VESSEL SPILL RESPONSE TECHNOLOGIES



GULF OF THE FARALLONES AND CORDELL BANK NATIONAL MARINE SANCTUARIES

Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils

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Executive Summary

In June 2011 the Superintendents of the Gulf of the Farallones (GF) and Cordell Banks (CB) National Marine Sanctuaries (NMS) established a Vessel Spills Working Group (VSWG) to provide an analysis and advisory report on the use of oil dispersants within the GF and CB NMS. The formation of the VSWG was the result of a recommendation in the GFNMS 2008 Management Plan. The objective of the VSWG is to provide a set of recommendations to the Sanctuary Advisory Councils (SAC) to consider and transmit to the Superintendents for their consideration. This process was completed in May 2012 and report presented to the SACs on June 7, 2012.

The VSWG had invited technical members who discussed inter-agency coordination and response, dispersant decision protocols, oil spill trajectory models, and response technologies. The VSWG decided to focus more on oil spill response technologies and specifically the use of dispersants. In order to fully understand the complexity and dynamics of the fate of oil and oil dispersants and the potential impacts of dispersed oil on the resources within the Sanctuaries, the VSWG has conducted a series of meetings with presentations from identified regional experts in the areas of toxicology, oceanography and the biological resources of the Sanctuaries. The effect of oil and dispersed oil on human health was not a topic discussed with the VSWG. However, a general discussion on this topic is included at the end of the background section based on a group consensus that the topic merits consideration.

The following are key points from this report:

Sanctuaries **are not** within a dispersant pre-approval zone.

Sanctuary Role in Spill Response
The Office of National Marine Sanctuaries has a consultative role in these decisions. The Sanctuary Superintendent <u>does not make the final decision</u>.

On-water Response Technologies
Three on-water response options: mechanical recovery (skimming), *in-situ* burning, chemical dispersants. Mechanical recovery rates are typically less than 20% in sheltered waters and often less than 10% in open-water. *In-situ* burning requires seas less than 2–3 ft. (0.6–0.9 m). Oceanic and regulatory limitations on *in-situ* burning limit its use as a primary oil spill response option in California. Effective chemical dispersion of oil requires surface mixing energy (typically a few knots of wind and a light chop). Dispersant operations encounter rates are 10-100 times greater than skimming or burning. Other than no action, dispersants may be the only response option during rough, open-water conditions. Chemically dispersed oil may adversely impact organisms in the upper water column.

Net Environmental Benefits Analysis (NEBA)

A Net Environmental Benefit Analysis (NEBA) uses a risk matrix to evaluate scenario-based comparisons of different response strategies and their associated environmental tradeoffs. The risk matrix provides a qualitative ranking of population percentage impacted and expected recovery time.

Toxicity of Oil and Oil/Dispersant Mixtures

Use of chemical dispersants does introduce higher total concentrations of petroleum hydrocarbons into the water column than naturally dispersed oil. This higher concentration may have a larger footprint to potentially impact a wider range of species that would not likely have been exposed or affected by the surface oil slick. Nearly all chemicals are toxic at some concentration, so to say that a particular chemical or chemical mixture is "toxic" may not necessarily be true at environmentally-relevant concentrations.

Embryo-larval stages and early juvenile life stages are generally more sensitive to chemicals than are adults of the same species. Water containing dispersed oil droplets and oil that reaches the gills of fish can potentially cause effects. Different organisms and life stages have varying sensitivities. Many California endemic species have been used in toxicity studies involving oil and dispersants (including red abalone, giant kelp, mysids shrimp, Chinook salmon and top smelt). Species of concern found in the Gulf of the Farallones that have not had toxicity test data include black abalone and Dungeness crab.

Oceanography of North-Central California

Transport of surface oil and subsurface (i.e. dispersed) oil may be different based upon wind and current patterns at the time of the spill. Oil dispersed into deeper water will move with midwater currents, while oil at the surface will move with the surface currents as influenced by winds and may move onshore.

During times of upwelling, it is expected dispersed oil will remain in the upper water column, while during times of downwelling, dispersed oil will be driven deeper into the water column where it will experience significant dilution. It is expected some dispersed oil will travel into the nearshore zone during downwelling. Unlike Southern California, there has been no regional current forecast modeling for Northern California.

Biological Resources in the Sanctuaries

Biological resources were evaluated for the potential negative effects from dispersants ranging from the simplest plankton to birds and mammals and we assembled a list of species of interest drawn from the larger list of species that occur in the region (Appendix IV). Ultimately, dispersant-use decisions will be guided by the potential percentage impact on the population and recovery time of a species.

Invertebrates
Most zooplankton populations are not likely to be permanently affected by oil spills and are expected to recover due to their high population numbers and wide distribution. Larval stages of invertebrates and fish are considered susceptible to oil or dispersants in the water column if exposed. For many invertebrates, the adult phase is considered a high priority for protection because of their reproductive capability. It is expected that individual larvae will be lost but population-level effects will be unlikely.

Fish
Adult salmon on their landward migration are less susceptible to dispersed oil exposure due to their generally rapid movement into San Francisco Bay and ability to swim quickly. Juvenile out-migrating salmon are potentially more vulnerable to oil and dispersed oil due to increased residency time in the GF and lower general swim speeds.

Rockfish are found wherever suitable habitat is located in the Sanctuaries. Rockfish do not move widely and are considered more vulnerable to oil spills locally, but are generally found at depths that provide significant dilution for dispersed oil and they would be replaced by natural recruitment of animals from adjacent areas.

Wide ranging species with large populations such as anchovies were not considered to be vulnerable to spills or dispersants at the population level. Research has demonstrated that herring eggs and larvae exposed to undispersed oil in the intertidal zone in SF Bay experienced significant mortality that was accelerated by sunlight.

Bird and Mammals
Indirect effects to birds may include accumulation of toxic components from their food, exposure to secondary chemicals (dispersants), and destruction of habitat or prey resources.

Some sea birds are attracted to surface oil slicks on the water because they look like fish oil slicks. Storm-petrels may be inadvertently attracted to sulfurous crude oil slicks because that particular oil smells like krill (on which they feed) that emit similar compounds.

There is much information on the potential effects of oiling on birds but little information on the effects of dispersants or dispersed oil on feathers or ingestion at environmentally-realistic concentrations.

For mammals, all breeding species are potentially vulnerable to oil spills because of nursing pups/calves that might ingest oil and because most species congregate during feeding. The species most vulnerable to exposure to oil are those that rely on fur for insulation including sea otters and fur seals.

Introduction

Purpose of the Working Group

There is a continuing risk of vessel spills that could impact marine mammals, seabirds, other biota, and cultural resources in and around the Gulf of the Farallones National Marine Sanctuary (GFNMS) and Cordell Bank National Marine Sanctuary (CBNMS). Historically, spills have occurred from transiting or sunken vessels with crude oil, bunker fuel, and/or other hazardous material onboard. These incidents have generally been discrete in time and place with the exception of the SS Jacob Luckenbach, a sunken vessel that was addressed once it was identified as the source of periodic oil releases. There are no oil platforms or other potential sources of repetitive spills in the GFNMS or CBNMS at this time. The 2008 GFNMS Management Plan recommended the creation of a vessel spills working group to aid the Sanctuary in understanding and minimizing spill-related risk to Sanctuary natural resources.

The purpose of the Vessel Spills Working Group on Oil Spill Response Technologies (Working Group or VSWG) was to engage agency responders, government resource trustees, and stakeholders such as conservation NGOs and commercial fishing interests in developing a set of recommendations for the Sanctuary Advisory Councils (SACs) to consider in making their recommendations to the GFNMS and CBNMS regarding the use of response technologies in the respective Sanctuaries.

The recommendations from the VSWG are forwarded to the GFNMS and CBNMS SACs for consideration. The SACs will then develop their recommendations on the use of spill response technologies in the respective Sanctuaries to the GFNMS and CBNMS Superintendents. These recommendations will be considered by the GFNMS and/or CBNMS, as appropriate, during a spill in making its recommendation(s) to the Unified Command and the NOAA representative to the Region IX Regional Response Team (RRT-9).

Process of the Working Group

To accomplish its purpose, the Working Group has met seven times and had one conference call between June 2011 and May 2012. Meeting topics included: Response Technologies 101, Net Environmental Benefits Analysis, Dispersants 101 and decision making, Dispersant Toxicity, Sanctuary Biological resources, and Sanctuary Oceanographic Setting. The Working Group has sought to achieve consensus (and record other positions) in the recommendations for the SAC to the fullest extent possible. The Working Group consists of a body of individuals representing diverse interests and perspectives (Appendix II). In addition to obtaining technical information and expertise to develop recommendations, members have engaged in meaningful dialogue and informed/educated their constituency groups.

Background

Sanctuary Role in Spill Response

Under the authority of the federal Oil Pollution Act of 1990, primary response responsibility for marine spills has been delegated to the U.S. Coast Guard (USCG). Therefore, the USCG is the lead federal agency on all marine spill response and planning activities. During a spill event, the Unified Command (UC) orchestrates all emergency response and cleanup activities and consists of the USCG (federal), the State of California's Office of Spill Prevention & Response (OSPR) if the spill is within or threatens state waters and/or resources, and the Responsible Party (RP). The UC may choose to bring in other agencies and/or private parties to assist during an event, including GFNMS and CBNMS as resource trustees. The UC establishes and oversees an Incident Command (IC) staff that is comprised of individuals with unique expertise from a variety of organizations.

A California Dispersant Plan and Federal On-Scene Coordinator checklist have been developed for determining the feasibility of using dispersants in California and can be found in the Regional Contingency Plan for Region 9 (California, Nevada, and Arizona) (2008 RCP). Dispersants have been "pre-approved" by the Region 9 Response Team (RRT-9) for use outside of Sanctuaries or beyond 3 nautical miles of any landfall (state waters) or Mexico. Pre-approval requires that the USCG follow the dispersant pre-approval checklist and ensure all criteria have been met. If this is the case, further consultation with the RRT-9 is not required. If, however, all criteria are not met, pre-approval is not authorized and RRT-9 approval shall be required. Since California National Marine Sanctuaries are not in the pre-approval zones, any dispersant use request made by the USCG during a spill in the Sanctuaries will require approval by the RRT-9.

Although the Sanctuary Superintendent does not make the final decision on whether dispersants or other applied technologies (e.g. in-situ burning) are used within the Sanctuaries, Sanctuary staff will be expected to provide input into the decision process through participation in the spill response and through the NOAA representative on the RRT-9. ONMS does not have a vote. ONMS does have a consultative role on major decisions such as use of dispersants, in-situ burning, bioremediation, and shoreline clean-up agents.

On-water Response Technologies

Typically three types of offshore response strategies may be deployed or considered for deployment during an oil spill in order to efficiently remove oil from the water's surface and to prevent the migration of oil to sensitive nearshore and shoreline habitats. Implementation of these strategies is based on San Francisco-Bay Delta Area Contingency Plan (SFBD ACP) and the Region 9 Regional Contingency Plan (RCP). ACPs are developed with input from numerous local, state and federal participants, industry, oil spill response organizations (OSROs) and non-government organizations (NGOs) and are frequently tested during various drills and exercises. ACPs are local in scope, and address sensitive resources, response strategies and general oil spill response concerns within a certain number of coastal counties (there are several ACPs to cover the entire coast of California). The RCP is, in contrast, a single document authored and maintained primarily by the federal and state members of RRT-9, which includes federal and state natural resource trustee agencies. The RCP addresses response actions that are statewide in nature, and therefore includes plans such as the one for dispersants that do not vary within a region. On-water response operations addressed by ACPs and the RCP generally include mechanical removal (on-water skimming), *in-situ* burning, and the application of chemical dispersants. All three include their own "window of opportunity" and unique set of operational constraints and ecological considerations. Each strategy is implemented with specific operational requirements to minimize impacts to sensitive resources to the greatest extent possible.

"Windows of opportunity" are the timeframes during a spill event when each response method works the best. Variables that influence the window of opportunity include, but are not limited to, the type of material spilled, location, oceanographic and weather conditions, product weathering, emulsion rates, and the different environments, species, and ecosystems that may be impacted. When response strategies are used within these windows, they are more effective. Selecting response options (including natural recovery) involves considering tradeoffs among predicted effectiveness, potential environmental impact, appropriateness for habitat, and timing.

The following discussion focuses only on the three primary on-water response strategies, and is drawn from NOAA's *Characteristics of Response Strategies: A Guide for Spill Response Planning in Marine Environments* job aid (available at www.response.restoration.noaa.gov) and other sources.

Mechanical Removal (or skimming)

On-water skimming operations in the Gulf of the Farallones would involve the use of slow-moving, relatively large vessels in conjunction with floating containment boom and surface skimming pumps to mechanically collect, skim and remove oil from the water's surface.

There are numerous types of skimming devices, including: brush, disc, drum, belt, rope mop, sorbent belt, suction, and weir skimmers. They are placed at the oil/water interface to recover, or skim oil from the water's surface and may be operated from shore, be mounted on vessels, or be completely self-propelled. Because large amounts of water are often collected with the oil, efficient operations require that floating oil be concentrated at the skimmer head using containment boom. Adequate storage of recovered oil/water mixtures must be available, along with suitable transfer capability.

Mechanical removal is most successful in quiet, protected conditions. Recovery rates for skimming operations can vary but seldom exceed 20% in the most sheltered waters and are often less than 10% in open-water conditions. This is largely because skimming is boom-dependent, requiring very slow speeds (often under one knot) and thus have low encounter rates. It can generate large volumes of oily water waste and even with experienced operators, oil will begin to escape from containment boom in seas greater than 2-3 feet. Skimming requires very slow speeds and constant monitoring to be effective, while the associated ecological impacts are typically expected to be minimal.

In-situ Burning

In-situ burn operations in the Gulf of the Farallones and Cordell Bank region would involve the use of slow-moving vessels and fire retardant containment boom to be effective. In addition, these operations utilize numerous spotter and air quality monitoring support craft to minimize potential impacts to human health and the environment.

In-situ burning has been extensively researched, tested, and utilized in response to oil spills and is believed to be one of the most efficient ways of removing surface oil. Even so, like skimming operations, *in-situ* burning is a boom-dependent operation, and thus susceptible to the same types of failures when seas exceed 2–3 ft (0.6–0.9 m) in height. Burning would need to be performed early in the spill event when the oil is relatively fresh and can be kept thick enough (at least 1-2 mm thick) to sustain the burn. A pre-approval for *in-situ* burning is in place for marine waters further than 35 nm from the California coast. Closer to shore, due to concerns about air quality, RRT approval is required for use of *in-situ* burning. Each Air District along the California coast has also developed Quick-Approval zones that can be used if winds are blowing parallel to or offshore, and these can factor into the RRT-9 decision about whether an *in-situ* burn very close to shore or on land will be safe to conduct. Thus, oceanic and regulatory limitations on *in-situ* burning limit its use as a primary oil spill response option in California. From an equipment perspective, California does not currently have any of the necessary and specialized fire boom available; the nearest west coast supply of fire boom is in Washington State, with a minimum 24-hr delivery time to California.

As with skimming operations, ecological impacts of vessel and boom operations during an *in-situ* burn would be expected to be minimal because operations are conducted under slow speeds and constant monitoring by numerous vessels. Though there is a possibility that some marine species might become entrapped within a boomed area, proper wildlife monitoring should minimize such potential impacts. Unlike the Gulf of Mexico, where numerous sea turtles rear starting at the hatchling life-stage, the chance of encountering juvenile sea turtles is discountable in the GFNMS and CBNMS. The probability of encountering adult sea turtles is relatively rare, but the required monitoring is expected to prevent impacting them in an in-situ burn. However, the possible effects of large volumes of smoke on wildlife and human health are not well known and the toxicological impacts from burn residues have not been evaluated. On water, burn residues may sink.

Dispersants

The surface application of chemical dispersants in the Gulf of the Farallones and Cordell Bank region would likely involve one or more vessels with spray arms and/or helicopters or fixed-wing aircraft. Applications would be guided by spotter aircraft to ensure dispersants are applied to the thickest and freshest areas of oil and to avoid individual marine mammals and concentrations of other wildlife to the greatest extent possible. Trained teams would also be deployed by boat and aircraft to monitor both the effectiveness in dispersing oil into the water column and to measure dispersed oil concentrations (at various upper water depths inside and outside the dispersant area of operations).

The dispersants in use today are relatively effective at dispersing oil into the water column, less toxic than earlier formulations and typically less toxic than the oils they are used to treat. Dispersants reduce the oil/water interfacial tension, making it easier for waves to break up oil into very small droplets, often less than 50-70 micrometers (µm); thus enhancing their biodegradation potential. They also prevent dispersed particles from re-coalescing and forming bigger, more buoyant droplets that will float to the surface, re-creating sheens or slicks. To accomplish this, effective chemical dispersion requires a threshold amount of surface mixing energy (typically a few knots of wind and a light chop).

As with in-situ burning, dispersant operations would need to be performed early in the spill event when the oil is relatively fresh, as effectiveness diminishes as the oil spreads and weathers. Dispersant applications are typically only possible during the first few days, at most, before an oil slick moves, spreads and weathers to the point that application would not be effective. Even so, dispersant operations have much higher encounter rates (10-100 times) than skimming or burning. And given the sea state constraints of the other strategies, dispersants may be the only response option during rough, open-water conditions other than the no-action alternative.

Oceanographic conditions, currents, upwelling, and downwelling will influence the spread of the dispersed oil. Ecological impacts from these dispersant operations must be carefully evaluated. Dispersant use within Sanctuaries would require incident-specific RRT-9 approval before use. Until sufficiently diluted, chemically dispersed oil may adversely impact organisms in the upper water column. At the time of this writing, the State of California has determined that such operations should only be considered in waters deeper than 60 ft (approximately 20m) and when the impact of floating oil is determined to be greater than that of dispersed oil on the water-column. Consideration is typically given to avoid directly spraying any wildlife, especially birds or fur-bearing marine mammals.

Net Environmental Benefits Analysis (NEBA)

In mounting an effective oil spill response, the USCG works with other agencies to direct efforts protecting public health, welfare, and the environment. Once oil is spilled to the ocean there will inevitably be impacts to the environment, no matter what response strategy is employed. Furthermore, response strategies themselves can cause impacts, so understanding the net environmental benefit of different response strategies can be critical to minimizing overall impacts of a spill event (i.e., from oil and response activities) and allow for quicker environmental recovery.

A formalized Net Environmental Benefit Analysis (NEBA) uses a risk matrix to evaluate scenario-based comparisons of different response strategies and their associated environmental tradeoffs. The risk matrix provides a qualitative ranking of impacts to affected resource populations or communities based on magnitude of concern. As in figure 1 (below), population percentage impacted and expected duration of recovery are graphed. In a format that can easily be compared, spill response options including: 1) no action, 2) mechanical cleanup, 3) *in situ* burning, and 4) dispersant use, can be scored and compared. Conducting such a thorough analysis during an actual spill emergency is exceedingly challenging, so many NEBAs have been completed along the California coast as part of the ACP and RCP planning processes and explicitly for the development of the Dispersant Use Plan.

Figure: Simplified example of NEBA risk matrix from the USCG's consensus-Ecological Risk Assessment guidebook.

		RECOVERY PERIOD			
		> 7 years (SLOW) (1)	**3 to 7 years (2)**	**1 to 3 years (3)**	**< 1 year (RAPID) (4)**
% of RESOURCE	**> 60% (LARGE) (A)**	1A	2A	3A	4A
	40 - 60% (B)	1B	2B	3B	4B
	20 - 40% (C)	1C	2C	3C	4C
	5 - 20% (D)	1D	2D	3D	4D
	0 - 5% (SMALL) (E)	1E	2E	3E	4E

Legend: Cells shaded dark gray represent a high level of concern, cells shaded gray represent a moderate level of concern, and cells not shaded represent a limited level of concern.

In the NEBA process, the benefits and risks of each cleanup option are evaluated separately and then compared. However, an effective spill response may use a combination of several available response options. Depending upon the oceanographic conditions, spill location, type of oil spilled the use of dispersants may be considered in conjunction with mechanical cleanup equipment and other response strategies.

The NEBA is one way to look at and understand differing strategies and their associated environmental trade-offs, singly or in combination. The outcomes of such discussions may then be used as “pre-loaded” information before a real spill event occurs so that time-critical decisions can be made more efficiently. They can be a very helpful way of quickly evaluating many of the spill-specific environmental trade-offs associated with the response strategies under consideration. Many of the NEBA workshops in California to date have focused on RRT-9 designated dispersant Pre-approval Areas. If dispersants are being considered in such areas, then responders will benefit from such pre-loaded information.

The Vessel Spills Workgroup meetings have discussed many of the elements commonly part of a focused NEBA process. Generally, evaluating oil spill response options include assessing environmental tradeoffs because each approach can cause impacts and because no single response approach is likely to protect all resources perfectly. As previously discussed, both mechanical cleanup (skimming) and *in situ* burning are relatively slow-moving, boom-dependent operations, and their success in offshore waters may be severely limited by sea conditions and distance offshore. At times, such response techniques may not significantly reduce the risk of spilled oil contacting biological resources at the sea surface or in coastal (*e.g.*, intertidal) regions.

Shoreline cleanup methods may not be available or appropriate for use in some remote or sensitive coastal habitats (*e.g.*, rocky intertidal, marshes, wetlands). Inappropriate use may pose a greater risk to these sensitive habitats and dependent species than the oil itself. In such cases the best option may be to keep the oil from ever reaching such sensitive areas or reducing the amount of oil that reaches those areas.

When used in an appropriate and timely manner, dispersants can remove a significant amount of oil from the water’s surface. Appropriate and timely application includes a number of decision factors.

- While dispersants may measurably reduce the risk of oil to surface and shoreline resources, there may be a short-term increase in impacts to the plankton community in the upper water column.
- Rapid decisions on dispersant use are essential as they must be applied quickly, before the oil significantly weathers, to be effective.
- Oil dispersed into the upper water column will quickly dilute to levels where acute toxic effects are much less likely.
- Few acute toxic effects have been reported for crude oil dispersed into the upper 10 m of well-mixed water (Mearns pers. comm.) although available information is limited.
- Dispersants are not appropriate for use on diesel and gasoline based on volatility and toxicity concerns of the spilled product, and are not approved for dispersant use in California.

Available field data and models indicate that concentrations of dispersed oil within the upper water column would be expected to decline below 1 part per million (ppm) at 10 m depth (Mearns pers. comm..) within hours as the cloud of micro-droplets diffuses in 3-dimensional space and begins to degrade. Within a matter of days, dispersion and biodegradation processes can remove much of the plume of oil droplets from the upper water column, and/or reduce concentrations to non-detectable levels.

In contrast, undispersed and unrecovered oil left on the water's surface in the open ocean will break up into smaller and smaller patches of weathered oil but may still persist at the surface for weeks to months, where it may continue to impact pelagic birds, mammals and perhaps sea turtles. If the oil moves toward shore, it can strand in sensitive coastal habitats (especially intertidal areas) and potentially pose a persistent threat, on a timescale of months to years, to those sensitive coastal habitats and their dependent species and communities. There may be circumstances when it would be acceptable for undispersed oil to come ashore for clean-up (e.g. sandy beach as compared to rocky intertidal) but this needs to be evaluated on a case-by-case basis.

Other NEBA-relevant points were also discussed during other VSWG meetings and will be covered in other parts of this workgroup report.

NEBA or NEBA-like processes can be very helpful in spill planning and pre-loading information to support time-critical USCG response decisions. The Gulf of the Farallones National Marine Sanctuary (GFNMS) is a unique ecosystem which provides a broad range of ecological benefits to a variety of plants, invertebrates, fish, birds, sea turtles and mammals. While the existing NEBAs for the areas within the Sanctuaries provide adequate and sufficient resource detail to make a real time assessment on the potential impacts of using dispersants within the GFNMS, current Sanctuary staff were not involved in developing those NEBAs. As NEBA information can be helpful for Sanctuary management staff during a spill event and will help make USCG operational decisions more robust and protective of the environment in the event of a large spill. It is therefore recommended that Sanctuary staff consider performing a small series of scenario-based NEBA discussions with USCG and subject matter experts to identify environmental decision drivers, existing data gaps and developing additional quick-turnaround inputs to support USCG time-critical response decisions.

Toxicity of Oil and Oil/Dispersant Mixtures

Determining whether or not to support the decision to apply chemical dispersants to maritime oil spills is often one of the most controversial and consequential decisions facing resource managers and spill responders. Their input should therefore be based on objective, science-based information and should weigh the environmental and other trade-offs associated with dispersants and the use of alternative response strategies that may be available.

Dispersant Formulations

How dispersants work, their strengths, limitations and environmental considerations are described elsewhere in this report. Early use of chemicals to treat oil spills was both effective and very toxic. Since that time, chemicals have been specifically formulated to disperse surface oil slicks with a higher level of efficacy while lowering the level of toxicity relative to the targeted oil. The working group discussed a range of variables related to toxicity, including genotoxic and mutagenic properties, and more detail on this discussion is provided below.

When considering the toxicological implications of a dispersant, it is important to remember that a cloud of dispersed particulates/micro-droplets will diffuse in three dimensions. This dispersed oil cloud is expected to dilute to lower concentrations in the water column and would thus not be much influenced by winds that could push the surface oil towards shore. Also, such micro-droplets are more readily biodegraded than naturally dispersed oils larger droplets, by virtue of their high surface to volume ratio. That being said, the use of chemical dispersants does introduce higher total concentrations of petroleum hydrocarbons into the water column than naturally dispersed oil. This higher concentration enters more rapidly into a larger volumetric footprint to potentially impact a greater number of organisms that may not have been affected by or exposed to the undispersed oil slick. The working group discussed the basis of these inputs and how they would be used in a formalized NEBA process.

General Toxicology Concepts

While there is broad agreement and strong data to support the known toxic and mutagenic properties of crude oil and related petroleum products, the range of chemical components represented in various dispersants has long complicated any discussion about the fates and effects of dispersant application in marine ecosystems. These differences of interpretation also emerged during technical presentations to, and deliberations among, the Vessel Spills Working Group. The time and scope of the workgroup process did not allow for the consideration of potential human health impacts of petroleum products and dispersants. However, human health issues were discussed broadly and the group felt these topics should be discussed more thoroughly at another time.

Nearly all chemicals are toxic at some concentration, so to say that a particular chemical or chemical mixture is “toxic” may not necessarily be true at environmentally-relevant concentrations and may therefore skew objective environmental trade-off discussions. Furthermore, both oil and dispersants are complex mixtures of many different chemical components, so a holistic view of a given oil or dispersants real-world toxicity to any one of a huge variety of organisms and habitats can quickly become complicated. Embryo-larval stages and early juvenile life stages are generally more sensitive to chemicals than are adults of the same species.

During the meeting Dr. Tjeerdema indicated that much toxicity testing of dispersants has occurred in CA since 1987 and that interpreting the body of available dispersant/oil toxicity data can be difficult. First, caution should be used to rely primarily on peer-reviewed documents authored by established experts in the fields of toxicology and oil spills since less rigorous, web-based sources of information may be of varying quality and/or may mislead readers by providing good information out of context. However, even peer-reviewed toxicity data can be confusing to many for a variety of reasons including:

- Varying oil/water, dispersant/water, oil/dispersant/water mixture preparations
- How concentrations are reported (e.g. THC, TPH, WAF, CEWAF, etc.)
- How effects are measured (e.g. lethality, sub-lethal, gene expression, metabolic changes, etc.)

Toxicity results are often reported in LC50s (the concentration of pollutant in water that causes <u>death</u> to 50% of the test organisms), EC50s (the concentration of pollutant in water that causes some <u>sub-lethal effect</u> to 50% of the test organisms), NOAEL (<u>No Observable</u> Adverse Effect Level), LOAEL (<u>Lowest Observed</u> Adverse Effect Level). Even with understandable toxicity results, applying them to a real world situation also requires an understanding of reasonable routes of exposure and realistic environmental concentrations and durations because <u>risk</u> to a given organism is a function of chemical concentration in the water, an actual exposure to said concentrations and duration of said exposures. The working group discussed these topics as well as acute and chronic exposures, likely environmental concentrations and exposures over space and time.

The Environmental Protection Agency (EPA) is charged with listing dispersants on the National Contingency Plan (NCP) Product Schedule based on both dispersant effectiveness and toxicity data provided by the manufacturers. Toxicity testing currently associated with listing of a product on the NCP Product Schedule focuses on acute toxicity within 48 and 96 hours after dispersant application. Specifically, this type of constant laboratory exposure regime typically overestimates acute toxicity probability as the concentrations during a spill are not constant over these periods of time and rarely models longer term and/or multigenerational exposures. Longer-term studies may help to better capture the impacts that occur over longer time periods, such as neurotoxicity, cardiovascular toxicity, organ damage, infertility, genetic damage and lesions and tumors.

Route of Exposure (Particulates versus Dissolved)

While undispersed oil generally poses the greatest threat to shorelines and surface-dwelling organisms, dispersed oil may also threaten water column organisms. Most oils float and though surface slicks will naturally break up over time into floating streamers, patches and then tarballs; even without dispersants some portion will also become naturally dispersed into the water column in the form of small particles or droplets and will also dissolve. When chemically dispersed, a floating oil will enter the water column as a more concentrated cloud of very small particles or micro-droplets and also as dissolved constituents. Water containing dispersed oil droplets and oil that reaches the gills of fish can potentially cause effects. Interestingly, research shows that the dissolved fraction of oil is similar regardless of dispersant use even though particulate/droplet load is greatly increased with dispersants. This becomes important when considering real-world routes of exposure because particulate-feeding organisms (e.g. zooplankton, small nekton) will have increased exposure to chemically-dispersed oils than naturally dispersed oils whereas non-ingesters (e.g. phytoplankton, eggs, etc.) will see virtually no difference in exposure whether dispersants are used or not. Therefore, organisms that don't ingest tiny oil droplets aren't exposed to different concentrations and so shouldn't be drivers for dispersant decisions (e.g. Herring eggs).

General Toxicity Results

Once dispersant is applied to a spill, three different mixtures might reasonably occur: 1) dispersant, 2) oil, and 3) dispersant/oil mixture; with each exhibiting different toxicities to water column organisms. As discussed above, dispersants are still toxic but have been formulated to be less toxic than the oil they are dispersing. Additionally, operational guidelines target applying dispersants at 1/20th the targeted oil volume so environmentally-relevant dispersant concentrations are a small fraction of the acute oil-chemical risk to water column organisms during dispersant operations. If the threshold of lethality of a particular organism or life stage of an organism is low, then dispersing may create a larger injury zone. In short, the ecological and toxicological risks posed by typical dispersant operations are more closely related to what dispersants do (e.g. put oil into the near surface water column and potentially increase the exposure to certain species) than their own, inherent chemical toxicity.

Another complication in the world of environmental toxicology is the varying sensitivities of different organisms and life stages. Although many California endemic species have been used in toxicity studies involving oil and dispersants (including red abalone, giant kelp, mysids shrimp, Chinook salmon and top smelt) they may not reliably represent all the species of concern found in the Gulf of the Farallones and Cordell Bank (e.g., black abalone, dungeness crab). Without species-specific data, reasonable inferences can often be made from existing data by using appropriate surrogate species.

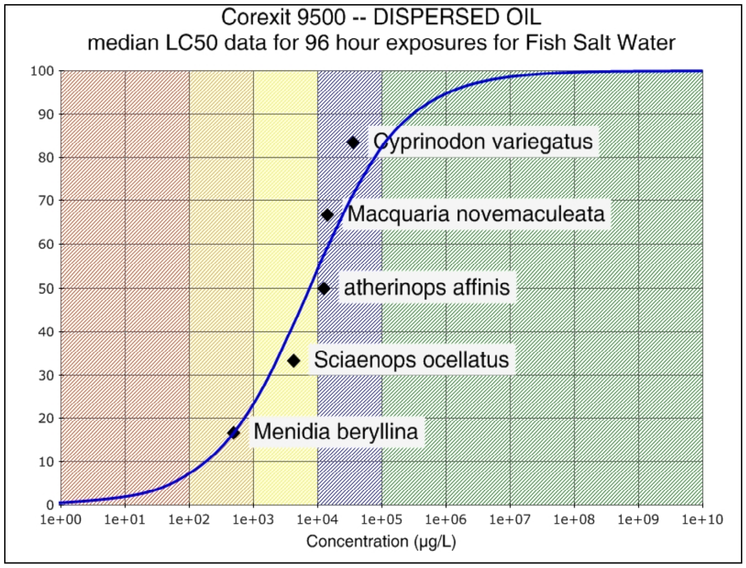

Figure 1: Marine fish Species Sensitivity Distribution (SSD) curve showing LC50s when exposed for 96 hours to chemically dispersed oil using Corexit 9500 LC50 concentrations. LC50 concentrations are given on the x-axis in ug/L of dispersed oil/L of water (equivalent to parts per billion or ppb) and cumulative percentage of test organisms are provided on the y-axis. The CAFE-extrapolated curve is based on data in the 2005 NRC book, Oil Dispersants: Efficacy and Effects.

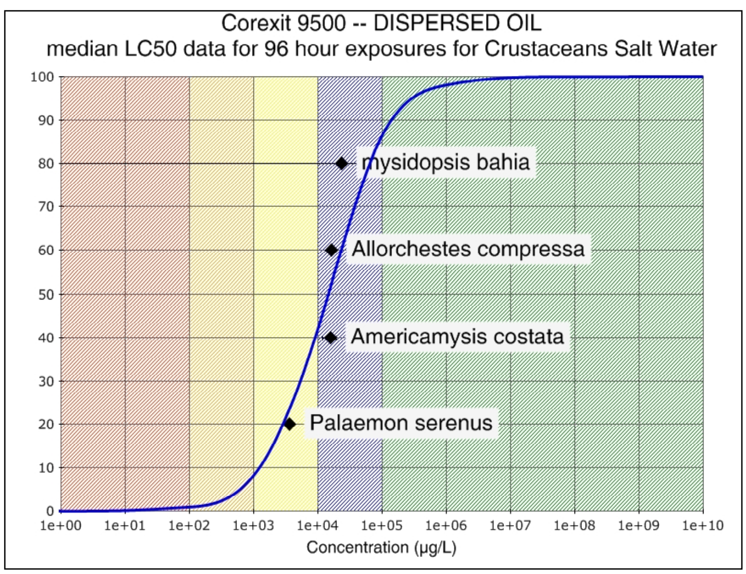

Figure 2: Marine crustacea Species Sensitivity Distribution (SSD) curve showing LC50s when exposed for 96 hours to chemically dispersed oil using Corexit 9500. LC50 concentrations. LC50 concentrations are given on the x-axis in ug/L of dispersed oil/L of water (equivalent to parts per billion or ppb) and cumulative percentage of test organisms are provided on the y-axis. The CAFE-extrapolated curve is based on data in the 2005 NRC book, Oil Dispersants: Efficacy and Effects.

If particular species of concern found in the Gulf of the Farallones or Cordell Bank are not specifically shown in Figures 1 and 2, then a similar or closely related species may serve as an appropriate surrogate. However, there might not be good surrogates for all species or life stages of concern. If the spectrum of species represented reasonably reflects the spectrum of vulnerabilities to dispersed oil, and species of concern might reasonably fall among them, then focusing on dispersed oil concentrations protective of the most sensitive species should be protective of others as well. Collecting this information and having it available in context at the time of a spill is the responsibility of the NOAA Scientific Support Coordinator (SSC) and Applied Response Technology Specialist.

Oceanography of North-Central California

<u>Transport along north-central California Coast</u>

This presentation summarized the oceanic processes that would affect oil transport and fate along California's north-central coast. Introduced concepts that could influence spill trajectory and response decisions included: coastal upwelling, relaxation, 3-D circulation patterns, and the synoptic, seasonal, and inter-annual variables. An important point is that transport of surface oil and subsurface (i.e. dispersed) oil may be different based upon wind and current patterns at the time of the spill. Oil dispersed in deeper water will move with midwater currents, while oil dispersed at the surface will move with the surface currents as influenced by winds and may move onshore. Thus, oil dispersed offshore may very well reduce the potential for oil impacts to nearshore and shallow water species. This may influence which species become the primary dispersant decision drivers. During times of upwelling, it is expected dispersed oil will remain in the upper water column, while during times of downwelling, dispersed oil will be driven deeper into the water column. It is expected some dispersed oil will travel into the nearshore zone during downwelling. Increased coverage of HF radar would facilitate rapid determination of surface currents. Dr. Largier demonstrated that local expertise must be cultivated in order to rapidly inform decision-making processes.

<u>Oil fates in San Francisco Bay: Why is it so hard to capture that oil?</u>

A discussion of the variable factors contributing to difficulties in modeling oil transport and fate in and around SF Bay was included, and the summary message was the system is highly variable both offshore and along SF Bay. Currents within the Bay are dominated by tides, driven by tidal forcing at the Golden Gate, and freshwater inflow. Oil tends to collect in Raccoon Strait and that buoyant material strongly coalesces at convergent zones resulting from buoyancy fronts and shear zones, topographically steered currents and Langmuir circulation. The strong presence of convergence zones in the Bay ensures that oil slicks will turn into linear features, at which point oil control and trajectory prediction ~~is~~ are very difficult; though may be advantageous to skimming operations. In addition, neutrally buoyant pollutants and possibly some portion of buoyant pollutants may be subducted below the surface in the shear zones. Dr. Largier indicated the importance of tackling the problem before the spill transforms into "strings"'. He also included a discussion regarding the utility of HFR radar; additional information for which is available at http://www.ioos.gov/hfradar/welcome.html.

Fate and Transport of Dispersed Oil

Mr. Glen Watabayashi provided a summary of NOAA's modeling capability and expertise in providing oil spill response support, along with first-hand knowledge of the 1984 M/V Puerto Rican incident. The Emergency Response Division, based in Seattle, maintains a suite of modeling tools, which are used in conjunction with GNOME (General NOAA Operational Modeling Environment), a transport model used to predict pollutant trajectories. Effective use of the model in our region could be improved by greater use of access to HF radar data (which is limited by operational funding). Discussion of the 1984 Puerto Rican incident included how unforeseen winds contributed to a shift in the trajectory of the spill towards the Farallones and north to Bodega Bay. Approximately 2,000 gallons of an earlier version of Corexit was in fact used during that incident, though there was disagreement regarding its effectiveness at treating the spilled lube oil. See Breaker and Bratkovich (1993) for more information on the Puerto Rican incident. Mr. Watabayashi closed with a slide showing priorities for improving modeling efforts, while emphasizing that increased data and modeling capacity is not a panacea for ensuring efficient oil spill response. It was pointed out that having water column information that included vertical density structure in the upper 100 meters of water to complement surface HF radar data would help to track and forecast dispersed oil. The speaker also pointed out that unlike Southern California, there is no regional ocean current forecast modeling for Northern California.

Biological Resources in the Sanctuaries

Biological resources were evaluated for the potential negative effects from dispersants ranging from the simplest plankton to birds and mammals and we assembled a list of species of interest drawn from the larger list of species that occur in the region (Appendix IV). Criteria applied to identify species were guided by, but not limited to: 1) significance in the coastal ecosystem as a keystone species or ecosystem driver, 2) federal or state status under endangered species laws, 3) presence of life stages most susceptible to injury or death from dispersed oil, and 4) location of proposed dispersant use in the Gulf of the Farallones. Ultimately, dispersant-use decisions will be guided by the potential percentage impact on the population and recovery time of a species.

Several speakers presented information on invertebrates, fish, birds and mammals of particular concern in the Sanctuary and most likely to be affected by oil or dispersed oil (see appendices for complete notes and presentations). A summary of their findings are presented below:

Zooplankton
Animal larvae within the plankton that are only capable of passively drifting with currents are generally thought to disperse in the water column close to home; replacement of these larvae will depend on their distribution in the area, how broadly this area was impacted, and time of the year. Larvae and plankton capable of independent movement can range over wider areas; impacts to their area may recover more quickly as plankton from non-impacted areas replace them. If larger areas are affected, then it would take longer to re-populate. Given their wide distribution in the Northern California coastal area, most zooplankton populations are generally not likely to be permanently affected by oil spills and are expected to recover. Drake's Bay specifically, and the Gulf of the Farallones region generally, are larval retention zones, and so have the potential to concentrate spilled oil, resulting in longer exposure to oil or dispersed oil. It is likely that a dispersed oil plume generated by an offshore dispersant operation will rapidly be diluted to concentrations not expected to be problematic to species occur in sufficient concentration to affect species within coastal embayments. Larval stages of invertebrates and fish are considered susceptible to oil or dispersants in the water column. However, the effects on certain species may be localized and, given their wide larval distribution, there may not be long-term/regional impacts or population-level effects from local dispersant use.

For many of these species, the adult phase is considered the most important one to protect because they generally experience high mortality rates through the larval and juvenile life stages and therefore protecting the adults producing the next generations of offspring is paramount. However, for some species local or regional effects may have serious consequences for populations. Abalone, for example, need to be in close proximity to each other for successful reproduction. Exposure of adult black abalone to oil may affect the survival and recovery of this endangered species.

Invertebrates
The planktonic stages of Dungeness crab (zoea and megalopa) are present in the GFNMS and CBNMS in Jan-May from mid-water to surface, and the majority of larval stages reside outside of the SF Bay. They are important prey of Chinook salmon and other fish. Dungeness are most vulnerable from Dec-May when larvae are present. Depending on the size of and duration of a chemical spill and subsequent window of dispersant application, a portion of that year class might be lost. It is expected that individual larvae will be lost but population-level effects will be unlikely. Market squid also spawn broadly and have large regional movements and are not considered to be vulnerable to spills or dispersants at the population level.

Fish
Salmon congregate where there are prey species which can be found on temperature and/or salinity fronts. Adult phase of salmon on their landward migration are less susceptible to exposure to dispersed oil due to their swimming speeds and generally rapid movement into San Francisco Bay. Juvenile out-migrating salmon are more

vulnerable to oil and dispersed oil due to increased residency time of the small fish in the GFNMS and CBNMS and their less robust swimming capabilities. Rockfish are found wherever suitable habitat is located in the Sanctuaries and nearby areas. In general for salmon, their main prey species and prey location change seasonally: herring/anchovies=Feb-Mar, in the northern inshore area; euphausiids (primarily *T. spinifera*)=Apr-May, between northern inshore and offshore; rockfish=Mar/Apr-Jun, in the offshore area; and herring/anchovies=Jul-Nov, in the central/southern inshore area. This pattern changes in El Niño years when euphausiids swarm offshore (as occurred in 1986) and salmon follow them).. Species such as rockfish that do not move widely are considered more vulnerable locally but are generally found at depths that provide significant dilution for dispersed oil and they would be replaced by movement of animals from adjacent areas. Wide ranging species with large populations such as anchovies were not considered to be vulnerable to spills or dispersants at the population level. There is evidence, though, of the effects of undispersed oil on larval herring that spawn in SF Bay and Tomales Bay.

Bird and Mammals

Birds are the most highly visible and some of the best studied group of species affected directly by oil, both by contact and ingestion. Indirect effects to birds include bioaccumulation of toxins through the food web, exposure to secondary chemicals (dispersants), and destruction of habitat or prey resources. Information we have to date is derived primarily from large spills in California since the early 1970s that have mostly occurred in the winter during the nonbreeding season. Consequently, the most common species that have come onshore, and therefore were documented, include common murre, cormorants, loons/grebes, and shearwaters and fulmars. However, effects to vulnerable offshore species (e.g., ashy storm-petrel, Cassin's auklet) are hard to document. Both species are regionally significant, and storm-petrels are a state species of concern. Marbled murrelets, a federally listed species, occur in the region and nest in Santa Cruz but little is known about where, when or how abundant they are in the region. Some sea birds are attracted to slicks on the water because they look like fish oil slicks. Storm-petrels may be inadvertently attracted to sulfurous crude oil slicks because that particular oil smells like krill (on which they feed) that emit similar compounds. Therefore, reducing surface area of a slick may reduce impact by reducing the "attractiveness" of a slick. There is much information on the potential effects of oiling on waterbirds but little information on the effects of dispersants or dispersed oil on feathers or ingestion at environmentally-realistic concentrations.

For mammals, all breeding species are potentially vulnerable to oil spills because of nursing pups/calves that might ingest oil and because most species congregate during feeding. However, most species range widely and are less likely to be affected depending upon the size, location and season of the spill. Pathways for exposure include inhalation, contact and ingestion. The species most vulnerable to exposure to oil are those that rely on fur for insulation including sea otters and fur seals, species that may be regionally important such as harbor porpoise, and nursing pinnipeds that are constrained to breeding colonies.

Based on integrated studies such as ACCESS, regional hot spots have been identified where many species of all groups congregate. Taking into account the above information, the complexity of the decision making on the application of dispersants is illustrated by the following scenario. If surface oil circulates in Drakes Bay (as a retention zone), decision makers would have to take into account that 1) any larvae there would have longer exposure to both oil or dispersed oil 2) dispersed oil might reduce potential exposure of water birds to oil floating on the surface and of Dungeness crabs if the oil sinks to the bottom but 3) adult crabs also might be susceptible to dispersed oil depending on how deep dispersed oil sinks and how long it takes for the dispersed oil to decrease in concentration by means of turbulent mixing in the water column

The following discussion on human health issues was not widely discussed with the VSWG but the consensus of the group did feel the topic was worth raising.

Human Health Issues

The broad range of monitoring activities and scientific studies that are still in progress as a result of the exposure of living organisms, including humans, to dispersants and to oil as a consequence of the 2010 Deep Water Horizon oil spill in the Gulf of Mexico are still in progress. Observations by fishermen, scientists, and residents of deformed shrimp, fish with lesions, and increased post-incident mortality of baby dolphins continue to be compiled in that region. There are functional differences between evaluations of acute and chronic exposure, and acute and chronic effects, with respect to both oil and to dispersant components, and some important lessons remain as follow-up studies of the Gulf of Mexico spill are completed.

One of any Marine Sanctuary's most valued resources is its people, including Site staff, affiliated partner agencies, and the general public served by the Site. Protection of human health and public safety is a paramount priority for the Sanctuary Program at all times. OSHA guidelines require training of sanctuary staff who are required to wear appropriate protective clothing in any response-related situations where they may come into contact with petroleum products or dispersants, and to utilize individual respiratory protection where indicated. Children, women who are pregnant, and those with compromised immune systems, should not be allowed near spill response or oiled wildlife recovery situations. The public must be fully advised to avoid any oil spill unless they are HAZMAT trained and deployed under the appropriate level of supervision.

Recommendations

General Science and Research Recommendations

1. Continue to follow and support research on the effects and impacts of alkylated PAHs in dispersed oil on fish and invertebrate egg and larvae.

2. Actively support the research and development of “next generation” biodegradable dispersants and alternative products for oil spill response. Consider establishing a policy that requires the use of alternatives to existing dispersants within the GFNMS and CBNMS.

3. Complete a review of the existing literature and identify data gaps on the status of marine life within the Greater Gulf of the Farallones Ecosystem, particularly during the winter. Identify opportunities for research on species of concern that would be affected by oil spills and dispersants in the GFNMS and CBNMS during winter.

4. Support NOAA and State research on the reproductive success and behavioral effects (spawning, foraging, predator avoidance) for black/red abalone exposed to dispersed oil. Specific research on the potential for behavioral responses from exposure to dispersed oil (narcosis) is needed.

5. Support research on the effects of dispersed oil on critical or surrogates species that represent important commercial and public trust resources in the GFNMS and CBNMS. Targeted research should include adult and juvenile Dungeness crab, and ESA listed Black Abalone and the potential impacts (short and long-term) to the habitats that support these resources.

6. Identify existing sources of real-time data feeds on surface and subsurface currents on the GFNMS and CBNMS (e.g. NOAA Data Buoys, HR Radar). Support the placement of an HR radar antenna on Southeast Farallon Island to close the existing radar shadow.

7. Identify current or published research on the effects of inhalation and dermal exposure of dispersed and non-dispersed oil on birds and marine mammals.

8. Identify the seasons and species that use GFNMS and CBNMS in substantive numbers where an oil spill and/or dispersed oil could have significant long-term impacts on the viability of the population (e.g. Ashy Storm-petrels).

9. Support research that includes:
    a) Standardization of dispersant toxicity studies for inter-comparability,
    b) Maximizing dispersant efficacy while minimizing potential toxicity, and

c) Filling data gaps on:
    1) Feather and fur wetting effects by environmentally realistic concentrations of dispersed oil, and
    2) Toxicity testing of species of concern and how they relate to surrogate species and species sensitivity curves.

10. Support research to find more effective seagoing and coastal oil spill containment and sorbent booms, skimmers, separators, and "oil mop" types of petroleum recovery devices for use in GFNMS and CBNMS.

General Education and Outreach Recommendations

1. The GFNMS and CBNMS Superintendents need to establish an annual coordination meeting with NOAA ERD and ARD, EPA, USCG and OSPR on coordinating the San Francisco Bay-Delta Contingency Plan pre-spill planning with the Sanctuary roles/response coordination.

2. The GFNMS and CBNMS Superintendents in coordination with OSPR need to develop an oil spill and response outreach plan for county and local governments that border the GFNMS in order to foster communication and awareness and to establish pre-spill working relationships.

3. The GFNMS and CBNMS Superintendents need to schedule an annual USCG and NOAA OR&R briefing at the joint SAC Meeting to provide SAC members updates on spill modeling, cleanup technologies, dispersants exposure research, non-toxic dispersant development or any emerging news on oil spill containment and response such as gelling agents, emulsion breakers, improved chemical spreading additives to enhance physical mixing/dispersant effectiveness.

General Policy and Management Recommendations

1. Seek funding to complete the SW ERMA placing a priority on the GFNMS and CBNMS and in the process of building data sets. Identify the highest priority/most sensitive species at risk during an oil spill for inclusion in the SW ERMA.

2. Working with the USCG, EPA and OSPR, develop a standing policy that provides for using commercial fishermen in response and clean-up which takes advantage of local knowledge and expertise to most effectively deploy response assets.

3. The GFNMS and CBNMS Superintendents need to support the development of a specialized NEBA within the Sanctuaries that focuses on specific resources and/or physical events such as seasonal upwelling, and sensitive habitats that support nearshore and subtidal species that are known to be highly sensitive to oil and/or dispersed oil (e.g. Dungeness crab, black and red abalone).

Specific Sanctuary Recommendations

1. Given the Superintendent's role is advisory/consultative to the RRT, the SAC recommends a precautionary approach to any incident response technology. America's National Marine Sanctuaries are "Special Ocean Places", worthy of special national recognition and protection. Any oil spill response decisions in the Sanctuaries waters will require a higher burden of proof of compelling need given the high resource productivity and sensitivity.

2. The Superintendents need to consider a policy of no-aerial spraying area within one mile of the Farallon Islands. If warranted boats would be authorized within one mile to apply dispersant in water >60' deep. In terms of other mainland coastal rookeries, haul-out sites and areas identified as sensitive habitats should follow the provisions of the Wildlife Response Plan.

3. To assist the Superintendents in making decisions on the application of dispersants attention needs to be given to the Sensitive Species Matrix (Appendix V), and that the Matrix is modified as new science-based information is obtained.

4. Provisions need to be made to review additional data collection needs and updating of the Sensitive Species Matrix (Appendix V) should the boundaries of the GFNMS and CBNMS change.

5. It is suggested that the Sanctuary Superintendents request that the appropriate public health entities (e.g. NIH,EPA, Public Health Departments, etc.) provide information regarding the human health effects of oil, dispersants, and dispersed oil on responders and general public. Sanctuary Superintendents consider this information in the deployment of Sanctuary staff and resources while actively supporting the research and development of alternative products for oil spill response (General Science and Research Recommendation #2).

Appendix I: Meeting Agendas

All meetings held at PRBO Conservation Science, 3820 Cypress Drive Petaluma, CA

June 20, 2011
Review WG process, ground rules, and timeline and presentation listed below:

1. **Irina Kogan**, Spill Response Structure and Decision Making Authority
2. **Yvonne Addassi**, Response Technology Overview and Dispersants 101

August 30, 2011
Review oil spill response decision making process as listed below:

1. **Yvonne Addassi**, NEBA overview
2. **Jordan Stout**, Spill Scenario and Trajectory
3. **Ellen Faurot-Daniels**, Simulation of Process for Dispersant Use/Non-use Recommendation Development to the Unified Command

February 2, 2012
Review toxicology of oil and dispersed oil with the speakers listed below:

1. **Ron Tjeerdema,** Toxicological effects of dispersed (and not dispersed) oil on 1) Salmon smolts and adults, 2) Fish larvae (top smelt), 3) Abalone larvae and adults, 4) Zooplankton species (mysids), 5) Kelp, and persistence of dispersants in the environment and bioaccumulation COREXIT ingredients and DOSS (dioctyl sodium sulfosuccinate).
2. **Gary Cherr,** Bodega Marine Lab, UC Davis Oil and Embryos Do Not Mix: Impacts of the Cosco Busan Bunker Fuel Oil Spill on Pacific Herring
3. **Alan Mearns,** Marine Environmental Tradeoffs of Dispersant Operations: Knowns, Unknowns and Dealing with Uncertainty, Toxicological effects of dispersed (and not dispersed) oil on 1) Rockfish, 2) Crab, 3) Oyster, mussels and other mollusks (not abalone), 4) Copepods and krill in water column, 5) Top predators (seabirds, pinnipeds, whales, etc).

March 8, 2012
Review bio-resources in the sanctuaries with the speakers listed below:

1. **Pete Kalvass**, Crab biology and population dynamics, spatial and temporal patterns in distribution, phenology, important times in their development most critical for spill response.
2. **Pete Adams**, Salmon Foraging areas, biology and population dynamics, spatial and temporal patterns in distribution, phenology, important times in their development most critical for spill response.

3. **Pete Warzybok** Birds and mammals, biology and population dynamics, spatial and temporal patterns in distribution, phenology, important times in their development most critical for spill response.

April 12, 2012
Review oceanography in the sanctuaries with the speakers listed below:

1. **John Largier,** Physical oceanography and how local conditions may affect the fate of non-dispersed and dispersed oil in the greater Gulf of the Farallones (currents?). Also currents and larval transport.
2. **Toby Garfield,** Physical oceanography and how local conditions may affect the fate of non-dispersed and dispersed oil in San Francisco Bay due to tides and currents.
3. **Al Venosa,** How deeply dispersed oil will sink? How quickly dispersed oil/dispersant breaks down? How quickly water column concentrations of oil with dispersant decrease to zero? What are the protocols for monitoring the effects of chemically dispersed oil on water column biota?
4. **Glen Watabayashi,** How you predict movement of dispersed oil? What are the parameters you use to predict how quickly the dispersed oil will break down; what can we expect in this region? How confident is NOAA about their predictions for this area? 4) how deeply would dispersed oil sink in this area, what are the local controls?

May 3, 2012
Review, science, outreach, and policy recommendations compiled to date.

May 10, 2012
Review toxicology section and other major changes needed to background document. Review recommendations to date and draft list of sensitive species.

Appendix II: Working Group Member Biographies

Yvonne Addassi is a bright scientist from OSPR who didn't prove a bio.

Sarah G. Allen is program lead for the Coast and Oceans Program of the National Park Service, Pacific West Region. She received her B.S., M.S. and Ph.D. from the University of California, Berkeley. She has been studying marine birds and mammals for more than 35 years, mostly in California. She has served on the Scientific Peer Review Panel of the San Francisco International Airport, the Governing Council of the Central and Northern California Ocean Observing System (CeNCOOS- http://www.cencoos.org/), NOAA Subtidal Habitat working group for San Francisco Bay, and the Science Advisory Team of north-central California Marine Life Protection Act Master Plan.

Richard Charter has worked for the past 34 years on ocean protection issues, including marine spatial planning, congressional liaison activities in support of conservation outcomes, and preventing and mitigating industrial impacts on marine habitats. Richard works with local and state elected officials, the fishing community, and regional and national NGO interests to secure advances in sustainable management of ocean ecosystems, marine and estuarine resource restoration projects, and protection of ocean-based regional economies and public health in the context of offshore oil and gas drilling issues. As Co-Chair of the National Outer Continental Shelf (OCS) Coalition, Richard was involved in initiating and maintaining the twenty-seven-year congressional moratorium on offshore oil and gas leasing which has thus far prevented new drilling along the U.S. West Coast, the Atlantic Coast, and Florida's Gulf Coast, as well as in Alaska's Bristol Bay. Richard also coordinated the local government support that helped to bring about the creation of the Gulf of the Farallones, Cordell Bank, Channel Islands, and Monterey Bay National Marine Sanctuaries. Richard serves on the Department of Energy's Methane Hydrates Advisory Committee FACA and is serving in his second term as chair of the Gulf of the Farallones Sanctuary Advisory Council.

Ellen Faurot-Daniels has a BA in Biological Sciences and an MS in Marine Science. Past work includes various CDFG projects (1979-90), environmental group Science Director (1992-97), university research assistant (1997-98), Oiled Wildlife Care Network (1997-98), and supervisor of the California Coastal Commission Oil Spill Program (1998-2009). She has been actively involved in oil spill prevention and response planning since 1992, was a working group member for various NMS planning teams, and was a stakeholder on two MLPA workgroups. One of her several oil spill responses included the Deepwater Horizon. She has been with CDFG-OSPR since 2009, coordinating the licensing and use of oil spill cleanup agents, the development of statewide policies for the use of applied response technologies, and serving as technical specialist for both ART and fishery closures during oil spills.

Joe Dillon is the Southwest Regional Water Quality Coordinator for NOAA's National

Marine Fisheries Service (NMFS). He has been with NMFS since 1999 serving in a number of capacities involving water quality, toxicology and fate and transport of pollutants. He was designated the NMFS oil spill responder for California in 2002 and continues to be the main NMFS point of contact for these issues from Monterey County north to the Oregon border (inclusive).

Barbara Emley started commercial fishing with her husband (Larry Collins) in 1985. She has fished for Salmon, Crab, Albacore and Rockfish using hook and line and traps. Barbara represents commercial fishing on the GFNMS SAC. She also is on the board of the Institute for Fisheries Resources (IFR); Pacific Coast Federation of Fishermen's Associations (PCFFA); and the California Salmon Council. Barbara is the public Commissioner for California on the Pacific States Marine Fisheries Commission (PSMFC). She and her husband worked together to form the San Francisco Community Fishing Association which just finished its first year of operation.

Jaime Jahncke joined PRBO in 2004. He received his Ph.D. in Biological Sciences from the University of California Irvine (2004). Jaime's doctorate research focused on how physical processes associated with coastal waters affect the abundance and distribution of marine birds in Peru and Alaska. Jaime's current research focuses on the spatial and temporal relationships between oceanographic processes, zooplankton, and marine birds and mammals in the region surrounding Cordell Bank and the Gulf of the Farallones. Jaime is the lead Principal Investigator for the Applied California Current Ecosystem Studies (ACCESS) Partnership between PRBO, NOAA's Cordell Bank and Gulf of the Farallones National Marine Sanctuaries and several agencies and academic institutions. He currently participates on both Cordell Bank and Gulf of the Farallones National Marine Sanctuaries Sanctuary Advisory Councils (Primary for Cordell Bank and alternate for Gulf of the Farallones).

Gerry McChesney has a B.A. in Biology with a focus in Marine Sciences, U.C. Santa Cruz, 1988. M.S. in Biology (Conservation Biology), Sacramento State University, 1997. He has been studying seabirds in California since 1986, focusing on breeding population surveys and breeding biology but also has conducted studies of at-sea distribution. Wildlife Biologist for Humboldt State University from 1989-2002. Has worked for the U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, since 2002. Since 2002, has managed the Refuge's seabird restoration program and since 2008 has also managed the Farallon National Wildlife Refuge.

Patrick Rutten has worked for NOAA for 35 years in ocean, coastal/estuarine research, and management positions within NOAA and NMFS. His career has focused on California fisheries and coastal habitat management. After 21 years of sea service in the Gulf of Alaska, Bering Sea, eastern Pacific and Hawaii with the NOAA Corps he retired in 1995 at the rank of Commander to assume the Central California Field Supervisor for NMFS, Protected Resources Division. In 2004 he took a new position with the NOAA Restoration Center as Southwest Field Supervisor for California and the Pacific Islands administering the Community-based Restoration Program and Damage Assessment and Remediation Program. Mr. Rutten has a B.S., Marine Biology, Cal Poly San Luis Obispo, CA, and a M.S. Management, Naval Postgraduate School, Monterey, CA.

Deb Self is Executive Director of San Francisco Baykeeper, an organization dedicated to protecting San Francisco Bay from pollution. Deb [d1] is Vice Chair of California's Office of Spill Preparedness and Response Technical Advisory Committee and is a member of the San Francisco Harbor Safety Committee. Deb also serves as Chair of the Waterkeeper Alliance, an international movement of on-the-water advocates for fishable, swimmable, drinkable waters, and is a Board member of the California Coastkeeper Alliance, the statewide affiliation of Waterkeeper organizations. Deb has a Masters in sociology focused on environmental justice and holds a bachelors degree in geology.

Jordan Stout currently serves as the NOAA Scientific Support Coordinator (SSC) here in California where he provides scientific & technical support to USCG & EPA for oil spills & hazmat releases. He has been involved in many significant incidents/responses in California and throughout the nation, including: *SS Montebello* assessment, Japanese Tsunami response, *MODU Deepwater Horizon* (MC252), *T/V Dubai Star*, *M/V Selendang Ayu*, *M/V Cosco Busan*, Sacramento River Humpback Whales, Hurricane *Katrina*, and numerous others. Jordan also serves as NOAA's representative on RRT-9 and the MEXUS-PAC Joint Response Team. Jordan has prior work experience with the USFWS' Environmental Contaminants Program in Alaska and with Miami-Dade County's Department of Environmental Resources Management. He holds a Master's of Environmental Management from Duke University's Nicholas School of the Environment (Focus: Environmental Toxicology & Risk Assessment) and a BS from the University of Miami (Double-major: Marine Science & Biology; Minor: Chemistry).

Bob Wilson is active in a number of environmental organizations. He is the former Chair of the Farallones Marine Sanctuary Association board, an acting executive director and is currently CFO. He has been an active Beachwatch and SEALS volunteer. He is on the GFNMS Sanctuary Advisory Council. He is a director emeritus of The Marine Mammal Center, is currently Policy Laison for TMMC and is an animal care and rescue volunteer. Bob is on the audit committee of the Desert Tortoise Preserve Committee. He is also on the advisory board of the Snow Leopard Conservancy. He is an attorney and retired from the Federal government.

Lieutenant Commander Blanca Rosas reported to her current position as the Chief of Incident Management Division (IMD) at Sector San Francisco in July of 2011, having completed a staff assignment as Chief of the Officers Promotions Section at Personnel Service Center (OPM-1) in Arlington, VA. LCDR Rosas joined the Coast Guard through the College Student Pre-Commissioning Initiative program in 1997. She acquired her commission as an Ensign from Officer Candidate School
in February of 2000. Her prior positions include Marine Environmental Protection Chief

at Sector Delaware Bay, Philadelphia and Contingency Planner / IMD Deputy Chief at Sector San Juan, Puerto Rico. LCDR Rosas has a B. S. in Computer Science from the University of Puerto Rico. Her military awards include the Coast Guard Commendation medal, two Achievement medals and various team awards.

Michael Carver is the Deputy Superintendent for Cordell Bank National Marine Sanctuary. Michael has been with Cordell Bank National Marine Sanctuary since 2000. Michael started the sanctuary's monthly at sea monitoring program and managed it for several years before moving on. Michael's responsibilities include overseeing enforcement, permitting, planning, and management actions to address threats to the Sanctuary. Michael also provides engineering support for sanctuary field operations, and serves as the staff lead on emergency response issues. In addition, Michael coordinates annual budget planning and execution, interagency agreements, manages contracts, and works closely with the sanctuary superintendent to ensure smooth operation of the sanctuary.

Irina Kogan is the Oil Spill Response Coordinator and Permit Coordinator at the Gulf of the Farallones National Marine Sanctuary. She has experience responding to oil spills and an academic background in Geology and Geochemistry. Irina's spill response and preparedness activities include representing the GFNMS at ACP and RRT meetings and ensuring GFNMS staff are prepared to participate in spill response activities affecting the sanctuaries.

Appendix III: Invited Speaker Biographies

Dr. Ron Tjeerdema received his PhD in Pharmacology & Toxicology from UC Davis. Initially a faculty member in the Department of Chemistry & Biochemistry at UC Santa Cruz, he is now Professor and Chair of the Department of Environmental Toxicology at UCD. He also currently holds the Donald G. Crosby Endowed Chair in Environmental Chemistry, and is certified in General Toxicology by the American Board of Toxicology. In over 25 years, Dr. Tjeerdema has attracted some $30 million in extramural research support and published in excess of 200 peer-reviewed research articles. His areas of expertise range from chemical fate in the environment, sensitive lifestage bioassays and biochemical mechanisms of toxicity. He has worked extensively with pesticides, marine planktonic toxins, and petroleum hydrocarbons and dispersants. Due to his extensive work with dispersants and dispersed oil, Dr. Tjeerdema served on the NOAA panel that recommended dispersant injection during the Gulf Oil Spill. He has since served on panels regarding the Gulf Spill for NOAA, EPA and NCEAS, and provided testimony to both the House of Representatives Subcommittee on Natural Resources and the President's Oil Spill Commission; he continues as an advisor to the California Office of Spill Prevention & Response. Dr. Tjeerdema is an Editor-in-Chief of Aquatic Toxicology, and serves on the editorial boards of the Reviews of Environmental Contamination & Toxicology, Marine Pollution Bulletin and Bulletin of Environmental Contamination & Toxicology.

Dr. Gary Cherr received his Ph.D. from the University of California Davis, was an NIH postdoctoral fellow, and has worked in reproductive and developmental toxicology for over 25 years. Dr. Cherr is Professor of Environmental Toxicology and Nutrition at the University of California Davis, and is currently the Director of the University of California Davis' Bodega Marine Laboratory. His laboratory studies stressor impacts on marine invertebrates and vertebrates, and embryo defenses to chemical stressors. Dr. Cherr's laboratory has investigated the impacts of salinity stress and petroleum hydrocarbons on fish embryos in S.F. Bay for over 20 years. His group was the first to show that creosote-treated wood pier pilings were toxic to herring embryos. Dr. Cherr serves on the Exxon Valdez Oil Spill Trustee Council's Science Panel, is a member of the National Center for Ecological Analysis and Synthesis' Gulf Oil Spill Working Group, and his laboratory participated in the NRDA for the 2007 Cosco Busan fuel oil spill in San Francisco Bay.

Dr. Alan Mearns is a marine ecologist and Senior Staff Scientist with NOAA's national Emergency Response and Division (ERD) in Seattle, Washington. He supports NOAA's regional Scientific Support Coordinators (SSC's) and U.S. Coast Guard Sector Offices during spills of oil and hazardous materials. Alan received his B.Sc. and M.A. degrees in Biology from California State University at Long Beach, and his Ph.D. in Fisheries from the University of Washington. During the 1970's, he was Leader of the Biology Division at the Southern California Coastal Water Research Project (SCCWRP) where his team pioneered studies on the effects and ecological tradeoffs of wastewater treatment for large ocean sewage outfalls. He joined NOAA in Seattle in 1980 serving as Ecologist for the Puget Sound MESA (Marine EcoSystem Assessment) Program. During the mid- and late 1980's he helped develop the NOAA National Status and Trends Program and continues to support the National Mussel Watch. In 1989 Alan participated in the first assessment surveys of the Exxon Valdez Oil Spill in Prince William Sound, then joined the ERD team in Seattle. Alan has provided support to NOAA and the US Coast Guard for dozens of major spill responses around the US and internationally. He provided 24/7 support on the 2010 Deepwater Horizon spill including focus on assessment of dispersant operation effectiveness and effects. Alan was Vice-Chair of the Technical Advisory Committee for the Santa Monica Bay Restoration Project, and a member of the Committee of Science Advisors for the San Francisco Estuary Institute (SFEI). In 1999 and again in 2004 Alan had the privilege of serving on both the 5- and 10-year science advisory board review committees for the San Francisco Bay Toxic Substances Monitoring Program conducted by SFEI. He also provided technical support on wastewater management for the Alaska Cruise Ship Initiative. Alan is a member of the Science and Technical Committee of the Oil Spill Recovery Institute (OSRI) in Cordova, Alaska. Dr. Mearns received the 1985 Biology Alumnus of the Year Award from California State University at Long Beach, a 1992 Silver Medal from the US Department of Commerce for work on the Exxon Valdez oil spill response and is listed in American Men and Women of Science.

Pete Kalvass - California Department of Fish and Game, Marine Region

Pete Adams, is the recently retired Fisheries Investigation Chief of the Southwest Fisheries Science Center, National Marine Fisheries Service, Santa Cruz, California, U.S.A., where he had overall responsibility for providing scientific advice on Southwest salmon and groundfish, the Endangered Species Act (ESA), and harvest management. His personal research focus has been on: (1) assessing population viability under the ESA, (2) harvest advice including the use of life history theory, (3) sample survey design, and (4) methods to communicate the level of uncertainty associated with estimates to decision makers.

Pete Warzybok, joined PRBO a volunteer seabird research assistant on the Farallon Islands in the spring of 2000, and was hired as a seabird biologist the following year. Prior to coming to PRBO, he worked on a waterfowl management project in surburban NY, and on seabird monitoring projects with USGS in Alaska and USFWS in Maine. Pete received his B.S. in biology from the State University of New York at Purchase in 1996, where his undergraduate research focused on geographic variation in the song of Brown-headed Cowbirds. His current research interests include diet, prey availability, and ecosystem variability and their effects on the breeding success and population dynamics of Farallon seabirds.

Dr. John Largier John Largier is Professor of Coastal Oceanography at the University of

California Davis (UCD), resident at Bodega Marine Laboratory. Prior to 2004, he was Research Oceanographer at Scripps Institution of Oceanography. He has also held positions at the University of Cape Town and the National Research Institute for Oceanology (CSIR) in South Africa. His research, teaching and public service is motivated by contemporary environmental issues and centered on the role of transport in ocean, bay, nearshore and estuarine waters. His work has addressed transport of plankton, larvae, contaminants, pathogens, heat, salt, nutrients, dissolved oxygen, and sediment – and he places this work in the context of issues as diverse as marine reserves, fisheries, mariculture, beach pollution, wastewater discharge, wildlife health, desalination, river plumes, coastal power plants, kelp forests, wetlands, marine mining, coastal zone management and impacts of coastal development. At UCD he heads the 16-person Coastal Oceanography Group. Dr Largier is a leader in developing the field of "environmental oceanography" through linking traditional oceanographic study to critical environmental issues. Dr Largier serves on the Science Advisory Team for the California Marine Life Protection Act (MLPA), the Governing Council for CeNCOOS (Central and Northern California Ocean Observing System), the Sanctuary Advisory Committee for the Gulf of Farallones, and several other advisory boards. He is president of the California Estuarine Research Society. In 2002-2004, Dr Largier played a significant role in advising the state on beach pollution and in the late 1990's, he played a key role in developing the knowledge foundation for the new coastal zone management policy in South Africa. He is an Aldo Leopold Leadership Fellow. Following undergraduate studies in Maths and Physics, he obtained a Ph.D. in Oceanography from the University of Cape Town (South Africa) in 1987.

Toby Garfield, my research focus is ocean current circulation along the continental margin, the region from the shore out to and beyond the continental shelves and slopes. Using both traditional tools and the new technologies of satellites and autonomous sampling vehicles I have studied the ocean circulation in the Gulf of Maine, the Brazil Current at tropical latitudes and the shelf and slope circulation between Pt. Sur and Bodega California. In addition I have conducted two studies in the Gulf of the Farallones and studied the California Undercurrent, a current that flows poleward, carrying subtropical water north into the North Pacific. Presently I am working with the CA Coastal Conservancy to establish a network of surface current monitoring instruments that will measure the coastal ocean circulation along the whole California coast and provide maps and data on the web in near real time

Albert D. Venosa, Director of Land Remediation and Pollution Control Division in EPA's National Risk Management Research Laboratory, Cincinnati, Ohio. For the past 20 years, Al has led EPA's oil spill research and development program to conduct basic and applied research in both the laboratory and the field in the area of spill response technology development. Al was an EPA team leader in the Exxon Valdez bioremediation project in 1989 and 1990. Al also conceived and led an important controlled oil spill project on the shoreline of Delaware Bay in 19941, which demonstrated statistically that bioremediation with simple inorganic nutrients enhances the biodegradation rate of crude oil on a marine shoreline compared to natural attenuation without amendments. Al repeated a similar experiment in 1999 on a Quebec freshwater wetland and again in 2001 on a Nova Scotia salt marsh in collaboration with our Canadian government partners. In addition to those field studies, Al led a research team in developing laboratory protocols to test the effectiveness of commercial bioremediation agents and chemical dispersant products for use in treating oil spills. Al I have conceived and led numerous other studies to understand how best to respond to and mitigate oil spills on land.

Glen Watabayashi, is the lead physical oceanographer for NOAA's Emergency Response Division (ERD) of the Office of Response and Restoration (OR&R). Glen started working for NOAA on modeling currents in 1974 while at the U. of W. School of Oceanography. Glen has worked on a number of high profile oil spills including: IXTOC ('79), Exxon Valdez ('89), First Gulf War('91), Deep Water Horizon ('10). Glen has also lent his expertise to other projects including the search for black box from Korean Airlines 007('83), the debris field from JFK Jr. airplane crash ('99) and the debris field from Japan tsunami debris ('12). In addition to this work Glen has also made significant computer code contributions for: ALOHA (1,2,3,4,5) OSSM (original oil spill model) ADIOS I. Glen, grew up in Honolulu, went to Columbia University for a BA and received his masters in physical oceanography from University of Washington.

Appendix IV: List of Marine Species of GFNMS and CBNMS

Important definitions

Sensitivity to oil: Species likely to have strong negative population effects due to a localized oiling event
More benefit from dispersants: Species likely to benefit from removing spilled oil from the surface of the ocean, or from reducing the amount of oil likely to hit the shoreline
More harm from dispersants: Species likely to be affected by the oil dispersed in the water column
Endangered Species Listing: Species currently included in the Federal endangered species list andin the California lists of species of special concern
Breeds locally: Species that breed within the Sanctuaries
Reason: The specific reason why the working group decided a species was sensitive to oil and would (or would not) benefit from dispersants

VERTEBRATES

Mammals

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Balaenoptera musculus	Blue Whale	Low	yes	no	E	no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion, oiling of baleen
Balaenoptera physalus	Fin Whale	Low	yes	no	E	no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion, oiling of baleen
Balaenoptera borealis	Sei Whale	Low	yes	no	E	no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion, oiling of baleen
Balaenoptera acutorostrata	Minke Whale	Low	yes	no		yes	Potentially affected by oil fumes, direct and indirect effects of oil ingestion, oiling of baleen
Megaptera novaeangliae	Humpback Whale	Low	yes	no	E	no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion, oiling of baleen
Eschrichtius robustus	Gray Whale	Low	yes	no	D	yes	Potentially affected by oil fumes, direct and indirect effects of oil ingestion,

							oiling of baleen
Eubalaena glacialis	Northern Right Whale	Low	yes	no	E	no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion, oiling of baleen
Phocoena phocoena	Harbor Porpoise	Medium	yes	no		yes	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Phocoenoides dalli	Dall's Porpoise	Low	yes	no		yes	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Lagenorhynchus obliquidens	Pacific White-sided Dolphin	Low	yes	no		yes	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Lissodelphis borealis	Northern Right Whale Dolphin	Low	yes	no		yes	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Delphinus delphis	Short-beaked Common Dolphin	Low	yes	no		no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Delphinus capensis	Long-beaked Common Dolphin	Low	yes	no		no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Tursiops truncatus	Bottlenose Dolphin	Low	yes	no		yes	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Stenella coeruleoalba	Striped Dolphin	Low	yes	no		no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Stenella attenuata	Spotted Dolphin	Low	yes	no		no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Steno bredanensis	Rough-toothed Dolphin	Low	yes	no		no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Grampus griseus	Risso's Dolphin	Low	yes	no		no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Orcinus orca	Killer Whale	Low	yes	no	E	no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Globicephala macrorhynchus	Short-finned Pilot Whale	Low	yes	no		no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Physeter macrocephalus	Sperm Whale	Low	yes	no	E	no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Kogia breviceps	Pygmy Sperm Whale	Low	yes	no		no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Kogia simus	Dwarf Sperm Whale	Low	yes	no		no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Ziphius cavirostris	Cuvier's Beaked Whale	Low	yes	no		no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Berardius bairdii	Baird's Beaked Whale	Low	yes	no		no	Potentially affected by oil fumes, direct

							and indirect effects of oil ingestion
Mesoplodon calrhubbsi	Hubb's Beaked Whale	Low	yes	no		no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Mesoplodon densirostris	Blainsville's Beaked Whale	Low	yes	no		no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Mesoplodon stejnegeri	Steineger's Beaked Whale	Low	yes	no		no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Eumetopius jubatus	Steller Sea Lion	Medium	yes	no	T	yes	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Zalophus califorianus	California Sea Lion	Medium	yes	no		yes	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Callorhinus ursinus	Northern Fur Seal	High	yes	no		yes	Oil effects on insulation, direct and indirect effects of oil ingestion
Arctocephalus townsendi	Guadalupe Fur Seal	High	yes	no	T	no	Oil effects on insulation, direct and indirect effects of oil ingestion
Mirounga angustirostris	Northern Elephant Seal	Medium	yes	no		yes	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Phoca vitulina	Harbor Seal	Medium	yes	no		yes	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Enhydra lutris	Sea Otter	High	yes	no		yes	Oil effects on insulation, direct and indirect effects of oil ingestion
Lantra canadensis	River Otter	Low	yes	no		yes	Estuarine species and studies shown low sensitivity

Birds

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Gavia stellata	Red-throated Loon	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Gavia pacifica	Pacific Loon	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Gavia immer	Common Loon	High	yes	no	SC	no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Gavia adamsii	Yellow-billed Loon	High	yes	no		no	Typical feather and ingestion effects,

							experience shows frequent oiling during oil spills
Podilymbus podiceps	Pied-billed Grebe	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Podiceps auritus	Horned Grebe	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Podiceps grisegena	Red-necked Grebe	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Podiceps nigricollis	Eared Grebe	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Aechmophorus occidentalis	Western Grebe	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Aechmophorus clarkii	Clark's Grebe	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Phoebastria immutabilis	Laysan Albatross	High	yes	no		yes	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Phoebastria nigripes	Black-footed Albatross	High	yes	no		yes	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Phoebastria albatrus	Short-tailed Albatross	High	yes	no	E	no	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Fulmarus glacialis	Northern Fulmar	High	yes	no		no	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Pterodroma ultima	Murphy's Petrel	High	yes	no		no	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Pterodroma inexpectata	Mottled Petrel	High	yes	no		no	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Pterodroma phaeopygia	Dark-rumped Petrel	High	yes	no	E	no	Oil effects on insulation, inhalation,

							direct and indirect effects of oil ingestion
Puffinus creatopus	Pink-footed Shearwater	High	yes	no		no	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Puffinus carneipes	Flesh-footed Shearwater	High	yes	no		no	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Puffinus bulleri	Buller's Shearwater	High	yes	no		no	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Puffinus griseus	Sooty Shearwater	High	yes	no		no	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Puffinus tenuirostris	Short-tailed Shearwater	High	yes	no		no	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Puffinus puffinus	Manx Shearwater	High	yes	no		no	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Puffinus opisthomelas	Black-vented Shearwater	High	yes	no		no	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Oceanites oceanicus	Wilson's Storm-Petrel	High	yes	no		no	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Oceanodroma furcata	Fork-tailed Storm-Petrel	High	yes	no		no	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Oceanodroma leucorhoa	Leach's Storm-Petrel	High	yes	no		yes	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Oceanodroma homochroa	Ashy Storm-Petrel	High	yes	no	SC	yes	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Oceanodroma melania	Black Storm-Petrel	High	yes	no		no	Oil effects on insulation, inhalation, direct and indirect effects of oil ingestion
Phaethon aethereus	Red-billed Tropicbird	Low	no	no		no	Low probability of being oiled

Phaethon rubricauda	Red-tailed Tropicbird	Low	no	no		no	Low probability of being oiled
Sula dactylatra	Masked Booby	Low	no	no		no	Low probability of being oiled
Sula leucogaster	Brown Booby	Low	no	no		no	Low probability of being oiled
Sula sula	Red-footed Booby	Low	no	no		no	Low probability of being oiled
Pelecanus occidentalis	Brown Pelican	High	yes	no	D	no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Pelecanus erythrorhynchos	American White Pelican	Medium	yes	no		no	Moderate probability of being oiled
Phalacrocorax penicillatus	Brandt's Cormorant	High	yes	no		yes	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Phalacrocorax auritus	Double-crested Cormorant	High	yes	no		yes	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Phalacrocorax pelagicus	Pelagic Cormorant	High	yes	no		yes	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Fregata magnificens	Magnificent Frigatebird	Low	no	no		no	Low probability of being oiled
Fregata minor	Great Frigatebird	Low	no	no		no	Low probability of being oiled
Botaurus lentiginosus	American Bittern	Medium	yes	no	SC	no	Moderate probability of being oiled
Ardea herodias	Great Blue Heron	Medium	yes	no		no	Moderate probability of being oiled
Ardea alba	Great Egret	Medium	yes	no		no	Moderate probability of being oiled
Egretta thula	Snowy Egret	Medium	yes	no		no	Moderate probability of being oiled
Butorides virescens	Green Heron	Medium	yes	no		no	Moderate probability of being oiled
Nycticorax nycticorax	Black-crowned Night-Heron	Medium	yes	no		no	Moderate probability of being oiled
Cathartes aura	Turkey Vulture	High	yes	no		no	Typical feather and ingestion effects
Branta canadensis	Canada Goose	Medium	yes	no	D	no	Typical feather and ingestion effects
Branta bernicla	Brant	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Anas strepera	Gadwall	Medium	yes	no		no	Moderate probability of being oiled
Anas penelope	Eurasian Wigeon	Medium	yes	no		no	Moderate probability of being oiled
Anas americana	American Wigeon	Medium	yes	no		no	Moderate probability of being oiled
Anas platyrhynchos	Mallard	Medium	yes	no		no	Moderate probability of being oiled
Anas discors	Blue-winged Teal	Medium	yes	no		no	Moderate probability of being oiled

Anas cyanoptera	Cinnamon Teal	Medium	yes	no		no	Moderate probability of being oiled
Anas clypeata	Northern Shoveler	Medium	yes	no		no	Moderate probability of being oiled
Anas acuta	Northern Pintail	Medium	yes	no		no	Moderate probability of being oiled
Anas crecca	Green-winged Teal	Medium	yes	no		no	Moderate probability of being oiled
Aythya marila	Greater Scaup	Medium	yes	no		no	Moderate probability of being oiled
Aythya affinis	Lesser Scaup	Medium	yes	no		no	Moderate probability of being oiled
Histrionicus histrionicus	Harlequin Duck	High	yes	no	SC	no	Typical feather and ingestion effects
Melanitta perspicillata	Surf Scoter	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Melanitta fusca	White-winged Scoter	High	yes	no		no	Typical feather and ingestion effects
Melanitta nigra	Black Scoter	High	yes	no		no	Typical feather and ingestion effects
Clangula hyemalis	Long-tailed Duck (Oldsquaw)	High	yes	no		no	Typical feather and ingestion effects
Bucephala albeola	Bufflehead	Medium	yes	no		no	Typical feather and ingestion effects
Bucephala clangula	Common Goldeneye	Medium	yes	no		no	Typical feather and ingestion effects
Mergus serrator	Red-breasted Merganser	High	yes	no		no	Typical feather and ingestion effects
	Common Merganser	Medium	yes	no		no	Moderate probability of being oiled
Oxyura jamaicensis	Ruddy Duck	Medium	yes	no		no	Moderate probability of being oiled
Pandion haliaetus	Osprey	High	yes	no		yes	Typical feather and ingestion effects
Haliaeetus leucocephalus	Bald Eagle	High	yes	no	T	yes	Typical feather and ingestion effects
	Golden Eagle	High	yes	no		yes	Typical feather and ingestion effects
Circus cyaneus	Northern Harrier	High	yes	no		yes	Typical feather and ingestion effects
Falco columbarius	Merlin	High	yes	no		yes	Typical feather and ingestion effects
Falco peregrinus	Peregrine Falcon	High	yes	no	D	yes	Typical feather and ingestion effects
Laterallus jamaicensis	Black Rail	Medium	yes	no	C	no	Moderate probability of being oiled
Rallus limicola	Virginia Rail	Medium	yes	no		no	Moderate probability of being oiled
Coturnicops noveboracensis	Yellow Rail	Medium	yes	no		no	Moderate probability of being oiled
Porzana carolina	Sora	Medium	yes	no		no	Moderate probability of being oiled
Fulica americana	American Coot	Medium	yes	no		no	Moderate probability of being oiled
Pluvialis squatarola	Black-bellied Plover	High	yes	no		no	Typical feather and ingestion effects
Charadrius alexandrinus	Snowy Plover	High	yes	no	T	yes	Typical feather and ingestion effects
Charadrius semipalmatus	Semipalmated Plover	High	yes	no		no	Typical feather and ingestion effects
Charadrius vociferus	Killdeer	Medium	yes	no		no	Moderate probability of being oiled
Haematopus bachmani	Black Oystercatcher	High	yes	no	SC	no	Typical feather and ingestion effects

Recurvirostra americana	American Avocet	High	yes	no		no	Typical feather and ingestion effects
Tringa melanoleuca	Greater Yellowlegs	High	yes	no		no	Typical feather and ingestion effects
Catoptrophorus semipalmatus	Willet	High	yes	no		no	Typical feather and ingestion effects
Heteroscelus incanus	Wandering Tattler	High	yes	no		no	Typical feather and ingestion effects
Actitis macularia	Spotted Sandpiper	High	yes	no		no	Typical feather and ingestion effects
Numenius phaeopus	Whimbrel	High	yes	no	SC	no	Typical feather and ingestion effects
Numenius americanus	Long-billed Curlew	High	yes	no	SC	no	Typical feather and ingestion effects
Limosa fedoa	Marbled Godwit	High	yes	no	SC	no	Typical feather and ingestion effects
Arenaria interpres	Ruddy Turnstone	High	yes	no		no	Typical feather and ingestion effects
Arenaria melanocephala	Black Turnstone	High	yes	no	SC	no	Typical feather and ingestion effects
Aphriza virgata	Surfbird	High	yes	no		no	Typical feather and ingestion effects
Calidris canutus	Red Knot	High	yes	no	SC	no	Typical feather and ingestion effects
Calidris alba	Sanderling	High	yes	no		no	Typical feather and ingestion effects
Calidris mauri	Western Sandpiper	High	yes	no		no	Typical feather and ingestion effects
Calidris minutilla	Least Sandpiper	High	yes	no		no	Typical feather and ingestion effects
Calidris ptilocnemis	Rock Sandpiper	High	yes	no		no	Typical feather and ingestion effects
Calidris alpina	Dunlin	High	yes	no		no	Typical feather and ingestion effects
Limnodromus griseus	Short-billed Dowitcher	High	yes	no		no	Typical feather and ingestion effects
Limnodromus scolopaceus	Long-billed Dowitcher	High	yes	no		no	Typical feather and ingestion effects
Gallinago gallinago	Common Snipe	High	yes	no		no	Typical feather and ingestion effects
Phalaropus lobatus	Red-necked Phalarope	High	yes	no		no	Typical feather and ingestion effects
	Wilson's Phalarope	High	yes	no		no	Typical feather and ingestion effects
Phalaropus fulicaria	Red Phalarope	High	yes	no		no	Typical feather and ingestion effects
Catharacta maccormicki	South Polar Skua	Low	no	no		no	Low probability of being oiled
Stercorarius pomarinus	Pomarine Jaeger	Low	no	no		no	Low probability of being oiled
Stercorarius parasiticus	Parasitic Jaeger	Low	no	no		no	Low probability of being oiled
Stercorarius longicaudus	Long-tailed Jaeger	Low	no	no		no	Low probability of being oiled
Larus philadelphia	Bonaparte's Gull	High	yes	no		no	Typical feather and ingestion effects
Larus heermanni	Heermann's Gull	High	yes	no		no	Typical feather and ingestion effects
Larus canus	Mew Gull	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Larus delawarensis	Ring-billed Gull	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling

							during oil spills
Larus californicus	California Gull	High	yes	no		yes	Typical feather and ingestion effects
Larus argentatus	Herring Gull	High	yes	no		no	Typical feather and ingestion effects
Larus thayeri	Thayer's Gull	High	yes	no		no	Typical feather and ingestion effects
Larus occidentalis	Western Gull	High	yes	no		yes	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Larus glaucescens	Glaucous-winged Gull	High	yes	no		no	Typical feather and ingestion effects
Larus hyperboreus	Glaucous Gull	High	yes	no		no	Typical feather and ingestion effects
Xema sabini	Sabine's Gull	High	yes	no		no	Typical feather and ingestion effects
Creagrus furcatus	Swallow-tailed Gull	High	yes	no		no	Typical feather and ingestion effects
Rissa tridactyla	Black-legged Kittiwake	High	yes	no		no	Typical feather and ingestion effects
Sterna caspia	Caspian Tern	High	yes	no		yes	Typical feather and ingestion effects
Sterna elegans	Elegant Tern	High	yes	no		yes	Typical feather and ingestion effects
Sterna hirundo	Common Tern	High	yes	no		no	Typical feather and ingestion effects
Sterna paradisaea	Arctic Tern	High	yes	no		no	Typical feather and ingestion effects
Sterna forsteri	Forster's Tern	High	yes	no		no	Typical feather and ingestion effects
Sterna antillarum browni	Least Tern	High	yes	no	E	yes	Typical feather and ingestion effects
Uria aalge	Common Murre	High	yes	no		yes	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Uria lomvia	Thick-billed Murre	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Cepphus columba	Pigeon Guillemot	High	yes	no		yes	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Brachyramphus marmoratus	Marbled Murrelet	High	yes	no	T	no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Brachyramphus perdix	Long-billed Murrelet	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Synthliboramphus hypoleucus	Xantus's Murrelet	High	yes	no	SC	no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills

Synthliboramphus craveri	Craveri's Murrelet	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Synthliboramphus antiquus	Ancient Murrelet	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Ptychoramphus aleuticus	Cassin's Auklet	High	yes	no	SC	yes	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Aethia psittacula	Parakeet Auklet	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Aethia pusilla	Least Auklet	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Aethia cristatella	Crested Auklet	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Cerorhinca monocerata	Rhinoceros Auklet	High	yes	no		yes	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Fratercula corniculata	Horned Puffin	High	yes	no		no	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Fratercula cirrhata	Tufted Puffin	High	yes	no		yes	Typical feather and ingestion effects, experience shows frequent oiling during oil spills
Asio flammeus	Short-eared Owl	Low	no	no		no	Low probability of being oiled
Ceryle alcyon	Belted Kingfisher	Medium	yes	no		yes	Moderate probability of being oiled
Sayornis nigricans	Black Phoebe	Low	no	no		no	Low probability of being oiled
Sayornis saya	Say's Phoebe	Low	no	no		no	Low probability of being oiled
Corvus corax	Common Raven	Medium	yes	no		yes	Typical feather and ingestion effects
Corvus brachyrhynchos	Common crow	Low	yes	no		yes	Low probability of being oiled
Eremophila alpestris	Horned Lark	Low	no	no		no	Low probability of being oiled
Tachycineta bicolor	Tree Swallow	Low	no	no		no	Low probability of being oiled
Stelgidopteryx serripennis	Northern Rough-winged Swallow	Low	no	no		no	Low probability of being oiled

Petrochelidon pyrrhonota	Cliff Swallow	Low	no	no		no	Low probability of being oiled
Hirundo rustica	Barn Swallow	Low	no	no		no	Low probability of being oiled
Salpinctes obsoletus	Rock Wren	Low	no	no		no	Low probability of being oiled
Cistothorus palustris	Marsh Wren	Low	no	no		no	Low probability of being oiled
Anthus rubescens	American Pipit	Low	no	no		no	Low probability of being oiled
Dendroica coronata	Yellow-rumped Warbler	Low	no	no		no	Low probability of being oiled
Passerculus sandwichensis	Savannah Sparrow	Low	no	no		no	Low probability of being oiled
Melospiza melodia	Song Sparrow	Low	no	no		no	Low probability of being oiled
Melospiza georgiana	Swamp Sparrow	Low	no	no		no	Low probability of being oiled
Agelaius phoeniceus	Red-winged Blackbird	Low	no	no		no	Low probability of being oiled
Sturnella neglecta	Western Meadowlark	Low	no	no		no	Low probability of being oiled

Fish

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Eptatretus deani	Black Hagfish						
Eptatretus stoutii	Pacific Hagfish						
Lampreta tridentata	Pacific Lamprey	Medium	yes	no	SC	yes	Effects of smothering of oil inside estuaries on eggs and larvae
Lampetra ayersii	Western River Lamprey						
Hydrolagus colliei	Spotted Ratfish						
Hexanchus griseus	Bluntnose Sixgill Shark						
Notorynchus cepedianus	Broadnose Sevengill Shark						
Echinorhinus cookei	Prickly Shark						
Squalus acanthias	Spiny Dogfish						
Somniosus pacificus	Pacific Sleeper Shark						
Squatina californica	Pacific Angel Shark						
Alopias vulpinus	Thresher Shark						
Cetorhinus maximus	Basking Shark						
Carcharodon carcharias	White Shark	Low	yes	no		yes	Limited potential exposure to oil
Isurus oxyrinchus	Shortfin Mako						
Lamna ditropis	Salmon Shark						
Apristurus brunneus	Brown Catshark						

Apristurus kampae	Longnose Catshark						
Parmaturus xaniurus	Filetail Catshark						
Galeorhinus galeus	Tope or Soupfin Shark						
Mustelus californicus	Gray Smoothhound						
Mustelus henlei	Brown Smoothhound						
Triakis semifasciata	Leopard Shark						
Prionace glauca	Blue Shark						
Torpedo californica	Pacific Electric Ray						
Rhinobatos productus	Shovelnose Guitarfish						
Platyrhinoidis triseriata	Pacific Thornback						
Amblyraja badia	Broad skate						
Bathyraja abyssicola	Deepsea Skate						
Bathyraja interrupta	Sandpaper Skate						
Bathyraja spinosissima	White Skate						
Bathyraja trachura	Black Skate						
Raja binoculata	Big Skate						
Raja inornata	California Skate						
Raja rhina	Longnose Skate						
Raja stellulata	Starry Skate						
Dasyatis dipterura	Diamond Stingray						
Dasyatis violacea	Pelagic Stingray						
Urolophus halleri	Round Stingray						
Myliobatis californica	Bat Ray						
Acipenser medirostris	Green Sturgeon	Low	yes	no	T	yes	Bottom dweller, highly mobile, juveniles of limited concern
Acipenser transmontanus	White Sturgeon						Vulnerability of egg and larvae in the upper water column to dissolved fraction of oil
Albula vulpes	Bonefish						
Ophichthus triserialis	Pacific Snake Eel						
Ophichthus zaphochir	Yellow Snake Eel						
Nemichthys scolopaceus	Slender Snipe Eel						
Serrivomer sector	Sawtooth Snipe Eel						
Cyema atrum	Bobtail Snipe Eel						

Engraulis mordax	Northern Anchovy						
Alosa sapidissima	American Shad						
Clupea pallasii	Pacific Herring	High	yes	no		yes	Toxic effects of oil on eggs at the intertidal
Sardinops sagax	Pacific Sardine						
Argentina sialis	Pacific Argentine						
Bathylagoides wesethi	Snubnose Blacksmelt						
Bathylagus pacificus	Pacific Blacksmelt						
Leuroglossus stilbius	California Smoothtongue						
Lipolagus ochotensis	Popeye Blacksmelt						
Pseudobathylagus milleri	Robust Blacksmelt						
Macropinna microstoma	Pacific Barreleye						
Alepocephalus tenebrosus	California Slickhead						
Talismania bifurcata	Threadfin Slickhead						
Sagamichthys abei	Shining Tubeshoulder						
Allosmerus elongatus	Whitebait Smelt						
Hypomesus pretiosus	Surf Smelt						
Spirinchus starksi	Night Smelt						
Spirinchus thaleichthys	Longfin Smelt	?					
Thaleichtys pacificus	Eulachon	Low	yes	no	T	no	Rare species in central California
Oncorhynchus gorbuscha	Pink Salmon						
Oncorhynchus keta	Chum Salmon	Low	yes	no	T	no	Rare species in central California
Oncorhynchus kisutch	Coho Salmon [Silver Salmon]	Medium	yes	no	E&T	yes	Potential effect of oil on smolts using local lagoons
Oncorhynchus mykiss	Rainbow Trout [Steelhead]	Medium	yes	no	E&T	yes	Potential effect of oil on smolts using local lagoons
Oncorhynchus nerka	Sockeye Salmon						
Oncorhynchus tshawytscha	Chinook Salmon	Low	yes	no	E&T	yes	Potential effect of oil on smolts using local lagoons
Cyclothone acclinidens	Benttooth Bristlemouth						
Cyclothone signata	Showy Bristlemouth						
Daphnos oculatus	Bigeye Lightfish						
Argyropelecus affinis	Slender Hatchetfish						
Argyropelecus hemigymnus	Spurred Hatchetfish						

Argyropelecus lychnus	Silver Hatchetfish
Argyropelecus sladeni	Silvery Hatchetfish
Sternoptyx spp.	Dollar Hatchetfishes
Aristostomias scintillans	Shiny Loosejaw
Bathophilus flemingi	Highfin Dragonfish
Chauliodus macouni	Pacific Viperfish
Idiacanthus antrostomas	Pacific Blackdragon
Tactostoma macropus	Longfin Dragonfish
Benthalbella dentata	Northern Pearleye
Synodus lucioceps	California Lizardfish
Lestidium ringens	Slender Barricudina
Anotopterus pharao	Daggertooth
Alepisaurus ferox	Longnose Lancetfish
Ceratoscopelus townsendi	Dogtooth Lampfish
Diaphus theta	California Headlightfish
Diogenes laternatus	Diogenes Lanternfish
Nannobrachium regale	Pinpoint Lampfish
Nannobrachium ritteri	Broadfin Lampfish
Notoscopelus resplendens	Patchwork Lampfish
Protomyctophum crockeri	California Flashlightfish
Protomyctophum thompsoni	Bigeye Lanternfish
Stenobrachius leucopsaurus	Northern Lampfish
Tarletonbaenia crenularis	Blue Lanternfish
Triphoturus mexicanus	Mexican Lampfish
Lampris regius	Opah
Desmodema lorum	Whiptail Ribbonfish
Trachipterus altivelis	King-of-the-salmon
Chilara taylori	Spotted Cusk Eel
Brosmophycis marginata	Red Brotula
Albatrossia pectoralis	Giant Grenadier
Coelorinchus scaphopsis	Shoulderspot Grenadier
Coryphaenoides acrolepis	Pacific Grenadier
Nezumia stelgidolepis	California Grenadier

Antimora microlepis	Finescale Codling
Physiculus rastrelliger	Hundred-Fathom Codling
Merluccius productus	Pacific Hake
Gadus microcephalus	Pacific Cod
Microgadus proximus	Pacific Tomcod
Theragra chalcogramma	Walleye Pollock
Porichthys notatus	Plainfin Midshipman
Atherinops affinis	Topsmelt
Atherinopsis californiensis	Jacksmelt
Leuresthes tenuis	California Grunion
Strongylura exilis	California Needlefish
Cololabis saira	Pacific Saury
Cheilopogon pinnatibarbatus	Smallhead Flyingfish
Melamphaes lugubris	Highsnout Bigscale
Poromitra crassiceps	Crested Bigscale
Scopeloberyx robustus	Longjaw Bigscale
Scopelogadus mizolepis	Twospine Bigscale
Anoplogaster cornuta	Fangtooth
Allocyttus folletti	Oxeye oreo
Aulorhynchus flavidus	Tubesnout
Gasterosteus aculeatus	Threespine Stickleback
Cosmocampus arctus	Snubnose Pipefish
Syngnathus californiensis	Kelp Pipefish
Syngnathus leptorynchus	Bay Pipefish
Sebastes aleutianus	Rougheye Rockfish
Sebastes alutus	Pacific Ocean Perch
Sebastes atrovirens	Kelp Rockfish
Sebastes auriculatus	Brown Rockfish
Sebastes aurora	Aurora Rockfish
Sebastes babcocki	Redbanded Rockfish
Sebastes brevispinis	Silvergray Rockfish
Sebastes carnatus	Gopher Rockfish
Sebastes caurinus	Copper Rockfish

Sebastes chlorostictus	Greenspotted rockfish						
Sebastes chrysomelas	Black-and-Yellow Rockfish						
Sebastes constellatus	Starry Rockfish						
Sebastes crameri	Darkblotched Rockfish						
Sebastes dallii	Calico Rockfish						
Sebastes diploproa	Splitnose Rockfish						
Sebastes elongatus	Greenstriped Rockfish						
Sebastes ensifer	Swordspine Rockfish						
Sebastes entomelas	Widow Rockfish						
Sebastes eos	Pink Rockfish						
Sebastes flavidus	Yellowtail rockfish						
Sebastes goodei	Chilipepper						
Sebastes helvomaculatus	Rosethorn Rockfish						
Sebastes hopkinsi	Squarespot Rockfish						
Sebastes jordani	Shortbelly Rockfish						
Sebastes levis	Cowcod	Low	yes	no		yes	Deep water species with limited potential exposure to oil
Sebastes maliger	Quillback Rockfish						
Sebastes melanops	Black Rockfish						
Sebastes melanostomus	Blackgill Rockfish						
Sebastes miniatus	Vermilion Rockfish						
Sebastes mystinus	Blue Rockfish						
Sebastes nebulosus	China Rockfish						
Sebastes nigrocinctus	Tiger Rockfish						
Sebastes ovalis	Speckled Rockfish						
Sebastes paucispinis	Bocaccio	Low	yes	no	SC	yes	Deep water species with limited potential exposure to oil
Sebastes phillipsi	Chameleon Rockfish						
Sebastes pinniger	Canary Rockfish	Low	yes	no		yes	Deep water species with limited potential exposure to oil
Sebastes proriger	Redstripe Rockfish						
Sebastes rastrelliger	Grass Rockfish						
Sebastes rosaceus	Rosy Rockfish						
Sebastes rosenblatti	Greenblotched Rockfish						

Sebastes ruberrimus	Yelloweye Rockfish	Low	yes	no	yes	Deep water species with limited potential exposure to oil
Sebastes rubrivinctus	Flag Rockfish					
Sebastes rufus	Bank Rockfish					
Sebastes saxicola	Stripetail Rockfish					
Sebastes semicinctus	Halfbanded Rockfish					
Sebastes serranoides	Olive Rockfish					
Sebastes serriceps	Treefish					
Sebastes wilsoni	Pygmy Rockfish					
Sebastes zacentrus	Sharpchin Rockfish					
Sebastolobus alascanus	Shortspine Thornyhead					
Sebastolobus altivelis	Longspine Thornyhead					
Prionotus stephanophrys	Lumptail Searobin					
Anoplopoma fimbria	Sablefish					
Erilepis zonifer	Skilfish					
Hexagrammos decagrammus	Kelp Greenling					
Hexagrammos superciliosus	Rock Greenling					
Ophiodon elongaus	Lingcod	Low	yes	no	yes	Deep water species with limited potential exposure to oil
Oxylebius pictus	Painted Greenling					
Zaniolepis frenata	Shortspine Combfish					
Zaniolepis latipinnis	Longspine Combfish					
Rhamphocottus richardsonii	Grunt Sculpin					
Artedius corallinus	Corraline Sculpin					
Artedius fenestralis	Padded Sculpin					
Artedius harringtoni	Scalyhead Sculpin					
Artedius lateralis	Smoothhead Sculpin					
Artedius notospilotus	Bonyhead Sculpin					
Ascelichthys rhodorus	Rosylip Sculpin					
Chitonotus pugetensis	Roughback Sculpin					
Clinocottus acuticeps	Sharpnose Sculpin					
Clinocottus analis	Wooly Sculpin					
Clinocottus embryum	Calico Sculpin					
Clinocottus globiceps	Mosshead Sculpin					

Clinocottus recalvus	Bald Sculpin
Enophrys bison	Buffalo Sculpin
Enophrys taurina	Bull Sculpin
Hemilepidotus hemilepidotus	Red Irishlord
Hemilepidotus spinosus	Brown Irishlord
Icelinus burchami	Dusky Sculpin
Icelinus filamentosus	Threadfin Sculpin
Icelinus oculatus	Frogmouth Sculpin
Icelinus quadriseriatus	Yellowchin Sculpin
Icelinus tenuis	Spotfin Sculpin
Jordania zonope	Longfin Sculpin
Leptocottus armatus	Staghorn Sculpin
Oligocottus maculosus	Tidepool Sculpin
Oligocottus rimensis	Saddleback Sculpin
Oligocottus rubellio	Rosy Sculpin
Oligocottus snyderi	Fluffy Sculpin
Orthonopias triacis	Snubnose Sculpin
Paricelinus hopliticus	Thornback Sculpin
Radulinus boleoides	Darter Sculpin
Scorpaenichthys marmoratus	Cabezon Sculpin
Synchirus gilli	Manacled Sculpin
Belpsias cirrhosus	Silverspotted Sculpin
Nautichthys oculofasciatus	Sailfin Sculpin
Agonopsis vulsa	Northern Spearnose Poacher
Bathyagonus pentacanthus	Bigeye Poacher
Bothragonus swanii	Rockhead
Chesnonia verrucosa	Warty Poacher
Hypsagonus mozinoi	Kelp Poacher
Odontopyxis trispinosa	Pygmy Poacher
Pallasina barbata	Tubenose Poacher
Stellerina xyosterna	Pricklebreast Poacher
Xeneretmus latifrons	Blackedge Poacher
Xeneretmus leiops	Smootheye Poacher

Xeneretmus triacanthus	Bluespotted Poacher
Psychrolutes phrictus	Blob Sculpin
Careproctus melanurus	Blacktail Snailfish
Liparis florae	Tidepool Snailfish
Liparis fuscensis	Slipskin Snailfish
Liparis mucosus	Slimy Snailfish
Liparis adiastolus	SouthernRingtail Snailfish
Lipris pulchellus	Showy Snailfish
Morone saxatilis	Striped Bass
Stereolepis gigas	Giant Sea Bass
Mycteroperca xenarcha	Broomtail Grouper
Paralabrax clathratus	Kelp Bass
Caulotilus princeps	Ocean Whitefish
Remora albescens	White Suckerfish
Remora australis	Whalesucker
Remora remora	Remora
Coryphaena hippurus	Dolphinfish
Trachurus symmetricus	Jack Mackerel
Seriola lalandi	Yellowtail Jack
Brama japonica	Pacific Pomfret
Caristius macropus	Veilfin
Atractoscion nobilis	White Seabass
Genyonemus lineatus	White Croaker
Seriphus politus	Queenfish
Pseudopentaceros wheeleri	North Pacific Armorhead
Girella nigricans	Opaleye
Medialuna californiensis	Halfmoon
Amphistichus argenteus	Barred Surfperch
Amphistichus koelzi	Calico Surfperch
Amphistichus rhodoterus	Redtail Surfperch
Brachyistius frenatus	Kelp Perch
Cymatogaster aggregata	Shiner Perch
Damalichthys vacca	Pile Perch

Embiotoca jacksoni	Black Perch					
Embiotoca lateralis	Striped Seaperch					
Hyperprosopon anale	Spotfin Surfperch					
Hyperprosopon argenteum	Walleye Surfperch					
Hyperprosopon ellipticum	Silver Surfperch					
Hypsurus caryi	Rainbow Seaperch					
Micrometrus aurora	Reef Perch					
Micrometrus minimus	Dwarf Perch					
Phanerodon atripes	Sharpnose Seaperch					
Phanerodon furcatus	White Seaperch					
Rhacochilus toxotes	Rubberlip Seaperch					
Zalembius rosaceus	Pink Seaperch					
Oxyjulis californica	Señorita					
Semicossyphus pulcher	California Sheephead					
Rathbunella alleni	Stripefin Ronquil					
Ronquilus jordani	Northern Ronquil					
Bothrocara brunneum	Twoline Eelpout					
Bothrocara molle	Soft Eelpout					
Embryx crotalina	Flatcheek Eelpout					
Lycodapus fierasfer	Blackmouth Eelpout					
Lycodapus mandibularis	Pallid Eelpout					
Lycodes cortezianus	Bigfin Eelpout					
Lycodes diapterus	Black Eelpout					
Lycodopsis pacifica	Blackbelly Eelpout					
Lyconema barbatus	Bearded Eelpout					
Melanostigma pammelas	Midwater Eelpout					
Anoplarchus purpurescens	High Cockscomb					
Cebidichthys violaceus	Monkeyface Prickleback	High	yes	no	yes	Intertidal and subtidal species likely to be afected by toxicity of oil
Chirolophis nugator	Mosshead Warbonnet					
Kasatkia seigeli	Sixspot Prickleback					
Phytichthys chirus	Ribbon Prickleback					
Plectrobranchus evides	Bluebarred Prickleback					
Poroclinus rothrocki	Whitebarred Prickleback					

Xiphister atropurpureus	Black Prickleback						
Xiphister mucosus	Rock Prickleback						
Apodichthys flavidus	Penpoint Gunnel						
Apodichthys fucorum	Rockweed Gunnel						
Pholis ornata	Saddleback Gunnel						
Pholis schultzi	Red Gunnel						
Anarrhichthys ocellatus	Wolf-Eel						
Zaprora silenus	Prowfish						
Scytalina cerdale	Graveldiver						
Trichodon trichodon	Pacific Sandfish						
Ammodytes hexapterus	Pacific Sand Lance						
Gibbonsia metzi	Striped Kelpfish						
Gibbonsia montereyensis	Crevice Kelpfish						
Heterostichus rostratus	Giant Kelpfish						
Neoclinus blanchardi	Sarcastic Fringehead						
Neoclinus uniornatus	Onespot Fringehead						
Icosteus aenigmaticus	Ragfish						
Gobiesox meandricus	Northern Clingfish						
Rimicola muscarum	Kelp Clingfish						
Acanthogobius flavimanus	Yellowfin Goby						
Clevelandia ios	Arrow Goby						
Eucyclogobius newberryi	Tidewater Goby	High	yes	no	E	yes	Toxic effects of oil, smothering of tide pools by oil
Gillichthys mirabilis	Longjaw Mudsucker						
Ilypnus gilberti	Cheekspot Goby						
Lepidogobius lepidus	Bay Goby						
Coryphopterus nicholsii	Blackeye Goby						
Luvarus imperialis	Louvar						
Sphyraena argentea	Pacific Barracuda						
Lepidocybrium flavobrunneum	Escolar						
Lepidopus fitchi	Pacific Scabbardfish						
Katsuwonus pelamis	Skipjack Tuna						
Sarda chiliensis	Pacific Bonito						
Scomber japonicus	Pacific Chub Mackerel						

Thunnus alalunga	Albacore
Thunnus obesus	Bigeye Tuna
Thunnus orientalis	Pacific Bluefin Tuna
Xiphias gladius	Swordfish
Tetrapturus angustirostris	Shortbill Spearfish
Tetrapturus audax	Striped Marlin
Icichthys lockingtoni	Medusafish
Tetrogonurus cuvieri	Smalleye Squaretail
Peprilus simillimus	Pacific Pompano
Citharichthys sordidus	Pacific Sanddab
Citharichthys stigmaeus	Speckled Sanddab
Paralichthys californicus	California Halibut
Atheresthes stomias	Arrowtooth Flounder
Clidoderma asperrimum	Roughscale Sole
Embassichthys bathybius	Deepsea Sole
Eopsetta jordani	Petrale Sole
Glyptocephalus zachirus	Rex Sole
Hippoglossoides elassodon	Flathead Sole
Hippoglossus stenolepis	Pacific Halibut
Isopsetta isolepis	Butter Sole
Lepidopsetta bilineata	Rock Sole
Lyopsetta exilis	Slender Sole
Microstomus pacificus	Dover Sole
Parophrys vetulus	English Sole
Platichthys stellatus	Starry Flounder
Pleuronichthys coenosus	C-O Sole
Pleuronichthys decurrens	Curlfin Sole
Pleuronichthys guttulatus	Diamond Turbot
Pleuronichthys verticalis	Hornyhead Turbot
Psettichthys melanostictus	Sand Sole
Reinhardtius hippoglossoides	Greenland Halibut
Symphurus atricauda	California Tonguefish
Balistes polylepis	Finescale Triggerfish

Lagocephalus lagocephalus	Oceanic Pufferfish
Diodon holocanthus	Balloonfish
Mola mola	Ocean Sunfish

Reptiles

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Chelonia mydas	Green Sea Turtle	Low	yes	no	T	no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Lepidochelys olivacea	Pacific (Olive) Ridley	Low	yes	no	T	no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Caretta caretta	Loggerhead Turtle	Low	yes	no	T	no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion
Dermochelys coriacea	Leatherback Turtle	Low	yes	no	E	no	Potentially affected by oil fumes, direct and indirect effects of oil ingestion

INVERTEBRATES

	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Note: All species below that are included in zooplankton and icthyoplankton	Low	yes	no		yes	Localized impacts and rapid repopulation expected

Annelida

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Arabella iricolor							
Cheilonereis cyclurus							
Errantia spp.							
Nereis guberi	Polycheate						
Phragmatopoma californica							

Phyllochaetopterus prolifica	
Platynereis bicanaliculata	
Serpula vermicularis	Tube worm
Spirorbis borealis	
Stylantheca prophyra	
Terribellidae	
Thelepus crispus	
Typosyllis aciculata	

Arthropoda

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Acanthomysis sp.							
Achelia chelata							
Achelia nudiscula							
Achelia spinoseta							
Allorchestes anceps							
Alpheus dentipes							
Ammothea hilgendorfi							
Amphiodia occidentalis							
Amphissa columbiana							
Amphissa versicolor							
Anatanais normani							
Balanus amphitrite							
Balanus cariosus	Barnacle						
Balanus glandula	Barnacle						
Balanus nubilus	Barnacle						
Balanus sp.							
Cancer antennarius							
Cancer magister		Low	yes	no		yes	Wide distribution, bottom dweller, not likely to encounter oil
Cancer productus		Moderate	yes	no		yes	Wide distribution, shallow water, maybe affected by oil on intertidal and

		subtidal
Caprella californica		
Chthamalus dalli		
Cirolana harfordi		
Elasmopus serricatus		
Euphausia pacifica	Krill	
Exosphaeroma inornata		
Exosphaeroma rhomburum		
Fabia subquadrata		
Hemigrapsus nudus		
Hyale frequens		
Hyale grandicornis		
Ianiropsis kincaidi		
Idotea fewkesi		
Idotea resecata		
Idotea schmitti		
Idotea sp.		
Idotea stenops		
Idotea urotoma		
Idotea wosnesenskii		
Lecythorychus hilgendorfi		
Ligia occidentalis		
Ligia pallasii		
Limnoria algarum		
Littorophiloscia richardsonae		
Lophopanopeus leucomanus		
Loxorhyncus crispatus	Crab	
Melita californica		
Metacaprella anomala		
Metacaprella kennerlyi		
Nebalia kensleyi		
Nymphopsis spinosissima		
Oedignathus inermis		

Oligochinus lighti	
Pachycheles rudis	
Pachygrapsus crassipes	Crab
Pachygrapsus nudus	
Pagurus granosimanus	
Pagurus hirsutiusculus	Hermit crab
Pagurus samuelensis	
Pagurus sp.	
Paracerceis cordata	
Paradynoides benedicti	
Parallorchestes ochotensis	
Paranthura elegans	
Paraxanthia taylorii	
Petrolisthes cinctipes	
Pinnixa franciscana	
Pollicipes polymerus	
Polycheria osborni	
Porcellio americanus	
Pugetia fragilissima	Crab
Pugettia gracilis	Crab
Pugettia producta	Crab
Pycnogonum rickettsi	Sea spider
Pycnogonum stearnsi	Sea spider
Scyra acutifrons	Crab
Semibalanus cariosus	Barnacle
Semibalanus sp.	
Tetraclita rubescens	Barnacle
Thysanoessa spinifera	Krill

Chordata

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason

Aplidium arenatum							
Aplidium californicum	Tunicate						
Cystodytes lobatus	Tunicate						
Didemnum carnulentum	Tunicate						
Polyclinum planum							
Pycnoclayella stanleyi	Tunicate						
Ritterella aequalisphonis	Tunicate						

Cnidaria

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Abietinaria sp.	Fern hydroid						
Aglaophenia inconspicua							
Aglaophenia latrirostris	Ostrich-plume hydroid						
Aglaophenia sp							
Anthopleura elegantissima	Aggregating anemone						
Anthopleura xanthogrammica	Giant green anemone						
Aurelia aurita							
Balanophyllia elegans	Orange cup coral						
Corynactis californica							
Epiactis prolifera	Poliferating anemone						
Eudendrium californicum							
Garveia annulata							
Metridium senile	White-plumed anemone						
Obelia sp.							
Sertularella turgida							
Sertularia sp.							
Stylatula elongata	Sea pen						
Tealia crassicornis							
Tealia lofotensis							
Tubularia crocea							
Urticina crassicornia							

Urticina lofotensis							

Echinodermata

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Amphipholis squamata							
Asterina miniata							
Cucumaria curata	Sea cucumber						
Cucumaria pseudocurata	Sea cucumber						
Dermasterias imbricata	Leather star						
Henricia leviuscula	Blood star						
Leptasterias aequalis							
Leptasterias hexactis	6-rayed star						
Leptasterias puscilla							
Ophiopholis aculeata							
Ophioplocus papillosa							
Ophiothrix spiculata	Brittle star						
Parastichopus parvimensis	Sea cucumber						
Patiria miniata	Bat star						
Pisaster giganteus							
Pisaster ochraceus	Ochre star						
Pycnopodia helianthoides	Sunflower star						
Strongylocentrotus droebachiensis							
Strongylocentrotus franciscanus	Red sea urchin						
Strongylocentrotus purpuratus	Purple sea urchin						

Ectoprocta

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Barentsia benedeni							

Bugula californica	Bryozoan
Crisia maxima	
Dendrobeania laxa	Bryozoan
Dendrobeania lichenoides	
Eurystomella bilabiata	
Flustrellidra corniculata	Bryozoan
Tricellaria occidentalis	
Tricellaria sp	
Tricellaria ternata	

Mollusca

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Loligo opalescens		Low	yes	no		yes	Low probability of exposure to oil at the surface, important prey base
Acanthina spirata	Angular unicorn						
Acanthina spp.							
Acanthodoris nanaimoensis							
Aclis shepardiana							
Acmaea mitra	White capped limpet						
Aeolidia papillosa	Shag-rug nudibranch						
Aeolidia papillosa	Nudibranch						
Alia carinata							
Amphissa versicolor	Variegated amphissa						
Anisodoris noblis	Sea lemon						
Antiopella barbarensis							
Archidoris montereyensis	Monterey dorid						
Balcis thersites							
Baptodoris mimetica							
Barleeia haliotiphila	Snail						
Barleeia subtenuis	Snail						
Batillaria attramentaria	Horn snail						
Bittium eschrichtii	Threaded bittium						

Bittium purpureum						
Bittium schrichtii						
Cadlina luteomarginata						
Cadlina modesta	Yellow-edged cadlina					
Calliostoma canaliculatum	Channeled top snail					
Callistoma ligatum	Blue top snail					
Ceratostoma foliatum						
Cerithiopsis carpenteri						
Chama arcana						
Collisella scabra						
Corolla spectabilis (Pteropod)						
Crassostrea gigas	Pacific oyster					
Crepidula adunca	Hooked slipper snail					
Crepidula nummaria						
Crepidula perforans						
Crepipatella lingulata						
Cryptochiton stelleri	Gumboot chiton					
Cryptomya californica						
Cymakra aspera						
Daphana californica						
Diaphana californica						
Diaulula sandiegensis	Ring spotted dorid					
Diplodonta orbella						
Discurria scutum						
Doto columbiana						
Entodesma saxicola						
Epitonium tinctum	Snail					
Fissurella volcano						
Fusinus luteopictus						
Granula margaritula						
Haliotis cracherodii	Black Abalone	High	yes	no	yes	Rare intertidal species likely to be afected by toxicity of oil
Haliotis rufescens	Red Abalone	High	yes	no	yes	Rare intertidal species likely to be afected by toxicity of oil

Hermissenda crassicornis	Hermissenda
Hiatella arctica	
Hinnites giganteus	
Hipponix craniodes	Hoof snail
Hopkinsia rosacea	Hopkin's Rose
Irus lamellifer	
Ischnochiton regularis	Chiton
Katharina tunicata	Chiton
Kellia laperousii	
Lacuna cistula	
Lacuna marmorata	Chink snail
Lacuna porrecta	
Lacuna unifasciata	
Lasaea cistula	
Lasaea subviridis	Clam
Lepidochitona dentiens	Chiton
Lepidozona sinudentata	
Littorina keanae	
Littorina planaxis	Eroded periwinkle
Littorina scutulata	Checkered periwinkle
Littorina sitkana	
Littorina sp.	
Lottia asmi	
Lottia digitalis	Ribbed limpet
Lottia gigantea	Owl limpet
Lottia instabilis	Unstable seaweed limpet
Lottia limantula	File limpet
Lottia pelta	Shield limpet
Lottia strigatella	
Lottia triangularis	Triangular limpet
Macclintockia scabra	Rough limpet
Milneria minima	
Mitrella carinata	

Mitrella tuberosa						
Modiolus capax	Fat horse mussel					
Modiolus carpenti						
Mopalia ciliata	Hairy chiton					
Mopalia muscosa	Mossy chiton					
Musculus pygmaeus	Pygmy mussel					
Mytilimeria nuttallii						
Mytilus californianus	California mussel	High	yes	no	yes	Intertidal species likely to be afected by toxicity of oil
Mytilus edulis	Bay mussel	High	yes	no	yes	Intertidal species likely to be afected by toxicity of oil
Nassarius mendicus						
Notoacmea insessa	Limpet					
Notoacmea persona	Limpet					
Nucella canaliculata	Channeled dogwinkle					
Nucella emarginata	Emarginate dogwinkle					
Nuttallina californica	Chiton					
Ocenebra atropurpurea						
Ocenebra interfossa						
Ocenebra lurida						
Octopus dofleini						
Octopus rubescens						
Octopus sp.						
Odostomia sp.						
Onchidella borealis						
Opalia wroblewskyi						
Ostrea lurida	Olympic oyster					
Palciphorella velatta						
Penitella conradi						
Penitella turnerae						
Petaloconchus montereyensis						
Petricola carditoides						
Philobrya setosa						
Pododesmus cepio	Abalone jingle					

Protothaca staminea							
Rostanga pulchra	Red sponge nudibranch						
Searlesia dira	Dire welk						
Stenoplax heathiana							
Stiliger fuscovittatus	Streaked stiliger						
Tresus capax		High	yes	no		yes	Intertidal species likely to be afected by toxicity of oil
Saxidomus giganteus		High	yes	no		yes	Intertidal species likely to be afected by toxicity of oil
Siliqua patula		High	yes	no		yes	Intertidal species likely to be afected by toxicity of oil
Tectura insessa							
Tectura persona							
Tectura scutum							
Tegula brunnea	Brown turban snail						
Tegula funebralis	Black turban snail						
Tonicella lineata	Lined chiton						
Transennella tantilla							
Trimusculus reticulatus	Reticulate button snail						
Triopha catalinae	Sea-clown nudibranch						
Triopha maculata							
Trivia californica							
Velutina velutina							

Nemertea

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Emplectonema gracile							
Tubulanus sexlineatus							

Porifera

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Acarnus erithacus	Sponge						
Allopora porphyra							
Anaata spongigartina	Sponge						
Antho lithophoenix							
Aplysilla glacialis	Keratose sponge						
Aplysilla polyraphis							
Axocielita originalis	Sponge						
Clathria sp.							
Cliona celata							
Geodia mesotriaence	Sponge						
Halichondria panicea	Crumb-of-bread sponge						
Halichondria sp.							
Haliclona permollis							
Haliclona sp.	Sponge						
Higginsia sp.							
Hinksia sandriana							
Hymedesmia sp.							
Hymenamphiastra cyanocrypta							
Leucandra heathi	Sponge						
Leucilla nuttingi	Sponge						
Leucosolenia eleanor	Sponge						
Lissodendoryx firma	Sponge						
Lissodendoryx topsenti	Sponge						
Mycale psila	Sponge						
Myxilla incrustans							
Ophlitaspongia pennata	Sponge						
Scypha sp.							
Spongia idia							
Stelletta clarella	Sponge						
Suberites sp.	Sponge						

Tedania gurjanovae	Sponge
Tethya aurantia	Sponge
Toxidocia sp.	Sponge
Xestospongia vanilla	Sponge
Zygherpe hyaloderma	Sponge

Sipuncula

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Phascolosoma agassizii							

Urochordata

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Archidistoma ritteri							
Styela montereyensis							
Styela truncata							

PLANTS

CLOROPHYTA

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Acrosiphonia coalita							
Bryopsis corticulans	Moss-like algae						
Cladophora columbiana	Pin cushion algae						
Cladophora graminea							
Cladophora sp.							
Codium fragile	Dead man's fingers						

Codium setchellii	Sponge weed						
Derbesia marina							
Endocladia viridis							
Endophyton ramosum							
Entermorpha flexuosa							
Enteromorpha clathrata							
Enteromorpha compressa							
Enteromorpha intestinalis	Intestine alge						
Halicystis ovalis							
Prasiola meridionalis							
Ulothrix flacca							
Ulothrix laetevirens							
Ulothrix pseudoflacca							
Ulva californica							
Ulva conglobata							
Ulva expansa							
Ulva lactuca							
Ulva lobata							
Ulva spp.	Sea lettuce						
Ulva taeniata							
Urophoro sp.							

HETEROKONTOPHYTA

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Alaria marginata	Winged kelp						
Analipus japonicus	Barefoot, Matsumo						
Coilodesme californica							
Colpomenia peregrina							
Compsonema serpens							
Costaria costata							
Cystoseira osmundacea	Bladder chain						

Desmarestia herbacea						
Desmarestia ligulata	Acid seaweed					
Desmarestia munda						
Dictyoneurum californicum	Nerve net					
Egregia menziesii	Feather Boa					
Fucus gardneri	Rock weed	High	Yes	No		Experience of injury documented in intertidal monitoring plots
Hincksia sandriana						
Laminaria ephemera						
Laminaria farlowii						
Laminaria setchellii	Split blade oarweed/Kombu					
Laminaria sinclarii	Oar weed/Kombu					
Laminaria sp.						
Leathesia difformis						
Macrocystis integrifolia						
Macrocystis pyrifera	Giant Kelp	Medium	Yes	No	yes	Hold fast protected at depth, mucus protects kelp, kelp may retain oil and increase toxic exposure of organisms in that habitat
Melanosiphon intestinalis						
Nereocystis luetkeana	Bull whip kelp					
Nereocystis luetkeana	Bull Kelp	Medium	Yes	No	yes	Hold fast protected at depth, mucus protects kelp, kelp may retain oil and increase toxic exposure of organisms in that habitat
Pelvetia fastigiata	Little rock weed					
Pelvetiopsis limitata	Tiny rock weed					
Petalonia fascia						
Phaeostrophion irregulare						
Pilayella sp.						
Postelsia palmaeformis	Sea palm	High	Yes	No	yes	Hold fast exposed at intertidal, kelp may retain oil and increase toxic exposure of organisms in that habitat
Pterygophora californica						
Ralfsia pacifica	Tar spot					

Ralfsia sp.	
Sargassum muticum	
Scytisiphon simplicissimus	Leather tube
Scytosiphon dotyii	
Scytosiphon lomentaria	
Soranthera ulvoidea	
Spongonema tomentosum	
Streblonema sp.	

RHODOPHYTA

Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Acrochaetium prophyrae	Dreadlock algae						
Acrochaetium sp.	Epiphytic algae						
Ahnfeltia cornucopiae	Garlic algae						
Ahnfeltia fastigiata	Mastocarpus crust						
Ahnfeltiopsis leptophylla							
Ahnfeltiopsis linearis							
Anotrichium furcellatum	Red membrane						
Antithamnion dendroidum							
Antithamnion densum							
Audouinella subimmersa	Tooth branch						
Bangia sp.	Braided hair algae						
Bornetia californica							
Bossiella corymbifera							
Bossiella dichotoma							
Bossiella plumosa							
Bossiella schmittii							
Branchioglossum bipinnatifidum							
Branchioglossum undulatum							
Callithamnion biseriatum							
Callophyllis cheilosporioides							

Callophyllis crenulata	
Callophyllis flabellulata	
Callophyllis heanophylla	
Callophyllis linearis	
Callophyllis obtusifolia	
Callophyllis pinnata	
Callophyllis sp.	
Callophyllis violacea	
Centroceras clavulatum	
Ceramium gardneri	
Ceramium pacificum	
Chiharaea bodegensis	
Cirrilicarpus sp.	
Clathromorphum parcum	
Constantinea simplex	
Corallina officinalis	
Corallina pinnatifolia	
Crustose corallines	
Cryptoplerua farlowiana	
Cryptopleura corallinara	
Cryptopleura crispa	
Cryptopleura lobulifera	
Cryptopleura rosacea	
Cryptopleura ruprechtiana	
Cumagloia andersonii	
Delesseria decipiens	
Dilsea californica	
Endocladia muricata	Beautifully jointed
Erythroglossum californicum	
Erythrophyllum delesseriodes	Wool weed
Erythrotrichia carnea	
Erythrotrichia pulvinata	
Farlowia compressa	

Farlowia conferta	
Farlowia mollis	
Fauchea fryeana	
Fauchea laciniata	
Faucheocolax attenuata	
Gastroclonium subarticulatum	Beautiful leaf
Gastroclonium subarticulatum	
Gelidium coulteri	Candy cane seaweed
Gelidium purpurascens	Arrow weed
Gelidium pusillum	
Gelidium robustum	
Gelidium sp.	
Gloiosiphonia verticullaris	
Goniotrichopsis sublittoralis	
Gracilariophila oryzoides	
Gracilariopsis sjoestedtii	Turkish towel
Grateloupia doryphora	
Grateloupia filicina	
Griffithsia pacifica	
Gymnogongrus chiton	
Halosaccion glandiforme	Turkish towel
Halymenia schizymenioides	
Halymenia templetonii	
Herposiphonia parva	
Herposiphonia plumula	
Hildenbrandia occidentalis	
Hildenbrandia rubra	
Hildenbrandia spp.	Narrow turkish towel
Hommersandia palmatifolia	
Hymenena coccinea	
Hymenena flabelligera	
Hymenena multiloba	
Janczewskia gardneri	

Leachiella pacifica	
Lithophyllum dispar	
Lithophyllum grumosum	
Lithophyllum proboscideum	
Lithothamnium sp.	Narrow turkish towel
Lithothrix aspergillum	Cup and saucer algae
Maripelta rotata	
Mastocarpus jardinii	Small coral
Mastocarpus papillatus	Hidden ribs
Mazzaella affinis	
Mazzaella californica	
Mazzaella cordata	
Mazzaella cornucopiae	Nail brush
Mazzaella flaccida	Red leaf
Mazzaella heterocarpa	Belly branch
Mazzaella leptorhynchos	
Mazzaella linearis	
Mazzaella rosea	
Mazzaella splendens	Agarweed
Mazzaella volans	
Melobesia marginata	
Melobesia mediocris	Agarweed
Membranoptera dimorpha	
Mesophyllum conchatum	
Mesophyllum lamellatum	
Microcladia borealis	Spaghetti weed
Microcladia coulteri	Sea sac
Myriogramme sp.	
Myriogramme spectabilis	
Myriogramme variegata	
Neoptilota densa	
Neoptilota hypnoides	
Neoptilota sp.	

Neorhodomela larix	Wine crust
Nienburgia andersoniana	
Nitophyllum sp.	
Nitophyllum sp.	
Odonthalia floccosa	crustose coralline
Opuntiella californica	Stone hair
Osmundea spectabilis	Little turkish towel
Petrocelis franciscana	Little turkish towel
Petrospongium rugosum	
Peyssonelliopsis epiphytica	
Peyssonnelia meridionalis	
Peyssonnelia pacifica	
Phycodrys setchellii	
Pikea californica	
Pikea pinnata	
Pleonosporium vancouverianum	
Plocamium cartilagineum	Bunny ears algae
Plocamium cartilagineum var. pacificum	
Plocamium oregonum	
Plocamium pacificum	
Plocamium sp.	
Plocamium violaceum	
Polyneura latissima	Iridesent seaweed
Polysiphonia hendryi	Warty algae
Polysiphonia hendryi	
Polysiphonia pacifica	
Polysiphonia saraticeri	
Polysiphonia sp.	
Porphyra gardneri	Many veined algae
Porphyra lanceolata	Many siphon algae
Porphyra nereocystis	Nori/laver
Porphyra perforata	Iridesent seaweed
Porphyra sp.	Serrated red weed

Prionitis australis	
Prionitis cornea	
Prionitis lanceolata	Phyllospadix crust
Prionitis linearis	
Prionitis lyallii	
Pronitis filiformis	
Pronitis sp.	
Pseudolithophyllum neofarlowii	
Pterochondria woodii	
Pterocladiella caloglossoides	
Pterocladiella capillacea	
Pterosiphonia baileyi	
Pterosiphonia bipinnata	
Pterosiphonia dendroidea	
Pterothamnion villosum	
Ptilota filicina	
Ptilothamnionopsis lejolisea	
Pugetia fragilissima	
Rhodochorton purpureum	Cactus weed
Rhodymenia californica	Small branch
Rhodymenia callophyllidoides	
Rhodymenia pacifica	
Sahlingia subintegra	
Sarcodiotheca gaudichaudii	
Schimmelemannia plumosa	
Schizymenia pacifica	
Scinaia confusa	
Smithora naiadum	
Stenogramma interrupta	
Stylonema alsidii	
Tiffaniella snyderae	
Titanoderma dispar	
Weeksia reticulata	

VASCULAR							
Scientific Name	Common Name	Sensitivity to oil	More Benefit from Dispersant	More Harm from Dispersant	ESA listing	Breeds locally	Reason
Phyllospadix scouleri	Surf grass	Medium	Yes	No		yes	Grass may retain oil and increase toxic exposure of organisms in that habitat
Phyllospadix torreyi		Medium	Yes	No		yes	Grass may retain oil and increase toxic exposure of organisms in that habitat
Zostera marina	Eel grass	Medium	Yes	No		yes	Grass may retain oil and increase toxic exposure of organisms in that habitat

Appendix V: Sensitive Species Matrix

Feb15-Aug15				Cordell Bank	Farallon Scarpment (a.k.a FNWR from Fanny Shoals to SEFI)	Deep Reef	Point Reyes	Drakes Bay	Devil's Slide	PR Convergent Zone	SF Bay Plume	Dunes and Beaches	Open Estuaries (SF, Tomales, Bolinas)	Seasonal Estuaries (Rodeo, San Antonio etc)	Tidepools (Duxbury, Fitzgerald, etc)
	COMMON NAME	SCIENTIFIC NAME	Benefit from dispersants?												
Mammals	Gray Whale	*Eschrichtius robustus*		-	1	-	1	1	1	1	1	-	1	-	-
Mammals	Humpback Whale	*Megaptera novaeangliae*		1	1	1	1	1	1	1	1	-	-	-	-
Mammals	Sea Otter	*Enhydra lutris*		-	-	-	-	-	1	-	1	-	-	-	1
Mammals	Harbor Porpoise	*Phocoena phocoena*		-	-	-	1	1	1	1	1	-	1	-	-
Mammals	Northern Fur Seal	*Callorhinus ursinus*		1	1	1	-	-	-	1	-	-	-	-	-
Mammals	Harbor Seal	*Phoca vitulina*		-	1	-	1	1	1	1	1	1	1	-	1
Bird	Ashy Storm-Petrel	*Oceanodroma homochroa*		1	1	1	1	1	-	1	1	-	-	-	-
Bird	Cassin's Auklet	*Ptychoramphus aleuticus*		1	1	1	-	-	-	1	1	-	-	-	-
Bird	Snowy Plover	*Charadrius alexandrinus*		-	-	-	-	-	-	-	-	1	-	-	-
Bird	Marbled Murrelet,	*Brachyramphus marmoratus*		-	-	-	1	1	1	1	1	-	-	-	-
Bird	Sooty Shearwater	*Puffinus griseus*		1	1	1	-	-	-	1	1	-	-	-	-
Bird	Surf Scoter	*Melanitta perspicillata*		-	-	-	1	1	1	1	1	-	1	-	-
Bird	Brandt's Cormorant	*Phalacrocorax penicillatus*		-	1	-	1	1	1	1	1	-	1	-	1
Bird	Common Murre	*Uria aalge*		1	1	1	1	1	1	1	1	-	1	-	-
Bird	Osprey	*Pandion haliaetus*		-	-	-	1	1	-	-	1	1	-	1	-
Bird	Peregrine	*Falco peregrinus*		-	1	-	1	1	1	-	-	1	1	1	1
Fish	Tidewater Goby	*Eucyclogobius newberryi*		-	-	-	-	-	1	-	-	-	1	1	1
Fish	Coho Salmon [Silver Salmon]	*Oncorhynchus kisutch*		1	1	1	1	1	1	1	1	-	1	1	-
Fish	Pacific Herring	*Clupea pallasii*		-	-	-	1	1	-	-	-	-	1	-	-
Fish	Rockfish (Juveniles)			1	1	1	1	1	1	1	1	-	-	-	-
Crustacea	Krill	*Euphausia pacifica*		1	1	1	1	-	-	-	-	-	-	-	-
Crustacea	Dungeness crab	*Cancer magister*		-	-	1	1	1	1	-	-	-	1	1	-
Mollusca	Red Abalone	*Haliotis rufescens*		-	1	-	1	1	1	-	-	-	-	-	1
Mollusca	California mussel	*Mytilus californianus*		-	1	-	1	1	1	-	-	-	1	-	1
Algae	Rock weed	*Fucus gardneri*		-	1	-	1	-	1	-	-	-	-	-	1
Algae	Sea palm	*Postelsia palmaeformis*		-	1	-	1	-	1	-	-	-	-	-	1
Vascular	Surf grass	*Phyllospadix scouleri*		-	-	-	-	1	-	-	-	-	1	-	1
Vascular	Eel grass	*Zostera marina*		-	-	-	-	1	-	-	-	-	1	-	-

Aug15-Nov15

	COMMON NAME	SCIENTIFIC NAME	Benefit from dispersants?	Cordell Bank	Farallon Scarpment (a.k.a FNWR from Fanny Shoals to SEFI)	Deep Reef	Point Reyes	Drakes Bay	Devil's Slide	PR Convergent Zone	SF Bay Plume	Dunes and Beaches	Open Estuaries (SF, Tomales, Bolinas)	Seasonal Estuaries (Rodeo, San Antonio etc)	Tidepools (Duxbury, Fitzgerald, etc)
Mammals	Gray Whale	*Eschrichtius robustus*		-	1	-	1	1	1	1	1	-	1	-	-
Mammals	Humpback Whale	*Megaptera novaeangliae*		1	1	1	1	1	1	1	1	-	-	-	-
Mammals	Sea Otter	*Enhydra lutris*		-	-	-	-	-	1	-	1	-	-	-	1
Mammals	Harbor Porpoise	*Phocoena phocoena*		-	-	-	1	1	1	1	1	-	1	-	-
Mammals	Northern Fur Seal	*Callorhinus ursinus*		1	1	1	-	-	-	1	-	-	-	-	-
Mammals	Harbor Seal	*Phoca vitulina*		-	1	-	1	1	1	1	1	1	1	-	1
Bird	Ashy Storm-Petrel	*Oceanodroma homochroa*		-	-	-	-	-	1	-	-	-	1	1	1
Bird	Cassin's Auklet	*Ptychoramphus aleuticus*		1	1	1	1	1	1	1	1	-	1	1	-
Bird	Snowy Plover	*Charadrius alexandrinus*		-	-	-	1	1	-	-	-	-	1	-	-
Bird	Marbled Murrelet,	*Brachyramphus marmoratus*		1	1	1	1	1	1	1	1	-	-	-	-
Bird	Sooty Shearwater	*Puffinus griseus*		1	1	1	1	-	-	-	-	-	-	-	-
Bird	Surf Scoter	*Melanitta perspicillata*		-	-	1	1	1	1	-	-	-	1	1	-
Bird	Brandt's Cormorant	*Phalacrocorax penicillatus*		-	1	-	1	1	1	-	-	-	-	-	1
Bird	Common Murre	*Uria aalge*		-	1	-	1	1	1	-	-	-	1	-	1
Bird	Osprey	*Pandion haliaetus*		-	-	-	1	1	-	-	1	1	1	1	-
Bird	Peregrine	*Falco peregrinus*		-	1	-	1	1	1	-	-	1	1	1	1
Fish	Tidewater Goby	*Eucyclogobius newberryi*		-	1	-	1	-	1	-	-	-	-	-	1
Fish	Coho Salmon [Silver Salmon]	*Oncorhynchus kisutch*		-	1	-	1	-	1	-	-	-	-	-	1
Fish	Pacific Herring	*Clupea pallasii*		-	-	-	-	1	-	-	-	-	1	-	1
Fish	Juvenile Rockfish			-	-	-	-	1	-	-	-	-	1	-	-
Crustacea	Krill	*Euphausia pacifica*		1	1	1	1	-	-	-	-	-	-	-	-
Crustacea	Dungeness crab	*Cancer magister*		-	-	1	1	1	1	-	-	-	1	1	-
Mollusca	Red Abalone	*Haliotis rufescens*		-	1	-	1	1	1	-	-	-	-	-	1
Mollusca	California mussel	*Mytilus californianus*		-	1	-	1	1	1	-	-	-	1	-	1
Algae	Rock weed	*Fucus gardneri*		-	1	-	1	-	1	-	-	-	-	-	1
Algae	Sea palm	*Postelsia palmaeformis*		-	1	-	1	-	1	-	-	-	-	-	1
Vascular	Surf grass	*Phyllospadix scouleri*		-	-	-	-	1	-	-	-	-	1	-	1
Vascular	Eel grass	*Zostera marina*		-	-	-	-	1	-	-	-	-	1	-	-

Nov15-Feb15				Cordell Bank	Farallon Scarpment (a.k.a FNWR from Fanny Shoals to SEFI)	Deep Reef	Point Reyes	Drakes Bay	Devil's Slide	PR Convergent Zone	SF Bay Plume	Dunes and Beaches	Open Estuaries (SF, Tomales, Bolinas)	Seasonal Estuaries (Rodeo, San Antonio etc)	Tidepools (Duxbury, Fitzgerald, etc)
	COMMON NAME	SCIENTIFIC NAME	Benefit from dispersants?												
Mammals	Gray Whale	*Eschrichtius robustus*		-	1	-	1	1	1	1	1	-	1	-	-
Mammals	Humpback Whale	*Megaptera novaeangliae*		1	1	1	1	1	1	1	1	-	-	-	-
Mammals	Sea Otter	*Enhydra lutris*		-	-	-	-	-	1	-	1	-	-	-	1
Mammals	Harbor Porpoise	*Phocoena phocoena*		-	-	-	1	1	1	1	1	-	1	-	-
Mammals	Northern Fur Seal	*Callorhinus ursinus*		1	1	1	-	-	-	1	-	-	-	-	-
Mammals	Harbor Seal	*Phoca vitulina*		-	1	-	1	1	1	1	1	1	1	-	1
Bird	Ashy Storm-Petrel	*Oceanodroma homochroa*		-	-	-	-	-	1	-	-	-	1	1	1
Bird	Cassin's Auklet	*Ptychoramphus aleuticus*		1	1	1	1	1	1	1	1	-	1	1	-
Bird	Snowy Plover	*Charadrius alexandrinus*		-	-	-	1	1	-	-	-	-	1	-	-
Bird	Marbled Murrelet,	*Brachyramphus marmoratus*		1	1	1	1	1	1	1	1	-	-	-	-
Bird	Sooty Shearwater	*Puffinus griseus*		1	1	1	1	-	-	-	-	-	-	-	-
Bird	Surf Scoter	*Melanitta perspicillata*		-	-	1	1	1	1	-	-	-	1	1	-
Bird	Brandt's Cormorant	*Phalacrocorax penicillatus*		-	1	-	1	1	1	-	-	-	-	-	1
Bird	Common Murre	*Uria aalge*		-	1	-	1	1	1	-	-	-	1	-	1
Bird	Osprey	*Pandion haliaetus*		-	-	-	1	1	-	-	1	1	1	1	-
Bird	Peregrine	*Falco peregrinus*		-	1	-	1	1	1	-	-	1	1	1	1
Fish	Tidewater Goby	*Eucyclogobius newberryi*		-	1	-	1	-	1	-	-	-	-	1	1
Fish	Coho Salmon [Silver Salmon]	*Oncorhynchus kisutch*		-	1	-	1	-	1	-	-	-	1	1	1
Fish	Pacific Herring	*Clupea pallasii*		-	-	-	-	1	-	-	-	-	1	-	1
Fish	Juvenile Rockfish			-	-	-	-	1	-	-	-	-	1	-	-
Crustacea	Krill	*Euphausia pacifica*		1	1	1	1	-	-	-	-	-	-	-	-
Crustacea	Dungeness crab	*Cancer magister*		-	-	1	1	1	1	-	-	-	1	1	-
Mollusca	Red Abalone	*Haliotis rufescens*		-	1	-	1	1	1	-	-	-	-	-	1
Mollusca	California mussel	*Mytilus californianus*		-	1	-	1	1	1	-	-	-	1	-	1
Algae	Rock weed	*Fucus gardneri*		-	1	-	1	-	1	-	-	-	-	-	1
Algae	Sea palm	*Postelsia palmaeformis*		-	1	-	1	-	1	-	-	-	-	-	1
Vascular	Surf grass	*Phyllospadix scouleri*		-	-	-	-	1	-	-	-	-	1	-	1
Vascular	Eel grass	*Zostera marina*		-	-	-	-	1	-	-	-	-	1	-	1