Designation of Critical Habitat for the Distinct Population Segments of Yelloweye Rockfish, Canary Rockfish, and Bocaccio

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OVERVIEW

Section 4 of the Federal Endangered Species Act (ESA) requires the designation of critical habitat for threatened and endangered species. This report contains a biological analysis compiled by the Protected Resources Division of the National Marine Fisheries Service (NMFS) in support of designating critical habitat for the threatened Distinct Population Segments (DPSs) of yelloweye rockfish (*Sebastes ruberrimus*), the threatened DPS of canary rockfish (*Sebastes pinniger*), and the endangered DPS of bocaccio (*Sebastes paucispinus*).

This report summarizes the best available information on yelloweye rockfish, canary rockfish, and bocaccio life history, distribution, and habitat use relevant to critical habitat designation. We identified the geographical area occupied by each DPS to include the Puget Sound/Georgia Basin. Within the United States portion of the geographical area, we identified five specific areas as candidates for critical habitat designation because they contain the essential features, which may require special management considerations. We have not identified any unoccupied areas that may be essential to the conservation of each DPS. We use the assessment and findings provided in this report in conjunction with other agency analyses (e.g., economic analyses) to support our critical habitat designation for each DPS.

BACKGROUND

On April 28, 2010, we listed the Puget Sound/Georgia Basin DPSs (Figure 1) of yelloweye rockfish (*Sebastes ruberrimus*) and canary rockfish (*S. pinniger*) as “threatened” under the Endangered Species Act (ESA), and bocaccio (*S. paucispinus*) as “endangered” (75 Fed. Reg. 22276). In our proposal to list yelloweye rockfish, canary rockfish, and bocaccio (74 Fed. Reg. 18516, April 23, 2009), we requested information on the identification of specific areas that meet the definition of critical habitat. We also solicited biological and economic information relevant to making a critical habitat designation for each species. We reviewed the comments provided and the best available scientific information, and at the time of listing we concluded that critical habitat was not determinable for each species because sufficient information was not available to: 1) identify the physical and biological features essential to conservation, and 2) assess the impacts of a designation. In addition to the data gaps identified at the time of listing, sufficient information was not available to fully determine the geographical area occupied by each species. Following promulgation of the final rule to list each species, we continued compiling the best available information necessary to consider a critical habitat designation. We have now researched, reviewed, and summarized this best available information on yelloweye rockfish, canary rockfish, and bocaccio, including recent biological surveys, geological surveys, reports, peer-reviewed literature, the NMFS status report (Drake et al. 2010), the proposed listing rule (74 Fed. Reg. 18516, April 23, 2009), and the final listing determination for each species (75 Fed. Reg. 22276, April 28, 2010). This report underwent pre-dissemination peer review pursuant to section 515 of Public Law 106-554 (the Data Quality Act) and was released for public review and comment along with our proposed critical habitat rule on August 6, 2013 (78 Fed. Reg. 47635). The information in this final report incorporates comments and new information received on the proposed critical habitat rule. The primary changes from the proposed rule and draft biological report are new bathymetry data and GIS tools; we used this new information to identify specific areas that may qualify as critical habitat. Consistent with section 3(5)A) of the ESA, we followed a five-step process in order to identify these specific areas:

(1) Determine the geographical area occupied by the species.

(2) Identify physical or biological habitat features essential to the conservation of the species.

(3) Delineate specific areas within the geographical area occupied by the species on which are found the physical or biological features.

(4) Determine whether the features in a specific area may require special management considerations or protections.

(5) Determine whether any unoccupied areas are essential for conservation.

CRITICAL HABITAT UNDER THE ESA

Section 3(5)(A) of the ESA defines critical habitat as "(i) the specific areas within the geographical area occupied by the species, at the time it is listed . . . on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed . . . upon a determination by the Secretary that such areas are essential for the conservation of the species."

Section 4(a)(3)(B)(i) of the ESA precludes from designation any lands owned by, controlled by, or designated for the use of the Department of Defense that are covered by an integrated natural resources management plan that the Secretary [of Commerce] has found in writing will benefit the listed species.

Section 4(b)(2) of the ESA requires NMFS to designate critical habitat for threatened and endangered species "on the basis of the best scientific data available and after taking into consideration the economic impact, impact on national security, and any other relevant impact, of specifying any particular area as critical habitat." In addition, "the Secretary may exclude any area from critical habitat if he determines that the benefits of such exclusion outweigh the benefits of specifying such area as part of the critical habitat, unless he determines that the failure to designate such an area as critical habitat will result in the extinction of the species concerned."

Once critical habitat is designated, section 7 of the ESA requires Federal agencies to ensure that they do not fund, authorize, or carry out any actions that will destroy or adversely modify that habitat. This is in addition to the requirement under section 7 of the ESA that Federal agencies ensure their actions do not jeopardize the continued existence of listed species.

The following sections provide the best available biological information on yelloweye rockfish, canary rockfish, and bocaccio and the best available scientific information relevant to identifying critical habitat for each species under the ESA.

YELLOWEYE ROCKFISH, CANARY ROCKFISH, AND BOCACCIO DISTRIBUTION, LIFE HISTORY, AND STATUS

Yelloweye rockfish, canary rockfish, and bocaccio are members of the family Scorpaenidae and are members of the *Sebastes* or *Sebastolobus* genera. Rockfish are characterized by having spines on their head (as juveniles), stiff dorsal fins, venom glands at the base of fins, internal fertilization of eggs, and birth of live larvae. Rockfish are iteroparous (i.e., have multiple reproductive cycles during their lifetime) and are typically long-lived. Being long-lived allows the adult population to persist through many years of poor reproduction until a good recruitment year occurs. As adults, each species generally inhabits relatively deep waters with steep and complex bathymetry. Their diets are diverse and include many species of marine invertebrates and fish. Successful reproduction occurs only sporadically and may be associated with broad-scale environmental conditions. Below we describe rockfish life-history by larval, juvenile, and sub-adult/adult stages which reflect different habitat use and food sources unique to each life stage. The life histories of yelloweye rockfish, canary rockfish, and bocaccio are described individually in Appendix A, which is patterned after descriptions in Drake et al. 2010.

Larval Stage

Upon parturition (birth) larval rockfish can occupy the full water column, but are generally in the upper 80 m (262 ft) (Love et al. 2002; Weis 2004). Larvae have also been observed immediately under free-floating algae, seagrass, and detached kelp (Shaffer et al. 1995; Love et al. 2002). Oceanographic conditions that include the presence of several sills within the Puget Sound/Georgia Basin region may result in the general retention of larvae near the area they are released rather than dispersal to adjacent basins (Drake et al. 2010). Larval transition to pelagic juveniles generally occurs when fish are from 2 to 3cm (0.79 to 1.1 inches) in length; larger juveniles generally occupy deeper areas of the pelagic environment (Love et al. 2002). There are few studies that have sampled for rockfish larvae presence in Puget Sound (e.g., Waldron 1972; Busby 2000; Weis 2004; Chamberlin et al. 2004). Larval rockfish have been documented in each basin of Puget Sound, though they have not been identified to species (Greene and Godersky 2012). There is little information regarding the habitat requirements of rockfish larvae, though other marine fish larvae are vulnerable to low dissolved oxygen levels and elevated suspended sediment levels that can alter feeding rates and cause abrasion to gills (Boehlert 1984; Boehlert and Morgan 1985; Morgan and Levings 1989). Most rockfish larvae occur within or above the thermocline and grow faster in warmer temperatures (Moser and Boehlert 1991).

Larval rockfish are extremely fragile and thus have high mortality rates. In a laboratory setting, rockfish larvae mortality was a total of 70 percent 7 to 12 days after 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. Poor larval survival in most years provides evidence that rockfish populations persist through what has been termed “the storage hypothesis” (Warner and Chesson 1985; Tolimieri and Levin 2005) where recruitment is generally poor because larval survival and settlement are dependent upon the vagaries of climate, abundance of predators, oceanic currents, and chance events. Poor larval survival in most years is balanced by the long lives of reproductive adults; thus, when beneficial conditions occur there are new larval cohorts that benefit from them (Drake et al. 2010). We do not know the relative importance of these factors in the Puget Sound/Georgia Basin.

Juvenile Stage

Larval and pelagic juvenile rockfish eventually move from the pelagic environment and associate with benthic environments when they reach about 3 to 9 cm (1.2 to 3.6 in) in length (Love et al. 2002). Canary rockfish and bocaccio associate with shallow nearshore areas as young-of-the-year juveniles, while juvenile yelloweye rockfish usually settle to deeper water habitats. Juvenile yelloweye rockfish, canary rockfish, and bocaccio have only been rarely documented in Puget Sound. This may be due to a relative lack of studies in Puget Sound that assessed nearshore rockfish assemblages prior to the onset of fisheries removals of adult rockfish. Many nearshore studies targeting juvenile salmon assemblages are unlikely to incidentally capture juvenile rockfish because they occur in the spring months when juvenile rockfish are less likely to occupy the nearshore. In addition, many small post-settlement rockfish are difficult to identify at the species level (Love et al. 2002). Love et al. (1991) describe three reasons that post-settlement habitat is essential for rockfish populations: 1) the successful recruitment of substrate-associated juveniles by larvae dispersed to the pelagic environment is crucial to the survival of local populations; 2) density-dependent regulation of populations may occur at the early juvenile stage; thus, the amount and functions of these habitats could strongly influence sub-adult and adult abundance; and 3) larval abundance can be a poor predictor of subsequent adult year-class strength—suggesting that post-settlement rearing habitat can strongly influence subsequent population viability.

Areas with floating and submerged kelp (families *Chordaceae, Alariaceae, Lessoniacea, Costariaceae,* and *Laminaricea*) support the highest densities of most juvenile rockfish species (Matthews 1989; Halderson and Richards 1987; Carr 1983; Hayden-Spear 2006). Kelp is photosynthetic and requires high ambient light levels and a lack of fine sediment in the water column that can reduce light or smother the gametophytes (Mumford 2007). There are over 20 annual or perennial species of kelp in Puget Sound, two of which have a floating canopy and the rest have non-floating stipulate or prostrate canopies (Mumford 2007). When solid substrates occur in lower intertidal and sub-tidal zones, kelp is often the dominant aquatic flora and forms dense canopies (Mumford 2007). Kelp are attached with a root-like structure, called a holdfast, to solid substrates such as bedrock, large rocks or pebbles, clam shells, or artificial substrates. Kelp grows in areas of high to moderate wave energy or currents to depths as great as 20 m (65 ft) (Mumford 2007). Most kelp species form blades 1 to 2 m (3 to 6 ft) long, though the one floating variety within the range of the three DPSs (*Nereocystis luetkeana*) grows to over 10 m (33 ft) long.

As they grow, juveniles of each rockfish species gradually move to deeper waters that have rock and/or diverse bathymetry (Gaines and Roughgarden 1987; Johnson et al. 2003; Love et al. 1991; Love et al. 2002). This movement to deeper water may also be driven by environmental conditions; over the fall and winter, temperatures decrease, turbulence increases, and submerged aquatic vegetation coverage decreases (Carr 1983; Halderson and Richards 1987; Matthews 1989; Love et al. 1991; Doty et al. 1995).

Yelloweye Rockfish. Juvenile yelloweye rockfish have been only rarely documented in Puget Sound (Palsson et al. 2009) and do not typically occupy intertidal waters (Love et al. 1991; Studebaker et al. 2009). A few juveniles have been documented in shallow nearshore waters (Love et al. 2002; Palsson et al. 2009; Cloutier 2011), but most settle in habitats along the shallow range of adult habitats in areas of complex bathymetry, rocky/boulder habitats, and cloud sponges in waters greater than 30 m (98 ft) (Richards 1986; Yamanaka et al. 2006). In British Columbia waters, juvenile yelloweye rockfish have been observed at a mean depth of 73 m (239 ft), with a minimum depth of 30 m (98 ft) (Yamanaka et al. 2006). Juvenile yelloweye rockfish occur in similar habitats as adults, though in areas with smaller crevices, including cloud sponge formations, crinoid aggregations on top of rocky ridges, and over cobble substrates (Weispfenning 2006; Yamanaka et al. 2006; Banks 2007).

Canary Rockfish and Bocaccio. Juvenile canary rockfish have been rarely documented in Puget Sound. We are unaware of juvenile bocaccio documentation in Puget Sound though the documentation of adult bocaccio strongly infers that rearing also occurs in each of the Puget Sound basins. Juvenile canary rockfish and bocaccio use similar habitats (Carr 1983). When they reach 3 to 9 cm (1 to 3.5 in) and ages of 3 to 6 months, juvenile canary rockfish and bocaccio move from open waters to settle onto nearshore benthic habitats. They most readily use rocky areas with and without kelp, and also use sandy areas and areas that support eelgrass (Moser 1967; Carr 1983; Kendall and Lenarz 1986; Love et al. 1991; Murphy et al. 2000; Love 1996; Love et al. 2002). Habitat among kelp provides structure for feeding, predation refuge, and reduced currents that enable energy conservation for juvenile canary rockfish and bocaccio. It is probable that nearshore habitats used by juvenile canary rockfish and bocaccio offer a beneficial mix of warmer temperatures, food, and refuge from predators (Love et al. 1991).

Adult Stage

Yelloweye rockfish, canary rockfish, and bocaccio are long-lived, mature slowly, and have sporadic episodes of successful reproduction (Drake et al. 2010). Yelloweye rockfish are one of the longest lived of the rockfishes, with some individuals reaching more than 100 years of age. Yelloweye rockfish reach 50 percent maturity at sizes of 40 to 50 cm (16 to 20 in) and ages of 15 to 20 years (Rosenthal et al. 1982; Yamanaka and Kronlund 1997). The maximum age of canary rockfish is at least 84 years (Love et al. 2002), although 60 to 75 years is more common (Cailliet et al. 2000). Canary rockfish reach 50 percent maturity at sizes around 40 cm (16 in) and ages of 7 to 9 years. The maximum age of bocaccio is unknown, but may range from 40 to 50 years. Bocaccio are estimated to reach 50 percent maturity at 35 to 50 cm (14 to 20 in) and become reproductively mature near ages 4 to 6 years (Stanley et al. 2001; FishBase 2010).

Yelloweye rockfish remain near the bottom and have relatively small home ranges, while some canary rockfish and bocaccio have larger home ranges, move long distances, and spend time suspended in the water column (Demott 1983; Love et al. 2002; Friedwald 2009). Individual female yelloweye rockfish produce up to 2,700,000 larvae, canary rockfish produce up to 1,900,000 larvae, and bocaccio produce up to 2,298,000 larvae annually (Love et al. 2002). The timing of larval release for each species varies throughout their geographic range. In Puget Sound, there is some evidence that larvae are extruded in early spring to late summer for yelloweye rockfish (Washington et al. 1978) and in British Columbia it occurs between April and September with a peak in May and June (Yamanaka et al. 2006). In British Columbia, parturition peaks in February for canary rockfish (Hart 1973; Westrheim and Harling 1975). Along the coast of Washington State, female bocaccio release larvae between January and April (Love et al. 2002).

There have not been historic or contemporary systematic surveys of rockfish populations in all of the basins of Puget Sound (Drake et al. 2010). Fisheries catch data can be used to assist in determining rockfish habitat (Yamanaka and Logan 2010), but the lack of systematic record keeping and unreliable species identification from commercial and recreational fishing in Puget Sound limits the utility of available fishery data (Palsson et al. 2009; Sawchuck 2012). Where most historic fisheries data do exist, the precise location of the catch is not documented (e.g., Bargmann 1977). The documented occurrences of yelloweye rockfish, canary rockfish, and bocaccio are from a wide range of years and with diverse sampling methods such as research trawls, drop cameras, scuba, Remotely Operated Vehicles (ROV), and commercial and recreational fishing (Table 1). Most of these documented occurrences are for sub-adult and adult life stages, with relatively few young-of-the-year fish documented.

Depth is generally the most important determinant in the distribution of many rockfish species of the Pacific Coast (Chen 1971; Williams and Ralston 2002; Anderson and Yoklavich 2007; Young et al. 2010). Adult yelloweye rockfish, canary rockfish, and bocaccio generally occupy habitats from approximately 30 to 425 m (90 to 1,394 ft) (Orr et al. 2000; Love et al. 2002), and in Federal waters off the Pacific Coast each species is considered part of the "shelf rockfish" assemblage under the authorities of the Magnuson-Stevens Fishery Conservation and Management Act because of their generally similar habitat usages (50 CFR 660, Subparts C-G).

Adult yelloweye rockfish, canary rockfish, and bocaccio most readily use habitats within and adjacent to areas that are highly rugose (rough). These are benthic habitats with moderate to extreme steepness; complex bathymetry; and/or substrates consisting of fractured bedrock, rock, and boulder-cobble complexes (Yoklavich et al. 2000; Love et al. 2002; Wang 2005; Anderson and Yoklavich 2007). Most of the benthic habitats in Puget Sound consist of unconsolidated materials such as mud, sand, clays, cobbles, and boulders (Burns 1985), and despite the relative lack of rock some of these benthic habitats are moderately to highly rugose. More complex marine habitats are generally used by higher numbers of fish species relative to less complex areas (Anderson and Yoklavich 2007; Young et al. 2010), and thus support food sources for sub-adult and adult yelloweye rockfish, canary rockfish, and bocaccio. More complex marine habitats also provide refuge from predators and their structure may provide shelter from currents, thus leading to energy conservation (Young et al. 2010).

Though areas near rocky habitats or other complex structure are most readily used by adults of each species, non-rocky benthic habitats are also occupied. In Puget Sound, adult yelloweye rockfish, canary rockfish, and bocaccio have been documented in areas with non-rocky substrates such as sand, mud, and other generally unconsolidated sediments (Haw and Buckley 1971; Washington 1977; Miller and Borton 1980; Reum 2006). Surveys from outside the DPSs also have documented each species in relatively less complex habitats, though generally on a less frequent basis than more complex habitats. Yelloweye rockfish have also been documented in areas with mud and mud/cobble habitats in waters off the coasts of Washington (Wang 2005), California (Yoklavich et al. 2000), Oregon (Stein et al. 1992), and British Columbia, Canada (Richards 1986), and have been observed adjacent to large and isolated boulders in areas of flat and muddy bottoms in Alaskan waters (O'Connell and Carlile 1993). Canary rockfish have been found to be slightly more abundant in less complex habitat than more complex habitat off the Washington coast (Jagielo et al. 2003). Wang (2005) also observed canary rockfish in a variety of benthic habitats off the Washington coast. Canary rockfish were most frequently found near boulders, but were also found near benthic habitats consisting of sand, mud, and pebble mixtures (Wang 2005). Johnson et al. (2003) reported that approximately 15 percent of canary rockfish were observed over soft-bottomed habitats in surveys in Alaska. Bocaccio also occupy benthic areas with soft-bottomed habitats, particularly those adjacent to structure such as boulders and crevices (Yoklavich et al. 2000; Anderson and Yoklavich 2007).

Prey

Food sources for yelloweye rockfish, canary rockfish, and bocaccio occur throughout Puget Sound. However, each of the basins has unique biomass and species compositions of fish and invertebrates that vary temporally and spatially (Rice 2007; Rice et al. 2012). Absolute and relative abundance and species richness of most fish species in the Puget Sound/Georgia Basin increase with latitude (Rice 2007; Rice et al. 2012). Despite these differences, each basin hosts common food sources for yelloweye rockfish, canary rockfish, and bocaccio as described below.

Larval and juvenile rockfish feed on very small organisms such as zooplankton, copepods and phytoplankton, small crustaceans, invertebrate eggs, krill, and other invertebrates (Moser and Boehlert 1991; Love et al. 1991; Love et al. 2002). Larger juveniles also feed upon small fish (Love et al. 1991). Adult yelloweye rockfish, canary rockfish, and bocaccio have diverse diets that include many species of fish and invertebrates including but not limited to crabs (*Crustacea spp*), various rockfish (*Sebastes spp*), flatfish (*Pleuronectidae spp*), juvenile salmon (*Oncorhynchus spp*), walleye pollock, (*Theragra chalcogramma*), Pacific hake (*Merluccius productus*), Pacific cod (*Gadus macrocephalus*), green sea urchin (*Stongylocentrotus droebachiensis*), lingcod (*Ophiodon elongates*) eggs, various shrimp species (*Pandalus spp)*, and perch (*Rhacochilus spp*). Common forage fish that are part of their diets include Pacific herring (*Clupea harengus pallasi*), surf smelt (*Hypomesus pretiosus*), and Pacific sand lance (*Ammodytes hexapterus*) (Washington et al. 1978; Lea et al. 1999; Love et al. 2002; Yamanaka et al. 2006).

Predators

Rockfishes of all sizes are an important food resource for a variety of predators in Puget Sound (Palsson et al. 2009). There is little data regarding specific predators of yelloweye rockfish, canary rockfish, and bocaccio in the Puget Sound/Georgia Basin; thus, we refer to available information regarding predation on *Sebastes* species generally. Rockfish are preyed upon by numerous fish species, birds, and several marine mammals (Mills et al. 2007; Palsson et al. 2009). Larvae and juveniles are eaten by birds, salmon, rockfish, lingcod, and other fish species (Mills et al. 2007). Juveniles and adults are eaten by lingcod and some marine mammals (mostly pinnipeds) (Love et al. 2002; Palsson et al. 2009). As with many other marine fish species, as rockfish grow, their potential predators are generally reduced in number because of their larger sizes, physiological development, and behavioral changes (Gislason et al. 2010).

Adult yelloweye rockfish, canary rockfish, and bocaccio have several defenses and behaviors to reduce the likelihood of predation. Adults have venom glands at the base of their fins to deter predators (Palsson et al. 2009). They also occupy deep waters, often near structure such as rock and boulders, where they can seek refuge and thus reduce their vulnerability to predation (Griffiths and Harrod 2007). These factors likely influence consumption rates of adult rockfish by some predators, such as marine mammals. Common pinnipeds within Puget Sound include California sea lions (*Zalophus californianus*) and harbor seals (*Phoca vitulina)*. Steller sea lions (*Eumetopias jubatus*), northern fur seals (*Callorhinus ursinus)*, and northern elephant seals (*Mirounga angustirostris*) also occur in Puget Sound, but are less abundant than sea lions and harbor seals. Rockfish predation by harbor seals varies annually by location and time of the year (Palsson et al. 2009). Rockfish (of all species) occurred in 12 percent of harbor seal diets in the San Juan area in 2006 and 2007, compared to 2.3 percent in 2005 and 2006 (Lance and Jeffries 2007; Palsson et al. 2009). Most of these rockfish were juveniles. Rockfish were found in 1 percent of seal scats in Hood Canal (London et al. 2002). Rockfish have been found as prey of killer whales (Ford et al 1998), but are not known to be a substantial component of the Southern Resident killer whales' (*Orcinus orca*) diet (Palsson et al. 2009; Hanson et al. 2010).

Status of Yelloweye Rockfish, Canary Rockfish, and Bocaccio

Based on information related to rockfish life history, and the environmental and ecological features of Puget Sound and the Georgia Basin, we identified a Puget Sound/Georgia Basin DPS for yelloweye rockfish, canary rockfish, and bocaccio (Drake et al. 2010). On April 28, 2010, we listed the Puget Sound/Georgia Basin DPSs of yelloweye rockfish and canary rockfish as threatened under the ESA, and bocaccio as endangered (75 Fed. Reg. 22276). We based the decision to list the yelloweye rockfish and canary rockfish DPSs as threatened and the bocaccio DPS as endangered on an evaluation of their status and of existing efforts to protect the species. We identified several extinction risk factors common to each DPS (Drake et al. 2010):

1) Declining trends in abundance within each DPS contribute significantly to extinction risk.
2) Each species has an inherently low growth rate and low productivity and these characteristics are likely exacerbated by the relative paucity of larger older fish. There is evidence of size truncation for each species, which shifts reproductive output to younger and less productive females.
3) These characteristics increase the extinction risk for each species when combined with continued threats from fisheries, loss of nearshore habitat, chemical contamination, and areas of low dissolved oxygen. Specifically, some commercial fishers can modify habitats and remove prey species; nearshore habitat degradation and loss can harm rearing habitats used by juvenile rockfish for predation refuge and feeding; chemical contamination can harm rockfish through accumulation in their food sources or direct exposure to the contaminant; and areas of low dissolved oxygen can alter rockfish behavior and habitat use, as well as kill prey sources.

Based on an evaluation of abundance trends, spatial structure, and diversity as well as the threats listed above, we determined that the 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). At the time that we listed each DPS, we concluded that critical habitat was not determinable. Since then, we have compiled and reviewed the best available information relevant to designating critical habitat.

GEOGRAPHICAL AREA OCCUPIED BY THE SPECIES

One of the first steps in the critical habitat designation process is to define the geographical area occupied by the species at the time of listing. We relied on the best available data from commercial and recreational harvest, published literature, unpublished research, field observations, opportunistic sightings, and anecdotal information to determine the geographical area occupied by the yelloweye rockfish, canary rockfish, and bocaccio DPSs at the time they were listed. In the status review for each species, we identified a Puget Sound/Georgia Basin DPS for yelloweye rockfish, canary rockfish, and bocaccio (Drake et al. 2010). As described in more detail below, the range of the DPSs includes all waters of Puget Sound, the Strait of Juan de Fuca east of Victoria Sill, and south of the North Strait of Georgia (Figure 1). This range includes portions of Canada; however, we cannot designate critical habitat in areas outside of the United States (refer to 50 CFR 424.12(h)).

Physical Description of the Occupied Area. Puget Sound and Georgia Basin make up the southern arm of an inland sea located on the Pacific Coast of North America and connected to the Pacific Ocean by the Strait of Juan de Fuca. The term Puget Sound proper refers to the waters east of and including Admiralty Inlet. Puget Sound is a fjord-like estuary covering 6,039.3 square km (2,331.8 square mi). Puget Sound has 14 major river systems and its benthic areas consist of a series of interconnected basins separated by relatively shallow sills, which are bathymetric shallow areas. Most of the water exchange in Puget Sound proper is through Admiralty Inlet, and the configuration of sills and deep basins results in the partial recirculation of water masses and the retention of contaminants, sediment, and biota (Strickland 1983). Tidal action, freshwater inflow, and ocean currents interact to circulate and exchange salty marine water from the Strait of Juan de Fuca at depth and less dense fresh water from the surrounding watersheds at the surface producing a net seaward flow of water at the surface (Strickland 1983).

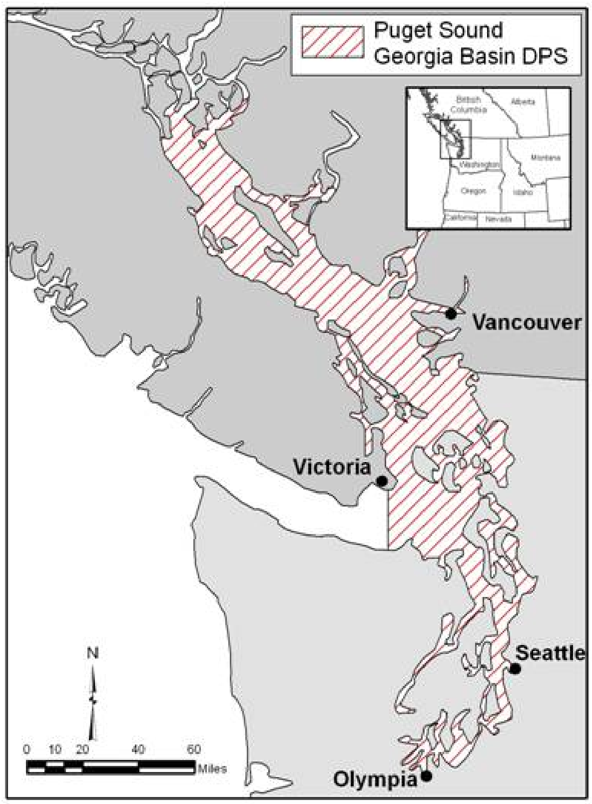

Figure 1. Area of the DPSs of ESA-listed rockfishes.

Puget Sound can be subdivided into biogeographic basins that encompass contiguous, ecologically unique, and spatially isolated freshwater, estuarine, and marine habitats (Downing 1983; Burns 1985). These five interconnected basins include: 1) The San Juan/Strait of Juan de Fuca Basin, 2) Main Basin, 3) Whidbey Basin, 4) South Puget Sound, and 5) Hood Canal (Appendix D). The sills largely define the boundaries between the biogeographic basins (except where the Whidbey Basin meets the Main Basin) and contribute to relatively fast water currents during portions of the tidal cycle. The sills, in combination with bathymetry, freshwater input, and tidal exchange, influence environmental conditions such as the movement and exchange of biota from one region to the next, water temperatures and water quality, and they also restrict water exchange (Ebbesmeyer et al. 1984; Burns 1985; Rice 2007). In addition, each basin differs in biological condition; depth profiles and contours; sub-tidal benthic, intertidal habitats; and shoreline composition and condition (Downing 1983; Ebbesmeyer et al. 1984; Burns 1985; Rice 2007; Drake et al. 2010). Puget Sound has approximately 3,862 km (2,400 miles) of shoreline, ranging from rocky sea cliffs to coastal bluffs and river deltas. Most of the shoreline of Puget Sound proper is composed of erodible gravel, sand, and clay deposited by glaciers more than 15,000 years ago, while much of the San Juan Basin's shoreline is composed of rock and large cobble materials (Downing 1983).

Rockfish Data in Occupied Area. Much of the documentation of species presence is from historic and contemporary fisheries catch records compiled by Washington State Department of Fish and Wildlife (WDFW); research trawls conducted by the University of Washington, WDFW, and others; and scuba and ROV-based observations (Table 1). Some additional data regarding species presence became available since the time of their listing, which added to the best available data for us to determine the geographical area currently occupied by the Puget Sound/Georgia Basin DPSs of yelloweye rockfish, canary rockfish, and bocaccio. These additional data sources include catch reports and scientific survey results provided by WDFW.

Given the longevity of some individual adult yelloweye rockfish, canary rockfish, and bocaccio (all approaching or in excess of 50 years), we considered occurrence data from each of the basins that span several decades (i.e., reports and literature in Table 1) in order to evaluate occupancy of each of the five basins. Our review of the best available data confirmed that yelloweye rockfish, canary rockfish, and bocaccio occupy each of the major regions of the Puget Sound/Georgia Basin (Table 1). Larval rockfish are often difficult to identify to species (Love et al., 2002); thus, most research is specific to *Sebastes* rather than individual species. Larval rockfish occupy open waters of Puget Sound, generally in the upper water column (Waldron 1972; Weis 2004; Greene and Godersky 2012). A recent assessment of larval rockfish was conducted across all basins of Puget Sound (Greene and Godersky 2012). Larval rockfish appeared to occur in two peaks (early spring, late summer) that coincide with the main primary production peaks in Puget Sound. Relative abundance of larval rockfish peaked in either April or May, or in August or September depending on location. The South Sound, Hood Canal, and Whidbey Basins exhibited high relative abundance of larval rockfish early in the year, while the areas of the Main Basin and San Juan/Strait of Juan de Fuca Basin exhibited the largest peaks later in the year. Larval rockfish essentially disappeared from the surface waters by the beginning of November (Greene and Godersky 2012).

Table 1. Documentation of yelloweye rockfish, canary rockfish, and bocaccio presence by biogeographic basin.

Biogeographic Basin	Bocaccio	Canary	Yelloweye
San Juan/ Strait of Juan de Fuca	d,j,v,h,a4	b,d,f,g,h,j,l,s,u,w,x,z,a1, a3,a4	a,b,c,d,h,j,k,l,m,t, u,w,x,a1,a2,a3,a4
Whidbey Basin	d,i,s,u,a1,a4	d,i,g,j,l,r,s,a3,a4	d,g,i,j,l,s,u,a1,a4
Main Basin	d,i,j,m,p,q,s,u,z,a3,a4	d,i,g,j,l,q,r,s,v,y,z,a2,a3,a4	c,d,g,i,j.l,o,q,s,u,a2,a3,a4
South Puget Sound	d,i,j,l,r,s,z,a1,a2,a3,a4	d,i,j,r,s,v,z,a1,a3,a4	d,i,j,s,u,a,a2,a3,a4
Hood Canal	d,n,l,r,a3,a4	d,g,i,l,u,z,a3,a4	d,i,j,l,u,a2,a3,a4

a: Olander 1991, b: Squire and Smith 1977, c: WDFW ROV Surveys, d: Miller and Borton 1980, e:WDFW trawl surveys (Palsson et al. 2009), f: WDFW VAT surveys (Palsson et al. 2009). g: WDFW Dive (Palsson et al. 2009), h: Pacunski et al. 2013, i: Washington, 1977, j: Moulton and Miller, 1987, k: Banks 2007, l: WDFW, unpublished sportfishing catch data 2003-2009, m:Palsson 2011, n: Williams et al. 2010, o: Reum 2006, p: Walton 1979, q: Gowan 1983, r: Haw and Buckley 1971, s:Washington et al. 1978, t: Miller et al. 1977, u: Delacy et al. 1972, v: Holmberg et al., 1967, w: Weispfenning 2006., x:Andrews 2012, y: Dinnel et al., 1986, z: Buckley and Satterthwaite 1970, a1 Buckley 1968, a2: Buckley 1967, a3: Bargmann 1977, a4: Pedersen and DiDonato 1982.

PHYSICAL AND BIOLOGICAL FEATURES ESSENTIAL FOR CONSERVATION

Joint NMFS-U.S. Fish and Wildlife Service (USFWS) regulations at 50 CFR 424.12(b) state that, in determining what areas are critical habitat, the agencies “shall consider those physical and biological features that are essential to the conservation of a given species and that may require special management considerations or protection.” Features to consider may include, but are not limited to:

1) Space for individual and population growth and for normal behavior
2) Food, water, air, light, minerals, or other nutritional or physiological requirements
3) Cover or shelter
4) Sites for breeding, reproduction, rearing of offspring, germination, or seed dispersal
5) Habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species

These regulations go on to emphasize that the agency shall focus on essential features within the specific areas considered for designation. These features “may include, but are not limited to, the following: spawning sites, feeding sites, seasonal wetland or dry land, water quality or quantity, geological formation, vegetation type, tide, and specific soil types.”

Based on the best available scientific information regarding natural history and habitat needs, we developed a list of physical and biological features essential to the conservation of adult and juvenile yelloweye rockfish, canary rockfish, and bocaccio and relevant to determining whether specific areas are consistent with the above regulations and the ESA section (3)(5)(A) definition of "critical habitat." We do not currently have sufficient information regarding the habitat requirements of larval yelloweye rockfish, canary rockfish, and bocaccio to determine which features are essential for conservation, and thus are not proposing to designate critical habitat specifically for this life stage. The physical or biological features essential to the conservation of yelloweye rockfish, canary rockfish, and bocaccio fall into major categories reflecting key life history phases:

<u>Adult canary rockfish and bocaccio, and adult and juvenile yelloweye rockfish</u>:

Benthic habitats or sites deeper than 30 m (98 ft) that possess or are adjacent to areas of complex bathymetry consisting of rock and/or highly rugose habitat are essential to conservation because these features support growth, survival, reproduction, and feeding opportunities by providing the structure for rockfish to avoid predation, seek food, and persist for decades. Several attributes of these sites determine the quality of the habitat and are useful in considering the conservation value of the associated feature and whether the feature may require special management considerations or protection. These attributes are also relevant in the evaluation of the effects of a proposed action in a section 7 consultation if the specific area containing the site is designated as critical habitat. These attributes include: 1) quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities, 2) water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities, and 3) the type and amount of structure and rugosity that supports feeding opportunities and predator avoidance.

<u>Juvenile canary rockfish and bocaccio only</u>:

Juvenile settlement habitats located in the nearshore[1] with substrates such as sand, rock, and/or cobble compositions that also support kelp are essential for conservation because these features enable forage opportunities and refuge from predators, and enable behavioral and physiological changes needed for juveniles to occupy deeper adult habitats. Several attributes of these sites determine the quality of the area and are useful in considering the conservation value of the associated feature and in determining whether the feature may require special management considerations or protection. These

[1] Most nearshore areas are contiguous with the shoreline from the line of extreme high water out to a depth no greater than 30 meters (98 ft) relative to mean lower low water. Several nearshore areas designated as critical habitat are not associated with a beach, but are shallower than 30 meters and can support kelp and rearing habitat. They include areas of Hein Bank, Partridge Bank, Coyote Bank, and Middle Bank, and several areas north of Orcas Island.

features also are relevant to evaluating the effects of a proposed action in a section 7 consultation if the specific area containing the site is designated as critical habitat. These attributes include: 1) quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities, and 2) water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities.

SPECIAL MANAGEMENT CONSIDERATIONS OR PROTECTION

Regulations for designating critical habitat at 50 CFR 424.12(b) state that the agencies shall consider physical and biological features essential to the conservation of a given species that "may require special management considerations or protection." Joint NMFS and USFWS regulations at 50 CFR 424.02(j) define "special management considerations or protection" to mean "any methods or procedures useful in protecting physical and biological features of the environment for the conservation of listed species." We identified a number of activities that may affect the physical and biological features essential to yelloweye rockfish, canary rockfish, and bocaccio such that special management considerations or protection may be required. Major categories of such activities include: 1) nearshore development and in-water construction (e.g., beach armoring, pier construction, jetty or harbor construction, pile driving construction, residential and commercial construction); 2) dredging and disposal of dredged material; 3) pollution and runoff; 4) underwater construction and operation of alternative energy hydrokinetic projects (tidal or wave energy projects) and cable laying; 5) kelp harvest; 6) fisheries; 7) non-indigenous species introduction and management; 8) artificial habitat creation; 9) research activities; 10) aquaculture; and 11) activities that lead to global climate change and ocean acidification. All of these activities may have an effect on one or more physical or biological features as described further below.

In the following paragraphs, we describe the potential effects on essential physical or biological features associated with each category of activities and we summarize the occurrence of these activities in the descriptions of the specific areas below. This is not an exhaustive list of potential effects, but rather a description of the primary concerns and potential effects that we are aware of at this time and that should be considered in the analysis of these activities under section 7 of the ESA.

1) Nearshore Development and In-water Construction: Beach and in-water construction activities include shoreline armoring, pier construction, pile driving, construction of jetties and harbors, and construction of other large in-water structures. These activities are often regulated by local and state jurisdictions, and the Army Corps of Engineers through section 10 of the Rivers and Harbors Act

and section 404 of the Clean Water Act. These activities may alter rearing environments for juvenile canary rockfish and bocaccio by the fill or degradation of intertidal waters, and construction includes activities that increase sedimentation and underwater noise (such as pile driving). Altered intertidal and nearshore habitats may impair the growth of kelp or eelgrass through shading or sedimentation, which reduces refuge from predators and protection from currents. The loss or degradation of intertidal habitat can also impair the production of sand lance and surf smelt, which spawn in these areas, and thus reduce prey sources of yelloweye rockfish, canary rockfish, or bocaccio. Potential modifications to avoid or mitigate effects include using best management practices to reduce construction-related sedimentation, the use of alternative shoreline armoring techniques, restoring shoreline habitats elsewhere, minimizing construction generated turbidity and noise, and changing project footprints to avoid sensitive rearing habitats.

2) Dredging and Disposal of Dredged Material: Dredging projects are regulated by the Army Corps of Engineers through section 404 of the Clean Water Act. The Army Corps of Engineers also leads the administration of the Puget Sound Dredged Material Management Program (DMMP). We discuss the management considerations associated with dredging and dredge disposal, but note that not all dreading projects result in in-water disposal. When disposal is approved by the DMMP in Puget Sound, it occurs in one of two different sites. Non-dispersive disposal sites are located in areas where currents are slow 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. Five non-dispersive and two dispersive sites are located in the range of the Puget Sound/Georgia Basin DPSs of ESA-listed rockfishes. Dredging and disposal activities may affect benthic habitats and water quality features. Dredging often occurs in areas with contaminated sediments (Appendix B). Contaminants can include metals, organometallic compounds, chlorinated hydrocarbons, phenols, pesticides/polychlorinated biphenyls[1], polybrominated diphenyl ethers, and polycyclic aromatic hydrocarbons (PAHs) (Army Corps of Engineers 2010). These contaminants can be released into the water column by the dredging process and may be taken up by phytoplankton, zooplankton, benthic invertebrates, demersal fish, forage fish, and other fishes (Army Corps of Engineers 2010). Those contaminants can then be bioaccumulated by long-lived predators such as rockfish and may disrupt behavior and immune system function (West et al. 2001; Palsson et al. 2009). Sediments are assessed through a screening process to determine the likelihood of contamination, which in turn dictates where they can be released at open water disposal sites. At the non-dispersive

[1] http://www.nws.usace.army.mil/PublicMenu/documents/DMMO/Nov_2009_UM.pdf

sites, disposed materials are generally released in areas with unconsolidated sand and mud substrates and relatively flat bathymetry (Army Corps of Engineers 2010). However, sediment plumes within the water column may disrupt the ability of rockfish to pursue prey and may obscure and homogenize depressions used by adult fish.

Dredging can potentially increase underwater noise and alter wave patterns and sediment transport mechanisms near the dredge site as well as cause physical changes to the seafloor geomorphology (e.g., substrate type and composition, surface texture) that can affect water circulation and nutrient distribution and cause sedimentation of rocky substrate. Possible modifications to dredging and disposal to avoid or mitigate effects to critical habitat include placing restrictions on the spatial and temporal extent of dredging activities and the deposition of dredge spoils, and to require some dredge spoil to be placed in approved upland disposal sites.

3) Pollution and Runoff: Projects that may result in pollution and runoff are often regulated by local and state jurisdictions, the Army Corps of Engineers through section 404 of the Clean Water Act, and the Environmental Protection Agency (EPA) or are initiated the Department of Defense. The discharge of pollutants and runoff from point and non-point sources (including but not limited to industrial discharges, urbanization, and road surfaces) can affect water quality and sediment of yelloweye rockfish, canary rockfish, and bocaccio habitat. Exposure to contaminants such as PAHs and various metals, such as copper, may disrupt behavior and immune system function (Palsson et al. 2009), may reduce overall growth and productivity of rockfish (West et al. 2014), and may be lethal to various life stages of each species. Excess nutrient input can reduce dissolved oxygen to lethal levels (Palsson et al. 2008).

Oil spills are another source of contamination that can have long-lasting impacts on habitat. Spills often distribute over nearshore intertidal areas and kill biota and biogenic substrates that include kelp and sponge gardens potentially occupied by juvenile bocaccio and canary rockfish. Oil can also break up and sink to benthic habitats outside the nearshore, impacting biogenic habitats through smothering and contamination.

In addition to chemical contamination, water quality in Puget Sound is influenced by sewage, animal waste, and nutrient inputs. Portions of Hood Canal have episodic periods of low dissolved oxygen, though the relative role of nutrient input from humans in exacerbating these episodes is in doubt (Cope and Roberts 2012). Typically, rockfish move out of areas with dissolved oxygen less than 2 mg/L (2 ppm); however, when low dissolved oxygen waters were upwelled to the surface in 2003, about 26 percent of the rockfish population was killed (Palsson et al. 2008). 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 input of nutrients could threaten nearshore habitats of juvenile canary rockfish and bocaccio because it can compromise the growth and recruitment of eelgrass by causing plankton blooms or excess growth of eelgrass epiphytes that collectively reduce light levels (Mumford 2007). Potential modifications for projects that result in pollution and runoff include changing the outfall location to less sensitive habitats, and using enhanced pollutant treatment techniques.

4) Underwater Construction and Operation of Alternative Energy Hydrokinetic Projects and Cable Laying: These types of projects are regulated by state agencies, the Federal Energy Regulatory Commission, and/or the Army Corps of Engineers. Tidal or wave energy projects generally require energy-generating equipment and supporting structures to be anchored on the seafloor. There is a wide range of designs currently being tested and the potential impacts of individual projects will vary depending on the type of unit being deployed. Physical structures associated with tidal, wind, or wave energy projects may alter benthic habitats for listed rockfishes by the risk of blade strike, introducing chemicals, generating noise, and removing energy from the overall tidal system. All of these may result in changes in distribution and behavior of listed rockfishes (Busch et al. 2013). In addition, construction and maintenance of these energy projects may require in-water construction or alterations, which would include the potential effects described above. Cable laying activities can alter benthic habitats by changing localized habitat characteristics, and for cables that lie on the seafloor, can provide attachment sites for marine biota (Polagye et al. 2011). Potential modifications for these types of projects to avoid or reduce effects include changing the project footprint and/or location to less sensitive benthic habitats, mitigating for impacts with habitat restoration actions, and monitoring the project effects on benthic areas.

5) Kelp Harvest: The harvest of kelp is regulated by WDFW. Kelp is not currently harvested commercially in Puget Sound, and the amount of recreational harvest is unknown. Kelp harvest is a potential concern because it may reduce the quality and quantity of rearing habitats for juvenile canary rockfish and bocaccio. In addition, kelp is a spawning substrate for herring, which are a prey item of rockfish. Thus, kelp harvest could reduce herring stock productivity and ultimately reduce food sources for yelloweye rockfish, canary rockfish, and bocaccio. Potential modifications to avoid or mitigate impacts from kelp harvest would include limiting harvest to various species of kelp, and limiting locations, harvest techniques, and total amount harvested.

6) Fisheries: Commercial and recreational fisheries in Puget Sound are a special management consideration because they have the potential to alter rockfish habitat. Commercial and recreational fisheries in Puget Sound target a variety of species with several gear types and the status of a particular fishery can change over time. Commercial and recreational fisheries are subject to annual rule making by WDFW, while the Puget Sound Treaty Tribes manage their fisheries in coordination with the State. Similarly, fisheries become active or inactive as a result of WDFW regulations and economic viability. Net fisheries for salmon include gill nets, purse seines, reef nets, and beach seines. Net fisheries for bottom fish include set nets and otter trawls. A forage fish purse-seine fishery targets surf smelt, and the Puget Sound lampara herring fishery nets are similar to purse seine nets. Beam trawls are used in shrimp fisheries. Pelagic trawls have been used to target Pacific hake and pollock. Non-net fisheries include long-lines (also termed set lines) targeting halibut or shark, and pot fisheries for bottom fish, Dungeness crab, and shrimp (WDFW 2010a).

On July 28, 2010, WDFW closed several commercial fisheries in Puget Sound in order to protect dwindling rockfish populations (WDFW 2010a). Closed fisheries included the set net, set line, bottom trawl, inactive scallop trawl, pelagic trawl, and bottom fish pot fishery (WDFW 2010b). As a precautionary measure, WDFW closed the above commercial fisheries west of the ESA-listed rockfishes' DPS boundaries to Cape Flattery. WDFW extended the closure west of the rockfish DPS boundaries to prevent commercial fishermen from concentrating gear in that area. WDFW initially closed the commercial fisheries listed above on a temporary basis (up to 240 days), and then permanently closed them in February 2011.

Some commercial fisheries can potentially alter habitat by gear contacting bottom substrates either when it is actively fished or when it is lost. For instance, bottom trawls come into contact with benthic habitats and alter habitat by suspending sediment and changing habitat complexity, smoothing of sand waves, and changing bottom roughness in localized areas. Trawls in less structurally complex habitats, such as areas fished by commercial shrimp trawlers, are less affected than areas of more complex habitat (Roberts 2008). Aside from bottom trawls, most of these net fisheries have little or no contact with bottom substrates and have minimal potential to impact habitat. The greatest potential effect to habitats from these fisheries comes from the loss of the net (termed derelict nets).

Gill nets are the vast majority of derelict nets in Puget Sound (Good et al. 2010). Gill net fisheries in Puget Sound are co-managed by WDFW and the Puget Sound Treaty Tribes. Gill net and other salmon fisheries occur within the Puget Sound Chinook Salmon Resource Management Plan (Plan), which is developed by WDFW and the tribes. The Plan is submitted to NMFS under provisions of the Puget Sound Chinook ESA section 4(d) rule. Nets are lost because of inclement weather, operator inexperience, tidal and current action, catching upon the seafloor, the weight of catch causing submersion, vessels inadvertently traveling through them, or a combination of these factors (NRC 2008; Gibson 2013). Nets fished in rivers and estuaries can be lost from floods and/or when large logs are caught moving downstream, and a few of these nets may drift to the marine environment. Nets can persist in the marine environment for decades because they do not biodegrade and are resistant to chemicals, light, and abrasion (Good et al. 2010). In some cases, nets can drift relatively long distances before they catch on the bottom or wash up on the shore (Good et al. 2010). Many nets hang on bottom structure that is also attractive to rockfish. This structure consists of high-relief rocky substrates or boulders located on sand, mud, or gravel bottoms (Good et al. 2010). The combination of complex structure and currents tend to stretch derelict nets open and suspend them within the water column, making them more deadly to marine biota (Good et al. 2010).

Aside from killing fish, derelict nets can alter habitat suitability by trapping fine sediments out of the water column. This creates a layer of soft sediment over rocky areas, changing habitat quality and suitability for benthic organisms (Good et al. 2010). Lost nets can cover habitats used by rockfish for shelter and pursuit of food, rendering the habitat unavailable, and can also reduce the abundance and availability of rockfish prey that include invertebrates and fish (Good et al. 2010). Potential management considerations for fisheries that lead to derelict fishing nets include the use of best practices and/or technologies to prevent their loss, locations of fisheries, methods to track lost nets, and response protocols for lost nets.

Recreational fisheries use jigs, weights, and hooks that have the potential to alter benthic habitats by snagging structure, and some gear can be lost. However, there is little documentation of adverse effects to the seafloor from lost recreational fishing gear in Puget Sound. Recreational and commercial shrimp and crab fishermen employ pots that rest on the bottom of the seafloor up to several hours when they are actively fished and some of these pots are lost. An estimated 12,193 commercial and recreational crab pots are lost, and an estimated 326 to 651 recreational shrimp pots are lost annually in Puget Sound (Antonelis et al. 2010; NRC 2012). These lost pots change native benthic habitat characteristics by adding structure, and may attract rockfish from natural habitats. Management considerations for pot fisheries include the use of best-practices and/or technologies to prevent pot loss, locations of fisheries, and response protocols upon their loss.

7) Non-indigenous Species Introduction and Management: Non-indigenous species are managed by local and state jurisdictions. Non-indigenous species along the seafloor are an emerging threat to biogenic habitat in Puget Sound. *Sargassum muiticum* is an introduced brown alga that is now

common throughout much of Puget Sound (Drake et al. 2010). The degree to which *S. muiticum* influences native macroalgae, eelgrass, or rockfish is not presently understood. In addition, several species of non-indigenous tunicates have been identified in Puget Sound. For example, *Ciona savignyi* was initially seen in one location in 2004, but within 2 years spread to 86 percent of sites surveyed in Hood Canal (Drake et al. 2010). The exact impact of invasive tunicates on rockfish or their habitats is unknown, but results in other regions (e.g., Levin et al. 2002) suggest the potential for introduced invertebrates to have widespread impacts on rocky reef fish populations. Management considerations for non-indigenous species along the seafloor include their possible removal or other control efforts, and actions to prevent their continued introduction to local habitats.

8) Artificial Habitat Creation: The intentional placement of artificial habitats in Puget Sound is regulated by WDFW, the Washington State Department of Natural Resources, and the Army Corps of Engineers. Artificial habitats consist of materials such as boulder piles, concrete rubble, tires, shipwrecks, and other materials that are not native to the local benthic habitat. Construction of artificial reef areas can increase underwater turbidity and noise. Rockfishes are found among artificial habitats relatively soon after their placement (Palsson et al. 2009). These habitats attract fish from the surrounding environment (Buckley and Hueckel 1985; Laufle and Pauley 1985), but how well the artificial reefs simulate the function of natural habitats is unclear (Palsson et al. 2009). There have been few artificial habitat projects in Puget Sound since the 1980s. The WDFW’s Puget Sound Rockfish Conservation Plan guides the placement of future artificial habitats in areas with already degraded benthic habitats, such as existing tire reefs (WDFW 2010c). Management considerations for artificial habitats include practices to reduce in-water construction effects, potential toxicity of the materials, ecosystem effects of changed benthic habitat characteristics, and overall efficacy of the project(s) to augment rockfish habitat and population viability.

9) Research Activities: Research conducted by NMFS, WDFW, University of Washington, and other governmental and private entities in Puget Sound include the use of gear that can alter habitats. Examples of such gear include tow-nets, purse seines, dredges, and bottom grabs. WDFW conducts research bottom trawl surveys in each of the five basins of Puget Sound and the University of Washington also conducts bottom trawls on occasion. The WDFW bottom trawl index survey deploys a bottom trawl to assess groundfish species assemblages and biomass.

The effects of research include a reduction of prey resources and potential benthic habitat alterations. The effect of sampling gear may include contact with and alteration of the seafloor, causing sediment mobilization and potential disruption to aquatic vegetation such as eelgrass and kelp. Trawls catch fish, shrimp, and other invertebrates that would otherwise be available as the prey of yelloweye rockfish, canary rockfish, and bocaccio. Bottom trawls may affect benthic habitats by suspending sediment and changing habitat complexity, smoothing sedimentary bedforms, and changing bottom roughness in localized areas. Trawls in less structurally complex habitats are generally less affected than areas of more complex habitat. Management considerations for research actions include locating some actions in less sensitive benthic habitats and reducing the magnitude of the particular research action.

10) Aquaculture Operations: Aquaculture operations in Puget Sound are regulated by local and state agencies, as well as the Army Corps of Engineers and the EPA. Operations in Puget Sound include shellfish (clam, geoduck, muscles, and oysters) and fish net-pen operations. The wild geoduck harvest is regulated by the Washington State Department of Natural Resources and Puget Sound tribes, and has similar effects to the environment as cultured geoduck harvest.

The Army Corps of Engineers regulates existing shellfish aquaculture facilities in Puget Sound under the Nationwide Permit 48 (NWP 48). Activities addressed under NWP 48 include shellfish harvest and seeding, installation and maintenance of buoys, floats, racks, trays, nets, lines, tube containers, and other structures necessary for existing commercial operations. Installation and maintenance of these facilities, as well as geoduck harvest, could disturb substrates, alter shoreline characteristics, induce turbidity, and result in hardening of intertidal and sub-tidal habitats by the addition of non-native oyster shells, gravel, and PVC tubes for clam and oyster aquaculture.

Fish net-pen operations have the potential to release contaminants and nutrients, and alter local habitat characteristics. The primary habitat feature that may be affected by net pens is the benthic environment near marine finfish rearing facilities. Nearshore sub-tidal and intertidal epibenthic invertebrates are important prey for juvenile rockfish and the prey of rockfish such as herring and sand lance. A study of three salmon net-pen operations in British Columbia, Canada found that quillback rockfish (*S. maliger*) and copper rockfish (*S. caurinus*) had elevated levels of mercury down-current of the net pens relative to fish from reference sites (Debruyn et al. 2006). Elevated mercury levels were attributed to food given to farmed fish that had settled to the sea-floor (and released in feces), in addition to the mobilization of naturally occurring mercury in sediment under and near the net pens because of farm-induced anoxia. Mercury was then incorporated through the localized food web. Rockfish with elevated levels of contaminants may have reduced growth rates and reproductive impairment (Drake et al. 2010).

Net-pen facilities alter habitat characteristics from open-water pelagic environments to habitats that more closely resemble some nearshore habitats. Kelp has been documented to grow on net-pen nets, floats, and anchor lines (Rensel and Forster 2007), and thus these areas may attract juvenile rockfish.

Management considerations include locating proposed fish net-pen structures to reduce impacts from nutrient loading or potential toxins. Management considerations for shellfish aquaculture facilities include placing new facilities away from native aquatic vegetation such as kelp or eelgrass, and reducing sediment-disturbing activities of existing operations.

11) Activities that Lead to Global Climate Change and Ocean Acidification: Activities that may affect global climate change are regulated by local and state agencies, as well as the EPA. Climate change (including sea level rise) and Ocean Acidification (OA) have the potential to result in fundamental alterations to habitats and food sources of listed rockfishes. In a recent study, OA was found to affect juvenile rockfish behavior (Hamilton et al. 2014). Behavior (characterized as “anxiety” by the researchers) significantly changed after juvenile Californian rockfish (*Sebastes diploproa*) spent 1 week in seawater with the OA conditions that are projected for the next century in the California shore. The study indicated that OA could have severe effects on rockfish behavior (Hamilton et al. 2014). Research conducted to understand adaptive responses to OA on other marine organisms has shown that although some organisms may be able to adjust to OA to some extent, these adaptations may reduce the organism’s overall fitness or survival (Wood et al. 2008).

Aside from OA, future climate-induced changes to rockfish habitat (such as sea level rise) could alter their productivity (Drake et al. 2010) and negatively affect their habitats. Harvey (2005) created a generic bioenergetic model for rockfish and found that their productivity is highly influenced by climate conditions. For instance, El Niño-like conditions generally lowered growth rates and increased generation time. The negative effect of the warm water conditions associated with El Niño appears 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 population viability of ESA-listed rockfishes (Drake et al. 2010).

Sea level has risen by an average of 1.7 + 0.3 mm per year (0.067 + 0.012 in) since 1950, after remaining relatively stable for approximately the last 3,000 years (Church and White 2006). However, satellite data collected more recently (from 1993 to 2009) recorded rates of 3.3 + 0.4 mm per year (0.12 + 0.015 in), suggesting that sea level rise may be accelerating (Ablain et al. 2009). Global sea level is projected to rise by approximately 60 cm (23.6 in) by 2100 (IPCC 2007) to as much as 1 m (39.4 in) because of recently identified declines in polar ice sheet mass (Pfeffer et al. 2008). However, Washington State sits above an active subduction zone, which may mean that sea level rise could differ from the global average depending on the activity of the zone (Dalton et al. 2013). Puget Sound lowlands are thought to be more stable in the north, but are tilting downward toward Tacoma in the south. This subsidence may amplify sea level rise and could effectively double the rate in areas of South Puget Sound (Craig 1993).

In areas of South Puget Sound, sea level rise could, among other impacts, alter the habitat of ESA-listed rockfishes by contaminating surface and groundwater, and causing shoreline erosion and landslides, which may lead to a loss of tidal and estuarine habitat (Craig 1993) and species distribution (Harley et al. 2006).

SPECIFIC AREAS WITHIN THE GEOGRAPHICAL AREA OCCUPIED BY THE SPECIES

After determining the geographical area of the Puget Sound/Georgia Basin occupied by yelloweye rockfish, canary rockfish, and bocaccio, and the physical and biological features essential to their conservation, we next identified the specific areas within the geographical area occupied by the species that contain the essential features. The U.S. portion of the Puget Sound/Georgia Basin that is occupied by yelloweye rockfish, canary rockfish, and bocaccio can be divided into five areas based on the distribution of adult and juvenile rockfish, geographic conditions, and habitat features. These areas are described above under "Physical Description of Occupied Area." These five interconnected areas are: 1) the San Juan/Strait of Juan de Fuca Basin, 2) Main Basin, 3) Whidbey Basin, 4) South Puget Sound, and 5) Hood Canal. These areas also meet the definition of specific areas under section (3)(5)(A) because the essential physical and biological features for juvenile rearing and/or adult reproduction, sheltering, or feeding for yelloweye rockfish, canary rockfish, and bocaccio are located within these specific areas. We do not currently have sufficient information regarding the habitat requirements of larval yelloweye rockfish, canary rockfish, and bocaccio to allow us to determine essential features specific to the larval life stage.

In order to delineate specific areas where these life stages may occur, we next considered the distribution of the essential features within them. We used available geographic data to identify specific locations of essential features within each of the specific areas. Two of the essential features (benthic sites with or adjacent to complex bathymetry and shoreline sites with specific substrate types and conditions) were suitable for this mapping exercise. The other essential features (water quality and prey) are more qualitative.

Mapping Areas of Complex Bathymetry Deeper than 30 Meters. We propose to designate habitats with and adjacent to complex bathymetry as critical habitat for each species. These habitats are primarily used by adult and sub-adult yelloweye rockfish, canary rockfish, and bocaccio. To determine the distribution of essential features (within the specific areas) of benthic habitats deeper than 30 m (98 ft) used by these species, we relied on benthic habitat characterizations of each of the five basins of Puget Sound. We used the Benthic Terrain Model (BTM), which classifies terrain in all five basins of the DPSs. We also assessed recent benthic maps in the San Juan Basin (Greene and Barrie 2011; Greene 2012). We used these information sources to assess the presence of essential features in waters deeper than 30 m (98 ft) for each species, where yelloweye rockfish and adult canary rockfish and bocaccio are most likely to occur.

The BTM classifies data based on a combination of slope (a first-order derivative of bathymetry) and broad- and fine-scaled bathymetric position indices (BPIs, second-order derivatives of bathymetry) that describe the depth of a specific point relative to the surrounding bathymetry and produces grid layers of terrain-based zones and structures. The BTM classifies benthic terrain at a 30 m (98 ft) scale in several categories that include flats, depressions, crests, shelves, and slopes, but does not delineate benthic substrate type. The BTM also provides a rugosity value, which is a measurement of variations or amplitude in the height of a surface—in this case, the seafloor (Kvitek et al. 2003; Dunn and Halpin 2009; Sappington et al. 2007). Rugosity values were developed using a neighborhood analysis with a 3-grid cell by 3-grid cell neighborhood. We binned the rugosity values into two groups using the geometric interval method (Price 2011) and refer to benthic areas with rugosity values of 0.001703 or higher as “high rugosity.” Rugosity values can be used as a surrogate for reef fish diversity when other data on habitats are lacking (Pittman et al. 2007). Similarly, areas of high rugosity have been used as an indicator of hard-bottomed habitat (Dunn and Halpin 2009). Habitats with higher rugosity values are more likely to be used by adult yelloweye rockfish, canary rockfish, and bocaccio because of its complexity that provides areas for foraging and refuge. Areas of high rugosity feature irregular and/or sloped bottoms that provide primary habitats for adult and sub-adult yelloweye rockfish, canary rockfish, and bocaccio. Areas of low rugosity in Puget Sound are generally relatively flat with substrates that consist of unconsolidated fine sediments, and therefore are likely to have lower densities of yelloweye rockfish, canary rockfish, and bocaccio compared to areas of high rugosity. We used several geoprocessing tools to delineate critical habitat among and adjacent to areas of high rugosity (detailed in Appendix C).

Sophisticated seafloor characterization and mapping has occurred in most of the San Juan Archipelago and southern Georgia Strait (Greene and Barrie 2011; Greene 2012). This mapping was generated by multibeam and backscatter surveys. These habitat maps provide information on the benthic terrain for most of the San Juan area, including specific benthic terrain types (i.e., “fractured bedrock” and “hummocky unconsolidated sediments”) which can be used to identify rockfish habitat. Sixty-two benthic terrain types have been mapped (Greene 2012). Fifty-three terrain types are composed of soft, unconsolidated sediment; one is a mixture of hard rock and soft sediment, and five are hard ground or bedrock exposures, including large boulders and pinnacles (Greene 2012).

We analyzed whether the BTM encompassed the mapped rocky habitats of the San Juan Islands and found just over 7.5 square km (2.9 square mi) was composed of rock and not designated as high rugosity, which is a small fraction of the overall amount of rocky areas mapped by Green and Barrie (2011). This served as verification that the BTM’s elevated rugosity values encompass most rocky terrain in the San Juan Basin. In addition to the areas identified as high rugosity by the BTM, we have designated the 7.5 square km of rocky areas not characterized as high rugosity as critical habitat (detailed in Appendix C).

Mapping Juvenile Nearshore Settlement Habitat. In delineating nearshore (shallower than 30 m (98 ft)) areas in Puget Sound, we focused on the area contiguous with the shoreline from extreme high water out to a depth no greater than 30 m (98 ft) relative to mean lower low water. This area generally coincides with the maximum depth of the photic zone in Puget Sound and can contain physical or biological features essential to the conservation of juvenile canary rockfish and bocaccio. To determine the distribution of essential features of nearshore habitats for juvenile canary rockfish and bocaccio, we used the Washington State Department of Natural Resources’ (DNR) ShoreZone inventory (Berry et al. 2001) in combination with the benthic habitat classifications of the BTM related to the locations where moderate to large rivers enter Puget Sound.

The DNR ShoreZone habitat classifications are available for all of the shoreline of the DPSs. We used the habitat characteristics described in the ShoreZone inventory to assist in determining if essential features for juvenile canary rockfish and bocaccio occur along particular areas of the nearshore. The ShoreZone inventory was conducted by aerial surveys between 1994 and 2000 along all of Washington State’s shorelines (Berry et al. 2001). The DNR subdivided beaches into units. Each unit is a section of beach with similar geomorphic characteristics. Within each unit, the DNR documented the presence of eelgrass or kelp, among other parameters. There are 6,856 shoreline segments in the rockfish DPSs, ranging from 0.02 to 14 km (0.01 to 8.7 mi) in length. The DNR delineated 15 different geomorphic shoreline types (Table 2). The DNR's mapping of aquatic vegetation was imperfect, because shoreline segments were observed by aerial surveys during different years and months. Aquatic vegetation growth, including kelp, is variable from month to month and year to year. Some kelp species are annuals; thus, surveys that took place during non-growing seasons may have not mapped kelp beds where they actually occur. Non-floating kelp species in particular may have also been underestimated by the DNR survey methods because they were more difficult to document compared to floating kelp. In particular, all species mapped were usually not visible by aerial surveys to their lower depth limit because of poor visibility through the water column. While beds of vegetation may have been visible underwater, often it was not possible to determine what particular type of vegetation was present because of a lack of color characteristics. In addition, because floating kelp occurs in shallow waters off-shore of the area visible from the aircraft, it was not mapped in many cases. For these reasons, the mapped kelp within the ShoreZone database is certainly an underestimation of the total amount of kelp along Puget Sound shorelines.

To determine if these shorelines contained essential features for juvenile canary rockfish and bocaccio, we reviewed their geomorphic classifications to see if they possessed rock, cobble, and other substrates that would support rearing juveniles. In addition, we assessed the relative overlap of mapped

Table 2. Department of Natural Resources shoreline types.

DNR Shoreline Type	Miles in Rockfish DPSs
Channel	0.36
Estuary Wetland	260
Mud Flat	173
Sand Beach	379
Sand Flat	344
Gravel Beach	27
Gravel Flat	3
Rock Cliff	189
Rock Platform	17
Rock w/ Gravel Beach	45
Rock w/Sand and Gravel Beach	60
Rock w/ Sand Beach	30
Sand and Gravel Beach	414
Sand and Gravel Flat	234
Man-Made	173
Total	**2,348.4**

kelp in these shoreline types. All but the "Estuary Wetland" and "Mud Flat" shoreline segments had at least 20 percent of the segment with "continuous" or "sporadic" kelp mapped by DNR (Figure 2). The estuary wetland and mudflat segments had very small portions of kelp (1.5 and 2.6 percent, respectively) (Figure 2). We found that the estuary wetland and mud flat shoreline segments 0.5 mile or longer lack essential features for canary rockfish and bocaccio.

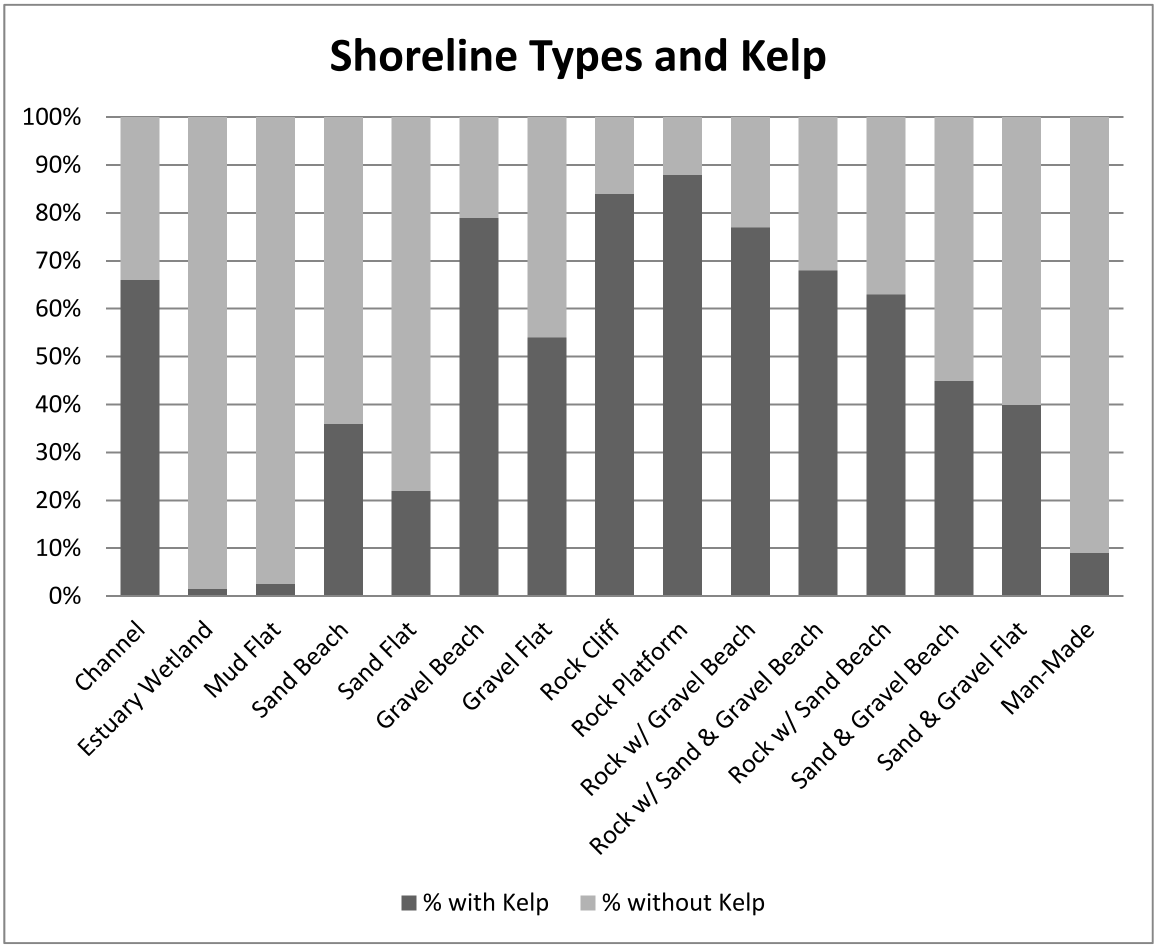

Figure 2. Assessment of DNR shoreline classifications and occurrence of kelp.

To assess nearshore estuaries and deltas of moderate and large rivers that enter Puget Sound, we used information from Burns (1985) and Teizeen (2012) to determine the location and annual flows of these rivers. These rivers input various volumes of sediment and fresh water into Puget Sound (Downing 1983; Burns 1985; Czuba et al. 2011) and profoundly influence local benthic habitat characteristics, salinity levels, and local biota. The nearshore areas adjacent to moderate-to-large river deltas[1] are characterized by the input of fresh water and fine sediments that create relatively flat habitats that do not support the growth of kelp. In addition, the net outward flow of these deltas may reduce post-settlement juvenile canary rockfish or bocaccio from readily using these habitats. For these reasons, we found that these nearshore areas do not contain the essential features of rearing sites for canary rockfish or bocaccio (juvenile yelloweye rockfish most commonly occupy waters deeper than the nearshore). We determined the geographical extent of these estuaries and shelves from the BTM "shelf" seafloor designation associated with the particular river. The shelf designation also indicates the geomorphic extension of the tidal and sub-tidal delta where fresh water enters Puget Sound. We delineated critical habitat at the border of these deltas at either the geomorphic terminus of the delta at the 30 m (98 ft) contour and/or at the shoreline segment with kelp mapped by the DNR.

The five specific areas are the biogeographic regions of the Puget Sound/Georgia Basin because each basin contains all of the essential physical or biological features (Table 3). These five basins have diverse habitats and biological communities, and yelloweye rockfish, canary rockfish, and bocaccio presence has been documented in each. A portion of the nearshore in each basin contains substrates such as rock and/or cobble compositions that support kelp. Some of the benthic habitats in each basin deeper than 30 m (98 ft) also contain areas of complex bathymetry that support growth, refuge, reproduction, and feeding opportunities. Each basin has different levels of human impacts related to the sensitivity of the local environment and the changes to habitat conditions from special management considerations. Each basin is described below, and we have also included examples of some of the activities that occur within these basins that may require special management considerations or protection.

The San Juan/Strait of Juan de Fuca Basin: This basin is the northwestern boundary of the U.S. portion of the DPSs. The basin is delimited to the north by the Canadian border and includes Bellingham Bay, to the west by the entrance to the Strait of Juan de Fuca, to the south by the Olympic Peninsula and Admiralty Inlet, and to the east by Whidbey Island and the mainland between Anacortes and Blaine, Washington. The predominant feature of this basin is the Strait of Juan de Fuca, which is 160 km (99.4 mi) long and 22 km (13.7 mi) wide at its western end, to over 40 km (24.9 mi) at its eastern end (Thomson 1994). Drake et al. (2010) considered the western boundary of the DPSs as the Victoria Sill because it is hypothesized to control larval dispersal for rockfish (and other biota) of the

[1] Including the Skagit, Snohomish, Puyallup, Nooksack, Nisqually, Stillaguamish, Lake Washington Ship Canal (Cedar River and Lake Washington tributaries), Duwamish, Skokomish, Deschutes, Dosewallips, Hamma Hamma, Duckabush, Samish, Tahuya, and Big Quilcene Rivers and the shelves associated with Totten Inlet, Sequim Bay, Oakland Bay, Pickering Bay, Lynch Cove, Henderson Inlet, Eld Inlet, Discovery Bay, and Little Skookum Inlet.

region. Water temperatures are lower and more similar to coastal marine waters than to Puget Sound proper and circulation in the strait consists of a seaward surface flow of diluted seawater (<30.0 practical salinity units [psu]) in the upper layer and an inshore flow of saline oceanic water (>33.0 psu) at depth (Drake et al. 2010). Water exchange in this basin has not been determined because, unlike the rest of the basins of the DPSs, it is more oceanic in character and water circulation is not nearly as constrained by both geography and sills as the other basins.

Table 3. Physical and biological features and management considerations of sub-adult and adult habitat for yelloweye rockfish, canary rockfish, and bocaccio.

DPS Basin	**Nearshore Square Miles[a] with essential features for juvenile canary rockfish and bocaccio only.**	**Deepwater Square Miles[a] with essential features for adult and juvenile yelloweye rockfish, adult canary rockfish, and adult bocaccio.**	**Physical or Biological Features**		**Management Considerations**
San Juan/Strait of Juan de Fuca	349.4	203.6	Deepwater sites (>30 meters) that support growth survival reproduction and feeding opportunities	Nearshore juvenile rearing[b] sites with sand, rock, and/or cobbles to support forage and refuge	1, 2, 3, 6, 9, 10, 11
Whidbey Basin	52.2	32.2			1, 2, 3, 4, 6, 9, 10, 11
Main Basin	147.4	129.2			1, 2, 3, 4, 6,7, 9, 10, 11
South Puget Sound	75.3	27.1			1, 2, 3, 4, 6,7, 9, 10, 11
Hood Canal	20.4	46.4			1, 2, 3, 6,7, 9, 10, 11

Management Considerations Codes: (1) Nearshore development and in-water construction (e.g., beach armoring, pier construction, jetty or harbor construction, pile driving construction, residential and commercial construction); (2) dredging and disposal of dredged material; (3) pollution and runoff; (4) underwater construction and operation of alternative energy hydrokinetic projects (tidal or wave energy projects) and cable laying; (5) kelp harvest; (6) fisheries; (7) non-indigenous species introduction and management; (8) artificial habitats; (9) research; (10) aquaculture; and (11) activities that lead to global climate change and ocean acidification. Commercial kelp harvest does not occur presently, but would probably be concentrated in the San Juan/Georgia Basin. Artificial habitats, non-indigenous species introduction and management, and activities that lead to global climate change and ocean acidification could occur in each basin.
a: These square miles include some Department of Defense and tribal areas excluded from designation (refer to the accompanying 4(b)(2) report for details).

The San Juan/Strait of Juan de Fuca Basin has the most rocky shoreline and benthic habitats of the U.S. portion of the DPSs. Most of the basin's numerous islands have rocky shorelines and extensive, submerged, aquatic vegetation and floating kelp beds that support juvenile canary rockfish and bocaccio settlement to benthic habitats, cover from predation, and rearing. Approximately 93 percent of the rocky benthic habitats of the U.S. portion of the range of all three DPSs are in this basin (Palsson et al. 2009). Plate tectonic processes and glacial scouring/deposition have produced a complex of fjords, grooved and polished bedrock outcrops, and erratic boulders and moraines along the seafloor of the San Juan Archipelago (Greene 2012). Banks of till and glacial advance outwash deposits have also formed and contribute to the variety of topographical relief and habitat within the basin. These processes have contributed to the development of benthic areas with steep and irregular bathymetry that support growth, refuge, reproduction, and feeding opportunities.

Yelloweye rockfish, canary rockfish, and bocaccio have been documented in the San Juan Archipelago in addition to the southern portion of this basin along the Strait of Juan de Fuca (Washington 1977; Moulton and Miller 1987; Pacunski 2013). The southern portion of this basin has several pinnacles that include Hein, Eastern, Middle, MacArthur, Partridge, and Coyote Banks. Yelloweye rockfish were once commonly caught by anglers along these areas, particularly Middle Bank (Table 1).

Temperatures generally range between 7° and 11°C (45° and 52°F), although occasionally surface temperatures reach as high as 14°C (57°F) (Ecology 1999). In the eastern portion of this basin, temperature and salinity vary from north to south, with waters in the Strait of Georgia slightly warmer than waters near Admiralty Inlet. Waters near Admiralty Inlet also tend to have higher salinities than waters to the north (Ecology 1999). Dissolved oxygen levels vary seasonally, with lowest levels of about 4 mg/L at depth during the summer months and highest levels of about 8 mg/L near the surface during the winter.

There are several special management considerations for this basin. Commercial and recreational fisheries occur here, as well as scientific research. The highest concentration of derelict fishing nets in the DPSs remain here, including an estimated 241 nets in waters shallower than 30.5 m (100 ft) and over 199 nets in deeper waters (NRC 2014). Because this basin has the most kelp in the DPSs, commercial kelp harvest could be proposed for the San Juan Islands area. The Ports of Bellingham and Anacortes are located in this basin, and numerous dredging and dredge disposal projects and nearshore development, such as new docks, piers, and bulkheads, occur in this basin. These development actions have the potential to alter nearshore rearing habitats of canary rockfish and bocaccio. Two open-water dredge disposal sites are located in the basin, one in Rosario Strait and the other northwest of Port Townsend. These are termed dispersive sites because they have higher current velocities; thus, dredged material does not readily accumulate at the disposal site and settles on benthic environments over a broad area (Army Corps of Engineers 2010). Recent research has found that fine-grained materials remain in the water column longer than coarser grained materials, are more widely dispersed, and stay within the water column for extended periods of time (DMMP 2012). One model analysis found that 80 percent of sediment parcels remained active in the water column for up to 36 hours following disposal (DMMP 2012). The results of this analysis indicate that there is potential for habitat changes in the water column while this material disperses. Sediment disposal activities in this specific area may temporarily alter the ability of juvenile rockfish to seek out prey. There are several areas with contaminated sediments along the eastern portion of this basin, particularly in Bellingham Bay and Guemes Channel near Anacortes (Appendix B).

Whidbey Basin: The Whidbey Basin includes the marine waters east of Whidbey Island and to the south by a line between Possession Point on Whidbey Island and Meadowdale, south of Mukilteo. The northern boundary is Deception Pass at the northern tip of Whidbey Island. The Skagit, Snohomish, and Stillaguamish Rivers flow into this basin and contribute the largest influx of freshwater inflow to Puget Sound (Burns 1985). Water retention is approximately 5.4 months because of the geography and sills at Deception Pass (Ebbesmeyer et al. 1984).

The nearshore of the Whidbey Basin consists of bluff-backed beaches with unconsolidated materials ranging from mud and sand to mixes of gravels and cobbles (McBride et al. 2006). Some of these nearshore areas support the growth of kelp and support juvenile canary rockfish and bocaccio settlement, cover from predation, and rearing. Some of the northern part of this basin is relatively shallow with moderately flat bathymetry near the Skagit, Stillaguamish, and Snohomish River deltas and does not support essential nearshore features such as holdfasts for kelp, and rock and cobble areas for rearing juvenile canary rockfish and bocaccio. The southern portion of the basin has more complex bathymetry compared to the north, with deeper waters adjacent to Whidbey Island, southern Camano Island, and off of Mukilteo. Benthic areas in this basin with steep and irregular bathymetry and high rugosity support growth, refuge, reproduction, and feeding opportunities.

The waters in this basin are generally stratified, with surface waters warmer in summer (generally 10° to 13°C/50° to 55°F) and cooler in winter (generally 7° to 10°C/45° to 50°F) (Collias et al. 1974; Ecology 1999). In Port Susan and Saratoga Passage, salinities of surface waters (27.0 to 29.5 psu) are generally lower than in the Central Sound because of runoff from the major rivers; moreover, after heavy rain these salinities range from 10 to 15 psu. Salinities in the southern section of the Whidbey Basin in Possession Sound are similar to those of the Main Basin.

Yelloweye rockfish, canary rockfish, and bocaccio have been documented in the Whidbey Basin, with most occurrences within the southern portion near south Camano Island, Hat (Gedney) Island, and offshore of the City of Mukilteo (Table 1).

Special management considerations for this basin include commercial and recreational fisheries, scientific research, dredging projects and dredge disposal operations, nearshore development projects, and tidal energy projects. An estimated 3 derelict nets remain in waters deeper than 30.5 m (100 ft) and 3 nets in deeper waters in this basin (NRC 2014). A potential tidal energy site is located within the Deception Pass area, at the northern tip of Whidbey Island. Pollution and runoff are also concerns in this basin, mostly near the Port Gardner area. There are several areas with contaminated sediments along the eastern portion of this basin, particularly near the Cities of Mukilteo and Everett (Appendix B).

Main Basin: The 100 km- (62.14 mile-) long Main Basin is delimited to the north by a line between Point Wilson near Port Townsend and Partridge Point on Whidbey Island, to the south by Tacoma Narrows, and to the east by a line between Possession Point on Whidbey Island and Meadow Point. The sill at the border of Admiralty Inlet and the eastern Straits of Juan de Fuca regulates water exchange of Puget Sound (Burns 1985). The Main Basin is the largest biogeographic basin, holding 60 percent of the water in Puget Sound proper. Water retention is estimated to be 1 month because of the sills at Admiralty Inlet and Deception Pass (Ebbesmeyer et al. 1984).

Approximately 33 percent (707 km (439.3 mi)) of Puget Sound's shoreline occurs within this basin, and nearshore habitats consist of bluff-backed beaches with unconsolidated materials ranging from mud and sand to mixes of gravels and cobbles (Drake et al. 2010). Some of these nearshore areas support the growth of kelp, juvenile canary rockfish and bocaccio settlement to benthic habitats, cover from predation, and rearing. Sub-tidal surface sediments in Admiralty Inlet tend to consist largely of sand and gravel, whereas sediments just south of the inlet and southwest of Whidbey Island are primarily sand. Sediments in the deeper areas of the central portion of the Main Basin generally consist of mud or sandy mud (PSWQA 1987). Possession Point is centrally located within this basin at the southern end of Whidbey Island and has relatively steep eastern, southern, and western edges. It also has some rocky substrates and has relatively consistent aggregations of forage fish (Squire and Smith 1977). There are benthic areas deeper than 30 m (98 ft) along Possession Point, Admiralty Inlet, and the rims of Puget Sound beyond the nearshore that feature sloping bathymetry and areas of high rugosity that support growth, refuge, reproduction, and feeding opportunities.

Yelloweye rockfish, canary rockfish, and bocaccio have been documented at Possession Point, near the port of Kingston and Apple Cove, and along much of the eastern shoreline of this basin (Washington, 1977; Moulton and Miller 1987) (Table 1).

Subsurface temperatures in the Main Basin are usually between 8° and 12°C (46° and 54°F); however, surface temperatures can reach 15°C to 18°C (59° to 64°F) in summer, and temperatures at depth can get as low as 7.5°C (45.5°F) in winter. Salinities in the deeper portions of the Main Basin are generally approximately 30 psu in summer and fall, but decrease to approximately 29 psu during the more rainy months. Surface waters are also usually about 29 psu, but occasionally have salinities as low as 25 to 27 psu during the rainy season (Ecology 1999). This basin has consistently higher temperatures and lower salinity relative to the San Juan Basin (Ecology 1999). Dissolved oxygen levels vary seasonally, with lowest levels of about 5.5 mg/L occurring at depth in summer months, and highest levels of about 7.5 mg/L near the surface. Occasionally, summertime highs reach 13 to 14 mg/L at the surface. Vessel traffic in the this basin is common as cargo ships transit to/from the Strait of Juan de Fuca to the Ports of Seattle and Tacoma and other destinations in the Main Basin and South Puget Sound (Bassett et al. 2012).

Special management considerations for this basin include commercial and recreational fisheries, scientific research, dredging projects and dredge disposal operations, nearshore development projects, and tidal energy projects. An estimated 20 derelict nets in waters shallower than 30.5 m (100 ft), and one in deeper waters remain in this basin (NRC 2014). A planned tidal energy site is located within the Admiralty Inlet area off Whidbey Island. Pollution and runoff are also concerns in this basin because of the extensive amounts of impervious surface. Two open-water dredge disposal sites are located in the basin; one located in Elliot Bay and the other in Commencement Bay. These are non-dispersive disposal sites, which are areas where currents are slow enough that dredged material is deposited on the disposal target area rather than dispersing broadly with prevailing currents (Army Corps of Engineers 2010). An estimated 36 percent of the shoreline in this area has been modified by human activities (Drake et al. 2010) and bulkhead/pier repair projects and new docks/piers are proposed regularly in this basin. There are several areas with contaminated sediments in this basin, particularly in Elliot Bay, Sinclair Inlet, and Commencement Bay (Appendix B).

South Puget Sound: This basin includes all waterways south of Tacoma Narrows. This basin is characterized by numerous islands and shallow (generally <20 m (65 ft)) inlets with extensive shoreline areas. The sill at Tacoma Narrows restricts water exchange between the South Puget Sound and the Main Basin and water retention is an estimated 1.9 months (Ebbesmeyer et al. 1984). This restricted water exchange influences environmental characteristics of the South Puget Sound such as nutrient levels and dissolved oxygen, and perhaps its biotic communities (Ebbesmeyer et al. 1984; Rice 2007). A wide assortment of sediments is found in the nearshore and intertidal areas of this basin

(Bailey et al. 1998). The most common sediments and the percent of the intertidal area they cover are: mud, 38.3 ± 29.3 percent; sand, 21.7 ± 23.9 percent; mixed fine, 22.9 ± 16.1 percent; and gravel, 11.1 ± 4.9 percent. Sub-tidal areas have a similar diversity of surface sediments, with shallower areas consisting of mixtures of mud and sand and deeper areas consisting of mud (PSWQA 1987). Some of the nearshore areas of the South Puget Sound support the growth of kelp and support juvenile canary rockfish and bocaccio settlement, cover from predation, and rearing. The southern inlets of this basin include Oakland Bay, Totten Inlet, Bud Inlet, and Eld Inlet, in addition to the Nisqually River delta. These inlets have relatively muddy habitats that do not support essential nearshore features such as holdfasts for kelp, and rock and cobble areas for rearing juvenile canary rockfish and bocaccio.

Sediments in Tacoma Narrows and Dana Passage consist primarily of gravel and sand. With a mean depth of 37 m (121 ft), this basin is the shallowest of the biogeographic basins (Burns 1985), and benthic areas deeper than 30 m (98 ft) occur in portions of the Tacoma Narrows. The rims of South Puget Sound beyond the nearshore have sloping bathymetry and areas of high rugosity that support growth, refuge, reproduction, and feeding opportunities. The major urban areas, and thus more pollution and runoff into the South Puget Sound, are found in the western portions of Pierce County. Other urban centers in the southern Puget Sound area include Olympia and Shelton.

The major channels of the southern basin are moderately stratified compared to most other greater Puget Sound basins. Salinities generally range from 27 to 29 psu and, although surface temperatures reach 14° to 15°C (57° to 59°F) in summer, the temperatures of subsurface waters generally range from 10° to 13°C (50° to 55°F) in summer and from 8° to 10°C (46° to 50°F) in winter (Ecology 1999). Dissolved oxygen levels generally range from 6.5 to 9.5 mg/L. Salinity in the inlets tends to be similar to those of the major channels, whereas temperatures and dissolved oxygen levels in the inlets are frequently much higher in summer. Two of the larger inlets, Carr and Case, have surface salinities ranging from 28 to 30 psu in the inlet mouths and main bodies, but lower salinities range from 27 to 28 psu at the heads of the inlets (Collias et al. 1974). Summertime surface waters in Budd, Carr, and Case Inlets commonly have temperatures that range from 15° to 19°C (59° to 66°F) and dissolved oxygen values of 10 to 15 mg/L.

Yelloweye rockfish, canary rockfish, and bocaccio have been documented within the South Puget Sound (Table 1). Canary rockfish may have been historically most abundant in the South Puget Sound (Drake et al. 2010).

Special management considerations in this basin include commercial and recreational fisheries, scientific research, dredging and dredge disposal, nearshore development, pollution and runoff, aquaculture operations, and potential tidal energy projects. An estimated 20 derelict nets in waters shallower than 30.5 m (100 ft) and one in deeper waters remain in this basin (NRC 2014). A non-dispersive dredge disposal site is located off Anderson/Ketron Island (Army Corps of Engineers 2010). A potential tidal energy site is located in the Tacoma Narrows area. Important point sources of waste include sewage treatment facilities and about 5 percent of the nutrients (as inorganic nitrogen) entering greater Puget Sound enter this basin through nonpoint sources (Embrey and Inkpen 1998). An estimated 34 percent of the shoreline in this area has been modified by human activities (Drake et al. 2010), and bulkhead/pier repair projects and new docks/piers are proposed regularly in this basin. There are several areas with contaminated sediments in this basin (Appendix B).

Hood Canal: Hood Canal branches off the northwest part of the Main Basin near Admiralty Inlet and is the smallest of the greater Puget Sound basins, being 90 km (55.92 mi) long and 1 to 2 km (0.62 to 1.24 mi) wide (Drake et al. 2010). Water retention is estimated at 9.3 months; exchange in Hood Canal is regulated by a 50-meter (164-foot) deep sill near its entrance that limits the transport of deep marine waters in and out of Hood Canal (Ebbesmeyer et al. 1984; Burns 1985). The major components of this basin consist of the Hood Canal entrance, Dabob Bay, the central basin, and the Great Bend at the southern end. A combination of relatively little freshwater inflow, the sill at Admiralty Inlet, and bathymetry lead to relatively slow currents; thus, water residence time within Hood Canal is the longest of the biogeographic basins, with net surface flow generally northward (Ebbesmeyer et al. 1984). The intertidal and nearshore zone consists mostly of mud (53.4 ± 89.3 percent of the intertidal area), with similar amounts of mixed fine sediment and sand (18.0 ± 18.5 percent and 16.7 ± 13.7 percent, respectively) (Bailey et al. 1998). Some of the nearshore areas of Hood Canal support the growth of kelp and have cobble and gravel substrates intermixed with sand that support juvenile canary rockfish and bocaccio settlement, cover from predation, and rearing. Surface sediments in the sub-tidal areas also consist primarily of mud and cobbles (PSWQA 1987). The shallow areas of the Great Bend, Dabob Bay, and the Hamma Hamma, Quilcene, Duckabush, Dosewallips, Tahuya, and Skokomish River deltas feature relatively muddy habitats that do not support essential nearshore features such as holdfasts for kelp, and rock and cobble areas for rearing juvenile canary rockfish and bocaccio. Benthic areas deeper than 30 m (98 ft) occur along the rim of nearly all of Hood Canal, and these areas have sloping and steep bathymetry and areas of high rugosity that support growth, refuge, reproduction, and feeding opportunities.

Portions of Hood Canal are stratified, with marked differences in temperature and dissolved oxygen between the entrance and the Great Bend. Water temperature, salinity, and concentration of dissolved oxygen in Hood Canal are routinely measured by Ecology at two sites—near the Great Bend and near the entrance (Ecology 1999). Salinities generally range from 29 to 31 psu and tend to be similar at both sites. In contrast, temperature and dissolved oxygen values are often markedly different between the two sites.

Bocaccio have been documented in Hood Canal (Table 1). Yelloweye and canary rockfish have been documented at several locations (Table 1) and have been caught in relatively low numbers for the past several years (WDFW 2011).

Special management considerations in Hood Canal include commercial and recreational fisheries, scientific research, nearshore development, non-indigenous species management, and pollution and runoff. An estimated three derelict nets in waters shallower than 30.5 m (100 ft) and two in deeper waters remain in this basin (NRC 2014). The unique bathymetry and low water exchange have led to episodic periods of low dissolved oxygen (Newton et al. 2007), though the relative role of nutrient input from humans in exacerbating these periods of hypoxia is in doubt (Cope and Roberts 2012). Dissolved oxygen levels have decreased to levels that cause behavioral changes and kill some rockfish (i.e., below 1.0 mg/L (1 ppm)) (Palsson et al. 2008). An estimated 34 percent of the shoreline in this area has been modified by human activities (Drake et al. 2010), and bulkhead/pier repairs and new docks/piers are regularly proposed in this basin. The non-indigenous tunicate (*Ciona savignyi*) has been documented at 86 percent of sites surveyed in Hood Canal (Drake et al. 2010)

UNOCCUPIED AREAS

Section 3(5)(A)(ii) of the ESA authorizes the designation of "specific areas outside the geographical area occupied at the time [the species] is listed" if these areas are essential for the conservation of the species. Regulations at 50 CFR 424.12(e) emphasize that the agency "shall designate as critical habitat areas outside the geographical area presently occupied by a species only when a designation limited to its present range would be inadequate to ensure the conservation of the species." We have not identified any unoccupied areas as critical habitat for yelloweye rockfish, canary rockfish, or bocaccio.

EVALUATION OF THE CONSERVATION VALUE OF THE SPECIFIC AREAS

In some previous critical habitat designations (e.g., Pacific salmon, [70 Fed. Reg. 52630, September 2, 2005] and green sturgeon [74 Fed. Reg. 52300, October 9, 2009]), we evaluated the conservation value of specific areas to help inform the designation of critical habitat. Assessing the conservation value of specific areas involves evaluating the quantity and quality of habitat features, the relationship of the area to other areas within the range of the DPSs, and the significance to the DPSs of the population occupying that area.

To evaluate the quantity and quality of features of the specific areas, we considered existing information on the habitat characteristics of each basin, the amount of habitat available, and available data for yelloweye rockfish, canary rockfish, and bocaccio. Though the available data on benthic habitats and yelloweye rockfish, canary rockfish, and bocaccio habitat use is uneven across Puget Sound, each basin of the DPSs features diverse habitats, biological communities, and is relatively spatially isolated in terms of water circulation and exchange of some biota. These factors suggest that all of the populations and basins are important in maintaining the diversity and spatial structure of each DPS. For the above reasons, we conclude that all of the specific areas have a high conservation value at this time.

Synthesis

To be eligible for designation as critical habitat under the ESA, each specific area within the geographic area that is occupied must contain at least one physical or biological feature that may require special management considerations or protection. As described above, the presence of yelloweye rockfish, canary rockfish, and bocaccio has been documented in each basin of the U.S portion of the Puget Sound/Georgia Basin. Each basin contains specific areas with identified essential features for adult and juvenile yelloweye rockfish, canary rockfish, and bocaccio. Each specific area occurs within the five biogeographic basins that encompass the DPSs. For each specific area, we verified that the essential features may require special management considerations or protection by identifying and documenting the potentially habitat-altering activities occurring in each specific area (refer to Table 3).

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Appendix A

Yelloweye Rockfish, Canary Rockfish, and Bocaccio

General Biology

(Patterned after Drake et al., 2010)

YELLOWEYE ROCKFISH GENERAL BIOLOGY

Geographical Distribution and Habitat

Yelloweye rockfish range along the U.S. and Canadian west coast, with individuals recorded from the Aleutian Islands to northern Baja California. The major portion of abundance is found from Alaska to central California (Love et al. 2002). Yelloweye rockfish use a broad depth range throughout their life history, with individuals recorded from 15 to 549 meters (m) (49 to 1,801 ft). Juveniles settle in the shallowest depth of this range and move deeper as they get older. Adults are most commonly found from 91 to 180 m (298 to 590 ft) (Love et al. 2002).

Yelloweye rockfish juveniles settle primarily in shallow, high-relief zones, crevices, and sponge gardens (Love et al. 1991; Richards et al. 1985) with only a few documented occurrences in waters shallower than 30 m (98 ft) in Puget Sound (Palsson et al. 2009). As they grow and move to deeper waters, adults continue to associate with rocky, high-relief areas (Richards 1986; Love et al. 1991; O'Connell and Carlisle 1993; Wang 2005). Submersible dives document the high affiliation yelloweye rockfish adults have to caves and crevices while spending large amounts of time lying at the base of rocky pinnacles and boulder fields (Richards 1986; Yoklavich et al. 2000). Documentation of yelloweye and other rockfish associations with deepwater corals demonstrated an association of some rockfishes to these habitats (Andrews et al. 2002; Krieger and Wing 2002). Yelloweye rockfish have also been documented in areas with mud and mud/cobble habitats (Richards 1986; Stein et al. 1992; Yoklavich et al. 2000; Wang 2005) and have been observed near large and isolated boulders in areas of flat and muddy bottoms (O'Connell and Carlile 1993). Yelloweye rockfish are infrequently found in aggregations, but are generally thought to be relatively solitary, demersal residents (Coombs 1979; DeMott 1983; Love et al. 2002).

Reproduction

Yelloweye rockfish are internally fertilized and store sperm for several months until fertilization occurs, commonly between September and April, though fertilized individuals may be found in most months of the year, depending on where they are observed (Wyllie-Echeverria 1987). Fertilization periods tend to get later from south to north in their range (Hitz 1962; DeLacy et al. 1964; Westrheim 1975; O'Connell 1987; Lea et al. 1999). Larvae are extruded after a typical gestation period of several months, peaking from April to August for California and extending to later months in Alaska (O'Connell 1987). In Puget Sound, yelloweye rockfish may fertilize eggs during the winter to summer months, giving birth in early spring to late summer (Washington et al. 1978).

Though yelloweye rockfish are generally thought to spawn once a year (MacGregor 1970), a study in Puget Sound offered evidence of at least two spawning periods per year (Washington et al. 1978). Larvae are extruded at about 4 to 5 millimeters (mm) (0.16 to 0.20 inches (in)) (DeLacy et al. 1964; Matarese et al. 1989) and remain pelagic for up to 2 months (Moser 1996a), settling at around 25 mm (Love et al. 2002). Female yelloweye rockfish can produce from 1.2 million to 2.7 million eggs over a reproductive season, with a mean eggs per gram of body weight of 300 (MacGregor 1970; Hart 1973). Reports on maturity for yelloweye rockfish vary among areas and are ambiguous, given the use of whole otoliths for aging in some studies, but generally seem to reach 50 percent maturity at around 40 to 50 cm (15.8 to 19.7 in) and ages of 15 to 20 years (Rosenthal et al. 1982; Wyllie-Echeverria 1987; Yamanaka and Kronlund 1997).

Growth and Development

Yelloweye rockfish have the potential to grow large during their long life spans. Mean asymptotic size in Alaska is documented at 69 cm (27 in) for males and females (Rosenthal et al. 1982). A study in British Columbia (Westrheim and Harling 1975) estimated this parameter at 67.6 and 65.9 cm (26.6 and 26 in) for males and females, respectively (Yamanaka et al. 2006). A study in California also noted males obtaining a mean size greater than females (Lea et al. 1999). Maximum size is reported as 91 cm (35.8 in) (Love et al. 2005) and maximum age as 118 years (Munk 2001). Natural mortality rates are estimated at 2 to 4.6 percent annually (Yamanaka and Kronlund 1997; Wallace 2007).

Migrations and Movements

An inshore to offshore ontogenetic movement of yelloweye rockfish is documented, with juveniles moving from shallow rock reefs to deeper pinnacles and rocky habitats. Yelloweye rockfish adults do not move extensively and are generally considered to be site-attached (Love 1978; Coombs 1979; DeMott 1983).

Trophic Interactions

Yelloweye rockfish are opportunistic feeders, targeting different food sources during different phases of their life history. Early life stages follow typical rockfish predator-prey relationships. Because adult yelloweye rockfish obtain such large size, they can handle much larger prey, including smaller yelloweye, and are preyed upon less frequently (Rosenthal et al. 1982), though predation by killer whales (*Orcinus orca*) has been reported (Ford et al. 1998). Typical prey of adult yelloweye rockfish include sand lance (*Ammodytes* spp.), gadids, flatfishes, shrimp, crabs, and gastropods (Love et al. 2002; Yamanaka et al. 2006).

CANARY ROCKFISH GENERAL BIOLOGY

Geographical Distribution and Habitat

Canary rockfish are found from the western Gulf of Alaska to northern Baja California, but are most abundant from British Columbia to central California (Miller and Lea 1972; Hart 1973; Cailliet et al. 2000; Love et al. 2002). Adults are most common from 80 to 200 m (272 to 656 ft) but have been found as deep as 439 m (1,440 ft) (Love et al. 2002). Juveniles are found in intertidal surface waters, and occasionally as deep as 838 m (2,749 ft) (Love et al. 2002). Larger fish tend to inhabit deeper waters with the mean size increasing in the 55 to 90 m (180 to 295 ft) depth range (Methot and Stewart 2005). Adults inhabit shallower areas in the north than in the south parts of their range.

The larvae and pelagic juveniles of canary rockfish are found in the upper 100 m (328 ft) of the water column (Love et al. 2002). Estimates of larval duration range from 1 to 2 months (Moser 1996) to 3 to 4 months (Krigsman 2000; Love et al. 2002) after which they settle to tide pools, rocky reefs, kelp beds, low rock, and cobble areas (Miller and Geibel 1973; Love et al. 1991; Cailliet et al. 2000; Love et al. 2002). Juveniles may occur in groups near the rock-sand interface in the 15- to 20-m (49- to 65-ft) depth range during the day, then move into sandy areas at night (Love et al. 2002). Juveniles remain on rocky reefs in shallower areas for as much as 3 years before moving to deeper waters (Boehlert 1980; Methot and Stewart 2005). Fish move deeper as they increase in size (Vetter and Lynn 1997) and adults are commonly found on rocky shelves and pinnacles (Phillips 1960; Rosenthal et al. 1988; Starr 1998; Cailliet et al. 2000; Johnson et al. 2003; Tissot et al. 2007). They are generally seen near but not resting on the bottom. Canary rockfish were once considered fairly common in the greater Puget Sound area (Holmberg et al. 1967). Wang (2005) documented canary rockfish most frequently near boulders, but also found fish near benthic habitats consisting of sand, mud, and pebble mixtures.

Reproduction

Off northern and central California, estimates for age at first maturity are 3 to 4 years and 18 to 28 cm (7 to 11 in) (Wyllie-Echeverria 1987; Lea et al. 1999) with 50 percent of males mature by 7 years and 40 cm (15.8 in) and all mature by 9 years and 45 cm (17.5 in). Females attain first maturity at 4 years and 27 cm (10.5 in). Fifty percent of females are mature by 9 years and 44 cm (17 in) and all attain maturity by 13 years and 54 cm (21 in) (Wyllie-Echeverria 1987). Off Oregon, the majority of females and males are mature at 7 to 9 years and 35 to 45 cm (14 to 17.5 in) in length and 7 to 12 years and 41 cm in length (16 in), respectively. In waters off Vancouver Island, 50 percent of females are mature at 41 cm (16 in) and males at 48 cm (19 in) (Westrheim 1975).

Females produce between 260,000 and 1.9 million eggs per year with larger females producing more eggs. On the coast, the relationship between egg production and female size does not seem to vary geographically (Gunderson et al. 1980; Love et al. 2002).

Fertilization occurs as early as September off central California (Lea et al. 1999), peaking in December (Phillips 1960; Wyllie-Echeverria 1987). Parturition occurs between January and April and peaks in April (Phillips 1960). Off Oregon and Washington, parturition occurs between September and March with peaks in December and January (Wyllie-Echeverria 1987). In British Columbia, parturition occurs slightly later with the peak in February (Hart 1973; Westrheim and Harling 1975). Canary rockfish spawn once per year (Guillemot et al. 1985).

Growth and Development

Eggs are 0.84 to 1.45 mm (0.03 to 0.06 in) in diameter (Waldron 1968). Larvae measure 3.6 to 4.0 mm (0.14 to 0.16 in) at birth (Waldron 1968; Richardson and Laroche 1979). Estimates of larval duration range from 1 to 2 months (Moser 1996) to 3 to 4 months (Krigsman 2000; Love et al. 2002). Juveniles settle at approximately 18.5 mm (0.73 in) (Richardson and Laroche 1979; Moser 1996a).

Females grow larger and more quickly than males (Lenarz and Echeverria 1991), although growth does not appear to vary with latitude (Boehlert and Kappenman 1980). A 58 cm (23 in) female is approximately 20 years of age; a male of the same age is approximately 53 cm (20 in). The maximum age of canary rockfish is at least 84 years, although 60 to75 years is more common (Cailliet et al. 2000). The maximum reported length is 76 cm (30 in) (Williams et al. 1999; Love et al. 2002; Methot and Stewart 2005).

Migrations and Movements

Canary rockfish tend to move to deeper water as they grow larger (Vetter and Lynn 1997). In terms of alongshore movements, they are transient (DeMott 1983; Casillas et al. 1998) and resident (Gascon and Miller 1981). DeMott (1983) tagged 348 fish off Oregon between 1978 and 1982. Of the 23 recaptures, 12 fish moved more than 100 km (62 miles) north or south with one fish moving as much as 236 km (146 miles). Other tagging studies have shown that some individuals move up to 700 km (435 miles) over several years (Lea et al. 1999; Love et al. 2002). They also appear to make a seasonal migration of 160 to 210 m (524 to 688 ft) in the late winter to 100 to 170 m (328 to 577 ft) in the late summer.

Trophic Interactions

Canary rockfish larvae are planktivores and feed primarily on nauplii and other invertebrate eggs and copepods (Moser and Boehlert 1991; Love et al. 2002). Juveniles are zooplanktivores, feeding on crustaceans (e.g., harpacticoids), barnacle cyprids, and euphasiid eggs and larvae. They also consume juvenile polychaetes (Gaines and Roughgarden 1987; Love et al. 1991) and are diurnal feeders (Singer 1982). Predators on juvenile canary rockfish include other fishes, especially rockfishes, lingcod (*Ophiodon elongatus*), cabezon (*Scorpaenichthys marmoratus*), and salmon (*Oncorhynchus* spp.), as well as birds and porpoises (Miller and Geibel 1973; Morejohn et al. 1978; Roberts 1979; Ainley et al. 1981; Love et al. 1991).

Adult canary rockfish are planktivores and carnivores consuming euphasiids and other crustaceans, small fishes such as shortbelly rockfish (*Sebastes jordani*), and myctophids and stomiatiods (Cailliet et al. 2000; Love et al. 2002). Canary rockfish predators include yelloweye rockfish, lingcod, salmon, sharks, dolphins, seals (Merkel 1957; Morejohn et al. 1978; Antonelis and Fiscus 1980; Rosenthal et al. 1982), and possibly river otters (*Lontra canadensis*) (Stevens and Miller 1983).

BOCACCIO GENERAL BIOLOGY

Geographical Distribution and Habitat

Bocaccio are found from Stepovac Bay on the Alaska Peninsula to Punta Blanca in central Baja California. They are most common from Oregon to California and were once common on steep walls in Puget Sound (Love et al. 2002). Genetic analyses suggest that there may be three general population regions of bocaccio along the west coast: a Queen Charlotte Island population, one from Vancouver Island to Point Conception, and a third south of Point Conception (Matala et al. 2004), though recent genetic analysis found little evidence of population substructure by geography or year class (Bounaccorsi et al. 2012).

Larvae and pelagic juveniles tend to be found close to the surface, occasionally associated with drifting kelp mats (Love et al. 2002). They have been found as far as 480 km (149 miles) offshore. Juveniles settle to shallow, algae-covered rocky areas or to eelgrass (*Zostera marina*) and sand (Love et al. 1991). Several weeks after settlement, fish move to deeper waters in the 18 to 30 m (59 to 98 ft) range where they are found on rocky reefs (Feder et al. 1974; Carr 1983; Johnson 2006; Love and Yoklavich 2008). Adults inhabit waters from 12 to 478 m (39 to 1,600 ft) but are most common at depths of 50 to 250 m (164 to 820 ft) (Feder et al. 1974; Love et al. 2002). Adults are also commonly found around oil platforms in central and southern California (Love et al. 2005), and occur in deeper waters to the south than in the north (Love et al. 2002). While generally associated with hard substrata, adults do occupy mud flats, particularly those near structure such as boulders and crevices (Yoklavich et al. 2000; Anderson and Yoklavich 2007). They are also typically found well off the bottom by as much as 30 m (98 ft) (Love et al. 2002).

Reproduction

In northern and central California waters, age at first maturity is 3 years for males and females, although at 32 cm (12 in) males are somewhat smaller than females at 36 cm (14 in). Fifty percent of males are mature by age 3 at 42 cm (16.5 in), and all are mature by 7 years and 55 cm (21.5 in). Fifty percent of females are mature by their fourth year at 48 cm (19 in), and all are mature by age 8 and 60 cm (23.6 in) (Wyllie-Echeverria 1987). Off southern California, 50 percent of males are mature at 35 cm (13.5 in) and all are reproductive at 42 cm (16.5 in). Fifty percent of females are mature at 36 cm (14.5 in) and all are reproductive at 44 cm (17.5 in). Off Oregon, bocaccio mature at larger sizes with females beginning to mature at 54 cm (21 in) and all mature by 61 cm (24 in) (Love et al. 2002). There is some evidence that fish may have begun to mature at earlier ages as population size had declined dramatically (MacCall 2002).

Bocaccio are fecund with females producing between 20,000 and 2.3 million eggs annually (Love et al. 2002). Copulation and fertilization occurs in the fall generally between August and November (Love et al. 2002). Females release larvae between November and May off northern and central California with a peak in February. In Southern California, parturition occurs between October and March but peaks in January. Off Washington and Oregon, larval release begins in January and runs through April and February, respectively (Lyubimova 1965; Moser 1967; Westrheim 1975; Wyllie-Echeverria 1987; Love et al. 2002).

Growth and Development

Larvae are 4.0 to 5.0 mm (0.16 to 0.2 in) long at release. They transform into pelagic juveniles at 1.5 to 3.0 cm (0.6 to 1.2 in) (Moser 1967; Matarese et al. 1989; Love et al. 2002). Most bocaccio remain pelagic for 3.5 months before settling to shallow areas, although some may remain pelagic as long as 5.5 months. Juveniles are typically 3.0 to 4.0 cm (1.2 to 1.6 in) in length at settlement, although in central California larvae may settle as small as 1.9 cm (0.6 in). Pelagic juveniles grow quickly at 0.56 to 0.97 mm (0.2 to 0.4 in) per day (Love et al. 2002). Females grow more quickly and attain larger sizes than males (MacCall 2003). Maximum size recorded is 91 cm (36 in) and 6.8 kg (15 pounds)

(Love et al. 2002). Though they are difficult to age, the maximum age is estimated at 54 years (Ralston and Ianelli 1998).

Migrations and Movements

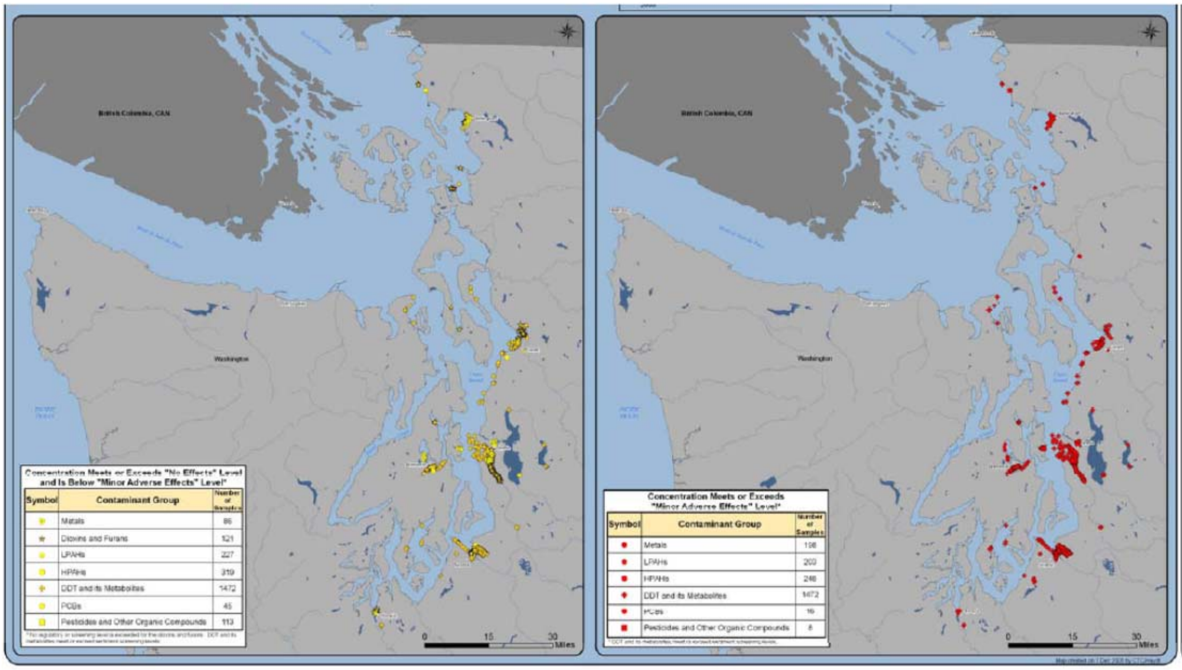
Juvenile bocaccio move to deeper water as they age. Tagging studies have recaptured juveniles between 0.9 and 148 km (0.6 and 92 mi) from their tagging location after 2 years (Hartmann 1987). In the same study, adults were recaptured at their tagging location as much as 827 days later. Acoustic tagging work has shown more complex behavior at more local scales. Approximately half of adult bocaccio stayed within areas of approximately 200 to 400 ha (494 to 988 acres) the majority of the time, although they made frequent small movements out of these home ranges, with some fish utilizing the entire 12 square km (7.4 square mile) study area as well as disappearing from the acoustic array for periods of time before returning. Some individuals remained at fairly constant depths while others changed depth by as much as 100 m (328 ft), generally moving to more shallow depths during the day (Starr et al. 2002).

Trophic Interactions

Bocaccio larvae are planktivores, feeding on larval krill, diatoms, and dinoflagellates. Pelagic juveniles are opportunistic feeders, taking fish larvae, copepods, krill, and other prey. Larger juveniles and adults are primarily piscivores, eating other rockfishes, hake (*Merluccius productus*), sablefish (*Anoplopoma fimbria*), anchovies (*Engraulis mordax*), lanternfishes, and squid (Love et al. 2002). Chinook salmon (*Oncorhynchus tshawytscha*), terns, and harbor seals (*Phoca vitulina*) are known predators on smaller bocaccio (Love et al. 2002).

Appendix B

Contaminated Sediments in Puget Sound



This figure depicts locations where contaminated sediments in Puget Sound meet or exceed "Minor Adverse Effects" levels. For the Southern Resident Killer Whale Recovery Plan and critical habitat designation, we analyzed sediment data from several sources to identify locations within inland habitat of killer whales where sediment samples have been analyzed for contaminants of interest. This information was analyzed further to identify locations where sediment sample analysis indicated that elevated levels of these contaminants were detected. We identified sampling locations where these contaminants were detected at concentrations that meet or exceed the "No Effects" and "Minor Adverse Effects" levels of the Washington State Sediment Quality January 2008 II-99 NMFS Standards (WAC 173-204). For some contaminants, no Washington State Sediment Quality Standards (WAC 173-204) exist. In some instances, we used screening levels developed by the Army Corps of Engineers for these compounds in sediment to identify locations of interest . In other instances, no sediment criteria or screening level existed. In these cases, we identified locations where these contaminants had been detected in sediment samples. We integrated the marine sediment quality data from these sources into a geodatabase to create maps. In some instances, the data from these datasets were excluded from subsequent analysis because no sampling location information was available (e.g., latitude and longitude), the data did not address sediment samples or contaminants of interest, or the data could not be integrated readily into the geodatabase.

Appendix C

Geographic Information Systems Methods

We modified our final critical habitat designation by incorporating information submitted during the public comment period on the proposed designation and using newly available data and GIS tools. We used updated gridded depth data at 30 m (98 ft) bathymetry coalesced by the Nature Conservancy. This new bathymetry grid provided a more accurate representation of the seafloor than that used in our proposed designation because it included updated surveys conducted in the San Juan area (Greene and Aschoff 2013). We used ArcGIS version 10.2, Spatial Analyst (an extension to ArcGIS), and the BTM (Wright et al. 2012) to assist in identifying important benthic habitats deeper than 30 m (98 ft) used by yelloweye rockfish, canary rockfish, and bocaccio in Puget Sound. The gridded depth data was the input to the BTM. The BTM classifies benthic terrain in several categories that include flats, depressions, crests, shelves, and slopes. The BTM does not identify the benthic substrate type. The BTM also generates “rugosity” (terrain complexity or bumpiness) values for the seafloor which is the ratio of surface area to planar area (Kvitek et al. 2003; Dunn and Halpin 2009). Rugosity was generated from running the terrain Vector Ruggedness Measure (VRM) script. This VRM was originally created by Mark Sappington, and was adapted for ArcGIS version 10.1 by the Massachusetts Office of Coastal Zone Management (Sappington et al. 2007). The VRM quantifies terrain ruggedness by measuring the dispersion of vectors orthogonal to the terrain surface. The VRM values are both low in flat areas and in steep areas, but values are high in areas that are both steep and rugged. VRM is thus able to differentiate smooth, steep topography from topography that is irregular and varied in gradient and aspect (Sappington et al. 2007). Rugosity values were developed using a neighborhood analysis with a 3-grid cell by 3-grid cell neighborhood. We binned the rugosity values into two groups using the geometric interval method (Price 2011). This method results in groups of classes in a geometric series by each class being multiplied by a constant coefficient to produce the next higher class. We refer to benthic areas with rugosity values of 0.001703 or higher as “high rugosity.” All areas of high rugosity (deeper than 30 m (98 ft)) served as anchor points for critical habitat for each species.

We also designated some habitat between and adjacent to high rugosity by using several generalization geoprocessing tools. The high rugosity polygons were the initial input data set to the following procedures: 1) the Smooth Polygon Tool was used with the Polynomial Approximation with Exponential Kernel smoothing algorithm with a 600-m (1,968.5-ft) tolerance; 2) a 200-m (656-ft) buffer was run on results from Step 1; 3) the Aggregate Polygons tool was run on results of Step 2 using an aggregation distance of 600 m (1,968.5 ft); and 4) small resultant non-adult critical habitat polygons that were 0.65 square km (0.25 square mi) in area or less in waters deeper than 30 m (98 ft) and having low rugosity were incorporated into surrounding “deepwater” critical habitat. Isolated polygons representing depths deeper than 30 m (98 ft) that were smaller than 0.65 square km (0.25 square mi) in area and were entirely surrounded by only nearshore critical habitat were incorporated into nearshore critical habitat making those areas more cohesive.

There were 7.5 square km (2.9 square mi) of rocky habitat in the San Juan area that was not determined to be high rugosity by the BTM. We designated these rocky areas as critical habitat. This mapped rocky habitat was incorporated as critical habitat by either: 1) incorporating mapped rock into immediately adjacent high rugosity areas, or 2) a 200-m (656-ft) buffer was run on those rocky areas that were not adjacent to high rugosity habitats.

We selected a rugosity value of 0.001703 and higher, in conjunction with the four steps described above, because the spatial area mapped as critical habitat encompassed the vast majority of the documented occurrences with precise spatial data of yelloweye rockfish, canary rockfish, and bocaccio within the DPSs as well as the known attributes of habitat use and life history summarized in Appendix A. In addition, the spatial area mapped, including areas adjacent to high rugosity, accounts for the movement of individual fish as they grow and move as adults. We further assessed the locations where yelloweye rockfish, canary rockfish, and bocaccio had been documented outside of areas of high rugosity. For locations that had reliable and precise locations, we incorporated these sites as critical habitat by creating a 200-m (656-ft) buffer on the site, which was subject to an aggregation step if it was within 600 m (1,968.5 ft) of adjacent critical habitat.

These GIS steps resulted in the designation of some habitats adjacent to benthic habitat with high rugosity. The designation of these areas next to highly rugose habitats is supported by our understandings of the life history of yelloweye rockfish, canary rockfish, and bocaccio, including movement of adult fish and ontogenic movement. As described in the Life History, Distribution, and Status section above, yelloweye rockfish, canary rockfish, and bocaccio have each been documented occupying habitats that are not highly rugose, though typically at lower densities than areas with high rugosity.

As previously stated, listed rockfishes also display ontogenetic movement as they grow, and thus can use a variety of habitat types, such as those with and without high rugosity, as they mature. Similarly, some adult canary rockfish and bocaccio have been documented to move long distances, indicating these two species occupy habitats not immediately adjacent to the seafloor with high rugosity. As such, the aggregation of benthic habitats within 600 m (1,968.5 ft) of high rugosity include habitat area important for yelloweye rockfish, canary rockfish, and bocaccio.

Appendix D

Maps of Rockfish Critical Habitat

List of Maps

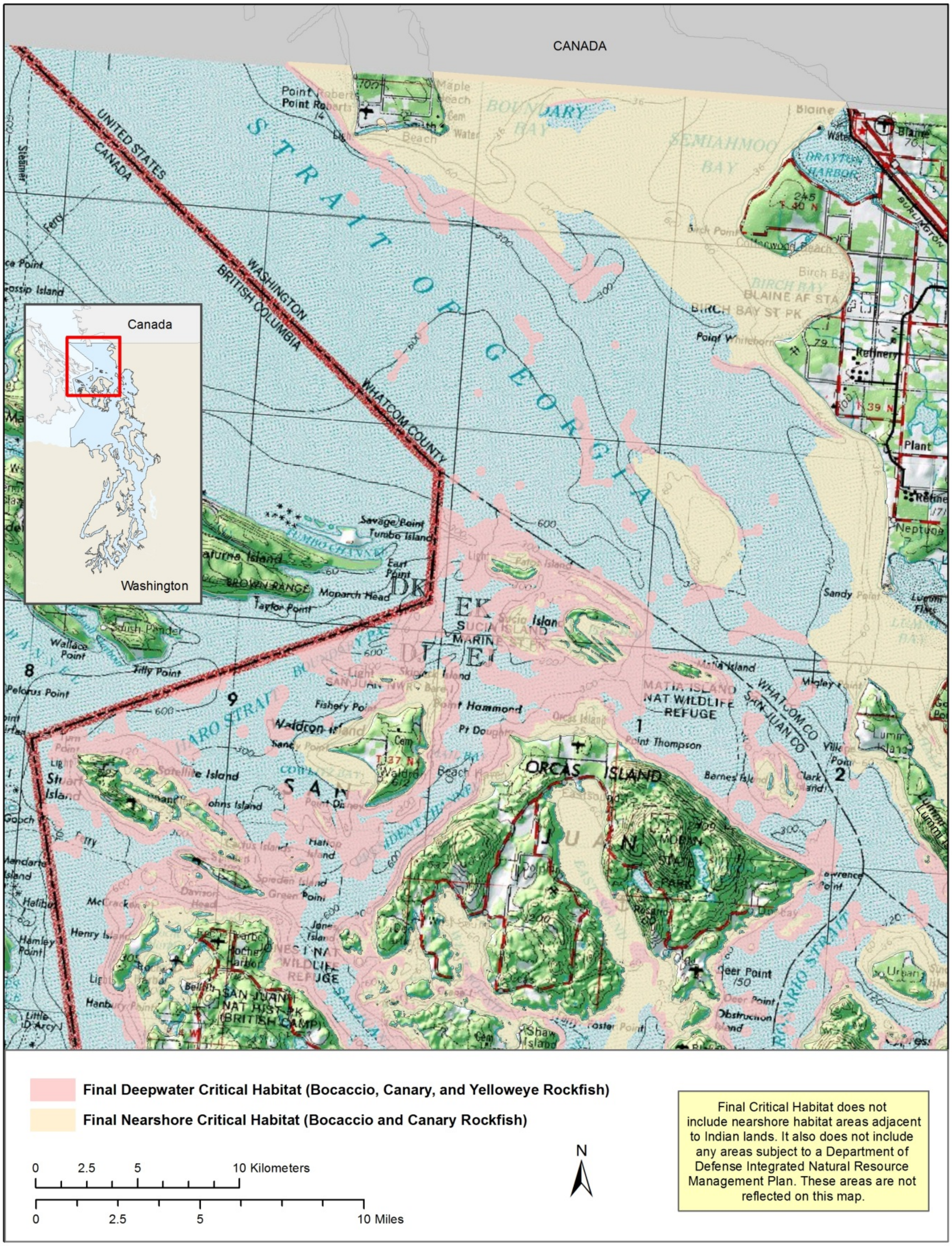


Figure 1A. Critical habitat for yelloweye rockfish, canary rockfish, and bocaccio in the northern San Juan/Strait of Juan de Fuca Basin.

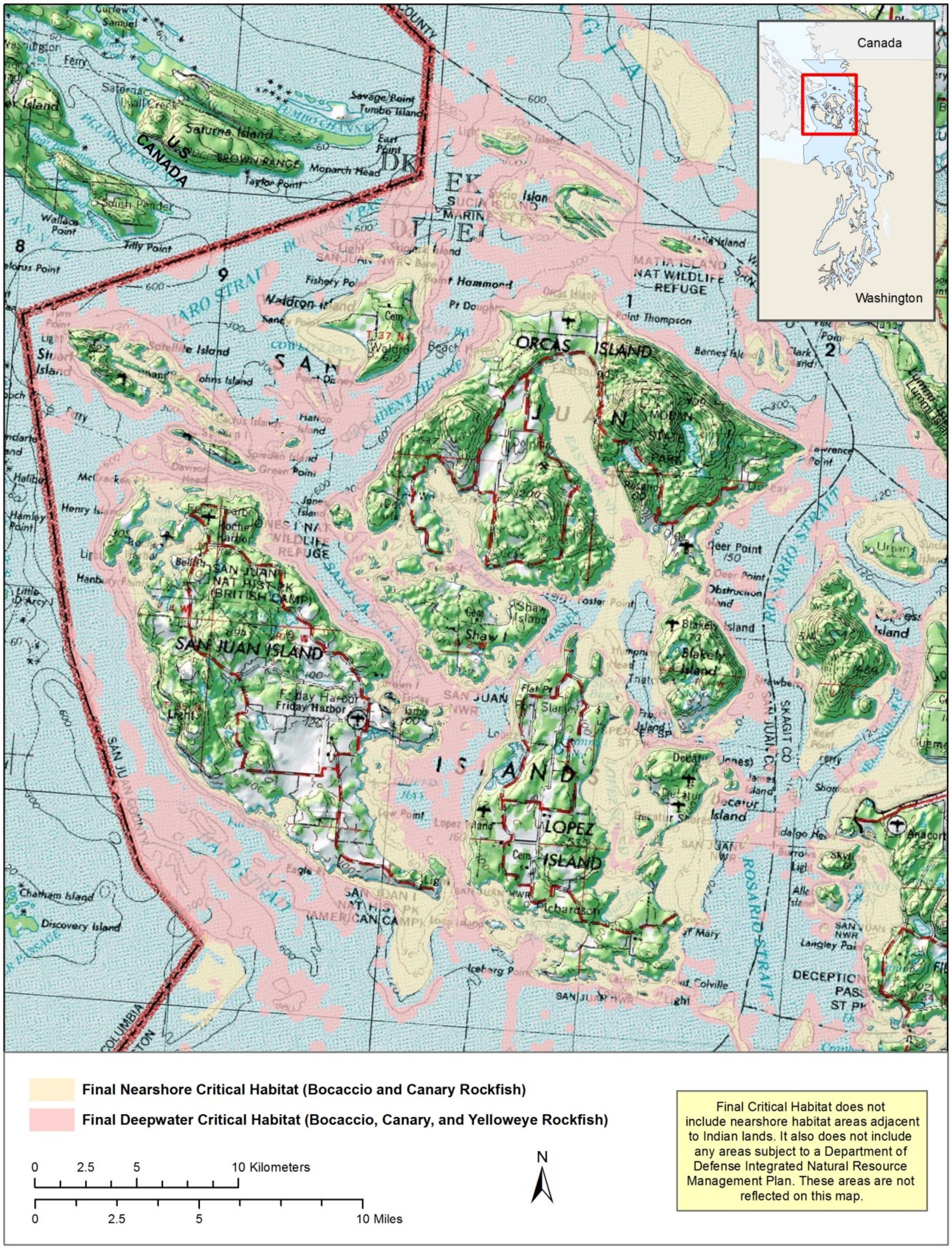


Figure 2A. Critical habitat for yelloweye rockfish, canary rockfish, and bocaccio in the central San Juan/Strait of Juan de Fuca Basin.

Figure 3A. Critical habitat for yelloweye rockfish, canary rockfish, and bocaccio in the southern San Juan/Strait of Juan de Fuca Basin.

Figure 4A. Critical habitat for yelloweye rockfish, canary rockfish, and bocaccio in the Whidbey Basin and northern Main Basin.

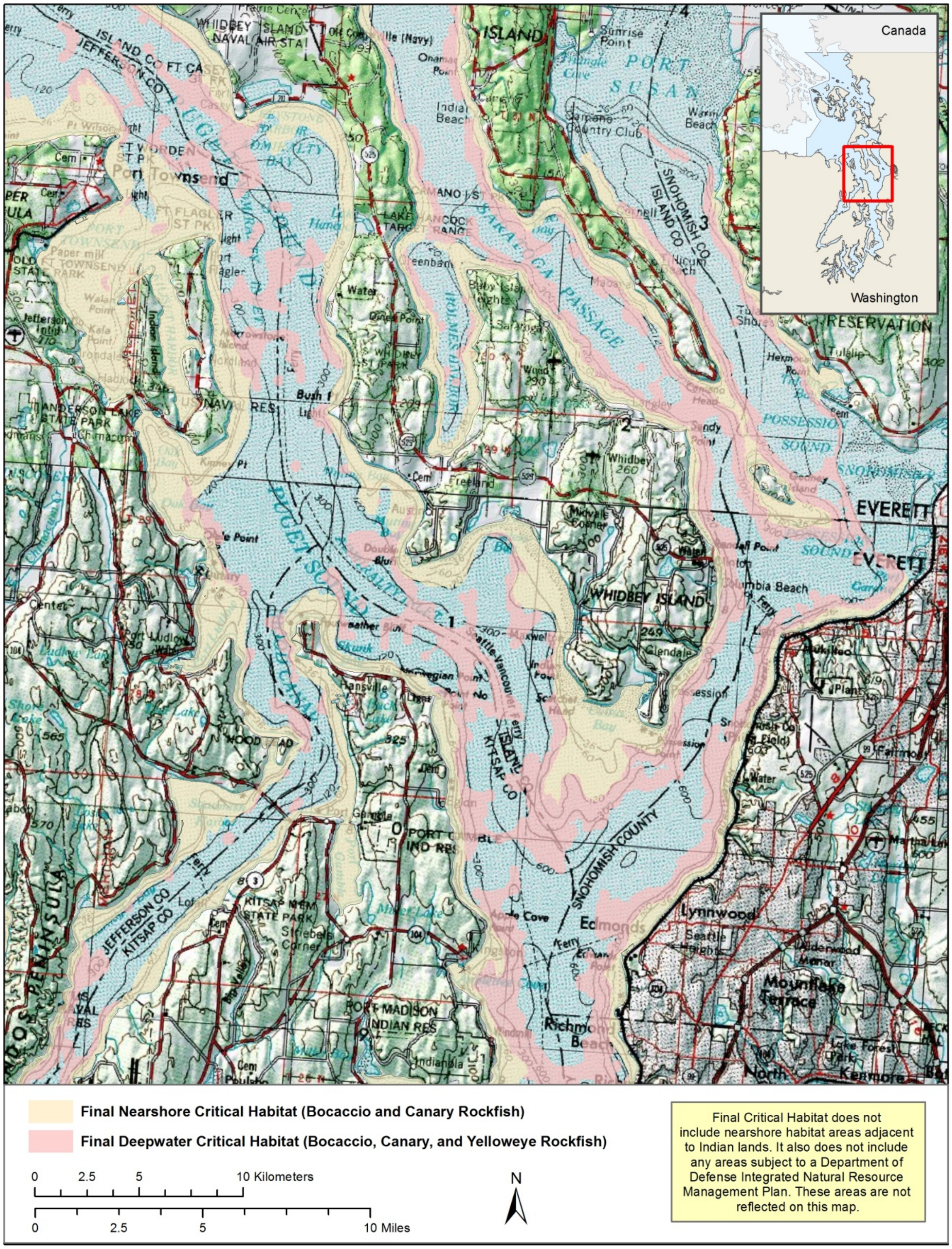


Figure 5A. Critical habitat for yelloweye rockfish, canary rockfish, and bocaccio in the Main Basin and Whidbey Basin.

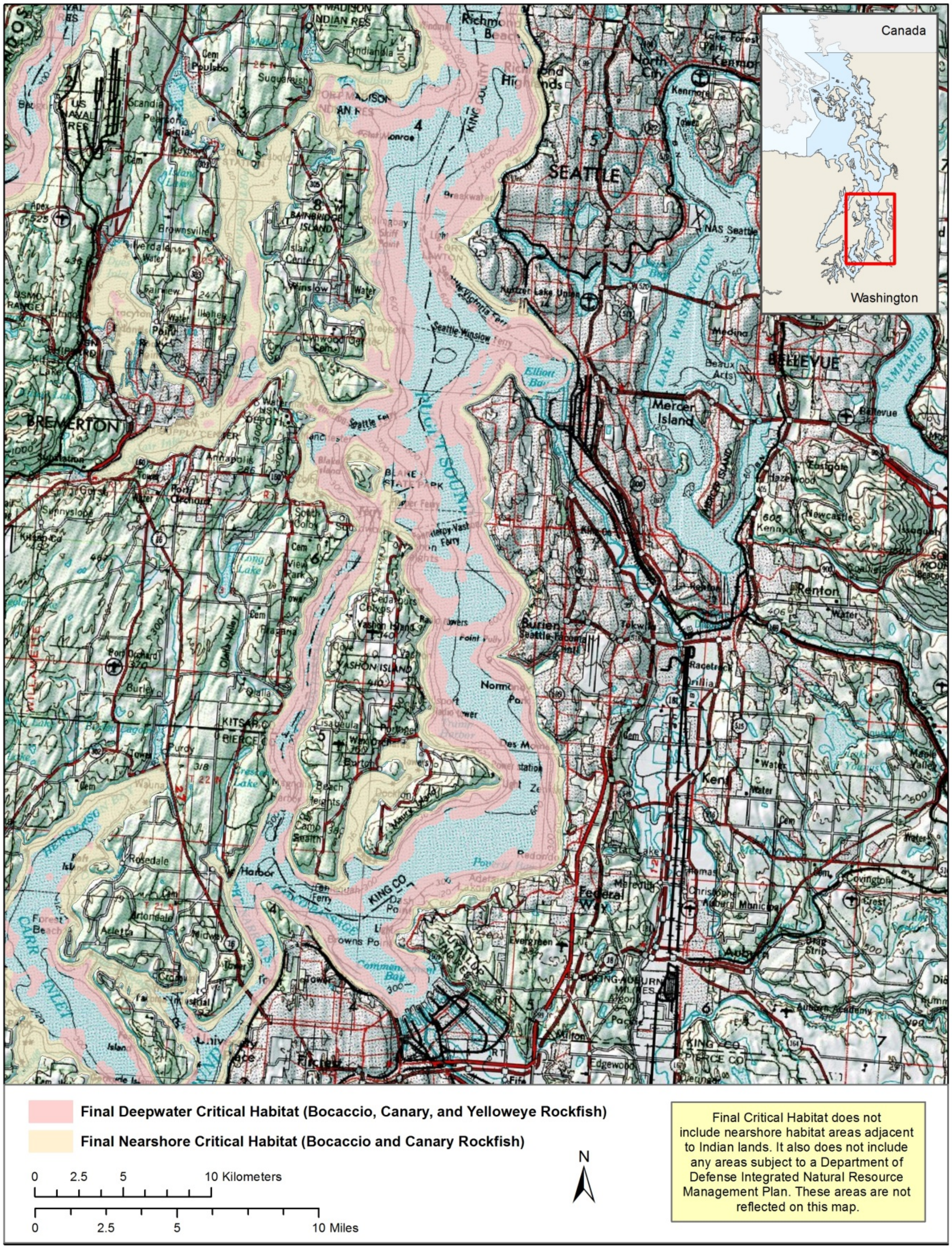


Figure 6A. Critical habitat for yelloweye rockfish, canary rockfish, and bocaccio in the Main Basin and northern portion of South Puget Sound.

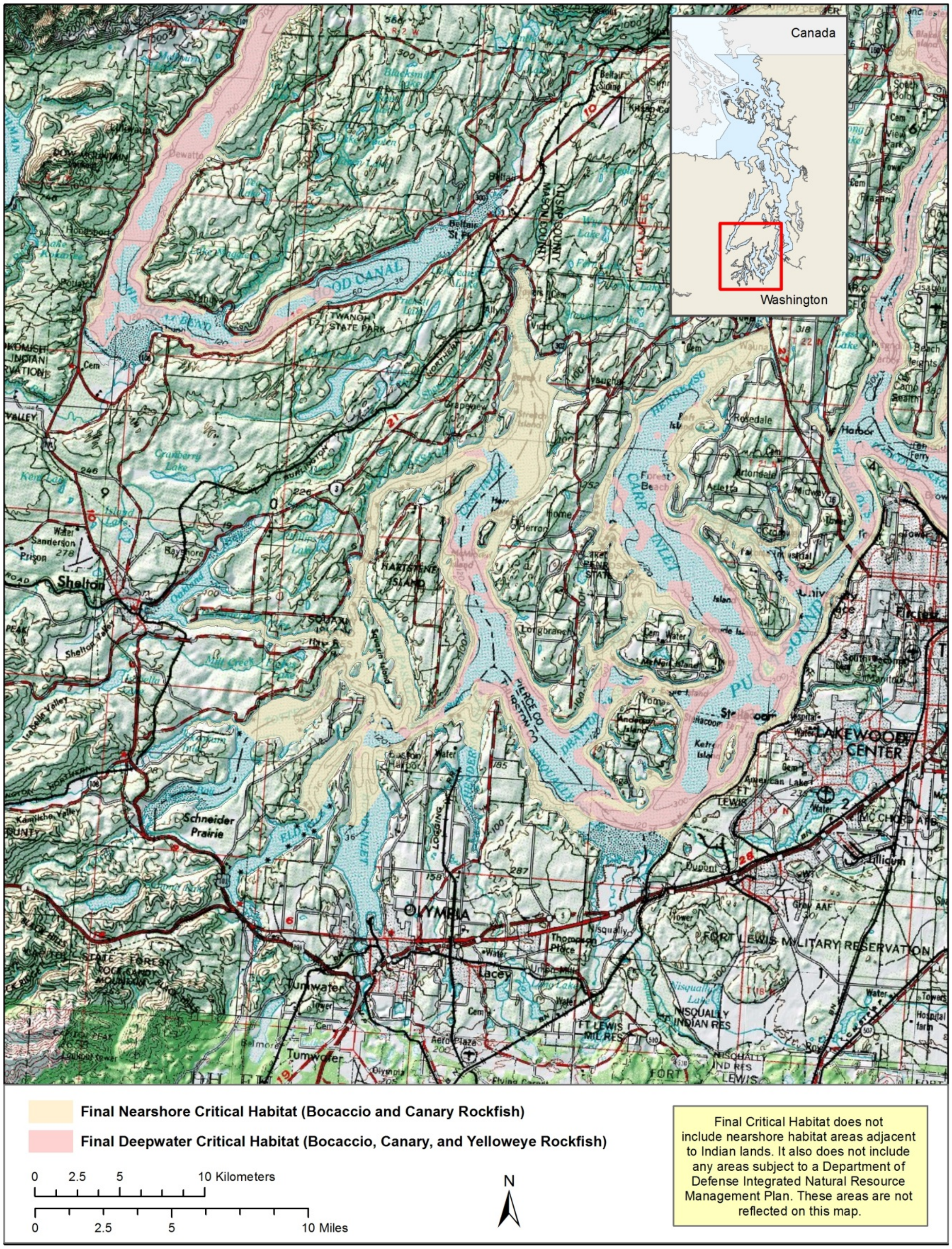


Figure 7A. Critical habitat for yelloweye rockfish, canary rockfish, and bocaccio in the south of Hood Canal Basin and South Puget Sound Basin.

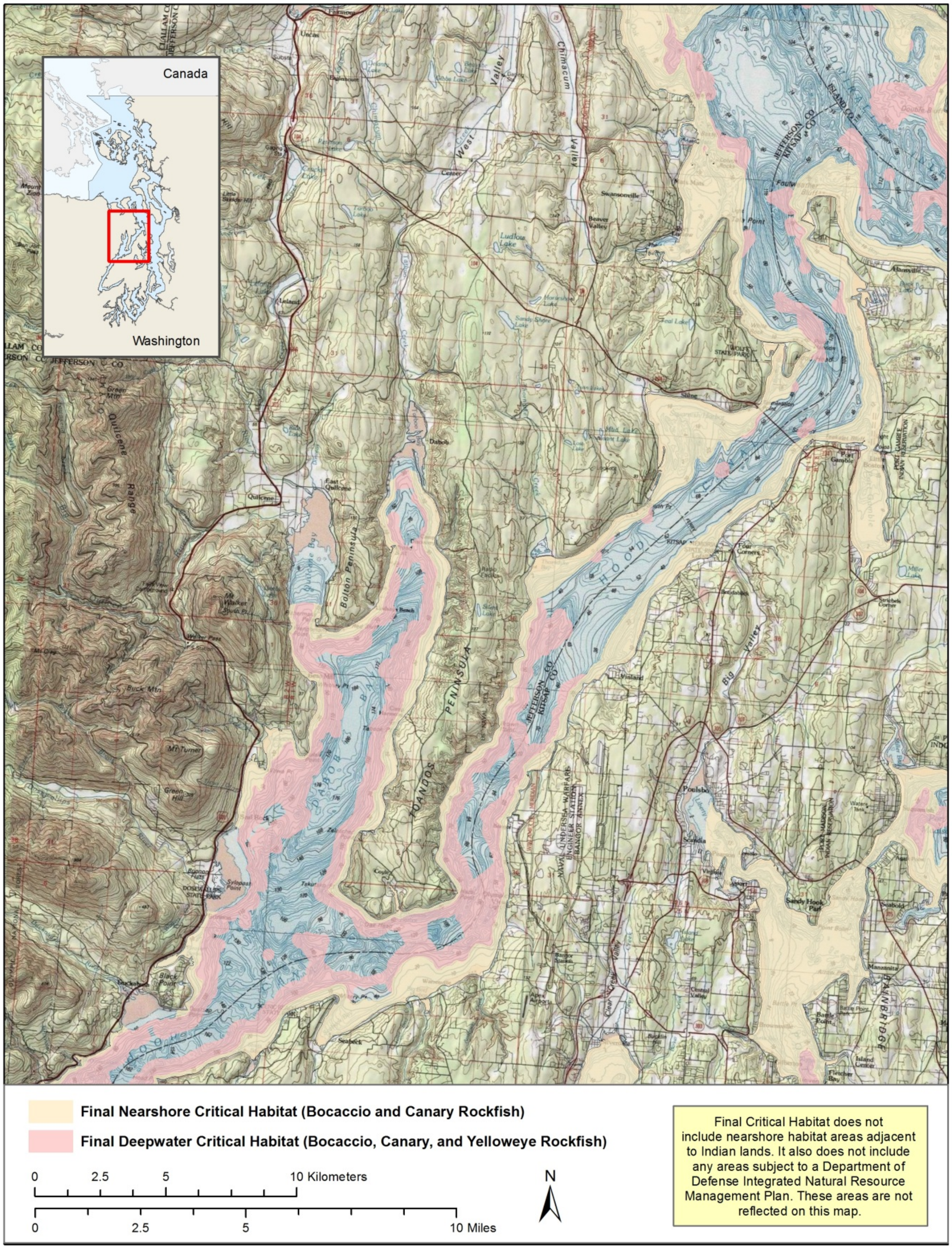


Figure 8A. Critical habitat for yelloweye rockfish, canary rockfish, and bocaccio in the northern portion of Hood Canal.

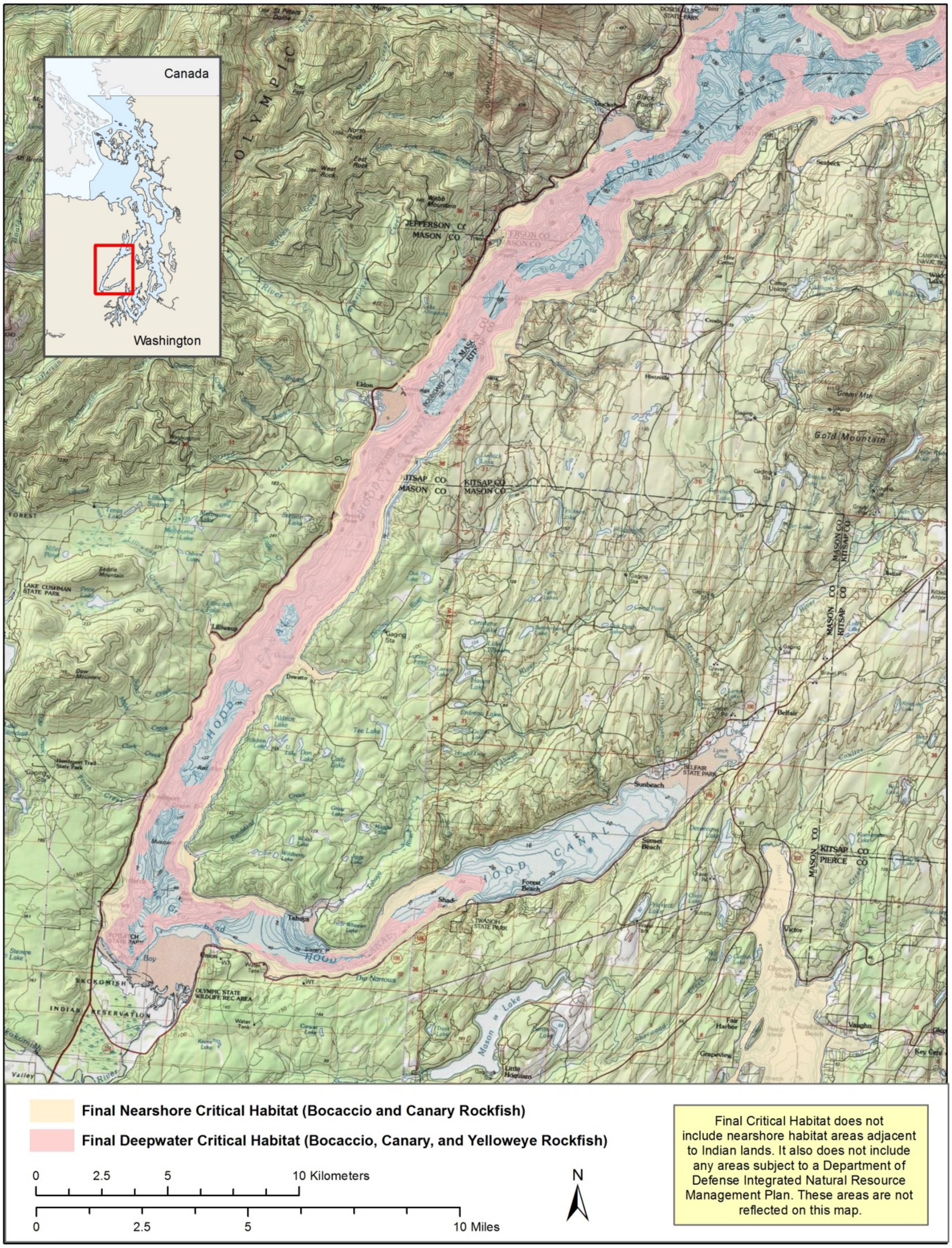


Figure 9A. Critical habitat for yelloweye rockfish, canary rockfish, and bocaccio in the Hood Canal.

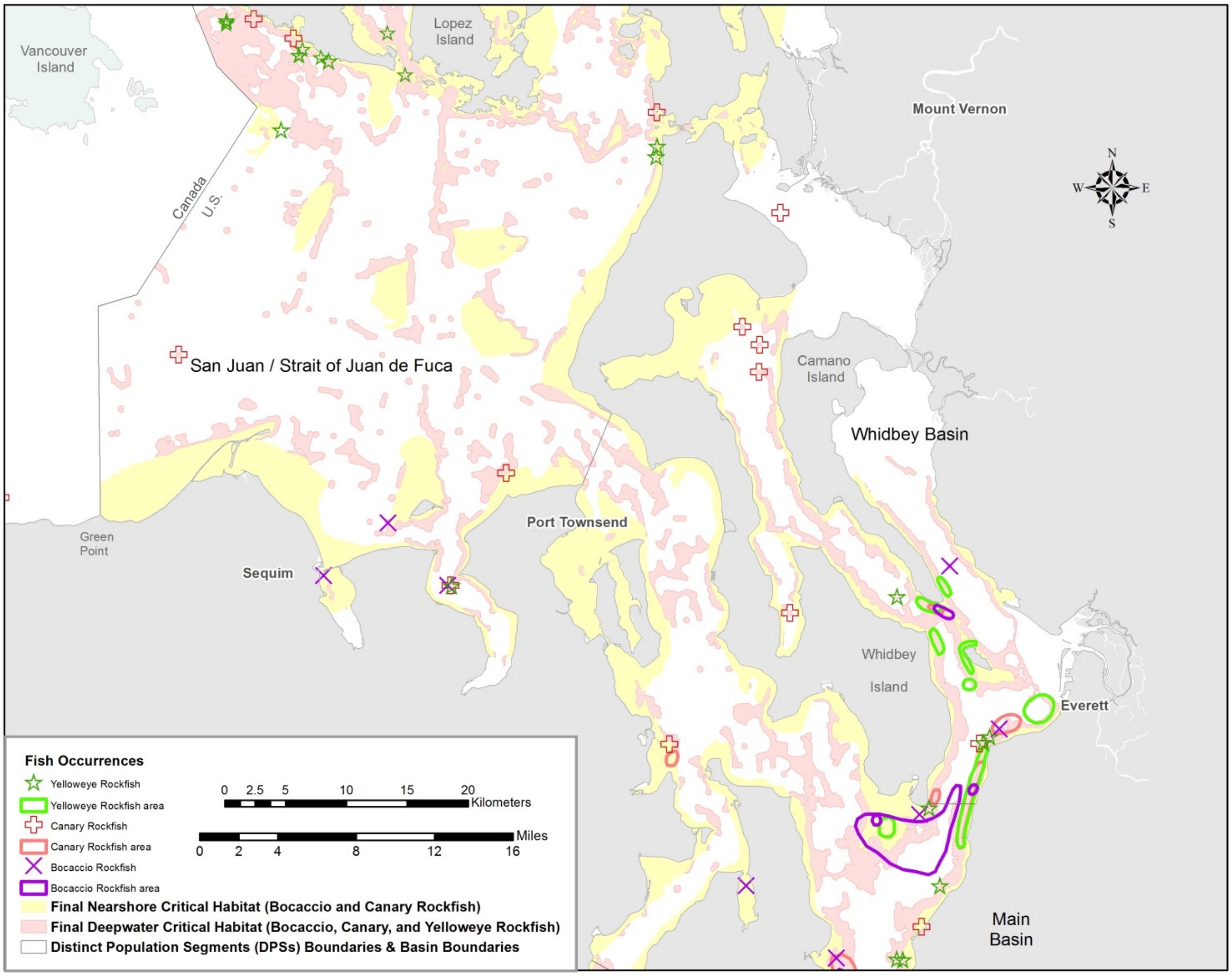


Figure 10A. Rockfish observations and critical habitat in the San Juan/Strait of Juan de Fuca Basin and Whidbey Basin.

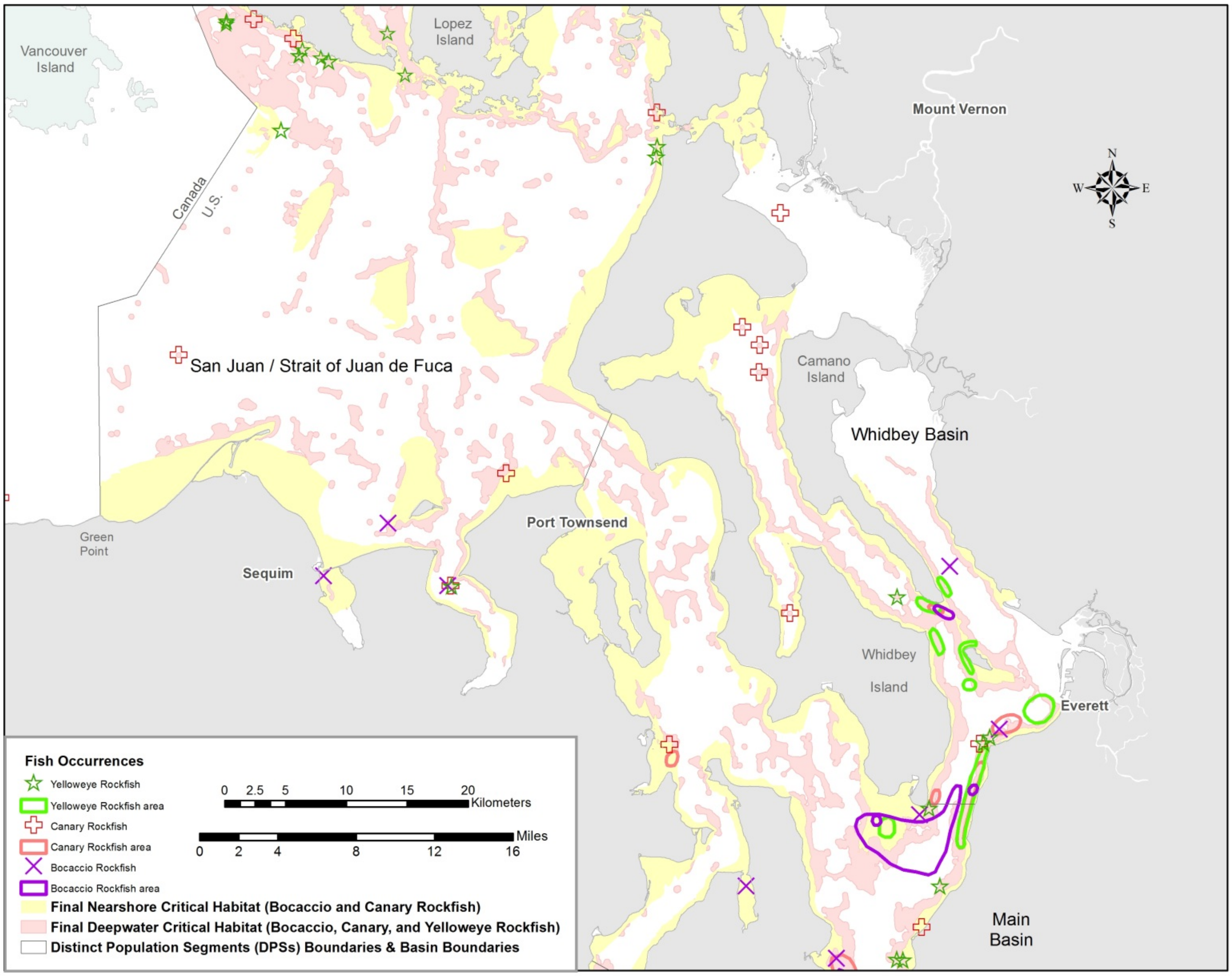


Figure 11A. Rockfish observations and critical habitat in the San Juan/Strait of Juan de Fuca Basin, Whidbey Basin, and Main Basin.

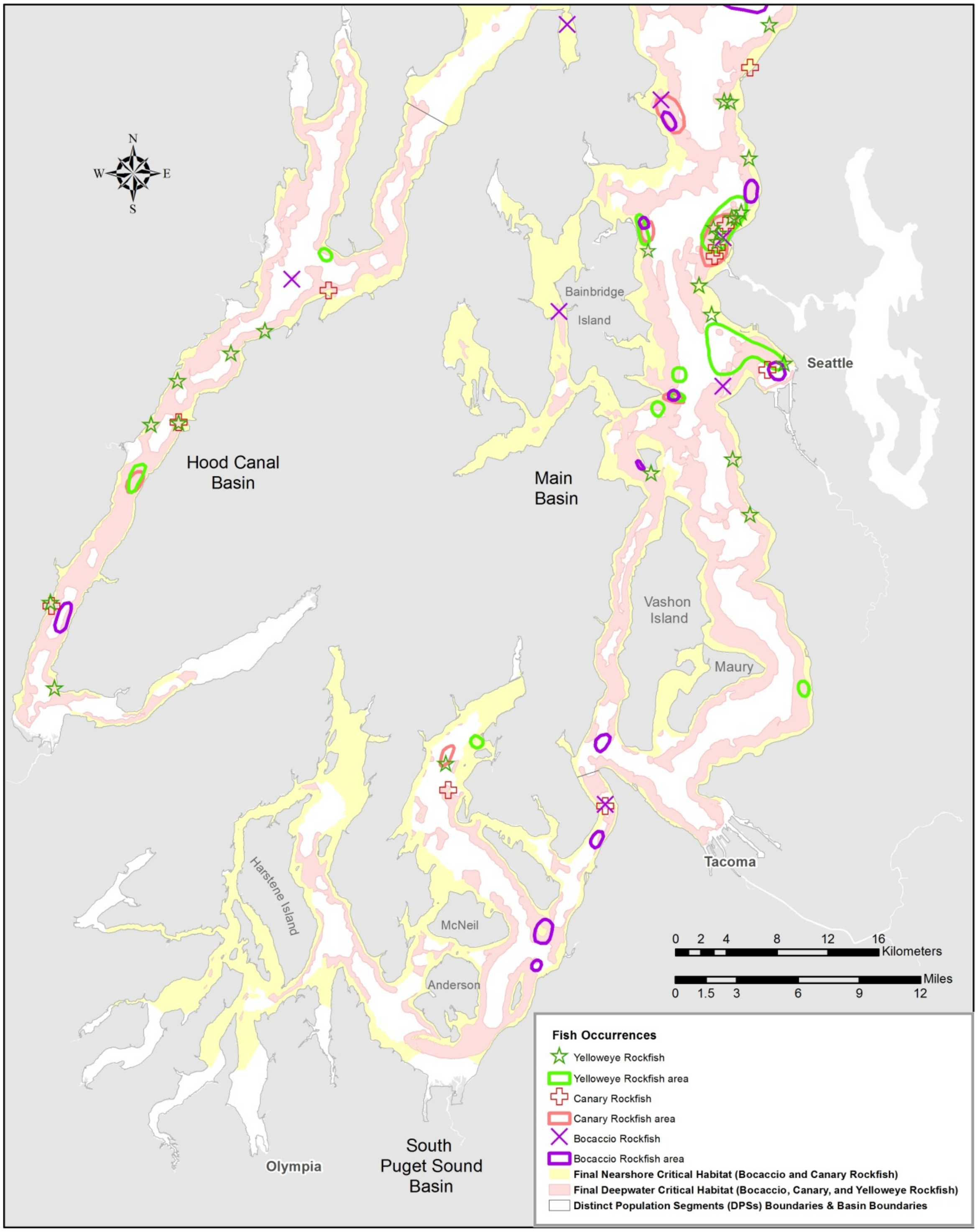


Figure12A. Rockfish observations and critical habitat in the Hood Canal Basin, Main Basin, and South Puget Sound.

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