected from Harbor Bay Isle. On October 31, mussels were collected from NOAA Mussel Watch stations on Yerba Buena Island (Mussel Watch Station ID SFYB) and in Emeryville (Mussel Watch Station ID SFEM). Oil had been spotted on the water near these areas but had not reached shore.

Once shoreline oiling had occurred, samples were collected from oiled areas beginning in Week 0 and continuing in approximately weekly intervals thereafter. Mussels were also collected from Harbor Bay Isle on October 31st, where oil was already on the beach. On November 2, NRDA teams collected clams at Crown Beach. Week 1 samples were collected on November 5 from areas with known shoreline oiling, i.e., Alameda Point, Ballena Bay Marina, Crown Beach, Crab Cove (which is part of Crown Beach), and Harbor Bay Isle. Reference mussel samples were also collected from the San Leandro Marina breakwater (south of the spill zone) on November 6. Week 2 samples were collected on November 13 from four of the five sites sampled in Week 1, with Alameda Point being excluded from further fishery closure sampling. Initial and Week 1 samples had been collected at Alameda Point for NRDA purposes, but because the Alameda Point area is inaccessible to the public, it was not considered a useful sampling site for fisheries closure. Week 1 mussels collected from the Ballena Bay Marina area were obtained only from a very large timber on the shoreline (Figure 4). During Week 2, mussels were collected at two locations in the Ballena Bay area: the timber and along the rocky intertidal shoreline approximately 100 m NE of the timber.

On November 19, following the Week 2 collection, analytical results from Week 0 and Week 1 collections became available. As only mussels from the Ballena Bay Marina area and Crown Beach had BaPE levels above background, Week 3 sampling (November 20) was limited to those two sites. Additionally, prior to Week 3 sampling, it was determined that the timber where some mussels had been collected in the Ballena Bay Marina area in Week 1 and Week 2 had washed ashore near the time of the spill and that mussels collected from the timber exhibited a predominantly pyrogenic PAH pattern, indicating a source other than oil. One possible source would be the timber itself, which may have been previously treated with creosote. It was thus decided that no further samples would be collected from the timber. NRDA teams collected mussel samples from the San Leandro Marina breakwater on November 30 and from Crown Beach and the Ballena Bay Marina area on December 1.

Field Sampling

Field Sampling Methods

The target sample size for fisheries closures purposes was 30 mussels per site. Mussels and other organisms were collected by hand and double wrapped in foil before being placed in a sealed plastic bag. Nitrile gloves were used to collect samples and were changed between each sample. The sample I.D., date and time of collection, site name, sampler, and latitude/longitude of the sampling location were written in indelible ink on a label. The sealed plastic bag of mussels was then placed in another plastic bag with the label inserted between the two bags. The outer bag was then sealed and placed on bagged ice or blue ice in a cooler. When time allowed, samples were taken directly to a FedEx drop-off location for shipping to TDI-Brooks or held on ice in the sampler's possession prior to FedEx drop-off. Other samples were transported to the CDFG Water Pollution Control Laboratory (WPCL) in Rancho Cordova where they were frozen prior to shipping to TDI-Brooks. All samples were shipped in sealed coolers on dry ice if already frozen, or wet ice or blue ice if unfrozen.

Field Documentation and Sample Custody

Standard CDFG chain-of-custody procedures were followed. Chain of custody forms were filled out at the end of each sampling day and enclosed inside the cooler in a sealed plastic bag.

Laboratory Methods

TDI-Brooks Laboratory in College Station, Texas was selected to prepare and analyze the tissue samples using EPA Method 8270 for multiple semi-volatile compounds including PAHs, with a detection limit of <1 ppb. Results for 51 PAH compounds were reported, but only a fraction of them have established toxicity values. Eight carcinogenic PAHs (chrysene, benz[a]anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo[a,h]anthracene, indeno[1,2,3,-cd]pyrene, naphthalene,

and BaP) were analyzed as well as five PAHs for which reference doses (non-cancer effects) are available (anthracene, fluoranthene, fluorene, naphthalene, and pyrene). Results for the five PAHs for which references doses are available were below levels of human health concern and are not presented.

Samples were maintained in a controlled-access freezer at -20° C prior to preparation and analysis. Mussels were shelled and byssal threads removed. Composites of 4-64 individuals were made using the body tissue including the gonads. Samples were prepared using the laboratory's standard preparation procedures supplemented with additional instructions from CDFG Method # MPSL-105 Laboratory Preparation of Trace Metals and Synthetic Organic Samples of Tissues in Marine and Freshwater Bivalves and Fish (CDFG, 2007).

Trace metal analyses were conducted by Laboratory and Environmental Testing, Inc., in Columbia, Missouri. Tissue samples were digested using US EPA method 3052 (Microwave Assisted Digestion) and analyzed by inductively coupled argon plasma spectroscopy (ICP-AES) method 6010C.

TDI-Brooks provided results and associated Quality Assurance (QA) documentation for all samples, including controls, demonstrating that sample processing was reproducible, accurate, and free from cross-contamination. Certified reference material from the National Institute of Standards and Technology (NIST) and National Research Council of Canada (NRCC) were included in sample processing to provide an additional measure of analytical comparability and are identified in the table below. CDFG WPCL reviewed the results and QA documentation. Reference materials and analytical quality controls were within acceptable ranges. All results passed QA review.

Analyte of Interest	***Source***	***Reference Material***	***Matrix***
PAH	NIST	SRM 1974-b	Organics in mussels
Petroleum	NIST	SRM-1582	Petroleum in crude oil
Metals	NRCC	NRCC-TORT-1 NRCC-TORT-2	Metals in dogfish tissue
Metals	NRCC	NRCC-DOLT-4	Metals in dogfish liver tissue

Contaminant Levels in Fish and Shellfish Tissue that Pose No Significant Risk

If available, the safety of commercial seafood consumption is generally determined by comparison of tissue contaminant concentrations to U.S. Food and Drug Administration action levels. Because action levels are not available for PAH compounds, risk-based criteria to establish the safety of commercial and recreational fish and shellfish

consumption impacted by the oil spill were developed by OEHHA for the 2007 Cosco Busan oil spill and are adopted here, as described below. As noted above, cancer is generally considered the health effect of concern for contaminants found in seafood following an oil spill. Nonetheless, the non-carcinogenic hazards of selected PAH compounds and vanadium analyzed in mussels from the affected area were calculated to confirm this belief. Results were vastly below levels of health concern and are thus not presented (see Appendix 6 for additional discussion and calculations on the non-cancer hazards of PAHs and vanadium).

In order to interpret the cancer risk for individual PAH compounds likely to be found in bunker fuel, the carcinogenic activity relative to BaP is estimated as the potency equivalency factor, or PEF (OEHHA, 2005). PEFs for BaP, benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, indeno[1,2,3-cd]pyrene, chrysene, dibenzo[a,h]anthracene, and naphthalene are listed in Table 3. Cancer slope factors for dibenzo[a,h]anthracene and naphthalene were converted to PEFs for ease of later calculations. Tissue concentrations of PAHs other than BaP are multiplied by their respective PEF and then added to the tissue concentration of BaP to determine the BaP equivalent (BaPE) concentration. BaPE concentration is considered the most valid measure of the cancer producing potency of a complex mixture of PAH compounds.

The following general equation was used to set the public health protective concentration (C, in μg/kg or ng/g or ppb, wet weight) for carcinogenic PAH compounds potentially found in fish or shellfish:

$$C = (RL \times BW \times AT \times CF)/(CSF \times CR \times ED)$$

where *RL* is the risk level; *BW* is the body weight (kilograms); *AT* is the averaging time; *CF* is the conversion factor (1000 μg/mg); *CSF* is the cancer slope factor of BaP; *CR* is the consumption rate (the daily amount of fish or shellfish consumed); and *ED* is the exposure duration.

The following specific factors and assumptions were used in the above equation:

- *Risk Level (RL):* Risk-based criteria were designed to prevent consumers from being exposed to the carcinogenic components of spilled oil in doses that exceed a risk level (RL) of $1x10^{-4}$ (1 in 10,000). This RL is within the acceptable range of risks ($1x10^{-4}$ to $1x10^{-6}$) used by the U.S. Environmental Protection Agency (U.S. EPA) in regulatory criteria for drinking water (U.S. EPA, 1998) and is provided as an example of a maximum acceptable risk level in U.S. EPA's Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories (U.S. EPA, 2000). OEHHA considers a RL of $1x10^{-4}$ appropriate for use in fish consumption advisories, when recognizing the counterbalancing benefits of fish consumption.
- *Body Weight (BW):* The default value for adult body weight for these calculations was assumed to be 70 kg.
- *Averaging Time (AT):* The default value for averaging time for these calculations was assumed to be 70 years (the presumed lifespan).

- *Cancer Slope Factor (CSF, also known as a Cancer Potency Factor):* For the purposes of this risk assessment, OEHHA used the CSF for benzo[a]pyrene (BaP) of 11.5 $(mg/kg\text{-}day)^{-1}$ (OEHHA, 2005). The risk of other carcinogenic PAH compounds was estimated relative to BaP using a potency equivalency factor (PEF) as noted above (OEHHA, 2005).
- *Consumption Rate:* The consumption rate was assumed to be 32.5 g/day (one 8-ounce meal per week, prior to cooking, or two 4-ounce meals per week, prior to cooking). This consumption rate is approximately equal to the 95th percentile fish consumption rate for "all consumers" (which includes infrequent and frequent consumers) reported in the San Francisco Bay Seafood Consumption Study (SFEI, 2000), and is also approximately equivalent to the American Heart Association's recommendation for a minimum weekly fish consumption rate for healthy adults (AHA, 2010).
- *Exposure Duration (ED):* The exposure duration (ED) was assumed to be 30 years. Thirty years is considered a high-end estimate (95th percentile) of the length of time that individuals reside at a single residence in the U.S. (OEHHA 2000; U. S. EPA, 1997).

Calculation of the Public Health Protective Concentration for Cancer Risk:

Applying the specific factors and assumptions to the equation above results in the following criterion for BaPE cancer risk:

$$C = \frac{(1\times10^{-4})(70\text{ kg})(70\text{ yr})(1000\mu g/mg)}{[11.5\ (mg/kg\text{-}day)^{-1}](0.0325\text{ kg/day})(30\text{ yr})} = 43.7\text{ ppb} \approx 44\text{ ppb (ng/g) wet weight}$$

In summary, only one additional cancer case (beyond what would otherwise occur) would be expected in a population of 10,000 people eating eight ounces of fish containing the equivalent of 44 parts per billion (ppb, wet weight) of BaPE weekly for 30 years.

Results and Conclusions

Mean BaPE concentrations in composite mussel (Mytilus) and clam (Venerupis) samples at Week 0 and Week 1 are presented in Table 4. Samples were collected from Emeryville at the northern end of the fisheries closure boundary, to Harbor Bay Isle near the southern most accessible fishing area within the closure boundary, and at points in between. Mussels were also collected from Yerba Buena Island, which was outside (to the east) of the closure boundary. Mean BaPE concentrations in mussels and clams collected within the closure boundary prior to shoreline oiling had mean BaPE concentrations ranging from 1.8 to 6.1 ng/g (ppb) wet weight. Mean BaPE concentration in mussels collected from Yerba Buena Island the day after the spill where oiling had not occurred was 4.3 ng/g (ppb). Mussel and clam samples collected after shoreline oiling during Week 0 had mean BaPE concentrations between 2.1 and 6.6 ng/g (ppb). All values were well below the public health protective concentration for

cancer risk of 44 ppb BaPE and, based on samples collected prior to oiling, are considered “background” concentrations for these species in this area.
Mussels collected during Week 1 had BaPE concentrations at background levels for all sites except the Ballena Bay Marina area and Crown Beach. Mussels taken from a timber near Ballena Bay Marina along Ballena Boulevard had a mean BaPE concentration of 150.5 ng/g. Mussels had not been collected from the timber at Week 0, but mussels collected at two sites within a few hundred meters of the timber on the day of the spill (pre-oiling) had BaPE concentrations of 2.8 and 5.6 ng/g. Mussels collected from the bay (north) side of the Elsie Roemer breakwall at Crown Beach at Week 1 had a mean BaPE concentration of 15.5 ng/g, compared to 3.4 ng/g BaPE for mussel samples collected from the same site the day of the spill (pre-oiling). In mussels collected from Alameda Point, Harbor Bay Isle, and Crab Cove and clams collected from Harbor Bay Isle in Week 1, mean BaPE concentrations ranged from 2.7 to 3.6 ng/g. A composite of mussels collected from a reference location (San Leandro Marina breakwater) one week after the spill had a mean BaPE concentration of 1.9 ng/g.

Mean BaPE concentrations in composite mussel samples from Weeks 2, 3 and 4 are presented in Table 5. For Week 2, mussels collected from the timber near Ballena Bay Marina along Ballena Boulevard had a mean BaPE concentration of 164.1 ng/g, while those collected from the Crown Beach/Elsie Roemer breakwall had a mean BaPE concentration of 8.6 ng/g. Other mussels collected from the Ballena Bay Marina area approximately 100 m NE of the timber, Crab Cove and Harbor Bay Isle had mean BaPE concentrations ranging from 2.1 to 5.1 ng/g.

Based on tests of mussels collected within the closure boundaries from Weeks 0, 1, and 2, OEHHA determined that consumption of mussels collected from most areas within the closure zone posed no ongoing significant oil-related health risk. However, elevated PAH levels in mussels from the Ballena Bay Marina area and Crown Beach required further monitoring. Because, as noted above, elevated BaPE concentrations in mussels from the timber near Ballena Bay Marina indicated a preponderance of non-oil derived PAHs, it was decided that this area should not remain closed pursuant to Fish and Game Code Section 5654 (the statute that provides for fisheries closure following marine oil spills). Additionally, although BaPE levels in mussels from Crown Beach at Week 2 were lower than those reported for Week 1, the boom protecting the area had been removed approximately one hour prior to the Week 2 sampling. As oil was still evident on the beach, it was considered possible that the boom had limited mussel oil exposure and BaPE levels might increase again once the boom was removed. On November 25, 2009, the OEHHA Director sent a memorandum to the CDFG Acting Director recommending that the closure zone be reopened for fishing and shellfish harvesting with the exception of Crown Beach, which should remain closed to mussel and other shellfish harvesting, only, pending results of further testing. Additionally, OEHHA issued a health advisory recommending that sport harvesters not take or eat mussels from the bayside shoreline on the west and south sides of Ballena Blvd. (Appendix 7; Figure 5). The CDFG Acting Director subsequently issued a declaration reopening the closure zone with the exception of shellfish harvesting at Crown Beach (Appendix 8).

As noted above, results from Week 0 and Week 1 were received one day prior to the scheduled Week 3 collection. Because BaPE concentrations in mussels were clearly elevated above background at only two sites (Ballena Bay Marina and Crown Beach), it was decided that mussel collections for Week 3 would be limited to those sites. However, because BaPE levels in mussels from the timber were considered confounded by another potential source of PAHs, mussels were only collected from the Ballena Bay Marina area approximately 100 meters northeast of the timber. Mean BaPE concentrations for mussels collected at Week 3 from this site and Crown Beach were 34.7 and 17.7 ng/g, respectively. The BaPE concentrations in mussels from the Ballena Bay Marina area were nearly seven-fold higher than they had been in mussels taken from approximately the same site the prior week, which may reflect spatial variability in oiling and mussel exposure. The PAH profile of these mussels was a mixture of pyrogenic and petrogenic sources. Mean BaPE levels in mussels from Crown Beach had increased, but were still below the human health risk criterion of 44 ppb, as were the mussels from Ballena Bay. For both areas, it was considered very unlikely that oil spill-related BaPE concentrations would increase substantially more than three weeks after the spill. Thus, on December 7, 2009, the OEHHA Director sent a memorandum to the CDFG Acting Director recommending reopening of Crown Beach to shellfish harvesting while maintaining the health advisory for mussels collected from the bayside shoreline south and west of Ballena Boulevard (Appendix 9). The CDFG Acting Director issued a declaration reopening shellfish harvesting on Crown Beach on that same day (Appendix 9).

BaPE levels in Week 4 mussel samples collected by NRDA teams were 1.1, 3.0, and 4.3 ppb for San Leandro Marina breakwater, Ballena Bay Marina and Crown Beach, respectively, reflecting background concentrations for those areas.

In conclusion, based on a recommendation by OEHHA following the Dubai Star oil spill, CDFG declared a shoreline fisheries closure on October 30, 2009, for a portion of the Alameda County shoreline. When shoreline oiling data became available, the fisheries closure boundaries were modified. OEHHA and CDFG began sampling for fisheries closure purposes in the spill zone on November 5, 2009, and at approximately weekly intervals until three weeks post-spill. Post-spill results were compared to pre-oiled samples and facilitated further modification of the scope and boundaries of the closure and the Fisheries Closure Sampling and Analysis Plan until the eventual reopening of the only remaining closed fishery (shellfish harvesting) on December 7, 2009. Mussel samples collected at Week 4 by NRDA teams confirmed the appropriateness of lifting the fisheries closure, as mussel BePE concentrations appeared to have returned to pre-spill levels. The time course of sampling and results from this spill will be useful to inform sampling plans for future spill events.

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Table 1. Timeline for Oil Spill Response

Date	Activity/Response
10/30/09 @ ~0650	T/V Dubai Star spills IFO 380 bunker fuel at Anchorage 9 in San Francisco Bay during a bunkering operation
10/30/09 @ 0740	OSPR receives notification of the spill
10/30/09 @ 1009	OEHHA receives SEN initial report
10/30/09 @ 1030	OSPR SSTS notifies OEHHA that she is deploying to Unified Command at Coast Guard Island in Alameda
10/30/09	NRDA teams collect pre-oiling samples from Alameda Point, Ballena Bay Marina, Crown Beach, and Harbor Bay Isle and clams from Harbor Bay Isle
10/30/09 @ 1659	OEHHA Director sends memorandum CDFG Chief Deputy director recommending fisheries closure along Alameda shoreline from the San Francisco-Oakland Bay Bridge to the San Mateo Bridge
10/30/09 @ 1730	CDFG Chief Deputy Director issues declaration of fisheries closure along Alameda shoreline from the San Francisco-Oakland Bay Bridge to the San Mateo Bridge
10/31/09	NRDA teams collect mussels from Yerba Buena Island, Emeryville, and Harbor Bay Isle (post-oiling)
10/31/09 @ 1404	OEHHA recommends closure be maintained
11/02/09	NRDA teams collect clams from Crown Beach and crabs from Harbor Bay Isle
11/02/09	OEHHA and OSPR hold telephone conference to discuss Shoreline Cleanup Assessment Team (SCAT) reports and sampling and analysis
11/03/09	NRDA team collects crabs from Harbor Bay Isle
11/03/09	OEHHA and OSPR staff hold telephone conference to select SSTAG, discuss sampling and analysis, and modification of closure boundaries based on SCAT reports; TDI-Brooks selected as analytical laboratory

Date	Activity/Response
11/04/09	OEHHA Director sends memorandum to DFG Acting Director recommending revision of closure boundaries
11/04/09	CDFG Acting Director issues declaration revising closure boundaries
11/05/09	NRDA and fisheries closure teams collect mussels from Alameda Point, Ballena Bay Marina, Crab Cove, Crown Beach, and Harbor Bay Isle, and clams from Harbor Bay Isle
11/06/09	NRDA team collects mussels from San Leandro Marina breakwater
11/09/09	SSTAG convenes to plan additional sampling
11/13/09	Fisheries closure team collects mussels from Ballena Bay Marina (two sites), Crown Beach, Crab Cove, and Harbor Bay Isle
11/16/09	SSTAG convenes to discuss sampling, signage and preparation for potential reopening following receipt of Week 2 analytical results
11/19/09	OEHHA receives validated analytical results for Week 0 and Week 1 (through 11/05/09); SSTAG convenes to discuss results and confirm Week 3 sampling
11/20/09	Fisheries closure team conducts Week 3 sampling at Ballena Bay Marina and Crown Beach
11/24/09	OEHHA receives analytical results from Week 2
11/25/09	SSTAG convenes to discuss Week 2 analytical results
11/25/09	OEHHA Director sends memorandum to CDFG Acting Director recommending that the closure zone be reopened for fishing and shellfish harvesting with the exception of Crown Beach, which should remain closed to mussel and other shellfish harvesting. OEHHA further issues a health advisory for mussels collected from the bayside shoreline on the west and south sides of Ballena Boulevard.
11/25/09	CDFG Acting Director issues declaration following OEHHA's recommendation

Date	Activity/Response
11/30/09	NRDA team collects mussels from San Leandro Marina breakwater and Harbor Bay Isle
12/01/09	NRDA team collects mussels from Ballena Bay Marina and Crown Beach
12/02/09	OEHHA receives analytical results from Week 3
12/03/09	SSTAG convenes to discuss Week 3 sampling results
12/04/09	OEHHA receives final QA for results for Week 2 and 3 data
12/07/09	OEHHA Director sends memorandum to Acting Director of CDFG to recommend reopening of Crown Beach to shellfish harvesting
12/07/09	CDFG Acting Director issues declaration reopening Crown Beach to shellfish harvesting

Table 2. Summary of Seafood Safety Sampling and Analysis Collections

Site	Date	Biota Type*	Number individuals/ composite	Collector/Sampling Lead	Sample I.D. CDFG I.D.	GPS** Coordinates (DD)
Week 0						
Alameda Point	10/30/09***	Mussels	7	Beckye Stanton	ALD001103009-RI1-01MU CFG 0067	37.7911 -122.3311
Alameda Point	10/30/09***	Mussels	5	Beckye Stanton	ALD001103009-RI1-02MU CFG 0068	37.7894 -122.3311
Ballena Bay Marina	10/30/09***	Mussels	6	Beckye Stanton	ALD001103009-RI1-03MU CFG 0069****	37.7679 -122.2883
Ballena Bay Marina	10/30/09***	Mussels	5	Toby McBride/John Henderson	ALD-RI2-103009-1-MU CFG 0071	37.764519 -122.286366
Crown Beach	10/30/09***	Mussels	7	Toby McBride/John Henderson	ALD-RI2-103009-2-MU CFG 0072	37.75360 -122.250505
Harbor Bay Isle	10/30/09***	Mussels	7	Toby McBride /John Henderson	ALD-RI2-103009-3-MU CFG 0073	37.74823 -122.25236
Harbor Bay Isle	10/30/09***	Clams	6	Toby McBride/John Henderson	ALD-RI2-103009-1-VC CFG 0070	37.74823 -122.25236
Emeryville	10/31/09***	Mussels	36	Toby McBride/Laurie Sullivan	ALB-RI2-103109-1-MU002 CFG 0076	37.8203 -122.33033
Yerba Buena Island	10/31/09***	Mussels	29	Toby McBride/Laurie Sullivan	SFF-RI2-103109-1-MU001 CFG 0075	37.81622 -122.37212
Harbor Bay Isle	10/31/09	Mussels	4	Bruce Joab	ALD12103109-RI3-01MU CFG 0074	37.7452 -122.2578
Crown Beach	11/02/09	Clams	50	Toby McBride/Carolyn Marn	ALD-BS1-110209-1-CL009 CFG 0077	37.75912 -122.26517
Crown Beach	11/02/09	Clams	64	Toby McBride/Carolyn Marn	ALD-BS1-110209-2-CL010 CFG 0078	37.75882 -122.26523
Crown Beach	11/02/09	Clams	42	Toby McBride/Carolyn Marn	ALD-BS1-110209-3-CL011 CFG 0079	37.75861 -122.26539
Week 1						
Alameda Point	11/05/09	Mussels	30	Beckye Stanton	ALD001-RI1-110509-3-MU CFG 0085	37.78946 -122.33106
Ballena Bay Marina – timber	11/05/09	Mussels	30	Beckye Stanton	ALD002-RI1-110509-1-MU CFG 0084	37.76660 -122.28894
Crab Cove	11/05/09	Mussels	30	John Henderson/Carolyn Marn	ALD02-RI2-110509-5-MU CFG 0083	37.76751 -122.27907

Site	Date	Biota Type*	Number individuals/ composite	Collector/Sampling Lead	Sample I.D. CDFG I.D.	GPS** Coordinates (DD)
Crown Beach/ Elsie Roemer breakwall	11/05/09	Mussels	30	John Henderson/Carolyn Marn	ALD03-RI2-110509-4-MU CFG 0082	37.75345 -122.25080
Harbor Bay Isle	11/05/09	Mussels	30	John Henderson/Carolyn Marn	ALD12-RI2-110509-1-MU CFG 0080	37.74764 -122.25299
Harbor Bay Isle	11/05/09	Clams	4	John Henderson/Carolyn Marn	ALD12-RI2-110509-2-CL CFG 0081	37.74764 -122.25299
San Leandro Marina Breakwater	11/06/09***	Mussels	14	Greg Baker	ALE-AH-110609-02-MU NOA 3959	37.6986 -122.1942
Week 2						
Ballena Bay Marina – NE of timber	11/13/09	Mussels	20	Ellen Faurot-Daniels	ALD02-RI1-111309-2-MU CFG 0087	37.76746 -122.28852
Ballena Bay Marina – timber	11/13/09	Mussels	30	Ellen Faurot-Daniels	ALD02-RI1-111309-1-MU CFG 0086	37.7666 -122.28891
Crab Cove	11/13/09	Mussels	30	Ellen Faurot-Daniels	ALD02-RI1-11139-4-MU CFG 0089	37.76765 -122.27849
Crown Beach /Elsie Roemer breakwall	11/13/09	Mussels	30	Ellen Faurot-Daniels	ALD03-RI1-111309-3-MU CFG 0088	37.75329 -122.25074
Harbor Bay Isle	11/13/09	Mussels	30	Ellen Faurot-Daniels	ALD12-RI1-111309-5-MU CFG 0090	37.74296 -122.2613
Week 3						
Ballena Bay Marina	11/20/09	Mussels	30	Ellen Faurot-Daniels/Susan Klasing	ALD02-RI1-112009-1-MU CFG 0099	37.76746 -122.28866
Crown Beach/Elsie Roemer breakwall	11/20/09	Mussels	30	Ellen Faurot-Daniels/Susan Klasing	ALD03-RI1-112009-2-MU CFG 0100	37.75329 -122.25074
Week 4						
San Leandro Marina Breakwater	11/30/09***	Mussels	10	Bruce Joab	ALE04-RI1-113009-1-MU CFG 0104	37.69851 -122.19427
Ballena Bay Marina	12/01/09	Mussels	10	Bruce Joab	ALD02-RI1-120109-4-MU CFG 0103	37.76633 -122.28906
Crown Beach	12/01/09	Mussels	10	Bruce Joab	ALD03-RI1-120109-2-MU CFG 0102	37.75323 -122.25079

*Mussels collected were Mytilus; clams were Venerupsis

**GPS waypoints (latitude, longitude) reported in decimal degrees (DD) in WGS 84

***Pre-oiled or reference site samples

****Sample I.D. was revised to ALD02

Table 3. Potency Equivalency Factors and Cancer Slope Factors for Selected PAH Compounds

Chemical	Potency Equivalency Factor[a] (PEF)	Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$
benzo[a]pyrene	1	11.5
benz[a]anthracene	0.1	
benzo[b]fluoranthene	0.1	
benzo[k]fluoranthene	0.1	
Indeno[1,2,3-cd]pyrene	0.1	
chrysene	0.01	
dibenzo[a,h]anthracene	0.36[b]	4.1
naphthalene	0.01[b]	0.12

[a] OEHHA, 2005
[b] This PEF was calculated from the OEHHA cancer slope factor for this chemical.

Table 4. BaPE Concentrations for Week 0 and Week 1 Samples

Site	Date	Biota Type*	Sample I.D.	BaPE ng/g wet weight (ppb)
Week 0				
Alameda Point	10/30/09**	Mussels	ALD001103009-RI1-01MU CFG 0067	3.3
Alameda Point	10/30/09**	Mussels	ALD001103009-RI1-02MU CFG 0068	3.0
Ballena Bay Marina	10/30/09**	Mussels	ALD001103009-RI1-03MU CFG 0069***	5.6
Ballena Bay Marina	10/30/09**	Mussels	ALD-RI2-103009-1-MU CFG 0071	2.8
Crown Beach	10/30/09**	Mussels	ALD-RI2-103009-2-MU CFG 0072	3.4
Harbor Bay Isle	10/30/09**	Mussels	ALD-RI2-103009-3-MU CFG 0073	3.0
Harbor Bay Isle	10/30/09**	Clams	ALD-RI2-103009-1-VC CFG 0070	1.8
Emeryville	10/31/09**	Mussels	ALB-RI2-103109-1-MU002 CFG 0076	6.1
Yerba Buena Island	10/31/09**	Mussels	SFF-RI2-103109-1-MU001 CFG 0075	4.3
Harbor Bay Isle	10/31/09	Mussels	ALD12103109-RI3-01MU CFG 0074	2.3
Crown Beach	11/02/09	Clams	ALD-BS1-110209-1-CL009 CFG 0077	6.6
Crown Beach	11/02/09	Clams	ALD-BS1-110209-2-CL010 CFG 0078	2.3
Crown Beach	11/02/09	Clams	ALD-BS1-110209-3-CL011 CFG 0079	2.1
Week 1				
Alameda Point	11/05/09	Mussels	ALD001-RI1-110509-3-MU CFG 0085	2.7
Ballena Bay Marina – timber	11/05/09	Mussels	ALD002-RI1-110509-1-MU CFG 0084	150.5
Crab Cove	11/05/09	Mussels	ALD02-RI2-110509-5-MU CFG 0083	3.6
Crown Beach/ Elsie Roemer breakwall	11/05/09	Mussels	ALD03-RI2-110509-4-MU CFG 0082	15.5
Harbor Bay Isle, Aughinbaugh Way	11/05/09	Mussels	ALD12-RI2-110509-1-MU CFG 0080	3.4
Harbor Bay Isle, Aughinbaugh Way	11/05/09	Clams	ALD12-RI2-110509-2-CL CFG 0081	2.8
San Leandro Marina Breakwater	11/06/09**	Mussels	ALE-AH-110609-02-MU NOA 3959	1.9

*Mussels collected were Mytilus; clams were Venerupsis

**Pre-oiled or reference site samples

Table 5. BaPE Concentrations for Week 2, Week 3 and Week 4 Samples

Site	Date	Biota Type*	Sample I.D.	BaPE ng/g wet weight (ppb)
Week 2				
Ballena Bay Marina – NE of timber	11/13/09	Mussels	ALD02-RI1-111309-2-MU CFG 0087	5.1
Ballena Bay Marina – timber	11/13/09	Mussels	ALD02-RI1-111309-1-MU CFG 0086	164.1
Crab Cove	11/13/09	Mussels	ALD02-RI1-111309-4-MU CFG 0089	2.1
Crown Beach /Elsie Roemer breakwall	11/13/09	Mussels	ALD03-RI1-111309-3-MU CFG 0088	8.6
Harbor Bay Island	11/13/09	Mussels	ALD12-RI1-111309-5-MU CFG 0090	3.5
Week 3				
Ballena Bay Marina	11/20/09	Mussels	ALD02-RI1-112009-1-MU CFG 0099	34.7
Crown Beach/Elsie Roemer breakwall	11/20/09	Mussels	ALD03-RI1-112009-2-MU CFG 0100	17.7
Week 4				
San Leandro Marina Breakwater	11/30/09**	Mussels	ALE04-RI1-113009-1-MU CFG 0104	1.1
Ballena Bay Marina	12/01/09	Mussels	ALD02-RI1-120109-4-MU CFG 0103	3.0
Crown Beach	12/01/09	Mussels	ALD03-RI1-120109-2-MU CFG 0102	4.3

*Mussels collected were Mytilus; clams were Venerupsis
** Pre-oiled or reference site samples
***Sample I.D. was revised to ALD02

Figure 1. NOAA Oil Trajectory Map

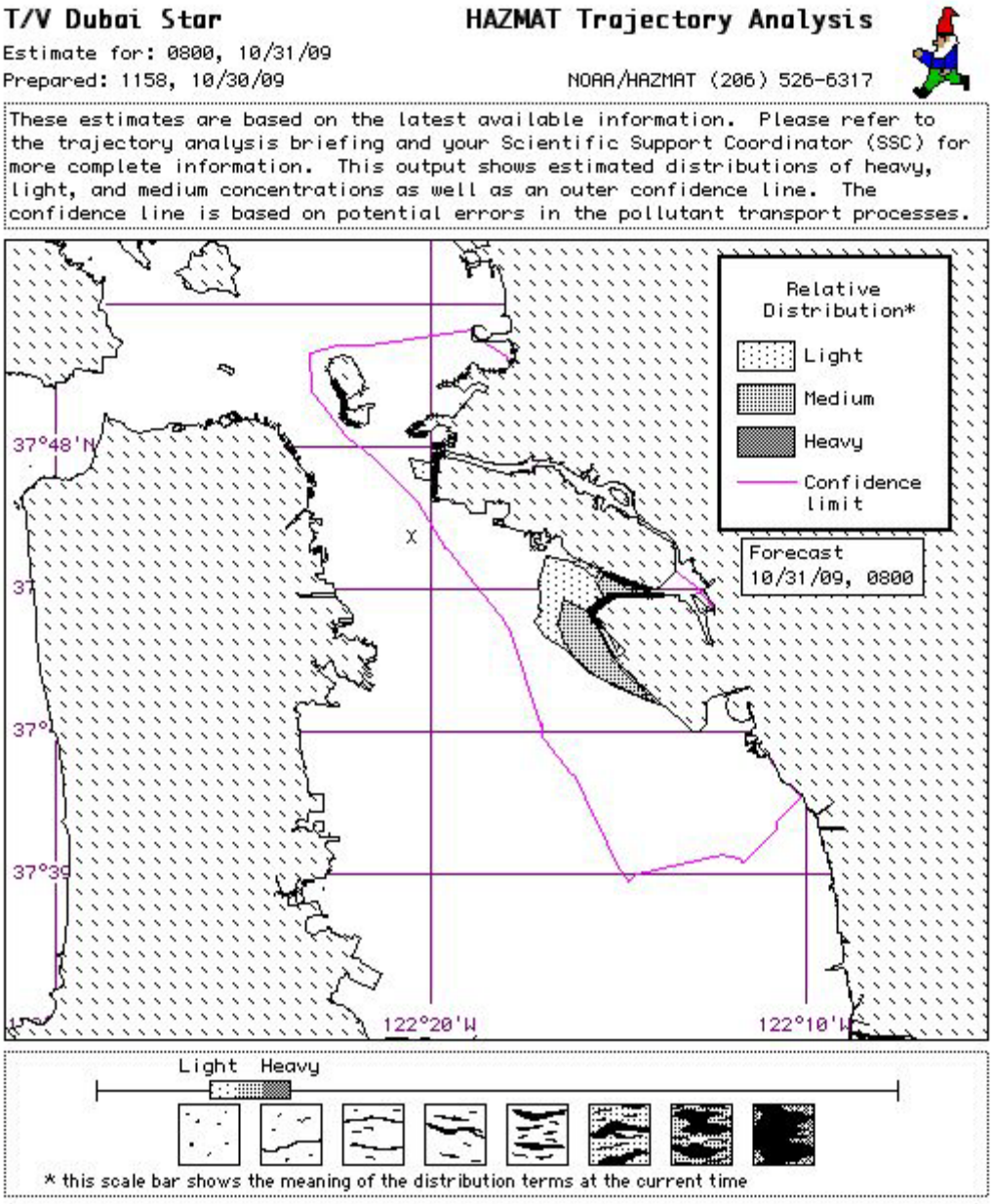

Figure 2. SCAT Shoreline Oiling Report

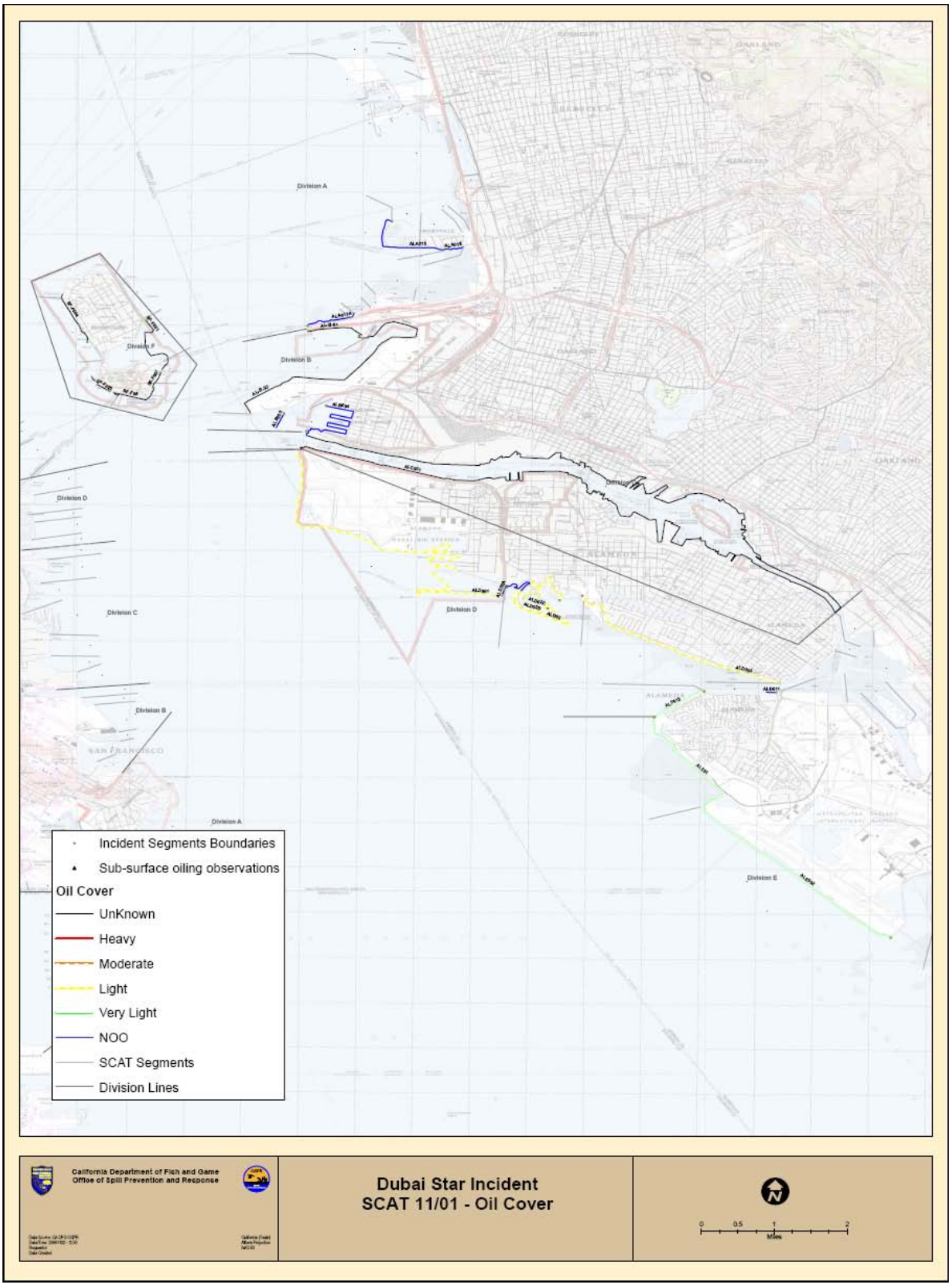

Figure 3. Sampling Locations

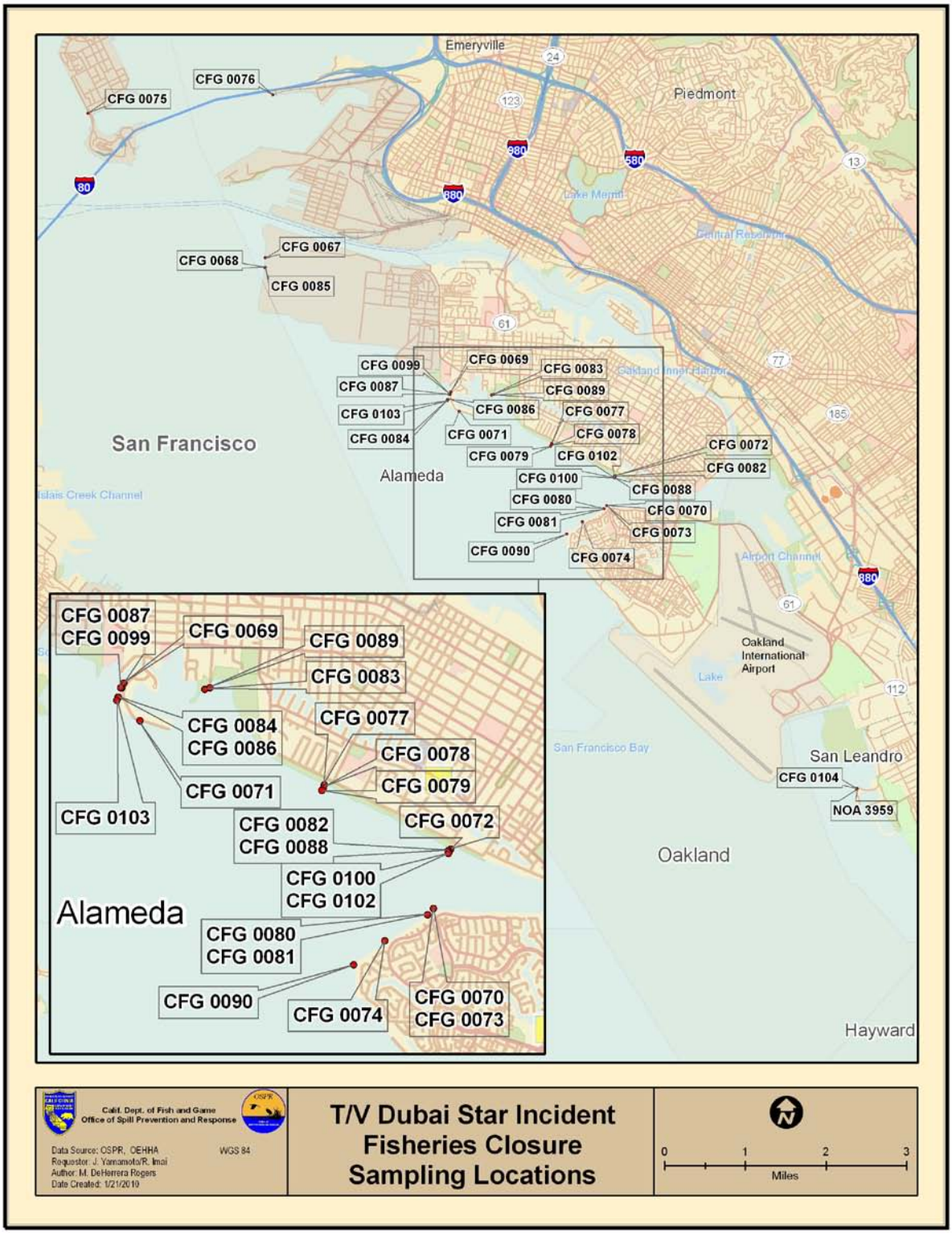

Figure 4. Timber near Ballena Bay Marina

Figure 5. Health Advisory for Mussels Along Ballena Boulevard

Bayside shorelines on the west and south sides of Ballena Boulevard

Appendix 1

FISH AND GAME CODE
SECTION 5654

5654. (a) (1) Notwithstanding Section 7715 and except as provided in paragraph (2), the director, within 24 hours of notification of a spill or discharge, as those terms are defined in subdivision (ad) of Section 8670.3 of the Government Code, where any fishing, including all commercial, recreational, and nonlicensed subsistence fishing, may take place, or where aquaculture operations are taking place, shall close to the take of all fish and shellfish all waters in the vicinity of the spill or discharge or where the spilled or discharged material has spread, or is likely to spread. In determining where a spill or discharge is likely to spread, the director shall consult with the Administrator of the Office of Spill Prevention and Response. At the time of closure, the department shall make all reasonable efforts to notify the public of the closure, including notification to commercial and recreational fishing organizations, and posting of warnings on public piers and other locations where subsistence fishing is known to occur. The department shall coordinate, when possible, with local and regional agencies and organizations to expedite public notification.

(2) Closure pursuant to paragraph (1) is not required if, within 24 hours of notification of a spill or discharge, the Office of Environmental Health Hazard Assessment finds that a public health threat does not or is unlikely to exist.

(b) Within 48 hours of notification of a spill or discharge subject to subdivision (a), the director, in consultation with the Office of Environmental Health Hazard Assessment, shall make an assessment and determine all of the following:

(1) The danger posed to the public from fishing in the area where the spill or discharge occurred or spread, and the danger of consuming fish taken in the area where the spill or discharge occurred or spread.

(2) Whether the areas closed for the take of fish or shellfish should be expanded to prevent any potential take or consumption of any fish or shellfish that may have been contaminated by the spill or discharge.

(3) The likely period for maintaining a closure on the take of fish and shellfish in order to prevent any possible contaminated fish or shellfish from being taken or consumed or other threats to human health.

(c) Within 48 hours after receiving notification of a spill or discharge subject to subdivision (a), or as soon as is feasible, the director, in consultation with the Office of Environmental Health Hazard Assessment, shall assess and determine the potential danger from consuming fish that have been contained in a recirculating seawater tank onboard a vessel that may become contaminated by the vessel's movement through an area where the spill or discharge occurred or spread.

(d) If the director finds in his or her assessment pursuant to subdivision (b) that there is no significant risk to the public or to the fisheries, the director may immediately reopen the closed area and waive the testing requirements of subdivisions (e) and (f).

(e) Except under the conditions specified in subdivision (d),

after complying with subdivisions (a) and (b), the director, in consultation with the Office of Environmental Health Hazard Assessment, but in no event more than seven days from the notification of the spill or discharge, shall order expedited tests of fish and shellfish that would have been open for take for commercial, recreational, or subsistence purposes in the closed area if not for the closure, to determine the levels of contamination, if any, and whether the fish or shellfish is safe for human consumption.

(f) (1) Within 24 hours of receiving a notification from the Office of Environmental Health Hazard Assessment that no threat to human health exists from the spill or discharge or that no contaminant from the spill or discharge is present that could contaminate fish or shellfish, the director shall reopen the areas closed pursuant to this section. The director may maintain a closure in any remaining portion of the closed area where the Office of Environmental Health Hazard Assessment finds contamination from the spill or discharge persists that may adversely affect human health.

(2) The director, in consultation with the commission, may also maintain a closure in any remaining portion of the closed area where commercial fishing or aquaculture occurs and where the department determines, pursuant to this paragraph, that contamination from the spill or discharge persists that may cause the waste of commercial fish or shellfish as regulated by Section 7701.

(g) To the extent feasible, the director shall consult with representatives of commercial and recreational fishing associations and subsistence fishing communities regarding the extent and duration of a closure, testing protocols, and findings. If a spill or discharge occurs within the lands governed by a Native American tribe or affects waters flowing through tribal lands, or tribal fisheries, the director shall consult with the affected tribal governments.

(h) The director shall seek full reimbursement from the responsible party or parties for the spill or discharge for all reasonable costs incurred by the department in carrying out this section, including, but not limited to, all testing.

Appendix 2

Office of Environmental Health Hazard Assessment

Joan E. Denton, Ph.D., Director
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Oakland Office • Mailing Address: 1515 Clay Street, 16th Floor • Oakland, California 94612

Linda S. Adams
Secretary for Environmental Protection

Arnold Schwarzenegger
Governor

MEMORANDUM

TO: John McCamman
Chief Deputy Director
Department of Fish and Game
1416 Ninth Street
Sacramento, CA 95814

FROM: Joan E. Denton, Ph.D.
Director

DATE: October 30, 2009

SUBJECT: SAN FRANCISCO OIL SPILL: OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT RECOMMENDATION

The Office of Environmental Health Hazard Assessment (OEHHA) has been informed that on October 30, 2009, an oil spill occurred in the San Francisco Bay.

Adequate information for OEHHA to determine the potential threat to public health from fishing or shellfish harvesting in the affected area or from consuming fish or shellfish from the area is not currently available. OEHHA recommends that a fishing and shellfish harvesting closure be initiated for the Alameda County shoreline between the San Francisco-Oakland Bay Bridge and the San Mateo Bridge pending an investigation to determine pending an investigation to determine and establish the degree and nature of any potential public health threat posed by the spill. Additionally, OEHHA is advising that fishers avoid fishing in areas where there is a visible sheen on the water.

If you have any questions, please contact me at (916) 322 6325.

Appendix 3

CALIFORNIA DEPARTMENT OF FISH AND GAME
DECLARATION OF FISHERIES CLOSURE
DUE TO A PUBLIC HEALTH THREAT
CAUSED BY AN OIL SPILL INTO MARINE WATERS

Pursuant to Fish & Game Code section 5654, I find and declare that:

I.

At 0800 on October 30, 2009, I received notice of a spill of 42 gallons or more into marine waters (tidally influenced).

II.

Fishing activities occur in the vicinity of the spill, which may include recreational, commercial, subsistence fishing, and aquaculture operations.

III.

The Office of Environmental Heath & Hazard Assessment (OEHHA) has recommended that a fishing and shellfish harvesting closure be initiated for impacted shorelines. Additionally, OEHHA is advising that fishers avoid fishing in areas where there is visible sheen on the water.

This fishing and shellfish harvesting closure is recommended during an investigation to determine and establish the degree and nature of the public health threat posed.

IV.

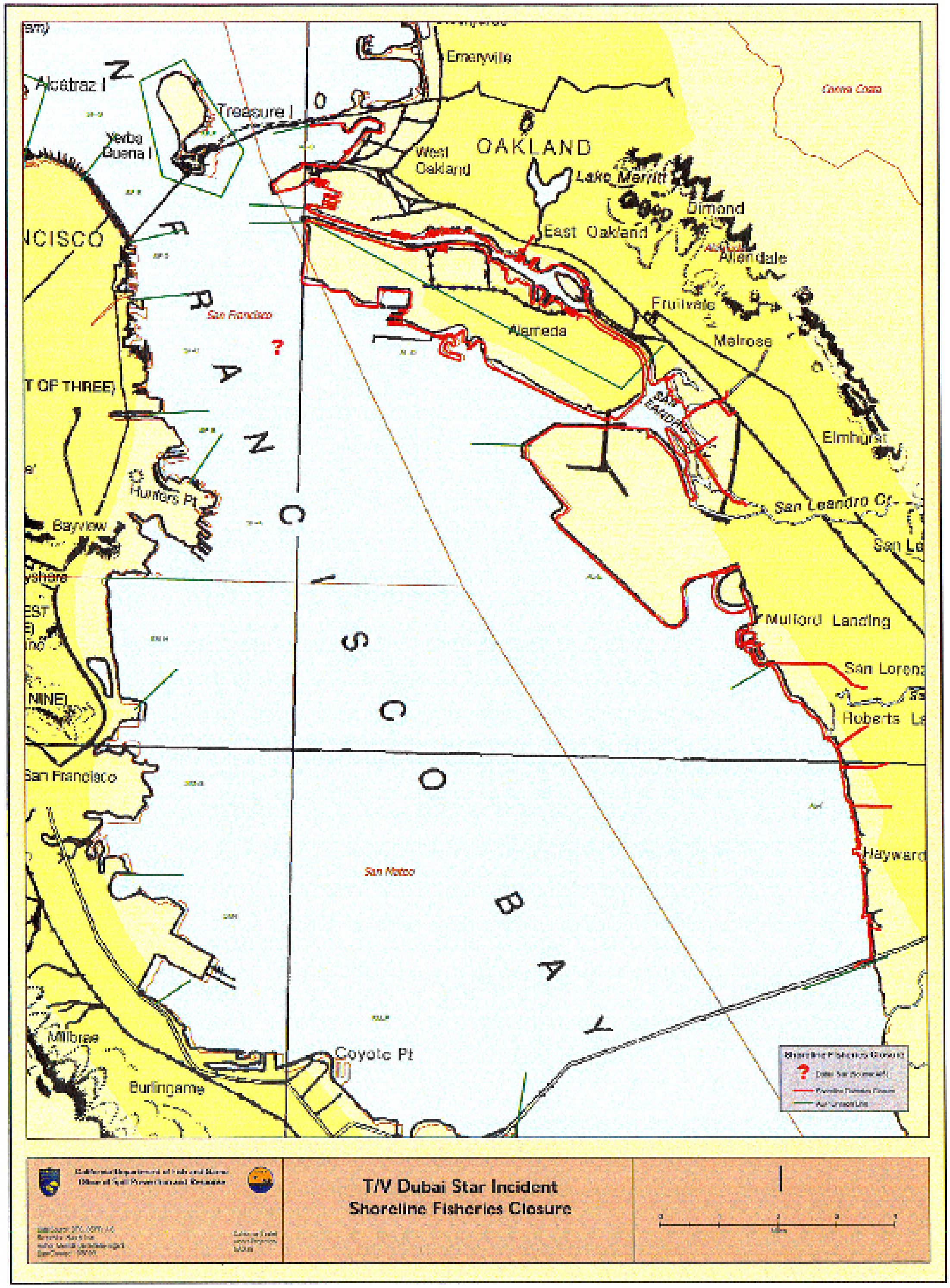
Therefore, I hereby ORDER that the take of all fish and shellfish is prohibited in the vicinity of the spill or where the spill is anticipated to spread, specifically the Alameda County shoreline between the San Francisco-Oakland Bay Bridge and the San Mateo Bridge. Attached hereto is a map of the initially closed areas. The extent of the closure will change as conditions and factors in the area change.

V.

This Order is not intended to, and does not, create any rights or benefits, substantive or procedural, enforceable at law or in equity, against the State of California, its departments, agencies, or other entities, its officers or employees, or any other person.

John McCamman, Chief Deputy Director
California Department of Fish & Game

10/30/09 5:30 p.m.
Date / Time


T/V Dubai Star Incident
Shoreline Fisheries Closure
California Department of Fish and Game
Office of Spill Prevention and Response
Emeryville
Alcatraz I
Treasure I
Yerba Buena I
West Oakland
OAKLAND
Lake Merritt
Dimond
East Oakland
Allendale
Fruitvale
Alameda
Melrose
Elmhurst
San Leandro
San Leandro Cr
Mulford Landing
Hunters Pt
Bayview
San Francisco
Contra Costa
Hayward
Coyote Pt
Millbrae
Burlingame
San Mateo
SAN FRANCISCO BAY
Miles

Appendix 4

Office of Environmental Health Hazard Assessment

Joan E. Denton, Ph.D., Director
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Mailing Address: P.O. Box 4010 • Sacramento, California 95812-4010
Oakland Office • Mailing Address: 1515 Clay Street, 16th Floor • Oakland, California 94612

Linda S. Adams
Secretary for Environmental Protection

Arnold Schwarzenegger
Governor

MEMORANDUM

TO: John McCamman
Acting Director
Department of Fish and Game
1416 Ninth Street
Sacramento, CA 95814

FROM: Joan E. Denton, Ph.D. Joan E. Denton, Ph.D.
Director

DATE: November 4, 2009

SUBJECT: SAN FRANCISCO OIL SPILL: OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT REVISED RECOMMENDATIONS

Based on recent data collected on shoreline oiling and areas of potential fishing/shellfishing activity, the Office of Environmental Health Hazard Assessment (OEHHA) recommends that the boundary of the existing fishing and shellfish harvesting closure be modified. Specifically, OEHHA recommends that a fishing and shellfish harvesting closure be maintained for the Alameda County shoreline along San Francisco Bay from Alameda Point (at the northwest corner of Alameda Naval Air station) to the southern boundary of the Oakland airport, pending the results of an investigation to determine and establish the degree and nature of any potential public health threat posed by the spill. With this action, we are recommending that Oakland Middle Harbor north to the Bay Bridge, the Oakland Inner Harbor and estuary between Oakland and Alameda, San Leandro Bay, and shoreline from the southern boundary of Oakland Airport to the San Mateo Bridge no longer be closed to fishing. Additionally, OEHHA further clarifies that this closure does not apply to fishing from boats in the bay. OEHHA continues to advise that fishers avoid fishing in areas where there is a visible sheen on the water.

If you have any questions, please contact me at (916) 322-6325.

Appendix 5

CALIFORNIA DEPARTMENT OF FISH AND GAME
DECLARATION OF FISHERIES CLOSURE
DUE TO A PUBLIC HEALTH THREAT
CAUSED BY AN OIL SPILL INTO MARINE WATERS

Amendment 1

Pursuant to Fish & Game Code section 5654, I find and declare that:

I.

On October 30, 2009, I received notice of a spill of 42 gallons or more into marine waters (tidally influenced).

II.

The Office of Environmental Heath & Hazard Assessment (OEHHA) recommended that a fishing and shellfish harvesting closure be initiated for impacted shorelines. Additionally, OEHHA advised that fishers avoid fishing in areas where there is visible sheen on the water.

This fishing and shellfish harvesting closure is recommended during an investigation to determine and establish the degree and nature of the public health threat posed.

III.

On October 30, 2009, I issued an order prohibiting the take of all fish and shellfish in the vicinity of the Alameda County shoreline between the San Francisco-Oakland Bay Bridge and the San Mateo Bridge.

This initial closure was based primarily on oil trajectories and projections of shoreline oiling. Some of the closed shoreline areas were never actually oiled. We now have shoreline oiling data on which to base a closure, warranting a change in the extent of the closure.

IV.

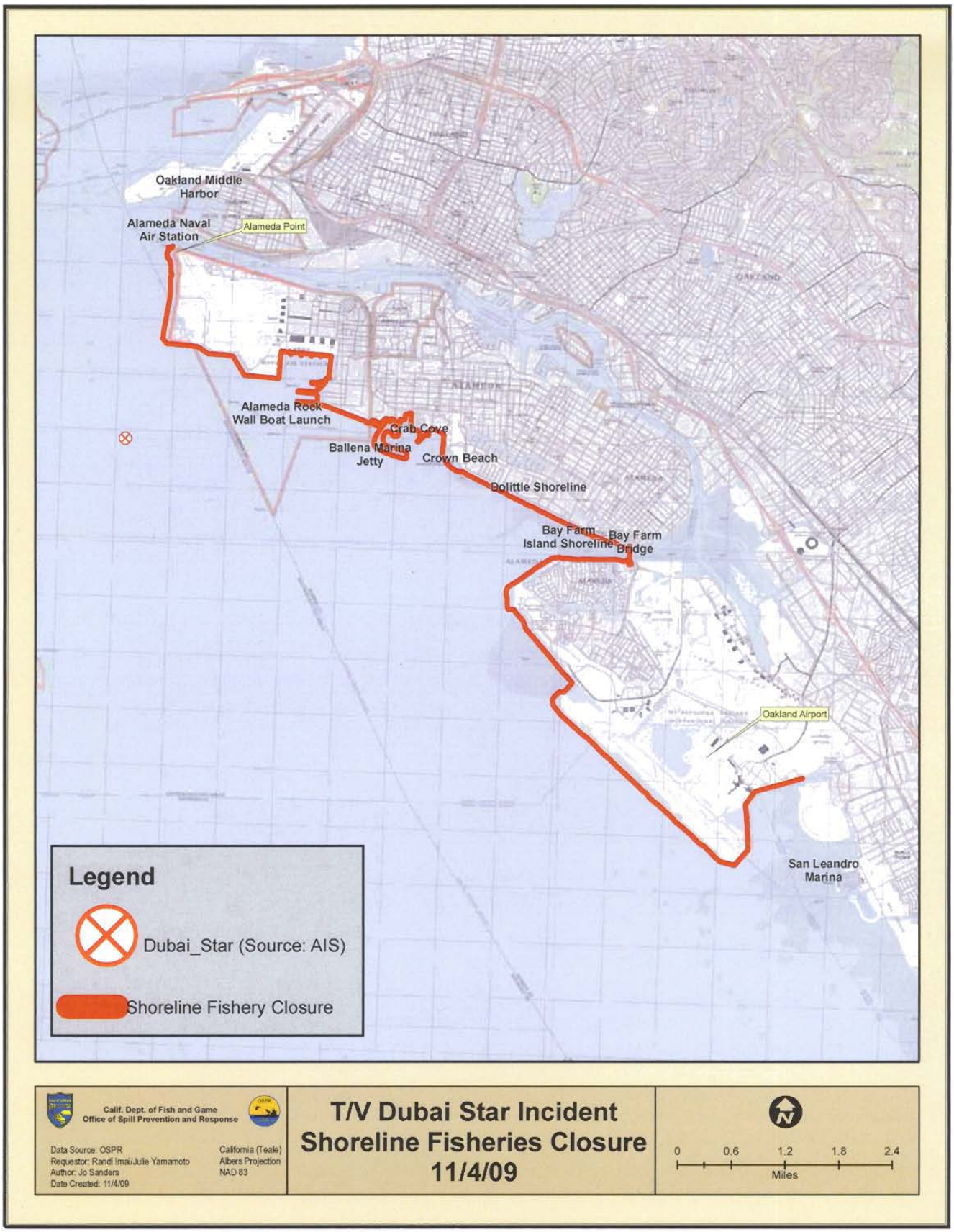
Therefore, I hereby ORDER that all shoreline fishing (inclusive of finfish and shellfish) is prohibited on the Alameda County shoreline along San Francisco Bay between Alameda Point (at the northwest corner of Alameda Naval Air station) and the southern boundary of the Oakland Airport. This prohibition does not apply to fishing from boats. The following areas are no longer closed to shoreline fishing: Oakland Middle Harbor north to the Bay Bridge; the Oakland Inner Harbor and San Leandro Bay; and shoreline south of the southern boundary of Oakland Airport to the San Mateo Bridge. Attached hereto is a revised map of the closed areas.

V.

This Order is not intended to, and does not, create any rights or benefits, substantive or procedural, enforceable at law or in equity, against the State of California, its departments, agencies, or other entities, its officers or employees, or any other person.

John McCamman, Acting Director
California Department of Fish & Game

11/4/09 1245
Date / Time


Oakland Middle Harbor
Alameda Naval Air Station
Alameda Point
Alameda Rock Wall Boat Launch
Crab Cove
Ballena Marina Jetty
Crown Beach
Dolittle Shoreline
Bay Farm Island Shoreline
Bay Farm Bridge
Oakland Airport
San Leandro Marina
Legend
Dubai_Star (Source: AIS)
Shoreline Fishery Closure
Calif. Dept. of Fish and Game
Office of Spill Prevention and Response
Data Source: OSPR
Requestor: Randi Imai/Julie Yamamoto
Author: Jo Sanders
Date Created: 11/4/09
California (Teale)
Albers Projection
NAD 83
T/V Dubai Star Incident
Shoreline Fisheries Closure
11/4/09
0 0.6 1.2 1.8 2.4
Miles

Appendix 6

In addition to calculation of cancer risks shown in the report, non-cancer hazards were determined for anthracene, fluoranthene, fluorene, naphthalene, and pyrene, those PAH compounds potentially found in bunker fuel for which non-cancer hazard estimates are available. A non-cancer hazard was also determined for vanadium, which may be elevated in bunker fuel.

The following general equation was used to set the public health protective concentration (C, in µg/kg or ppb, wet weight) for non-cancer hazards for these compounds, using the assumptions described below:

$$C = (RfD \text{ or } MRL)(BW)(CF)/(CR)$$

where *RfD* is the reference dose and MRL is the minimal risk level (mg/kg-day); *BW* is the body weight (kilograms); *CF* is the conversion factor (1000 µg/mg); and *CR* is the consumption rate.

The following specific factors and assumptions were used in the above equation:

- *Reference Dose (RfD)(for PAH compounds) or Minimal Risk Level (MRL)(for vanadium only):* RfDs for the non-cancer effects of PAH compounds likely to be found in bunker fuel were obtained from U.S. EPA's Integrated Risk Information System (IRIS) and are listed in the table below. An MRL for vanadium obtained from the Agency for Toxic Substances and Disease Registry (ATSDR) is also listed in the table below.
- *Body Weight (BW):* The default value for adult body weight for these calculations was assumed to be 70 kg.
- *Consumption Rate:* The consumption rate was assumed to be 16 g/day. This allows for a balancing of risks and benefits of fish consumption, which is considered appropriate when calculating non-cancer hazards (see Klasing and Brodberg, 2008, for further discussion).

Compound	RfD or MRL	Critical Effect
Anthracene	$3x10^{-1*}$	No observed effects (NOEL)
Fluoranthene	$4x10^{-2*}$	Nephropathy, increased liver weights, hematological alterations, clinical effects
Fluorene	$4x10^{-2*}$	Decreased red blood cells, packed cell volume and hemoglobin
Naphthalene	$2x10^{-2*}$	Decreased mean terminal body weight in males
Pyrene	$3x10^{-2*}$	Renal tubular pathology, decreased kidney weight
Vanadium	$1x10^{-2**}$	No observed adverse effects (NOAEL)

*RfDs (References Dose), in mg/kg-day, were obtained from U.S. EPA's Integrated Risk Information Service (IRIS) in March, 2010.

**An oral RfD is available for vanadium pentoxide, based on a 2.5 year, 1953 study showing decreased hair cysteine levels in rats. More recently, however, an intermediate-duration (15-364 days) oral Minimal Risk Level (MRL) was derived by the Agency for Toxic Substances and Disease Registry (ATSDR, 2009),

based on a 12-week study in humans exposed to vandanyl sulfate. This study examined the effects of vanadium on hematology and blood pressure. OEHHA determined that the MRL for vanadium is a better criterion than the RfD for assessing the risk to humans from consumption of seafood following an oil spill.

Using the above equation and assumptions, the Non-cancer Health Protective Concentrations for individual PAHs and vanadium were calculated as shown in the following table:

Compound	Non-Cancer Health Protective Concentrations (wet weight)
Anthracene	1,312,500 ppb
Fluoranthene	175,000 ppb
Fluorene	175,000 ppb
Naphthalene	87,500 ppb
Pyrene	131,250 ppb
Vanadium	43,750 ppb

Appendix 7

Office of Environmental Health Hazard Assessment

Joan E. Denton, Ph.D., Director
Headquarters • 1001 I Street • Sacramento, California 95814
Mailing Address: P.O. Box 4010 • Sacramento, California 95812-4010
Oakland Office • Mailing Address: 1515 Clay Street, 16th Floor • Oakland, California 94612

Linda S. Adams
Secretary for Environmental Protection

Arnold Schwarzenegger
Governor

MEMORANDUM

TO: John McCamman
Acting Director
Department of Fish and Game
1416 Ninth Street
Sacramento, CA 95814

FROM: Joan E. Denton, Ph.D. Joan E. Denton, Ph.D.
Director

DATE: November 25, 2009

SUBJECT: SAN FRANCISCO BAY OIL SPILL: OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT RECOMMENDATIONS – PARTIAL REOPENING

As a result of the Dubai Star oil spill, the Alameda County shoreline along the San Francisco Bay from Alameda Point (at the northwest corner of Alameda Naval Air Station) to the southern boundary of the Oakland airport has been closed to fishing and shellfish harvesting since October 30, 2009.

The Office of Environmental Health Hazard Assessment (OEHHA) finds that there is no longer a potential health hazard associated with shoreline fishing as a result of this spill.

Based on tests of mussels collected within the closure boundaries between October 31 and November 13, 2009, OEHHA finds that consumption of mussels collected from most areas within the closure zone similarly pose no ongoing significant oil-related health risks. However, there are elevated levels of polycyclic aromatic hydrocarbons (PAHs) in mussels from Crown Beach and the neighboring Ballena Bay area in Alameda that require continued monitoring. The test results suggest that mussels from the Ballena Bay area have been exposed to another contamination source unrelated to the spill.

As a result, OEHHA recommends that the closure zone be reopened for fishing and shellfish harvesting with the exception of Crown Beach, which should remain closed to mussel and other shellfish harvesting pending the results of further testing. OEHHA will

also be issuing a health advisory for mussels collected from the bayside shoreline on the west and south sides of Ballena Boulevard. OEHHA recommends that consumers do not eat mussels taken from this area.

OEHHA reminds the public to continue to follow the existing San Francisco Bay and Delta region fish consumption advisory that has been in place for many years (http://www.oehha.ca.gov/fish/general/sfbaydelta.html).

If you have any questions, please contact me at (916) 322-6325.

Appendix 8

CALIFORNIA DEPARTMENT OF FISH AND GAME
DECLARATION OF FISHERIES CLOSURE
DUE TO A PUBLIC HEALTH THREAT
CAUSED BY AN OIL SPILL INTO MARINE WATERS

Amendment 2

I.

Pursuant to Fish & Game Code section 5664, in consultation with the Office of Environmental Heath Hazard Assessment (OEHHA), on October 30, 2009, I issued an order prohibiting the take of all fish and shellfish in the vicinity of the Alameda County shoreline between the San Francisco-Oakland Bay Bridge and the San Mateo Bridge, during an investigation to determine and establish the degree and nature of the public health threat posed by a marine oil spill.

II.

Thereafter, on November 4, 2009, in consultation with OEHHA, I issued an order limiting the extent of the closure to the Alameda County shoreline of San Francisco Bay between Alameda Point (at the northwest corner of Alameda Naval Air Station) and the southern boundary of the Oakland Airport. The modified closure was based on actual oiling data rather than projections of shoreline oiling. The prohibition applied to fishing (inclusive of finfish and shellfish) from the shoreline and did not apply to fishing from boats.

III.

After further consultation with OEHHA and based on expedited testing of shellfish in the closure area, a determination has been made that no likely significant health threat is posed by the take of finfish in any closed areas. However, take of shellfish from certain areas still may pose significant health threats.

IV.

THERFORE, I hereby order that the closure originally issued on October 30, 2009 and subsequently modified on November 4, 2009 be modified further as follows:

1. All areas previously closed are hereby opened for fishing and the consumption of finfish and the taking and consumption of shellfish, with the following exception.

2. Crown Memorial State Beach shall remain closed to mussel and other shellfish harvesting.

Though not a part of this order, OEHHA advises the public to avoid harvesting and consuming mussels from the shoreline adjacent to Ballena Boulevard due to another source of contamination unrelated to the Dubai Star oil spill.

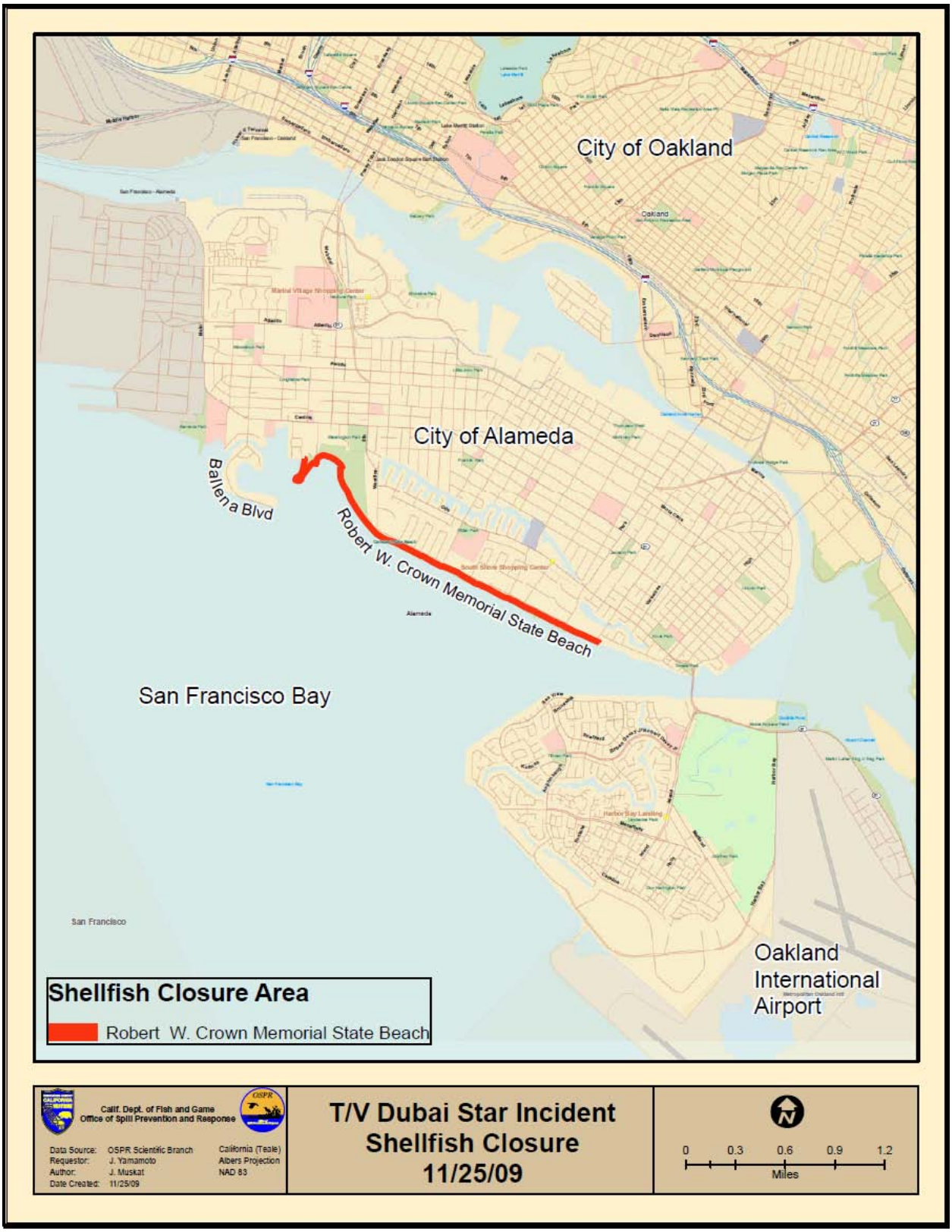
Attached hereto is a map of the current closure area.

V.

This Order is not intended to, and does not, create any rights or benefits, substantive or procedural, enforceable at law or in equity, against the State of California, its departments, agencies, or other entities, its officers or employees, or any other person.

John McCamman, Acting Director
California Department of Fish & Game

11/25/09 3:10 pm
Date / Time


City of Oakland
City of Alameda
Ballena Blvd
Robert W. Crown Memorial State Beach
San Francisco Bay
San Francisco
Oakland International Airport
Shellfish Closure Area
Robert W. Crown Memorial State Beach
Calif. Dept. of Fish and Game
Office of Spill Prevention and Response
Data Source: OSPR Scientific Branch
Requestor: J. Yamamoto
Author: J. Muskat
Date Created: 11/25/09
California (Teale) Albers Projection
NAD 83
T/V Dubai Star Incident
Shellfish Closure
11/25/09
0 0.3 0.6 0.9 1.2
Miles

Appendix 9

Office of Environmental Health Hazard Assessment

Joan E. Denton, Ph.D., Director
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Mailing Address: P.O. Box 4010 • Sacramento, California 95812-4010
Oakland Office • Mailing Address: 1515 Clay Street, 16th Floor • Oakland, California 94612

Linda S. Adams
Secretary for Environmental Protection

Arnold Schwarzenegger
Governor

MEMORANDUM

TO: John McCamman
Acting Director
Department of Fish and Game
1416 Ninth Street
Sacramento, CA 95814

FROM: Joan E. Denton, Ph.D.
Director

DATE: December 7, 2009

SUBJECT: SAN FRANCISCO OIL SPILL: OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT CROWN MEMORIAL STATE BEACH RECOMMENDATIONS

As a result of the Dubai Star oil spill, Crown Memorial State Beach in Alameda County, has been closed to shellfish harvesting since October 30, 2009.

Based on expedited testing of mussels collected at Crown Beach between October 30 and November 20, 2009, the Office of Environmental Health Hazard Assessment (OEHHA) finds that consumption of mussels collected from Crown Beach poses no ongoing significant oil-related health risks.

As a result, OEHHA recommends that Crown Beach be reopened for mussel and other shellfish harvesting. OEHHA advises the public to continue to avoid harvesting and consuming mussels from the shoreline on the west and south sides of Ballena Boulevard. There are elevated levels of polycyclic aromatic hydrocarbons (PAHs) in mussels from that area that require continued monitoring. The test results suggest that mussels from the Ballena Bay area have been exposed to an additional contamination source unrelated to the spill.

OEHHA reminds the public to continue to follow the existing San Francisco Bay and Delta region fish consumption advisory that has been in place for many years (http://www.oehha.ca.gov/fish/general/sfbaydelta.html).

If you have any questions, please contact me at (916) 322-6325.

CALIFORNIA DEPARTMENT OF FISH AND GAME
REOPENING OF FISHERIES CLOSURE
DUE TO MARINE OIL SPILL

I.

Pursuant to Fish & Game Code section 5654, in consultation with the Office of Environmental Heath Hazard Assessment (OEHHA), on October 30, 2009, I issued an order prohibiting the take of all fish and shellfish in the vicinity of the Alameda County shoreline between the San Francisco-Oakland Bay Bridge and the San Mateo Bridge, during an investigation to determine and establish the degree and nature of the public health threat posed by a marine oil spill.

II.

Thereafter, on November 4, 2009, in consultation with OEHHA, I issued an order limiting the extent of the closure to the Alameda County shoreline of San Francisco Bay between Alameda Point (at the northwest corner of Alameda Naval Air Station) and the southern boundary of the Oakland Airport. On November 25, 2009, again in consultation with OEHHA, I issued an order that re-opened all closed areas except Crown Memorial State Beach, which remained closed to shellfish harvesting.

III.

After further consultation with OEHHA and based on expedited testing of shellfish in the closure area, a determination has been made that no likely significant health threat is posed by the take of shellfish from Crown Memorial State Beach.

IV.

THEREFORE, I hereby order that the aforementioned area is now open to the taking of shellfish. Though not a part of this order, OEHHA advises the public to avoid harvesting and consuming mussels from the shoreline adjacent to Ballena Boulevard due to an additional source of contamination unrelated to the Dubai Star oil spill.

Attached hereto is a map indicating the re-opened area, Crown Memorial State Beach.

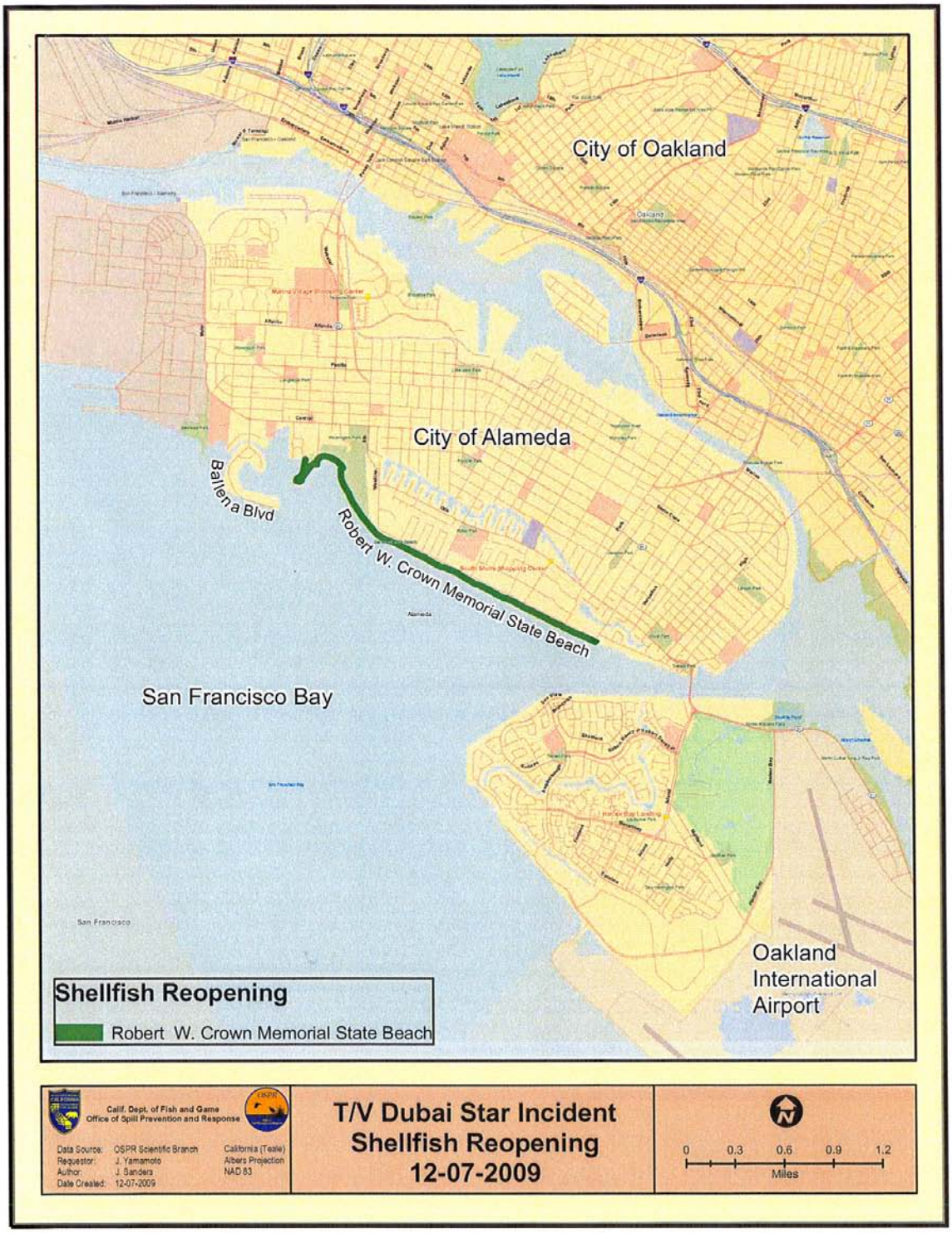
V.

This Order is not intended to, and does not, create any rights or benefits, substantive or procedural, enforceable at law or in equity, against the State of California, its departments, agencies, or other entities, its officers or employees, or any other person.

For 12.7.09 1300

John McCamman, Acting Director
California Department of Fish & Game

Date / Time


City of Oakland
City of Alameda
Ballena Blvd
Robert W. Crown Memorial State Beach
San Francisco Bay
Oakland International Airport
Shellfish Reopening
Robert W. Crown Memorial State Beach
Calif. Dept. of Fish and Game
Office of Spill Prevention and Response
Data Source: OSPR Scientific Branch
Requestor: J. Yamamoto
Author: J. Sanders
Date Created: 12-07-2009
California (Teale) Albers Projection NAD 83
T/V Dubai Star Incident
Shellfish Reopening
12-07-2009
0 0.3 0.6 0.9 1.2
Miles