OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT

OFFICE OF SPILL PREVENTION AND RESPONSE

Protocol for Seafood Sampling and Analysis to Support Fisheries Re-Opening Decisions Following Aquatic Oil Spills in California

March 2020

Fish, Ecotoxicology, and Water Section
Pesticide and Environmental Toxicology Branch
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

Office of Spill Prevention and Response
California Department of Fish and Wildlife

LIST OF CONTRIBUTORS

Office of Environmental Health Hazard Assessment (OEHHA)
Office of Spill Prevention and Response (OSPR)

Authors

Susan Klasing, Ph.D., OEHHA
Wesley Smith, Ph.D., OEHHA
April DaSilva, Ph.D., OSPR

Primary Reviewers

Beckye Stanton, Ph.D., OEHHA
Lori Chumney, M.S., OEHHA
Shannon Murphy, Ph.D., OEHHA
Annie Nelson, OSPR
Regina Donohoe, Ph.D., OSPR
Greg McGowan, OSPR

Final Reviewers

David Ting, Ph.D., Branch Chief, OEHHA
David Siegel, Ph.D., Assistant to the Deputy Director, OEHHA
Allan Hirsch, Chief Deputy Director, OEHHA
Julie Yamamoto, Ph.D., Assistant Deputy Administrator, OSPR

Director

Lauren Zeise, Ph.D., OEHHA

ACKNOWLEDGMENTS

The authors would like to thank Huyen Tran Pham (OEHHA) for creating maps in Figures 1 and 2 using ArcMap (10.3) from Environmental Systems Resource Institute (ESRI, Redlands, California).

For further information about this report, contact:

Pesticide and Environmental Toxicology Branch
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

1515 Clay Street, 16th Floor
Oakland, California 94612
Telephone: (510) 622-3170
Email address: fish@oehha.ca.gov

1001 I Street, P.O. Box 4010
Sacramento, CA 95812-4010
Telephone: (916) 324-7572

LIST OF ACRONYMS AND ABBREVIATIONS

CDFW	California Department of Fish and Wildlife
cm	Centimeters
COC	Chain-of-Custody
cPAHs	Carcinogenic polycyclic aromatic hydrocarbons
DIVER	Data Integration Visualization Exploration and Reporting
ERMA	Environmental Response Mapping Application
FDA	Food and Drug Administration
GC/MS-SIM	Gas chromatography/Mass Spectrometry-Selective Ion Monitoring
GPS	Global Positioning Unit
HAZWOPER	Hazardous Waste Operations and Emergency Response
ID	Identification
LOC	Level of concern
MDL	Method detection limit
mm	Millimeters
NAS	National Academy of Sciences
NIST	National Institutes for Standards and Technology
NRDA	Natural Resource Damage Assessment
NOAA	National Oceanic and Atmospheric Administration
OEHHA	Office of Environmental Health Hazard Assessment
OSHA	Occupational Safety and Health Administration
OSPR	Office of Spill Prevention and Response
PAHs	Polycyclic aromatic hydrocarbons
ppb	Parts per billion
RL	Reporting limit
SAP	Sampling and Analysis Plan
SCAT	Shoreline Cleanup and Assessment Technique
SLO	San Luis Obispo
SRM	Standard reference material
US EPA	United States Environmental Protection Agency

PREFACE

The Office of Environmental Health Hazard Assessment (OEHHA), a department within the California Environmental Protection Agency, is responsible for evaluating potential public health risks associated with seafood consumption following aquatic oil spills in California. This task includes making recommendations on fisheries closure and re-opening to the California Department of Fish and Wildlife. This report presents a seafood sampling protocol and analysis that OEHHA will use to support recommendations. OEHHA's authorities to conduct these activities are based on a mandate in the California Fish and Game Code, Section 5654:

5654. (a) (1) Notwithstanding Section 7715 and except as provided in paragraph (2), the director[1], 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[2] 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

[1] The Director of the California Department of Fish and Wildlife
[2] The California Department of Fish and Wildlife

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.

TABLE OF CONTENTS

List of Tables, Figures, and Appendices

INTRODUCTION

The Office of Environmental Health Hazard Assessment (OEHHA), a department within the California Environmental Protection Agency, is responsible for assessing the public health threat from the consumption of seafood after an oil spill into state waters (Fish & Game Code §5654). Following an oil spill of any size, the California Department of Fish and Wildlife (CDFW) must close fisheries in the affected area within 24 hours unless OEHHA concludes that there is not likely to be a public health threat from consumption of seafood. Closure boundaries are jointly determined by OEHHA and CDFW's Office of Spill Prevention and Response (OSPR). If a closure is in effect for more than 48 hours after notification of the spill, expedited testing is required before fisheries can be re-opened. If expedited testing is required, OEHHA and OSPR will jointly prepare and execute a sampling and analysis plan (SAP), and OEHHA will conduct a human health risk assessment before making a recommendation to CDFW regarding fisheries re-opening.

This document provides general guidance for preparing an SAP to be used in the human health risk assessment to support fisheries re-opening decisions. OEHHA previously developed a seafood risk assessment protocol, which describes how the department will evaluate seafood tissue concentrations of chemicals of concern following an oil spill into state waters (OEHHA, 2015a). Some of the information in this report is excerpted from that document or from the document describing the seafood risk assessment conducted following the Refugio Beach oil spill in Santa Barbara, California" (OEHHA, 2015b), and the references cited therein.

Risk assessments are designed to estimate health risks from the highest potential exposures to the chemicals with the greatest potential to affect human health, with the assumption that risks from other chemical exposures will be lower. The contaminants of greatest concern in seafood following an oil spill are specific polycyclic aromatic hydrocarbons (PAHs) that are considered to have the potential to cause cancer (cPAHs) (although other chemicals, such as dispersant components, may also be evaluated based on the spill scenario). For this reason, sampling efforts are targeted towards identifying species, locations, and time periods where cPAH concentrations would be found at the highest levels in seafood.

The SAP protocol addresses the following topics:

- Target species
- Sampling sites
- Number and size of species
- Sampling timing
- Sample collection
- Sample handling and documentation procedures
- Chemical analysis
- Data management

TARGET SPECIES

Seafood species are targeted for sampling based on the following factors:

- Potential to bioaccumulate PAHs
- Commercial, recreational, or subsistence importance
- Habitat
- Likelihood of exposure to the oil

Fish and shellfish accumulate PAHs to varying degrees, depending on seafood species, exposure, and chemical properties. Finfish, in particular, can often swim away from a spill, depending on the extent of the spill relative to their home range and the availability of suitable habitat. Bivalve mollusks such as mussels, on the other hand, are sessile and cannot escape the oil. Additionally, bivalves do not metabolize PAHs as rapidly as finfish and some other shellfish and tend to accumulate higher molecular weight PAHs that are more likely to be carcinogens (Meador et al., 1995; NAS, 2003; Yender et al.; 2002; OEHHA, 2015b; Webster et al., 2018). As a result of these factors, bivalve mollusks pose a greater likelihood of accumulating specific oil-spill-related chemicals of human health concern (Eisler, 2000; Meador et al., 1995; Topping et al., 1997; Hwang et al., 2014). Mussels are also typically easier to harvest than finfish and offshore invertebrates. Thus, when present in the impacted area, mussels are used as an indicator species when assessing the risk of seafood consumption following an oil spill near the shoreline.

However, if a spill is of significant size or impact, it may be important to characterize the extent of contamination in additional seafood species. OEHHA will make that determination at the time of a spill, in consultation with CDFW. Additionally, commercial fishers and aquaculture farmers may request that their species be tested to prove the safety of their product to buyers. These requests will be evaluated on a case-by-case basis.

There is limited information on bioaccumulation potential of oil-related chemicals in specific species except as noted above. Therefore, other species will be targeted largely based on their importance to commercial, recreational, and subsistence fishers, representation of a broad range of habitat associations and feeding modes, and the likelihood that they have been exposed to oil (which typically will target species with limited mobility). A robust sampling design will ensure that impacted species are not overlooked.

A tiered sampling approach can be used for the collection of offshore species, according to sampling priority. Tier 1 species are directly targeted for collection; Tier 2 species are taken as incidental bycatch. Tier 2 species can be retained and frozen for analysis, if required.

Table 1 lists common marine, anadromous, and freshwater seafood species that may be caught or harvested in California, the regions in which they are likely to be found,

and the typical habitat for each species. Commercial and recreational catch data from 2018 were used to create this list as a starting point. Fishery seasons should also be considered when developing an SAP.

SAMPLING SITES

Sites are targeted for sampling based on the following factors:

- Degree of shoreline oiling
- Location within the impacted area
- Expected presence of target species
- Accessibility and popularity for fishing

Sampling sites selected for seafood safety evaluation are focused on areas most impacted by the spill. Various sources of data, including aerial surveys, field observations, and oil spill trajectory models are used to make determinations about the path of oil on water and the degree of shoreline oiling. Trajectory maps are produced by the National Oceanic and Atmospheric Administration (NOAA) and include a forecast of where the oil may go and an estimate of the model uncertainty. A trajectory map is generally provided to the Unified Command during the first few hours of an event and updated daily, if requested (NOAA, 2010; 2015). Shoreline Cleanup and Assessment Technique (SCAT) specialists use aerial and ground-level observations to produce maps indicating the location and degree of shoreline oiling (NOAA, 2013; 2015). Although the primary purpose of SCAT is to aid shoreline cleanup, it is also useful for determining sampling sites for on- or near-shore species.

Figure 1 depicts a hypothetical oil spill scenario in the San Diego Bay area and includes typical data that might be shown on actual oil spill trajectory and SCAT maps[3]. Using this type of information, sampling sites can be selected to reflect areas of greatest on- and off-shore oiling. Urban runoff from stormwater drains can introduce non-spill-related PAHs; collection from sites in proximity to such inflows or other sources of PAHs (e.g., creosoted wood pilings) should be avoided. Reference sites that are not impacted by the spill (e.g., upstream locations in flowing waters) should also be sampled. For lakes or reservoirs, sites near a freshwater input into the waterbody can be considered as a reference site if there is not a risk of other sources of PAHs in the water. Sampling outside the known spill zone gives confidence that affected areas have not been overlooked and may also provide background PAH concentrations for sampled species.

[3] Data for the hypothetical spill scenario was developed using WebGNOME software developed by NOAA (https://gnome.orr.noaa.gov/)

TABLE 1. MARINE AND FRESHWATER SPECIES COMMONLY CAUGHT IN CALIFORNIA

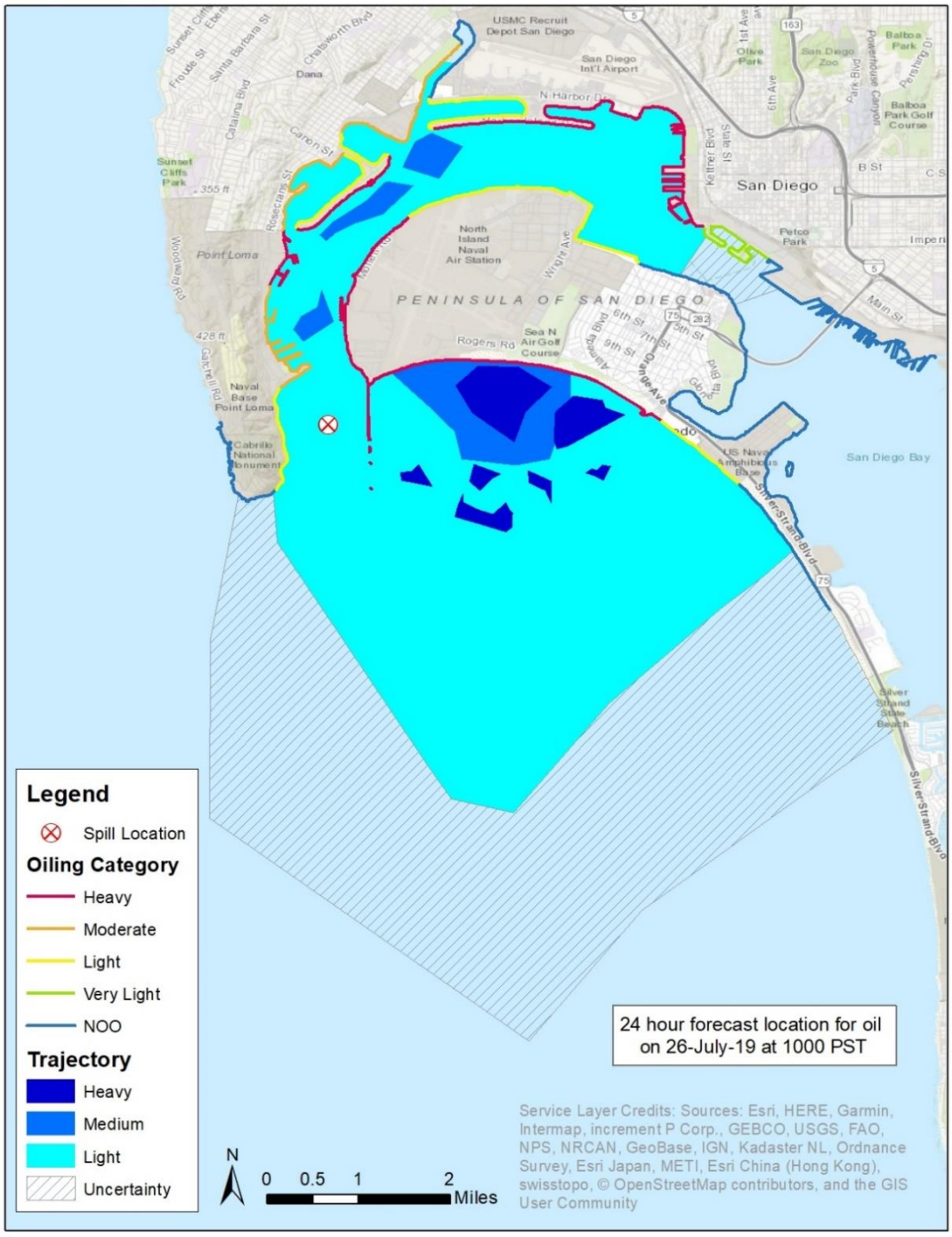
Aquatic Environment	Organism Type	Species or Group	Scientific Name	Region*	Habitat
Marine	Bivalves	Clams	Multiple species	1,2,3	Intertidal soft bottom (filter feeder)
		Mussels	*Mytilus spp.*	1,2,3	Intertidal rock bottom (filter feeder)
	Offshore invertebrates	California Spiny Lobster	*Panulirus interruptus*	2,3	Shallow rock/kelp (detritovore/predator)
		Dungeness Crab	*Metacarcinus magister*	1,2	Deep-soft bottom
		Market Squid	*Doryteuthis opalescens*	1,2,3	Deep-soft bottom
		Red Sea Cucumber	*Parastichopus californicus*	1,2,3	Deep offshore soft bottom (deposit filter)
		Red Sea Urchin	*Strongylocentrotus franciscanus*	1,2,3	Shallow-hard/kelp (grazer)
		Ridgeback Prawn	*Sicyonia ingentis*	2,3	Soft bottom > 1 mi from shore
		Rock Crab (Yellow, Brown, Red)	*Cancer anthonyi, C. antennarius, C. productus*	1,2,3 (varies by region)	Deep-hard and soft bottom (detritovore/predator)
	Finfish	Blue Rockfish	*Sebastes mystinus*	1,2,3	Shallow nearshore kelp (20-60 ft)
		California Halibut	*Paralichthys californicus*	1,2,3	Soft bottom > 1 mi from shore
		Chinook Salmon	*Oncorhyncus tshawytscha*	1,2,3	Pelagic

Aquatic Environment	Organism Type	Species or Group	Scientific Name	Region*	Habitat
Marine	Finfish	Chilipepper Rockfish	*Sebastes goodei*	1,2,3	Deep rocky bottom
		Pacific (Chub) Mackerel	*Scomber japonicus*	1,2,3	Pelagic
		Lingcod	*Ophiodon elongatus*	1,2	Deep rocky bottom
		Pacific Bonito	*Sarda chiliensis*	3	Pelagic
		Pacific Herring	*Clupea pallasi*	1,2,3	Pelagic
		Vermillion Rockfish	*Sebastes miniatus*	1,2,3	Deep, offshore kelp rock bottom (>100 ft)
		Widow Rockfish	*Sebastes entomelas*	1,2,3	Deep rocky bottom
Anadromous	Finfish	American Shad	*Alosa sapidissima*	2,4	Ocean, estuaries, and main channels of large rivers
		Chinook Salmon	*Oncorhyncus tshawytscha*	1,2,4	Ocean, estuaries, and main channels of large rivers
		Steelhead Trout	*Oncorhyncus mykiss*	1,2,3,4	Ocean, estuaries, and main channels of large rivers
		Striped Bass	*Morone saxitilis*	1,2,4	Primarily estuaries, large bodies of water and rivers
		White Sturgeon	*Acipensar transmontanus*	1,2,3,4	Ocean, estuaries, and main channels of large rivers
Freshwater	Bivalves	Freshwater bivalves	Multiple species (varies by location)	4	Ponds, lakes and rivers

Aquatic Environment	Organism Type	Species or Group	Scientific Name	Region*	Habitat
Freshwater	Other Invertebrates	Crayfish (Northern, Red Swamp)	*Orconectes virilis, Procambarus clarkii*,	4	Deep holes in rivers
	Finfish	Black Bass (Largemouth, Smallmouth, Spotted)	*Micropterus salmoides, M. dolomieu, M. punctulatus*	4	Warm lakes and ponds
		Brown Trout	*Salmo trutta*	4	Cold rivers and lakes
		Bullhead (Black and Brown Bullhead and White Catfish)	*Ameiurus melas, A. nebulosus, A. catus.*	4	Warm lakes and slow rivers
		Channel Catfish	*Ictalurus punctatus*	4	Main channels in large, warm rivers
		Common Carp	*Cyprinus carpio*	4	Large rivers and lakes
		Rainbow Trout	*Oncorhynchus mykiss*	4	Cold rivers and lakes
		Sunfish (Bluegill, Green, Redear)	*Lepomis macrochirus, L. cyanellus, L. microlophus*	4	Shallow waters of lakes, ponds, rivers and creeks

*Numbers indicate regions where fish are likey to be found: 1-Oregon/California border to the Golden Gate Bridge, 2-Golden Gate Bridge to Point Conception, 3-Point Conception to California/Mexico border, and 4-all inland waters.

FIGURE 1. MODELED TRAJECTORY AND SCAT[4] DATA FOR A HYPOTHETICAL OIL SPILL NEAR SAN DIEGO BAY[5]



[4] Shoreline Cleanup and Assessment Technique

[5] Data for the hypothetical spill scenario was developed using WebGNOME software developed by NOAA (https://gnome.orr.noaa.gov/)

Because oil movement in and on the water is dependent on a variety of factors (e.g., product, currents, wind), trajectory and SCAT maps are often updated on a daily basis. Sampling plans may thus be refined as a more complete picture of on- and offshore oiling is obtained.

Once areas of significant oiling are identified, sampling site selection is then dependent on the location of the target species and fishing site access and popularity. As noted, Table 1 lists geographic regions and habitats for common California marine and freshwater seafood species. Additionally, CDFW and county experts, NOAA's Environmental Response Management Application (ERMA: https://erma.noaa.gov/southwest/erma.html), and various commercial and recreational fishing resource materials can be used to determine species locations, as well as fishing access and popularity. To avoid duplication of effort, invertebrate and fish tissue sampling may be coordinated with CDFW Natural Resource Damage Assessment (NRDA; https://www.wildlife.ca.gov/OSPR/NRDA) staff.

For onshore marine and inland sampling, locations are identified using operational divisions and segments as outlined in the various contingency and geographic response plans for the state (https://www.wildlife.ca.gov/OSPR/Contingency) and shown in ERMA. For offshore marine sampling, locations are identified using commercial fishing areas designated geographically as "CDFW Commercial Fishing Blocks." Fishing blocks are numbered and consist of approximately 10 x 10 nautical-mile areas that commercial fishermen use to report the location of their catch. Following an oil spill, fishing blocks can be further subdivided into smaller, centrally-located "sampling blocks" to target sampling efforts. This will allow decisions to lift a fisheries closure to be made on a fishing block-by-block basis, if appropriate. OEHHA recognizes that it may not be possible to collect all samples within the strict boundaries of a sampling block.

An example of operational divisions and segments and sampling blocks within commercial fishing blocks is shown for a hypothetical spill scenario on the northern California coast in Figure 2. The number and location of sampling blocks would be dependent on the spill scenario.

NUMBER AND SIZE OF SPECIES

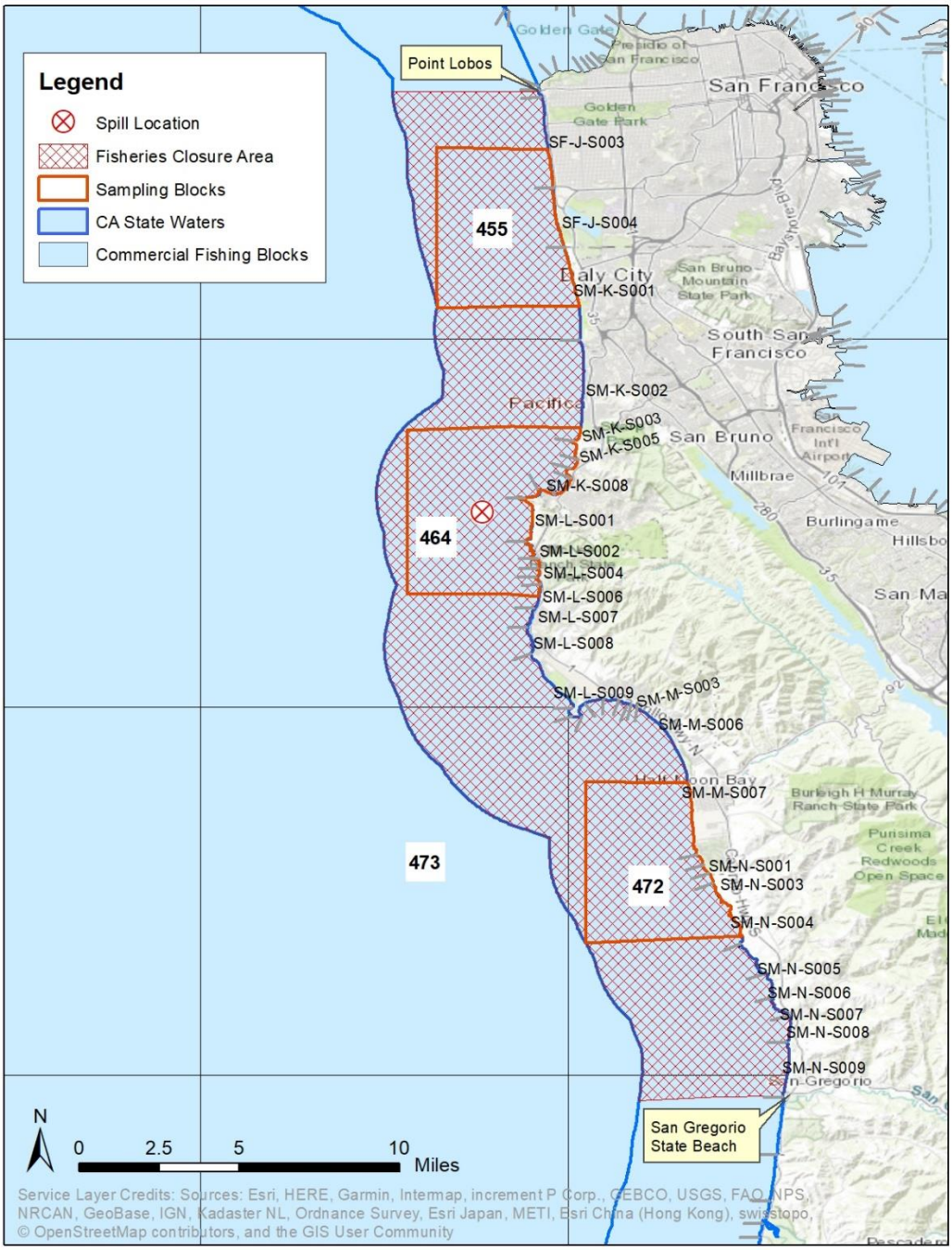
MUSSELS

Typically, a group of 10 or more average sized (≥50 millimeters [mm]) mussels, sufficient to provide approximately 10-20 grams of tissue, are composited for each collection site. If only smaller mussels are available, a larger number should be collected.

OTHER SPECIES

For finfish and offshore invertebrates, OEHHA considers one composite of at least nine individual market-sized animals, per species, to be representative of a sampling block,

FIGURE 2. SAMPLING BLOCKS AND OPERATIONAL DIVISIONS AND SEGMENTS FOR A HYPOTHETICAL NORTHERN CALIFORNIA OIL SPILL



small- or mid-sized lake or reservoir, or river segment. Many species have legal size limits as stipulated by CDFW. For species without legal size limits, OEHHA has determined minimum "edible" sizes (the typical size at maturity) for many marine and freshwater species. Legal and edible size limits for common marine, anadromous, and freshwater species are shown in Table 2. These limits should be adhered to in any sampling plan to best represent the size of fish that would be eaten by consumers.

SAMPLING TIMING

MUSSELS OR OTHER ONSHORE BIVALVES

Limited research (Fassato and Canzonier, 1976; Pruell et al., 1986), as well as California spill experience (OEHHA, 2010; 2014; 2015b), has provided insight into the bioaccumulation and depuration rates of PAH compounds in mussels. In most cases, PAH levels are expected to rise quickly before returning to ambient levels over a two-to-three week period, relative to the presence of ongoing oiling and timing of the cleanup. If possible, mussels or other onshore bivalves should be collected as reference samples before oiling occurs in areas where oil is expected to strand. This will allow for determination of ambient PAH levels in the area. Subsequent to oiling, mussels can be collected as soon as feasible and then at approximately 10-14 day intervals, depending on tide and other factors, until PAH levels have fallen below levels of concern (LOC; see OEHHA, 2015a). Note that the typical turn-around-time for expedited PAH analysis is generally about ten days. It may be prudent to wait until the prior sampling results are available before conducting subsequent mussel sampling events. A minimum of two post-oiling collection periods are required to determine that PAH levels are decreasing.

OTHER SPECIES

The collection of finfish and offshore invertebrates should be timed to minimize the duration of the fisheries closure and to limit the number of sampling events, to the extent possible. Finfish and offshore invertebrates are much less likely to have PAH levels that exceed the LOC and, thus, it is expected that only one sampling event per species per sampling block or segment will be necessary, if timed appropriately. For marine spills, the results of the first mussel sampling can be used to establish the timing for collecting finfish and offshore invertebrates. Following the Refugio Beach oil spill near Santa Barbara, California, for example, offshore species were collected over a 10-day period in each of the three fishing blocks about three to four weeks after the spill. This overlapped with the third mussel collection period, at which point all mussel samples fell below the LOC. No offshore species exceeded the LOC (OEHHA, 2015b). Similar procedures can be used to establish inland collection schedules.

An example of sampling timing used for fisheries closure purposes following the Refugio Beach oil spill can be found in Figure 3.

TABLE 2. SIZE LIMITS AND CATCH METHODS FOR MARINE AND FRESHWATER SPECIES COMMONLY CAUGHT IN CALIFORNIA

Aquatic Environment	Organism Type	Species or Group	Legal or Edible Size Limit (mm)[1, 2]	Catch Methods
Marine	Bivalves	Littleneck Clams, Chiones, Northern Quahog, Cockles	38	Hand harvest
		Mussels	50	Hand harvest
		Pismo Clams	127: North of Monterey and San Luis Obispo (SLO) County Line 114: South of Monterey and SLO County Line	Hand harvest
	Other Invertebrates	California Spiny Lobster	83	Hoop nets, traps, and divers
		Dungeness Crabs	146	Hoop nets, traps, and divers
		Rock Crab (Brown, Red, and Yellow)	102	Hoop nets, traps, and divers
		Sea Urchin	83: North of Monterey and SLO County Line 89: South of Monterey and SLO County Line	Divers
		Warty Sea Cucumber	~150	Divers and Trawl
	Finfish	Blue Rockfish	200[2]	Hook and line

Aquatic Environment	Organism Type	Species or Group	Legal or Edible Size Limit (mm)[1, 2]	Catch Methods
Marine	Finfish	California Halibut	560	Bottom trawl, Hook and line
		Chinook Salmon	Refer to CDFW regulations	Hook and line (trolling)
		Chilipepper Rockfish	230[2]	Hook and line
		Pacific (Chub) Mackerel	360[2]	Hook and line (trolling)
		Lingcod	560	Hook and line
		Pacific Bonito	610 (FL)[3]	Hook and line (trolling)
		Pacific Herring	170[2]	Purse Seine, Gill net
		Vermillion Rockfish	355[2]	Hook and line
		Widow Rockfish	360[2]	Hook and line
Anadromous	Finfish	American Shad	275[2]	Hook and line
		Chinook Salmon	Refer to CDFW regulations	Hook and line
		Steelhead Trout	406	Hook and line
		Striped Bass	457	Hook and line
		White Sturgeon	>1016 to <1524	Hook and line
Freshwater	Bivalves	Freshwater Clams	38[2]	Hand
	Other Invertebrates	Crayfish	No limit	Trap
	Finfish	Black Bass	305	Hook and Line, Electrofishing
		Brown Trout	200[2]	Hook and Line, Electrofishing
		Black Bullhead	170[2]	Hook and Line, Electrofishing

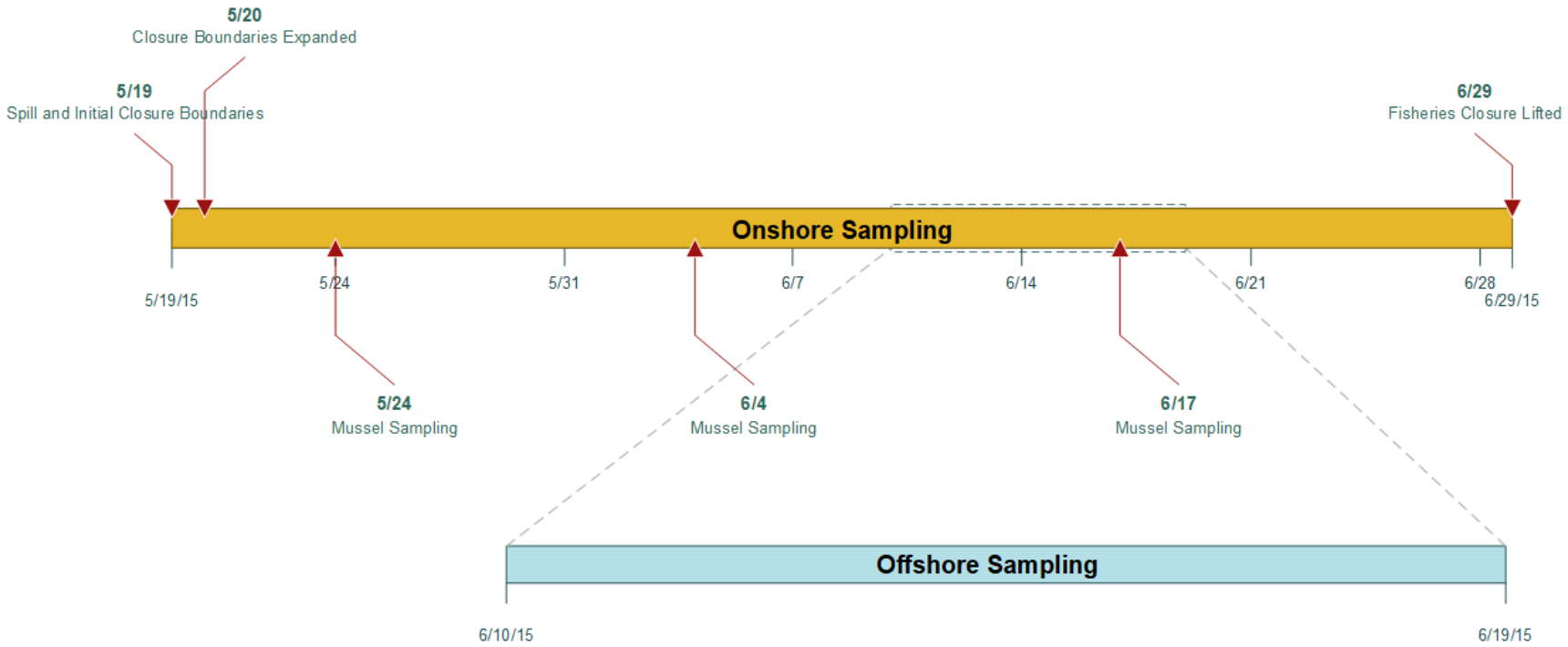
Aquatic Environment	Organism Type	Species or Group	Legal or Edible Size Limit (mm)[1, 2]	Catch Methods
Freshwater	Finfish	Brown Bullhead, Channel Catfish, and White Catfish	200[2]	Hook and Line, Electrofishing
		Common Carp	200[2]	Hook and Line, Electrofishing
		Rainbow Trout	200[2]	Hook and Line, Electrofishing
		Sunfish (Bluegill, Green, Redear)	100[2]	Hook and Line, Electrofishing

[1] When legal minimum and/or maximum sizes are not available, OEHHA's develops minimum "edible" size based on species size at maturity, and professional judgment (as described in OEHHA, 2005). Edible size limits are measured in the same manner as required by CDFW regulations: greatest shell diameter for mollusks, carapace length for crustaceans, and total length for finfish.

[2] OEHHA edible minimum.

[3] "Twenty-four inches fork length (FL) or five pounds except that: Five fish less than twenty-four inches fork length or weighing less than five pounds may be taken and possessed" (CDFW 2019-2020 Ocean Sport Fishing Regulations).

FIGURE 3. SAMPLING TIMING FOR FISHERIES CLOSURE PURPOSES FOLLOWING THE REFUGIO BEACH OIL SPILL



SAMPLE COLLECTION

Collection methods are dependent on the species and location. Table 2 provides suggestions for collection methods and legal or edible size minimums of common species in California.

SAMPLING TEAMS

Sampling teams should consist of staff experienced with sample collection, who meet the appropriate health and safety requirements (e.g., Occupational Safety and Health Administration [OSHA] Hazardous Waste Operations and Emergency Response [HAZWOPER] certification), and are familiar with species identification. Field teams must have a scientific collection permit or CDFW representative present during sampling. Onshore sampling teams may be a minimum of two people. Offshore sampling necessarily requires more equipment and staff than onshore sampling. In some cases, sampling may be contracted to local fishers or dive teams who have the necessary certification, gear and expertise.

ONSHORE AND NEARSHORE COLLECTION

Following oil spills in marine environments, mussels are the most commonly collected onshore marine invertebrate species. Freshwater bivalves or invertebrates, such as crayfish, may prove to be a suitable surrogate following inland oil spills. Bivalves should be removed from the substrate (e.g., rocks or rip rap) by hand or with a tool (e.g., a putty knife) that is cleaned between sites. Care should be taken to obtain the most highly exposed individuals (e.g., those on surfaces facing the incoming oil, including those that are visibly oiled). Do not collect mussels with gaping shells. Crayfish are generally collected by trap.

In certain circumstances, nearshore collection of finfish may be indicated. In these cases, hook and line, trap, or nets may be used, depending on species and location.

OFFSHORE COLLECTION

As presented in Table 2, offshore sampling of finfish or invertebrates may require specialized personnel and equipment, such as divers, crab traps, and fishing vessels with trawl capabilities. Specific collection methods should be chosen based on species and sampling logistics.

SAMPLE HANDLING AND DOCUMENTATION PROCEDURES

GENERAL FIELD PROCESSING METHODS

For all sampling activities, the health and safety of the sampling staff is always the highest priority. Samplers should wear nitrile gloves and change gloves between

sample locations. Additional personal protective equipment such as Tyvek® suits, outer gloves and booties, high visibility vests, and hardhats should be worn as dictated by the applicable health and safety plan. Whole organisms should be collected and identified by a qualified expert. Avoid exposing samples to boat exhaust. All individuals of each species from each collection site should be combined, when possible, double wrapped in foil (dull side to the sample), and then placed in a heavy duty re-sealable bag. Large fish may be individually foil-wrapped before being bagged together in a large plastic bag with other samples of the same species at each site. In either case, the sealed plastic bag should be placed in a second re-sealable plastic bag and placed on ice in an ice chest. Samples should be held on ice until transported to the laboratory.

PHOTO DOCUMENTATION

At each collection site, a photograph should be taken of the Global Positioning System (GPS) unit, showing the site latitude and longitude, followed by upcoast or upstream, downcoast or downstream, seaward and landward photographs of the sampling site. A photograph should be taken of each sample (e.g., a group of mussels) on foil next to a scale for size reference. If samples are too large to be combined in a single foil wrap, a single photo of a representative sample of each species at each site will suffice.

SAMPLE LABELING

The sample identification (ID), date and time of collection, site name, sampler, and latitude/longitude of the sampling location should be written in indelible ink on an adhesive label, and placed on the inner sealed plastic bag. Samples are identified using the following conventions for onshore and offshore locations:

Onshore: *FisheriesClosure Team# (two letters) Date (MMDDYY) SampleType (two letters) Sample# (two numbers)*

Offshore: *FishingBlock (three numbers) Date (MMDDYY) SampleType (two letters) Sample# (two numbers)*

Codes for fishing blocks (three numbers) are available from ERMA and various contingency and geographic response plans for the state (https://www.wildlife.ca.gov/OSPR/Contingency).

FIELD DOCUMENTATION

Work assignments are documented in the Fisheries Closure Daily Team Field Form. Information to be listed on the form includes team members, affiliations, cell phone numbers, HAZWOPER certifications, assigned tasks (e.g., recorder, camera/GPS, or sample collecting), and meeting time and location. Additionally, the general location (including the county, division, and segment or fishing block), sampling site details, types and numbers of samples, and objectives/instructions/equipment (GPS and

camera make, model, and ID number) are recorded, as well as overall notes and observations (e.g., weather, sampling deviations). An example of the Fisheries Closure Daily Team Field Form is found in Appendix 1.

A separate Fisheries Closure Sample and Photo Log Form is also filled out, which includes the site number, site name/description, waypoint number, latitude/longitude (decimal degrees; WGS84), county/division/segment, and activity (e.g., mussel collection). Finfish and offshore invertebrates are measured and recorded in total length or carapace width or length (crab or lobster, respectively). Each photo and sample is logged with the site number, camera image number or sample ID, and description (including waypoint and time). An example of the Fisheries Sample and Photo Log Form is found in Appendix 2.

Sample Storage

Store samples in an ice chest with enough ice to chill and preserve the samples at approximately 4°C. Samples must arrive at the laboratory under 6°C. The sample hold time for fresh samples is 14 days from time of collection until time of extraction, including transport. Samples can be held frozen for up to a year for subsequent analysis, if necessary.

Chain-of-Custody

Properly fill out each chain-of-custody (COC) form (Appendix 3) with the sample ID, date, time, sample type, container type, and requested chemical analysis. The sampler, as identified on the COC, must hold the samples in their possession (i.e., in possession of, within sight of, or in a secure storage with restricted access) until the samples are relinquished to another person or shipped. If relinquished, both individuals must sign the COC; the original COC is maintained with the samples. If the samples are to be shipped, the original COC form(s) must accompany the samples. The original COC form(s) should be placed in a resealable bag, and then taped to the inside lid of the ice chest.

Shipping

Samples should be shipped with ice in a secure ice chest. Ice should be placed in the ice chest and then the lid taped shut with duct tape. The samples should be shipped to the laboratory as directed by the Fisheries Closure Coordinator. Shippers must comply with all applicable hazardous shipping regulations. When the laboratory receives the samples, the person accepting the samples should sign his or her name in the “Received by” box on the bottom of the COC form.

CHEMICAL ANALYSIS

Samples should be processed, analyzed, and stored by a certified and approved laboratory. The edible tissues are removed from each organism for analysis. Edible

tissues are considered the soft tissues (viscera and meat) of bivalves, body and leg meat of crustaceans (viscera should be discarded), and the fillets of finfish (skin removed). All individuals of each species are composited for each site with a single sample ID number unless other instructions are provided.

Generally, tissues are extracted by pressurized fluid extraction, followed by gel permeation chromatography and silica clean-up, and then analyzed for PAHs/alkylated homologs by gas chromatography/mass spectrometry-selective ion monitoring (GC/MS-SIM;SW846 EPA Method 8270 Mod). Results for 54 individual compounds or groups of compounds (e.g., alkylated homologue groups) are reported. Of those, OEHHA considers eight PAHs to be cPAHs: benz[a]anthracene, benzo[a]pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz[a,h]anthracene, indeno[1,2,3,-cd]pyrene, and naphthalene, including their respective alkylated homologues, when present. The method detection limit (MDL) for each individual PAH should be approximately 1 part per billion (ppb), or less. Results should be reported as surrogate-corrected wet weight values and moisture content provided.

The analyzing laboratory should provide results and associated Quality Assurance (QA) documentation for all samples, including controls, demonstrating that sample processing was reproducible, accurate, and free of cross-contamination. A certified standard reference material (SRM) from the National Institute of Standards and Technology (NIST) for organics in mussels (SRM 1974c) should be included in sample processing of mussel samples to provide an additional measure of analytical comparability. CDFW Water Pollution Control Laboratory (WPCL) staff should review the results and QA documentation in order to demonstrate that sample processing was reproducible, accurate, and free from cross-contamination.

In addition to PAHs, analysis for dispersants (or components) may be requested. Additives, such as glutaraldehyde, are sometimes added to oil for controlling growth of microbes and other purposes. If other chemicals are identified as posing a potential health threat, additional analyses may be requested.

DATA MANAGEMENT

Sampling documentation (e.g., GPS coordinates, photos, field forms, COC copies) should be provided to OEHHA and OSPR staff. This documentation should also be made available for uploading to relevant common operating platforms such as the National Oceanic and Atmospheric Administration's (NOAA) Data Integration Visualization Exploration and Reporting (DIVER) and the Environmental Response Management Application (ERMA), as appropriate. Chemical analysis results should be provided to OEHHA and OSPR staff.

REFERENCES

Eisler R (2000). Polycyclic Aromatic Hydrocarbons. In: Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals, Vol. 2. Organics. Boca Raton, FL: Lewis Publishers, 1343-1411.

Fossato VU and Canzonier WJ (1976). Hydrocarbon uptake and loss by the mussel *Mytilus edulis*. *Mar Biol*. **36**:234-250.

Hwang HM, Stanton B, McBride T and Anderson MJ (2014). Polycyclic aromatic hydrocarbon body residues and lysosomal membrane destabilization in mussels exposed to the *Dubai Star* Bunker Fuel Oil (Intermediate Fuel Oil 380) Spill in San Francisco Bay. *Environ Tox Chem*. **33**(5);1117-1121.

Meador JP, Stein JE, Reichert WL and Varanasi U (1995). Bioaccumulation of polycyclic aromatic hydrocarbons by marine organisms. *Rev Environ Contam Tox.* **143**:79-163.

NAS (2003). Oil in the Sea III: Inputs, Fates, and Effects. Committee on Oil in the Sea: Inputs, Fates, and Effects. National Research Council, National Academy of Sciences. http://www.nap.edu/catalog/10388.html

NOAA (2010). Field Guide to NOAA's Oil Trajectory Maps. https://response.restoration.noaa.gov/sites/default/files/TrajectoryFieldGuide.pdf

NOAA (2013). NOAA Shoreline Assessment Manual. 4th Edition. https://response.restoration.noaa.gov/sites/default/files/manual_shore_assess_aug2013.pdf

NOAA (2015). An FOSC's Guide to NOAA Scientific Support. https://response.restoration.noaa.gov/sites/default/files/FOSC_Booklet_2015.pdf

OEHHA (2010). 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. https://oehha.ca.gov/media/downloads/fish/report/dubaistar2010.pdf

OEHHA (2014). Risk Assessment of Seafood Following the FV *Royal Pacific* Diesel Spill in Ventura Harbor, California. https://oehha.ca.gov/media/downloads/fish/report/royalpacificdieselseafoodriskassessment.pdf

OEHHA (2015a). Protocol for Seafood Risk Assessment to Support Fisheries Re-opening Decisions for Aquatic Oil Spills in California. November 2013 (Updated March 2015a). https://oehha.ca.gov/media/downloads/fish/document/2015updateseafoodoilspills.pdf

OEHHA (2015b). Risk Assessment of Seafood Consumption Following the Refugio Beach Oil Spill Incident in Santa Barbara, California. https://oehha.ca.gov/media/downloads/fish/report-oil-spill-information/refugiobeachseafoodrisk12202015.pdf

Pruell RJ, Lake JL, Davis WR and Quinn JG (1986). Uptake and depuration of organic contaminants by blue mussels (*Mytilus edulis*) exposed to environmentally contaminated sediment. *Mar Biol.* **91**:497-507.

Topping G, Davies JM, Mackie PR and Moffat CF (1997). The Impact of the Braer spill on commercial fish and shellfish. In: J.M. Davies and G. Topping (eds.). The Impact of an Oil Spill in Turbulent Waters: The Braer. Proceedings of a symposium held at the Royal Society of Edinburgh: The Stationery Office. pp. 121-143.

Webster L, Russell M, Shepherd N, Packer G, Dalgarno EJ and Neat F (2018). Monitoring of polycyclic aromatic hydrocarbons (PAHs) in Scottish deepwater environments. *Mar Pollut Bull*. **128**:456–459

Yender R, Michel J and Lord C (2002). Managing Seafood Safety After an Oil Spill. Seattle: Hazardous Materials Response Division, Office of Response and Restoration, National Oceanic and Atmospheric Administration. https://response.restoration.noaa.gov/sites/default/files/managing-seafood-safety-oil-spill.pdf

APPENDIX 1. FISHERIES CLOSURE DAILY FIELD TEAM FORM

DAILY FIELD TEAM FORM

Incident/Case:_____ Field Team Name and #:_____

Date (MMDDYY):_____

Table 1. Field Team Members and Assignments

Printed Name/Affiliation [1]	Fed/State/RP [1]	Phone # [1] *(indicate if a personal number)*	HAZWOPER [1]	Assigned Task(s) [2]	Signature [3]

[1] use for field team assignments; [2] use for assigned task (e.g., team lead, camera, GPS, sampler, recorder, or other); [3] member authentication

Field Lead Contact: Name:_____ Phone #:_____ Alternate #:_____

Field Team Meeting Time & Location:_____

Data Intake Meeting Time & Location:_____

Team Member Initials:_____ Date:_____

DAILY FIELD TEAM FORM

Incident/Case:_____ Field Team Name and #:_____

Date (MMDDYY):_____

Table 2. Sites/Locations and Field Team Objectives (include initial set up and proposed sampling locations)

General Location/ Site Name [1]	Sampling Site Details [1]	Type(s) and # of samples [1]	Objectives/Instructions/Equipment [1]

[1] use for field team assignments

DATA INTAKE: (*Data Intake Staff Complete*)

Name:_____ Initials:_____ Date:_____

Photo/Sample Log:_____ (total # of Pages ____) Sample COC:_____ GPS waypoints & track:_____ Camera photos:_____

Site Safety Plan (incl. review page):_____ Other (describe):_____

DATA MANAGEMENT: (*Data Management Staff Complete*)

Name:_____ Initials:_____ Date:_____

Photos Processed (Y/N):_____ Loaded to DIVER/Database:_____ Photos / Samples:_____

Post to DFW Document library:_____ Trustee Only / Trustee-RP:_____ Other (describe):_____

Team Member Initials:_____ Date:_____

APPENDIX 2. FISHERIES CLOSURE PHOTO LOG

PHOTO LOG

Incident/Case:_____ Field Team Name and #:_____

Date (MMDDYY):_____

This form must be filled out for photos taken in the field.

Field Team Lead/ Photographer Name: Phone # (*Indicate if a personal number)*:	Camera Make/Model/ID: Time zone:
Agency/Affiliation:	GPS Make/Model/ID: Time zone:

Photos must include: GPS unit (displaying time and date), up coast, down coast, landward, seaward, tissue sample (with photo scale ruler), sample label(s) and misc. sampling photos

WP # [1]	**Photo #** *from camera*	**Description/Notes/Comments** ***Include Location/Site name and Keywords***	***Sample ID [2]*** ***(if collected)***

[1] *GPS Waypoint;* [2] *Sample ID: Field Team Name (2 letters); Field Team # (1 number); Date (MMDDYY); Sample Type (2 letters); Sample # (sequential numbering begin with 01)*

Team Member Initials:_____ Date:_____

PHOTO LOG

Incident/Case:_____ Field Team Name and #:_____

Date (MMDDYY):_____

Suggested Keywords – These are suggested keywords to describe your photos. Keywords are used when importing the photos, where they will be queried by field staff, management, or outreach staff. Please select keywords that are general enough to represent the photos. Specific details should be entered into the Description/Notes/Comments section above.

Response Related	Response Related	Habitats	Habitats	Organisms	Conditions
Barge	Outreach	Agricultural land	Marine Water	Amphibian	Cold/ Cool
Barrel	Overflight	Barren land	Marine Protected Area	Birds	Drought
Boat	Pipeline	Beach-Sandy	Marsh	Coral	Dry
Boom	Pits/Trenches	Beach-Gravel	Riverine	Crab	Fire
Cleanup Operations	Produced water	Cave	Riparian	Dead Wildlife	Flood
Dispersant	Railroad	Chaparral	Rip-Rap	Fish	High elevation
Dredging	Quadrat	Desert land	Rocky Shoreline	Insect	High tide
Drilling Platforms	Response Vessel	Desert shrub	Sediment/Soil	Invertebrate -Aquatic	Hot
Ephemeral data	Sample Container	Dry creek	Stream	Invertebrate -Terrestrial	Ice
GPS Unit	Sampling	Dune	Streambed	Mammal-Marine	Leak
Grounding	SCAT	Ephemeral Wetland	Subtidal	Mammal-Terrestrial	Low tide
Human Uses	Skimmer	Estuary	Tree dominated	Native/ Non-native	Rain/wet
In-Situ Burn	Source Oil	Forest	Vernal pool	Reptile	Snow
Marine Debris	Sunken Vessel	Grassland	Wetland	Shellfish	Storm
Oil	Tank	Herbaceous		Threatened/ Endangered	Wind
Oil-Emulsified	Tanker Ship	High Sierra		Tree	
Oil-Sheen	Transect	Intertidal		Vegetation-Aquatic	
Oil-Surface Residue	Waste Site	Kelp Bed		Vegetation-Riparian	
Oil-Stain/Coat		Lake			

Photos & GPS Data Relinquished By	Photos & GPS Data Received By
Name Signature:	Name Signature:
Name Printed:	Name Printed:
Agency/Affiliation Name Printed:	Agency/Affiliation Name Printed:
Date/Time:	Date/Time:

I, _____ ***[Data Intake Manager print name]***, without modification, downloaded the photographs referenced on this form in accordance with the NOAA OR&R Data Intake Protocols and uploaded without modification to DIVER in the File Collection ID number _____ with the following Photo Zip file named _____ and GPS File named _____.

_____ _____

Signature *Date/Time*

Team Member Initials:_____ Date:_____

APPENDIX 3. CHAIN OF CUSTODY FORM

CDFW REQUEST FOR ANALYSIS AND CHAIN OF CUSTODY RECORD

Page_____ of _____

Sampler	Ph #	Send Results To	Lab Number
Address		Address	Field Number
City	Zip	City Zip CA	Lab Storage
	CA	Copies To	Spill Title
Date Required/Reason		Address	Suspect
Shipped Via		City Zip	Index-PCA

☐ Fish & Wildlife Loss Date:_____ Region:_____

☐ DFG Code Violation:_____

☐ Suspected or Potential Problem

☒ Routine Analysis

Analysis Requested >>>

Water Temp: F or C pH: DO: mg/L Conductivity: *u* mhos/cm

Sample Identification/Location (Draw map on separate sheet if necessary)	Collection Date	Collection Time	Sample Type: Water	Filtered Water	Soil	Tissue	Number of Containers: Plastic	Glass	VOA Vial		Preservation: Temp	Acid	

Problem Description

Suspect/Incident Location

Comments/Special Instructions

Pollution Action Kit: Yes☐ No☐

Glove Size: Large ☐ Medium ☐

Hazmat Shipper Requested: Yes☐ No☐

Samples Reliquished By (Signature)	Print Name	Date	Received By (Signature)	Print Name	Date

Pesticide Investigations Lab
1701 Nimbus Road
Rancho Cordova, CA 95670
(916) 358-2950

☐

Petroleum Chemistry Lab
1995 Nimbus Road
Rancho Cordova, CA 95670
(916) 358-2803

☐

Water Pollution Control Lab
2005 Nimbus Road
Rancho Cordova, CA 95670
(916) 358-2858

☒

FG 1000 (Rev. 9/01)