UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way NE
Seattle, Washington 98115

December 22, 2010

Colonel Anthony Wright
U.S. Army Corps of Engineers
P.O. Box 3755
Seattle, WA 98124-3755

Re: Endangered Species Act Section 7 Formal Consultation for the Continued Use of Puget Sound Dredged Disposal Analysis Program Dredged Material Disposal Sites, Puget Sound, Washington (HUCs, 171100200306 Lower Dungeness River, 171100200403 Ennis/Tumwater Creek, 171100020204 Anacortes, 171100020104 Lower Whatcom Creek, 171100110202 Lower Snohomish River, 171100130399 Lower Green River, 171100140599 Lower Puyallup River, 171100190503 Anderson Island). NMFS Consultation Number: 2010/04249

Dear Colonel Wright:

The National Marine Fisheries Service (NMFS) has prepared the enclosed biological opinion in response to your request for Endangered Species Act (ESA) consultation on the effects of the Dredged Disposal Analysis Program on yelloweye rockfish (*Sebastes ruberrimus*) and canary rockfish (*Seb. pinniger*), and bocaccio (*Seb. paucispinis*) within the Puget Sound/Georgia Basin, pursuant to 50 CFR 402.16. NMFS listed the Puget Sound/Georgia Basin Distinct Population Segments (DPSs) of each species on April 27, 2010 (75 FR 22276).

In this biological opinion, NMFS concludes that the action, as proposed, is not likely to jeopardize the continued existence of the DPSs of yelloweye rockfish, canary rockfish or bocaccio.

As required by section 7 of the ESA, we have provided an incidental take statement with this biological opinion. The incidental take statement describes reasonable and prudent measures that are necessary or appropriate to minimize incidental take associated with this action. The take statement sets forth nondiscretionary terms and conditions, including reporting requirements, that the Federal agency and any person who performs the action must comply with to carry out the reasonable and prudent measures. Incidental take from actions that meet these terms and conditions will be exempt from the ESA take prohibition.

This document also includes a description of the action's likely effects on Essential Fish Habitat pursuant to section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act and includes conservation recommendations.

Federal agencies are required to provide a detailed written response to NMFS' EFH conservation recommendations within 30 days of receipt of these recommendations [50 CFR 600.920(j)(1)]. The response must include a description of measures proposed to avoid, mitigate, or offset the adverse affects that the activity has on EFH. If the response is inconsistent with the EFH conservation recommendations, the response must explain the reasons for not following the

recommendations, including the scientific justification for any disagreements over the anticipated effects of the proposed action and the measures needed to avoid, minimize, mitigate, or offset such effects.

If you have any questions about this correspondence, please contact Dan Tonnes at (206) 526-4643, or Dan.Tonnes@noaa.gov.

Sincerely,

for William W. Stelle, Jr.,
Regional Administrator

Cc:
David R. Kendall, COE

Cc address:

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P.O. Box 3755
Seattle, WA 98124-3755

Endangered Species Act (ESA) section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation.

NMFS Consultation Number: 2010/04249

Action Agency: Army Corps of Engineers, Environmental Protection Agency.

Affected Species and Determinations:

ESA-Listed Species	Distinct Population Segment/Evolutionary Significant Unit (& Federal Register Notice)	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Yelloweye rockfish (*Sebastes ruberrimus*)	Puget Sound/Georgia Basin (75 FR 22276 - April 27, 2010)	Threatened	Yes	No	NA
Canary rockfish (*S. pinniger*)		Threatened	Yes	No	NA
Bocaccio (*S. paucispinis*)		Endangered	Yes	No	NA

Fishery Management Plan that Describes EFH in the Project Action Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific coast groundfish (PFMC 2005), coastal pelagic species (PFMC 1998), and Pacific coast salmon (PFMC 1999).	Yes -- Pacific coast groundfish EFH only.	Yes

Consultation Conducted by: National Marine Fisheries Service, Northwest Region

Issued by: _____
William, W. Stelle Jr., Regional Administrator

Date: 12-22-10

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1. INTRODUCTION

1.1 Background

This biological opinion (opinion) and the incidental take portions of this document were prepared by the National Marine Fisheries Service (NMFS) in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531, et seq.), and implementing regulations at 50 CFR 402.

NMFS also completed an Essential Fish Habitat (EFH) consultation, prepared in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 USC 1801, et seq.) and implementing regulations at 50 CFR 600. The opinion and EFH conservation recommendations are both in compliance with section 515 of the Treasury and General Government Appropriations Act of 2001 (Data Quality Act) (44 U.S.C. 3504 (d)(1) and 3516), and underwent pre-dissemination review.

1.2 Consultation History

This opinion documents a consultation with the Army Corps of Engineers (COE) regarding their proposal to continue the Puget Sound Dredge Disposal Agency program (PSDDA program) for a period of five years. NMFS previously consulted on this proposed action informally for ESA-listed salmonids and marine mammals (consultation numbers 1999/01195, 1999/01261, 2000/00696, 2005/00484 and 2007/03507).
The PSDDA program is lead by the COE, but is also administered by several other Federal and state agencies that are termed Dredge Material Management Program (DMMP) agencies. These agencies are the Environmental Protection Agency; the Washington Department of Natural Resources; and the Washington Department of Ecology. The COE is the lead Federal agency for this consultation. The COE leads administration of the program, which includes sediment tests, transport, and disposal of dredged sediment at eight Puget Sound open-water sediment disposal sites located in Puget Sound and the Strait of Juan de Fuca, Washington State.

In a letter dated August 27, 2010, the COE requested that we consult with them on the effects this project may have on the species listed on the cover page of this opinion. The COE described the implementation of the PSDDA program in a Biological Evaluation (referenced as COE 2010). The COE and NMFS staff met on October 6, 2010 and by phone on November 16, 2010 to discuss the proposed action. In addition, numerous emails were exchanged which further clarified the proposed action.

The Puget Sound Dredge Disposal Analysis and dredge material management program (PSDDA program) was initiated in the 1980s. Its purpose was to locate dredge disposal sites in Puget Sound and the Strait of Juan de Fuca that minimized transportation costs and kept effects on the benthic environment to a low level (among other factors) (COE 2010). As part of the process for selecting dredge disposal sites, the COE commissioned several studies to assess fish and invertebrate assemblages and determine the benthic

characteristics of candidate sites[1]. These studies used bottom trawls and submersibles to document the types and relative abundance of fish and invertebrates in various depth zones around and within the proposed dredge disposal sites (Dinnel et al., 1986, Donnelly et al., 1988). The disposal site selection process and the dredge material quality screening process were assessed in a Draft and Final Environmental Impact Statement in 1988 and 1989 (COE 2010). Eight sites were selected in the Puget Sound and Strait of Juan de Fuca. The decision was based on the sites' proximity to the sources of dredged materials, their bathymetry, local water currents, and the characteristics of benthic substrates, and other considerations. Each of eight sites has been in periodic use for the past 21 years.

1.2 Proposed Action

Action means all activities or programs of any kind authorized, funded, or carried out, in whole or part, by Federal agencies. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration.

The COE administers the PSDDA program on a five year cycle. This time period allows for review of any needed changes to the program. This five year cycle runs from the date of ESA compliance at the end of the five year they would request consultation for listed species. The COE did not request consultation for the projects that generate sediment (COE 2010):

> All dredging actions that generate material for open-water disposal at PSDDA sites require the issuance of a Section 10 and Section 404 permit (Clean Water Act). The issuance of a Section 10/404 permit is a Federal action requiring an ESA Section 7 consultation. Therefore, the potential effects of specific dredging activities on threatened and endangered species will be addressed in separate biological evaluations prepared by individual project proponents once specific future plans are known.

We do not assess the dredging projects that generate sediment for several reasons. Project proponents can choose to dispose of their sediment at upland sources (and thus not use the open water disposal sites), thus these projects (which are identified on an individual basis and not known at this time) do not rely on the COE's approval for open-water disposal. The existence of the PSDDA program (and finished consultation with NMFS) also does not result in the pre-approval of subsequent dredging projects. These actions may or may not occur, and must be approved separately by the PSDDA program and by the issuance of section 10 and 404 permits issued by the COE. In each of these instances, separate consultation occurs with NMFS, which allows a site-specific assessment of the direct and indirect effects of the proposed dredge project.

The PSDDA program authorizes the use of three dispersive and five non-dispersive sites (Table 1). Non-dispersive disposal sites are located in areas where currents are slow

[1] Some of these studies can be found at https://digital.lib.washington.edu/researchworks

enough that dredged material is deposited on the disposal site; dispersive sites have higher current velocities, so dredged material does not accumulate at the disposal site and settles on benthic environments elsewhere. All sites but one near Port Angeles are located in the range of the Puget Sound/Georgia Basin DPSs of ESA-listed rockfish. The locations, depth, and size of each of the sites are described in Table 1.

Table 1. Sediment disposal sites of the PSDDA program (from COE 2010)

Site	Type	Area (acres)	Depth	Location (Lat Long NAD 83)
Bellingham Bay	Non-Dispersive	260	96 ft (29 m)	Lat 48° 42.82' Long 122° 33.11'
Port Gardner	Non-Dispersive	318	420 ft (128 m)	Lat 47° 58.85' Long 122° 16.74'
Elliott Bay	Non-Dispersive	415	300-360 ft (91-110 m)	Lat 47° 35.91' Long 122° 21.45'[5]
Commencement Bay	Non-Dispersive	310	540-560 ft (165-171 m)	Lat 47° 18.145' Long 122° 27.815'[6]
Anderson Island	Non-Dispersive	318	442 ft (135 m)	Lat 47° 09.42' Long 122° 39.47'
Port Angeles	Dispersive	884	435 ft (133 m)	Lat 48° 11.67' Long 123° 24.94'
Port Townsend	Dispersive	884	361 ft (110 m)	Lat 48° 13.61' Long 122° 59.03'
Rosario Strait	Dispersive	650	97-142 ft (30-43 m)	Lat 48° 30.87' Long 122° 43.56'

The PSDDA program consists of four management actions. They are: (1) the evaluation of sediment quality before it is dredged, (2) the transportation of sediment. Some sediment is transported to upland areas if it is too contaminated for open-water disposal. If the sediment is deemed by the DMMP agencies as clean enough, it is transported to the nearest open-water disposal site. Once on-site, (3) the materials are dumped into the water, and (4) the sites are monitored. Each of these steps are described in COE (2010), and summarized below.

Sediment Evaluation

Sediment quality is evaluated before dredging to determine its suitability for open-water disposal. The COE administers a four-tiered process to assess possible contaminant levels (Figure 1). The first tier is conducted to assess possible contaminant sources near the dredge project, such as outfalls, recent chemical spills, and past sediment quality

testing data. No new sediment testing is required if the site history and data indicate it is suitable for open-water disposal. If the first tier assessment finds possible contaminant sources, tier two screening begins which requires new sediment tests. New sediment tests are required for 11 metals, one organometallic compound, 18 organics, 12 chlorinated hydrocarbons, six phthalates, four phenols, six miscellaneous extractables, four volatile organics, and eight pesticides. Invertebrate toxicity research is used to determine if contaminant levels (if present) are low enough to allow in-water disposal (COE 2010). Testing is conducted to assess whether sediments have the potential to adversely affect biological resources by exceeding acute or chronic toxicological effects thresholds (typically for invertebrate species such as bivalves and polycheates). The thresholds are termed 'screening levels' (SL) and 'maximum levels'[2] (ML). If all contaminants are below screening levels in tier two tests, the sediment is considered acceptable for open water disposal. If contaminants are above screening levels but below maximum levels, tier three tests are required. If maximum levels are exceeded, tier three and four tests are required.

The PSDDA sediment screening process also requires the assessment of some chemicals based on their potential for accumulation in invertebrates termed a bioaccumulation trigger (COE 2010). Bioaccumulation triggers have been developed for 10 metals, one organometallic compound, two organics, one chlorinated hydrocarbon, one phenol, and four pesticides/ polychlorinated biphenyls (PCBs)[3], but have not been developed for polybrominated diphenyl ethers (PBDEs). Tier three is initiated if the bioaccumulation trigger is reached. Bioaccumulation testing must be performed before suitability of the test sediment for open-water disposal can be determined. The results of a tier three bioaccumulation test are compared directly with invertebrates from nearby reference sites to determine ecological effects. Significant bioaccumulation of chemicals of concern in test species relative to reference areas may signify food-web effects. If the mean tissue concentration of one or more contaminants of concern is greater than or equal to the target tissue level, the dredged material would not be acceptable for open-water disposal. If the mean tissue concentration of a chemical of concern is less than the applicable target tissue level, a one-tailed one-sample t-test is conducted. The dredged material is considered acceptable for open-water disposal if the null hypothesis is rejected, meaning that there is no significant difference between the tissue levels of the on-site and reference site organism.

[2] The COE defines screening levels as "...the concentration level of specific chemicals below which there is no reason to believe that disposal of that material would result in unacceptable adverse biological impacts." The COE defines maximum levels as "...a concentration above which there is reason to believe that the material would be unsuitable for unconfined, open-water disposal." (COE 2010).
[3] http://www.nws.usace.army.mil/PublicMenu/documents/DMMO/Nov_2009_UM.pdf

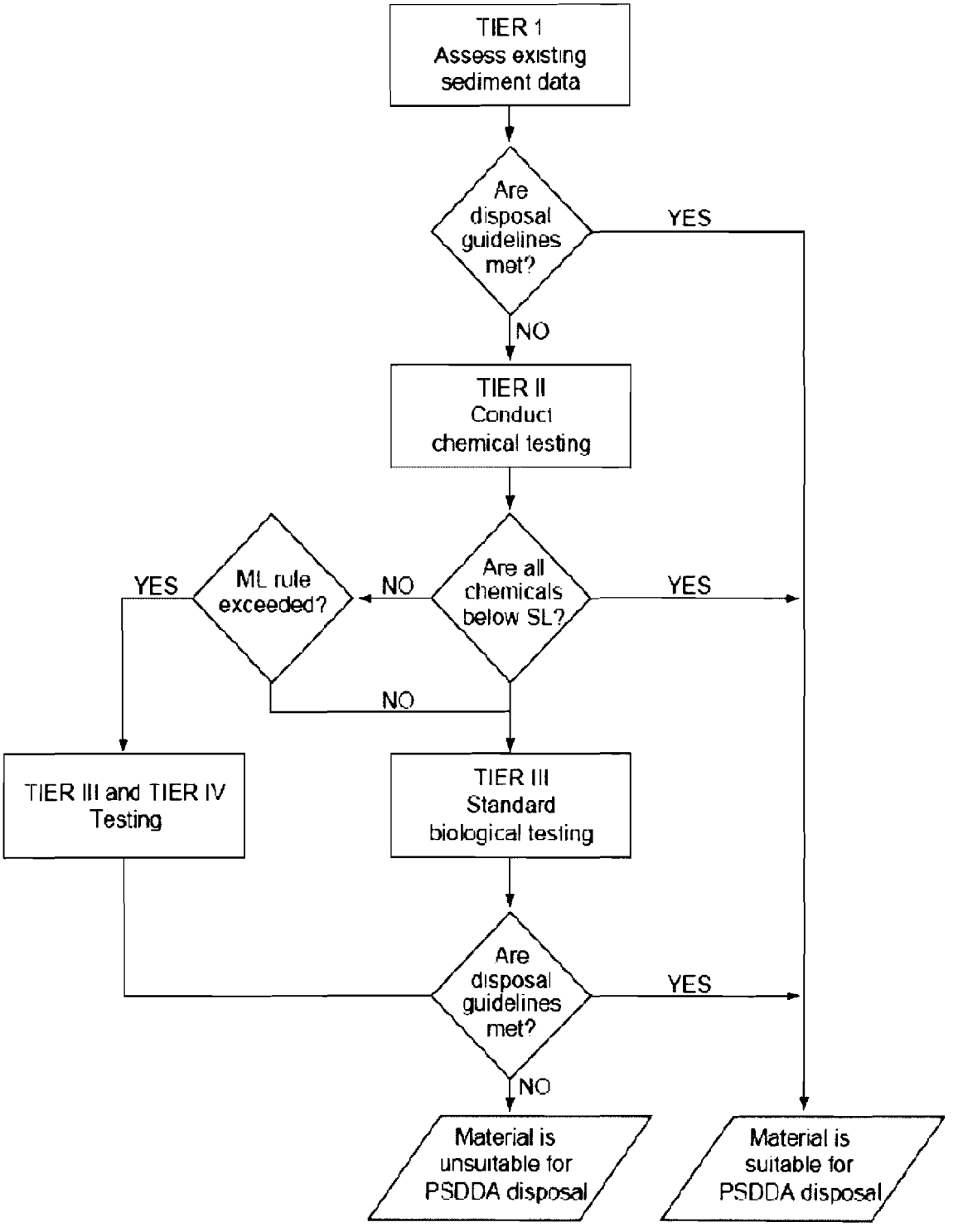

Figure 1. Schematic of the COE's sediment screening process. From COE (2010). This diagram does not depict the bioaccumulation screening, which is discussed in detail in COE (2010).

If test results show all chemicals are below screening levels, then the sediment is determined to be suitable for open water disposal. The DMMP agencies determine that adverse biological effects could occur if one or more chemical is above the screening level but below the maximum level. If one or more chemical is above the maximum level, then adverse biological effects are presumed and the proposed dredge area is unsuitable for open-water disposal.

Tier three (and possibly tier four) sediment evaluation would occur if: (1) one chemical concentration is more than double the maximum level concentration, or (2) two or more chemicals exceed the maximum level. Tier three involves solid phase bioassay testing to assess the effects of a particular chemical on an organism. Tier four testing would include time-sequenced bioaccumulation or tissue analysis of organisms collected from the area to be dredged. The PSDDA program has not conducted tier four testing to date because dredge proponents have chosen to dispose of materials at upland locations.

Sediment Transport and Disposal

Dredged material is transported to the disposal site by a tugboat pulling a bottom-dump (split-hull) barge. The barges transport approximately 1,500 cubic yards (cy) of material each trip. Dredging projects dictate the timing of sediment disposal. Most dredging takes place between July 16 and February 15. The disposal sites near Port Townsend and Port Angeles are closed from September 1 to November 30 to protect a shrimp fishery, and the Bellingham Bay site is closed from November 1 to February 28 to protect crab and shrimp resources. Disposal is not allowed anywhere in the Puget Sound between March 15 and June 15 (COE 2010).

Dredged material disposal at the non-dispersive sites is designed to maintain dispersion within a 600-foot radius target zone at each site. The barges doing the disposal are towed at the minimum speed necessary to maintain control. In most instances, material is released from the bottom of the barge which is about 10 feet down in the water column. All disposal tugs are required to record and report when and where sediment is released within the target zone. The disposal sites were originally sized so that a barge being towed at an average speed of three knots can unload completely in 10 minutes.

The total volume of disposed sediment for the next five years is expected to be similar to the past five years (COE 2010). The total yearly average of the non-dispersive sites is 736,911 cy. The total yearly average for the dispersive sites is 641,190 cy.

Benthic Habitat Monitoring

Non-Dispersive Sites

Monitoring at each site and nearby reference sites involves the collection of physical, chemical and biological data. This data is then used to inform an annual review of site management. The trigger for post-disposal monitoring is 300,000 cy at the Bellingham Bay site and the Anderson/Ketron Island disposal sites. The trigger for post-disposal

monitoring at the Commencement Bay, Elliott Bay, and the Port Gardner sites is 500,000 cy. The triggers for post-disposal monitoring were established to verify that sediment is staying on the non-dispersal sites, and that sediment is not accumulating at the dispersal sites. They were also established to assess the benthic communities of the non-dispersive sites (such as abundance, species composition) and any toxin levels within sediment (when full monitoring occurs). These triggers were established to assess the general condition of the benthic environment.

There are three types of post-disposal monitoring:
(1) Full monitoring entails mapping the disposal site with a sediment vertical profiling system (SVPS) which determines the depth and spread of dredged material. Box core benthic samples and SVPS are used to provide quantitative and qualitative information on benthic infaunal conditions both on and off site. Chemical monitoring is used to determine the concentrations of chemicals of concern present on and off the site. Biological monitoring includes toxicity bioassays to assess dredged material that has been deposited on the site. Offsite benthic communities are evaluated by a comparison of baseline data and post-disposal data along a gradient. The COE looks at sediment chemistry, conducts sediment bioassays, monitors infaunal tissue chemistry, and takes a census of infaunal abundance.
(2) Partial monitoring takes place when the dredged material doesn't exceed the screening levels (or does so only to a minimal degree). The COE conducts bathymetric mapping of the site with a SVPS in order to determine the depth of dredged material and sediment dispersal. The SVPS is also used to provide information on general benthic conditions both on and off site and includes collection of sediment at and near the site for chemical analysis. No quantitative biological information is collected during partial monitoring events.
(3) Tiered monitoring is triggered when tier one or two monitoring indicates that materials are creating offsite impacts to biota or sediment quality. To determine possible toxicity level changes, archived samples of invertebrates from the late 1980's are used for comparisons to recently sampled invertebrates.

Dispersive Sites

Dispersive sites are only monitored for possible bottom composition changes. Post-disposal monitoring is conducted to determine if sediment is unintentionally depositing at the site. The survey consists of using precision vertical soundings to detect possible mounding of dredged material. During the baseline and post-disposal phases of monitoring, soundings are made over continuous transects spaced 328 feet (100 meters) apart, and begin and end 328 feet outside the target area. The baseline and post-disposal soundings are then compared to determine if there is mounding of dredged material within the target area.

1.3 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The COE

determined that the action area is the entire Puget Sound that includes the Strait of Georgia westward to Low Point and north to the Canadian Border (Figure 2).

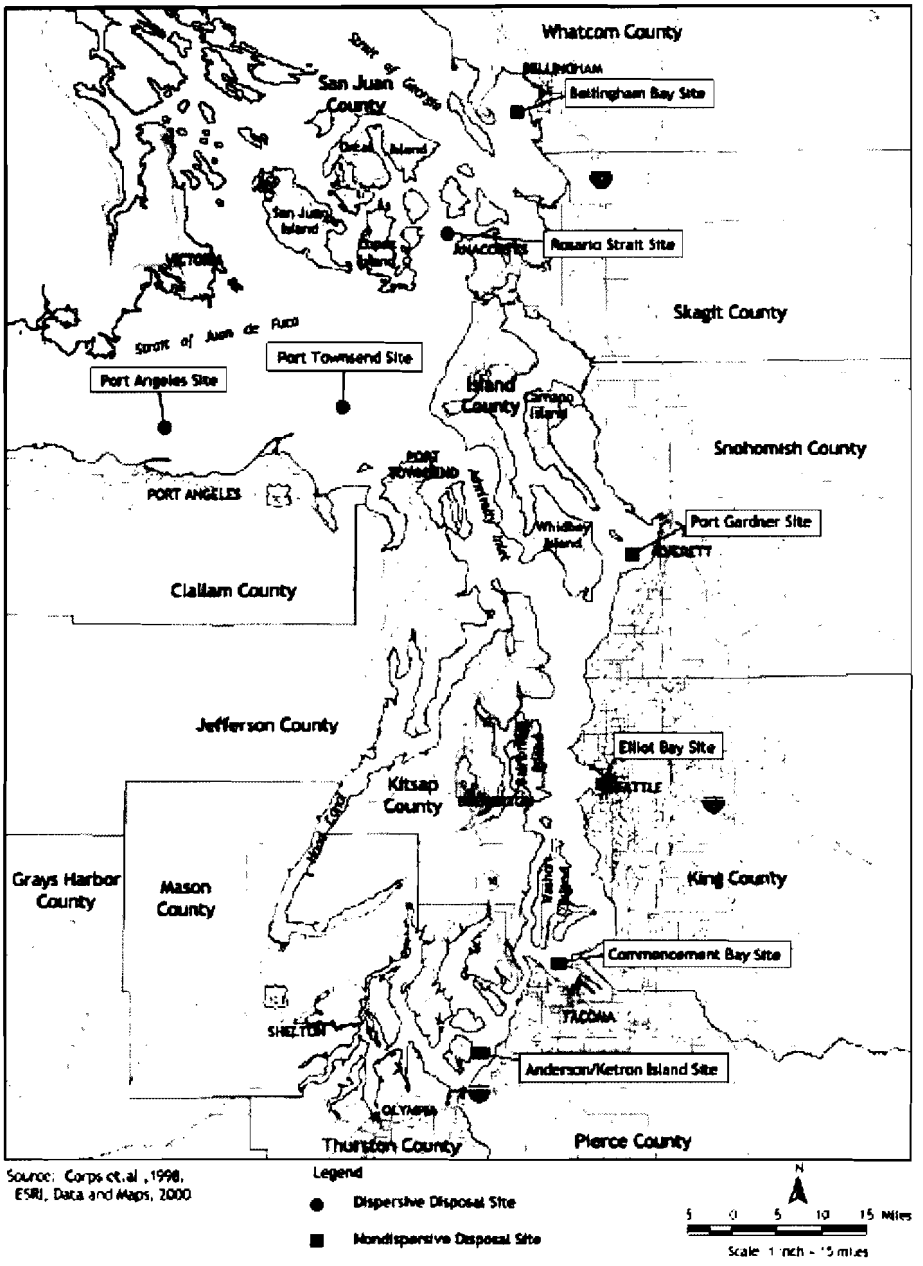

Figure 2. Sediment disposal sites. All but the Port Angeles site are within the action area for ESA-listed rockfish. The ESA-listed rockfish DPS boundary is approximately five miles eastward of the Port Angeles site.

NMFS agrees with this delineation of the action area because the sediment disposal sites are located throughout the Puget Sound and could alter habitat conditions (such as food availability or quality) for ESA-listed rockfish throughout their range. Habitats within the action area are used by larval, juvenile and adult yelloweye rockfish, canary rockfish, and bocaccio.

2. ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat on which they depend. Section 7(a)(2) of the ESA requires Federal agencies to consult with the United States Fish and Wildlife Service (USFWS), NMFS, or both, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Section 7(b)(3) requires that at the conclusion of consultation, the Service provide an opinion stating how the agencies' actions will affect listed species or their critical habitat. Section 7(b)(4) requires Federal agencies to provide an incidental take statement (ITS) that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts.

2.1 Introduction to the Biological Opinion

Section 7(a)(2) of the ESA requires Federal agencies to consult with NMFS to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat.

'To jeopardize the continued existence of a listed species' means to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR 402.02). We have not designated critical habitat for yelloweye rockfish, canary rockfish and bocaccio of the Puget Sound/Georgia Basin DPSs.

We will use the following approach to determine whether the proposed action described in Section 1.3 is likely to jeopardize listed species:

- *Identify the range-wide status of the species and critical habitat likely to be adversely affected by the proposed action.* This section describes the current status of each listed species and its critical habitat (if applicable) relative to the conditions needed for recovery. In describing the range-wide status of listed species, we rely on viability assessments and criteria in biological review team documents and recovery plans, where available, that describe how viability criteria are applied to specific populations, major population groups, and species. Species status is discussed in Section 2.2.
- *Describe the environmental baseline for the proposed action.* The environmental baseline includes the past and present impacts of Federal, state, or private actions and other human activities *in the action area.* It includes the anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation and the impacts of state or private actions that are contemporaneous with the consultation in process. The environmental baseline is discussed in Section 2.3 of this opinion.

- *Analyze the effects of the proposed actions.* In this step, NMFS considers how the proposed action would affect the species' reproduction, numbers, and distribution or, in the case of ESA-listed rockfish, their viability characteristics (Appendix A). The effects of the action are described in Section 2.4 of this opinion.
- *Describe any cumulative effects.* Cumulative effects, as defined in NMFS' implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation. Cumulative effects are considered in Section 2.5 of this opinion.
- *Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat.* In this step, NMFS adds the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5) to assess whether the action could reasonably be expected to appreciably reduce the likelihood of both survival and recovery of the species in the wild by reducing its viability characteristics. This assessment is made in full consideration of the status of the species (Section 2.2). Integration and synthesis occurs in Section 2.6 of this opinion.
- *Reach jeopardy conclusions.* Conclusions regarding jeopardy are presented in Section 2.7. These conclusions flow from the logic, facts and rationale presented in the Integration and Synthesis section (2.6).
- *If necessary, define a reasonable and prudent alternative to the proposed action.* If, in completing the last step in the analysis, NMFS determines that the action under consultation is likely to jeopardize the continued existence of listed species NMFS must identify a reasonable and prudent alternative (RPA) to the action in Section 2.8. The RPA must not be likely to jeopardize the continued existence of ESA-listed species and it must meet other regulatory requirements.

When they initiated this consultation, the COE requested that we concur with their determination that their action, as proposed, were "not likely to adversely affect" Puget Sound/Georgia Basin yelloweye rockfish, canary rockfish and bocaccio. NMFS cannot concur with the COE regarding the effects of the proposed action on rockfish because we have determined that the PSDDA program is likely to adversely affect some individuals of yelloweye rockfish, canary rockfish and bocaccio in the Puget Sound/Georgia Basin.

2.2 Rangewide Status of the Species

Puget Sound/Georgia Basin Distinct Population Segments of yelloweye rockfish and canary rockfish were listed as threatened and bocaccio as endangered under the ESA on April 27, 2010 (75 FR 22276). We determined that Puget Sound/Georgia Basin DPS of bocaccio is at high risk of extinction throughout all of its range and that the Puget Sound/Georgia Basin DPSs of yelloweye rockfish and canary rockfish are at moderate risk of extinction throughout all of their range (Drake et al., 2010). In this section we describe each species' abundance and productivity, spatial structure/connectivity, and diversity (collectively termed viability criteria). We will then assess how the proposed action would affect these viability criteria in section 2.4.

2.21 Life Histories

The Puget Sound/Georgia Basin DPSs include all yelloweye rockfish, canary rockfish and bocaccio found in waters of the Puget Sound, the Strait of Georgia, and the Strait of Juan de Fuca east of Victoria Sill. The Victoria sill is delineated from Low Point and north to the Canadian Border. Puget Sound can be subdivided into five interconnected basins separated by shallow sills: (1) The San Juan/Strait of Juan de Fuca basin, (2) Main Basin, (3) Whidbey Basin, (4) South Puget Sound, and (5) Hood Canal. We use the term "Puget Sound Proper" to refer to all of these basins except the San Juan/Strait of Juan de Fuca basin.

The life-histories of yelloweye rockfish, canary rockfish, and bocaccio are made up of a larval and pelagic juvenile stage, a juvenile stage, sub-adult stage, and an adult stage. These three species share similar life histories and biological requirements, but there are a few differences noted below.

Larval and Pelagic Juvenile Stage. Rockfish fertilize their eggs internally and the young are extruded as larvae. Larvae can make small local movements to pursue food immediately after birth (Tagal et al., 2002) but they are thought to be passively distributed with prevailing currents (NMFS 2003). Larvae are often observed under free-floating algae, seagrass, and detached kelp (Shaffer et al., 1995, Love et al., 2002) but they also occupy the full water column (Moser and Boehert 1991, Weis 2004). Unique oceanographic conditions in Puget Sound Proper likely keep most larvae near where they are born rather than dispersing them to adjacent basins (Drake et al., 2010).

Though there is a dearth of studies that have sampled for rockfish larvae presence in Puget Sound outside of the spring time, larval rockfish do occur throughout the year along the Pacific Coast and very likely occupy the action area throughout the year (Waldron 1972, Westrheim and Harling 1975, Wylie Echerverria 1987, Moser and Boehert 1991, Love et al., 2002, Weis 2004). Each species produces from several thousand to over a million eggs within one birth event (Love et al., 2002). We use the term 'cohort' to refer to larvae released within one birth event from one mother.

Larval rockfish are extremely fragile and mortality rates range from approximately 21% to 50% per day immediately after birth (Weis 2004) and rise to 70% seven to 12 days after their birth (Canino and Francis 1989). Their small size, relative inability to store food within their gut, and slow swimming speeds likely contribute to this high mortality rate by making them vulnerable to predators and starvation. Predators of larval rockfish include herring, surf smelt, salmon, and other fish.

Nearshore Juvenile Stage. When bocaccio and canary rockfish reach sizes of 1.1 to 3.5 inches (3 to 9 cm) (approximately 3 to 6 months old), they settle onto shallow nearshore waters in rocky or cobble substrates with or without kelp (Love et al., 1991, Love et al., 2002). These habitat features offer a beneficial mix of warmer temperatures, food, and refuge from predators (Love et al., 1991). Areas with floating and submerged kelp

species support the highest densities of most juvenile rockfish (Carr 1983, Halderson and Richards 1987, Matthews, 1989, Hayden-Spear 2006). Unlike bocaccio and canary rockfish, juvenile yelloweye rockfish do not typically occupy intertidal waters (Love et al., 1991; Studebaker et al. 2009), but settle in waters near the upper depth range of adults (Yamanaka and Lacko 2001).

Sub-Adult and Adult. Subadult and adult yelloweye rockfish, canary rockfish and bocaccio typically use habitats with moderate to extreme steepness, complex bathymetry, and rock and boulder-cobble complexes (Love et al., 2002). A measure of this habitat complexity comes from a "rugosity" value, which is a measurement of small-scale variations or amplitude in the height of a surface—in this case, the ocean bottom. Benthic habitats with higher rugosity values are more likely to be used by adult rockfish.

In Puget Sound Proper, yelloweye rockfish, canary rockfish and bocaccio have been documented both in areas of high relief (rocky) and in non-rocky substrates such as sand, mud, and other unconsolidated sediments (Washington 1977, Miller and Borton 1980, WDFW unpublished data). Yelloweye rockfish remain near the bottom and have small home ranges, while some canary rockfish and bocaccio have larger home ranges, move long distances, and spend time suspended in the water column (Love et al., 2002). Adults of each species are most commonly found in waters deeper than 120 feet (36 meters) (Love et al., 2002, Orr et al., 2000).

Yelloweye rockfish are one of the longest lived of the rockfishes, with some individuals reaching more than 100 years of age (Love et al., 2002). They reach 50% maturity at sizes around 16 to 20 inches (40 to 50 cm) and ages of 15 to 20 (Rosenthal et al., 1982, Yamanaka and Kronlund 1997). Maximum age of canary rockfish is at least 84 years (Love et al., 2002), although 60 to 75 years is more common (Caillet et al., 2000). They reach 50% maturity at sizes around 16 inches (40 cm) and ages of 7 to 9. The maximum age of bocaccio is unknown, but may exceed 50 years, and they are first reproductively mature near age 6 (FishBase 2010).

Food Sources. Rockfish feed on diverse assemblages of invertebrates and fish during their various life stages. Larvae feed on very small organisms such as zooplankton, copepods and phytoplankton. Juvenile rockfish feed on small invertebrates and fish. Sub adult and adult rockfish eat crab larvae, shrimp euphasids (*Crustacea spp*) and jellyfish (*Scyphozoans spp*) other species of rockfish (*Sebastes spp*) and many other fish species (Washington et al., 1978, Lea et al., 1999, Love et al., 2002, Palsson et al., 2009)[4].

[4] Fish eaten by adult rockfish include flatfish (*Family Pleuronectidae),* Pollock (*Theragra chalcogramma*), Pacific hake (*Merluccius productus*), Pacific cod (*Gadus macrocephalus*) perch (*Rhacochilus spp*) and forage fish that include Pacific herring (*Clupea harengus pallasi*), surf smelt (*Hypomesus pretiosus*), and Pacific sand lance (*Ammodytes hexapterus*).

Previous section 7(a)(2) Consultations

The status of the species is influenced by the actions contemplated in previously completed section 7(a)(2) consultations. Thus far, five opinions have addressed adverse effects on ESA-listed rockfish within the Puget Sound/Georgia Basin DPS as listed in Table 3.

Table 3. Consultations Completed Regarding Adverse Affects on Listed Puget Sound/Georgia Basin Rockfish Species.

Consultation Number	Action Area	Duration	Maximum Authorized Take (fish or habitat area)		
			Yelloweye	Canary	Bocaccio
F/NWR/2010/01850 (Conference Opinion for ESA-listed rockfish)	U.S. portion of the Puget Sound/Georgia Basin	May 1 through July 31, 2010.	76 fish	172 fish	7 fish
F/NWR/2010/00314	U.S. portion of the Puget Sound/Georgia Basin	April 24, 2010 to December 31, 2012.	6 fish	6 fish	1 fish
F/NWR/2010/01714	San Juan Basin of the Puget Sound/Georgia Basin	April 30, 2010 to December 31, 2011	Up to 45,000 square feet of benthic habitat of the San Juan basin.		
F/NWR/2010/03521	U.S. portion of the Puget Sound/Georgia Basin	August 1, 2010 to April 30, 2011	27 fish	57 fish	2 fish
F/NWR/2010/02406	Sinclair Inlet in Puget Sound	2010-2012	Up to 17,000 square feet of aquatic habitat.		

Viability Criteria

In the following section, we summarize the condition of the yelloweye rockfish, canary rockfish and bocaccio at the DPS level according to the following demographic viability criteria: abundance and productivity, spatial structure/connectivity, and diversity. These viability criteria are outlined in McElhaney et al. (2000), and reflect concepts that are well founded in conservation biology and are generally applicable to a wide variety of species. These criteria describe demographic risks that individually and collectively provide strong indicators of extinction risk (Drake et al., 2010).

Abundance & Productivity

The abundance of individuals in a population is important to assessing two aspects of extinction risk. First, population size can be an indicator of whether it can sustain itself in the face of environmental fluctuations and small-population stochasticity. Second, abundance in a declining population is an indicator of the time expected until the population reaches critically low numbers (Drake et al., 2010). Small rockfish populations are subject to the following risks: (1) environmental variation such as altered temperature regimes and circulation patterns that could disrupt food-webs, larval

dispersal or juvenile rearing, (2) genetic processes such as the accumulation of negative mutations, (3) demographic stochasticity such as imbalanced gender ratios, (4) ecological feedback such as other fish species occupying the niche left by the depleted population, and (5) catastrophes such as oil spills that may disrupt benthic environments or larval/juvenile rearing habitats and food sources (McElhaney et al., 2000). Low abundance may also pose a risk to the species by making them vulnerable to depensatory processes (termed "Allee" effects) that occur when mates cannot find one another (Courchamp et al., 2008).

There is no single reliable historic or contemporary population estimate for any of the DPSs (Drake et al., 2010). Despite this limitation, there is clear evidence based on catch data each species' abundance has declined dramatically (Drake et al., 2010). The total rockfish population in the Puget Sound region is estimated to have declined around 3% per year for the past several decades, which corresponds to an approximate 70% decline from 1965 to 2007 (Drake et al., 2010). Catches of yelloweye rockfish, canary rockfish, and bocaccio have declined as a proportion of the overall rockfish catch (Palsson et al., 2009, Drake et al., 2010).

Fishery-independent estimates of population abundance come from spatially and temporally limited research trawls, drop camera surveys and underwater remotely operated vehicle (ROV) surveys conducted by the Washington Department of Fish and Wildlife (WDFW). Using these methods, the WDFW has estimated that 50,655 yelloweye rockfish, 20,449 canary rockfish, and 4,487 bocaccio inhabit the San Juan/Strait of Juan de Fuca area (NMFS 2010). There are no population estimates of yelloweye rockfish, canary rockfish and bocaccio in Puget Sound Proper. The available population estimates for the San Juan/Strait of Juan de Fuca area have generally large variances (or standard errors), and thus there remains uncertainty regarding the total abundance and distribution of ESA-listed rockfish in the Puget Sound/Georgia Basin DPSs.

Productivity is the measurement of a population's growth rate through all or a portion of its life-cycle. Life-history traits of yelloweye rockfish, canary rockfish and bocaccio suggest generally low levels of inherent productivity because they are long-lived and mature slowly, with sporadic episodes of successful reproduction (Tolimieri and Levin 2005, Drake et al., 2010). This naturally low-productivity can be exacerbated by fishery removals, environmental toxicity and habitat changes derived from environmental regime changes.

Historic over fishing can have dramatic impacts on the size or age structure of the population, with effects that can influence ongoing productivity. When the size and age of females decline, there are negative impacts to reproductive success. These impacts, termed maternal effects, are evident in a number of traits. Larger and older females of various rockfish species have a higher weight-specific fecundity (number of larvae per unit of female weight) (Boehlert et al., 1982, Bobko and Berkeley 2004, Sogard et al., 2008). A consistent maternal effect in rockfishes relates to the timing of parturition. The timing of larval birth can be crucial in terms of matching favorable oceanographic

conditions for larvae because most are released on only one day each year. Larger or older females release larvae earlier in the season compared to smaller or younger females in several studies of rockfish species (Sogard et al., 2008, Nichol and Pikitch 1994). Larger or older females provide more nutrients to larvae by developing a larger oil globule released at birth, which provides energy to the developing larvae (Berkeley et al. 2004, Fisher et al. 2007), and in black rockfish enhances early growth rates (Berkeley et al., 2004).

Contaminants such as PCBs, chlorinated pesticides, PBDEs, ploycholinated dioxins/furans (PCDD/F) (collectively referred to as bioaccumative toxins) appear in rockfish collected in urban areas of the Puget Sound, such as Port Gardner, Elliot Bay and Commencement Bay (West et al., 2001, Palsson et al., 2009). While the highest levels of contamination are found in urban areas, toxins can be found in the tissues of salmon and forage fish throughout the region (Puget Sound Action Team 2007).

Reproductive function and therefore productivity of rockfish is likely affected by contaminants (Palsson et al., 2009). Adverse reproductive effects in rockfish could occur via maternal transfer of bioaccumulative toxics to larvae. Male rockfish typically accumulate more toxins than females, which provide evidence that the transfer of some toxins from females to larvae occurs during gestation (Palsson et al., 2009) (Figure 2).

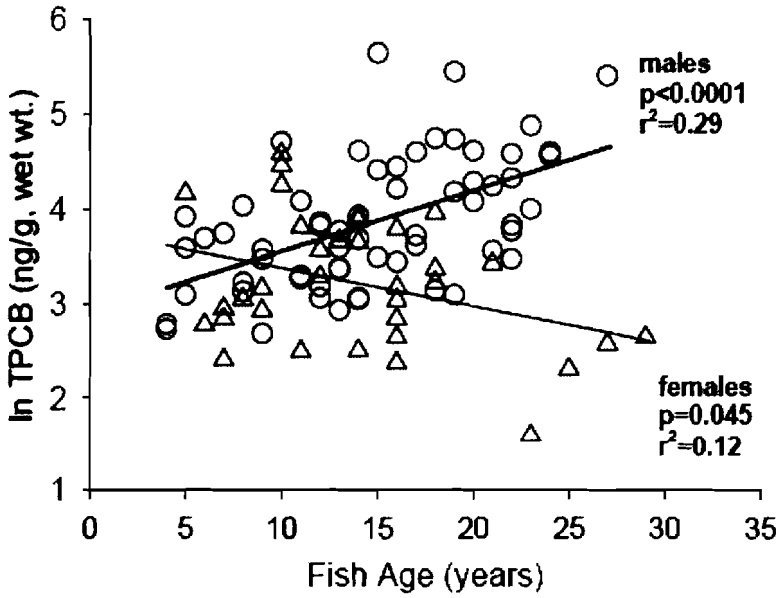

Figure 2. Total PCBs (log transformed) in quillback rockfish (Sebastes maliger) accumulates in males (circles) but not females (triangles) from Elliot Bay, Puget Sound. From Palsson et al., 2009.

Future climate-induced changes to rockfish habitat could alter their productivity (Drake et al., 2010). Harvey (2005) created a generic bioenergetic model for rockfish, showing that productivity of rockfish is highly influenced by climate conditions such that El Nino-like conditions generally lowered growth rates and increased generation time. The negative effect of the warm water conditions associated with El Nino appear to be common across rockfishes (Moser et al. 2000). Recruitment of all species of rockfish appears to be correlated at large scales. Field and Ralston (2005) hypothesized that such

synchrony was the result of large-scale climate forcing. Exactly how climate influences rockfish in Puget Sound is unknown; however, given the general importance of climate to rockfish recruitment, it is likely that climate strongly influences the dynamics of the ESA-listed rockfish population productivity and therefore their overall population viability (Drake et al., 2010).

Spatial Structure and Connectivity

Spatial structure consists of a population's geographical distribution and the processes that generate that distribution (McElhaney et al., 2000). A population's spatial structure depends on habitat quality, spatial configuration, and dynamics as well as dispersal characteristics of individuals within the population (McElhaney et al., 2000).

The apparent steep reduction of ESA-listed rockfish in Puget Sound Proper leads to concerns about the viability of these populations (Drake et al., 2010). Yelloweye rockfish spatial structure and connectivity is likely threatened by the apparently severe reduction of fish throughout the DPSs and in particular all or portions of Hood Canal and the South Puget Sound, combined with their small home ranges as adults. Similarly, several historically large aggregations of canary rockfish in Puget Sound have been depleted, including an area of historic distribution in South Puget Sound (Drake et al., 2010). Bocaccio were historically most abundant in the Central and South Puget Sound, but are now rarely observed in these areas (Drake et al., 2010).

For canary rockfish and bocaccio, positive signs for spatial structure and connectivity come from the propensity of some adults and pelagic juveniles to migrate long distances, which could reestablish aggregations of fish in formerly occupied habitat (Drake et al., 2010).

Diversity

Rockfish diversity characteristics are fecundity, timing of the release of larvae and their condition, morphology, age at reproductive maturity and physiology, and molecular genetic characteristics. In spatially and temporally varying environments, there are three general reasons why diversity is important for species and population viability: (1) diversity allows a species to use a wider array of environments, (2) it protects a species against short-term spatial and temporal changes in the environment, and (3) genetic diversity provides the raw material for surviving long-term environmental changes. Though there are no genetic data for any of the listed DPSs, the unique oceanographic features and relative isolation of some of its basins may have led to unique adaptations, such as larval release timing (Drake et al., 2010).

ESA-listed rockfish size (and age) distributions have been truncated which likely hampers diversity in terms of larval release timing and energy reserves. Recreationally caught yelloweye rockfish, canary rockfish, and bocaccio in the 1970's spanned a broad range of sizes. By the 2000's, there was evidence of proportionately fewer older fish (Drake et al., 2010). For each species, the reproductive burden may be shifted to younger and smaller fish. This shift could alter the timing and condition of larval release, which

may be mis-matched with habitat conditions in the Puget Sound, potentially reducing the offspring's viability (Drake et al., 2010).

2.3 Environmental Baseline

The environmental baseline for biological opinions includes the past and present impacts of all state, Federal or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR §402.02). The condition of the environmental baseline includes the previous formal consultations (Table 3) for ESA-listed rockfish, which in turn informs our analysis of the proposed actions effect would have upon each species within the Puget Sound/Georgia Basin (Section 2.4)

Puget Sound is the second largest estuary in the United States, located in northwest Washington State, covering an area of about 1,020 square (sq) miles, including 2,500 miles of shoreline. It is home to a rapidly-expanding human population. Puget Sound is part of a larger inland waterway, the Georgia Basin, situated between southern Vancouver Island, British Columbia, Canada and the mainland coasts of Washington State. The five basins of the Puget Sound have unique temperature regimes, water residence times and circulation patterns, biological conditions, depth profiles and contours, species compositions, and nearshore and benthic habitats (Ebbesmeyer 1984, Burns 1985, Rice 2007). All but the Hood Canal basin have at least one dredge disposal site.

Habitats of ESA-listed rockfish DPSs can be divided into the nearshore, demersal, and pelagic zones. The nearshore refers to intertidal waters to roughly 90 feet deep, which is typically the deepest extent of photosynthesis. The demersal zone refers to the water column near the sea-bottom, and the pelagic zone refers to the water column. These habitats have been influenced by a number of human-induced alterations, and we discuss the environmental baseline of the demersal and pelagic zones in more detail than the nearshore, as these habitats are most affected by sediment disposal.

The nearshore of the action area consists of rocky, sandy or cobble-sized shorelines and benthic areas. Development has occurred along approximately 30% of the Puget Sound shoreline (Broadhurst 1998), and has increased in recent years (Cornwall and Mayo 2008). Development along the shoreline has been linked to reductions in invertebrate abundance, species diversity (Dugan et al. 2003), and forage fish egg viability (Rice 2007).

Habitats of the demersal zone are most prevalently influenced by pollution that includes excess nutrients and contaminants, and derelict fishing gear (Palsson et al., 2009). As with the nearshore areas, the sea-bottom of the demersal zone consists of rocky/cobble areas, and soft-bottomed habitats of mud, sand or clay. Most of the bottom substrates of the action area consist of unconsolidated sediments that are clay, sand and mud. Rocky

habitats are extremely limited in Puget Sound Proper, with only 3.8 sq miles (10 km^2) in Hood Canal and waters east of Admiralty Inlet, and 80 sq miles (207 km^2) in the eastern Strait of Juan de Fuca and the San Juan basin (Palsson et al. 2009). There are 14 major river basins that deposit sediment into Puget Sound and the Strait of Juan de Fuca as well as natural shoreline-bluff deposition (Burns 1985). The Frasier and Skagit Rivers alone deposit approximately 24 million metric tons of sediment annually (COE 1989). This sediment ranges from sand (less than 1/16 millimeters (mm)) to mud, silt and clay (greater than1/16mm to less than 1/256mm) (Burns 1985). Many of these sediments settle onto local estuaries and nearshore areas that have been transformed for human uses that include vessel navigation and marinas. Some finer-grained sediment is distributed more broadly across the Puget Sound/Georgia Basin and eventually settles onto demersal habitats, mostly in areas with relatively slow currents (Burns 1985). The amount of suspended sediments within the pelagic zone of the Puget Sound typically ranges from 0.5 to 2 milligrams per liter (mg/l), but is quite variable with higher concentrations generally occurring near the surface, and in demersal areas (COE 1989). Sediment accumulates on the bottom of North Puget Sound at an annually estimated rate of 200 to 300 milligrams per square centimeter (COE 1989).

Demersal habitats of the Puget Sound and Strait of Juan de Fuca have been altered by human activities such as past bottom trawling, accumulation of marine debris, and the deposition of pollutants (Palsson et al., 2009). Bottom trawls have likely damaged some habitats used by rockfish by homogenizing rock/boulder structure (WDFW 1998). Marine debris such as lost fishing nets and crab pots catch on structure that is also attractive to rockfish and thereby kill rockfish and their various prey (Good et al., 2010). The removal of thousands of derelict nets from the region has improved benthic habitats for rockfish, but nets deeper than 100 feet persist and likely continue to kill fish.

Over the last century, human activities have introduced a variety of toxins into the action area. Areas of higher concentrations of contaminated sediments include Bellingham Bay, Commencement Bay, Elliot Bay and Port Gardner. Some toxins remain suspended within the pelagic zone. However, most of these toxins bind to sediments and settle onto demersal habitats. The Washington State Department of Ecology estimates that Puget Sound receives between 14 and 94 million pounds of toxic pollutants per year, which include oil and grease, bioaccumulative toxins, and heavy metals such as zinc, copper, and lead (Ecology 2010).

In addition to chemical contamination, water quality in the Puget Sound region is also influenced by sewage, animal waste, and other nutrient inputs. Hood Canal has seen persistent and increasing areas of low dissolved oxygen since the mid 1990's. Typically, demersal fish move out of areas with dissolved oxygen less than 2 mg/l; however, when low dissolved oxygen waters were quickly upwelled to the surface in 2003, about 26% of the rockfish population was killed as well as other demersal species (Palsson et al. 2009). In addition to Hood Canal, periods of low dissolved oxygen are becoming more widespread in waters south of Tacoma Narrows (Palsson et al. 2009). The environmental condition of the seven disposal sites within the ESA-listed rockfish DPSs is described in more detail below.

Non-Dispersive Sites

The non-dispersive sites are in Bellingham Bay, Port Gardner, Elliot Bay and Commencement Bay and are close to major industrial ports and large rivers. Each has relatively slow currents and fine-grained benthic sediments. The Anderson/Ketron Island site is not near a major port or large river, but it is also characterized by relatively slow currents and fine-grained sediments. Adult yelloweye rockfish, canary rockfish, and bocaccio have been documented within one mile of all sites except the Commencement Bay site. Larval rockfish have been documented near each of the non-dispersive sites (Waldron 1972). In addition, small numbers of quillback and copper rockfish have been documented near all sites and various flatfish species were found to be the most dominant group of fish near all of them (Donnelly et al., 1988). Sediment quality monitoring has generally found concentrations of tested chemicals to be lower than nearby reference sites (Figure 2). The concentration of PCBs in sediments within the disposal zones of Bellingham Bay, Port Gardner, and Commencement Bay are within the range of average or lower than Puget Sound benthic concentrations (COE 2010). At Elliot Bay, PCBs were detected in 88.6% of the samples from the disposal site, and 87.6% of the samples from off-site areas, and the onsite and offsite median concentrations were not significantly different (with 95% confidence).

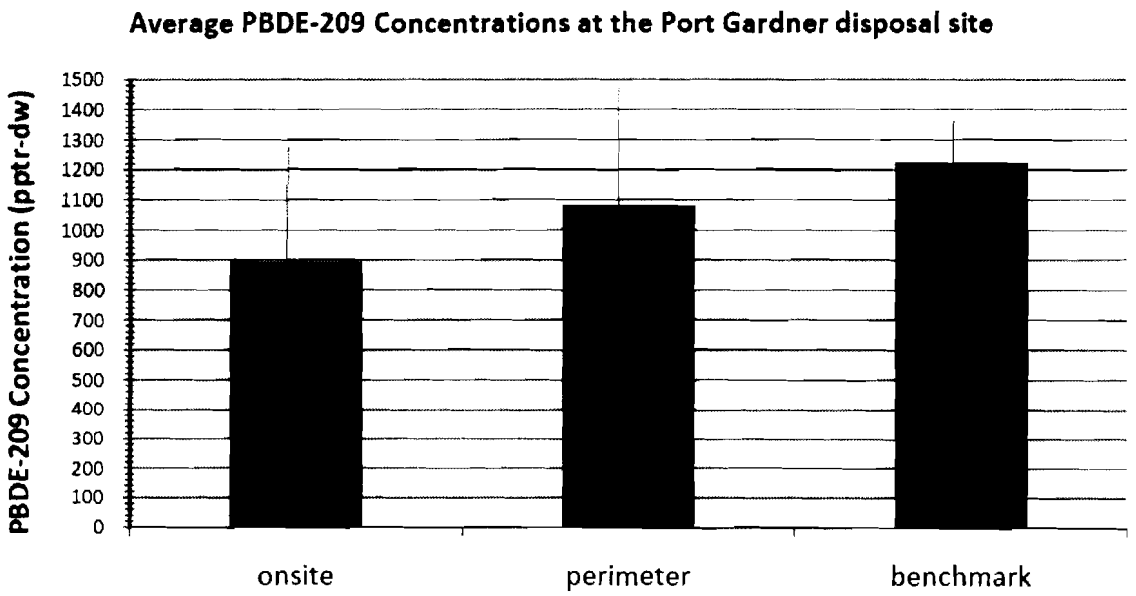

Figure 3. Concentrations of PBDE-209 in Port Gardner. The red line shows one standard deviation (electronic mail from the COE). Similar results have been found for PCDD/F, at the Port Gardner and Anderson/Ketron Island, Elliot Bay and Bellingham Bay site and reference sites.

Dispersive Sites

The dispersive sites within the DPSs are in Rosario Straight near Fidalgo Island and near Port Townsend Bay in Admiralty Inlet (each within the San Juan Basin). Epibenthic organisms such as scallops are more numerous than infaunal organisms such as annelid worms, which is typical for these types of benthic habitats. Common invertebrate biota

also includes shrimp and sea urchins (Donnelly et al., 1988). Twelve demersal fish species have been document at these sites, including Dover sole, rex sole, Pacific cod, and walleye pollock and arrowtooth flounder (Donnelly et al., 1988). The benthic habitats of the dispersive sites are homogenous, with no aggregations of structure or steep slopes that would typically attract rockfish. Habitats near the Rosario Strait and Port Townsend sites have steeper slopes and greater benthic habitat complexity. The Rosario Strait site seafloor is composed of coarse-grained sediments, rocks and cobble, which is typical for areas which experience strong current flows. The currents at the Rosario Strait site typically range from 10 to 30 cm/sec, with peak speeds of 100 cm/sec. Mean current speeds at the Port Townsend site are between 30 to 50 cm/sec, with peak speeds of 75 to 100 cm/sec (COE 2010).

2.4 Effects of the Action

"Effects of the action" means the direct and indirect effects of an action on the listed species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur. Effects of the action that reduce the ability of a listed species to meet its biological requirements may increase the likelihood that the proposed action will jeopardize that listed species or destroy or adversely modify designated critical habitat. NMFS has not identified any interrelated or independent actions, nor indirect effects associated with this project (Section 1.2). No critical habitat has been designated for ESA-listed rockfish, thus we do not conduct an adverse modification analysis.

The COE has proposed review of implementation of the PSDDA program for a period of five years. This time period allows NMFS to assess the effects of the action across multiple rockfish reproductive seasons and enables a more comprehensive analysis by ensuring that new information relevant to the proposed action is accounted for. A review of the PSDDA program for a period of less than five years would not enable an assessment of its potential effects on multiple cohorts of ESA-listed rockfish. A review of the PSDDA program for a period of longer than five years would not enable accounting for changes to the environmental baseline or species status based on additional scientific studies and reports, each of which may change the relative effects the proposed action may have upon ESA-listed rockfish.

Several components of the proposed action are unlikely to result in harm to any life stage of ESA-listed rockfish. They include: (1) the transportation of sediment, and (2) the monitoring of benthic habitats. Each aspect of those components would not alter the behavior and habitats of ESA-listed rockfish because they would not alter habitat suitability for any life stage, or result in behavioral alterations. Similarly, sediment disposal activities at the Port Angeles site are unlikely to harm ESA-listed rockfish because they would occur outside of the DPSs' boundaries, and very little sediment is likely to drift eastward into the areas inhabited by the DPSs because of its distance from the border of the Victoria Sill. Thus, these components of the proposed action are not

analyzed further.

Adult yelloweye rockfish, canary rockfish and bocaccio have been documented within several miles of each of the disposal sites with the exception of the Commencement Bay site (Washington 1977, Dinnel 1986, WDFW unpublished data). Demersal habitats within several miles of Commencement Bay disposal could be occupied by adult rockfish because they have appropriate depths, steepness, and rugosity (Section 2.21). Larval rockfish have been documented within several miles of all of the dispersive and non-dispersive sites within the DPS boundaries (Waldron 1972).

Thus it is likely that some larval rockfish would be exposed to sediment as it is dumped at both the dispersive and non-dispersive sites. The trajectory of dumped sediment differs at the two site types. The trajectory and concentrations of dumped sediment at the dispersive sites is difficult to predict because the sites are characterized by complex and strong currents. However, the COE has predicted that a 1,500 cy disposal would reach extremely low concentrations after one hour (COE 1989). When sediment is released from barges at the non-dispersive sites, it travels through the water column "...as a dense fluid like jet. When it hits the bottom it collapses, and moves radially outward" (COE 1989). The COE has modeled the estimated sediment concentrations for the surface, mid-water, and bottom of a typical disposal scenario at the non-dispersive sites (Figure 3). Model result suggest that surface sediment concentrations would remain at low levels for up to 24 minutes, while mid-water and bottom concentrations spike for shorter periods of time, but at much higher levels (COE 2010). Upon contact with the bottom the estimated diameter of the jet at a 400 foot side is 250 feet (COE 2010). For our analysis, we conservatively set the diameter of the jet at 250 feet for the full water column at each of the non-dispersive sites.

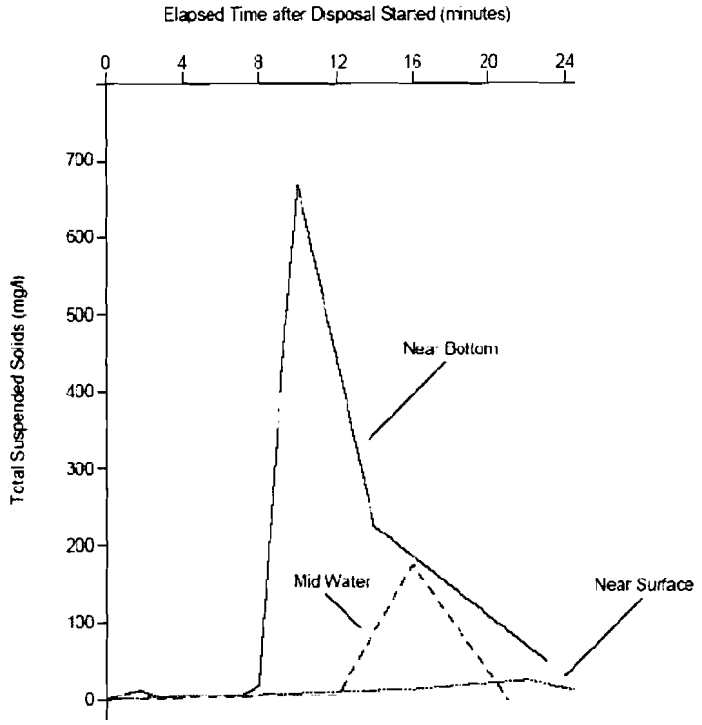

Figure 3. Modeled suspended sediment concentrations and duration at non-dispersive sites (COE 2010).

Larvae/pelagic juveniles

For the purpose of this analysis, we refer to larval and pelagic juvenile rockfish as "larvae" because there is no clear delineation between these life stages, and each would be similarly affected from the proposed action. The effects on larval rockfish would occur within the five years which the proposed action would occur. Larval rockfish have been documented near each of the disposal sites (Waldron 1972). In addition, some larvae and pelagic juveniles of ESA-listed rockfish broadly disperse from the area of their birth (NMFS 2003, Drake et al., 2010) and are likely to be using habitat in the action area during sediment disposal activities. The concentrations and duration of suspended sediments within the water column depends upon the depth, currents, and composition of the material, and concentrations of up to 1,000 mg/l have been documented (COE 2010).

Suspended sediment would affect larvae by injuring or killing them or altering their feeding rate (which is a sublethal affect) at the non-dispersal and dispersal sites. A number of studies have assessed suspended sediment effects on Pacific herring larvae, as well as other marine fish. Larval herring death rates ranged from 82.8 to 99.4%, compared to 23.6% of the control group when they were exposed to suspended sediment levels of 10,000, 5,000, and 500 mg/l for four days (Morgan and Levings 1989). Larval herring had abraded yolk sacs that increased relative to the concentration when exposed for 24 hours to suspended sediment concentrations of up to 8,000 mg/l (Boelhert 1984), and their feeding rates were observed to maximize when concentrations reached 500 mg/l, and decreased at higher concentrations (Boehlert and Morgan 1985). When

exposed to 10,000, 5,000 and 500 mg/l for ten days, larval lingcod death rates ranged from 90 to 98%, compared to 18% in a control group (Morgan and Levings 1989). None of the aforementioned studies replicate the short term but very high concentrations of suspended sediment that would result from sediment disposal in Puget Sound. Larvae could be exposed to contaminants within the water column after dumping, but this exposure time would likely be too short, and contaminant levels too low to result in harm (COE 2010).

Given the extreme fragility of larval rockfish, some fish within the water column of the active disposal zone would be injured or killed by ruptured capillaries, maceration of highly vascular organs and internal bleeding, and/or temporarily reduced dissolved oxygen levels. As an example of their fragility, larval rockfish were observed to be injured by strong water flow in laboratory-rearing environments (Canino and Francis 1989).

To estimate the amount of larvae exposed to sediment disposal at each of the non-dispersive sites on an annual basis, we: (1) estimated the range of abundance of larval yelloweye rockfish, canary rockfish, and bocaccio based on data reported by Weis (2004) and recent recreational rockfish catch data compiled by WDFW (WDFW unpublished data), (2) used estimates of the water column altered from disposal activities for the non-dispersive sites (COE 2010), (3) used the number of anticipated sediment disposal events at each of the non-dispersive sites in the DPS (COE 2010), and (4) calculated the range of larvae within the affected water column for each site. We were unable to calculate how many larvae could be affected by sediment dumping at the dispersive sites due to the complexity of currents that probably cause rapid spreading of materials.

Larval rockfish densities have been documented to range from approximately 0.75 to 2.5 fish per 10,763 sq feet (1,000 m) in the San Juan Basin (Weis 2004). Rockfish larvae are difficult to identify from morphological features alone until they are several weeks to months old (Love et al., 2002), thus Weis did not identify species. To estimate the abundance of rockfish larvae that would be in the water column when sediment is disposed, we used the densities of all rockfish larvae reported in Weis (2004), and bounded it by the proportion of yelloweye rockfish, canary rockfish, and bocaccio caught in recent fisheries (WDFW 2010). For the purposes of this analysis we assume that the proportion of ESA-listed rockfish caught by recreational anglers compared to the total rockfish caught roughly represents the proportion of larval rockfish. We also assume that the range of densities of rockfish larvae caught in the San Juan basin and reported by Weis (2004) would be the same at each of the disposal sites, including those in Puget Sound Proper. Finally, we assume that the distribution of larvae is uniform throughout the DPSs.

The proportion of adult yelloweye rockfish caught by recreational anglers from 2004 to 2008, as a proportion of the total rockfish catch, was 0.008% (WDFW 2010). Canary rockfish were 0.012% of the catch, and bocaccio were 0.00026% of the total rockfish caught (WDFW unpublished data). By multiplying the percentage of the recreational catch by the density ranges reported by Weis we derive the estimated densities of

yelloweye rockfish, canary rockfish, and bocaccio larvae at the non-dispersive sites. This calculation results in estimated densities of 0.006 to 0.02 yelloweye rockfish larvae, 0.0093 to 0.031 canary rockfish larvae, and 0.00019 to 0.0006 bocaccio larvae per 10,763 square feet (1,000m). With these estimated densities, we approximate the number of larval ESA-listed rockfish that would be affected by the sediment disposal activities at each of the non-dispersive sites (Table 4). These estimates are likely higher than would occur at the sites in Puget Sound Proper because they are based on rockfish larvae density from the San Juans (Weis 2004). There are more rockfish in the San Juan region than the Puget Sound Proper (Palsson et al., 2009) thus there are likely more larvae in this region as well.

Table 4. Estimated Numerical Ranges of Larval ESA-listed Rockfish Likely to be Exposed to Sediment Disposal Activities on an Annual Basis.

Non-dispersive sites			
	Range of estimated annual yelloweye rockfish larvae exposed	Range of estimated annual canary rockfish larvae exposed	Range of estimated annual bocaccio larvae exposed
Port Gardner	1,401.5 to 68,743.2	2,170.1 to 7,233.7	45.2 to 150.7
Elliot Bay	1,040 to 3,466.2	1,610.1 to 5,367	33.5 to 111.8
Commencement Bay	4,751 to 15,835.0	7,355.6 to 24,518.7	153.2 to 510.8
Anderson/Ketron Island	69 to 19.9	107 to 356.6	2.2 to 7.4
Bellingham Bay	8.4 to 28.07	13 to 43.5	0.3 to 0.90
Total range of larvae	7,269.4 to 88,092.4	2,170 to 37,519.5	234.5 to 781.7

Though we were unable to estimate the number of larval rockfish that may be exposed to or killed by sediment disposal at the dispersive sites, it is likely that the overall number affected would be fewer than the non-dispersive sites because of the rapid sediment dispersal at those sites.

Adults

Adult yelloweye rockfish are unlikely to occupy demersal habitats at either the dispersive or non-dispersive sites because of their steepness and relative lack of structural complexity. A quantitative measure of this lack of complexity comes from their low rugosity values. Only 2.1% of the Elliot Bay disposal site has a rugosity value greater than 1.005, and the rest of the sites have values less than 1.005, meaning they have fairly flat and homogenous benthic habitats. The Port Gardner and Port Townsend sites (indicated by black arrows and circles in Figure 4) have much less complex habitat compared to adjacent and steeper benthic areas (indicated by white arrows in Figure 4), as is the case for each of the disposal sites.

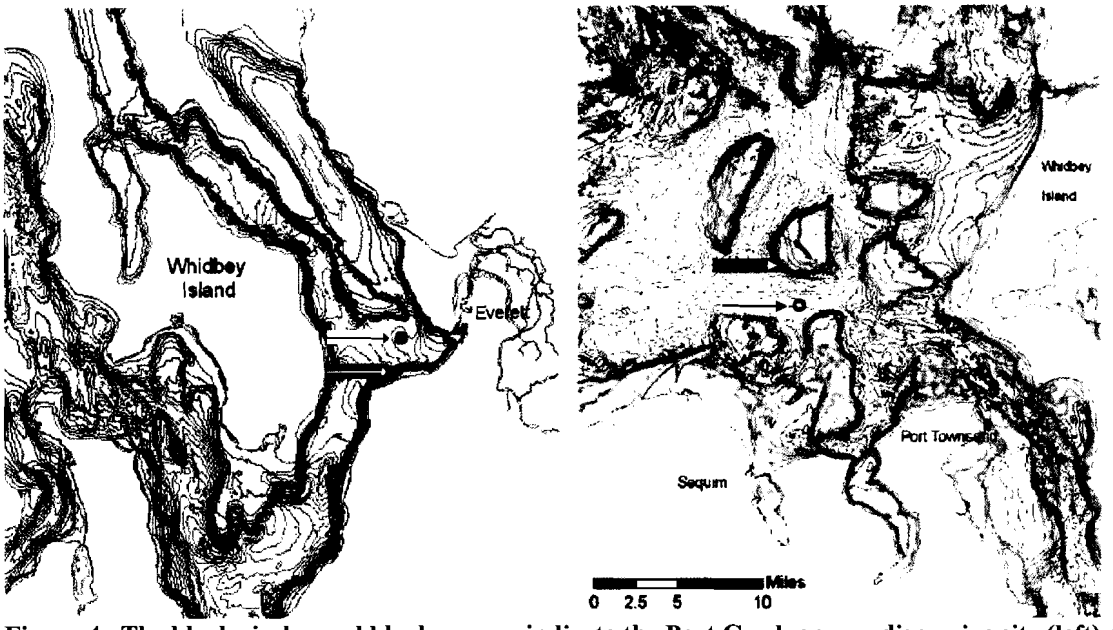

Figure 4. The black circles and black arrows indicate the Port Gardner non-dispersive site (left) and Port Townsend dispersive sites (right). Benthic areas with increased steepness (and rugosity values) are indicated by thick purple, blue and green bathymetric lines (examples indicated by the white arrows). Images generated by NMFS.

It is possible that some adult canary rockfish or bocaccio could occupy the water column near or within the disposal sites because of their propensity to travel. Adult yelloweye are sedentary (Love et al., 2002) and thus unlikely to occupy the water column of any of the disposal sites. Given the low abundance of canary rockfish and bocaccio, it is unlikely that they would be traveling though the affected water column (which is less than 0.006% of the Puget Sound) for the few minutes of sediment disposal activities. present during sediment disposal.

If an adult ESA-listed rockfish is present within the affected water column during a disposal event they would likely move away from the sediment plume and thus avoid injury. Suspended sediment concentrations from the dumping at the non-dispersive sites would be at extremely low concentrations by the time they reach any habitat likely to contain adult listed rockfish, and thus would not result in harm. At the non-dispersive sites the COE estimated that a typical 1,500 cy sediment dump would create sediment concentrations of 0.0007 mg/l six hours after the event. This is equivalent to $1/100^{th}$ of the typical background concentration of suspended sediment (COE 1989). This level of additional sediment concentration is well within the range of natural variation (Burns 1985, COE 1989), thus exposure would be unlikely to have any short-term or lasting effects on adults.

Loss of Food Sources and Bioaccumulation

There are two different mechanisms by which sediment disposal could affect rockfish by altering their food sources. First, some rockfish prey are probably injured or killed by the sediment plume, and sediments with low levels of contaminants could accumulate in benthic habitats. Second, contaminants adhering to sediments could accumulate in the

rockfishes' food. Effects to food quality and bioaccumulation could persist beyond the five years of the implementation of the proposed action.

Adult, larval, and rearing juvenile surf smelt, Pacific sand lance, and herring are present in the action area throughout the year, and likely use habitat within each of the disposal zones on a sporadic basis. Other life-stages of potential rockfish food (e.g., flatfish and other species) also use habitat in the affected water column or demersal habitats at the dispersive and non-dispersive sites (Dinnel et al., 1986, Donnelly et al., 1988). As dumped sediment descends some of these species' larvae and juveniles would be killed or injured within the water column by similar injures as rockfish larvae. Flatfish and invertebrates could be smothered as the jet hits bottom and expands outward, causing high turbidity and temporarily reduced dissolved oxygen levels at the non-dispersive sites. Because forage fish move throughout the Puget Sound, the loss of some forage fish in one area could eventually reduce later prey availability in other areas.

The loss of rockfish prey from sediment disposal is unlikely to appreciably alter rockfish feeding opportunities for a number of reasons. First, invertebrate production has been found to respond relatively quickly after disposal events (COE 2010). For example, the Commencement Bay site has more individuals of some invertebrate taxa (polychaetes, crustacean, and mollusks) than were found at the nearby reference site (COE 2010). Second, the habitat area affected by sediment disposal is less than 0.006% of the benthic habitats of Puget Sound, thus the number of rockfish prey killed would constitute only a fraction of available food sources during transitory sediment disposal. Third, rockfish eat many different species of fish and invertebrates (Washington et al., 1978, Lea et al., 1999, Love et al., 2002, Palsson et al., 2009) thus the loss of some of their prey would be unlikely to result in fewer feeding opportunities.

The proposed action would not result in the addition of contaminates within the Puget Sound/Georgia Basin. The sediment screening process is designed to assess existing pollutant levels within benthic sediments of proposed dredge projects. However, it would result in sediment disposal that would transfer low levels of some contaminants from the relatively shallow waters of rivers and marinas to the disposal sites. Contaminants such as PCBs, PCDD/F and PBDEs can slowly leach from sediments in soluble form and be taken up by phytoplankton, zooplankton, benthic invertebrates, demersal fish, forage fish and other fishes (COE 2010). Those contaminants can then be bioaccumulated by long-lived predators such as rockfish (West et al., 2001, Palsson et al., 2009).

The COE assessed bioaccumulation of PCCD/F (dioxin) in English sole that occupy demersal habitats of the non-dispersive sites (COE 2010). English sole occupy these habitats continuously and eat invertebrates living with disposed sediments, thus are more likely than rockfish to bioaccumulate contaminants in disposed sediment (COE 2010). Small concentrations of PCCD/F were found in English sole tissue, but most were at levels below "no-effects thresholds[5]" for fish (COE 2010). Though ESA-listed rockfish typically live longer than English sole, they are less likely to bioaccumulate chemicals

[5] "No-effect threshold" means the tested dose is below which there is a measurable effect in the organism, such as behavioral change, injury or death.

adhered to disposed sediments because adult rockfish do not reside at the non-dispersive sites. ESA-listed rockfish also occupy habitats of the San Juan and Straits of Georgia that are potentially influenced by disposal activities at the dispersive sites. Risk of bioaccumulation occurring in these areas would be less than the non-dispersive sites because disposed sediment does not accumulate within any one area (COE 2010) but is broadly distributed, resulting in a discountable effect upon potential bioaccumulation within food sources of ESA-listed rockfish. The COE does not include PBDEs on the list of potentially bioaccumulative substances to be tested at dredge sites, but we consider it likely that dredge disposal will introduce PBDEs to benthic habitats of the disposal sites. This is because the prevalence of PBDEs throughout Puget Sound makes it likely they would be present at dredge sites. The COE has tested PBDE levels at some disposal sites, and recent data at the Port Gardner site indicates that PBDE levels are less than reference sites (Figure 2).

There is additional evidence that sediment disposal is unlikely to exacerbate bioaccumulation within ESA-listed rockfish: (1) The PSDDA program has resulted in a net removal of contaminated sediments within the Puget, and this trend is expected to continue for the foreseeable future. Over the past 22 years, approximately 5% of the dredged sediment has been deemed too contaminated for in-water disposal, and was disposed at upland sites. As an example, nearly 50% of the dredged sediments of Elliot Bay and the Duwamish River area have been disposed at upland locations. In addition, the proportion of contaminants within dredged material that is removed from the Puget Sound is probably much greater than 5%, though we are unable to precisely quantify this amount. (2) The non-dispersive sites encompass less than 0.006% of the habitat of the rockfish DPSs, and these habitats are unlikely to host adult ESA-listed rockfish anyway. (3) Concentrations of sediments settling in the San Juan region from the dispersive sites are extremely low. (4) Monitoring of the non-dispersive sites provides evidence that sediment disposal has the same or improved sediment quality compared to nearby reference sites (Figure 2).

2.5 Cumulative Effects

'Cumulative effects' are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

In early 2010, the WDFW adopted a series of measures to reduce mortality of rockfish from non-tribal fisheries within the Puget Sound/Georgia Basin. These measures include:

- A closure of the entire Puget Sound to the retention of any rockfish species
- Prohibition of fishing for bottomfish deeper than 120 feet
- Closure of the set net and set line fishery

- Closure of the bottom trawl fishery
- Closure of the inactive smelt purse seine fishery
- Closure of the inactive scallop trawl fishery
- Closure of the inactive pelagic trawl fishery
- Closure of the inactive bottomfish pot fishery

The measures will eliminate direct harvest of rockfish, and reduce or prevent bycatch from non-tribal recreational and commercial fisheries within the U.S. portion of the Puget Sound/Georgia Basin that were factors of decline for yelloweye rockfish, canary rockfish and bocaccio (Drake et al., 2010).

2.6 Integration and Synthesis

The Integration and Synthesis section is the final step of NMFS' assessment of the risk posed to species and critical habitat as a result of implementation of the proposed action. In this section, we add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5) to formulate the agency's biological opinion as to whether it is reasonable to expect that the proposed action is likely to result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution. This assessment is made in full consideration of the status of the species (Section 2.2).

The abundance of ESA-listed rockfish has declined dramatically due to past fishery removals (Drake et al., 2010). Yelloweye rockfish, canary rockfish and bocaccio of the Puget Sound/Georgia Basin are likely affected by existing contaminants and nutrient inputs (West et al., 2001, Palsson et al., 2009). Rockfish productivity is naturally low in most years, and their long life span is an adaptation to this low productivity by enabling multiple years of reproduction (Love et al., 2002). Further evidence of their naturally low productivity comes from the birth of up to several million larvae per mature female per season, and the extremely low survival rates of larvae in most years (Love et al., 2002, Weis 2004). Their naturally low productivity is likely further compromised by past fishery removals (that reduced larger and older fish) and bioaccumulative chemicals (Drake et al., 2010). These factors lead to concerns about the viability of each species (Drake et a., 2010).

There are a number of reasons why the proposed action is unlikely to harm adult ESA-listed and juvenile rockfish occupying nearshore and benthic habitats. First, they are unlikely to occupy benthic habitats of the non-dispersive sites, but rather occupy habitats nearby (they are also unlikely to occupy benthic habitats of the dispersive site, though sediment would not settle on these areas anyway). Second, they are also unlikely to be in the water column when sediments are dumped, and even if they are present, they would

likely be able to avoid any briefly harmful sediment concentrations. Third, suspended sediment at the non-dispersive sites would be at extremely low concentrations by the time it reaches any habitat used by adult listed rockfish, and thus would not result in harm.

However, suspended sediment from the dumping would probably kill or injure some larval ESA-listed rockfish. We were able estimate the number of larvae exposed to suspended sediment at the non-dispersive sites based on the anticipated amount of sediment disposed on an annual basis (COE 2010), data provided by Weis (2004), Palsson et al., (2009) and WDFW (unpublished data). Yelloweye rockfish produce between 1,200,000 and 2,700,000 larvae per year. Canary rockfish produce between 260,000 and 1,900,000 larvae per year (Love et al., 2002). Bocaccio produce between 20,000 and 2,298,000 eggs per year (Love et al., 2002). The estimated number of fish exposed to suspended sediment at the non-dispersive sites on an annual basis would be a maximum of 88,092 yelloweye rockfish larvae, 37,519 canary rockfish larvae and 781 bocaccio larvae. If we conservatively assume that all of these larvae would be killed, it would be the equivalent of about 3% to 7% of one cohort of an adult yelloweye rockfish, 2% to 14% of one full cohort of an adult canary rockfish, and 0.003% to 4% of one cohort of one adult bocaccio per year. Though we were unable to estimate the number of larval rockfish that may be exposed to or killed by sediment disposal at the dispersive sites, it is likely that the overall number affected would be fewer than the non-dispersive sites because of the rapid sediment dispersal occurring at those sites. These very low levels of mortality are unlikely to result in an appreciable reduction of the number of larvae that eventually reach adulthood, and therefore are unlikely to further exacerbate the low productivity and abundance of yelloweye rockfish, canary rockfish and bocaccio of the Puget Sound/Georgia Basin. In addition, rockfish larvae naturally experience extremely low survival rates in most years (Love et al., 2002). Juvenile survival rates are generally poor because larval survival and settlement are dependent upon the vagaries of climate, the abundance of predators, oceanic currents and chance events. Long-lived rockfish populations enable persistence through many years of poor reproduction until one good recruitment year (Tolimieri and Levin., 2005, Drake et al., 2010).

Our maximum estimate of larvae killed from high concentrations of sediment at the non-dispersive sites is probably greater than would take place on an annual basis. Our analysis was informed by the rockfish larvae data reported in Weis (2004), which occurred only in the San Juan basin, where the rockfish population is greater than in the Puget Sound Proper (Palsson et al., 2009). Thus there are probably fewer ESA-listed rockfish larvae at the Port Gardner, Elliot Bay, Commencement Bay and Anderson/Ketron Island sites than we have estimated and therefore fewer are likely to be killed than we have accounted for.

The proposed action would also kill some invertebrates and forage fish in the action area that are possible rockfish prey. Adult rockfish have diverse diets that include many species of fish and invertebrates (Washington et al., 1978, Lea et al., 1999, Love et al., 2002). Therefore the death of some invertebrates, flatfish, sand lance, surf smelt, herring and other fish near the disposal sites is not expected to appreciably reduce forage opportunities.

All life stages of ESA-listed rockfish could be exposed to toxins, including bioaccumulative toxins, which enter the food chain after they leach from disposed sediments. However, the COE use several screening methods that reduce the potential for sediments to cause rockfish to be exposed to toxins (such as copper and zinc) and bioaccumulate contaminants (such as PCBs and PCCD/F). Evidence of the effectiveness of these screening criteria comes from the best available science that leads to the general finding that the sediment quality at non-dispersive sites is comparable to or better than nearby reference sediment quality, and the net removal of the estimated five percent of sediment that is deemed too contaminated (COE 2010).

The benthic environment of the Puget Sound has been affected by past bottom-trawling, toxin loading, bioaccumulating contaminants, and the accumulation of derelict fishing gear. Recent and on-going removal of derelict fishing gear has improved benthic habitat suitability for ESA-listed rockfish and their prey base, though nets deeper than 100 feet persist. The cumulative effects of new non-tribal recreational and commercial fishing regulations will further reduce risks to the viability parameters of ESA-listed rockfish.

Thus, while the proposed action may have some small affect on the species' abundance (by killing a relatively small number of larvae at each of the non-dispersive and dispersive sites in the DPSs) it is unlikely to kill juveniles using the nearshore or benthic habitats of the action area, or kill any adults, and thus it is not likely to have an appreciable effect in the likelihood of both survival and recovery of the species in the wild by effects on their productivity, diversity, or structure within the Puget Sound/Georgia Basin.

2.7. Conclusion

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of the Puget Sound/Georgia Basin DPSs of yelloweye rockfish, canary rockfish and bocaccio. No critical habitat has been designated for these species, therefore, none will be affected.

2.8. ENDANGERED SPECIES ACT INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.

For purposes of this consultation, we interpret "harass" to mean an intentional or negligent action that has the potential to injure an animal or disrupt its normal behaviors to a point where such behaviors are abandoned or significantly altered[6].
Section 7(b)(4) and Section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA, if that action is performed in compliance with the terms and conditions of this incidental take statement.

2.8.1 Amount or Extent of Take

Larvae and some pelagic juveniles of yelloweye rockfish, canary rockfish, and bocaccio would be present in the affected water column of the non-dispersive and dispersive sites, and thus exposed to elevated sediment levels and attached to sediment. This exposure to elevated sediment levels is likely to incidentally harm some larvae of each species by injuring or killing them. NMFS defines harm as acts that actually injure or kill individuals, or habitat degradation which kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering (50 CFR 222.102).

We estimate up to 88,092 yelloweye rockfish larvae, 37,519 canary rockfish larvae, and 781 bocaccio larvae would be killed at the non-dispersive sites on an annual basis. Although we have information indicating various life stages of ESA-listed rockfish will be present and exposed to elevated sediment levels at the two dispersive sites, we were unable to quantify the number of larvae harmed or killed by sediment dumping at these sites. We also have no information that enables us to precisely predict how many of the affected fish would be injured rather than killed at the non-dispersive or dispersive sites. We have conservatively assumed that all exposed larvae would be killed. In addition, it would be extremely difficult to monitor the numbers of affected rockfish larvae because there would only be a small number at each individual dumping event and their small size makes them difficult to detect and identify.

Thus, we cannot estimate the amount of take in numbers of affected fish of each species at the dispersive sites, and enumerating rockfish larvae killed (e.g. by observation or collecting them) as a result of the proposed action is not possible. The relationship between habitat affected by sediment disposal at the dispersive sites and the distribution and abundance of those individuals in the action area is imprecise, so a specific number of individuals taken cannot be practically obtained through analysis of the collective effects of the action. In such circumstances, NMFS uses the causal link established

[6] NMFS has not adopted a regulatory definition of harassment under the ESA. The World English Dictionary defines harass as "to trouble, torment, or confuse by continual persistent attacks, questions, etc." The U.S. Fish and Wildlife Service defines "harass" in its regulations as an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3). The interpretation we adopt in this consultation is consistent with our understanding of the dictionary definition of harass and is consistent with the U.S. Fish and Wildlife interpretation of the term.

between the activity and a change in habitat conditions affecting the species to describe a quantity of habitat disturbance which causes harm as the extent of take. Therefore we estimate the extent of take based on the extent of habitat modified by those elements of the proposed action that will cause harm as defined above. The extent of habitat change to which fish will be exposed is more readily discernable and presents a reliably measureable surrogate for the number of individuals to be affected. When the specific number of individuals "harmed" cannot be predicted, NMFS quantifies the extent of take based on the extent of habitat modified (51 FR 19926 at 19954; June 3, 1986).

The size of the area within which adverse effects are likely to occur is defined by the full benthic footprint of the dumping (and the water column through which the sediments fall) at both the dispersive and non-dispersive sites:

1. The applicant is authorized to dispose of sediment within the following areas:

    a. At the non-dispersive sites, the 260 acres of the Bellingham Bay site, 318 acres of the Port Gardner site, 415 acres of the Elliot Bay site, 310 acres of the Commencement Bay site, and 318 acres of the Anderson/Ketron Island site (conforming with the latitudes and longitudes of Table 1 in this opinion), and;

    b. At the dispersive sites, the 650 acres of the Rosario Strait site, and 884 acres of the Port Townsend site (conforming to the latitudes and longitudes of Table 1 in this opinion).

2.8.2 Reasonable and Prudent Measures and Terms and Conditions

'Reasonable and prudent measures' are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02). 'Terms and conditions' implement the reasonable and prudent measures (50 CFR 402.14). These must be carried out for the exemption in section 7(o)(2) to apply.

The COE has the continuing duty to regulate the activities covered in this ITS where discretionary Federal involvement or control over the action has been retained or is authorized by law. The protective coverage of section 7(o)(2) will lapse if the COE fails to exercise its discretion to require adherence to terms and conditions of the ITS, or to exercise that discretion as necessary to retain the oversight to ensure compliance with these terms and conditions. Similarly, if the COE (and DMMP agencies) fail to act in accordance with the terms and conditions of the ITS, protective coverage will lapse.

The RPMs and terms and conditions described below are necessary and sufficient to avoid, minimize, and offset the incidental take of listed species resulting from the proposed action.

Reasonable and Prudent Measures

The COE (and by extension the DMMP agencies) shall:

1. Ensure that disposal activities take place at times and in locations that will minimize incidental take.

2. Ensure that the activities are monitored and regular reports are submitted regarding how well the action agencies are meeting their obligation to minimize incidental take (per 50 CFR 402.14(i)(1)(iv) and (I)(3)).

Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the COE and the DMMP agencies must fully comply with conservation measures described as part of the proposed action and the following Terms and Conditions that implement the RPMs described above. Partial compliance with these terms and conditions may invalidate this take exemption, result in more take than anticipated, and lead NMFS to a different conclusion regarding whether the proposed action will result in jeopardy.

1. To implement RPM Number 1 (project timing and location), the COE shall ensure that:

   a. No sediment disposal activities occur between March 15 and June 15 of any year.

   b. All sediment disposal activities take place within the latitude and longitudes listed in Table 1 of this opinion.

2. To implement RPM Number 2 (monitoring), the COE shall:

   a. Ensure that all disposal tugs record and report when and where the doors on the barge are opened and closed to ensure that all disposals occur within the target zone.

   b. Annually quantify the amount of sediment disposed at all sites—upland and open water.

   c. Conduct monitoring as described in Section 1.2 of this opinion, and in the Biological Evaluation (COE 2010).

   d. Submit yearly monitoring reports by no later than December 31, summarizing implementation of RPMs 1 and 2. They shall be sent to:

      National Marine Fisheries Service, Washington State Habitat Office
      Attention: Dan Tonnes
      7600 Sandpoint Way NE, Building #1
      Seattle, Washington 98115.

NOTICE: If a sick, injured or dead specimen of a threatened or endangered species is found in the action area, the finder must notify NMFS Law Enforcement at (206) 526-6133 or (800) 853-1964, through the contact person identified in the transmittal letter for this opinion. The finder must take care in handling sick or injured specimens to ensure effective treatment, and in handling dead specimens to preserve biological material in the best possible condition for later analysis of cause of death. The finder should carry out instructions provided by Law Enforcement to ensure evidence intrinsic to the specimen is not disturbed unnecessarily.

2.9 ENDANGERED SPECIES ACT CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

- Conduct or support comprehensive ichthyplankton surveys near each of the PSDDA program dispersive and non-dispersive sites within the Puget Sound/Georgia Basin. Methodologies should follow those outlined in Weis (2004).

- Analyze the dissolved and particulate PCB and PBDEs in the open waters of Puget Sound. This may be accomplished through ongoing studies or new studies initiated under the PSDDA program.

- Initiate the administrative and scientific steps to facilitate the inclusion of PBDEs on the list of potentially bioaccumulative substances that require testing under the PSDDA program.

- Develop a model or conduct field tests to determine the trajectory of drift, concentrations and deposition of sediment disposed at the dispersive sites.

- Continue to assess new scientific research for bioaccumulative compounds, including new literature regarding effect thresholds (that include synergistic and sublethal effects) for aquatic species.

2.10 ENDANGERED SPECIES ACT REINITIATION OF CONSULTATION

As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action on listed species or designated critical habitat in a manner or to an extent not considered in this Opinion, (3) the agency

action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this Opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

Consultation can be reinitiated by contacting the Protected Resource Division of NMFS. When reinitiating consultation, refer to NMFS Tracking No. 2010/04249 and provide the pertinent information about the action that has triggered the reinitiation requirement.

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

The consultation requirement of section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions, or proposed actions that may adversely affect EFH. The MSA (section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effects include the direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside EFH, and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures the action agency may take to conserve EFH.

This analysis is based, in part, on information provided by the COE and descriptions of EFH for Pacific coast groundfish (PFMC 2005), coastal pelagic species (PFMC 1998), and Pacific coast salmon (PFMC 1999) contained in the Fishery Management Plans developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce.

3.1 EFH in Project Area

The following species have EFH within the project/action area of the PSDDA program (Table 4):

Table 4. List of species with EFH in the project/action area.

Groundfish Species	redstripe rockfish *S. proriger*	Dover sole *Microstomus pacificus*
spiny dogfish *Squalus acanthias*	rosethorn rockfish *S. helvomaculatus*	English sole *Parophrys vetulus*
big skate *Raja binoculata*	rosy rockfish *S. rosaceus*	flathead sole *Hippoglossoides elassodon*
California skate *Raja inornata*	rougheye rockfish *S. aleutianus*	petrale sole *Eopsetta jordani*
longnose skate *Raja rhina*	sharpchin rockfish *S. zacentrus*	rex sole *Glyptocephalus zachirus*
ratfish *Hydrolagus colliei*	splitnose rockfish *S. diploproa*	rock sole *Lepidopsetta bilineata*
Pacific cod *Gadus macrocephalus*	striptail rockfish *S. saxicola*	sand sole *Psettichthys melanostictus*
Pacific whiting (hake) *Merluccius productus*	tiger rockfish *S. nigrocinctus*	starry flounder *Platichthys stellatus*
black rockfish *Sebastes melanops*	vermilion rockfish *S. miniatus*	arrowtooth flounder *Atheresthes stomias*
bocaccio *S. paucispinis*	yelloweye rockfish *S. ruberrimus*	
brown rockfish *S. auriculatus*	yellowtail rockfish *S. flavidus*	**Coastal Pelagic Species**
canary rockfish *S. pinniger*	shortspine thornyhead *Sebastolobus alascanus*	anchovy *Engraulis mordax*
China rockfish *S. nebulosus*	cabezon *Scorpaenichthys marmoratus*	Pacific sardine *Sardinops sagax*
copper rockfish *S. caurinus*	lingcod *Ophiodon elongatus*	Pacific mackerel *Scomber japonicus*
darkblotch rockfish *S. crameri*	kelp greenling *Hexagrammos decagrammus*	market squid *Loligo opalescens*
greenstriped rockfish *S. elongatus*	sablefish *Anoplopoma fimbria*	**Pacific Salmon Species**
Pacific ocean perch *S. alutus*	Pacific sanddab *Citharichthys sordidus*	chinook salmon *Oncorhynchus tshawytscha*
quillback rockfish *S. maliger*	butter sole *Isopsetta isolepis*	coho salmon *O. kisutch*
redbanded rockfish *S. babcocki*	curlfin sole *Pleuronichthys decurrens*	Puget Sound pink salmon *O. gorbuscha*

6.2 Adverse Effects on EFH

As described in Section 2.4 of this opinion, NMFS believes that the PSDDA program would have the following adverse effects on the EFH of some individual groundfish (i.e. flatfish spp.):

1. Disposal of dredged material is expected to cause a short-term increase in turbidity and suspended sediments in the vicinity of the disposal sites. Fishes may be entrained by released dredged material as it falls through the water column.

Increased turbidity could cause a temporary, localized reduction in feeding success. High levels of suspended sediments can clog gills and cause sublethal physiological effects or mortality. Most of the suspended sediment is found in deep water as the jet of dredged material impacts the bottom and is therefore most likely to affect groundfishes. As the material impacts the bottom, it spreads out and can affect epibenthic and benthic organisms.

2. Low levels of bioaccumulation may occur to some groundfishes (flatfish spp) residing at the non-dispersive sites.

6.3 EFH Conservation Recommendations

The COE should ensure that all sediment disposal activities:

- Do not take place between March 15 and June 15 of any year.
- Take place only within bounds of the latitude and longitudes listed in Table 1 of this opinion.

The COE should ensure that all sediment disposal continues to minimize potential bioaccumulation, by:

- Conduct or support comprehensive ichthyplankton surveys near each of the PSDDA program dispersive and non-dispersive sites within the Puget Sound/Georgia Basin. Methodologies should follow those outlined in Weis (2004).
- Analyze the dissolved and particulate PCB and PBDEs in the open waters of Puget Sound. This may be accomplished through ongoing studies or new studies initiated under the PSDDA program.
- Initiate the administrative and scientific steps to facilitate the inclusion of PBDEs on the list of potentially bioaccumulative substances that require testing under the PSDDA program.
- Develop a model or conduct field tests to determine the trajectory of drift, concentrations and deposition of sediment disposed at the dispersive sites.
- Continue to assess new scientific research for bioaccumulative compounds, including new literature regarding effect thresholds (that include synergistic and sublethal effects) for aquatic species.

6.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the Magnuson-Stevens Act, the Federal agency must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation from NMFS. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations, unless NMFS and the Federal agency have agreed to use alternative time frames for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with NMFS Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects [50 CFR 600.920(k)(1)].

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

6.5 Supplemental Consultation

The COE must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations [50 CFR 600.920(l)].

7. Data Quality Act Documentation and Pre-Dissemination Review

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554) (Data Quality Act) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the biological opinion addresses these Data Quality Act components, documents compliance with the Data Quality Act, and certifies that this biological opinion has undergone pre-dissemination review.

7.1 Utility

This ESA section 7 supplemental biological opinion considers new information related to the effect of COE implementation of the PSDDA program. In this biological opinion NMFS concludes that this project is not likely to jeopardize ESA-listed rockfish. The intended users are the COE and DMMP agencies, various interested groups, Tribes and local communities.

Copies of the biological opinion will be provided to the COE. This biological opinion will be posted on the NMFS NW Region web site (www.nwr.noaa.gov). The format and naming adheres to conventional standards for style.

7.2 Integrity

This biological opinion was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, Security of Automated Information Resources, Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

7.3 Objectivity

Information Product Category: Natural Resource Plan.

Standards: This opinion and supporting documents are clear, concise, complete, and unbiased, and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA Regulations (50 CFR 402.01 et seq.), and the Magnuson-Stevens Fishery Conservation and Management Act (MSA) implementing regulations regarding Essential Fish Habitat (50 CFR 600.920(j)).

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the literature cited section. The analyses in this biological opinion contain more background on information sources and quality.

Referencing: All supporting materials, information, data, and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with Northwest Region ESA quality control and assurance processes.

8. REFERENCES

Army Corps of Engineers (COE). 1989. Puget Sound Dredged Disposal Analysis (PSDDA) Phase II (North and South Puget Sound). Disposal site selection technical appendix. Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency and the Washington Departments of Ecology and Natural Resources. Seattle, WA

Army Corps of Engineers (COE). 2010. Biological Assessment of the PSDDA dredge management program.

Berkeley, S. A., C. Chapman, and S. M. Sogard. 2004. Maternal age as a determinant of larval growth and survival in a marine fish, *Sebastes melanops*. Ecology 85:1258-1264.

Bobko, S. J., and S. A. Berkeley. 2004. Maturity, ovarian cycle, fecundity, and Age-specific parturition of black rockfish, (*Sebastes melanops*). Fishery Bulletin, U.S. 102:4180-429.

Boehert, G.W. 1984. Abrasive effects of Mount St. Helens, Washington, USA ash upon epidermis of yolk sac larvae of Pacific Herring (*Clupea harengus pallasi*). Marine Environmental Research 12: 113-126.

Boehlert, G. W., W. H. Barss, and P. B. Lamberson. 1982. Fecundity of the widow rockfish, *Sebastes entomelas*, off the coast of Oregon. Fishery Bulletin, U.S. 80:881-884.

Boehlert, G.W. and J.B. Morgan. 1985. Turbidity enhances feeding ability of larval Pacific herring (*Clupea harengus pallasi*). Hydrobiologia 123: 161-170.

Broadhurst, G. 1998. Puget Sound Nearshore Habitat Regulatory Perspective: A Review of Issues and Obstacles. Puget Sound/Georgia Basin International Task Force Work Group on Nearshore Habitat Loss for Coastal Training Program by Elliott Menashe, Greenbelt Consulting. 2004.

Burns, R. 1985. The shape and forms of Puget Sound. Published by Washington Sea Grant, and distributed by the University of Washington Press.

Cailliet, G. M., E. J, Burton, J. M. Cope, and L. A. Kerr (eds). 2000. Biological characteristics of nearshore fishes of California: A review of existing knowledge. Vol. Final Report and Excel Data Matrix, Pacific States Marine Fisheries Commission. California Department of Fish and Game.

Canino, M. and R.C. Francis. 1989. Rearing of Sebastes culture larvae (*Scorpaenidae*) in static culture. FRI-UW-8917.

Carr, M.H. 1983. Spatial and temporal patterns of recruitment of young of the year

rockfishes (genus Sebastes) into a central California kelp Forest. Masters thesis, San Francisco State University, CA 94132, 104p)

Cornwall, W. and J. Mayo. 2008. Beaches suffer as walls go up. Seattle Times. Printed May 13, 2008.

Courchamp, F., L. Berec, and J. Gascoigne. 2008. Allee Effects in Ecology and Conservation. Oxford: Oxford University Press, 2008.

Dinnel, P.A., Armstrong, D.A., Miller, B.S. and R.F. Donnelly. 1986. Puget Sound Dredge Disposal Analysis disposal site investigations: Phase 1 trawl studies in Saratoga Passage, Port Gardner, Elliot Bay and Commencement Bay, Washington. FRI-UW-8615.

Donnelly, R.F., B.S. Miller, J.H. Stadler, L. Christensen, K. Larsen, and P.A. Dinnel. 1988. Puget Sound Dredged Disposal Analysis (PSDDA) Phase II disposal site bottomfish investigations. Prepared by the University of Washington School of Fisheries, Fisheries Research Institute. Seattle, WA.

Drake, J. and nine co-authors. 2010. (Preliminary Scientific Conclusions of the Review of the Status of 5 Species of Rockfish: Bocaccio (*Sebastes paucispinis*), Canary Rockfish (*Sebastes pinniger*), Yelloweye Rockfish (*Sebastes ruberrimus*), Greenstriped Rockfish (*Sebastes elongatus*) and Redstripe Rockfish (*Sebastes proriger*) in Puget Sound, Washington National Marine Fisheries Service, Northwest Fisheries Science Center. Seattle, WA. 225p

Dugan, J.E., Hubbard, D.M., McCrary, M.D. and M.O. Pierson. 2003. The response of macrofauna communities and shorebirds to macrophyte wrack subsidies on exposed sandy beaches of southern California. Estuarine, Coastal and Shelf Science 58S (2003) 25–40.

Ebbesmeyer, C.C., Cannon, G.A., and Barnes, C.A. 1984. Synthesis of current measurements in Puget Sound, Washington. Volume 3: Circulation in Puget Sound: an interpretation based on historical records of currents. NOAA Tech. Memo. NOS OMS, **5**: 1–73.

Field, J. C. and S. Ralston. 2005. Spatial variability in rockfish (*Sebastes* spp.) recruitment events in the California Current System. Canadian Journal of Fisheries and Aquatic Sciences 62:2199-2210

Finlayson, D., 2006. The geomorphology of Puget Sound beaches. Puget Sound Nearshore Partnership Report No. 2006-02. Washington Sea Grant Program, University of Washington. Available at http://pugetsoundnearshore.org.

FishBase. 2010. Life-history of bocaccio. Accessed May 20, 2010. www.fishbase.org.

Fisher, R., S. M. Sogard, and S. A. Berkeley. 2007. Trade-offs between size and energy reserves reflect alternative strategies for optimizing larval survival potential in rockfish. Marine Ecology Progress Series 344: 257-270.

Good, T.P., June, J.A, Etnier, M. A, and G. Broadhurst. 2010. Derelict fishing nets in Puget Sound and the Northwest Straits: Patterns and threats to marine fauna. Marine Pollution Bulletin 60 (2010) 39-50.

Griffin, F.J., Smith, E.H., C.A. Vines, and G.N. Cherr. 2009. Impact of suspended sediment on fertilization, embryonic development, and early larval life stages of the Pacific Herring, *Clupea Pallasi*. Biological Bulletin. 216: 175-187.

Halderson, L. and L.J. Richards. 1987. Habitat use and young of the year copper rockfish in British Columbia. In Proc. In. Rockfish Symp., Anchorage, Alaska, p. 129-141. Alaska Sea grant Rep. 87-2, Fairbanks 99701.

Harvey, C. J. 2005. Effects of El Niño events on energy demand and egg production of rockfish (Scorpaenidae: *Sebastes*): a bioenergetics approach. Fishery Bulletin 103:71-83.

Hayden-Spear, J. 2006. Nearshore habitat associations of young-of-year copper (*Sebastes caurinus)* and quillback (*S. maliger)* rockfish in the San Juan Channel, Washington.

Lea, R.N., McAllister, R.D. and D.A. VenTresca. 1999. Biological aspects of nearshore rockfishes of the Genus Sebastes from Central California with notes on ecologically related sport fishes. State of California, the Resource Agency Department of Fish and Game. Fish Bulletin 177.

Love, M.S., M. Carr, and L. Haldorson. 1991. The ecology of substrate associated juveniles of the genus *Sebastes*. Env. Bio. Fish. 30:225-243.

Love, M.S., M. M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the Northeast Pacific. University of California Press, Berkeley, California.

Matthews, K.R. 1989. A comparative study of habitat use by young-of-the year, subadult, and adult rockfishes on four habitat types in Central Puget Sound. Fishery Bulletin, U.S. 88-223-239.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U. S. Dept. Commerce NMFS-NWFSC-42.

Miller, B.S., and S.F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. University of Washington Fisheries Research Institute, 3 vols.

Morgan, J.D. and C.D. Levings. 1989. Effects of suspended sediment on eggs and larvae of lingcod (*Ophiodon elongates*) Pacific herring (*Clupea harengus pallasi*) and surf smelt (*Hypomesus pretiosus*).

Morgan, R.P., Rasin V. J., and N. A Noe. 1983. Sediment effects on eggs and larvae of striped bass and white perch. Transaction of American Fisheries Society. Volume 112, No. 2a, pp. 220-224.

Moser, G.H. and G.W. Boehert. 1991. Ecology of pelagic larvae and juveniles of the genus Sebastes. Environmental biology of fishes 30: 203-224.

Nichol, D. G., and E. K. Pikitch. 1994. Reproduction of darkblotched rockfish off the Oregon coast. Transactions of the American Fisheries Society 123(4): 469□481.

NMFS (National Marine Fisheries Service). 2003. Alaska Fishery Science Center, processed report 2003-10. Marine protected areas and early life-history of fishes.

NMFS (National Marine Fisheries Service). 2010. Biological opinion and Magnuson-Stevens Fishery Conservation Act and Management Act Essential Fish Habitat Consultation. Biological opinion on the impacts of programs administered by the Bureau of Indian Affairs that support Puget Sound Tribal Fisheries and salmon fishing activities authorized by the U.S. Fish and Wildlife Service in Puget Sound from May 1 to July 31, 2010 on the Puget Sound Chinook Evolutionary Significant Unit and the Puget Sound Distinct Population Segment (Puget Sound) and Conference opinion on the same actions for the Puget Sound/Georgia Basin Rockfish Puget Sound's listed under the Endangered Species Act and Magnuson-Stevens Essential Fish Habitat Consultation. NMFS Tracking Number: F/NWR/2010/01850.

Orr J.W., M.A. Brown, and D.C. Baker. 2000. Guide to rockfishes (Scorpaenidae) of the genera Sebastes, Sebastolobus, and Abelosebastes of the northeast Pacific Ocean, Second Edition. NOAA Technical Memorandum NMFS-AFSC

Palsson, W. A., T.-S. Tsou, G. G. Bargman, R. M. Buckley, J. E. West, M. L. Mills, Y. W. Cheng, and R. E. Pacunski. 2009. The biology and assessment of rockfishes in Puget Sound. Washington Department of Fish and Wildlife, Olympia WA.

Puget Sound Action Team. 2007. State of the Sound 2007. Puget Sound Action Team, Olympia, WA. Publication No. Puget SoundAT:07-01.

Rice, C. A. 2007. Evaluating the biological condition of Puget Sound. Ph.D. dissertation University of Washington, School of Aquatic and Fisheries Sciences. 270 pp.

Rosenthal, R.J., L. Haldorson, L.J. Field, V. Moran-O'Connell, M.G. LaRiviere, J.

Underwood, and M.C. Murphy. 1982. Inshore and shallow offshore bottomfish resources in the southeastern Gulf of Alaska. Alaska Coastal Research and University of Alaska, Juneau. 166 p.

Shaffer, J. A. Doty, D.C., Buckley, R.M., and J. E. West. 1995. Crustacean community composition and trophic use of the drift vegetation habitat by juvenile splitnose rockfish *Sebastes diploproa.* Marine Ecology Progress Series. Vol. 123, pp 13-21. 1995.

Sogard, S. M., S. A. Berkeley, and R. Fisher. 2008. Maternal effects in rockfishes *Sebastes* spp.: a comparison among species. Marine Ecology Progress Series 360: 227-236.

Studebaker, R.S., Cox, K.N., and T. J. Mulligan. 2009. Recent and historical spatial distributions of juvenile rockfish species in rocky intertidal tide pools, with emphasis on black rockfish. Transactions of the American Fisheries Society 138:645-651, 2009.

Tagal, M, K. C. Massee, N. Ashton, R. Campbell, P. Plesha, and M. B. Rust. 2002. Larval development of yelloweye rockfish, sebastes ruberrimus. National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center.

Tolimieri, N. and P. S. Levin. 2005. The roles of fishing and climate in the population dynamics of bocaccio rockfish. Ecological Applications 15:458-468.

Waldron, K. D. 1972. Fish larvae collected from the northeastern Pacific Ocean and Puget Sound during April and May 1967. NOAA Technical Report NMS SSRF-663.

Washington State Department of Ecology. 2010. Reports reconfirm surface runoff as leading source of toxics in Puget Sound. Water Quality Program. Available at: http://www.ecy.wa.gov/pubs/0810097.pdf

Washington, P. 1977. Recreationally important marine fishes of Puget Sound, Washington. National Oceanic and Atmospheric Administration, Northwest and Alaska Fisheries Center.

Washington State Department of Fish and Wildlife. Unpublished rockfish bycatch data, on file with the National Marine Fisheries Service, 7600 Sandpoint Way NE, Seattle, WA 98115.

Washington State Department of Fish and Wildlife. Unpublished locations of yelloweye rockfish, canary rockfish and bocaccio within the Puget Sound/Georgia Basin. On file with the National Marine Fisheries Service, 7600 Sandpoint Way NE, Seattle, WA 98115.

Washington State Department of Fish and Wildlife. 1998. Puget Sound Groundfish Management Plan (Revised). Available at: http://wdfw.wa.gov/publications/00927/wdfw00927.pdf

Washington, P. M., R. Gowan, and D. H. Ito. 1978. A biological report on eight species of rockfish (*Sebastes* spp.) from Puget Sound, Washington. Northwest and Alaska Fisheries Center Processed Report, National Marine Fisheries Service, Seattle.

Weis, L.J. 2004. The effects of San Juan County, Washington, marine protected areas on larval rockfish production. A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, University of Washington.

West, J., O'Neil, S., Lomax, D., and L. Johnson. 2001. Implications for reproductive health in rockfish (Sebastes spp.) from Puget Sound exposed to polychlorinated biphynels. Puget Sound Research 2001. Available at http://wdfw.wa.gov/publications/01041/wdfw01041.pdf

Westrheim, S. J., and W. R. Harling. 1975. Age-length relationships for 26 scorpaenids in the northeast Pacific Ocean. Technical Report 565, Fisheries and Marine Service Research Division, Nanaimo, British Columbia.

Wylie Echeverria, T. 1987. Thirty-four species of California rockfishes: maturity and seasonality of reproduction. Fisheries Bulletin of the U.S. 85 (2):229-250.

Yamanaka, K.L., and A.R. Kronlund. 1997. Inshore rockfish stock assessment for the west coast of Canada in 1996 and recommended yields for 1997. Can. Tech. Rep. Fish. Aquat. Sci. 2175.

Yamanaka K.L., and L.C. Lacko. 2001. Inshore Rockfish (Seb. ruberrimus, S. malinger, S. cauinus, S. melanops, S. nigrocinctus, and S. nebulosus).

Appendix A.

The jeopardy regulation requires all Federal agencies to ensure that proposed actions do not "reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the *reproduction, numbers, or distribution* of that species." While we use different terms for ESA-listed rockfish (abundance, productivity, distribution and diversity), the concepts are consistent with the regulatory concepts and language. The table below illustrates the relationship of the concepts contained in each.

Viability Attribute	**Jeopardy Regulation**	**Description**
Population Abundance	Numbers	The metric *population abundance* is important because small populations face a host of risks intrinsic to their size; conversely, large populations exhibit a greater degree of resilience. Small populations are at greater risk of extinction than large populations primarily because several processes that affect population dynamics operate differently in small populations than they do in large populations.
Population Growth Rate	Reproduction	The parameter *population growth rate* is similar in meaning to *reproduction* in the regulations. Population growth rate, which means production over the entire life cycle, and factors that affect population growth rate provide information on how well a population is performing during its life cycle. Population growth rate is also closely linked with population abundance.
Population Spatial Structure	Distribution	The parameters *population spatial structure* and aligns closely, although not solely, with *distribution* in the regulations. Spatial structure within a population (or group of populations) affects extinction risk in ways that may not be readily apparent from short-term observations of abundance and productivity. The spatial structure of a population refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. Spatial structures that consist of groups of individuals in discrete patches are often generically referred to as metapopulations. Metapopulation dynamics underlie the viability concept.
Diversity	Distribution	Diversity refers to the distribution of genotypic and phenotypic traits within and among populations. Rockfish diversity characteristics are fecundity, timing of the release of larvae and their condition, morphology, age at reproductive maturity and physiology, and molecular genetic characteristics.