Literature Review of Life History Aspects of All 86 Groundfish Species Managed by the Pacific Fishery Management Council

This product is due to, in part, the work of Cheryl Barnes, Madison Bargas, and Holland Vernon. The Pacific Fishery Management Council appreciates their contributions.

1. Introduction

This document is the literature review of life history aspects for 66 species of groundfish managed by the Pacific Fishery Management Council (Council). The function of the information presented in this document is to support the analysis and adoption of stock definitions for these species, as appropriate, in the Council's Phase 2 process .

The Council has defined stocks of species previously under Phase 1. In that action, the Council defined 20 stocks of 14 species. The literature review for those Phase 1 species is available in Appendix 1. An action concurrent to Phase 2 will define stocks for up to eight species, those species are included in this document as Appendix 2.. The following species will be considered by the Council under Phase 2 stock definitions process (see Appendix 2) in their decision making process.

Prior to the stock definitions process, the Council's Scientific and Statistical Committee (SSC) had discussions related to this issue, e.g., Agenda Item E.3.a, Supplemental SSC Report 1, November 2021. The recommendations in that statement are germane to how the following analysis attempts to define groundfish populations as stocks. The SSC recommended that when considering population structure, that the most conclusive sources of information are typically genetic differences if they exist, less conclusive information is exchange/movement of adults, followed by larval dispersal (Agenda Item E.3.a, Supplemental SSC Report 1, November 2021). The lowest tier was demographic differences, such as size at age.

The one oft-used attribute is genetic differentiation. When members of a fish species are segregated into multiple reproductive stocks, allele frequencies at neutral genetic markers diverge under genetic drift such that the variance in gene frequencies reflects the magnitude of reproductive isolation among these stocks. Thus, gene frequency differences among geographic samples can be used to indirectly estimate patterns of gene flow and hence population structure of the species. Genetic differences often provide signals on long-time scales (e.g., geologic), and thus can miss more recent and relevant time scales unless extremely sensitive markers are used. Population connectivity by measuring dispersal and movement (which can also be done using natural markers, such as in otolith microchemistry studies) in at least one stage of the life cycle is a more direct way to measure contemporaneous connections among subpopulations along a species range (Gunderson and Vetter 2006).

Homogeneous population structure assumes there is connectivity in the population, meaning reproductive units within the population are not isolated from one another. It only takes exchange in a few individuals to cause this homogeneity using genetic markers, though this type of population structure may also suggest high mixing patterns in terms of larvae, juveniles, and/or adults along the species range. In brief, evidence suggests that individuals in homogeneous populations are not isolated from one another on the geographic scale i.e., the population is connected. Heterogeneous population structure assumes the converse, with low connectivity caused by life history, geographic, and/or oceanographic constraints. Within a heterogeneous population, there would be identifiable subpopulations that are likely reproductively isolated from other subpopulations. Reproductively isolated subpopulations are known to show genetic differences, suggesting limited connectivity along the species range.

Population connectivity is not the only criterion to use for defining a stock. Ideally, a stock should consist of a collection of individuals that interact enough to create a coherent population trend (i.e., have the same population dynamics). This defines subpopulations as from the same stock if they demonstrate comparable recruitment patterns, life history values and exploitation histories, thus exhibiting similar population trends (Cope and Punt 2009; 2011). In fact, exploitation history alone can cause localized depletion events despite total population connectivity via larval dispersal or adult movements. Ignoring this can lead to mismanagement of stocks (Cope and Punt 2011), thus providing spatially-resolved population assessments when considering each of the factors can provide the most appropriate resolution to set catch limits. Many of the species considered in this action are nearshore fishes. Nearshore rockfishes, in particular, are known to be rocky reef and kelp forest dependent, thus associated with patchy habitat along a long latitudinal stretch. Within that long latitude it is not uncommon to encounter gradients in biology and differential exploitation histories (Gertseva et al. 2017; Lam et al. 2021). In addition, nearshore fishes often demonstrate low larval dispersal as larvae are often retained close to shore and settle in the nearshore environment (Larson et al. 1994; Love et al. 2002, Largier 2003; Gunderson and Vetter 2006). This dispersal range of many nearshore rockfishes is thought to be small (on the order of 10 to perhaps 100s of kms) but those metrics are highly uncertain (Baetscher et al. 2019; Buonaccorsi et al. 2004; Miller and Shanks 2004; Miller et al. 2005). It is thus very common to encounter stepping-stone or isolation by distance genetic models among nearshore stocks (Buonaccorsi et al. 2002; Cope 2004; Bernston and Moran 2008).

Literature suggests there are multiple sub-populations of nearshore rockfish species along the coast that may be isolated by distance from one another (Bernston and Moran 2008). Populations isolated from one another indicate that there may be low connectivity between them. Species with distinct (heterogeneous) population structure are likely not single populations, which assumes no discernible (homogeneous) population structure.

Assessments attempt to model population dynamics at a geographic scale that is informed by BSIA for population structure. Meaning, a coastwide assessment assumes the population is homogeneous throughout its west coast range and assessments at the less than coastwide scale assumes the population is heterogeneous. In heterogeneous populations, assessors often use state boundaries to delineate sub-areas (e.g., quillback rockfish), though sub-areas can be based on more discrete biogeographical data (e.g., vermilion/sunset rockfish north and south of Point Conception [34° 27` N]). These sub-areas are informed by BSIA. Population delineations can also be informed by data availability, history of fishery exploitation, etc. Population breaks can often correspond to biogeographic boundaries that occur within state lines (Keller et al. 2018; Brooks 2021). Spatially explicit assessment methods that reflect population structure, as well as incorporate fishery exploitation data at the same scale, likely increase the understanding of the species as well as improve managers ability to maintain a sustainable resource (Brooks 2021).

Structure indicates population connectivity. In general, high connectivity implies a single connected unit of fish across the species' range (i.e., a single stock); whereas low connectivity implies isolated, unconnected units of fish across species' range homogeneous population (i.e., multiple stocks). Population structure can be determined on a geographic basis, giving a base method to determine geographical boundaries for the population.

Synthesis of Spatial Population Structure Literature

There is extensive literature describing the progression of knowledge around understanding the spatial structure of fishery populations, how to incorporate that knowledge into assessments, and how that knowledge can inform management. Cadrin and Secor (2009) describe this progression for assessments from early assumptions of homogeneity to more complex concepts of spatial and temporal variability. Hammer and Zimmerman (2005) discuss that management units have traditionally grown and are not adjusted to either the changes in distribution of stocks or to the change of scientific perception of the particular stock boundaries. In recent years, there has been an increase in the application of simulation models to evaluate alternative approaches to address misalignment of biological and management units (e.g., Kell et al. 2009; Cope and Punt 2011; Ying et al. 2011; Kerr et al., 2014b; Berger et al. 2021).

Understanding the spatiotemporal scale of population structure for a species in relation to management units is important for effective long-term sustainable management (Goethel et al. 2011). Most species demonstrate variability in life history characteristics, uneven distributions across a species range, and connectivity across population components that can lead to different responses to harvest (Kerr et al. 2017; Zipkin and Saunders 2018; Punt 2019). Not accounting for differences in these characteristics when they exist can result in inaccurate estimates of stock productivity and sustainable yield and misinterpretation of trends in abundance (e.g., Kerr et al. 2014a; Secor 2015). Kerr et al. (2014) found that the Atlantic cod populations located off the northeastern United States appeared more robust to fishing pressure when management boundaries were used rather than the correct biological stock delineations, which could lead to overfishing. Spawning biomass and fishing mortality rate were also biased for Atlantic herring when management boundaries were used to assess population status rather than biological boundaries (Guan et al. 2013). Berger et al. (2021) found increased bias in estimates of terminal spawning biomass as management areas misaligned with biological areas. This bias increased when fishing mortality was disproportionate to vulnerable biomass, demographic parameters were not homogenous, and connectivity existed between the management areas and was not accounted for (Berger et al. 2021). Altogether, the situations described in the above papers create barriers to successful management such as increased risk for local depletion, inappropriate allocations of catch across regions, loss of sustainable yield, and overall biased estimates informing decisions.

A particular concern with assuming no population structure when in fact population structure exists is with localized dynamics. Although system-wide biomass was found to be unbiased when assumptions about spatial structure did not align with the underlying dynamics, looking only at system-wide biomass or assuming a single homogeneous areas masked localized depletion (Goethel and Berger 2017; Bosley et al. 2019; Berger et al. 2021). Consequently, if a coastwide population is assumed, but the underlying population is structured at a finer scale, there are risks that localized depletion can occur.

The above examples emphasize the importance of aligning management boundaries with the underlying biological dynamics. Kerr et al. (2017) noted that management units usually cannot exactly match biological boundaries, because the latter are not precisely known and do not have abrupt edges, and the spatial resolution of fishery management (e.g., reporting of fishing effort, monitoring of catch, and enforcement of regulations) is limited. However, key elements can be incorporated and the literature consulted to ensure setting of management boundaries follows the best scientific information available.

Kerr et al. (2017) outline a process for updating management and assessment considerations in relation to population structure. The first step of that process involves a "holistic review of available stock identity information by a group of experts." Cadrin et al. (2014) describes the elements of such a holistic review as including the following steps:

i. Clearly define the current spatial management units and their scientific or practical justification.
ii. Identify all a priori hypotheses about population structure, including the paradigm used to justify current management units.
iii. Conduct a comprehensive review of information related to the specific fishery resource being evaluated, ideally considering information from throughout the species' geographic range.
iv. Synthesize the information available within each discipline with respect to population structure and the stated hypotheses and evaluate the perception of population structure across the disciplines.
v. Consider each a priori hypothesis, the information that rigorously tested the hypotheses, and whether the information could be used to either reject or support hypotheses. Draw final conclusions on biological stocks based on the most robust and parsimonious view of population structure that is consistent with the best scientific information available.

The International Council for the Exploration of the Sea (ICES) Stock Identification Methods Working Group is an example of such a group, with representatives from diverse fields, and updates best practices related to identifying stocks in the Atlantic Ocean (Cadrin 2020). Cadrin (2020) provides additional considerations when identifying stocks. These include three broad categories of data including spatial distribution, dispersal, and geographic variation, each of which contains multiple sub-categories. A few sub-categories include adult and larval distribution for dispersal, and patterns in life history traits, abundance, size composition, and genetics for geographic variation. Both Kerr et al. (2017) and Cadrin (2020) stress the importance of interdisciplinary identification of stocks to both increase the chance of correctly identifying population structure and also to account for information across ecological and evolutionary time scales that the different disciplines capture.

Identifying population structure requires fine scale data that does not always exist. Assuming population structure based on imperfect information does have risks. Through simulation Punt et al. (2016) showed some of the consequences of assuming spatial structure but still missing critical differences. Models capturing all spatial differences between two areas performed best among simulations, but assuming spatial structure, yet incorrectly assuming constant growth between the areas, performed no better than assuming a single homogeneous area. This contrasts with Bosely et al. (2022) who found allowing for spatial population structure is likely to be less detrimental than ignoring it completely. Bosley et al. (2022) found that allowing assessments flexibility in movement estimation could mitigate against the risk of not knowing the correct underlying spatial structure.

Large and fine scale habitat and oceanographic features are often considered to be key drivers of population or stock structure for marine species, where such structure exists. Within the California Current ecosystem, the nearshore, shelf, slope and offshore regions generally have their greatest changes in physical and biological characteristics at major promontories, with Point Conception (34°

27` N), Cape Mendocino (40° 30` N), and Cape Blanco (42° 50` N) generally considered to be among the most important biogeographic features along the U.S. West coast (Hickey 1979; Checkley and Barth 2009; Gottscho 2014). These features typically reflect strong shifts in biological community structure and other ecological features (Horn et al. 2006; Tolimieri and Levin 2006; Tolimieri 2007) as well as often being regions in which greater genetic diversity within species is observed (Sivasundar and Plumbi 2010; Hess et al. 2011; others). However, within species or populations, differences in depth and habitat distributions, seasonality of reproduction, larval durations and both juvenile and adult movement patterns also factor into the degree of population structure or connectivity over larger spatial scales, and a wide range of potential population structure "types" is possible depending on a suite of life history factors.

Gunderson and Vetter (2006) and Gunderson et al (2008) built on previous analyses to develop a useful conceptual model for a suite of plausible population structure types for rocky reef fishes throughout the Northeast Pacific (i.e., U.S. West coast north through the Gulf of Alaska). They suggest four primary types of population structures that are useful to consider in this analysis. In the first, there is broad dispersal of larvae throughout most or all of the Northeast Pacific, and consequently little to no population structure. They suggest that this is likely to be a reasonable conceptual model for many deep-water species for which spawning occurs in deep or offshore waters, and larval duration can be extensive (a year or more), such as the thornyheads or Dover sole. In a second model, major biogeographic features (such as Cape Mendocino, Point Conception, and the northern tip of Vancouver Island) help to define population structure by limiting (but not eliminating) dispersal across these oceanographic domains. Their review suggests that this is likely to be the most appropriate model for many shelf and some nearshore rockfishes, and indeed this is consistent with many genetic population structure studies (e.g., Rochas-Olivares and Vetter 1999; Hess et al. 2011). Their third model reflects "diffusive dispersal" in which nearshore species, particularly those associated with kelp forests and with shorter larval durations, are subject to more constraining advective processes, such as "sticky water" zones in which larvae tend to be entrained in nearshore water masses that are rarely advected offshore or great distances (Largier 2003). The fourth model is described as "non-dispersing," and relates primarily to a very limited number of species with high parental investment and no larval or juvenile dispersal stages, such as some elasmobranchs and live bearing surfperches.

Species Literature Review

A key first step in defining stocks is understanding the species biology. The SSC recommended at least three tiers of biological attributes to consider when deciding a stock definition (Agenda Item E.3.a, Supplemental SSC Report 1, November 2021). The highest tier of these attributes is a genetic difference among meaningful markers. The next highest tier of information is exchange or movement of adults, followed by larval dispersal between areas. The lowest tier of information is differences in demographic characteristics (Agenda Item H.5, Attachment 1, November 2022).

The following species descriptions summarizes the current knowledge surrounding population structure of the priority species by expanding on Table 1 in Agenda Item H.5, Attachment 1, November 2022. In our investigation we examine genetic information, adult, juvenile, and larval movement, demographic information as well as past assessment stratification. This information originates from current scientific literature, the 2022 Groundfish Stock Assessment and Fishery Evaluation (SAFE) document, and from the species-specific assessments. The majority of the species detailed below have ranges that exceed the U.S./Mexico and/or the U.S./Canada borders; however, assessments focus only on the populations off of the U.S. West coast, though posit on potential connectivity to other populations. Some of these species could be considered sub-populations of a larger population (or metapopulation) that extends beyond the U.S. given their geographic extent. While the following centers on the scientific rationale for stock definitions, the Council could consider other issues as relayed in National Standards guidance. Implications regarding defining these populations are discussed under the Alternative analyses.

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2. Elasmobranchs

Big skate (Beringraja binoculata)

Species Information

Big skate (*Beringraja binoculata*) range from the eastern Bering Sea to Baja California and the Gulf of California, Mexico (Castro-Aguirre et al. 1993; Castro-Aguirre and Pérez 1996; Mecklenburg et al. 2002). Survey-based indices of abundance suggest similar biomass densities of big skate from California to Washington (Wetzel and Hastie 2022). They are reported to occupy depths up to 523 m (Love et al. 2021), often buried in sand or mud (Mecklenburg et al. 2002). They tend to avoid hard substrates but the use of mixed substrate (e.g., mud with boulders) tends to increase throughout their ontogeny (Bizzarro 2015).

Assessment History

A benchmark assessment for big skate was conducted at a coastwide scale in 2019 (Taylor et al. 2019). Prior to this assessment, big skate was assessed as part of the other fish complex (Taylor et al. 2013). Big skate has a target assessment frequency of 4 yr (PFMC 2024).

Genetics

In 2012, the genus for big skate and the mottled skate (*B. pulchra*) was revised from *Raja* to *Beringraja* (Ishihara et al. 2012). These two species share distinct clasper morphology and produce multiple embryos per egg case (Ishihara et al. 2012). There is no information about spatial variation in big skate genetics.

Larval Dispersal

Embryos hatch after 1 yr (Delacy and Chapman 1935; Hitz 1964). There is no information on dispersal distances for newly hatched big skates.

Adult Movement

Of 18,180 big skates tagged in British Columbia, 18 recaptures (all with a time at liberty > 6 months) traveled over 800 km to the south (King and McFarlane 2010). Three of these traveled over 2000 km (King and McFarlane 2010). Half of the satellite tags recovered from another study(n = 6) showed movements over 100 km in the Gulf of Alaska, with one individual traveling > 2100 km (Farrugia et al. 2016).

Other Life History Traits

Big skates exhibit a latitudinal cline in longevity, living to 12 yr off California (Zeiner and Wolf 1993), 15 yr in the Gulf of Alaska, (Gburski et al. 2007), and 26 yr in British Columbia (McFarlane and King 2006). Big skates reach a maximum size of 244 cm and 91 kg (Eschmeyer et al. 1983). There are also regional differences in maturation but without a clear latitudinal pattern. Length-at-first-maturity is 100 cm for males and 129 cm for females off central California (Zeiner and Wolf 1993). In the Gulf of Alaska, lengths-at-maturity are 109 cm (first) and 119 cm (50%) for males or 126 cm (first) and 149 cm (50%) for females (Ebert et al. 2008). Males reach 50% maturity at 72 cm (6 yr) and females reach 50% maturity at 90 cm (8 yr) in British Columbia (McFarlane and King 2006). Big skates reproduce on sand or mud throughout the year (Ford 1971). They produce multiple broods with 1 to 8 embryos per egg case each year, though interspawning intervals are not known (Ebert 2003; King and McFarlane 2010).

Data Quality/Quantity to Inform Stock Definitions

Limited: There is insufficient information on genetics and dispersal distances of newly hatched big skates. There is, however, evidence of considerable movements and spatial variation in life history traits of big skate from the Gulf of Alaska to California.
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Leopard shark (Triakis semifasciata)

Species Information

Leopard sharks (*Triakis semifasciata*) range from Samish Bay, WA to Mazatlan, Mexico and show greater relative abundances in shallow, coastal waters off California (Farrer 2009). A single leopard shark was captured in Samish Bay in 2009, which extended the edge of their range north of Oregon (Ebert 2003; Farrer 2009). Leopard sharks use shallow bays and estuaries as nursery and foraging habitat (Smith 2001; Ebert and Ebert 2005; Carlisle and Starr 2009).

Assessment History

Leopard sharks have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 6 yr (PFMC 2024).

Genetics

Analyses of mtDNA control sequences show that leopard sharks exhibit relatively low levels of genetic variation off California (Lewallen et al. 2007). Leopard sharks were, however, found to be polymorphic using inter simple sequence repeats (ISSRs), which characterize a broad range of the nuclear genome (Lewallen et al. 2007). There is evidence of isolation by distance along the California coast, with seven distinct gene pools identified from Humboldt Bay to San Diego, CA (Lewallen et al. 2007). Spatially-limited gene flow resulting from considerable distances between breeding sites may have led to some degree of population structure for leopard sharks (Lewallen et al. 2007

Larval Dispersal

Leopard sharks use shallow bays and estuaries as nursery areas (Carlisle and Starr 2009). There is no information on movement rates of juvenile leopard sharks.

Adult Movement

There is evidence of high site fidelity and seasonal variation in the distributions of leopard sharks, though broad-scale movement patterns remain unknown (Carlisle and Starr 2009; Barker et al. 2015). A tagging study found some mixing among populations in San Francisco Bay and Elkhorn Slough, though leopard sharks in San Francisco Bay are generally considered year-round residents (Smith and Abramson 1990; Smith 2001). Those found in Elkhorn Slough in the early spring tend to leave in the fall and winter when temperatures decline (Carlisle and Starr 2009).

Other Life History Traits

Leopard sharks live to 30 yr (Smith 1984) and reach a maximum length of 198 cm (Miller and Lea 1972). Females reach slightly larger maximum sizes but males grow faster off central California (Kusher et al. 1992). All female leopard sharks mature by 100 cm and 17 yr (Kusher et al. 1992).

Data Quality/Quantity to Inform Stock Definitions

Robust: Multiple genetic markers provide evidence of spatial population structure for leopard sharks along the California coast. Leopard sharks in Humboldt Bay, CA may have undergone localized adaptation given evidence of genetic isolation, delayed maturity, and relatively low fecundity.

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Longnose skate (Beringraja rhina)

Species Information

Longnose skate (*Beringraja rhina*) range from the Bering Sea to Baja California, Mexico (Love et al. 2005). Survey-based indices of abundance suggest greater biomass densities of longnose skate off California and slightly lesser densities off Oregon and Washington (Wetzel and Hastie 2022). They can tolerate a broad range of environmental conditions, including depths from 9 to 1,294 m but are most common between 150 and 400 m (Love et al. 2005; Bizzarro 2015). Longnose skates are often found on mud or sand, with larger individuals most frequently found in mixed substrate habitats or high relief rock outcrops (Bizzarro 2015).

1.1. Assessment History

Benchmark assessments for longnose skate were conducted in 2007 and Assessment History

Benchmark assessments for longnose skate were conducted in 2007 and 2019 (Gertseva and Schirripa 2007; Gertseva et al. 2019). Both assessments modeled longnose skate at the coastwide scale. Longnose skate has a target assessment frequency of 4 yr (PFMC 2024).

Genetics

There is no information about spatial variation in longnose skate genetics.

Larval Dispersal

Longnose skates utilize rocky reefs between 125 and 150 m as nursery habitat off southern California (Love et al. 2008). Egg survival tends to increase in the presence of sponges (Love et al. 2008). There is no information on dispersal distances for newly hatched longnose skates.

Adult Movement

There is no information on movement rates for adult longnose skate.

Other Life History Traits

Longnose skates may live to 26 yr (McFarlane and King 2006; Gburski et al. 2007), though an age validation study has yet not been completed. They reach a maximum length of 214 cm and exhibit sexually dimorphic growth (McFarlane and King 2006; Gburski et al. 2007). Longnose skates first mature in Monterey Bay, CA at 62 cm (males) and 100 cm (females) (Zeiner and Wolf 1993). They produce one pup per egg case, which incubate for several months in benthic habitats (Zeiner and Wolf 1993).

Data Quality/Quantity to Inform Stock Definitions

Limited: There is insufficient information on genetics, larval dispersal, adult movement rates, and/or spatial variation in life history traits with which to assess stock structure for longnose skate.

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3. Scorpaenids

Cabezon (Scorpaenichthys marmoratus)

Species Information

Cabezon (*Scorpaenichthys marmoratus*) range from Sitka, AK to Baja California, Mexico (Miller and Lea 1972). They tend to occupy nearshore rocky reefs and kelp forests to 82 m (Eschmeyer et al. 1983). Benthic juveniles reside in tidepools and shallow subtidal habitats (Yoshiyama 1986; Moring 1990).

Assessment History

Benchmark assessments for cabezon were conducted in 2003, 2005, 2009, and 2019. The 2003 model pertained to all California state waters (Cope et al. 2004). The 2005 assessment accounted for spatial differences in catch histories, genetics, and population dynamics by splitting cabezon into two models: one north and one south of Point Conception, CA (Cope and Punt 2006). The 2009 assessment retained the two model structure for California and developed a third model to assess cabezon off Oregon (Cope and Key 2009). The 2019 assessment subsequently added a data-limited model for cabezon off Washington (Cope et al. 2019). Cabezon has a target assessment frequency of 4 yr (PFMC 2024).

Genetics

A mtDNA study found seven distinct subpopulations of cabezon in the California Current: one in southern Oregon, three north of Point Conception, and three south of Point Conception (Villablanca and Nakamura 2008).

Larval Dispersal

The larval duration for cabezon is 3 to 4 months (Love 2011). Dispersal is thought to be low (Mireles et al. 2012), however, actual dispersal distances for cabezon larvae remain unknown.

Adult Movement

Cabezon exhibit very small home ranges (< 1 km^2) and moderate to high site fidelity (Miller and Geibel 1973; Coombs 1979; Lea et al. 1999; Lowe et al. 2009; Mireles et al. 2012).

Other Life History Traits

Cabezon off Washington have been aged to 20 yr (Cope et al. 2019). Those off Oregon, northern California, and southern California have been aged to 17 yr (O'Connell 1953; Lauth 1987; Cope et al. 2019) and). There is a latitudinal gradient in maximum size, with cabezon reaching 65 (males) to 71 (females) cm off Washington, 53 (males) to 60 (females) cm off Oregon, and 44 (males) to 65 (females) cm off (Cope et al. 2019). Cabezon mature at larger sizes off Oregon or Washington compared to California. Lengths-at-50%-maturity were estimated at 43 cm for Oregon and 35 cm for California (Grebel and Cailliet 2010; Cope et al. 2019). Spawning takes place from November to March off California, with peak activity from January to February (O'Connell 1953). Spawning occurs year-round off Oregon, with peak activity from March to June (Hannah et al. 2009). Males guard nests (Feder et al. 1974). There is limited information regarding spatial differences in growth and maturity among the four substocks identified.

Data Quality/Quantity to Inform Stock Definitions

Robust: There is evidence of regional differences in genetics and relative abundance, spatial variation in life history traits, and limited connectivity of cabezon via larval dispersal or adult movement.

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California scorpionfish (Scorpaena guttata)

Species Information

California scorpionfish (Scorpaena guttata) range from central California to the Gulf of California, Mexico (~ 28° N) (Turner et al. 1969; Eschmeyer et al. 1983; Love et al. 1987). They are residential reef fish that can be found from the intertidal to 183 m or traveling over soft sediment (Frey 1971; Love et al. 1987). California scorpionfish are nocturnal and often feed at night.

Assessment History

Benchmark assessments for California scorpionfish were conducted in 2004 and 2017 (Maunder et al. 2005; Monk et al. 2018). California scorpionfish are rare north of Point Conception, CA. Thus, these models encompassed the areas between Point Conception to the US-Mexico border, (Maunder et al. 2005; Monk et al. 2018). California scorpionfish has a target assessment frequency of 4 yr (PFMC 2024).

Genetics

California scorpionfish have a higher prevalence of parasites in the southern extent of their range (Rodriguez-Santiago et al. 2020). There is no information available about spatial variation in California scorpionfish genetics.

Larval Dispersal

Larvae are abundant off northern Baja California, Mexico (Moser et al. 1993). There is no information on dispersal distances for California scorpionfish larvae.

Adult Movement

California scorpionfish exhibit moderate home ranges (24 to 34 km^2) (Turner et al. 1969; Hartmann 1987; Love et al. 1987). Considerable net movements (up to 200 km), however, have been observed off southern California (Hanan and Curry 2012). Mark-recapture studies show that mature California scorpionfish move into deeper waters (37 to 110 m) between May and September, suggesting some degree of site fidelity related to spawning (Hartmann 1987; Love et al. 1987; Hanan and Curry 2012).

Other Life History Traits

California scorpionfish live to 21 yr and reach a maximum length of 43 cm, with sexually dimorphic growth (Love et al. 1987). Spawning takes place from May to August, with peak activity in July (Love et al. 1987). California scorpionfish reach 50% maturity at 18 cm (2 yr) and 100% maturity by 22 cm (4 yr) (Love et al. 1987). They utilize an "explosive breeding assemblage" meaning that they aggregate at a single spawning site for an undetermined amount of time (Love et al. 1987). There is no information about spatial variation in the life history traits of California scorpionfish.

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, adult movement rates, and/or spatial variation in life history traits with which to assess stock structure for California scorpionfish. Small home ranges and regional differences in the prevalence of parasites may suggest some limitations on population connectivity

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Kelp greenling (Hexagrammos decagrammus)

Species Information

Kelp greenling (Hexagrammos decagrammus) range from the Aleutian Islands to southern California but are rare south of Point Conception (Eschmeyer et al. 1983; Feder et al. 1974). They are typically found nearshore, in rocky reef, kelp forest, and eelgrass habitats (Bodkin 1986; Pacunski and Palsson 2001). There is some evidence of ontogenetic movements, with smaller fish occupying shallower waters (DeMartini 1986).

Assessment History

A benchmark assessment for kelp greenling was conducted in 2005 (Cope and MacCall 2005). Two separate models were developed based on different catch and management histories for Oregon and California (Cope and MacCall 2005). Another benchmark assessment was conducted in 2015, was limited to Oregon waters (Berger et al. 2015). Kelp greenling has a target assessment frequency of 4 yr (PFMC 2024).

Genetics

Extracted mtDNA from livers of adult kelp greenling off Canada and California showed no regional differences in haplotype frequencies (Crow et al. 1997).

Larval Dispersal

There is no information on dispersal distances for kelp greenling larvae.

Adult Movement

Kelp greenling exhibit small home ranges (0.00 to 0.27 km^2) off central and northern California (DeWees and Gotshall 1974; Matthews 1985). There is no correlation among depth, size, or food availability and home range for female kelp greenling, suggesting that more substantial movements are driven by spawning (Freiwald 2009).

Other Life History Traits

Kelp greenling live to 18 yr (Munk 2001) and rarely exceed 63 cm (Love 2011). Adults can reach 50 cm off Oregon (Rodomsky et al. 2015). Kelp greenling exhibit sex-specific coloration that varies by season, geographic location, and among individuals (Love 2011). Females reach 50% maturity at 29 cm and 100% maturity at 33 cm (Rodomsky et al. 2015). Maturation rates are not available for males. Kelp greenling are batch spawners that produce three clutches between September and December (Crow et al. 1997; Rodomsky et al. 2015).

Data Quality/Quantity to Inform Stock Definitions

Insufficient: There is insufficient information on genetics and spatial variation in life history traits with which to assess stock structure for kelp greenling. Their reproductive strategy and small home ranges, however, suggest limited population connectivity.

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4. Rockfishes

Aurora rockfish (Sebastes aurora)

Species Information

Aurora rockfish (*Sebastes aurora*) range from British Columbia to southern California (Moser et al. 1985) but are most abundant from northern Oregon south (Thompson and Hannah 2010). Survey-based indices of abundance suggest an order of magnitude greater biomass densities of aurora rockfish off California compared to Oregon and Washington (Wetzel and Hastie 2022). Aurora rockfish were not reported north of Langara Island, Canada until a single individual was sampled in the Gulf of Alaska (Gillespie 1991; Laman and Orr 2011). They can be found over hard and soft substrates from 81 to 768 m (Love et al. 2002).

Assessment History

A benchmark assessment was conducted for aurora rockfish on the coastwide scale in 2013 (Hamel et al. 2013; Sampson et al. 2013). Exploitation rates may vary north and south of Cape Mendocino, CA, with lower survey biomass but higher catches to the north (Hamel et al. 2013). Aurora rockfish has a target assessment frequency of 10 yr (PFMC 2024).).

Genetics

There is no information about spatial variation in aurora rockfish genetics.

Larval Dispersal

Aurora rockfish larvae are most abundant near Point Conception, CA and relatively evenly distributed in nearshore habitats to the south (Moser et al. 2000). Larval abundance is concordant with adult habitat (Moser et al. 2000). There is no information on dispersal distances for aurora rockfish larvae

Adult Movement

There is no information on movement rates of adult aurora rockfish, though they are generally considered sedentary ambush predators.

Other Life History Traits

Aurora rockfish live to 118 yr and reach a maximum length of 37 cm (Thompson and Hannah 2010). Growth rates of aurora rockfish increase with increasing latitude (Gertseva et al. 2017; Head et al. 2020). Females reach 50% maturity at 25.5 cm and 12.6 yr (Thompson and Hannah 2010). Parturition peaks from April to June (Moser et al. 1985; Kendall and Lenarz 1986; Thompson and Hannah 2010). Aurora rockfish larvae increase in abundance during winter, peak from May to June, and tend to decrease in cold years (Moser et al. 2000

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for aurora rockfish.

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Bank rockfish (Sebastes rufus)

Species Information

Bank rockfish range from Queen Charlotte Sound in British Columbia to central Baja California, Mexico (Love 2011). They tend to aggregate in midwater habitats with high relief, including boulder fields and steep rocky slopes (Taylor et al. 2004; Love 2011). Adult bank rockfish are common from 100 to 300 m but can occur to 454 m (Love et al. 1990; Taylor et al. 2004; Watters et al. 2006; Love et al. 2009). Juveniles occupy depths from 100 to 350 m (Love et al. 2009).

Assessment History

A data-limited assessment for bank rockfish was conducted in 2000 (Piner et al. 2000). This assessment includes California waters only. Bank rockfish has a target assessment frequency of 10 yr (PFMC 2024).

Genetics

There is no information about spatial variation in bank rockfish genetics.

Larval Dispersal

There is no evidence that larval distribution is consistent with adult habitat off southern California (Taylor et al. 2004). There is no information about dispersal distances for bank rockfish larvae.

Adult Movement

Based on ^{226}Ra uptake rates in otoliths, bank rockfish are thought to exhibit small home ranges (Watters et al. 2006).

Other Life History Traits

Bank rockfish may live to 85 yr (Love et al. 2002) but confirmed ages are to 53 yr (Watters 1993). Bank rockfish reach a maximum length of 55 cm (Love et al. 2002). Lengths-at-maturity are 28 cm (first), 31 cm (50%), and 38 cm (100%) for males and 31 cm (first), 36 cm (50%), and 39 cm (100%) for females off southern California (Love et al. 1990). Bank rockfish spawn from December to May, with peak activity in January for southern California and in February for northern California (Love et al. 1990).

Data Quality/Quantity

Insufficient: There is insufficient information on genetics, larval dispersal, and/or adult movement rates with which to assess stock structure for bank rockfish. Small inferred home ranges and regional differences in peak spawning activity, however, may indicate limited population connectivity along the California coast.

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Black-and-yellow rockfish (Sebastes chrysomelas) & Gopher rockfish (S. carnatus)

Species Information

Black-and-yellow rockfish (*Sebastes chrysomelas*) range from Cape Blanco, OR to Bahia Santa Maria, Mexico (Butler et al. 2012). Gopher rockfish (*S. carnatus*) range from Cape Blanco, OR to Punta San Roque in Baja California (Butler et al. 2012). Both species are most abundant north of Point Conception, CA and uncommon north of Point Arena, CA (Monk and He 2019). Black-and-yellow rockfish are found from the intertidal zone to 37 m but most abundant from 2 to 15 m. Gopher rockfish are found from the intertidal zone to 86 m but most abundant between 12 and 50 m (Larson 1980a). Both species are relatively shallow, demersal, solitary, and territorial (Larson 1980b). Black-and-yellow rockfish occupy complex habitats that include high and low relief rock as well as kelp forests (Butler et al. 2012). Gopher rockfish are found in high relief habitats such as rocky reefs and kelp forests (Larson 1980b). In kelp forests, both species tend to move down the water column as they age (Hoelzer 1982).

Assessment History
A benchmark assessment for gopher rockfish north of Point Conception was conducted in 2005 (Key et al. 2005). Catch-only projections were completed for gopher rockfish south of Point Conception in 2010 (Dick and MacCall 2010). In 2019, a benchmark assessment combined gopher rockfish and black-and-yellow rockfish between Cape Mendocino, CA and the US-Mexico border (Monk and He 2019). This was the first assessment to include data on black-and-yellow rockfish. The two species show evidence of ongoing gene flow (Baetscher 2019) and display morphological similarities that make it difficult to obtain species-specific catch histories. The black-and-yellow and gopher rockfish complex has a target assessment frequency of 6 yr (PFMC 2024).

Genetics
Black-and-yellow rockfish and gopher rockfish are closely related but genetically distinct (Narum et al. 2004). A study using mtDNA and microsatellites found conflicting information about genetic variation among gopher rockfish along the California coast (N_{cenCA} = 18 and N_{soCA} = 26; Sivasundar and Palumbi 2010). There is no information about spatial variation in black-and-yellow rockfish genetics.

Larval Dispersal
Little is known about the spawning habits and early life history of black-and-yellow and gopher rockfishes because the larvae and juveniles are very difficult to differentiate from other *Sebastes* species without DNA (Stein and Hassler 1989). There is no information on dispersal distances for larvae of either species.

Adult Movement
Black-and-yellow rockfish and gopher rockfish have home ranges between 2 and 10 m^2 (Matthews 1990). Net movements up to 109 km have been recorded for gopher rockfish (Freiwald 2012; Hamilton et al. 2021; Hanan and Curry 2012).

Other Life History Traits
Black-and-yellow rockfish live to 50 yr and gopher rockfish live to 30 yr (Kolora et al. 2021). Maximum sizes are 39 cm for black-and-yellow rockfish and 43 cm for gopher rockfish (Love et al. 2002). There is some evidence that gopher rockfish are smaller off southern California (Key et al. 2005). Lengths-at-maturity for gopher rockfish are 17 to 24 cm (first) and 17 cm (50%; 4 yr) (Wyllie Echeverria 1987; Lea et al. 1999).

Data Quality/Quantity
<u>Limited</u>: There i is evidence of genetic differences among gopher rockfish. Small home ranges and spatial variation in life history traits suggest limited population connectivity of gopher rockfish. More information on genetics differences, larval dispersal, adult movement, and/or spatial variation in life history traits is needed to assess the potential for stock structure among black-and-yellow rockfish.

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Blackgill rockfish (Sebastes melanostomus)

Species Information

Blackgill rockfish (*Sebastes melanostomus*) range from the Queen Charlotte Islands, Canada to Isla Cedros, Mexico; though pelagic juveniles have been caught off Punta Abreojos, suggesting a southern extension to their range (Miller and Lea 1972; Butler et al. 2012). Blackgill rockfish are most common off California (Miller and Lea 1972; Butler et al. 2012) and rare north of Cape Mendocino (Field and He 2018). Blackgill rockfish are considered transitional (i.e., residing several meters above the seafloor and along the bottom). They occupy depths from 88 to 768 m but are most common from 200 to 600 m (Miller and Lea 1972; Taylor et al. 2004; Love et al. 2022). Blackgill rockfish can be solitary or found in small aggregations. Adults tend to live near rocky ridges and boulder fields with high relief (440 to 520 m), whereas juveniles are often found on soft sediment (Eschmeyer et al. 1983; Love et al. 1990; Butler et al. 2012). Juveniles reside near the surface for up to 7 months before settling to the seafloor and moving onto rocky outcrops as they mature (Helser 2005).

Assessment History

The first benchmark assessment for blackgill rockfish was conducted in 1998, encompassing both central and southern California (Butler et al. 1999). The next benchmark assessment was completed in 2005 and expanded the spatial extent to include Oregon (Helser 2005). In 2011, a benchmark assessment was conducted for the Point Conception and Monterey INPFC areas, though a large proportion of blackgill rockfish habitat was located within Cowcod Conservation Areas and thus unavailable to standardized surveys (Field and Pearson 2011). Catch-only projections with updated maturity and fecundity information were completed in 2017 (Field and He 2018). Blackgill rockfish has a target assessment frequency of 10 yr (PFMC 2024).

Genetics

Fin clips showed no evidence of genetic variation among blackgill rockfish collected near Morro Bay (n = 74) and Santa Barbara, CA (n = 23) (Field and Pearson 2011).

Larval Dispersal

The larval duration for blackgill rockfish lasts up to 7 month(s) (Moser et al. 2000). A prolonged pelagic larval phase may promote considerable dispersal, increasing the probability of a well-mixed stock along the US West Coast (Helser 2005). Actual dispersal distances, however, remain unknown. A study off southern California found that larval distributions were generally consistent with adult distributions (Taylor et al. 2004).

Adult Movement

There is no information on movement rates of adult blackgill rockfish.

Other Life History Traits

Blackgill rockfish live to 90 yr, though age validation has only been completed to 41 yr (Love and Butler 2001; Munk 2001; Stevens et al. 2004). The maximum length for black gill rockfish is 61 cm (Munk 2001). The availability of sex-based length and age data varies throughout the region (Field and Pearson 2011). Lengths-at-maturity for blackgill rockfish are 33 cm (first), 34 cm (50%), and 38 cm (100%) for males and 31 cm (first), 34 cm (50%), and 38 cm (100%) for females off southern California (Love et al. 1990). Blackgill rockfish spawn from January to June, with peak activity in February (Love et al. 1990). Females produce one brood per year (Love et al. 1990). There is no information on spatial variation in life history traits of blackgill rockfish.

Data Quality/Quantity to Inform Stock Definitions

Insufficient: There is some indication of genetic differences among blackgill rockfish off California. This finding, however, contradicts inferences made about larval dispersal. Information about adult movement rates and spatial variation in life history traits is still needed to assess stock structure..

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Blue rockfish (Sebastes mystinus) & Deacon rockfish (Sebastes diaconus)

Species Information

Blue rockfish (*Sebastes mystinus*) are pelagic and found in large aggregations from central Oregon to northern Baja California, Mexico (Miller and Geibel 1973; Frable et al. 2015). Originally, their distribution extended northward to British Columbia and Alaska (Burford et al. 2011) but individuals from British Columbia to central Oregon have been genetically identified as deacon rockfish (*S. diaconus*) (Frable et al. 2015). Deacon rockfish range from Vancouver Island, Canada to Morro Bay, CA (Frable et al. 2015). Both species inhabit kelp forests and rocky reefs, with blue rockfish occupying depths from 0 to 90 m (Reilly 2001) and deacon rockfish occupying depths from 8 to 72 m (Frable et al. 2015). Blue and deacon rockfishes are more abundant north of Point Conception, CA (Hamilton et al. 2021). All specimens previously identified as blue rockfish (*S. mystinus*) in the Gulf of Alaska are now classified as dark (previously dusky) rockfish (*S. ciliatus*; Frable et al. 2015). Adult deacon rockfish are found further offshore and in deeper waters than blue rockfish (Frable et al. 2015). Juveniles form dense aggregations with olive (*S. serranoides*) and/or black rockfish (*S. melanops*) (Carr 1991; Green et al. 2014).

Assessment History

A benchmark assessment for blue rockfish was conducted in 2008 (Key et al. 2008). This assessment consisted of a single model from the Oregon-California border to Point Conception, CA (Key et al. 2008). Blue and deacon rockfishes were modeled together because they had not yet been identified to species (Dick et al. 2018). Blue and deacon rockfishes were assessed as a stock complex (blue-deacon rockfish; BDR) in 2017, with two separate models informed by different species compositions and exploitation histories off Oregon and California (Dick et al. 2018). The California model included fish from the California-Oregon border to Point Conception and the Oregon model represented the entirety of the Oregon coast. The BDR complex has a target assessment frequency of 6 yr (PFMC 2024).

Genetics

Genetic evidence suggested that there were two subpopulations of blue rockfish, separated by Cape Mendocino, CA (Cope 2004; Berntson and Moran 2009). Another study using mtDNA and microsatellites found genetic differences between blue rockfish off Oregon and California ($N_{OR} = 23$ and $N_{CA} = 50$; Sivasundar and Palumbi 2010). In 2015, two reproductively-isolated, cryptic species of rockfish (blue and deacon) were identified (Hannah et al. 2015). Genetics specific to blue rockfish reflect considerable variation across their natural range, with distinct populations off Oregon, the Farallon Islands, Half Moon Bay, the Channel Islands, and many other sites (Bizzarro et al. 2020). There is no clear pattern, however, of isolation by distance (Bizzarro et al. 2020). Deacon rockfish exhibit considerable gene flow throughout their range, showing little to no genetic differences along the Oregon coast (Vaux et al. 2019; Bizzarro et al. 2020).

Larval Dispersal

The larval duration for blue rockfish was reported at 69 d (Laidig 2010). However, larval duration was estimated prior to the genetic differentiation of the BDR complex. There is no information on dispersal distances for larvae of either species

Adult Movement

Blue and deacon rockfishes are primarily residential, exhibit relatively small home ranges of 1.3 km (Miller and Giebel 1973) and are considered non-migratory (Burford et al. 2006). Movements typically occur near kelp canopy or pinnacles (Miller and Geibel 1973; Lea et al. 1999; Jorgensen et al. 2006). There is little known about the long-term movements of blue and deacon rockfishes due to the lack of persistent acoustic telemetry studies (Green et al. 2014). Approximately 10% of relevant studies report large movements (up to 92 km) of blue rockfish (Freiwald et al. 2012; Hanan and Curry 2012). Mark-recapture studies suggest intermediate movement rates relative to black rockfish (*S. melanops*) and olive rockfish (*S. serranoides*) (Freiwald et al. 2012; Hamilton et al. 2021). Some deacon rockfish may exhibit seasonal ontogenetic migrations (Rasmuson et al. 2021), though an acoustic tagging study showed that larger females stayed at the same reef year-round (Rasmuson et al., unpublished).

Other Life History Traits

Prior to differentiation of blue and deacon rockfish, blue rockfish were reported to live to 44 yr and reach a maximum length of 51 cm (Laidig et al. 2003). Species-specific longevity remains unknown (Vaux et al. 2019; Rasmuson et al. 2021). Blue rockfish grow faster and reach larger maximum sizes off Oregon compared to California, though there are no state-based differences in the maximum recorded lengths of males (Bizarro et al. 2020). Deacon rockfish grow slower but reach larger maximum sizes off California compared to Oregon (Bizarro et al. 2020). Female blue rockfish reach 50% maturity at 26 cm and 4 yr (Hannah et al. 2015). Female deacon rockfish reach 50% maturity at 29 cm and 6 yr (Hannah et al. 2015).

Data Quality/Quantity of Information

Limited: There is a moderate amount of information on genetics, adult movement rates, and spatial variation in life history for the blue-deacon rockfish complex. Finer-scale genetic studies and species-specific information on movement and life history would provide better insight into stock structure for these recently differentiated species.

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Bocaccio (Sebastes paucispinis)

Species Information

Bocaccio (*Sebastes paucispinis*) range from the Shumagin Islands in the Gulf of Alaska to Punta Blanca, Mexico (Miller and Lea 1972; Eschmeyer et al. 1983; Butler et al. 2012). They are most abundant from northern California to Bahia San Quentin, with some relatively high densities in British Columbia (Butler et al. 2012). Survey-based indices of abundance suggest at least four-fold increases in biomass of bocaccio south of 40°10` N (Miller and Lea 1972; Harvey et al. 2006; Wetzel and Hastie 2022). Bocaccio in Puget Sound represent a distinct population segment (DPS) (Drake et al. 2010). Boccacio are considered transitional (i.e., residing several meters above the seafloor and along the bottom) and can be found in aggregations (Love et al. 1990). Bocaccio are most common between 27 and 320 m (Eschmeyer et al. 1983; Love et al. 2009; Love et al. 2022) but can be found as deep as 478 m (Taylor et al. 2004). Juveniles occupy shallower kelp and rocky reef habitats, both in the water column and near the seafloor (Love et al. 1990). Adults tend to migrate into deeper waters (> 210 m) with high relief habitat and can be found on soft sediment (Miller and Lea 1972; Love et al. 1990; Harvey et al. 2006).

Assessment History

Benchmark assessments for bocaccio were conducted in 2005, 2007, 2009, and 2015 (MacCall 2005a, 2008a; Punt et al. 2005; Sampson et al. 2007; Dorn et al. 2009, 2015; Field et al. 2009; He et al. 2015). Update assessments were completed in 2011, 2013, and 2017 (Field 2011a, 2013; He and Field 2018). Bocaccio was declared overfished in 1999 and rebuilding began in 2000 (MacCall 2005b). All assessments conducted before 2009 pertained to California waters only. Remaining assessments included areas from the California-Oregon border to Cape Blanco, OR (He et al. 2015). Bocaccio was declared overfished in 1999 and rebuilding began in 2000 (MacCall 2005b). Rebuilding analyses were completed in 2005, 2007, 2009, and 2011 (MacCall 2005b, 2008b; Field and He 2009; Field 2011b). Bocaccio has a target assessment frequency of 4 yr (PFMC 2024). Dorn et al (2015) found no evidence of genetic differences among bocaccio but noted that regional differences in growth, maturity, and longevity may indicate some spatial stock structure.

Genetics

A PCR study from British Columbia to Baja California, Mexico (N = 336) found evidence of genetic divergence but not isolation by distance among bocaccio (Matala et al. 2004; Bernston and Moran 2009). Another study using mtDNA and microsatellites found low genetic diversity among fish caught off central and southern California (N_{cenCA} = 10 and N_{soCA} = 15; Sivasundar and Palumbi 2010). Single sequence repeat (SSR) loci also showed no evidence of genetic differences among bocaccio sampled between British Columbia and the Southern California Bight (NBC = 96, NcenCA = 96, NsoCA = 96; Buonaccorsi et al. 2012). al. 2012).

Larval Dispersal

Larval boccacio have been observed along central and southern Baja California, Mexico (Matala et al. 2004). Bocaccio larvae tend to occupy the upper 100 m of the water column for an average of 3.5 month(s) before settling to the bottom (Hitchman et al. 2012). A study off southern California found that larval distributions were generally consistent with adult habitat types (Taylor et al. 2004). There is no information on dispersal distances for bocaccio larvae.

Adult Movement

Bocaccio have home ranges < 12 km (Starr et al. 2002). Juveniles are generally diurnal and adults are generally nocturnal (Bond et al. 1999).

Other Life History Traits

Bocaccio live to 46 yr (Munk 2001) and reach a maximum length of 91 cm (Eschmeyer et al. 1983). Bocaccio tend to be larger off Washington and Oregon, with sizes decreasing southward along the California coast (Harvey et al. 2006). Length-at-50%-maturity for bocaccio females off California (coastwide) is 40 cm (Phillips 1964). Females along the Southern California Bight reach maturity at 35 cm (first), 35 cm (50%), and 42 cm (100%) for males and 36 cm (first), 36 cm (50%), and 44 cm (100%) for females (Love et al. 1990). Bocaccio spawn from October to July, with peak activity in January off southern California and February off northern California (Love et al. 1990). Females produce multiple broods each year.

Data Quality/Quantity to Inform Stock Definitions

Limited: There is evidence of spatial variation in life history traits of bocaccio but conflicting information about genetic differences.

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Bronzespotted rockfish (Sebastes gilli)

Species Information

Bronzespotted rockfish (*Sebastes gilli*) range from Monterey Bay, CA (36° 48) to northern Baja California, Mexico (~ 30 ° N) (Eschmeyer et al. 1983; Love et al. 2002). Bronzespotted rockfish tend to share similar habitats with cowcod, including boulder fields and high relief rocks (Jiao 2009). Adult bronzespotted rockfish occupy a depth range of 75 to 415m and juveniles are found in the shallower part of that range from 75 to 252 m (Love et al. 2002, 2022). They are demersal, solitary, and inhabit high relief rocky reefs (Love et al. 2002).

Assessment History

A draft data-limited assessment for bronzespotted rockfish off California was reviewed in 2009 (Jiao 2009). The model, however, was not proposed or adopted for use in management. The target frequency for assessing bronzespotted rockfish has not been identified.

Genetics

There is no information about spatial variation in bronzespotted rockfish genetics.

Larval Dispersal

There is no information on dispersal distances for bronzespotted rockfish larvae.

Adult Movement

There is no information on movement rates of adult bronzespotted rockfish.

Other Life History Traits

Bronzespotted rockfish live to 47 yr and reach a maximum length of 71 cm (Love et al. 2002). Growth rates may differ between northern and southern California, though data collected during the same time period are necessary for such a comparison (Jiao 2009).

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and/or adult movement rates with which to assess stock structure for bronzespotted rockfish.

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Brown rockfish (Sebastes auriculatus)

Species Information

Brown rockfish (*Sebastes auriculatus*) range from Prince William Sound, AK (59° 32` N, 151° 36` W) to Bahia Magdelena, Mexico but are most common from Southeast Alaska to Puget Sound, WA and from Bodega Bay, CA to Bahia Tortugas, Mexico (Miller and Lea 1972; Buonaccorsi et al. 2005). Brown rockfish are demersal and found in relatively shallow waters (0 to 55 m) near rocky reefs (Miller and Lea 1972; Matthews 1990). They are most abundant in the nearshore at depths < 35 m (West et al. 1994; Stephens et al. 2006). Adult brown rockfish are more common in high relief habitats, whereas juveniles more frequently occupy shallower, lower relief portions of the reef (West et al. 1994). They occasionally are seen in small aggregations (Love and Johnson 1998).

Assessment History

A data-moderate assessment for brown rockfish was conducted at a coastwide scale in 2013 (Cope et al. 2015). Brown rockfish has a target assessment frequency of 6 yr (PFMC 2024).

Genetics

There is evidence of isolation by distance and potential introgression for brown rockfish (Seeb 1998; Buonaccorsi et al. 2005; Bertson and Moran 2009). There are genetic differences between brown rockfish in Puget Sound and those found along the California coast, with genetic variation observed across all sites > 300 km apart (Seeb 1998; Buonaccorsi et al. 2005). Another study using mtDNA and microsatellites found genetic differences between brown rockfish off central and southern California (NcenCA = 23 and NsoCA = 29; Sivasundar and Palumbi 2010). Genetic isolation of brown rockfish supports the consideration of Puget Sound as a distinct population segment (DPS).

Larval Dispersal

Brown Rockfish have a relatively short larval duration (36 to 73 d) and tend to remain near the surface (Markel et al. 2017). Using genetics as an indicator of larval dispersal suggests that brown rockfish larvae remain within 10 km of their origin site (Buonaccorsi et al. 2005).

Adult Movement

Brown rockfish have a home range of 0.4 to 1.5 km^2 (Matthews 1990), though net movements of 89 to 104 km have been observed (Hamilton et al. 2021; Hanan and Curry 2012).

Other Life History Traits

Brown rockfish live to 78 yr and reach a maximum length of 56 cm (Miller and Lea 1972; Munk 2001). Brown rockfish mature between 22 and 28 cm (2 to 5 yr) (Love and Johnson 1999). Brown rockfish spawn in June in Puget Sound and between December and January and/or May and June off central California (Love and Johnson 1999).

Data Quality/Quantity of Information

Robust: There is evidence of genetic differentiation to support multiple stocks for brown rockfish, which is supported by short larval durations, limited adult movement rates, and regional differences in spawning seasons..

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Calico rockfish (Sebastes dallii)

Species Information

Calico rockfish (*Sebastes dallii*) range from San Francisco, CA to Baja California, Mexico (Miller and Lea 1972). They can be found in nearshore rocky reefs and soft substrate from 18 to 256 m (Mearns 1979; Moser and Butler 1981). Adults are benthic and commonly found between 60 and 89 m (Love et al. 1990).

Assessment History

Calico rockfish have not yet been assessed in the California Current and no target frequency has been identified.

Genetics

There is no information about spatial variation in calico rockfish genetics.

Larval Dispersal

There is no information on dispersal distances for calico rockfish larvae.

Adult Movement

There is no information on movement rates of adult calico rockfish.

Other Life History Traits

Calico rockfish are one of the shortest-lived rockfish species, with a longevity of 12 yr (Heras et al. 2015; Love et al. 2002). They reach a maximum length of 25 cm (Smith 2001). Lengths-at-maturity for calico rockfish are 7 cm (first), 9 cm (50%), and 14 cm (100%) for males and 9 cm (first), 9 cm (50%), and 10 cm (100%) for females off southern California (Love et al. 1990). Calico rockfish spawn from January to May off northern California, with peak activity in February (Love et al. 1990). Juveniles show strong recruitment to the continental shelf in southern California (Mearns 1979).

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for calico rockfish.

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Chameleon rockfish (Sebastes phillipsi)

Species Information
Chameleon rockfish (*Sebastes phillipsi*) range from the Oregon-California border to the Santa Catalina Islands, CA but this may be an underestimate (Love et al. 2002). Chameleon rockfish are most abundant in rocky habitats from 174 to 275 m south of Point Conception, CA (Love et al. 2002).

Assessment History
Chameleon rockfish have not yet been assessed in the California Current and no target frequency has been identified.

Genetics
There is no information about spatial variation in calico rockfish genetics.

Larval Dispersal
There is no information on dispersal distances for chameleon rockfish larvae.

Adult Movement
There is no information on movement rates of adult chameleon rockfish.

Other Life History Traits
Chameleon rockfish live to 53 yr and reach a maximum length of 52 cm (Love et al. 2002). Young-of-the-year are found at depths to 275 m (Laidig and Watters 2023). There is no information about spatial variation in life history traits for chameleon rockfish.

Data Quality/Quantity of Information
Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for chameleon rockfish.

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China rockfish (Sebastes nebulosus)

Species Information
China rockfish (*Sebastes nebulosus*) range from Kodiak Island, AK to Redondo Beach, CA but are most common from British Columbia to central California (Johnson et al. 2003; Butler, et al. 2012). They are demersal, solitary, and occupy complex habitats with high relief structures such as boulder fields and kelp beds (Johnson et al. 2003; Hannah and Rankin 2011; Butler et al. 2012). China rockfish can be found between 3 and 128 m but are most common > 10 m (Eschmeyer et al. 1983).

Assessment History
A data-moderate assessment for China rockfish was conducted in 2013 (Cope et al. 2015). Two models were constructed to account for regional differences in biomass and exploitation rates: one north and one south of 40° 10` N (Cope et al. 2015). A benchmark assessment was conducted in 2015 and involved three models based on regional differences in catch histories, length compositions, and growth rates of China rockfish: Washington, north of 40° 10` N to the Oregon-Washington border,

and south of 40° 10` N to the California-Mexico border (Dick et al. 2016). China rockfish has a target assessment frequency of 8 yr (PFMC 2024).

Genetics

There is no available information on spatial variation in China rockfish genetics.

Larval Dispersal

Evidence suggests that larvae are dispersed by nearshore ocean currents (Avila 2022). There is no information about dispersal distances of China rockfish larvae.

Adult Movement

China rockfish adults show high site fidelity and home ranges < 6.8 km^2 (Hannah and Rankin 2011; Calvanese 2016).

Other Life History Traits

China rockfish live to 78 yr (Munk 2001) and reach a maximum length of 45 cm (Love et al. 2002). Individuals north of 40° 10` N tend to be smaller (≤ 35 cm) than those to the south (≤ 48 cm) (Cope et al. 2015). Lengths-at-maturity for China rockfish are 26 cm (first; 3 yr), 27 cm (50%; 4 yr), and 30 cm (100%; 6 yr) (Wyllie Echeverria 1987; Lea et al. 1999; Love and Johnson 1999). China rockfish release larvae in April and May (Cope et al. 2015).

Data Quality/Quantity of Information

Limited: There is insufficient information on genetics for China rockfish. There is also support for regional differences in catch histories, length compositions, and growth rates of China rockfish.

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Cowcod (Sebastes levis)

Species Information

Cowcod (*Sebastes levis*) range from Newport, OR to central Baja California, Mexico and are relatively abundant south of Cape Mendocino, CA (Moser et al. 1994). Cowcod are considered transitional (i.e., residing several meters above the seafloor and along the bottom) (Love et al. 1990). Adult cowcod are most common near rocky substrate in deeper waters (> 150 m), whereas juveniles occupy shallower, sandy habitats (Butler et al. 2002). Young-of-the-year are found between 52 and 277 m (Butler et al. 2002; Love and Yoklavich 2008).

Assessment History

Cowcod were assessed south of Point Conception, CA in 2005, 2007, 2009, 2011, 2013, and 2019 (Piner et al. 2005; Dick et al. 2007, 2009; Simon et al. 2011; Dick and MacCall 2014; Dick and He 2019). These assessments assumed a single, well-mixed stock with little to no movement. Cowcod were declared overfished in 2000 (Dick and MacCall 2014) and rebuilding analyses were conducted in 2005, 2007, 2009, and 2013 (Piner 2005; Dick and Ralston 2007; Dick and Ralston 2009; Dick and MacCall 2014). Cowcod has a target assessment frequency of 10 yr (PFMC 2024).

Genetics

Microsatellite and mtDNA data suggest as many as three genetically distinct lineages of cowcod off California: one north of Point Conception and two south of Point Conception (Hess et al. 2014). The northern lineage can be found along the Southern California Bight, suggesting some degree of mixing (Hess et al. 2014). The two southern lineages showed no evidence of depth stratification or spatial structure (Hess et al. 2014). Point Conception serves as a potential stock boundary, though higher spatial resolution data are needed for confirmation (Hess et al. 2014; Dick and He 2019).

Larval Dispersal

Cowcod larvae are found in the water column from November to June off southern California (Moser et al. 2000). Juveniles tend to settle 100 d after parturition (Johnson et al. 2001). There is no information on dispersal distances of cowcod larvae.

Adult Movement

There is no information on movement rates of adult cowcod.

Other Life History Traits

Cowcod live to 55 yr (Cailliet et al. 2001; Dick et al. 2019) and reach a maximum length of 94 cm (Love et al. 2002). Lengths-at-maturity for cowcod are 34 cm (first), 44 cm (50%), and 48 cm (100%) for males and 42 cm (first), 43 cm (50%), and 52 cm (100%) for females off southern California (Love et al. 1990). Cowcod spawn from November to May, with peak activity in December off northern California and in January off southern California (Love et al. 1990). There is evidence of multiple broods in larger individuals off southern California (Love et al. 1990).

Data Quality/Quantity of Information

Robust: There is some evidence of spatial variation in cowcod genetics and regional differences in spawning activity. There is no information about larval dispersal or adult movement rates of cowcod.

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Darkblotched rockfish (Sebastes crameri)

Species Information

Darkblotched rockfish (*Sebastes crameri*) range from the Aleutian Islands to Laguna Beach, CA but are most common from Yakutat, AK to Catalina Island, CA (Love et al. 2002; Wallace and Gertseva 2017). Survey-based indices of abundance suggest similar biomass densities of darkblotched rockfish off California, Oregon, and Washington. Exceptions were in 2005, when densities increased south to north, and in 2016, when exceptionally high densities were observed off Oregon (Wetzel and Hastie 2022). Darkblotched rockfish are demersal and typically occupy depths between 25 to 915 m, over boulder and cobble habitats (Love et al. 2002). They are rarely seen in underwater surveys, so little is known about their habits (Love et al. 2002; Wallace and Gertseva 2017). Larvae and juveniles have been observed in relatively shallow waters and tend to move into deeper water as they grow (Frey et al. 2015; Wallace and Gertseva 2017). Spatially-distinct and temporally-variable hotspots of juvenile darkblotched rockfish have been observed along the US West Coast (Tolimieri et al. 2020).

Assessment History

Darkblotched rockfish was initially assessed and declared overfished in 2000 (Rogers 2005a). Prior to this assessment, darkblotched rockfish were managed as part of the *Sebastes* complex (Rogers 2005a). Benchmark assessments were conducted at the coastwide scale in 2000, 2005, 2007, 2013, and 2015 (Rogers 2005a; Hamel 2007a; Gertseva and Thorson 2013; Gertseva et al. 2015). Update assessments were completed in 2009, 2011, and 2017 (Wallace and Hamel 2009; Stephens et al. 2011; Wallace and Gertseva 2017). Rebuilding analyses were conducted in 2003, 2005, 2007, 2009, and 2011 (PFMC 2003; Rogers 2005b; Hamel 2007b; Wallace 2009; Stephens 2011). Darkblotched rockfish has a target assessment frequency of 10 yr (PFMC 2024).

Genetics

There is some evidence of genetic isolation by distance for darkblotched rockfish (Gomez-Uchida and Banks 2005; Berntson and Moran 2009). Darkblotched rockfish genetics differ from Washington to northern California, with northern and southern regions displaying lower levels of heterozygosity (Gomez-Uchida and Banks 2005). However, genetic differentiation was low, supported by only three loci, and limited by sample sizes (Gomez-Uchida and Banks 2005).Larval Dispersal

Despite having planktonic larvae with relatively long durations, dispersal of darkblotched rockfish is thought to be < 1 km (Love at al 2002; Gomez-Uchida and Banks 2005).

Adult Movement

There is no information on movement rates of adult darkblotched rockfish.

Other Life History Traits

Darkblotched rockfish have been aged to 48 yr along the US West Coast and 105 yr north of the US-Canada border (Love et al. 2002; Wallace and Gertseva 2017). The maximum length for darkblotched rockfish is 58 cm (Archibald et al. 1981). Growth rates are similar along the US West Coast, except for darkblotched rockfish collected between Cape Mendocino, CA and Cape Blanco, OR, which tend to be smaller (Gertseva et al. 2017). Female darkblotched rockfish reach 50% maturity at 30 cm (6 yr) (Frey et al. 2015). The previous estimate was 34 cm (8 yr) (Nichol and Pikitch 1994). A greater proportion of mature females have been observed north of 44° N (Frey et al. 2015). Spawning takes place from August to December, fertilization occurs between December and March, and parturition is from December through March (Nichol and Pikitch 1994).

Data Quality/Quantity of Information

Limited: There is some evidence of genetic differences among darkblotched rockfish, spatial variation in life history traits, and limited larval dispersal for darkblotched rockfish.

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[Light] dusky rockfish (Sebastes ~~ciliatus~~ variabilis)

Species Information

Two rockfish species were previously referred to as "dusky rockfish." *Sebastes ciliatus* is now identified as dark rockfish and *S. variabilis* has the common name light dusky rockfish. Together, this species complex ranges from Japan to the Aleutian Islands and south to Johnstone Strait in British Columbia; they are most abundant in the Gulf of Alaska (Love et al. 2002; Orr and Blackburn 2004). The distribution of light dusky rockfish extends into central Oregon (Orr and Blackburn 2004). As such, light dusky rockfish is the species that is of interest to the Pacific Fishery Management Council. Dark rockfish are relatively shallow, occupying depths < 160 m, whereas light dusky rockfish tend to be found deeper up to 675 m (Orr and Blackburn 2004; Lunsford et al. 2004). Both are associated with hard, rocky substrates (Lunsford et al. 2011). Juvenile light dusky rockfish are pelagic, found in shallower waters, and tend to move deeper with age (Orr and Blackburn 2004; Lunsford et al. 2011).

Assessment History

Light dusky rockfish have not yet been assessed in the California Current and no target frequency has been identified. Light dusky rockfish are regularly assessed in the Gulf of Alaska (Lunsford et al. 2011; Fenske et al. 2018; Williams et al. 2021; Omori and Williams 2023). Prior to 2011, light dusky rockfish were included as part of the pelagic shelf rockfish complex in the Gulf of Alaska (Clausen et al. 2003; Reuter and Spencer 2008).

Genetics

Phylogenetic differences between dark rockfish (*S. ciliatus*) and light dusky rockfish (*S. variabilis*) were used to delineate the two species (Orr and Blackburn 2004). The complete mitogenomes of dark and light dusky rockfishes are very similar, with only 0.5% divergence between them (Searle et al. 2023). There is no information about spatial variation in light dusky rockfish genetics.

Larval Dispersal

There is no information on dispersal distances of light dusky rockfish larvae.

Adult Movement

There is no information on movement rates of adult light dusky rockfish.

Other Life History Traits

Light dusky rockfish live to 67 yr (Munk 2001; Chilton 2010) and reach a maximum length of 53 cm (Love et al. 2002). Light dusky rockfish reach 50% maturity at 43 cm and 11 yr (Chilton 2010). There is no information about spatial variation in life history traits of light dusky rockfish.

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for light dusky rockfish.

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Dwarf-red rockfish (Sebastes rufinanus)

Species Information

Dwarf-red rockfish (Sebastes rufinanus) range from southern California to San Clemente Island, CA (Love et al. 1990; Love 2011). They occupy offshore high relief habitats from 98 to 217 m (Love et al. 2022) and form large aggregations near the bottom (Love 2011). There is very little information available for dwarf-red rockfish.

Assessment History
Dwarf-red rockfish have not yet been assessed in the California Current and no target frequency has been identified.

Genetics
There is no information about spatial variation in dwarf-red rockfish genetics.

Larval Dispersal
There is no information on dispersal distances for dwarf-red rockfish larvae.

Adult Movement
There is no information on movement rates of adult dwarf-red rockfish.

Other Life History Traits
Dwarf-red rockfish reach a maximum length of 17 cm (Love 2011). Maximum age is unknown. There is no information about spatial variation in life history traits for dwarf-red rockfish.

Data Quality/Quantity of Information
Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for dwarf-red rockfish.

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Flag rockfish (Sebastes rubrivinctus)

Species Information
Flag rockfish (*Sebastes rubrivinctus*) range from Heceta Bank, OR to Baja California, Mexico (Phillips 1957; Heyamoto and Hitz 1962; Westrheim 1965; Edwards et al. 2017). Due to similarities in coloration, flag rockfish are often confused with redbanded rockfish *(S. babcocki*). Flag rockfish previously reported north of Heceta Bank were likely misidentified redbanded rockfish (Love 1996; Edwards et al. 2017; McCain et al. 2019). Flag rockfish are most commonly found between 30 and 183 meters (Orr et al. 2000; McCain et al. 2019). Juveniles are occupy more shallow waters and move deeper as they grow (Love 1996). They are often found on their own and are considered a solitary species (Love et al. 2006). Juveniles are often found at the surface, far from the coast (McCain et al. 2019).

Assessment History
Flag rockfish have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 8 yr (PFMC 2024).

Genetics
Flag rockfish are closely related to redbanded rockfish, tiger rockfish (*S. nigrocinctus*), and treefish (*S. serriceps*) (Love et al. 2002). There is no information about spatial variation in flag rockfish genetics.

Larval Dispersal
There is no information on dispersal distances of flag rockfish larvae.

Adult Movement
Acoustic telemetry data suggest that flag rockfish exhibit relatively high site fidelity (Hanan and Curry 2012). In the Santa Barbara Channel, > 61% of flag rockfish showed high site fidelity to oil platforms (Lowe et al. 2009). Adults are generally solitary but can sometimes be found in small aggregations (Love et al. 2002). Immature flag rockfish are common from 75 to 79 m off southern California (Love et al. 2006; Laidig et al. 2009). Adults can be found in rocky habitats and submarine canyons.

Other Life History Traits
Flag rockfish live to 18 yr and reach a maximum length of 51 cm (Love 1996; Love et al. 2002). They reach 50% maturity at 38 cm off California (Love 1996; McCain et al. 2019). Flag rockfish spawn from March to June off southern California, July to August off northern California, and April to May off Oregon (Kendall and Lenarz 1987; McCain et al. 2019).

Data Quality/Quantity of Information
Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for flag rockfish.

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Freckled rockfish (Sebastes lentiginosus)

Species Information

Freckled rockfish (*Sebastes lentiginosus*) range from Eureka, CA and to the Southern California Bight (Harms et al. 2008; Love et al. 2019). Freckled rockfish are most common in warmer waters . from 94 to 200 m (Love et al. 1990; Love et al. 2002).

Assessment History

Freckled rockfish have not yet been assessed in the California Current and no target frequency has been identified.

Genetics

There is no information about spatial variation in freckled rockfish genetics.

Larval Dispersal

There is no information on dispersal distances for freckled rockfish larvae.

Adult Movement

There is no information on adult movement for freckled rockfish.

Other Life History Traits

Freckled rockfish live to 22 yr and reach a maximum length of 23 cm (Love et al. 2002). There is no information about spatial variation in life history traits for freckled rockfish.

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for freckled rockfish.

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Grass rockfish (Sebastes rastrelliger)

Species Information

Grass rockfish (*Sebastes rastrelliger*) range from Oregon to Baja California, Mexico (Miller and Lea 1972). They are benthic-associated and generally found nearshore. Grass rockfish abundances decreased in the California Current from 1980 to 1990, a time period characterized by weaker upwelling, downwelling, and relatively warm waters (Jarvis et al. 2004). More recent abundance trends are not available.

Assessment History
Grass rockfish have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 6 yr (PFMC 2024).

Genetics
There is some evidence to support genetic isolation by distance for grass rockfish, which may have resulted from high larval retention nearshore (Buonaccorsi et al. 2004; Berntson and Moran 2009). Allele frequencies off California showed little heterogeneity but significant differences among geographic locations (Buonaccorsi et al. 2004; Berntson and Moran 2009). There is also a high correlation between genetic and geographic distances off Oregon, with multidimensional scaling (MDS) analysis illustrating cohesion among adjacent sample sites. Estimates of genetic differences using global and pairwise FST (the proportion of genetic variance within a subpopulation relative to total genetic variance) and population clustering provide support for high gene flow across their range (Martinez et al. 2017).

Larval Dispersal
Mean dispersal distances are estimated at 11 km (Buonaccorsi et al. 2004). Genetic isolation by distance has been used to infer limited larval dispersal (Buonaccorsi et al. 2004).

Adult Movement
There is little information on movement rates of adult grass rockfish. Available data suggest very small home ranges and/or high site fidelity (Hartmann 1987).

Other Life History Traits
Grass rockfish live to 23 yr and reach a maximum length of 56 cm (Love and Johnson 1998). Lengths-at-maturity for grass rockfish are 22 cm (first), 24 to 25 cm (50%), and 28 cm (100%) (Love and Johnson 1998). Grass rockfish spawn from January to March, with peak activity in January (Love and Johnson 1998). Females tend to have a 6 month(s) resting stage (Love and Johnson 1998). There is no information on spatial differences in life history traits of grass rockfish.

Data Quality/Quantity of Information
Limited: There is some evidence of limited larval dispersal and genetic differences among grass rockfish but insufficient information about adult movement rates or spatial variation in life history.

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Greenblotched rockfish (Sebastes rosenblatti)

Species Information

Greenblotched rockfish (*Sebastes rosenblatti*) range from Point Delgada, CA to Baja California, Mexico (Love et al. 2002). Abundances tend to increase with decreasing latitude. Greenblotched rockfish occupy benthic habitats from 75 to 250 m (Love et al. 1990). Adults are typically found > 210 m and juveniles reside in slightly shallower waters (Love et al. 1990).

Assessment History

Greenblotched rockfish have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 6 yr (PFMC 2024).

Genetics

Greenblotched rockfish are closely related to greenspotted rockfish (*S. chlorostictus*) (Hyde and Vetter 2007; Olivares-Zambrano et al. 2022). There is no information about spatial variation in greenblotched rockfish genetics.

Larval Dispersal

There is no information on dispersal distances for greenblotched rockfish larvae.

Adult Movement

There is no information on movement rates of adult greenblotched rockfish.

Other Life History Traits

Greenblotched rockfish live to 50 yr and reach a maximum length of 48 cm (Cailliet et al. 2001; Love et al. 2002). Lengths-at-maturity for greenblotched rockfish off southern California are 23 cm (first), 30 cm (50%), and 32 cm (100%) for males and 16 cm (first), 28 cm (50%), and 34 cm (100%) for females off southern California (Love et al. 1990). Greenblotched rockfish spawn from December to July off southern California, with peak activity in April (Love et al. 1990). There is no information about spatial variation in life history traits of greenblotched rockfish.

Data Quality/Quantity of Information

<u>Insufficient:</u> There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for greenblotched rockfish.

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Greenspotted rockfish (Sebastes chlorostictus)

Species Information

Greenspotted rockfish (*Sebastes chlorostictus*) range from Copalis Head, WA to Baja California, Mexico and are most abundant south of Mendocino, CA (Dick et al. 2011). Survey-based indices of abundance suggest increasing biomass densities of greenspotted rockfish from Washington to California (Wetzel and Hastie 2022).Although greenspotted rockfish reside in Mexican waters, the relationship between US and Mexico populations is unclear (Matson et al. 2011). Greenspotted rockfish are benthic-associated, with juveniles occupying 30 to 220 m and adults found slightly in deeper waters (Love et al. 1990; Orr et al. 2000; Starr et al. 2002; Love et al. 2009).

Assessment History

An age-structured model for greenspotted rockfish was developed to evaluate its performance relative to data-poor, length-based assessment methods (Dick et al. 2009; Jiao 2009). A benchmark assessment was conducted in 2011 (Dick et al. 2011; Matson et al. 2011). Regional differences in growth and exploitation histories prompted the use of two models separated by Point Conception, CA (Dick et al. 2011; Matson et al. 2011). Greenspotted rockfish has a target assessment frequency of 10 yr (PFMC 2024).

Genetics

Molecular systematic studies show evidence that greenspotted rockfish are closely related to pink rockfish (*S. eos*) and greenblotched rockfish (*S. rosenbatti*) (Hyde and Vetter 2007; Olivares-Zambrano et al. 2022). There is no information about spatial variation in greenspotted rockfish genetics.

Larval Dispersal

Positive species identifications are difficult for pelagic larvae and juvenile greenspotted rockfish (Benet et al. 2009). There is no information on dispersal distances for greenspotted rockfish larvae

Adult Movement

Greenspotted rockfish have a home range of 0.58 to 1.6 km^2, typically move horizontally, and exhibit almost no vertical movement (Starr et al. 2002). Acoustic tagging suggests that greenspotted rockfish are relatively sedentary and spend approximately 94% of their time within an area of 0.58 km^2 (Starr et al. 2002).

Other Life History Traits

Greenspotted rockfish live to 33 yr and reach a maximum length of 50 cm (Eschmeyer et al. 1983). Greenspotted rockfish females reach 50% maturity at 26 cm off northern California (Benet et al. 2009). Lengths-at-maturity for greenspotted rockfish off southern California are 20 cm (first), 22 cm (50%), and 28 cm (100%) for males and 15 cm (first), 22 cm (50%), and 32 cm (100%) for females (Love et al. 1990). Greenspotted rockfish spawn from March to September off northern and central California, with peak parturition between April and June (Wyllie Echeverria 1987; Dick et al. 2011). The spawning period off southern California is briefer, ranging from February to July, with peak activity in April (Love et al. 1990). There is evidence of multiple broods off southern California (Love et al. 1990).

Data Quality/Quantity of Information

Limited: There is no information on genetic variation, larval dispersal, or adult movement rates with which to assess stock structure for greenspotted rockfish. There is, however, evidence of spatial differences in growth, spawning activity, and exploitation histories.

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Greenstriped rockfish (Sebastes elongatus)

Species Information

Greenstriped rockfish (*Sebastes elongatus*) range from Chirikof Island in the Aleutian Islands to central Baja California, Mexico but are most abundant from British Columbia south (Shaw and Gunderson 2006; Hicks et al. 2009). Greenstriped rockfish in Puget Sound represent a distinct population segment (DPS) (Drake et al. 2010). Survey-based indices of abundance suggest similar biomass densities of greenstriped rockfish off Oregon and Washington and slightly lesser densities off California (Wetzel and Hastie 2022). Greenstriped rockfish are considered transitional (i.e., residing several meters above the seafloor and along the bottom), occurring over mud, sand, cobble, boulder, and mixed rock habitats from 12 to 500 m (Stein et al. 1992; Drake et al. 2010). Juveniles reside in shallower waters and move deeper (> 150 m) with age (Love et al. 1990; Love 2002; Keller et al. 2012). Juveniles and adults commingle between 100 and 250 m (Love et al. 2009).

Assessment History

The first and only benchmark assessment for greenstriped rockfish was conducted at the coastwide scale in 2009 (Hicks et al. 2009). Although life history data were insufficient to support a spatially-structured assessment, trawl survey data were used to separate northern (Oregon-Washington) and southern (California) models (Hicks et al. 2009). Greenstriped rockfish has a target assessment frequency of 8 yr (PFMC 2024).

Genetics
There is no information about spatial variation in greenstriped rockfish genetics.

Larval Dispersal
There is no information on dispersal distances of greenstriped rockfish larvae.

Adult Movement
There is no information on movement rates of adult greenstriped rockfish.

Other Life History Traits
Greenstriped rockfish live to 54 yr (Munk 2001; Shaw and Gunderson 2006) and reach a maximum length of 47 cm (Love et al. 2002). Growth rates tend to decrease from north to south along the US West Coast, with older and larger individuals found off Washington (Keller et al. 2012). Greenstriped rockfish have a higher length-to-weight ratio north of Cape Mendocino, CA (Keller et al. 2012). Lengths-at-maturity for greenstriped rockfish are 15 cm (first), 18 cm (50%), and 26 cm (100%) for males and 16 cm (first), 19 cm (50%), and 25 cm (100%) for females off southern California (Love et al. 1990). Greenstriped rockfish spawn from January to July, with peak activity in April off northern California and May off southern California (Love et al. 1990). They generally reproduce once per year, though there is evidence to suggest multiple broods off southern California (Love et al. 1990; Shaw and Gunderson 2006).

Data Quality/Quantity of Information
Limited: There is some degree of spatial variation in size, age, and biomass but no information about genetic variation throughout the range of greenstriped rockfish.

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Halfbanded rockfish (Sebastes semicinctus)

Species Information

Halfbanded rockfish (*Sebastes semicinctus*) range from northern Washington to central Baja California, Mexico and are abundant south of central California (Love et al. 2002). Halfbanded rockfish is a midwater species that occupies depths from 15 to 402 m (Love et al. 2009). Most individuals along the Southern California Bight occupy depths from 10 to 290 m (Love et al. 2009). Adults frequent boulder fields and high relief habitats (Love et al. 2002). Juveniles recruit to low relief rock or sand and shell mounds surrounding oil platforms.

Assessment History

Halfbanded rockfish have not yet been assessed in the California Current and no target frequency has been identified.

Genetics

Halfbanded rockfish are most closely related to stripetail rockfish (*S. saxicola*) (Li et al. 2005). There is no information about spatial variation in halfbanded rockfish genetics.

Larval Dispersal

There is no information on dispersal distances for halfbanded rockfish larvae.

Adult Movement

There is no information on movement rates of adult halfbanded rockfish.

Other Life History Traits

Halfbanded rockfish live to 15 yr and reach a maximum length of 25 cm (Shanks and Ebert 2005). Lengths-at-maturity for off southern California are 10 cm (first), 11 cm (50%), and 15 cm (100%) for males and 10 cm (first), 11 cm (50%), and 14 cm (100%) for females (Love et al. 1990). Halfbanded rockfish spawn from December to March off southern California, with peak activity in February (Love et al. 1990). Young-of-the-year recruit to kelp beds at 220 m beginning in May (Love et al. 1990).

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for halfbanded rockfish.

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Harlequin rockfish (Sebastes variegatus)

Species Information

Harlequin rockfish (*Sebastes variegatus*) range from the Bering Sea and Aleutian Islands to Bowers Bank, OR and are most abundant in the Aleutian Islands (TenBrink et al. 2023). They tend to occupy high relief reef habitats between 5 and 558 m, with adults residing in deeper, colder waters (Love 2011; TenBrink and Helser 2021).

Assessment History

Harlequin rockfish have not yet been assessed in the California Current and no target frequency has been identified. Harlequin rockfish is assessed and managed as part of the other rockfish complex in the Bering Sea and Aleutian Islands (Sullivan et al. 2022).

Genetics

There is no information about spatial variation in harlequin rockfish genetics.

Larval Dispersal

Harlequin rockfish may use coral as nursery habitat in the western Gulf of Alaska (Wilborn et al. 2022). There is no information on dispersal distances for harlequin rockfish larvae.

Adult Movement

There is no information on movement rates of adult harlequin rockfish.

Other Life History Traits

Harlequin rockfish have been aged to 43 yr in British Columbia (Munk 2001) and 79 yr in the Aleutian Islands (TenBrink et al. 2023). They reach a maximum length of 38 cm (Love et al. 2002). Growth rates for Harlequin rockfish increase from east to west in the Gulf of Alaska (TenBrink et al. 2023). Females reach 50% maturity at 188 cm (5 yr) in the Gulf of Alaska (TenBrink and Helser 2021). Spawning and parturition take place in spring and summer (TenBrink and Helser 2021).

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, and adult movement rates with which to assess stock structure for harlequin rockfish. There is evidence of spatial variation in life history traits for harlequin rockfish in the Gulf of Alaska (TenBrink and Helser 2021; TenBrink et al. 2023) but comparable information is unavailable for the California Current.

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Honeycomb rockfish (Sebastes umbrosus)

Species Information
Honeycomb rockfish (*Sebastes umbrosus*) range from Point Pinos, CA to Baja California, Mexico and are most abundant south of Point Dume, CA (Love et al. 2002). They are found in boulder field habitats between 30 and 270 m (Love et al. 2002). Honeycomb rockfish are considered dwarf species because they are relatively small-bodied and short-lived (Love and Johnson 1998).

Assessment History
Honeycomb rockfish have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 8 yr (PFMC 2024).

Genetics
There is no information about spatial variation in honeycomb rockfish genetics.

Larval Dispersal
There is no information on dispersal distances for honeycomb rockfish larvae.

Adult Movement
There is no information on movement rates of adult honeycomb rockfish.

Other Life History Traits
Honeycomb rockfish live to 31 yr and reach a maximum length of 30 cm (Love et al. 2002). There are no sex-specific differences in growth rates for honeycomb rockfish (Chen 1971). They reach 50% maturity at 15 cm and 100% maturity at 18 cm (Love et al. 2002). They spawn from March to July (Love et al. 2002). There is no information about spatial variation in life history traits for honeycomb rockfish.

Data Quality/Quantity of Information
<u>Insufficient:</u> There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for honeycomb rockfish.

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Kelp rockfish (Sebastes atrovirens)

Species Information
Kelp rockfish (*Sebastes atrovirens*) range from Timber Cove, CA to Baja California, Mexico (Miller and Lea 1972; Love 2011). They are found nearshore, associated with rocky reefs and kelp forests, and occupy surface waters to 300 m (Miller and Lea 1972; Baetscher et al. 2019). Kelp rockfish exhibit the greatest densities near Point Conception, CA and are most common shallower than 24 m (Love 2011; Hamilton et al. 2021).

Assessment History
Kelp rockfish have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 6 yr (PFMC 2024).

Genetics
There is conflicting information about spatial variation in kelp rockfish genetics. Taylor (2004) found isolation by distance among kelp rockfish off southern California, whereas Gilbert-Horvath et al. (2006) found no evidence of population structure despite sampling on either side of Point Conception, CA (Bertson and Moran 2009).

Larval Dispersal
The larval duration for kelp rockfish is approximately 108 d (Gilbert-Horvath et al. 2006). Kelp rockfish larvae recruit during periods of weaker upwelling, when coastal waters are relatively warm (Sivasundar and Palumbi 2010). There is some support for limited dispersal distances (0 to 25 km) that is controlled by nearshore oceanographic processes (Baetscher et al. 2019).

Adult Movement
Kelp rockfish exhibit small home ranges (3 to 6 m^2) and high site fidelity (Miller and Geible 1973; Van Dykhuizen 1983; Hartmann 1987; Lea et al. 1999).

Other Life History Traits
Kelp rockfish live to 25 yr and reach a maximum length of 43 cm (Love et al. 2002). Lengths-at-maturity for female kelp rockfish are 22 cm (first) and 26 cm (50%; 4 to 5 yr) (Romero 1988; Lea et al. 1999). Spawning takes place between February and June and produce one brood per year (Gilbert-Horvath et al. 2006). There is no information about spatial variation in life history traits of kelp rockfish.

Data Quality/Quantity of Information
Insufficient: There is conflicting information about genetic variation among kelp rockfish. Minimal larval dispersal and relatively small home ranges may limit population connectivity among kelp rockfish throughout their range. There is no information about spatial variation in life history traits.

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Mexican rockfish (Sebastes macdonaldi)

Species Information
Mexican rockfish range from Point Sur, CA to southern Baja California, but are most abundant south of the US-Mexico border (Eschmeyer et al. 1983; Love 2011). They are benthic-associated and found between 76 and 350 m (Love 2011). Juveniles are pelagic and settle to the bottom (Love 2011).

Assessment History
Mexican rockfish have not yet been assessed in the California Current and no target frequency has been identified.

Genetics
Microsatellite and PCR studies show no evidence of genetic differences for Mexican rockfish in Baja California and the Gulf of California (Bernardi et al. 2003; Rocha-Olivares et al. 2003; Berntson and Moran 2009).

Larval Dispersal
There is no information on dispersal distances of Mexican rockfish larvae.

Adult Movement
There is no information on movement rates of adult Mexican rockfish.

Other Life History Traits
Mexican rockfish are difficult to age and the oldest individual is estimated to be 20 yr (Love et al. 2002). Mexican rockfish reach a maximum length of 56 cm (Love et al. 2002). There is no information about spatial variation in life history traits for Mexican rockfish.

Data Quality/Quantity of Information
Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and/or adult movement rates with which to assess stock structure for Mexican rockfish.

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Olive rockfish (Sebastes serranoides)

Species Information
Olive rockfish (*Sebastes serranoides*) range from southern Oregon to central Baja California, Mexico (Love et al. 2002). They are relatively abundant from Cape Mendocino, CA to Santa Barbara, CA (Love et al. 2002). All life stages of olive rockfish occupy kelp forests and depths to 172 m (Love et al. 2002).

Assessment History
Olive rockfish have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 6 yr (PFMC 2024).

Genetics
Olive rockfish are most closely related to yellowtail rockfish (*S. flavidus*) (Wallace et al. 2022). A study using mtDNA and microsatellites found conflicting information about genetic variation among olive rockfish along the California coast (N_{cenCA} = 30 and N_{soCA} = 33; Sivasundar and Palumbi 2010).

Larval Dispersal
The pelagic larval duration for olive rockfish is between 3 and 6 month(s) (Love and Westphal 1981). There is no information on dispersal distances for olive rockfish larvae.

Adult Movement
Olive rockfish have a mean home range of 0.3 to 0.8 km^2 (Turner et al. 1969; Love 1980; Hartmann 1987; Bond et al. 1999; Hamilton et al. 2021). The majority of olive rockfish stay within 1 km^2, though the net movement of one mature individual was estimated at 510 km (Hanan and Curry 2012). Movements of olive rockfish are generally restricted to nearshore habitats and islands offshore of southern California (Love 1980; Hanan and Curry 2012).

Other Life History Traits
Olive rockfish live to 25 yr and reach a maximum length of 52 cm (Love et al. 2002). Olive rockfish mature at the same rates off of central and southern California (Love 1978; Love and Westphal 1981). Lengths-at-maturity for female olive rockfish are 31 cm (first; 3 yr) and 34 cm (50%; 4 yr). Lengths-at-maturity for male olive rockfish are 28 cm (first; 3 yr) and 32 cm (50%; 5 yr) (Love and Westphal 1981). Olive rockfish spawn from December to March, with peak activity in January (Love and Westphal 1981).

Data Quality/Quantity of Information
Insufficient: There is conflicting information about genetics, no estimate of larval dispersal, no evidence of spatial variation in life history traits, and potentially limited adult movement rates of olive rockfish.

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Pink rockfish (Sebastes eos)

Species Information

Pink rockfish (*Sebastes eos*) range from central Oregon to southern Baja California, Mexico (Love et al. 2002). Pink rockfish are relatively uncommon throughout their range, though they may have areas of greater abundance between southern California and northern Baja California from depths of 45 to 366 m (Love et al. 2002). Very little is known about this species.

Assessment History

Pink rockfish have not yet been assessed in the California Current and no target frequency has been identified.

Genetics

Molecular studies show that pink rockfish are closely related to greenspotted rockfish (*S. chlorostictus*) and greenblotched rockfish (*S. rosenblatti*) (Love et al. 2002). There is no information about spatial variation in pink rockfish genetics.

Larval Dispersal

There is no information on dispersal distances for pink rockfish larvae.

Adult Movement

There is no information on movement rates of adult pink rockfish.

Other Life History Traits

Pink rockfish are difficult to age. A 51 cm individual was estimated to be between 52 and 82 y; a 49 cm individual was estimated to be between 40 and 60 yr (Love et al. 2002). No maximum length has been reported. There is no information about spatial variation in life history traits for pink rockfish.

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for pink rockfish.

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Love MS, MM Yoklavich, and L Thorsteinson. 2002. The rockfishes of the Northeast Pacific. University of California Press. Berkeley and Los Angeles, CA. 406 pp.

Pinkrose rockfish (Sebastes simulator)

Species Information

Pinkrose rockfish (*S. simulator*) can be easily misidentified because of physical similarities to rosethorn rockfish (*S. helvomaculatus*) (Love et al. 2002). As a result, there is very little information about this species. Pinkrose rockfish may range from central California to central Baja California, Mexico and can be found up to 265 m (Love et al. 2002; Taylor et al. 2004).

Assessment History

Pinkrose rockfish have not yet been assessed in the California Current and no target frequency has been identified.

Genetics

Morphological data suggest that pinkrose rockfish are closely related to rosethorn rockfish (Love et al. 2002). There is no information about spatial variation in pinkrose rockfish genetics.

Larval Dispersal

There is no information on dispersal distances for pinkrose rockfish larvae.

Adult Movement

There is no information on movement rates of adult pinkrose rockfish.

Other Life History Traits

Few pinkrose rockfish have been aged, but the oldest individual was reported to be 53 yr (Love et al. 2002). Males reach 50% maturity at 17 cm and 100% at 23 cm (Love et al. 2018). Females reach 50% maturity at 14 cm and 100% maturity at 18 cm (Love et al. 2018). Pinkrose rockfish spawn from January to July (Love et al. 2018). There is no information about spatial variation in life history traits for pinkrose rockfish.

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for pinkrose rockfish.

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Puget Sound rockfish (Sebastes emphaeus)

Species Information

Puget Sound rockfish (*Sebastes emphaeus*) range from Prince William Sound, AK to northern California, though they are rare south of Washington (Love et al. 2002). Puget Sound rockfish occupy habitat on boulder fields or near ledges and caves from 3 to 366 m, inhabiting shallower waters (> 11

m) in summer and migrating to deeper waters (> 35 m) in winter (Love et al. 2002). Puget Sound rockfish are considered a dwarf species due to their relatively short lifespans and smaller body sizes (Magnuson-Ford et al. 2009).

Assessment History

Puget Sound rockfish have not yet been assessed in the California Current and no target frequency has been identified.

Genetics

A study using mtDNA found high genetic variation among Puget Sound rockfish but no location-based differences between the San Juan Islands and Puget Sound (N = 128; Sotka et al. 2005). There is no information about spatial variation in Puget Sound rockfish genetics off Oregon or California.

Larval Dispersal

There is no information on dispersal distances for Puget Sound rockfish larvae.

Adult Movement

There is no information on movement rates of adult Puget Sound rockfish.

Other Life History Traits

Puget Sound rockfish live to 22 yr and reach a maximum length of 18 cm (Love et al. 2002). Puget Sound rockfish spawn from June to August, with peak activity in July (Love et al. 2002). They reach 50% maturity at about 2 yr (Sotka et al. 2005). Maturation rates are not reported. There is no information about spatial variation in life history traits for Puget Sound rockfish.

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for Puget Sound rockfish.

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Pygmy rockfish (Sebastes wilsoni)

Species Information

Pygmy rockfish (*Sebastes wilsoni*) range from the Gulf of Alaska to southern California (Love et al. 2002). They are a dwarf species that form aggregations over rocks and soft substrate between 30 and 274 m (Stein et al. 1992; Yoklavich et al. 2000; Love et al. 2009; Martel 2020). Because pygmy rockfish they sometimes form aggregations with Puget Sound rockfish (*S. emphaeus*), with whom they closely resemble, they are sometimes included as part of a "pygmy/Puget Sound rockfish complex" (Hart et al. 2010).

Assessment History

Pygmy rockfish have not yet been assessed in the California Current and no target has been identified.

Genetics
There is no information about spatial variation in pygmy rockfish genetics.

Larval Dispersal
There is no information on dispersal distances for pygmy rockfish larvae.

Adult Movement
There is no information on movement rates of adult pygmy rockfish.

Other Life History Traits
Pygmy rockfish live to 26 yr, though longevity may be underestimated due to low sample sizes (Munk 2001). Pygmy rockfish reach a maximum length of 23 cm (Love et al. 2002). Larval and juvenile stages frequently occupy deeper and colder waters than other rockfishes, which may explain their relatively slow growth rates (0.28 mm day^{-1}) (Laidig et al. 2004). Maturation rates are not available and there is no information about spatial variation in life history traits for pygmy rockfish.

Data Quality/Quantity of Information
Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for pygmy rockfish.

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Pacific Ocean perch (Sebastes alutus)

Species Information
Pacific Ocean perch (POP; *Sebastes alutus*) range from the Bering Sea to central Baja California, Mexico (Eschmeyer et al. 1983; Wetzel et al. 2017a). They are most abundant in the Bering Sea and along the Aleutian Islands and sparsely encountered south of Oregon (Eschmeyer et al. 1983; Wetzel et al. 2017a). Survey-based indices of abundance suggest little to no biomass of Pacific Ocean perch south of 40° 10` N (Wetzel and Hastie 2022). POP are found in large aggregations near mixed sand and boulder habitats from the surface to 825 m but are most abundant in waters between 100 and 400

m (Wilkins and Golden 1983; Scott 1995). Juveniles occur in shallower waters (< 180 m), whereas adults are more commonly found > 180 m (Rooper et al. 2007; Love 2011).

Assessment History
POP has been routinely assessed in US waters since the late 1970s (Wetzel et al. 2017a). A 20-yr rebuilding plan was adopted in 1981 and formalized in 2001, following an overfished status designation (Punt and Ianelli 2001; Wetzel et al. 2017a). Stock assessments in 1992 and 1998 estimated a continued overfished status, thereby identifying the need for additional catch restrictions (Ianelli and Zimmerman 1998; Wetzel et al. 2017a). Benchmark assessments for POP were conducted at the coastwide scale in 2005, 2011, and 2017 (Hamel 2005a; Hamel and Ono 2011; Wetzel et al. 2017a, 2017b). Update assessments were completed in 2007 and 2009 (Hamel 2007a; 2009a). Subsequent rebuilding analyses were completed in 2003, 2005, 2007, 2009, and 2011b (PFMC 2003; Hamel 2005b; 2007b; 2009b; 2011). POP has a target assessment frequency of 8 yr (PFMC 2024).

Genetics
There is evidence of isolation by distance for POP (Wishard et al. 1980; Seeb and Gunderson 1988; Bertson and Moran 2009). There is also support for spatial variation in POP genetics throughout the Gulf of Alaska (Palof et al. 2011) and three known subpopulations off the coast of British Columbia that are separated by as little as 70 km (Withler et al. 2001). There is no information about spatial variation in POP genetics for the California Current.

Larval Dispersal
There is no information on dispersal distances of POP larvae.

Adult Movement
Adult POP migrations are confined to seasonal shifts in depth, where females move into deeper waters for parturition and return to shallower waters to feed (Seeb and Gunderson 1988).

Other Life History Traits
POP live to 105 yr and reach a maximum length of 53 cm (Kastelle et al. 2000; Munk 2001). Differences in size distributions, year-class strengths, and age-length relationships support the delineation of four subpopulations of POP in the North Pacific (Chikuni 1975). This includes: 1) an eastern Pacific stock that extends from British Columbia to California, 2) a Gulf of Alaska stock that does not mix with the eastern Pacific stock, 3) an Aleutian Islands stock that may be supported by larvae from the Gulf of Alaska, and 4) a Bering Sea stock that may be supported by larvae from the Gulf of Alaska and the Aleutian Islands (Chikuni 1975; Seeb and Gunderson 1988). POP mature from 20 to 35 cm (4 to 9 yr), with fish in the western Gulf of Alaska maturing faster than those in Southeast Alaska or British Columbia (Westrheim 1975). There is no information about the occurrence of subpopulations in the California Current (Wetzel et al. 2017a).

Data Quality/Quantity of Information
Limited: There is insufficient information on genetics, larval dispersal, adult movement rates, and/or spatial variation in life history traits with which to assess stock structure for POP in the California Current. There is, however, support for spatial population structure in other regions (via genetic differences and spatial variation in demography), which may warrant consideration of multiple stocks throughout their natural range.

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Redstripe rockfish (Sebastes proriger)

Species Information

Redstripe rockfish (*Sebastes proriger*) range from the Aleutian Islands to southern Baja California, Mexico, with relatively high abundances from Southeast Alaska to central Oregon (Love et al. 2002). Redstripe rockfish in Puget Sound represent a distinct population segment (DPS) (Drake et al. 2010). They can be solitary or form aggregations near rocky reefs and low relief cobble habitats (Drake et al. 2010). Redstripe rockfish occupy 12 to 425 m, with older individuals found at deeper depths (Moser and Boehlert 1991).

Assessment History

Redstripe rockfish have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 8 yr (PFMC 2024).

Genetics

There is no information about spatial variation in redbanded rockfish genetics.

Larval Dispersal

Redstripe rockfish have a pelagic larval duration of 2 month(s) (Moser 1996). There is no information on dispersal distances for redstripe rockfish larvae.

Adult Movement

Although they are thought to have high site fidelity (Drake et al. 2010), there is no information on movement rates of adult redstripe rockfish.

Other Life History Traits

Redstripe rockfish live to 55 yr (Cailliet et al. 2001) and reach a maximum length of 51 cm (Shaw 1999). Lengths-at-maturity for redstripe rockfish are 21 cm (first) and 24 cm (50%) for males; 22 cm (first) and 26 cm (50%) for females (Shaw 1999). Spawning takes place from April to May and parturition occurs in June (O'Connell 1987; Wyllie Echeverria 1987; Shaw 1999). There is no information about spatial variation in life history traits for redstripe rockfish.

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for redstripe rockfish.

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Rosethorn rockfish (Sebastes helvomaculatus)

Species Information

Rosethorn rockfish (*Sebastes helvomaculatus*) range from the western Gulf of Alaska to central Baja California, Mexico and in Puget Sound, WA (Yoklavich et al. 2000; Love et al. 2002). Survey-based indices of abundance suggest similar biomass densities of rosethorn rockfish from California to Washington except for a few years (e.g., 2013 and 2017) when estimates were greater off Oregon (Wetzel and Hastie 2022). Rosethorn rockfish is a benthic, solitary species that can be found near mud or hard substrate from 25 to 549 m (Love et al. 2002).

Assessment History

Rosethorn rockfish have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 10 yr (PFMC 2024).

Genetics

There is evidence to suggest environmental effects on rosethorn rockfish genetics, with a potential barrier to connectivity between Sitka, AK and Vancouver Island, Canada (Rocha-Olivares and Vetter 2009; Berntson and Moran 2009).

Larval Dispersal

There is no information on dispersal distances for rosethorn rockfish larvae.

Adult Movement

There is no information on movement rates of adult rosethorn rockfish.

Other Life History Traits

Rosethorn rockfish live to 87 yr and reach a maximum length of 41 cm (Love et al 2002). Rosethorn rockfish reach 50% maturity at 22 cm and 100% maturity at 27 cm (Love et al. 2002). There are no reported sex-differences in size at maturity. Rosethorn rockfish spawn between February and September, with peak activity from April to June (Love et al. 2002). There is no information about spatial variation in life history traits of rosethorn rockfish.

Data Quality/Quantity of Information

Insufficient: There is insufficient information on larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for rosethorn rockfish. There are, however, some data to suggest a genetic break in rosethorn rockfish genetics between Southeast Alaska and British Columbia, Canada.

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Rosy rockfish (Sebastes rosaceus)

Species Information

Rosy rockfish range from the Strait of Juan De Fuca, WA to southern Baja California, Mexico (27°30` N, 114°50` W) (Love 2011). They are benthic, associated with high relief rock and cobblestone substrate (Fields 2016). Rosy rockfish are generally found from 97 to 210 m, with adults being most common between 60 and 119 m (Love et al. 1990; Love et al. 2002).

Assessment History

Rosy rockfish have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 8 yr (PFMC 2024).

Genetics

There is no information about spatial variation in rosy rockfish genetics.

Larval Dispersal

There is no information on dispersal distances for rosy rockfish larvae.

Adult Movement

There is no information on movement rates of adult rosy rockfish.

Other Life History Traits

Rosy rockfish live to 30 yr and reach a maximum length of 36 cm, with older ages and higher mortality off central California (Wedding and Yoklavich 2015; Fields 2016). Lengths-at-maturity for rosy rockfish off southern California are 14 cm (first), 15 cm (50%), and 19 cm (100%) for males and 12 cm (first), 15 cm (50%), and 18 cm (100%) for females (Love et al. 1990). They spawn from January to July, with peak activity in May off southern California and June off northern California (Love et al. 1990). Rosy rockfish produce multiple broods per year, and rosy rockfish fecundity increases with maternal length (Love et al. 1990; Beyer et al. 2021).

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for rosy rockfish. This is, however, some indication of spatial variation in life history traits of rosy rockfish

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Sharpchin rockfish (Sebastes zacentrus)

Species Information

Sharpchin rockfish (*Sebastes zacentrus*) range from the Gulf of Alaska to San Diego, CA but are most abundant from Kodiak Island, AK to northern California (Love 2011; Cope et al. 2015). Survey-based indices of abundance suggest greater biomass densities of sharpchin rockfish off Oregon and similarly lesser biomass densities off Oregon and Washington (Wetzel and Hastie 2022). Sharpchin rockfish can occupy a variety of habitats, including high and low relief areas or mixed hard and soft substrate (Butler et al. 2012). They are typically associated with deep sea sponges from 25 to 300 m (Bosley et al. 2020) but can be found as deep as 650 m (Love 2011).

Assessment History

Sharpchin rockfish were managed as part of the slope rockfish complex until 2015, when a data-moderate assessment was conducted (Cope et al. 2015). Sharpchin rockfish has a target assessment frequency of 10 yr (PFMC 2024).

Genetics

There is no information about spatial variation in sharpchin rockfish genetics.

Larval Dispersal

There is no information on dispersal distances of sharpchin rockfish larvae.

Adult Movement

There is no information on movement rates of adult sharpchin rockfish.

Other Life History Traits

Sharpchin rockfish live to 58 yr and have a maximum length of 49 cm (Munk 2001; Cope et al. 2015). There is no information about spatial variation in life history traits for sharpchin rockfish..

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for sharpchin rockfish.

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Shortraker rockfish (Sebastes borealis)

Species Information
Shortraker rockfish (*Sebastes borealis*) range from Japan to the Gulf of Alaska and south to Point Conception (Orlov 2001; Love et al. 2002). They are abundant from Kamchatka Island, AK to British Columbia, near steep boulders, from 300 to 500 m, though shortraker rockfish can be found from 25 to 1200 m (Love et al. 2002).

Assessment History
Shortraker rockfish have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 10 yr (PFMC 2024). Shortraker rockfish are physically similar to rougheye rockfish (*S. aleutianus*); thus the two species are difficult to differentiate and often grouped (Clausen et al. 2003). Much of the data available for stock assessments also combine rougheye and shortraker rockfishes with blackspotted rockfish (Hicks et al. 2014).

Genetics
There is some evidence to suggest genetic variation among shortraker rockfish in Alaska, though not consistent with isolation by distance (Matala et al. 2004; Berntson and Moran 2009). There is no information about spatial variation in shortraker rockfish genetics in the California Current.

Larval Dispersal
There is no information on dispersal distances for shortraker rockfish larvae.

Adult Movement
There is no information on movement rates of adult shortraker rockfish.

Other Life History Traits
Shortraker rockfish live to 157 yr and reach a maximum length of 108 cm (Kastelle et al. 2000; Munk 2001). Fork length tends to decrease from east to west in the Gulf of Alaska and Aleutian Islands, suggesting that shortraker rockfish growth may be affected by localized conditions (Matala et al. 2004). In Southeast Alaska, length-at-50%-maturity is 34 cm for males and 37 cm for females. Both sexes reach 50% maturity at 45 cm off Vancouver Island, Canada (McDermott 1994). There is information about spatial variation in life history traits of shortraker rockfish in the California Current.

Data Quality/Quantity of Information
<u>Insufficient</u>: There is insufficient information on genetics, larval dispersal, and adult movement rates with which to assess stock structure for shortraker rockfish. There is some evidence of spatial variation and maturation rates in growth in Alaskan waters.

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Silvergray rockfish (Sebastes brevispinis)

Species Information

Silvergray rockfish (*Sebastes brevispinis*) range from the western Gulf of Alaska to central Baja California, Mexico but are most abundant in Southeast Alaska and British Columbia (Love et al. 2002; Clausen 2009). Silvergray rockfish can be found from the surface to 436 m, with juveniles most commonly encountered in kelp beds and adults over rocky substrate (Love et al. 2002). Adults typically form loose aggregations with other rockfish species (Love et al. 2002). Silvergray rockfish tend to occupy shallower depths (< 200 m) during summer (Stanley and Kronlund 2005).

Assessment History

Silvergray rockfish have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 10 yr (PFMC 2024). Silvergray rockfish are assessed as part of the other rockfish complex in the Gulf of Alaska and Canada (Clausen 2007; Clausen 2009; Starr et al. 2016).

Genetics

There is no information about spatial variation in silvergray rockfish genetics.

Larval Dispersal

There is no information on dispersal distances for silvergray rockfish larvae.

Adult Movement

There is no information on movement rates of adult silvergray rockfish.

Other Life History Traits

Silvergray rockfish live to 82 yr (Stanley and Kronlund 2005) and reach a maximum length of 71 cm (Mecklenburg et al. 2002). Lengths-at-maturity for silvergray rockfish are 43 cm (50%; 9 yr) and 50 cm (100%; 20 yr) for males and 46 cm (50%; 10 to 11 yr) and 57 cm (100%; 30 yr) for females in

British Columbia (Stanley and Kronlund 2005). Peak parturition occurs in late spring in the Gulf of Alaska and late summer from British Columbia to Oregon (Stanley and Kronlund 2005

Data Quality/Quantity of Information

Insufficient: There is, however, some indication of spatial variation in spawning activity for silvergray rockfish.

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Speckled rockfish (Sebastes ovalis)

Species Information

Speckled rockfish (*Sebastes ovalis*) range from northern Washington to central Baja California, Mexico (Love et al. 2002; Love et al. 2022). The greatest abundances are located off southern California. Speckled rockfish is a midwater species that typically forms aggregations at depths from 93 to 210 m (Love et al. 2002). Adults are most common in boulder fields and bedrock habitats between 90 and 149 m (Love et al. 1990; Love et al. 2002; Rooper et al. 2020).

Assessment History

Speckled rockfish have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 8 yr (PFMC 2024).

Genetics

There is no information about spatial variation in speckled rockfish genetics.

Larval Dispersal

Larval distributions tend to reflect areas of known adult habitat (Taylor et al. 2004). There is, however, no information on dispersal distances for speckled rockfish larvae.

Adult Movement

There is no information on movement rates of adult speckled rockfish.

Other Life History Traits

Speckled rockfish live to 37 yr (Cailliet et al. 2001) and reach a maximum length of 56 cm (Love et al. 2002). Lengths-at-maturity for speckled rockfish off southern California are 23 cm (first), 24 cm (50%), and 29 cm (100%) for males and 24 cm (first), 25 cm (50%), and 32 cm (100%) for females

(Love et al. 1990). Speckled rockfish spawn from October to May, with peak activity in January and February off southern California and in May off northern California (Love et al. 1990).

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, and adult movement rates with which to assess stock structure for speckled rockfish. There is, however, indication of spatial variation in spawning activity of speckled rockfish..

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Splitnose rockfish (Sebastes diploproa)

Species Information

Splitnose rockfish (*Sebastes diploproa*) range from the western Gulf of Alaska to Baja California, Mexico (Boehlert 1978). Survey-based indices of abundance suggest greater biomass densities of splitnose rockfish south of 40° 10` N (Wetzel and Hastie 2022). Splitnose rockfish are often associated with low-relief mud fields, isolated rock, cobble, or shell debris (Gertseva et al. 2009). They occupy depths from 150 to 795 m and tend to move into deeper waters as they age (Ottmann et al. 2019). Relatively high juvenile densities of splitnose rockfish have been noted near Santa Catalina Island and San Diego, CA (Tolimieri et al. 2020

Assessment History

A benchmark assessment for splitnose rockfish was conducted at the coastwide scale in 2009 (Cook et al. 2009; Gertseva et al. 2009). Splitnose rockfish has a target assessment frequency of 10 yr (PFMC 2024).

Genetics

There is no information about spatial variation in splitnose rockfish genetics.

Larval Dispersal

The larval duration for splitnose rockfish extends up to 1 yr (Boehlert 1978, Ottmann et al. 2019). There is no information on dispersal distances of splitnose rockfish larvae.

Adult Movement

There is no information on movement rates of adult splitnose rockfish.

Other Life History Traits

Splitnose rockfish maximum is inclusive, it is somewhere between 86 or 103 yr (Bennett et al. 1982; Munk 2001; Gertseva et al. 2009; 2010) and reach a maximum length of 117 cm (Gertseva et al. 2010). Growth rates for splitnose rockfish tend to increase with increasing latitude (Gertseva et al. 2017). Maturation rates are not available. There is no information about spatial variation in life history traits for silvergray rockfish.

Data Quality/Quantity to Inform Stock Definitions

Limited: There is evidence of spatial variation in growth rates and spatiotemporal differences in juvenile densities but no information about larval dispersal, adult movement, or spatial variation in the genetics of sharpchin rockfish.

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Starry rockfish (Sebastes constellatus)

Species Information

Starry rockfish (*Sebastes constellatus*) range from San Francisco Bay, CA to southern Baja California, Mexico. They are benthic-associated and inhabit rocky reefs from 94 to 222 m (Eschmeyer et al. 1983; Love et al. 1990; Love et al. 2022). Both juveniles and adults are common between 30 and 200 m (Love et al. 2009). Adults are more likely to be encountered from 90 to 149 m (Love et al. 1990).

Assessment History

Starry rockfish have not been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 6 yr (PFMC 2024).

Genetics

There is no information about spatial variation in starry rockfish genetics.

Larval Dispersal
There is no information on dispersal distances for starry rockfish larvae.

Adult Movement
Starry rockfish typically stay within 1 km^2, though offshore movements are relatively common and considerable alongshore distances have been observed for mature fish (Hanan and Curry 2012).

Other Life History Traits
Starry rockfish live to 32 yr and reach a maximum length of 46 cm (Wedding and Yoklavich 2015). Lengths-at-maturity for starry rockfish off southern California are 18 cm (first), 19 cm (50%), and 27 cm (100%) for males and 21 cm (first), 22 cm (50%), and 29 cm (100%) for females (Love et al. 1990). Starry rockfish spawn from February to July, with peak activity in April off northern California and May off southern California (Love et al. 1990). They produce multiple broods per season (Love 1990).

Data Quality/Quantity of Information
Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for starry rockfish.

References

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Stripetail rockfish (Sebastes saxicola)

Species Information
Stripetail rockfish (*Sebastes saxicola*) is a midwater species that ranges from southeastern Alaska to Baja California, Mexico but are most abundant from British Columbia to southern California (Phillips 1964; Eschmeyer et al. 1983; Love et al. 1990; Love et al. 2002). Stripetail rockfish are found in soft sandy bottoms, mixed habitats, and rock bottoms between 46 and 547 m but are most common between 70 to 200 m (Eschmeyer et al. 1983; Laidig et al. 1996; Johnson et al. 2001; Taylor et al. 2004; Love et al. 2009). Like many other rockfish species, juveniles occupy shallower waters and tend to move deeper (180 m) with age (Love et al. 1990; Johnson et al. 2001). Survey-based indices of abundance suggest greater biomass densities of stripetail rockfish off California compared to Oregon and Washington (Wetzel and Hastie 2022).

Assessment History

Stripetail rockfish were assessed using data-moderate methods and at a coastwide scale in 2015 (Cope et al. 2015). Stripetail rockfish has a target assessment frequency of 8 yr (PFMC 2024).

Genetics

There are two genetically distinct populations off California with a north-south barrier between the northern Channel Islands and Point Conception. (Berntson et al. 2004; Hyde and Vetter 2007). Stripetail rockfish are most closely related to halfbanded rockfish (Berntson et al. 2004; Hyde and Vetter 2007).

Larval Dispersal

There is evidence that larval distributions for stripetail rockfish are within 500 m of adult habitat off southern California (Taylor et al. 2004).There is, however, no information on dispersal distances for stripetail rockfish larvae

Adult Movement

There is no information on movement rates of adult stripetail rockfish.

Other Life History Traits

Stripetail rockfish live to 38 yr (Cailliet et al. 2001; Cope et al. 2005) and reach a maximum length of 41 cm (Love et al. 2002). Lengths-at-maturity for starry rockfish off southern California are 9 cm (first), 10 cm (50%), and 16 cm (100%) for males and 9 cm (first), 10 cm (50%), and 17 cm (100%) for females (Love et al. 1990). Stripetail rockfish spawn from September to March, with peak activity in December off southern California and January off northern California (Love et al. 1990).

Data Quality/Quantity of Information

Limited: There is evidence of genetic differences but no information about larval dispersal, adult movement, or spatial variation in life history traits of stripetail rockfish.

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Swordspine rockfish (Sebastes ensifer)

Species Information

Swordspine rockfish (*Sebastes ensifer*) range from San Francisco Bay, CA to Baja California, Mexico and are most abundant off southern California (Miller and Lea 1972; Love et al. 2022). They are benthic-associated, can be found from 94 to 260 m, and often inhabit caves or crevices (Love et al. 2002; Taylor et al. 2004). Adult swordspine rockfish are most common >180 m but have been observed to 433 m (Love et al. 1990).

Assessment History

Swordspine rockfish have not yet been assessed in the California Current and no target frequency has been identified.

Genetics

Swordspine rockfish are closely related to rosethorn rockfish (*S. helvomaculatus*) (Rocha-Olivares and Vetter 1998). There is no information about spatial variation in swordspine rockfish genetics.

Larval Dispersal

There is no information on dispersal distances for swordspine rockfish larvae.

Adult Movement

There is no information on movement rates of adult swordspine rockfish.

Other Life History Traits

Swordspine rockfish live to 43 yr (Love et al. 2002) and reach a maximum length of 31 cm (Love et al. 2018). Length-at-maturity for swordspine rockfish 15 cm (50%; 8 to 10 yr) and 23 cm (100%; 16 yr) for females and 16 cm (50%; 10 yr) and 23 cm (100%; mid-20s) for males (Love et al. 2018). Females release multiple broods of larvae from January to July along southern California, with peaks in March (Love et al. 2018; Love et al. 2002). There is no information about spatial variation in life history traits for swordspine rockfish.

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for swordspine rockfish.

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Tiger rockfish (Sebastes nigrocinctus)

Species Information

Tiger rockfish (*Sebastes nigrocinctus*) range from Kodiak Island, AK to Cortes Banks, CA (Love et al. 2002). Peak abundances of tiger rockfish are from Southeast Alaska to northern California. They can be found between 18 and 298 m, often on rock outcrops (Love et al. 2002).

Assessment History

Tiger rockfish have not yet been assessed in the California Current and no target frequency has been identified. Tiger rockfish are assessed as part of the demersal shelf rockfish complex with a target assessment frequency of 3 yr in Alaska (Olson et al. 2018).

Genetics

Tiger rockfish are closely related to redbanded rockfish (*S. babcocki*), treefish (*S. serriceps*), and flag rockfish (*S. rubrivinctus*) (Love et al. 2002). There is no information about spatial variation in tiger rockfish genetics.

Larval Dispersal

There is no information on dispersal distances for tiger rockfish larvae.

Adult Movement

Tiger rockfish exhibit high site fidelity and small vertical movements ranging from 2 to 3 m (Hannah and Rankin 2010).

Other Life History Traits

Tiger rockfish live to 116 yr and reach a maximum length of 61 cm (Munk 2001; Love et al. 2002). They spawn from February to June in Southeast Alaska, with peak activity in April and May (Love et al. 2002). Tiger rockfish settle from July to September (Riera 2016). There is no information about spatial variation in life history traits of tiger rockfish.

Data Quality/Quantity of Information

<u>Insufficient</u>: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for tiger rockfish.

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Treefish (Sebastes serriceps)

Species Information

Treefish (*Sebastes serriceps*) range from San Francisco Bay, CA to central Baja California, Mexico but are most abundant south of the US-Mexico border (Love et al. 2002). They are commonly found in high relief habitats < 60 m (Love et al. 2002). Treefish are solitary, highly territorial, and tend to exhibit high site fidelity (Lowe et al. 2009; Hanan and Curry 2012; McCain et al. 2019). Their broad lateral banding is similar to that of tiger rockfish (*S. nigrocinctus*), redbanded rockfish (*S. babcocki*), and flag rockfish (*S. rubrivinctus*) (Lea and Haas 2012).

Assessment History

Treefish have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 6 yr (PFMC 2024).

Genetics

Treefish are closely related to flag, redbanded, and tiger rockfishes (Love et al. 2002). There is no information about spatial variation in treefish genetics.

Larval Dispersal

There is no information on dispersal distances for treefish larvae.

Adult Movement

There is no information on movement rates of adult treefish.

Other Life History Traits

Treefish live to 25 yr (Colton and Larson 2007) and reach a maximum length of 41 cm (Love et al 2002). They do not exhibit sexual dimorphism (Colton and Larson 2007). Parturition occurs in February and March (Colton and Larson 2007). Treefish reach 50% maturity at 4 yr and 3 yr for females and males, respectively (Colton and Larson 2007). Both sexes reach 50% maturity at 19 cm to 20 cm (Colton and Larson 2007). There is no information about spatial variation in life history traits for treefish.

Data Quality/Quantity of Information

<u>Insufficient</u>: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for treefish.

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Yellowmouth rockfish (Sebastes reedi)

Species Information

Yellowmouth rockfish (*Sebastes reedi*) range from the Gulf of Alaska to San Francisco Bay, CA, with greater relative abundances between Southeast Alaska and Oregon (Love et al. 2002). They can be found over high relief rocks between 180 to 275 m (Love et al. 2002).

Assessment History

Yellowmouth rockfish have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 10 yr (PFMC 2024). Yellowmouth rockfish are assessed as part of the other rockfish complex in the Gulf of Alaska (Tribuzio et al. 2017) and British Columbia (Edwards et al. 2012).

Genetics

There is no information about spatial variation in yellowmouth rockfish genetics.

Larval Dispersal

There is no information on dispersal distances for yellowmouth rockfish larvae.

Adult Movement

There is no information on movement rates of adult yellowmouth rockfish.

Other Life History Traits

Yellowmouth rockfish live to 99 yr (Cailliet et al. 2001) and reach a maximum length of 54 cm (Hart 1973). Yellowmouth rockfish exhibit slower growth rates in British Columbia compared to the southern extent of their range (Love et al. 2002). Yellowmouth rockfish reach 50% maturity at 37 cm (males) and 38 cm (females) (Hart 1973) and spawn from February to June (Love et al. 2002).

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for yellowmouth rockfish.

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5. Thornyheads

Longspine thornyhead (Sebastolobus altivelis)

Species Information
Longspine thornyhead (*Sebastolobus altivelis*) range from the western Gulf of Alaska to Baja California, Mexico (Love et al. 2002). Survey-based indices of abundance suggest considerably greater biomass off California compared to Oregon and Washington (Wetzel and Hastie 2022). Longspine thornyhead are commonly found on soft substrates (e.g., mud) from 201 to 1756 m (Love et al. 2002). Density hotspots of longspine thornyhead span broad latitudinal and depth ranges (Tolimieri et al. 2020). Unlike shortspine thornyhead, longspine thornyhead do not move into deeper water as they grow (Jacobson and Vetter 1996).

Assessment History
Longspine thornyhead were assessed in 1990, 1991, 1994, 1997, 2005, and 2013 (Jacobson 1990, 1991; Ianelli et al. 1994; Rogers et al. 1997; Fay 2005; Stephens and Taylor 2013). The 2005 and 2013 assessments were the first to construct a species-specific model for longspine thornyhead along the US West Coast, without also including shortspine thornyhead (Fay 2005; Stephens and Taylor 2013). Longspine thornyhead has a target assessment frequency of 8 yr (PFMC 2024).

Genetics
There is no information about spatial variation in longspine thornyhead genetics.

Larval Dispersal
Longspine thornyhead have a pelagic larval duration of 18 to 20 months larvae and settle into adult habitats (Moser 1974; Wakefield 1990; Stephens and Taylor 2013). There is no information on dispersal distances for longspine thornyhead larvae.

Adult Movement
There is no information on movement rates of adult longspine thornyhead.

Other Life History Traits
Longspine thornyhead live to 45 yr and reach a maximum length of 39 cm (Love et al. 2002). Females reach 50% maturity between 18 and 22 cm (12 to 15 yr) (Jacobson 1991; Ianelli et al. 1994; Pearson and Gunderson 2003). Spawning occurs from January to May off California and from March to April off Oregon (Love et al. 2002). There is no information on spatial variation in growth or maturity of adult longspine thornyhead.

Data Quality/Quantity of Information
Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for longspine thornyhead.

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6. Roundfishes

Pacific whiting (hake) (Merluccius productus)

Species Information

Pacific whiting (*Merluccius productus*), also known as Pacific hake, range from Southeast Alaska to southern California (Hamel 2015; Malick et al. 2020). Pacific hake tend to shift northward during El Niño and southward during La Niña (Malick et al. 2020). Pacific hake are semi-pelagic and occupy depths from 50 to 500 m (Alverson and Larkins 1969). Localized hotspots of juvenile hake are temporally variable but tend to be high near Point Conception, CA (Tolimieri et al. 2020).

Assessment History

Pacific hake is managed as a single stock with separate data treatments for the US and Canada. The Joint US-Canada Agreement for Pacific hake was implemented in 2010 (Grandin et al. 2020). This agreement ensured that stock assessments for Pacific hake are prepared by the Joint Technical Committee, consisting of scientists from both the US and Canada, and reviewed by representatives from both countries. Pacific hake was assessed in the following years: 1984-1985, 1987-1993, 1996-1998, 2000-2001, 2003-2004, 2006-2023 (Francis and Hollowed 1984; Francis et al. 1984, 1985; Hollowed and Francis 1987; Hollowed et al. 1988a, 1988b; Dorn et al. 1990; Dorn and Methot 1991, 1992; Hollowed 1992; Dorn et al. 1994; Dorn 1996, 1997; Dorn et al. 1999; Helser et al. 2001, 2002, 2004, 2005, 2006; Helser et al. 2007; Helser et al. 2008; Hamel and Stewart 2009; Stewart and Hamel 2010; Stewart et al. 2011, 2012; Hicks et al. 2013; Taylor et al. 2014, 2015; Grandin et al. 2016; Berger et al. 2017; Edwards et al. 2018; Berger et al. 2019; Grandin et al. 2020; Johnson et al. 2021; Edwards et al. 2022; Berger et al. 2023). Pacific hake were not assessed in 1986, 1994-1995, 1999, 2002, or 2005. The target frequency for assessing Pacific hake has not been identified. Pacific hake is comprised of four distinct stocks: Strait of Georgia, Puget Sound, Baja California, and a coastal stock (Sakuma and Ralston 1997).

Genetics

There is evidence of genetic differences between Pacific hake in Puget Sound and those offshore that suggests multiple, reproductively isolated populations (Utter 1969; Utter and Hodgins 1969, 1971). There is also evidence that Pacific cod in the Salish Sea are genetically different from those on the outer coast (Iwamoto et al. 2015). Pacific hake in the Georgia Basin represent a distinct population segment (Iwamoto et al. 2004).

Larval Dispersal

Pacific hake juveniles are abundant in the upper mixed layer and larvae are abundant below the mixed layer, showing consistent ontogenetic movements at these life stages (Saukma and Ralston 1997). Though larvae are found in deeper waters, the presence of juveniles in the upper mixed layer may make them susceptible to movement and dispersal (Saukma and Ralston 1997). There is no information on dispersal distances or spatial variation for Pacific hake larvae.

Adult Movement

Pacific hake found along the coast tend to exhibit seasonal migrations (Stewart and Hamel 2010), moving northward or offshore along the continental shelf to feed in spring and forming midwater aggregations on the shelf-slope break to feed during summer (Dorn and Methot 1991, 1992). Juveniles are often most abundant off California, while adults are found further north (Bailey et al.

1982). Older individuals exhibit a more northern migration than younger individuals (Berger et al. 2019).

Other Life History Traits

In the Strait of Georgia, Pacific hake spawn March to May and reach 50% maturity at 37 cm and 33 cm for females and males, respectively (McFarlane and Beamish 1985). In Puget Sound, Pacific hake reach 50% maturity at 31 cm and 29 cm for females and males, respectively (Pedersen 1985). Within the California Current, they reach 50% maturity at 1.5 yr south of Point Conception [34.44 ° N] and 2.5 yr north of Point Conception (Berger et al. 2019). Pacific hake live to 20 yr (McFarlane et al. 1983) and reach a maximum length of 112 cm (Alvarez-Trasvina et al. 2022).

In the Strait of Georgia, there is a distinct population that is smaller in size than offshore Pacific Hake (Beamish et al. 1982). They can also be distinguished by the shape of their otoliths, with offshore Pacific hake having more elongate otoliths than those in the Strait of Georgia (McFarlane and Beamish 1985). Individuals in the Strait of Georgia also lack a common parasite found in the offshore stock, *K. paniformis* (McFarlane and Beamish 1985).

Data Quality/Quantity of Information

Limited: There is sufficient information on distinct genetic populations (i.e., Utter et al. 1970, Iwamoto et al. 2004) though we are lacking information on larval dispersal distances

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Pacific cod (Gadus macrocephalus)

Species Information

Pacific cod (*Gadus macrocephalus*) range from Korea to the Bering Sea and south to Santa Monica, CA (Stroganov and Orlov 2012) but are rare south of British Columbia and almost never found south of Cape Blanco, OR (Ketchen 1961). Survey-based indices of abundance suggest an order of magnitude in densities of Pacific cod off Washington compared to Oregon (Wetzel and Hastie 2022). Pacific cod are demersal and occupy a broad range of habitats from 0 to 500 m (Spies et al. 2023). Younger fish are often found in relatively sheltered embayments (Spies et al. 2023).

Assessment History

Pacific cod have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 4 yr (PFMC 2024). Four stocks of Pacific cod have been identified in northern waters: 1) Bering Sea/Aleutian Islands, 2) Gulf of Alaska, 3) Hecate Strait, and 4) western Vancouver Island (Ormseth and Norcross 2008). In Alaska, Pacific cod are now assessed separately for the Bering Sea (e.g., Barbeaux et al. 2023), Gulf of Alaska (e.g., Hulson et al. 2023) and Aleutian Islands (e.g., Spies et al. 2023).

Genetics

Microsatellite DNA suggests isolation by distance for Pacific cod in the Gulf of Alaska, along the eastern Aleutian Islands, and off the coast of Washington (Cunningham et al. 2009; Spies 2012; Spies et al. 2021; Hulson et al. 2023). Single nucleotide polymorph markers indicate that non-spawning stocks in the northern Bering Sea do not differ from spawning stocks in the eastern Bering Sea, which has been used to infer northward movement of the eastern Bering Sea stock during summer (Spies et al. 2019). Pacific cod in the Strait of Georgia and Puget Sound are genetically distinct from those found along the open coast (Cunningham et al. 2009).

Larval Dispersal

The larval duration for Pacific cod is between 106 to 131 d (Hurst et al. 2010). Larvae are capable of considerable dispersal distances because they remain in the water column for > 3 months (Rugen and Matarese 1988; Hurst et al. 2009; Hurst et al. 2012). Recruitment strength is negatively correlated with temperature (e.g., Laurel et al. 2008; Hurst et al. 2010). Actual dispersal distances for Pacific cod, however, remain unknown.

Adult Movement

Pacific cod have been observed moving > 150 km from the eastern to northern regions of the Bering Sea (Shimada and Kimura 1994); Rand et al. 2015; Spies et al. 2019). Pacific cod tend to move into deeper, cooler waters during summer (Ketchen 1961). More restricted temperature ranges limit depth-based seasonal movements in Canadian waters (Ketchen 1961). According to catch data, larger Pacific cod may spend more time at deeper depths and move offshore in summer and fall (West et al. 2020).

Other Life History Traits

Pacific cod live to 25 yr (Munk 2001) and reach a maximum length of 120 cm (Mecklenburg et al. 2002). Pacific cod tend to be larger in the Aleutian Islands than the Bering Sea and Gulf of Alaska (Barbeaux et al. 2023; Hulson et al. 2023; Spies et al. 2023). There is also an increase in size of Pacific cod from west to east in the Gulf of Alaska (West et al. 2020). They reach 50% maturity at 58 cm (6 yr) in the Bering Sea and Aleutian Islands, 50 cm (5 yr) in the Gulf of Alaska, 54 cm (4 yr) in Hecate Strait, and 48 cm (2yr) in western Vancouver Island (Westrheim 1996; Stark 2007). Pacific cod typically form large aggregations to spawn once per year (Stark 2007). There is no information about spatial variation in life history traits for Pacific cod in the California Current

Data Quality/Quantity of Information

Limited: There is substantial information about spatial variation in genetics and life history traits for Pacific cod in the Bering Sea, Aleutian Islands, and Gulf of Alaska. Despite the potential for considerable larval dispersal and adult movement, complex circulation patterns may limit population connectivity among Pacific cod in the Bering Sea, Aleutian Islands, and Gulf of Alaska. Similar information is lacking for the California Current

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7. Flatfishes

Arrowtooth flounder (Atheresthes stomias)

Species Information
Arrowtooth flounder (*Atheresthes stomias*) range from the northern Bering Sea to central California (Hart 1973). Survey-based indices of abundance suggest increasing biomass densities of arrowtooth flounder northward from California to Washington (Wetzel and Hastie 2022). Density hotspots of arrowtooth flounder span a broad latitudinal range along the continental shelf and upper slope of the US West Coast (Tolimieri et al. 2020). Adults can be found from 12 to 900 m (Blood et al. 2007). Benchmark assessments for arrowtooth flounder were conducted at the coastwide scale in 2007 and 2017 (Kaplan and Helser 2007; Sampson et al. 2017). Arrowtooth flounder has a target assessment frequency of 4 yr (PFMC 2024).

Genetics
Before genetic differences were identified, close resemblances between arrowtooth flounder and Kamchatka flounder (*Athresthes evermanni*) prevented their identification to species (Ranck et al. 1986; Zimmermann and Goddard 1996). Known differences in gill raker morphology now allow for positive identification in the field (Rohan and Buckley 2018). There is no evidence of spatial variation in arrowtooth flounder genetics..

Larval Dispersal
Arrowtooth flounder eggs have been observed along the edge of the continental shelf in the Gulf of Alaska (Blood et al. 2007). Their larval duration lasts several months and larvae spend about a month in waters up to 100 m before settling in the early spring (Rickey 1995; Fargo and Starr 2001). There is no information on dispersal distances for arrowtooth flounder larvae.

Adult Movement
Movement rates for adult arrowtooth flounder are not well documented, though they tend to move into deeper waters as they grow (Zimmerman and Goddard 1996).

Other Life History Traits
Although arrowtooth flounder have been aged to 36 yr in the Aleutian Islands and 23 yr in the Gulf of Alaska, they are typically younger than 10 yr in the Bering Sea (Sampson et al. 2017; Munk 2001). The female:male sex ratio for arrowtooth flounder is 1.6:1 in the Aleutian Islands, 2.2:1 in the Gulf of Alaska, and 2.4:1 in the Bering Sea (Sampson et al. 2017). Off the US West Coast, males reach a maximum length of 68 cm and females grow to 90 cm (Sampson et al. 2017). Males reach 50% maturity at 42 cm (5.5 yr) and females reach 50% maturity at 46 cm (7 yr) (Stark 2008; Love 2011). Maturation rates are not available for arrowtooth flounder in the California Current. Arrowtooth flounder spawn along the continental shelf in fall and winter (Rickey 1995; Blood et al. 2007). Ripe females have been found at 400 m and early-stage eggs have been sampled at depths > 450 m (Rickey 1995; Blood et al. 2007).

Data Quality/Quantity of Information
Limited: There is insufficient information on genetics and larval dispersal with which to assess stock structure for arrowtooth flounder. There is evidence, however, of spatial variation in life history traits among the Aleutian Islands, Gulf of Alaska, and Bering Sea, where more data are available for this species

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Butter sole (Isopsetta isolepis)

Species Information

Butter sole (*Isopsetta isolepis*) range from the southeastern Bering Sea to southern California (Mecklenburg et al. 2002). They live in muddy habitats (Mulligan et al. 2017) and exhibit latitudinal differences in depth, found < 91 m in Hecate Strait and from 101 to 119 m along the US West Coast (Kutty 1963).

Assessment History

Butter sole have not yet been assessed in the California Current and no target frequency has been identified. Butter sole is assessed as part of the "shallow-water flatfish" complex with a target frequency of 4 yr in the Bering Sea and Gulf of Alaska (Bryan et al. 2018).

Genetics

There is no information about spatial variation in butter sole genetics. Butter sole and English sole (*Parophrys vetulus*) may hybridize as a result of spatiotemporal overlap in spawning activity. Both species spawn in February and March over sand or mud (< 80 m) (Garrison and Miller 1982).

Larval Dispersal

Butter sole are among the most abundant species in the nearshore Oregon larval fish assemblage (Richardson and Pearcy 1977). There is no information on dispersal distances for butter sole larvae.

Adult Movement
Butter sole are found offshore with no seasonal or site-specific differences, suggesting a preference for deeper habitats near Humboldt Bay, CA (Mulligan et al. 2017).

Other Life History Traits
Butter sole reach a maximum length of 55 cm (Mecklenburg et al. 2002). There is no longevity estimate available. Butter sole move offshore to spawn from February to May and into estuaries after their first year of life (Richardson et al. 1979). There is no information spatial variation in life history traits or maturation rates of butter sole.

Data Quality/Quantity of Information
Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for butter sole.

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Curlfin sole (Pleuronichthys decurrens)

Species Information
Curlfin sole (*Parophrys decurrens*) range from the southeastern Bering Sea to Baja California, Mexico (Mecklenberg et al. 2002). Survey-based indices of abundance suggest much greater biomass densities of curlfin sole off California compared to Oregon and Washington (Wetzel and Hastie 2022). They primarily occupy soft sediment habitats from 8 to 533 m (Mecklenburg et al. 2002). Curlfin sole tend to move offshore and/or southward during cool periods in the California Current (Keller et al. 2013).

Assessment History
Curlfin sole have not yet been assessed along the US West Coast and are managed using data-limited methods with a target assessment frequency of 4 yr (PFMC 2024).

Genetics
There is no information about spatial variation for curlfin sole genetics.

Larval Dispersal
There is no information on dispersal distances for curlfin sole larvae.

Adult Movement
There is no information on movement rates of adult curlfin sole.

Other Life History Traits

Curlfin sole reach a maximum length of 37 cm (Eschmeyer et al. 1983). There is no longevity estimate available or information regarding spatial variation in life history traits of curlfin sole.

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for curlfin sole.

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Flathead sole (Hippoglossoides elassodon)

Species Information

Flathead sole *(Hippoglossoides elassodon*) range from the eastern Bering Sea to Point Reyes, CA (Hart 1973). Survey-based indices of abundance suggest greater biomass densities of flathead sole off Washington compared to Oregon (Wetzel and Hastie 2022). Flathead sole occupy sandy and muddy habitats < 300 m (Stark and Clausen 1995; Norcross et al. 1997; McConnaughey and Smith 2000). Juveniles (< 2 yr) have not been observed mixing with the adult population (Turnock et al. 2017).

Assessment History

Flathead sole have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 6 yr (PFMC 2024).

Genetics

There is no information about spatial variation in flathead sole genetics.

Larval Dispersal

Flathead sole larvae are typically found on the continental shelf, near bays and estuaries (Porter 2004). Eggs are pelagic and can be found throughout the water column (Porter and Cianelli 2018). There is no information on dispersal distances for flathead sole larvae.

Adult Movement

Distribution of flathead sole shift to avoid the cold pool in the Bering Sea (Porter and Ciannelli 2018). Adults are benthic and have separate winter spawning and summer feeding locations in the Gulf of Alaska (Porter and Ciannelli 2018).

Other Life History Traits

Flathead sole live to 27 yr (Munk 2001) and reach a maximum length of 56 cm (Mecklenburg et al. 2002). Flathead sole are sexually dimorphic (Stark 2004). Males grow faster in the Bering Sea compared to the Gulf of Alaska but slower than females in both regions (Stark 2004). Females reach

50% maturity at 33 cm (9 yr) (Stark 2004). Spawning occurs from February to August, with peak spawning in April and May (Stark 2004).

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for flathead sole.

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Pacific sanddab (Citharichthys sordidus)

Species Information

Pacific sanddab (*Citharichthys sordidus*) range from the Bering Sea to Baja California, California, Mexico and are most abundant from Eureka to San Francisco, CA (Rackowski and Pikitch 1989). Survey-based indices of abundance suggest increasing biomass densities of Pacific sanddab from Washington to California (Wetzel and Hastie 2022). Pacific sanddab are generally benthic but can also be found in the water column, occupying depths from 18 to 275m (Pearcy and Hancock 1978). Early life history stages occur in the water column while adults typically move to deeper waters (He et al. 2013). Density hotspots of Pacific sanddab span a broad latitudinal.

Assessment History

A benchmark assessment for Pacific sanddab was conducted at the coastwide scale in 2013 (He et al. 2013). Pacific sanddab are managed using data-limited methods with a target assessment frequency of 4 yr (PFMC 2024).

Genetics

Low genetic diversity was observed from the Strait of Juan de Fuca to Santa Barbara, CA (Wilson 2009). There is no information that indicates spatial variation in Pacific sanddab genetics.

Larval Dispersal

The larval duration for Pacific sanddab is 271 d (Donohoe 2000). Larvae have been collected off central and southern California (Lefebvre et al. 2016). Pacific sanddab settle on the continental shelf in late fall and winter (Donohoe 2000). There is no information on dispersal distances for Pacific sanddab larvae.

Adult Movement

There is no information on movement rates of adult Pacific sanddab.

Other Life History Traits

Pacific sanddab live to 13 yr and reach a maximum length of 35 cm (Arora 1951). Pacific sanddab do not exhibit spatial variation in growth rates (He et al. 2013). Length-at-50%-maturity is 12 cm (95% = 15 cm) off California (Lefebvre et al. 2016). Spawning occurs between June and September in California (Lefebvre et al. 2016) and in late fall or early winter at higher latitudes (Arora 1951; Chamberlain 1979). Spawn timing is positively correlated with sea surface temperature (Lefevbre et al. 2016).

Data Quality/Quantity of Information

Limited: Low genetic diversity, a long larval duration, and no spatial variation in life history traits suggest a single coastwide stock for Pacific sanddab

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Sand sole (Psettichthys melanostictus)

Species Information

Pacific sand sole (*Psettichthys melanostictus*) range from the Bering Sea to Newport Beach, CA (Love et al. 2005). Sand sole occupy the intertidal zone to 325 m and are commonly found in sandy habitats < 70 m (Kramer et al. 1995; Moore et al. 2011). Juveniles can be found in estuaries off of Oregon and Washington during summer (Rooper et al. 2004).

Assessment History

Sand sole have not been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 4 yr (PFMC 2024). Sand sole are assessed as part of the shallow-water flatfish complex in the Gulf of Alaska (Turnock et al. 2009; Bryan et al. 2018).

Genetics

There is no information about spatial variation in sand sole genetics.

Larval Dispersal

There is no information on dispersal distances for sand sole larvae.

Adult Movement

There is no information on movement rates of adult sand sole.

Other Life History Traits

Sand sole live to at least 8 yr (Pearson and McNally 2005) and reach a maximum length of 63 cm (Mecklenburg et al. 2002). Males reach 50% maturity by 1 yr (~ 20 cm) and 100% maturity by 4 yr (~ 30 cm) (Pearson and McNally 2005). Females reach 50% maturity between 1 and 2 yr (~ 25 cm) and 100% maturity by 5 yr (~ 35 cm) (Pearson and McNally 2005). Adults spawn nearshore during downwelling events in late winter and early spring, resulting in some degree of larval retention in the coastal zone (Hickmann 1959; Auth and Brodeur 2006).

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for sand sole.

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Southern rock sole (Lepidopsetta bilineata)

Species Information

Southern rock sole (Lepidopsetta bilineata) range from the Bering Sea to Baja California, Mexico and are most abundant in the central Gulf of Alaska and British Columbia (Stark and Somerton 2002). They can be found in sandy habitats to 600 m (Allen and Smith 1988), moving deeper in winter and spring and shallower in summer (Shvetsov 1978). Southern rock sole can be easily misidentified as northern rock sole (L. polyxystra), though northern rock sole comprise a much more proportion of those sampled from Puget Sound to the Aleutian Islands (Stark and Somerton 2002).*L*

Assessment History

Southern rock sole have not yet been assessed in the California Current and are managed using data-limited methods with a target assessment frequency of 6 yr (PFMC 2024). Southern rock sole were previously managed as part of the shallow water flatfish complex in Alaska and are now assessed along with northern rock sole (Turnock et al. 2009).

Genetics

Southern rock sole are closely related to and often confused with northern rock sole *L. polyxystra*). Both southern and northern rock sole were classified as a single species (*L. bilineata*) until morphometrics enabled positive identification (Orr and Matarese 2000). There is no information about spatial variation in southern rock sole genetics.

Larval Dispersal

There is no information on dispersal distances for southern rock sole larvae.

Adult Movement

Southern rock sole feed and spawn in relatively shallow waters along the continental shelf. Adults in the Gulf of Alaska and Bering Sea migrate to deeper waters in the winter, likely to avoid extreme temperatures and low prey availability (Love 2011). There is no information on movement rates of adult southern rock sole.

Other Life History Traits

Southern rock sole live to 26 yr (Munk 2001) and reach a maximum length of 58 cm with sexually dimorphic growth (Mecklenburg et al. 2002; Stark and Somerton 2022). Southern rock sole tend to grow faster and experience higher natural mortality in British Columbia compared to the Bering Sea (Levings 1967). Females reach 50% maturity at 35 cm (9 yr) and 100% maturity at 40 cm (13 yr) (Stark and Somerton 2022). Southern rock sole

Data Quality/Quantity of Information

<u>Insufficient</u>: There is insufficient information on genetics, larval dispersal, life history traits, and adult movement with which to assess stock structure for southern rock sole.

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Starry flounder (Platichthys stellatus)

Species Information

Starry flounder (*Platichthys stellatus*) range from the Korean Peninsula to Los Angeles, CA but rare south of Point Conception, CA (Kramer et al. 1995). They typically occur over sandy habitats at depths < 80 m and are commonly encountered in estuaries (Kramer et al. 1995).

Assessment History

A benchmark assessment for starry flounder was conducted in 2005 and included waters from Cape Flattery, WA to Point Conception, CA (Ralston 2005). Due to differences in abundance, one model was developed for Washington and Oregon and another model was developed for California (Ralston 2005). Starry flounder are managed using data-limited methods with a target assessment frequency of 8 yr (PFMC 2024managed using data-limited methods with a target assessment frequency of 8 yr (PFMC 2024).

Genetics

Starry flounder exhibit phenotypic variation with latitude (Rolan-Alverez et al. 1997). Although the cause (e.g., genetics or environmental conditions) remains unknown, dextral (i.e., left-eyed) individuals are primarily found near Japan (Hart 1973) and the frequency of sinistral (i.e., right-eyed) starry flounder seems to increase with increasing latitude (Birtwell et al. 1993). The proportion of sinistral fish increases from 50% in California to 100% in Japan (Bergstrom 2007). Sinistral starry flounder exhibit shorter snouts off Alaska compared to British Columbia and Washington and have more gill rakers across their range (Bergstrom 2007). There is no information about spatial variation in starry flounder genetics.

Larval Dispersal

There is no information on dispersal distances of starry flounder larvae.

Adult Movement

Starry flounder are considered sedentary (Love 1996) but move seasonally into shallow waters to spawn (Orcutt 1950). A tagging study in the 1950s showed that starry flounder traveled up to 200 km, though most were recaptured between 14 and 40 km of the tagging site (Westrheim 1955).

Other Life History Traits

Starry flounder live to 42 yr (Code and Reist 2018) and reach a maximum length of 91 cm (Mecklenburg et al. 2002). Starry flounder spawn from November to February off central California, with peak activity in December and January (Orcutt 1950). There is no information about spatial variation in the life history traits of starry flounder.

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, life history traits, and adult movement with which to assess stock structure for starry flounder.

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Appendix 1: Literature Review for Amendment 31 Groundfish Species

Priority Species Literature Review

A key first step in defining stocks is understanding the species biology. The SSC recommended at least three tiers of biological attributes to consider when deciding a stock definition (Agenda Item E.3.a, Supplemental SSC Report 1, November 2021). The highest tier of these attributes is a genetic difference among meaningful markers. The next highest tier of information is exchange or movement of adults, followed by larval dispersal between areas. The lowest tier of information is differences in demographic characteristics (Agenda Item H.5, Attachment 1, November 2022).

The following priority species descriptions summarizes the current knowledge surrounding population structure of the priority species by expanding on Table 1 in Agenda Item H.5, Attachment 1, November 2022. In our investigation we examine genetic information, adult, juvenile, and larval movement, demographic information as well as past assessment stratification. This information originates from current scientific literature, the 2022 Groundfish Stock Assessment and Fishery Evaluation (SAFE) document, and from the species-specific assessments. The majority of the species detailed below have ranges that exceed the U.S./Mexico and/or the U.S./Canada borders; however, assessments focus only on the populations off of the U.S. West coast, though posit on potential connectivity to other populations. Some of these species could be considered sub-populations of a larger population (or metapopulation) that extends beyond the U.S. given their geographic extent. While the following centers on the scientific rationale for stock definitions, the Council could consider other issues as relayed in National Standards guidance. Implications regarding defining these populations are discussed under the Alternative analyses.

We note all of the 2021 assessments, as well as past assessments of the following priority species, have previously been endorsed as BSIA by the SSC and NMFS. While U.S. West coast populations of these species do not have officially defined stock units in the FMP, the assessments treat the populations as de facto stocks and have developed harvest specifications based on these assumed units. To date, the Council has managed to apply these harvest specifications to inform management decisions under the same assumption.

Black rockfish

Black rockfish (*Sebastes melanops*) range from Southern California (San Miguel Island) to the Aleutian Islands in Alaska (Amchitka Island), and they occur most commonly from San Francisco northward (Phillips, 1957; Miller and Lea, 1972; Hart, 1988; Stein and Hassler, 1989). Black rockfish are key targets of recreational fisheries from central California to Alaska and are a major presence in nearshore rocky reefs systems in those areas.

Genetic studies have found evidence that there may be at least three populations along the species range; one concentrated in the south (U.S. West coast), one at Brookings, Oregon, and one that is concentrated in Western Alaska (Hess et al., 2022) The 2003 assessment of black rockfish considered the population in California and Oregon as a population unit (Ralston and Dick, 2003). In contrast, the 1999 and 2007 assessments modeled two separate populations north and south of Cape Falcon

(Wallace et al., 1999; 2008). However, research conducted by Baker (1999) concluded that black rockfish from north and south of Cape Falcon (45°46′ N. lat.) were genetically very similar.

Distance of larval dispersal of black rockfish appears to be limited (Miller and Shanks, 2004; Lotterhos et al., 2014) and may be a result of oceanographic conditions on the U.S. West coast (Strub et al., 1987; Miller and Shanks, 2004). Larvae and pelagic juveniles are associated with upwelling fronts but are also found landward and seaward of such oceanographic fronts (Larson et al., 1994, Sakuma et al. 2013). Parturition of larvae occurs during winter (Wyllie-Echeverria, 1987) and larvae and small juveniles are pelagic for several months before settling to kelp forest or other nearshore habitats (Boehlert and Yoklavich, 1983, Laidig et al., 2007). The abundance of pelagic juveniles of black rockfish and most other winter-spawning species is highly variable in time and space, and generally covaries among species and in response to large-scale oceanographic conditions associated with transport and source waters in the California Current (Ralston et al., 2013; Schroeder et al., 2019; Field et al., 2021).

Black rockfish off the northern Washington coast and outer Strait of Juan de Fuca exhibit no significant movement. However, fish appear to move from the central Washington coast southward to the Columbia River, but not into waters off Oregon. Movement displayed by black rockfish off the northern Oregon coast is primarily northward to the Columbia River (Culver 1987). Black rockfish form mixed sex, midwater schools, especially in shallow water (Hart, 1988; Stein and Hassler, 1989).

Tagging studies have documented some individuals moving several hundreds of miles, yet the majority of recaptured individuals were found relatively close to the areas of initial capture and tagging (Culver, 1987; Ayres, 1988; Starr and Green, 2007; Wallace et al., 2010; Friewald 2012). Acoustic tagging studies off Oregon noted tagged fish had relatively small home ranges that did not vary seasonally (Parker et al., 2007). Green and Starr (2011) report similar findings from a study in Carmel Bay, California of 23 acoustically tagged black rockfish, finding that approximately two-thirds of their tagged fish demonstrated small home ranges, although the remaining third (9 of 23 fish) appeared to leave the study area within six months of release. A more recent extensive tagging effort in Central California over the last 15 years suggests somewhat higher movement rates for black rockfish in California waters, in which over a dozen tagged individuals (out of 61 recaptures) moved hundreds of kilometers (the average movement rate was 168 km), with all extensive movements being to northern California or Oregon (Hamilton et al., 2021).

Black rockfish was last assessed in 2015 by three assessment stratifications (California, Oregon, Washington). The SSC and NMFS endorsed the California, Oregon, and Washington 2015 black rockfish assessments as BSIA (Agenda Item I.3.a, Supplemental SSC Report 1, November 2015). Although both the California and Washington assessment models estimated recruitment deviations and recruitment, the Oregon model did not, thus an evaluation of similarities in recruitment among the three models (which might be suggestive of population connectivity and structure) is not feasible with current information. Black rockfish is being reassessed for 2023. Black rockfish is currently managed as individual species in California and Washington; whereas, in Oregon it is currently managed within the black/blue/deacon rockfish complex.

Canary rockfish

Canary rockfish (*Sebastes pinniger*) are distributed in the northeastern Pacific Ocean from the western Gulf of Alaska to northern Baja California; however, the species is most abundant from British Columbia to central California (Miller and Lea, 1972; Love et al., 2002).

Little direct information exists regarding the population structure of canary rockfish off the U.S. West coast. Previous genetic analysis of population structure conducted by Wishard et al. (1980) found patterns that suggest two stocks may exist for canary rockfish – one located off northern California and southern Oregon and the other located off northern Oregon and Washington. However, more recent work using microsatellite loci and restriction site associated DNA sequencing (RAD-seq), suggest little support for canary rockfish population structure along the U.S. West coast (Gomez-Uchida et al., 2003; Budrick, 2016; Andrews et al., 2018). Genetic studies in Puget Sound, Washington, similarly show no differentiation between Puget Sound and coastal populations (Andrews et al., 2018). In addition, isotopic analysis of canary rockfish otoliths did not show distinct differences indicating that canary rockfish in Washington and Oregon may belong to a single spawning stock (Gao et al., 2013).

Information about larval dispersal of canary rockfish is sparse. Canary rockfish spawn in the winter, producing pelagic larvae that remain in the upper water column for 3-4 months (Krigsman, 2000; Love et al., 2002). Juveniles settle in shallow water around nearshore rocky reefs, where they may congregate for up to three years (Boehlert, 1980; Sampson, 1996) before moving into deeper water as they increase in body size. Andrews et al. (2021) showed via simulation that canary rockfish larvae in Puget Sound could disperse more widely than yelloweye rockfish due to timing of spawning and extend across multiple basins and out to coastal areas.

Significant movement of adult canary rockfish was found in the few studies on the topic. Tagging research conducted off Oregon found that of 10 canary rockfish recovered, 4 moved over 25 km, and 3 moved more than 100 km over a period of several years (DeMott, 1982). A single canary from that study moved 326 km to the south, and those that moved the farthest also moved to much greater depths than the shallow reefs at which they had been tagged. Another tagging study conducted off Oregon concluded canary rockfish exhibit wide-ranging movements and showed low site fidelity, with movement extending beyond the spatial range of their study (Hannah and Rankin, 2011).

Canary rockfish show latitudinal patterns in life history parameters. Individuals sampled in non-trawlable areas from colder, northern port locations exhibited larger sizes-at-age, lived longer, had variable condition, matured at larger sizes and older ages, and had lower mortality rates than those from warmer, southern locations (Brooks, 2021). Keller et al. (2018) sampled canary rockfish using fishery-independent trawl gear and similarly found that weight relative to length for males and females, growth rates of females, and maximum size of males increased with latitude.

There are few biogeographic boundaries clearly applicable to rockfish on the U.S. and Canadian West coasts. Keller et al. (2018) assessed the spatial variability of life history parameters independently and used predetermined regions separated by prominent biogeographic breakpoints (Point Conception [34°27′ N. lat.] and Cape Mendocino [40°30′ N. lat.], California) along the U.S. West coast. Recent work by Brooks (2021) identified subpopulations based on similarities in life history traits among focal ports and found a break in the canary rockfish stock to occur just north of Cape Blanco (42°50′ N. lat.), Oregon. Discrepancies of the breakpoints in the two studies could be a result of the differences in analytical techniques used to delineate subpopulations, and differences in the habitats sampled (Brooks, 2021).

Canary rockfish assessments have modeled the resource as a single coastwide population (Methot and Piner, 2002; Methot and Stewart, 2005; Stewart, 2009; Wallace and Cope, 2011; Thorson and Wetzel, 2016). The last assessment in 2015 assumed a single coastwide stock but incorporated spatial structure within the model that corresponded to state boundaries to account for variation in exploitation history among regions (Thorson and Wetzel, 2016).

The SSC and NMFS endorsed the 2015 assessment as BSIA (Agenda Item D.8.a, Supplemental SSC Report 1, June 2015). Canary rockfish is being reassessed for 2023. Canary rockfish is currently managed as a single population coastwide.

Copper rockfish

Copper rockfish (*Sebastes caurinus*) are found from Mexico to Alaska as well as in Puget Sound, Washington. Information regarding population delineation for copper rockfish in the 2021 assessment was provided in Agenda Item E.3, Attachment 5, November 2021, which is incorporated by reference.

Sivasundar and Palumbi (2010) measured moderate differentiation mtDNA structure but no nuclear structure in the coastal copper rockfish population. They noted the Oregon and Monterey Bay populations were both genetically differentiated from the Santa Barbara populations, but the Oregon and Monterey Bay populations could not be distinguished from each other (Sivasundar and Palumbi, 2010). This could indicate that there is some level of mixing between northern California and Oregon populations, while limited mixing within southern and northern California. Buonaccorsi et al. (2002) identified significant divergence along the U.S. West coast when measured as variance in allele frequency or mean repeat number, indicating a substantial isolation between regions. Johansson et al. (2008) had robust sample sizes for copper rockfish ranging from coastal Washington through San Diego, California, with most samples from coastal Oregon, and identified isolation by distance among these regions. Their results were consistent with some level of population structure at a finer than coastwide scale, with some indication that Cape Blanco (42°50′ N. lat.) or other habitat features (including an extensive sand barrier separating rocky habitats) in southern Oregon as likely mechanisms for the greatest differences observed in their study. They specifically suggest that their results are consistent with mesoscale population structure in which populations are self-recruiting on a regional scale with limited external recruitment from adjacent habitats.

Copper rockfish are spring, rather than winter spawners, with a shorter larval duration relative to most winter spawners of about 1-2 months, and the juveniles settle on kelp or soft bottom habitats and move to rocky areas with perennial macrophytes as they grow (Haldorson and Richards, 1987). Mean larval dispersal in copper rockfish based on data from Buonaccorsi et al. (2002) and the Rousset (1997) analytical model were low (under 40 km), even when accounting for four orders of magnitude of variation in possible effective population size (Buonaccorsi et al., 2004, 2005). However, as noted in the Buonaccorsi et al. (2002) study, the extensive spacing between samples leaves the cause of population divergence essentially unresolved, due to the large number of confounding variables.

Adult copper rockfish exhibit high site fidelity and generally show low to moderate movement in their home range (Lea et al, 1999; Tolimieri et al, 2009; Reynolds et al., 2010). However, in Santa Barbara Channel, California, Lowe et al. (2009) found tagged individuals showed low degrees of site fidelity, and both Hanan and Curry (2012) and Hamilton et al. (2022) saw movement of up to several hundred kilometers in a small number of copper rockfish tagged off southern and/or central California. Adult life history and morphological evidence suggest that realized gene flow among regions of the copper rockfish distribution may be restricted. Adults exhibit extremely limited migrations (a few kilometers) and are unlikely to leave the reef on which they have settled (e.g., Lea et al., 1999).

Copper rockfish was last assessed in 2021 as four assessment stratifications (California south of Point Conception, California north of Point Conception, Oregon, Washington). The SSC and NMFS endorsed all four 2021 assessments of copper rockfish as BSIA (Agenda Item C.6.a, Supplemental SSC Report, September 2021). Only the portion of the copper rockfish population off California is being reassessed in 2023. Copper rockfish are considered a coastwide stock, due primarily to the lack of a stock definition. Copper rockfish are currently managed in the nearshore rockfish complex with two units, north and south of 40° 10′ N. latitude.

Dover sole

Dover sole (*Microstomus pacificus*) are distributed from the Navarin Canyon in the northwest Bering Sea and westernmost Aleutian Islands, Alaska to San Cristobal Bay, Baja California, Mexico (PFMC, 2022b).

Dover sole was assessed as a single stock in 2021 (Wetzel and Berger, 2021). The assessment stated that population structure is not well understood. However, adults display ontogenetic movement from shallow to deeper waters with some level of spatial aggregation by sex (e.g., larger older females found in deeper waters compared to males) and larvae have an extended pelagic phase, up to two years off the U.S. West coast (Pearcy et al., 1977; Markle et al., 1992; Butler et al., 1996). Notable differences in growth and maturity of Dover sole across the U.S. West coast have been noted by multiple studies (Brodziak and Mikus, 2000; Wetzel and Berger, 2021) with fish in Oregon and Washington maturing at earlier size and growing to larger sizes-at-age. The movement of Dover sole across the U.S. West coast is generally unknown. Recent analysis examining data collected during the summer and fall months indicated movement from shallow to deeper water and shifts in aggregations moving southward off the California coast and northward to areas off the Washington coast (Ono et al., 2016). However, historical tagging studies indicated only limited latitudinal movement of Dover sole (Westrheim et al., 1992). Genetic analysis sampling Dover sole at different sites ranging between southern California to the Gulf of Alaska indicated some level of potential clustering of genetically similar individuals (Stepien, 1999). Areas off the U.S. West coast have been observed to have aggregations of age-1 fish potentially indicating some population structure by age or size (Tolimieri et al., 2020), however, the overall connectivity of the population remains uncertain.

Dover sole was last assessed in 2021 as a single population. The SSC and NMFS endorsed this assessment as BSIA (Agenda Item E.2.a, Supplemental SSC Report 1, November 2021). Dover sole is currently managed as a single coastwide unit.

Lingcod

Lingcod (*Ophiodon elongatus*) ranges from Baja California, Mexico, to Kodiak Island in the Gulf of Alaska (PFMC, 2022b). Lingcod was assessed in 2021 (Johnson et al., 2021; Taylor et al., 2021). The assessments assumed two distinct lingcod populations on the U.S West coast that are split at 40° 10’ N. lat. based on the results of a genetic analysis (Longo et al., 2020). Longo et al. (2020) determined sufficient evidence for distinct north and south genetic clusters with the presence of admixed individuals (i.e., mixes of previously diverged or isolated genetic lineages) in the region of overlap. The general results of the occurrence of two distinct genetic clusters were contrary to previous genetic work using mitochondrial DNA that found no genetic differentiation in the lingcod population (Marko et al., 2007)

Lingcod larvae are epipelagic for approximately 90 days (Hart, 1988; Phillips and Barraclough,1977; Cass et al., 1990). Young-of-the-year typically recruit to sandy, low-relief habitat near eelgrass or kelp beds, staying on soft bottom and move into rocky, high-relief substrate as they grow (Petrie and Ryer, 2006; Bassett et al., 2018). Adults are generally sedentary and exhibit high site fidelity (Greenley, 2009; Bishop et al., 2010; Stahl et al., 2014).

Genetic information corresponded with results from recent work demonstrating that lingcod growth, longevity, and timing at maturity exhibit a latitudinal gradient (Johnson et al., 2021; Taylor et al., 2021). Lingcod from higher latitudes are larger at age, live longer, and reach biological maturity at larger sizes compared to lingcod in southern regions (Richards, et al. 1990; Silberberg, et al., 2001; Johnson et al., 2021; Lam et al., 2021; Taylor et al., 2021). Individuals north of 40° 10′ N. lat. generally grow faster, live longer, and mature at larger sizes. Outside of the spawning season, male and female lingcod are segregated by depth. Females tend to inhabit deeper offshore waters and males inhabit nearshore rocky reefs.

Lingcod was last assessed in 2021 by two area assessments (north of 40° 10′ N. lat. and south of 40° 10′ N. lat.) The SSC and NMFS endorsed the 2021 full assessments of northern and southern lingcod as BSIA (Agenda Item C.6.a, Supplemental SSC Report, September 2021). Currently, Lingcod has two management units, north and south of 40° 10′ N. latitude.

Pacific spiny dogfish

Pacific spiny dogfish (*Squalus suckleyi*) occur from the Gulf of Alaska, with isolated individuals found in the Bering Sea, southward to San Martin Island, in southern Baja California (PFMC, 2022b). Pacific spiny dogfish was most recently assessed in 2021. The 2021 assessment, as well as the 2011 assessment, assumed Pacific spiny dogfish off the U.S. West coast, bounded by the U.S./Canada border and U.S./Mexico border, consist of a single coastwide stock whose dynamics are independent of Pacific spiny dogfish populations off Canada and Mexico (Gertseva et al., 2021). While there is limited information on population structure of Pacific spiny dogfish populations within U.S. and Canadian waters, some level of cross border movement is likely occurring based on historical studies examining movement and population connectivity.

A spatial population dynamics model (Taylor, 2008) which included these tagging data (along with much larger tagging experiments conducted in Canada and inside U.S. waters of Puget Sound), estimated movement rates of about 5% per year between the U.S. coastal sub-population of Pacific spiny dogfish and that found along the west coast of Vancouver Island in Canada. The model also estimated movement rates of less than 1% per year between Pacific spiny dogfish in the U.S. coastal subpopulation of Pacific spiny dogfish and that in the Puget Sound. Off the U.S. West coast high densities of Pacific spiny dogfish have been observed close to the U.S./Canada border near the mouth of the Strait of Juan de Fuca (Gertseva et al., 2021). Additionally, some evidence exists of inshore versus offshore populations migratory behavior, though inshore migratory distance may be less than offshore populations (Brodeur et al., 2009).

Pacific spiny dogfish was last assessed in 2021 as a single population (Gertseva et al, 2021). The SSC and NMFS endorsed this assessment as BSIA (Agenda Item E.2, Supplemental SSC Report 1, November 2021). Pacific spiny dogfish is currently managed as a single coastwide unit.

Petrale sole

Petrale sole (*Eopsetta jordani*) range from the western Gulf of Alaska to the Coronado Islands, northern Baja California (PFMC, 2022b). A full assessment for petrale sole was performed in 2013 (Haltuch et al., 2013), with two subsequent assessment updates conducted in 2015 (Stawitz, et al., 2015) and 2019 (Wetzel, 2019). These assessments assumed petrale sole off the U.S. West coast was a single population. There is strong evidence of a mixed population from tagging studies, a lack of genetic studies on population structure , and a lack of evidence for differences in growth, as well as confounding differences in data collection between Washington, Oregon, and California (Haltuch et al., 2013).

Petrale sole have pelagic larvae and, after hatching, the larvae rise to the upper 50 m of the water column and remain there for approximately 5 months, through the feeding larval stage (Alderdice and Forrester, 1971; Casillas et al., 1998; Hart, 1973; Love, 1996; Pearcy et al., 1977). Planktonic petrale sole larvae range in size from approximately 3-20 mm and were found up to 150 km offshore foraging upon copepod eggs and nauplii (Casillas et al., 1998; Hart, 1988; MBC Applied Environmental Sciences, 1987; Moser, 1996) and juveniles show little coastwide or bathymetric movement. Studies suggest that adults generally move inshore and northward onto the continental shelf during the spring and summer to feeding grounds and offshore and southward during the fall and winter to deep water spawning grounds (Hart, 1988; MBC, 1987; Love, 1996). Adult petrale sole are highly mobile and have been observed to move up to 350-390 miles (Alverson and Chatwin, 1957; MBC, 1987). Demographic differences, in the form of fecundity, have been noted between fish off California and Oregon/Washington (Lefebvre et al., 2019).

The most recent full assessment for petrale sole was conducted in 2013 as a single population. The SSC and NMFS endorsed the full assessment as well as the subsequent 2015 and 2019 update assessments as BSIA (Agenda Item F.5.b, Supplemental SSC Report, June 2013). It is being reassessed for 2023. Petrale sole is currently managed as a single population.

Quillback rockfish

Quillback rockfish (*Sebastes maliger*) are found from southern California to the Gulf of Alaska (Love, et al., 2002). Information regarding population delineation for quillback rockfish in the 2021 assessment was provided in Agenda Item E.3, Attachment 6, November 2021, which is incorporated by reference.

There has been limited genetic work on coastal populations of quillback rockfish. High site-fidelity (Hannah and Rankin, 2011) and relatively small home ranges (Tolimieri et al., 2009) for quillback rockfish suggest patterns of isolation-by-distance as found for other rockfish. However, localized studies within the Puget Sound, Washington area have shown significant genetic differences between Puget Sound and coastal stocks of quillback rockfish. However, there was no significant differentiation in populations of quillback rockfish between coastal Washington and Alaska (Seeb, 1998; Stout et al., 2001; Schwenke et al.,2018).

Larvae are extruded from March through June (Love et al., 2002), and pelagic larvae and juveniles spend ~1−2 months in the upper water column before recruiting to nearshore benthic habitats. In Oregon, juveniles typically settle from June through August, but can settle as early as May and as late as September (Ottmann et al., 2018; Fennie et al., 2020).

Quillback rockfish exhibit long periods of residency with limited movements. In a tagging study in Puget Sound, Washington, which included quillback rockfish, Matthews (1990a; 1990b) found quillback rockfish had home ranges between 30m^2 to 1,500m^2. Home ranges on low relief reefs were greater than home ranges on low relief reefs (Matthews, 1990). Tolimieri et al. (2009) also found that home ranges of quillback rockfish in Puget Sound, Washington were relatively small (~1,500m^2 to ~2,500m^2). However, it is important to note that movement of fish in the Puget Sound may not be representative of movement in coastal populations (Langseth et al., 2021). Rankin et al. (2013) observed larger home ranges of quillback rockfish at Cape Perpetua Reef, Oregon of approximately 1,200m^2 to 8,000m^2 for most individuals, with one quillback rockfish extending out to 24,000m^2. Lea et al. (1999) summarized tagging data from Morro to Monterey Bays, California that reported species of the gopher complex (which includes quillback rockfish although no quillback rockfish data were provided) to have no movement and therefore considered very residential in California.

Limited differences are observed in growth based on the original age-length estimates between fish off the Oregon and Washington coast (Langseth et al., 2021). However, it is commonly observed that there are spatial gradients of growth along the U.S. West coast (Keller et al., 2012; 2018; Gertseva et al., 2017).

Quillback rockfish were last assessed in 2021 by three assessment stratifications (California, Oregon, Washington) and endorsed by the SSC and NMFS as BSIA (Agenda Item C.6.a, Supplemental SSC Report, September 2021) Quillback rockfish is currently managed in the nearshore rockfish complex with two units, north and south of 40° 10′ N. latitude.

Rex Sole

Rex sole (*Glyptocephalus zachirus*) ranges from central Baja California to the Aleutian Islands and the western Bering Sea (PFMC, 2022b). Rex sole was last assessed in 2013 (Cope et al., 2014) and was assumed to be a single population coastwide. A search of available literature revealed little to no information about the population structure off of the U.S. West coast. Information from Alaska notes there are growth differences in Eastern Gulf of Alaska (GOA) relative to Western and Central GOA as well as marked difference in growth rates and size at maturity between Oregon and GOA stocks (Abookire, 2006). Larvae are distributed broadly over the shelf and slope and exhibit cross-shelf transport, moving to nearshore nursery areas where they remain as juveniles (Abookire and Bailey, 2007; Bailey et al., 2008). Larvae attain a large size and have long pelagic lives, suggesting wide distribution by oceanic currents (Pearcy et al., 1977; Abookire and Bailey, 2007).

Rex sole was last assessed in 2013 as a single population. The SSC and NMFS endorsed the assessment as BSIA (Agenda Item F.5.b, Supplemental SSC Report, June 2013). It is being reassessed for 2023. Rex sole is currently managed on a coastwide basis within the Other Flatfish Complex.

Sablefish

Sablefish, or also referred to as black cod, (*Anoplopoma fimbria*) are distributed in the northeastern Pacific Ocean from the southern tip of Baja California, northward to the north-central Bering Sea and in the Northwestern Pacific Ocean from Kamchatka, southward to the northeastern coast of Japan. Although few studies have critically evaluated issues regarding the population structure of this species, it appears there may exist at least three different stocks of sablefish along the West coast of North America: (1) a stock that exhibits relatively slow growth and small maximum size that is found south of Monterey Bay, California (Cailliet et al., 1988; Phillips and Inamura, 1954); (2) a stock that is characterized by moderately fast growth and large maximum size that occurs from northern California to Washington; and (3) a stock that grows very quickly and contains individuals that reach the largest maximum size of all sablefish in the northeastern Pacific Ocean, distributed off British Columbia, Canada and in the Gulf of Alaska (Mason et al., 1983; McFarlane and Beamish, 1983).

Spawning occurs annually in the late fall through winter in waters greater than 300 m (Hart, 1988; NOAA, 1990). Sablefish are oviparous with external fertilization (NOAA, 1990). Eggs hatch in about 15 days (Mason et al., 1983; NOAA, 1990) and are demersal until the yolk sac is absorbed (Mason et al., 1983). Age-zero juveniles become pelagic after the yolk sac is absorbed. Older juveniles and adults are benthopelagic. Larvae and small juveniles move inshore after spawning and may rear for up to four years (Boehlert and Yoklavich, 1985; Mason et al., 1983). Older juveniles and adults inhabit progressively deeper waters.

Sablefish was last assessed in 2021 as a single area (coastwide) population. The SSC and NMFS endorsed the assessment as BSIA (Agenda Item C.6.a, Supplemental SSC Report, September 2021). Currently, sablefish has two management units, north and south of 36° N. latitude.

Shortspine thornyhead

Shortspine thornyhead (*Sebastolobus alascanus*) are found in waters off the U.S. West coast from northern Baja California to the Bering Sea (PFMC, 2022b). Shortspine thornyhead were assessed in 2014 and are considered one homogeneous population, though apportioned at Point Conception (34°27′ N. lat.), California for management purposes (Taylor and Stephens, 2014). Genetic studies of population structure do not suggest separate stocks along the U.S. West coast (Siebenaller, 1978). Stepien (1995) found few genetic differences among shortspine thornyhead along the Pacific coast but suggested there may be a separate population of shortspine thornyhead in the isolated area around Cortes Bank off San Diego, California. There are signals of genetic divergence between Alaska to southern California, but this seems to be more related to geographic distance rather than distinct population signals (Stepien et al., 2000; Taylor and Stephens, 2014).

Shortspine thornyhead along the U.S. West coast spawn pelagic, gelatinous masses between December and May (Wakefield, 1990; Erickson and Pikitch, 1993; Pearson and Gunderson, 2003). The larval and juvenile stages are pelagic and can last up to 15 months and adults are benthic (Moser, 1974; Wakefield, 1990; Wakefield and Smith, 1990; Dorval et al., 2022). Juveniles migrate down the slope with age and size to the oxygen minimum zone (Taylor and Stephens, 2014). Size distribution patterns have been consistently observed from survey data and have been conceptualized as a 'J-shape' migration hypothesis (Piner and Methot, 2001; Taylor and Stephens, 2014; Dorval et al., 2022). Stepien (1995) suggested juvenile dispersion might be limited in the area where the Alaska and California currents split. This occurs towards the northern boundary of the assessment area, near 48° N. latitude.

Shortspine thornyhead do not appear to be distributed evenly across the U.S. West coast, with higher densities of thornyheads in shallower areas (under 500 meters) off of Oregon and Washington, and higher densities in deeper areas off of California (Wakefield, 1990). The ontogeny and behavior of shortspine thornyhead are not conducive to large-scale latitudinal migrations, but these life history aspects cannot fully explain either the current distributional patterns (Dorval et al., 2022). Large mature fish reside mostly off central–northern California and oceanic currents could have played a role in transporting their offspring back to northern habitats (i.e., Washington and Oregon), where juveniles and young-of-the-year are most abundant. Otolith chemistry shows two distinct settlement regions of immature fish: one off the Columbia River plume expanding south to northern California and another off central and southern California (Dorval et al., 2022), which is consistent with the predicted ontogenetic movement (Jacobson and Vetter, 1996) as well as the pelagic life phase of larvae and early juveniles (Moser 1974; Wakefield, 1990).

The most recent shortspine thornyhead assessment was conducted in 2013 (document finalized in 2014) as a single coastwide population. The SSC and NMFS endorsed the shortspine thornyhead assessment as BSIA (Agenda Item F.5.b, Supplemental SSC Report, June 2013). It is being reassessed for 2023. Shortspine thornyhead currently has a single ACL control rule with apportioned ACLs north and south of 34° 27′ N. lat north and south of 34° 27′ N. lat.

Squarespot rockfish

Squarespot rockfish (*Sebastes hopkinsi*) are found from southern Oregon to central Baja California (Love et al, 2002). This species was first assessed in 2021 (Cope et al., 2021). It is a relatively small rockfish found from Mexico to southern Oregon, with a core distribution in southern California. Squarespot rockfish were treated as one population in the most recent assessment due to their limited population distribution combined with the current lack of evidence of population structure off the U.S. West coast (Cope et al., 2021). Similar to many other rockfish species, squarespot rockfish exhibit sexual dimorphism, with females reaching larger sizes compared to males (PFMC, 2022b). Squarespot rockfish bear live planktonic larvae and can be found in the water column for up to 100 days post parturition (Taylor, 2004). A search of the literature revealed little life history information regarding this species. Squarespot rockfish are predominantly located south of 40° 10′ N. latitude. Since 1981, approximately 99.73 percent of the total catch has occurred south of 40° 10′ N. latitude off the U.S. West coast (Cope et al., 2021).

Squarespot rockfish was most recently assessed in 2021 off of California. The SSC and NMFS endorsed the 2021 squarespot rockfish assessment as BSIA (Agenda Item C.6.a, Supplemental SSC Report, September 2021). Squarespot rockfish is currently managed in the shelf rockfish complex with two units, north and south of 40° 10′ N. latitude.

Vermilion and Vermilion/Sunset rockfish

Vermilion rockfish (*Sebastes miniatus*) was originally considered a single species; however, Hyde et al. (2008) determined it is actually a pair of cryptic species, vermilion rockfish and sunset rockfish *(Sebastes crocotulus*). Vermilion rockfish range from Prince William Sound, Alaska, to central Islas San Benito, Baja California at depths of 6 m to 436 m (Love et al., 2002). Vermilion and sunset rockfishes have a high degree of range overlap from central California to northern Baja, Mexico. However, vermilion rockfish are more common in shallower waters (< 100 m) in kelp forest habitat while sunset rockfish are typically found deeper (> 100 m) at offshore banks (Hyde et al., 2008a; 2008b; Love and Passarelli, 2020; Longo et al., 2022). The primary biomass of sunset rockfish appears to be in the Southern California Bight, though their range does somewhat extend north of Point Conception, California (Hyde et al., 2008; Hyde and Vetter, 2009; Budrick, 2016; PFMC, 2022b). Vermilion rockfish are abundant at least from central Oregon south into Mexico (Hyde and Vetter, 2009). For purposes of management, this cryptic species pair are currently treated as a single species.

Studies indicate significant genetic heterogeneity in this complex, with notable genetic barriers at Point Conception, Cape Mendocino, Santa Monica Bay, and along the Washington coast (Matala et al., 2004; Buonaccorsi et al., 2004; 2005; Hyde and Vetter, 2009).

Larvae and juveniles may spend from a month to a year in the water column before recruiting to benthic habitat (Boehlert 1977; Love et al., 2002). This lengthy dispersal phases could allow for large-scale geographic transport (Parrish et al., 1981). However, fish with both high fecundity, such as rockfish, and lengthy periods of larval dispersal are expected to show a high degree of gene flow with little or no genetic differentiation between populations (Hyde and Vetter, 2007), which is not the case for vermilion/sunset rockfishes. Isolation by distance analyses suggested that larval dispersal is relatively small (Hyde and Vetter, 2009).

Vermilion rockfish appear to exhibit high site fidelity (Hartman, 1987; Lea et al., 1999; Hannah and Rankin, 2011), and low average larval dispersal distance (Hyde and Vetter, 2009). A study by Lowe et al. (2009) suggested vermilion rockfish may not have strong site fidelity but noted this finding may be a result of not considering the depth preferences of the two species.

Vermilion/Sunset rockfish were assessed in 2021 in four assessments: California south of Pt. Conception (Dick et al, 2021), California north of Pt. Conception (Monk et al, 2021), Oregon (Cope and Whitman, 2021), and Washington (Cope et al, 2021). This spatial structure reflects the distribution of this cryptic species complex. The assessments represent the aggregate population dynamics of the cryptic species pair vermilion rockfish and sunset rockfish. The SSC and NMFS endorsed each assessment as BSIA (Agenda Item C.6.a, Supplemental SSC Report 1, November 2021). At present, vermilion/sunset rockfish are managed within the shelf rockfish complex with two units, north and south of 40° 10′ N. latitude.

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Appendix 2: Literature Review for Species to be Assessed in 2025 and 2027.

Blackspotted rockfish (Sebastes melanostictus) & Rougheye rockfish (S. aleutianus)

Species Information

Rougheye rockfish (*Sebastes aleutianus*) range from Japan to the Bering Sea and south to Point Conception, CA (Clausen et al. 2003; Shotwell et al. 2009; Sullivan et al. 2021). The center of rougheye rockfish abundance is in the eastern Gulf of Alaska (Clausen et al. 2003). Blackspotted rockfish (*S. melanostictus*) are more common to the north and in the western Gulf of Alaska (Orr and Hawkins 2008). Survey-based indices of abundance suggest similar biomass densities of rougheye rockfish off Oregon and Washington and little to no biomass off California (Wetzel and Hastie 2022). Adults of both species are abundant between 200 to 350 m (Clausen et al. 2003). Juveniles are typically found in nearshore rocky habitats (Shotwell et al. 2009).).

Assessment History

Rougheye and blackspotted rockfishes were assessed at the coastwide scale in 2013 (Hicks et al. 2014). The rougheye and blackspotted rockfish complex has a target assessment frequency of 10 yr (PFMC 2024).Rougheye rockfish are similar to shortraker rockfish (*S. borealis*); thus the two species are difficult to differentiate in the field and often grouped (Clausen et al. 2003). Much of the data available for stock assessments combines rougheye, shortraker, and blackspotted rockfishes (Hicks et al. 2014).

Genetics

Blackspotted rockfish were originally thought to be a distinct "type" of rougheye rockfish (Gharrett et al. 2005; Hawkins et al. 2005). Advancements in technology, however, revealed that blackspotted rockfish is genetically distinct from rougheye rockfish (Orr and Hawkins 2008). There is some evidence of genetic differentiation among rougheye rockfish in the Gulf of Alaska (Seeb 1986; Hawkins et al. 1997; Matala et al. 2004; Gharrett et al. 2006), though the extent to which is unknown (Clausen et al. 2003).

Larval Dispersal

There is little information about the larval, post-larval, and early juvenile stages of rougheye and blackspotted rockfishes. This is partially because genetic information is necessary to positively identify their larvae to species (Gharrett et al. 2001). Post-larval rougheye rockfish have been collected from epipelagic waters in the Gulf of Alaska (Matarese et al. 1989). There is no information about settlement size or age (Clausen et al. 2003).).

Adult Movement

Adult rougheye rockfish are 300 to 500 m depth contours (Ito 1999). Rougheye rockfish may comprise a greater proportion of the rougheye and blackspotted rockfish complex off Washington and Oregon compared to the Gulf of Alaska (Gharrett et al. 2005; Hawkins et al. 2005; Orr and Hawkins 2008).

Other Life History Traits

Rougheye rockfish live to 205 yr and reach a maximum length of 97 cm (Kastelle et al. 2000; Munk 2001). There are no longevity or maximum size estimates for blackspotted rockfish. Lengths-at-50%-

maturity are 45 cm (20 yr) for rougheye rockfish and 45 cm (27 yr) for blackspotted rockfish in the Gulf of Alaska (Conrath 2017). Rougheye rockfish have protracted reproductive periods with parturition taking place between December and April in Alaska (McDermott 1994). There is no information about spatial variation in the life history traits of rougheye or blackspotted rockfishes (Clausen et al. 2003).

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for rougheye/blackspotted rockfish.

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Chilipepper rockfish (Sebastes goodei)

Species Information

Chilipepper rockfish *(Sebastes goodei)* range from the British Columbia to the US-Mexico border (Field et al. 2016), with peak abundance near Cape Mendocino, CA and declines north of Cape Blanco, OR (Beyer et al. 2015). Survey-based indices of abundance suggest considerably greater biomass densities of chilipepper rockfish south of 40° 10` N (Wetzel and Hastie 2022).
Chilipepper rockfish are semi-pelagic, form large aggregations in midwater environments (75 to 325 m), and move into deeper waters as they grow (Beyer et al. 2015). Adults are common in waters deeper than 100 m (Love et al. 1990, 2009).

Assessment History

The first benchmark assessment for chilipepper rockfish was conducted at the coastwide scale in 2007 (Field 2007). An update assessment was conducted in 2015 (Field et al. 2016), which included a selectivity offset for recreational fishing effort to account for chilipepper rockfish moving into deeper water throughout their ontogeny. Stock assessment authors recommend that future assessments consider northern and southern models whenever data permit (Field et al. 2016). Chilipepper rockfish has a target assessment frequency of 4 yr (PFMC 2024).

Genetics

There is no evidence of population structure for chilipepper rockfish (Wishard et al. 1980; Berntson and Moran 2009). Chilipepper rockfish are genetically similar to canary rockfish (*Sebastes pinniger*) and display a very close relationship for nonsibling species (Wishard et al. 1980).

Larval Dispersal

Chilipepper rockfish remain in the pelagic juvenile stage for 3.5 to 6 months (Solinger 2019; Ralston and Stewart 2013). Young-of-the-year are most abundant off central California, though they are encountered at many sites from the southern Channel Islands to north of the Columbia River (Field et al. 2021). There is evidence of spatial synchrony in year-class strength for chilipepper rockfish throughout the California Current, with potential differences north and south of Cape Mendocino, CA (Field and Ralson 2005). There is no information about dispersal distances for chilipepper rockfish larvae.

Adult Movement

There is no information on movement rates of adult chilipepper rockfish.

Other Life History Traits

Chilipepper rockfish live to 27 yr (Love et al. 1998) and reach a maximum length of 59 cm (Love et al. 2002). Length-at-50%-maturity for female chilipepper rockfish is 30 cm off southern California and 34 cm off central and northern California (Wyllie Echeverria 1987; Beyer et al. 2015). Chilipepper rockfish tend to move inshore to spawn from December to March, with peak activity between January and February ((Petersen et al. 2010; Harvey et al. 2011). Larvae are released from August to April off southern California, with peak abundance in December and January, whereas larvae are released from November to June off northern California, with peak activity in January and February (Wyllie Echeverria 1987). There is evidence of geographic, seasonal, and annual differences in the occurrence of secondary broods (Beyer et al. 2015). Multiple broods are more common among rockfishes with more southern distributions, perhaps due to more optimal reproductive conditions (Mapes et al. 2023). There is also evidence of spatial variation in the size at which females produce multiple broods (Lefebvre et al. 2018). For example, multiple brooding females tend to be smaller off southern California (Holder and Field 2019). Winter upwelling decreases recruitment success off northern California and increases recruitment success in Morro Bay, CA (Solinger 2019). Life history data are limited south of Point Conception (Field et al. 2016).

Data Quality/Quantity of Information

Limited: is insufficient information on genetics and adult movement rates with which to assess stock structure for chilipepper rockfish. The combination of long larval durations and synchronous recruitment dynamics suggests a high degree of population connectivity among chilipepper rockfish, though there is evidence of regional differences in growth, maturation, and spawning activity.

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Redbanded rockfish (Sebastes babcocki)

Species Information

Redbanded rockfish (*Sebastes babcocki*) range from the Gulf of Alaska to southern California (Sullivan et al. 2022) but are most abundant in Southeast Alaska (Rooper 2007). They can be found over hard substrate and sometimes mud at 150 to 400 m depth (Mecklenberg et al. 2002) (Edwards et al. 2017). Redbanded rockfish are considered a data-limited species and do not have a directed fishery (Haigh and Starr 2006; Sullivan et al. 2022). Due to similarities in coloration, redbanded rockfish are often confused with flag rockfish *(Sebastes rubrivinctus)*. Flag rockfish previously reported north of Heceta Bank, OR were likely misidentified and should be classified as redbanded rockfish (Love 1996; Edwards et al. 2017; McCain et al. 2019). Redbanded rockfish can often be found intermixed with Pacific Ocean perch *(Sebastes alutus)* and darkblotched rockfish *(Sebastes crameri)*.

Assessment History

A data-limited assessment for redbanded rockfish was conducted in 2010 (Dick and MacCall 2010; Wetzel and Hastie 2022). A target assessment frequency of 10 yr has been identified (PFMC 2024).

Genetics

Redbanded rockfish are closely related to treefish (*S. serriceps*), tiger rockfish (*S. nigrocinctus*), and flag rockfish (*S. rubrivinctus)* (Love et al. 2002). There is no information about spatial variation in redbanded rockfish genetics.

Larval Dispersal

The pelagic larval duration for redbanded rockfish is approximately 109 d (Ottman et al. 2019). There is no information on dispersal distances for redbanded rockfish larvae.

Adult Movement

There is no information on movement rates of adult redbanded rockfish.

Other Life History Traits

Redbanded rockfish live to 106 yr and reach a maximum length of 64 cm (Cailliet et al. 2001; Alaska Department of Fish and Game, unpubl. data). Redbanded rockfish reach maturity at 19 yr in the Gulf of Alaska (Mangel et al. 2006). It is unknown if this is first, 50%, or 100%. Length estimates are not provided for Alaska. In British Columbia, they reach 50% maturity at 18 yr for females and 16 yr for males. Females grow to larger sizes than males (Edwards et al. 2014). Off of Oregon, females reach first maturity at 36 cm and 9 yr, 50% maturity at 40 cm and 14 yr, and 100% maturity at 49 cm and 22 yr (Hannah and Kautzi 2015). Male ages and lengths at maturity are not available. There is no further information on redbanded rockfish life history traits in the California Current.

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits, and adult movement rates with which to assess stock structure for redbanded rockfish.

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Widow rockfish (Sebastes entomelas)

Species Information

Widow rockfish (*Sebastes entomelas*) is a midwater species that ranges from Southeast Alaska to Baja California, Mexico (Love et al. 1990: He et al. 2007a; Hicks 2015; Adams et al. 2019). They are most abundant from British Columbia to northern California and tend to occupy a broader range of depths with increasing latitude (Ressler et al. 2009; Adams et al. 2019). Survey-based indices of abundance suggest similar biomass densities of widow rockfish from Washington to California (Wetzel and Hastie 2022). Adults are most common at depths > 150 m (Love et al. 1990). Juveniles tend to occupy waters 50 to 225 m (Love et al. 2009).

Assessment History

Benchmark assessments for widow rockfish were conducted at a coastwide basis in 1984, 1986, 1989, 1990, 1993, 1997, 2000, 2003, 2005, 2009, 2011, and 2015 (Hightower and Lenarz 1989, 1990; Rogers and Lenarz 1993; Ralston and Pearson 1997; Williams et al. 2000; He et al. 2003a; He et al. 2006; He et al. 2009a; He et al. 2011a; He et al. 2015). In 1989, the widow rockfish assessment consisted of two models separated at Coos Bay, OR (~ 43° N) (Hightower and Lenarz 1989). In 2011, a coastwide assessment produced results comparable to a two-area model with differing growth and maturation rates (He et al. 2011; Hicks and Wetzel 2015). Update assessments were conducted in

2007 and 2019 (He et al. 2007a; Adams et al. 2019). The population was declared overfished in 2001, thus rebuilding analyses were conducted in 2003, 2005, 2007, and 2009 (He et al. 2003b; He et al. 2005; He et al. 2007; He et al. 2009b). A catch-only projection was conducted in 2023 (Wallace 2023). Widow rockfish has a target assessment frequency of 4 yr (PFMC 2024).

Genetics
A study using mtDNA and microsatellites found no genetic variation among widow rockfish along the California coast (N_{cenCA} = 36 and N_{soCA} = 36; Sivasundar and Palumbi 2010).

Larval Dispersal
The larval duration for widow rockfish is approximately 3 to 4 months (Sivasundar and Palumbi 2010). here is evidence of spatial synchrony in year-class strength for widow rockfish, with potential differences north and south of Cape Mendocino, CA (Field and Ralson 2005). There is no information on dispersal distances for widow rockfish larvae.

Adult Movement
Adult widow rockfish tend to be active in the water column at night and disperse during the day (Wilkins 1986). Mark-recapture data suggest small home ranges and/or high site fidelity (Hartmann 1987). NWFSC bottom trawl survey data suggest that widow rockfish recruit to central or southern California and move northward as they age (Adams et al. 2019).

Other Life History Traits
Widow rockfish live to 60 yr (Cailliet et al. 20010) and reach a maximum length of 59 cm (Love et al. 2002). Widow rockfish off California mature at smaller lengths than those off of Oregon (Barss and Echeverria 1984; Echeverria 1987). Widow rockfish do not show clear latitudinal patterns in growth (Gertseva et al. 2017). Lengths-at-maturity for widow rockfish off southern California are 26 cm (first), 32 cm (50%), and 37 cm (100%) for males and 34 cm (first), 35 cm (50%), and 36 cm (100%) for females (Love et al. 1990). Age-at-50%-maturity has been estimated at 5.5 yr (Adams et al. 2019). Widow rockfish spawn from December to May, with peak activity in February (Love et al. 1990). Parturition occurs from December to March off California and in April off British Columbia (Barss and Echeverria 1987; Adams et al. 2019).

Data Quality/Quantity of Information
Limited: There is insufficient information on genetics and larval dispersal with which to assess stock structure for widow rockfish. There is evidence, however, of spatial variation in life history traits throughout the California Current.

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Yelloweye rockfish (Sebastes ruberrimus)

Species Information

Yelloweye rockfish (*Sebastes ruberrimus*) are distributed from the western Gulf of Alaska to northern Baja California, Mexico (Hart 1973; Eschmeyer et al. 1983). They are most abundant from Southeast Alaska to central California. Yelloweye rockfish in Puget Sound represent a distinct population segment (DPS) (Drake et al. 2010). Adults are typically found along the continental shelf to 400 m. Juveniles are often found in shallower waters (Gertseva and Cope 2017). Survey-based indices of abundance suggest similar biomass densities of yelloweye rockfish off California and Oregon and lesser biomass densities off Washington (Wetzel and Hastie 2022).

Assessment History

Before 2000, yelloweye rockfish were managed as part of the *Sebastes* complex. From 2000 to 2002, yelloweye rockfish were considered part of the minor shelf complex (Wallace et al. 2006). Benchmark assessments for yelloweye rockfish were conducted in 2005, 2006, 2009, and 2017 (Wallace et al. 2005, 2006; Stewart et al. 2009; Gertseva and Cope 2017). The 2009 assessment modeled three areas: California, Oregon, and Washington (Stewart et al. 2009). The 2017 assessment used region-specific catch histories to model two areas: California and Oregon-Washington (Gertseva and Cope 2017). Update assessments were conducted in 2007 and 2011 (Wallace 2008; Taylor and Wetzel 2011). Rebuilding analyses were conducted in 2005-2007, 2009, 2011, 2017, and 2023 (Tsou and Wallace 2005, 2006; Wallace 2007; Stewart 2009; Taylor 2011; Gertseva and Cope 2018; Wallace 2023). Yelloweye rockfish has a target assessment frequency of 10 yr (PFMC 2024).

Genetics

There may be genetic separation between yelloweye rockfish in the Strait of Georgia (British Columbia) and the outer coasts of Washington and Oregon (Yamanaka et al. 2001; Siegle et al. 2013). The coastal populations, however, are not genetically distinct.

Larval Dispersal

Little is known about the pelagic juvenile stage for yelloweye rockfish (Taylor and Wetzel 2011). The pelagic larval phase may last up to 1 yr in Alaska (Olson et al. 2018). This extended period promotes some mixing of reproductive output, which is dependent upon environmental factors such as upwelling (Gertseva and Cope 2017). Yelloweye rockfish do not settle within a well-defined depth range (Stewart et al. 2009). An otolith microchemistry study suggested complete mixing of offspring between Oregon and Washington (Gao et al. 2010).

Adult Movement

There is little information about the movement rates of adult yelloweye rockfish. Although yelloweye rockfish are generally considered sedentary (Coombs 1979; DeMott 1983; Hannah and Rankin 2011), recent studies suggest movements up to 233 km (Rasmuson et al., in prep).

Other Life History Traits

Yelloweye rockfish live to 118 yr and reach a maximum length of 104 cm (Kastelle et al. 2000; Tian et al. 2017). Length-at-50%-maturity is 46 cm for females and 54 cm for males in British Columbia (Olson et al. 2018). The age-at-50%-maturity for female yelloweye rockfish is between 20 and 25 yr (O’Connell and Fujioka 1991). Spawning output is greatest off Oregon, followed by California and Washington (Stewart et al. 2009). Parturition occurs from February to September in Alaska, with shorter spawning periods south of British Columbia (O'Connell 1987; Hannah et al. 2009; Olson et al. 2018).

Data Quality/Quantity of Information

<u>Insufficient</u>: There is insufficient information on genetics, larval dispersal, spatial variation in life history traits with which to assess stock structure for yelloweye rockfish. There is, however, recent evidence to suggest greater adult movement rates than previously documented. This, combined with otolith microchemistry, suggests that yelloweye rockfish may exhibit a high degree of population connectivity along the US West Coast.

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Yellowtail rockfish (Sebastes flavidus)

Species Information

Yellowtail rockfish (*Sebastes flavidus*) are a midwater species found from the Aleutian Islands to Baja California, Mexico, are abundant from British Columbia, Canada to Oregon, and rare south of Point Conception (Love et al. 1990; Tagart et al. 2000; Wallace and Lai 2005). Adults occur in the water column near rocky reefs (49 to 98 fm) and are commonly found aggregated near deep (60 to 110 fm) pinnacles (Carlson and Haight 1972; Tagart and Kimura 1982; Wallace and Lai 2005; Hess et al. 2011). Survey-based indices of abundance suggest much greater biomass densities of yellowtail rockfish north of 40° 10` N (Wetzel and Hastie 2022).

Assessment History

The first benchmark assessment for yellowtail rockfish was conducted in 1999 (Tagart et al. 2000). This stock assessment pertained to the northern stock, which was divided into three models: Southern Vancouver (from Cape Elizabeth to ~ 49° N), Northern Columbia (from Cape Falcon to Cape Elizabeth), and Eureka-South Columbia (from Cape Mendocino to Cape Falcon). An update assessment was conducted in 2004 (Wallace and Lai 2005). A data-moderate assessment was conducted in 2013, given that abundance indices but no length or age data were available for inclusion in the model (Cope et al. 2015). A depletion-based stock reduction analysis was used to assess yellowtail rockfish south of Cape Mendocino in 2011 (Dick and MacCall 2011). Yellowtail rockfish were most recently assessed in 2017 as two stocks separated by Cape Mendocino, CA (Stephens and Taylor 2017). The northern stock extends from Cape Mendocino to the US-Canada border. The southern stock is managed as part of the "minor shelf rockfish" complex from Cape Mendocino to the US-Mexico border (Stephens and Taylor 2017). The reduction from three to two sub-area models was due to a lack of available fine-scale data. Yellowtail rockfish has a target assessment frequency of 4 yr (PFMC 2024).

Genetics

Yellowtail rockfish are closely related to black rockfish (*Sebastes melanops*) (Baetscher 2019). Wishard et al. (1980) and McGauley and Mulligan (1995) found no evidence of genetic differences among yellowtail rockfish along the US West Coast. Hess et al. (2011), however, found a genetic break at Cape Mendocino, with greater genetic diversity to the south. A study using mtDNA and microsatellites found genetic differences between yellowtail rockfish off Oregon and California (N_{OR} = 18 and N_{CA} = 49; Sivasundar and Palumbi 2010).

Larval Dispersal

Yellowtail rockfish have a pelagic larval duration of 3 to 4 months (Hess et al. 2010). There is evidence of spatial synchrony in year-class strength for yellowtail rockfish, with potential differences north and south of Cape Mendocino, CA (Field and Ralson 2005). There is no information about dispersal distances for yellowtail rockfish larvae.

Adult Movement

Yellowtail rockfish have been identified as having mean home ranges from 0 to 67 km^2 (Carlson and Haight 1972; DeMott 1983; Matthews and Barker 1983; Hartmann 1987; Stanley et al. 1994; Freiwald 2012). A mark-recapture study (n = 36) estimated that 75% of yellowtail rockfish caught in Canadian waters moved [illegible] from their release location (Stanley et al. 1994). Notably, three individuals traveled over 100 km. Of the fish tagged off Alaska, all five recaptures moved southward, between 425 and 1400 km (Stanley et al. 1994).

Other Life History Traits

Yellowtail rockfish live to 64 yr (Cailliet et al. 2001) and reach a maximum length of 55 cm (Tagart et al. 2000). Asymptotic sizes are slightly larger off northern California compared to southern California (Tagart et al. 2000). Length-at-50% maturity for females from northern California were estimated at 42.5 cm but sample sizes were limited (Stephens and Taylor 2017). Lengths-at-maturity for yellowtail rockfish off southern California are 31 cm (first), 32 cm (50%), and 37 cm (100%) for males and 33 cm (first), 36 cm (50%), and 38 cm (100%) for females (Love et al. 1990). Females at Cordell Bank, CA have been observed with developing ovaries or embryos between October and January (Eldridge et al. 1990). Spawning takes place from January to July, with peak activity in February (Love et al. 1990). Parturition typically occurs in March and April (Eldridge et al. 1990). Yellowtail rockfish reproduction varies spatially along the California coast (Beyer et al. 2015). Larger, older yellowtail rockfish tend to spawn earlier in the season (Eldridge et al. 1990; Bobko and Berkely 2004).

Data Quality/Quantity of Information

Limited: There is some information about spatial variation in yellowtail rockfish genetics along the US West Coast. However, larval dispersal and adult movement rates may promote considerable population connectivity.

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English sole (Parophrys vetulus)

Species Information

English sole (*Parophrys vetulus*) range from Unimak Island, AK to Baja California, Mexico (Fargo and Kronlund 2000). Survey-based indices of abundance suggest similar biomass densities of English sole from California to Washington (Wetzel and Hastie 2022). English sole have distinct and spatially-explicit hotspots with narrow depth distributions (100 to 200 m) and exhibit relatively high densities near Point Conception, CA (Tolimieri et al. 2020). Juveniles are more common in estuaries and bays than along the open coast (Krygier and Pearcy 1986

Assessment History

A benchmark assessment for English sole was conducted in 2005 and updated in 2007 (Stewart 2005, 2007). A data-moderate assessment for English sole was also conducted in 2013 (Cope et al. 2015). All assessments were modeled at the coastwide scale. English sole has a target assessment frequency of 4 yr (PFMC 2024).

Genetics

A study from the Salish Sea found little genetic diversity among sampled individuals (Winans et al. 2022). There is no information about spatial variation in English sole genetics.

Larval Dispersal

The pelagic larval duration for English sole is 6 to 10 weeks (Laroche et al. 1982). English sole settle into estuaries and other coastal zones (Gunderson et al. 1990). Nursery areas along Oregon and Washington are thought to support the entire coastwide population (Rooper 2002; Rooper et al. 2004). There is no information on dispersal distances for English sole larvae.

Adult Movement

English sole tend to emigrate from estuaries as juveniles (~ 2 yr) (Gunderson et al. 1990). Adults move into shallow waters (18 to 73 m) during spring and deeper waters (36 to 91 m) during winter (Barss 1976). English sole tend to move southward in the fall and northward in spring (Barss 1976).

Other Life History Traits

English sole live to 22 yr (Munk 2001) and reach a maximum length of 61 cm with sexually dimorphic growth (Mecklenburg et al. 2002). Female growth rates surpass that of males at 3 yr (Fargo and Kronlund 2000). Both sexes exhibit interannual variation in growth and maturity (Fargo and Tyler 1994; Fargo and Kronlund 2000). English sole mature between 3 and 4 yr off Oregon (Barss 1976). Length-at-50%-maturity is estimated at 23 cm for females along the US West Coast (Stewart 2005). English sole spawn between September and April (Barss 1976; Kruse and Tyler 1983), with smaller fish spawn later in the season (Fargo and Kronlund 2000). There is no information about spatial variation in life history traits of English sole..

Data Quality/Quantity of Information

Insufficient: There is insufficient information on genetics, larval dispersal, adult movement rates, and/or spatial variation in life history traits with which to assess stock structure for English sole.

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Appendix 3: Latitudinal and depth distributions of groundfish species (adults) managed under the Pacific Coast Groundfish Fishery Management Plan.[a/]

Table 1. Latitudinal and depth distributions of groundfish species (adults) managed under the Pacific Coast Groundfish Fishery Management Plan (Source, SAFE 2024)

		Latitudinal Distribution and Depth Distribution (fm)			
Common Name	**Scientific Name**	**Overall**	**Highest Density**	**Overall**	**Highest Density**
Flatfish Species					
Arrowtooth flounder	*Atheresthes stomias*	N 34° N. lat.	N 40° N. lat.	10-400	27-270
Butter sole	*Isopsetta isolepis*	N 34° N. lat.	N 34° N. lat.	0-200	0-100
Curlfin sole	*Pleuronichthys decurrens*	Coastwide	Coastwide	4-291	4-50
Dover sole	*Microstomus pacificus*	Coastwide	Coastwide	10-500	110-270
English sole	*Parophrys vetulus*	Coastwide	Coastwide	0-300	40-200
Flathead sole	*Hippoglossoides elassodon*	N 38° N. lat.	N 40° N. lat.	3-300	100-200
Pacific sanddab	*Citharichthys sordidus*	Coastwide	Coastwide	0-300	0-82
Petrale sole	*Eopsetta jordani*	Coastwide	Coastwide	10-250	160-250
Rex sole	*Glyptocephalus zachirus*	Coastwide	Coastwide	10-350	27-250
Rock sole	*Lepidopsetta bilineata*	Coastwide	N 32°30' N. lat.	0-200	summer 10-44, winter 70-150
Sand sole	*Psettichthys melanostictus*	Coastwide	N 33°50' N. lat.	0-100	0-44
Starry flounder	*Platichthys stellatus*	Coastwide	N 34°20' N. lat.	0-150	0-82
Scorpaenids					
Cabezon	*Scorpaenichthys marmoratus*	Coastwide	Coastwide	0-60	0-27
California scorpionfish	*Scorpaena gutatta*	S 37° N. lat.	S 34°27' N. lat.	0-100	0-100
Thornyheads					
Longspine thornyhead	*Sebastolobus altivelis*	Coastwide	Coastwide	167->833	320-550
Shortspine thornyhead	*Sebastolobus alascanus*	Coastwide	Coastwide	14->833	55-550
Rockfish					
Aurora rockfish	*Sebastes aurora*	Coastwide	Coastwide	45-420	160-270
Bank rockfish	*Sebastes rufus*	S 39°30' N. lat.	S 39°30' N. lat.	17-135	115-140
Black rockfish	*Sebastes melanops*	N 34° N. lat.	N 34° N. lat.	0-200	0-30
Black-and-yellow rockfish	*Sebastes chrysomelas*	S 40° N. lat.	S 40° N. lat.	0-20	0-10
Blackgill rockfish	*Sebastes melanostomus*	Coastwide	S 40° N. lat.	48-420	125-300
Blackspotted rockfish	*Sebastes melanostictus*	Coastwide	N 40° N. lat.	27-400	27-250
Blue rockfish	*Sebastes mystinus*	Coastwide	Coastwide	0-300	13-50
Bocaccio	*Sebastes paucispinis*	Coastwide	S 40° N. lat., N 48° N. lat.	15-180	54-82
Bronzespotted rockfish	*Sebastes gilli*	S 37° N. lat.	S 37° N. lat.	41-205	110-160

		Latitudinal Distribution and Depth Distribution (fm)			
Common Name	**Scientific Name**	**Overall**	**Highest Density**	**Overall**	**Highest Density**
Brown rockfish	*Sebastes auriculatus*	Coastwide	S 40° N. lat.	0-70	0-50
Calico rockfish	*Sebastes dallii*	S 38° N. lat.	S 33° N. lat.	10-140	33-50
Canary rockfish	*Sebastes pinniger*	Coastwide	Coastwide	27-460	50-100
Chameleon rockfish	*Sebastes phillipsi*	37°-33° N. lat.	37°-33° N. lat.	95-150	95-150
Chilipepper rockfish	*Sebastes goodei*	Coastwide	34°-40° N. lat.	27-190	27-190
China rockfish	*Sebastes nebulosus*	N 34° N. lat.	N 35° N. lat.	0-70	2-50
Copper rockfish	*Sebastes caurinus*	Coastwide	S 40° N. lat.	0-100	0-100
Cowcod	*Sebastes levis*	S 40° N. lat.	S 34°27' N. lat.	22-270	100-130
Darkblotched rockfish	*Sebastes crameri*	N 33° N. lat.	N 38° N. lat.	16-300	96-220
Deacon rockfish	*Sebastes diaconus*	N 35° N. lat.	N 40°10’ N. lat.	4-27	4-27
Dusky rockfish	*Sebastes ciliatus*	N 55° N. lat.	N 55° N. lat.	0-150	0-150
Dwarf-Red rockfish	*Sebastes rufinanus*	33° N. lat.	33° N. lat.	>100	>100
Flag rockfish	*Sebastes rubrivinctus*	S 38° N. lat.	S 37° N. lat.	17-100	Shallow
Freckled rockfish	*Sebastes lentignosus*	S 33° N. lat.	S 33° N. lat.	22-92	22-92
Gopher rockfish	*Sebastes carnatus*	S 40° N. lat.	S 40° N. lat.	0-45	5-20
Grass rockfish	*Sebastes rastrelliger*	S 44°40' N. lat.	S 40° N. lat.	0-25	0-8
Greenblotched rockfish	*Sebastes rosenblatti*	S 38° N. lat.	S 38° N. lat.	33-217	115-130
Greenspotted rockfish	*Sebastes chlorostictus*	S 47° N. lat.	S 40° N. lat.	27-110	50-100
Greenstriped rockfish	*Sebastes elongatus*	Coastwide	Coastwide	33-220	27-136
Halfbanded rockfish	*Sebastes semicinctus*	S 36°40' N. lat.	S 36°40' N. lat.	32-220	32-220
Harlequin rockfish c/	*Sebastes variegatus*	N 40° N. lat.	N 51° N. lat.	38-167	38-167
Honeycomb rockfish	*Sebastes umbrosus*	S 36°40' N. lat.	S 34°27' N. lat.	16-65	16-38
Kelp rockfish	*Sebastes atrovirens*	S 39° N. lat.	S 37° N. lat.	0-25	3-4
Mexican rockfish	*Sebastes macdonaldi*	S 36°20' N. lat.	S 36°20' N. lat.	50-140	50-140
Olive rockfish	*Sebastes serranoides*	S 41°20' N. lat.	S 40° N. lat.	0-80	0-16
Pacific ocean perch	*Sebastes alutus*	Coastwide	N 42° N. lat.	50-450	110-250
Pink rockfish	*Sebastes eos*	S 37° N. lat.	S 35° N. lat.	40-200	40-200
Pinkrose rockfish	*Sebastes simulator*	S 34° N. lat.	S 34° N. lat.	54-160	108
Puget Sound rockfish	*Sebastes emphaeus*	N 40° N. lat.	N 40° N. lat.	6-200	6-200
Pygmy rockfish	*Sebastes wilsoni*	N 32°30' N. lat.	N 32°30' N. lat.	17-150	17-150
Quillback rockfish	*Sebastes maliger*	N 36°20' N. lat.	N 40° N. lat.	0-150	22-33
Redbanded rockfish	*Sebastes babcocki*	Coastwide	N 37° N. lat.	50-260	82-245
Redstripe rockfish	*Sebastes proriger*	N 37° N. lat.	N 37° N. lat.	7-190	55-190
Rosethorn rockfish	*Sebastes helvomaculatus*	Coastwide	N 38° N. lat.	65-300	55-190
Rosy rockfish	*Sebastes rosaceus*	S 42° N. lat.	S 40° N. lat.	8-70	30-58
Rougheye rockfish	*Sebastes aleutianus*	Coastwide	N 40° N. lat.	27-400	27-250
Semaphore rockfish	*Sebastes melanosema*	S 34°27' N. lat.	S 34°27' N. lat.	75-100	75-100
Sharpchin rockfish	*Sebastes zacentrus*	Coastwide	Coastwide	50-175	50-175
Shortraker rockfish	*Sebastes borealis*	N 39°30' N. lat.	N 44° N. lat.	110-220	110-220
Silvergray rockfish	*Sebastes brevispinis*	Coastwide	N 40° N. lat.	17-200	55-160
Speckled rockfish	*Sebastes ovalis*	S 38° N. lat.	S 37° N. lat.	17-200	41-83

		Latitudinal Distribution and Depth Distribution (fm)			
Common Name	**Scientific Name**	**Overall**	**Highest Density**	**Overall**	**Highest Density**
Splitnose rockfish	*Sebastes diploproa*	Coastwide	Coastwide	50-317	55-250
Squarespot rockfish	*Sebastes hopkinsi*	S 38° N. lat.	S 36° N. lat.	10-100	10-100
Sunset rockfish	*Sebastes crocotulus*	S 34°27' N. lat.	S 34°27' N. lat.	55-164	55-110
Starry rockfish	*Sebastes constellatus*	S 38° N. lat.	S 37° N. lat.	13-150	13-150
Stripetail rockfish	*Sebastes saxicola*	Coastwide	Coastwide	5-230	5-190
Swordspine rockfish	*Sebastes ensifer*	S 38° N. lat.	S 38° N. lat.	38-237	38-237
Tiger rockfish	*Sebastes nigrocinctus*	N 35° N. lat.	N 35° N. lat.	30-170	35-170
Treefish	*Sebastes serriceps*	S 38° N. lat.	S 34°27' N. lat.	0-25	3-16
Vermilion rockfish	*Sebastes miniatus*	Coastwide	Coastwide	0-150	4-130
Widow rockfish	*Sebastes entomelas*	Coastwide	N 37° N. lat.	13-200	55-160
Yelloweye rockfish	*Sebastes ruberrimus*	Coastwide	N 36° N. lat.	25-300	27-220
Yellowmouth rockfish	*Sebastes reedi*	N 40° N. lat.	N 40° N. lat.	77-200	150-200
Yellowtail rockfish	*Sebastes flavidus*	Coastwide	N 37° N. lat.	27-300	27-160
Roundfish Species					
Kelp greenling	*Hexagrammos decagrammus*	Coastwide	N 40° N. lat.	0-25	0-10
Lingcod	*Ophiodon elongatus*	Coastwide	Coastwide	0-233	0-40
Pacific cod	*Gadus macrocephalus*	N 34° N. lat.	N 40° N. lat.	7-300	27-160
Pacific whiting	*Merluccius productus*	Coastwide	Coastwide	20-500	27-270
Sablefish	*Anoplopoma fimbria*	Coastwide	Coastwide	27->1,000	110-550
Cartilaginous Fish Species					
Big skate	*Beringraja binoculata*	Coastwide	N 34°27' N. lat.	2-440	2-60
Leopard shark	*Triakis semifasciata*	S 46° N. lat.	S 46° N. lat.	0-50	0-2
Longnose skate	*Beringraja rhina*	Coastwide	N 46° N. lat.	30-410	30-340
Pacific spiny dogfish	*Squalus suckleyi*	Coastwide	Coastwide	0->640	0-190

a/ Data from (Casillas, et al. 1998), (Eschmeyer, et al. 1983), (Hart 1988), (Miller and Lea 1972), (Love, et al. 2002), (Frable, et al. 2015), and NMFS survey data. Depth distributions refer to offshore distributions, not vertical distributions in the water column.

b/ The category "rockfish" includes all genera and species of the family Scorpaenidae, even if not listed, that occur in the Washington, Oregon, and California area.

c/ Only two occurrences of harlequin rockfish south of 51° N. lat. (off Newport, OR and La Push, WA; (Casillas, et al. 1998)).