STATUS OF THE PACIFIC COAST GROUNDFISH FISHERY

Stock Assessment and Fishery Evaluation

DESCRIPTION OF THE FISHERY

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August 2024

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Acronyms and Abbreviations

ABC	Acceptable biological catch
ACL	Annual catch limit
ACT	Annual catch target
AFSC	Alaska Fisheries Science Center
AIS	Adaptive Importance Sampling
AM	Accountability measure
B_0	Unfished spawning biomass or spawning output
$B_{X\%}$	Spawning biomass at X% of unfished spawning biomass or spawning output
BC	British Columbia
BDR	Blue and deacon rockfishes
BDS	Biological Data System (in the PacFIN database)
B_{MSY}	Spawning biomass predicted to produce MSY
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CA	California
CCA	Cowcod Conservation Area
CCE	California Current Ecosystem
CCFRP	California Collaborative Fisheries Research Program
CCIEA	California Current Integrated Ecosystem Assessment
CDFG	California Department of Fish and Game (now CDFW)
CDFW	California Department of Fish and Wildlife
CFR	Code of Federal Regulations
Council	Pacific Fishery Management Council
CP	Catcher-processor
CPFV	Commercial passenger fishing vessel
CPS	Coastal pelagic species
CPUE	Catch per unit of effort
CRFS	California Recreational Fisheries Survey
CV	Coefficient of variation
DB-SRA	Depletion-based stock reduction analysis
DCAC	Depletion-corrected average catch
DMR	Discard mortality rate
DNA	Deoxyribonucleic acid
DO	Dissolved oxygen
DTL	Daily trip limit (fishery)
DTS	Dover sole, thornyheads, and sablefish
E	Exploitation
EA	Environmental Assessment
EC	Ecosystem component
EDCP	Economic Data Collection Program
EEZ	Exclusive Economic Zone
EFH	Essential fish habitat
EFHCA	Essential fish habitat conservation area
EFP	Exempted fishing permit
EIS	Environmental Impact Statement
EM	Electronic monitoring

ENSO	El Niño Southern Oscillation
EO	Executive Order
EPIRB	Emergency Position Indicating Radio Beacon
ESA	Endangered Species Act
ExSSS	Extended Simple Stock Synthesis
F	Fishing mortality
FEIS	Final Environmental Impact Statement
FEP	Fishery Ecosystem Plan
fm	Fathom
FMP	Fishery Management Plan
F_{MSY}	Predicted fishing mortality rate at MSY
FR	Federal Register
FSSI	Fish Stock Sustainability Index
GBYR	Gopher and black-and-yellow rockfishes
GLM	Generalized Linear Model
GLMM	Generalized Linear Mixed Model
GMT	Groundfish Management Team
H	Stock-recruitment steepness
HA	Hectares
HCR	Harvest control rule
HG	Harvest guideline
IFQ	Individual fishing quota
INPFC	International North Pacific Fisheries Commission
IOPAC	Input-output model for West Coast fisheries
IPHC	International Pacific Halibut Commission
IUCN	International Union for the Conservation of Nature
JMC	Joint Management Committee in the U.S.-Canada Pacific Whiting Treaty process
JTC	Joint Technical Committee in the U.S.-Canada Pacific Whiting Treaty process
k	Von-Bertalanffy Growth Coefficient
LE	Limited entry
LEFG	Limited entry fixed gear
M	Instantaneous rate of natural mortality
MCMC	Markov Chain Monte Carlo
MFMT	Maximum Fishing Mortality Threshold
MHW	Marine heat wave
MRFSS	Marine Recreational Fisheries Statistical Survey
MS	Mothership
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSE	Management strategy evaluation
MSST	Minimum Stock Size Threshold
MSY	Maximum sustainable yield
mt	Metric ton
mtDNA	Mitochondrial deoxyribonucleic acid
NCS	Northern California sub-stock
NEPA	National Environmental Policy Act
NIOSH	National Institute for Occupational Safety and Health
nm	Nautical miles

NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NWFSC	Northwest Fisheries Science Center
OA	Open access
ODFW	Oregon Department of Fish and Wildlife
OFL	Overfishing limit
OFS	Overfished species
OMZ	Oxygen minimum zone
OR	Oregon
ORS	Oregon sub-stock
ORBS	Ocean Recreational Boat Survey
OY	Optimum yield
P*	Overfishing probability
PacFIN	Pacific Fisheries Information Network
PDO	Pacific Decadal Oscillation
PFD	Personal flotation device
PFMC	Pacific Fishery Management Council
POP	Pacific ocean perch
POTW	Publicly-Owned Treatment Works
PR	Private/rental boats
PSA	Productivity-susceptibility analysis
PSMFC	Pacific States Marine Fisheries Commission
PWCC	Pacific Whiting Conservation Cooperative
q	Catchability coefficient
QP	Quota pounds
QS	Quota share
R_0	Virgin recruitment
Rec	Recreational
RecFIN	Recreational Fisheries Information Network
RCA	Rockfish Conservation Area
RREAS	Rockfish Recruitment and Ecosystem Analysis Survey
SAFE	Stock Assessment and Fishery Evaluation
SCB	Southern California Bight
SCS	Southern California sub-stock
SPR	Spawning potential ratio
SRG	Scientific Review Group in the U.S.-Canada Pacific Whiting Treaty process
SSC	Scientific and Statistical Committee
SSS	Simple Stock Synthesis
STAR	Stock Assessment Review
STAT	Stock assessment team
SWFSC	Southwest Fisheries Science Center
TAC	Total allowable catch
T_{MAX}	The statutory maximum allowable time for a stock to rebuild
T_{MIN}	The biologically-determined minimum time for a stock to rebuild
T_{TARGET}	The target year to rebuild a stock specified in a rebuilding plan
US	United States
USCG	United States Coast Guard

USFWS	United States Fish and Wildlife Service
USSR	Union of Soviet Socialist Republics
V	Vulnerability
VAST	Vector Autoregressive Spatial Temporal (model)
VMS	Vessel monitoring system
WA	Washington
WCGBT	West Coast Groundfish Bottom Trawl (Survey)
WCGOP	West Coast Groundfish Observer Program
WDFW	Washington Department of Fish and Wildlife
WMC	Whiting Mothership Cooperative
XDB-SRA	Extended Depletion-based Stock Reduction Analysis
YOY	Young-of-the-year
YRCA	Yelloweye Rockfish Conservation Area

1. Description of the West Coast Groundfish Fishery

This chapter documents the evolution of West Coast groundfish fishery management. The West Coast groundfish fishery occurs in the West Coast Exclusive Economic Zone (EEZ), which extends from the U.S.-Mexico border north to the U.S.-Canada border from 3-200 nautical miles (nm) offshore of the continental United States (Figure 1-1).

The West Coast groundfish fishery has been in existence for over 100 years with documented commercial landings of some species off California in the late 1890s. West Coast indigenous peoples have subsisted on some groundfish species for thousands of years. The U.S. government has recognized four West Coast tribes (Makah, Quileute, Hoh, and Quinault in northern Washington) with fishing rights in the West Coast EEZ in treaties ratified over 100 years ago.

Figure 1-1. The Exclusive Economic Zone off the U.S. West Coast where the Pacific Fishery Management Council has jurisdiction in Federal fisheries management.

1.1 Legal Authority for Federal Fishery Management

Federal management of the West Coast groundfish fishery and the creation of the Pacific Fishery Management Council (hereafter "Council" or "PFMC") was enabled by passage of the Magnuson-Stevens Fishery Management and Conservation Act (MSA) in 1976 and implementation of the Pacific Coast Groundfish Fishery Management Plan (FMP) in 1982. Prior to implementation of the MSA and FMP, management of domestic groundfish fisheries was under the jurisdiction of the states of Washington, Oregon, and California. State regulations had been in effect on the domestic fishery for more than 100 years, with each state acting independently in both management and enforcement. Many fisheries overlapped state boundaries and participants often operated in more than one state. As management and a lack of uniformity of regulations became a difficult problem, it stimulated the formation of the Pacific States Marine Fisheries Commission (PSMFC) in 1947. PSMFC has no regulatory power but acts as a coordinating entity with authority to submit specific recommendations to states for their adoption. Between MSA implementation in 1977 and the implementation of the groundfish FMP in 1982, state agencies worked with the Council to address conservation issues.

Management of foreign fishing operations began in February 1967 when the U.S. and U.S.S.R. signed the first bilateral fishery agreement affecting trawl fisheries off Washington, Oregon, and California. The U.S. later signed bilateral agreements with Japan and Poland for fishing off the U.S. West Coast. Each of these agreements was renegotiated to reduce the impact of foreign fishing on important West Coast stocks, primarily rockfish, Pacific whiting, and sablefish. When the U.S. extended its jurisdiction to 200 nm upon signing the MSA, the National Marine Fisheries Service (NMFS) developed and implemented the preliminary management plan for the foreign trawl fishery off the Pacific Coast. From 1977 to 1982, the foreign fishery was managed under that plan. Many of these regulations were incorporated into the FMP, which provided for continued management of the foreign fishery.

Joint-venture fishing, where domestic vessels caught the fish to be processed aboard foreign vessels, began in 1979 and by 1989 had entirely supplanted directed foreign fishing. These joint ventures primarily targeted Pacific whiting. Joint-venture fisheries were then rapidly replaced by wholly domestic processing; by 1991, foreign participation had ended and U.S.-flagged motherships (MS), catcher-processors (CPs), and shore-based vessels had taken over the Pacific whiting fishery. Since then, U.S. fishing vessels and seafood processors have fully utilized Pacific Coast fishery resources.

1.1.1 Magnuson-Stevens Fishery Management and Conservation Act

The MSA is the principal law governing marine fisheries in the United States, although other applicable Federal laws, such as the Endangered Species Act and the National Environmental Policy Act, as well as Executive Orders need to be complied with under any Federal fisheries action. The primary goals of the MSA were to extend control of U.S. waters to 200 nautical miles (nm) in the ocean (i.e., the Exclusive Economic Zone or EEZ); to phase out foreign fishing activities; to prevent overfishing, especially by foreign fleets; to allow overfished stocks to recover; and to conserve and manage fishery resources. Achieving optimum yield (OY) of managed stocks is a primary mandate of the MSA.

Passage of the MSA also created the Regional Fishery Management Councils, with the PFMC being one of eight nationwide charged with recommending fishery policy and regulations to NMFS for federally-managed fisheries in the EEZ.

The MSA includes 10 national standards for management, which declare that conservation and management measures shall:

1. Prevent overfishing while achieving optimum yield.
2. Be based upon the best scientific information available.
3. Manage individual stocks as a unit throughout their range, to the extent practicable; interrelated stocks shall be managed as a unit or in close coordination.
4. Not discriminate between residents of different states; any allocation of privileges must be fair and equitable.
5. Where practicable, promote efficiency, except that no such measure shall have economic allocation as its sole purpose.
6. Take into account and allow for variations among and contingencies in fisheries, fishery resources, and catches.
7. Minimize costs and avoid duplications, where practicable.
8. Take into account the importance of fishery resources to fishing communities to provide for the sustained participation of, and minimize adverse impacts to, such communities (consistent with conservation requirements).
9. Minimize bycatch or mortality from bycatch.
10. Promote safety of human life at sea.

Congress has twice made significant revisions to the MSA, first in 1996 with the passage of the Sustainable Fisheries Act (SFA), and in 2007 with the MSA Reauthorization Act. Both acts provided more stringent conservation standards with the SFA specifying standards for rebuilding overfished stocks and the 2007 reauthorization specifying standards for minimizing the risk of overfishing a stock.

1.2 The Groundfish Fishery Management Plan

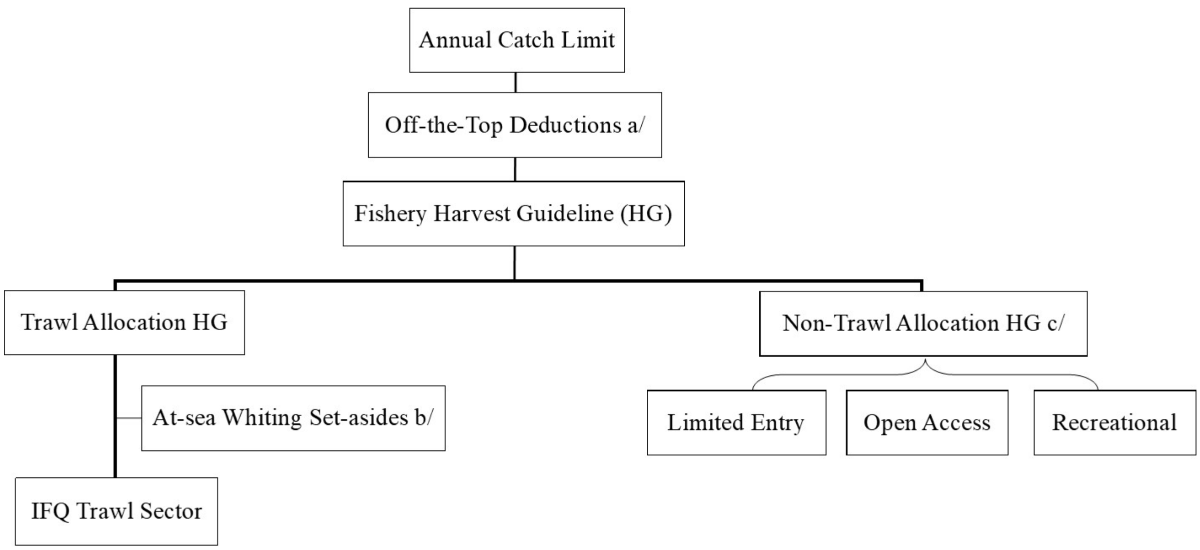
The FMP was implemented in 1982 to achieve MSA objectives for the West Coast groundfish fishery and has been amended 33 times as of June 2024. The FMP provides a framework for managing West Coast groundfish fisheries, with some specified management prescriptions such as prohibitions, formal allocations, and conservation mandates. The management framework is designed to provide flexibility to meet changing social and economic needs of the fishery and fluctuations in marine resources supporting the fishery. The complete FMP is available through the Council's website and is incorporated by reference

Most of the species managed in the current FMP (Table 2-1) were incorporated in the initial FMP with additional stocks added under Amendment 27 in 2015. Under Amendment 31 in 2023, the Council defined 20 stocks of 14 species.

1.3 Current Fishery Structure Overview

The Federal Pacific coast groundfish fishery is a year-round mixed stock fishery occurring in the EEZ off of California, Oregon, and Washington (Figure 1-1) and comprises Tribal and non-Tribal user groups. The fishery is complex and a diverse set of vessels and gear types are used to harvest groundfish. The non-Tribal fishery comprises the commercial and recreational sectors. The commercial fishery is divided into trawl and non-trawl sectors (Figure 1-2), wherein the trawl fishery includes the Pacific whiting at-sea component and the non-trawl sector includes limited entry fixed gear, open access, and the recreational sectors. The recreational fisheries are managed by each of the coastal states.

The FMP stocks and stock complexes targeted in the Pacific coast groundfish fishery are described in Chapter 2. Some of these species are primarily harvested in state waters. In these cases, it is common for these stocks and stock complexes to be managed with harvest guidelines specified in Federal regulations and managed by the coastal states. FMP stocks incidentally caught in other state-managed fisheries (e.g., California halibut trawl) are usually managed with yield set-asides to reduce the probability of overfishing these stocks. Details of groundfish sector management follows.



a/ Deductions for research, exempted fishing permits, tribal fisheries, and other fisheries not targeting groundfish ("incidental open access")

b/to account for at-sea mortality of non-whiting stocks

c/ the non-trawl HG allocation scheme complex, in general these three subsectors share it

Figure 1-2. Sectors and subdivisions of the non-Tribal commercial Pacific coast groundfish fishery.

1.3.1 Groundfish Trawl Fishery

The trawl sector comprises two overarching sectors, the At-sea whiting fishery and the shorebased individual fishing quota (IFQ) fishery. The At-sea fishery is further divided into the mothership (MS) and catcher-processor (CP) sectors. The IFQ fishery comprises midwater trawl, and bottom trawl vessels. The whiting fishery is jointly managed with Canada via the Pacific Hake Treaty; whereas, the IFQ trawl program is managed by the Council only.

Shorebased IFQ Sector

The shorebased individual fishing quota (IFQ) sector was created in 2011 with implementation of the trawl catch share program (see §1.5.1). Shorebased IFQ management is market-based and each participant in the shorebased IFQ sector is responsible for managing their catch. Quota share (QS) owners receive quota pounds (QP) at the start of each year for 30 species, which can then be used by vessels with limited entry trawl endorsed permits to harvest these species. Total catch (landings plus at-sea discards) are debited against the QP held in vessels' accounts with possible significant penalties, both monetary and loss of fishing access, levied against those participants catching in excess of whatever quota they hold or can obtain from other participants in this system of transferable quotas. Participants in the shorebased IFQ sector are subject to a series of control mechanisms to limit consolidation, including QS accumulation limits (the percentage of QS that can be owned by one entity) and annual vessel limits (the amount of catch a vessel can harvest of a species in a year).

While all vessels in the shorebased IFQ sector can trade quota up to control limits, there is a diversity of target strategies. The largest trawl vessels in the sector target pelagic species, such as Pacific whiting, widow rockfish, and yellowtail rockfish with midwater trawl nets and other vessels target other IFQ species using a variety of trawl and fixed gears. Vessels in the sector specialize in targeting Pacific whiting, midwater rockfish, and a variety of non-whiting IFQ species using bottom trawls and/or fixed gears. Most non-whiting shorebased IFQ vessels target multiple species, including Dover sole, thornyheads, and sablefish (i.e., DTS) and flatfish using bottom trawls.

Vessels that target Pacific whiting in the shorebased IFQ sector target whiting with midwater trawls and deliver their catch to shoreside processors are classified as the shoreside whiting fishery). Some of these vessels also cross-participate in the Mothership fishery; however, there are separate quotas for each sector and intersector quota trading is prohibited. Such vessels need to declare which fishery they are engaged in and debit their catch against sector-specific quota.

A provision was included in the trawl catch share program to allow shorebased IFQ vessels to use non-trawl gears (known as gear switching) to target their quota. Gear switching was envisaged as a strategy to harvest species not otherwise accessible in a mixed stock trawl fishery with some conservation benefits due to less bottom habitat disturbance. While some shorebased IFQ vessels do use both trawl gear and fixed gear within a fishing year, the primary target of vessels deploying fixed gear is sablefish.

At-Sea Whiting Trawl Sectors

The at-sea whiting trawl sectors (CP and MS) have been managed with cooperatives since 2011. Unlike the shorebased IFQ sector characterized for its diversity of target species and strategies, the at-sea sectors strictly target Pacific whiting in sector-specific harvest cooperatives. When the trawl catch share program was implemented in 2011, the at-sea sectors were also managed with allocations for select species (canary rockfish, darkblotched rockfish, widow rockfish, and Pacific ocean perch), which were constraining for all trawl sectors. As of 2020, all non-whiting groundfish species are managed with yield set-asides in the at-sea whiting fisheries.

Catcher-processors (CP) catch and process Pacific whiting at sea. Vessels in the CP sector have been operating under a harvest cooperative, the Pacific Whiting Conservation Cooperative, since 1997. The CP fleet is capped in terms of participation by the ten CP-endorsed permits. There are no processing limits for the vessels, unlike the MS vessels discussed below. There is an ownership limit on the number of permits (five) that can be owned by a single entity in the case of dissolution of the CP cooperative. In such a case, the vessels in the CP sector are managed under an IFQ system.

The MS sector is comprised of motherships (large processing vessels) and catcher vessels that target Pacific whiting and deliver their catch to motherships at sea. The Whiting Mothership Cooperative (WMC) was formed by the owners of the 37 catcher vessel limited entry trawl permit holders endorsed for operation in the MS sector based on historical participation. As in the CP sector, there is a limit on the number of MS permits (six) an entity can control. The WMC receives the allocation based on the cumulative catch histories of member vessels, which is the entirety of the sector's allocation since all catcher vessels have committed to the WMC since 2011. The MS cooperative operates in a pool system with an apportionment of the total Pacific whiting and any allocations/set-asides across five pools throughout the season based on the number of vessels participating.

1.3.2 Groundfish Non-Trawl Sector

The non-trawl groundfish sector include commercial and recreational fisheries and targets groundfish with fixed gear, e.g., hook and line, pots, longline, etc. The commercial sector is divided into the LEFG and OA sectors. Non-trawl sectors are managed with a variety of cumulative landing limits, time/area restrictions, and gear restrictions. Historically, the commercial sector was grouped into the "nearshore" and "non-nearshore" fisheries recognizing the fisheries that occur within state nearshore waters off California and Oregon and coastwide fishing activities further offshore, primarily targeting sablefish. Washington closed its state waters to commercial fisheries in 1995. While these fisheries may target different stocks, the nearshore and non-nearshore fisheries operate within the same series of trip limits depending on if they possess a limited entry permit or are participating in the OA fishery.

Limited Entry Fixed Gear

The LEFG sector is comprised of vessels fishing under a sablefish-endorsed LEFG permit and vessels fishing under an LEFG permit without a sablefish endorsement. All LEFG permits are also endorsed for their qualifying gear type (longline or traps/pots). An LEFG-permitted vessel with a sablefish endorsement can fish in the April – December primary sablefish fishery north of 36° N. lat. under the 'tier fishery' (see § 1.5.2) LEFG permits without a sablefish endorsement target northern sablefish in the daily-trip-limit (DTL) fishery. Sablefish-endorsed permits allow participation in the DTL fishery before and after the primary season or when the cumulative trip limit is attained during the primary season. All other species coastwide are managed with trip limits that are typically higher than those provided to OA vessels.

Open Access

OA groundfish vessels are not subject to LE permit requirements and, for most stocks, have lower landing limits than those provided to LEFG vessels. Those OA vessels landing nearshore groundfish species in the nearshore fishery are subject to state LE permits and limits in California and Oregon.

Recreational Fisheries

Recreational fisheries are largely managed by the coastal states, though Federal limits and management measures decided in the PFMC process apply in Federal waters. States cannot manage their recreational fisheries to exceed Federal limits (ACLs, harvest guidelines (HGs), etc.); however, the states can specify more conservative management measures than specified in Federal regulations. Each state manages their respective recreational fisheries to federally-specified state HGs for select stocks (e.g., HGs for rockfish species managed in the Nearshore Rockfish complex north of 40°10' N. lat., yelloweye rockfish, canary rockfish). Total recreational catch (landings plus estimated discard mortalities) counts against any specified non-trawl allocations.

Recreational fisheries primarily target groundfish using hook and line angling gears, although groundfish are also targeted by divers using spears. Recreational fisheries that occur in Federal waters are limited to boat-based modes, including private boats and charter/commercial passenger fishing vessels (CPFVs, charter boast, etc.); however, any catch of Council managed species from a shore-based mode (beach, pier, jetty, etc.) is contributes to the total mortality of the species.

1.3.3 The Tribal Fishery

There are four West Coast Tribes (Makah, Hoh, Quinault Indian Nation, and Quileute) with treaty rights to harvest federally-managed groundfish in their Usual and Accustomed (U&A) fishing areas (§660.4). Under these treaties, the four coastal treaty Tribes manage their fisheries within their respective U&As. The Tribes participate in trawl and non-trawl fisheries. Each biennium, the Tribes notify NMFS as to their groundfish needs – in terms of metric tons of specific stock/stock complexes. These amounts are set-aside/deducted from ACLs before any non-tribal allocations are made. The Tribal sablefish allocation is specified in the FMP at 10 percent of the northern ACL (i.e. north of 36° N. latitude). The Tribal allocation of Pacific whiting is decided annually in a consultation with NMFS.

1.3.4 Evolution of Federal Management and Resource Conservation Strategies

The first Federal management measures implemented for the groundfish fishery were cumulative landing limits, also known as "trip limits", for select species. One of the objectives in the early days of Federal groundfish management, based on the scientific understanding of achieving maximum sustainable yield (MSY), was to fish stocks down to the estimated biomass that produces MSY (B_{MSY}) to "optimally" utilize these resources. Increased understanding of rockfish sustainability evolved to a realization that harvest rates for these species were too aggressive, and more conservative limits were specified for rockfish beginning in the late 1990s.

The Sustainable Fisheries Act prompted Amendments 11 and 12, which incorporated new provisions for developing a rebuilding plan and managing the recovery of overfished species. Based on those provisions, nine stocks were declared overfished from 1999 to 2002 (Pacific ocean perch, bocaccio, lingcod, canary rockfish, cowcod, darkblotched rockfish, widow rockfish, yelloweye rockfish, and Pacific whiting). A tenth stock, petrale sole, was declared overfished in 2010.

A number of significant management measures were implemented in the late 1990s/early 2000s to respond to these overfished species' declarations and reduce the fishery mortality rates on these species. Area closures in habitats where these species occur began in 2000 with the closure of the two Cowcod Conservation Areas (CCAs) in the southern California Bight (see section 2.9.10). The first of the gear-specific Rockfish Conservation Areas (RCAs), depth-based areas defined by latitudinal and longitudinal waypoints closed to certain gears, was implemented in late 2002 before coastwide RCAs were implemented at the start of 2003. Large footrope trawls (footrope diameters > 8 in.) were prohibited for landing any shelf rockfish beginning in 2000. Small footropes on bottom trawls keep the gear out of high relief, rocky habitats where many of these overfished rockfish occur, since larger footropes are needed to be able to "bounce" or roll over these structures without destroying the nets. Coupled with retention prohibitions for many of these species (e.g., cowcod and yelloweye rockfish were and still are prohibited species), these measures effectively rebuilt nine of the ten overfished species with only yelloweye rockfish currently managed under a rebuilding plan (see section 2.3.1).

The 2007 MSA re-authorization prompted Amendment 23, which created the current harvest management framework of overfishing limits (OFLs), acceptable biological catches (ABCs), annual catch limits (ACLs), and accountability measures (AMs) to reduce the risk of overfishing (i.e., exceeding an OFL; see section 5).

1.4 Area Management

The Non-Trawl RCA was initiated as part of an emergency rule in January 2003 to mitigate impacts to overfished groundfish species (Section 6.8 of the Groundfish Fishery Management Plan (FMP). This rule closed a large portion of the continental shelf and portions of the slope to non-trawl fishing; however, the depths closed varied by area. Washington had the widest depth closure range, from 0 to 100 fm; whereas the area South of 34°27" N. lat has the narrowest closure range, from 100-150 fm. The depth range did not necessarily equate to area coverage as shelf width varies along the coast. For example, just south of Cape Mendocino, CA the Non-Trawl RCA is approximately 1.2 km wide whereas at Pt St. George, CA, the Non-Trawl RCA is approximately 16 km wide. These two geographic points are within the same management area, approximately 90 miles apart. The closed areas depth range was modified throughout the duration of this large-scale area-based closure. By October 2021, all overfished groundfish species, except for yelloweye rockfish were rebuilt. While the Non-Trawl RCA was not designed to mitigate impacts to habitat; however, it is likely this closure has had a positive impact on habitat.

In November 2019, the Pacific Fishery Management Council (Council) directed the Groundfish Advisory Subpanel (GAP) to develop the scope of action and draft a purpose and need statement for non-trawl area management during the GAP's March and April 2020 meetings. The GAP then submitted Informational Report 4 in June 2020 for Council consideration and scheduling of further scoping of the issues. In April 2021, the Council initiated a scoping process to address modifying existing the Non-Trawl RCA and developing measures to allow groundfish fishing inside the Non-Trawl RCA using only select gears that minimize bottom contact. In November 2021, the Council refined the purpose and need statement as well as the range of alternatives (ROAs). The Council expanded the action to include changes to the Cowcod Conservation Areas off California (CCA), including commercial and recreational fisheries), added specific measures that would include access to the Non-Trawl RCA off Washington, and included potential changes to essential fish habitat conservation area (EFHCA) designations that may be exposed to fishing activity under the alternatives.

In April 2022, the Council revised the range of alternatives as described in April 2022 Decision Summary Document. In September 2022, the Council adopted a final range of alternatives and preliminary preferred alternatives (PPA as described in the September 2022 Decision Summary Document The Council adopted their final preferred alternative (FPA) in March 2023.

Specifically, the FPA modified catch restrictions and gear configurations in the Non-Trawl RCA between the OR/WA border and the U.S./Mexico border for the directed open access (OA), limited entry fixed gear (LEFG), and individual fishing quota (IFQ) gear switching fisheries to allow LEFG vessels to fish up to their LEFG trip limits and IFQ gear switching vessels to fish their quota pounds (QPs) in the Non-Trawl RCA using stationary vertical jig gear or groundfish troll gear, allow vessels to use natural bait when using stationary vertical jig gear., and allow stationary vertical jig gear to be suspended no less than 30 ft off the bottom.

The FPA also changed the seaward boundary of the Non-Trawl RCA to 75 fm between the OR/WA border and 34° 27' N. lat. for groundfish and directed halibut and developed several conservation areas. This process created new EFHCAs at Nehalem Bank East, Bandon High Spot East, Garibaldi Reef North, Garibaldi Reef South, and Arago Reef that could prohibit non-trawl groundfish bottom contact and directed halibut gear. A new YRCA west of Heceta Bank was implemented, which prohibited non-trawl groundfish and directed halibut bottom contact gear. Additionally, three new YRCAs as described in Supplemental REVISED ODFW Report 1 were created, but not implemented, for potential use in the future. Further, the Action modified the 75 fm line described in CDFW Report 1 and Supplemental CDFW Report 2..

The CCA was repealed for non-trawl commercial and recreational fisheries, which necessitated developing new Non-Trawl RCA boundary lines around the islands and banks within the current CCA boundaries. Eight new Groundfish Exclusion Areas that prohibit non-trawl groundfish activity were implemented. The GEAs allow for continuous transit through the proposed closed areas with groundfish onboard, provided gear is stowed (commercial) or not deployed (recreational). They also allow for fishing for non-groundfish species as long as groundfish is not aboard the vessel. The action also allows for the Council to develop Block Area Closures for commercial non-trawl groundfish, as appropriate.

The process to modify the Non-Trawl RCA required Amendment 32 to the FMP. NMFS issued the final rule issued on December 1, 2023 (88 FR 83830). The regulations are effective as of January 1, 2024.

1.4.1 Trawl Area Management

In 2002, a depth-based bottom trawl closure was put into place coastwide since. This closure, referred to as the trawl RCA, prohibited fishing with limited entry groundfish trawl gear to reduce impacts to species that were overfished at that time (Pacific Ocean perch and darkblotched rockfish). Seven of the eight overfished stocks rebuilt by 2011, except for yelloweye rockfish, and, as such, the trawl RCA was reconsidered as part of Amendment 28: Essential Fish Habitat process.

The Council reopened the trawl RCA to bottom trawling in the Shorebased Individual Fishing Quota (IFQ) fishery off of Oregon and California. Areas closed to bottom trawling that overlap with the trawl RCA, such as EFH conservation areas and California state waters, remain closed to bottom trawling. The process to reopen these areas was undertaken due to the success of the trawl rationalization program and other commercial and recreational fishing innovations that have reduced bycatch of overfished and depleted stocks. The areas this rule reopened were predominantly substrates most resilient to trawl disturbance. When considered with EFHCAs, the reopening of the trawl RCA off Oregon and California resulted in new bottom trawl closures totaling 13,151 square miles (34,061 square km) and reopening of 2,958 square miles (7,661 square km). The existing trawl RCA remained off Washington, which means that fishing with bottom trawl gear and transiting without bottom trawl gear stowed is prohibited within the boundaries of the trawl RCA.

Noting that reopening an area that has not been fished with bottom trawl gear for over 15 years was not without risk, the Council adopted discrete spatial management tool more flexible and responsive than the trawl RCA, Block Area Closures (BACs). BACs are a type of groundfish conservation area bounded on the north and south by commonly used geographic coordinates in regulation and on the east and west by boundary lines approximating depth contours, defined with latitude and longitude coordinates in regulation. These closures which can be temporary, with a specific implementation or termination dates, or may be in effect until modified and used to address conservation objectives, such as reduction of protected species bycatch, prevent overfishing, etc. BACs may be implemented or modified as routine management measures, per regulations in the EEZ seaward of Washington, Oregon and California for vessels using limited entry bottom trawl and/or midwater trawl gear. BACs can also close areas to specific trawl gear types (e.g., closed for midwater trawl, bottom trawl, etc.) and/or specific programs within the trawl fishery (e.g., at-sea whiting, midwater trawl, etc.). If BACs are implemented within tribal Usual and Accustomed fishing areas only apply to non-tribal vessels.

Amendment 28 also implemented a deep-water closure, whereby bottom trawling was closed within the entire EEZ seaward (west) of a boundary line approximating the 700 fm (1,280 m) depth contour.

1.5 Fishery Rationalization

Groundfish fishery rationalization, a plan to promote economic efficiency and to maximize the net value of groundfish production, began with an effort to reduce capacity in the fishery and reduce derby fisheries where fishermen race to catch a limited quota. These efforts complied with MSA mandates and FMP objectives to promote domestic fisheries, promote safety at sea, and take into account the dependence of fishing communities and participants on groundfish resources while adhering to conservation requirements.

Rationalization of the West Coast groundfish fishery was initiated in the 1990s with a license limitation program and creation of the limited entry (LE) and open access (OA) sectors under Amendment 6 in 1992 (implemented for the 1994 fishery). Owners of vessels who met a minimum landing requirement within a qualifying period of July 11, 1984 through August 1, 1988 were given limited entry permits endorsed for the gear that was used to meet the requirement and endorsed for the size of the vessel. Minimum landing requirements were set with the intent of establishing limited entry fleets that were the size of the active fleet in 1987. Permits were endorsed for trawl, longline, and fishpot vessels, and were allowed to qualify for more than one gear endorsement (but only one permit was issued for each vessel). Under Amendment 6, most harvestable yields (i.e., stock-specific fishery harvest guidelines) were allocated to the limited entry sectors, while remaining yields were allocated to the OA sector.

The license limitation program created under Amendment 6 was recognized as a start to slow the growth in capacity and the Council immediately began consideration of an individual fishing quota (IFQ) program for the limited entry fixed gear (LEFG) sector under Amendment 8. However, with passage of the SFA, Congress imposed a moratorium on implementing new IFQ programs through October 1, 2000 and Amendment 8 was therefore not adopted.

The limited entry sectors were rationalized in different ways and the following sections describe how sector management rationalization evolved. The Council is continuing to refine these sector management strategies to achieve greater economic efficiencies and to maximize resource production and fishery profits.

1.5.1 Rationalization of the Limited Entry Trawl Fishery

In 2003, Congress financed a $46-million capacity-reducing buyback loan for permanent removal of 91 limited entry trawl vessels (35 percent of permits) from the bottom trawl and associated fisheries to reduce capacity and increase economic efficiency in the limited entry trawl sector. In 2004, the Council began development of a trawl catch share program with consideration of IFQs.

Amendment 20, implemented in 2011, created the trawl catch share program where participants in the limited entry shorebased trawl sector (consisting of trawl vessels delivering to shoreside processors) are managed under a system of IFQs and participants in the limited entry at-sea sectors (consisting of large trawl vessels that catch and process whiting at sea) are managed under a system of harvesting cooperatives.

Participants in the trawl catch share program are subject to 100 percent at-sea monitoring of their catch. One effect of trawl rationalization is a significant decrease in at-sea discarding, which was an increasing problem under trip limits due to vessels high-grading for higher priced fish and the effect of species-specific trip limits in a mixed stock fishery. There has also been increased specialization in the shoreside trawl fishery with participants tailoring their fishing strategies to their quota portfolio and their vessels' capabilities.

1.5.2 Rationalization of the Limited Entry Fixed Gear Fishery

With the implementation of the license limitation program, there was also the formalization of the trawl/non-trawl allocations for northern sablefish (discussed more below). Industry representatives for participants in the non-trawl sablefish fisheries expressed their desire that the fishery be managed on a seasonal basis (as opposed to the year-round policy the Council pursued for most sectors of the groundfish fishery). Amendment 9 was adopted in 1996 to allow participation in the seasonal primary sablefish fishery by limited entry fixed gear vessels with enough catch history to have sablefish endorsements on their permits. LEFG permits with sablefish endorsements enable targeting of sablefish under higher cumulative landing limits in the primary sablefish fishery north of 36° N. lat. than those without a sablefish endorsement.

The original structure of the primary sablefish season created under Amendment 9 allocated equal cumulative landing limits that led to a race for fish and shorter, more dangerous derby fisheries. A regulatory amendment established a three-tier system for fisheries starting in 1998, which provided each vessel with a single cumulative limit; however, sablefish endorsement holders were ranked into three different tiers based on their permit histories, with the lowest tier (tier 3) having the lowest qualification requirements and receiving the lowest cumulative limits. While somewhat more equitable than the cumulative limit program, the three-tier system still required some fishermen to make large cutbacks in their harvest levels while allowing others to expand. The fishery still had to be managed as a modified derby, and the seasons were still too short (between 6-9 days) to allow fishermen to operate safely.

In 2001, after the Congressional moratorium on new IFQ programs expired, Amendment 14 implemented the permit stacking program, in which up to three sablefish-endorsed permits could be registered for use with a single vessel and that vessel could then have access to the primary season sablefish cumulative limits associated with each of those permits. Amendment 14 also established the longer April 1 to October 31 primary sablefish season so that each vessel could fish against its limits at its own speed. The limit structure of the primary fishery under Amendment 14 specifies landing limits for tiers 1 and 2, which are 3.85 and 1.75 times greater, respectively, than tier 3 limits.

1.6 Groundfish Sector Allocations

1.6.1 Formal Allocations

Formal allocations (i.e., those prescribed in the FMP) of important stocks to different sectors of the groundfish fishery are important policy decisions designed to share the resource equitably according to need and foster longer-term stability and economic efficiency in the fishery. The Formal allocations are detailed in the FMP at §6.3.2 and summarized below.

Sablefish

The sablefish north of 36° N. lat. allocation of was established in 1987 for non-tribal commercial The allocation, as of 2024, is shown in Figure 1-3.

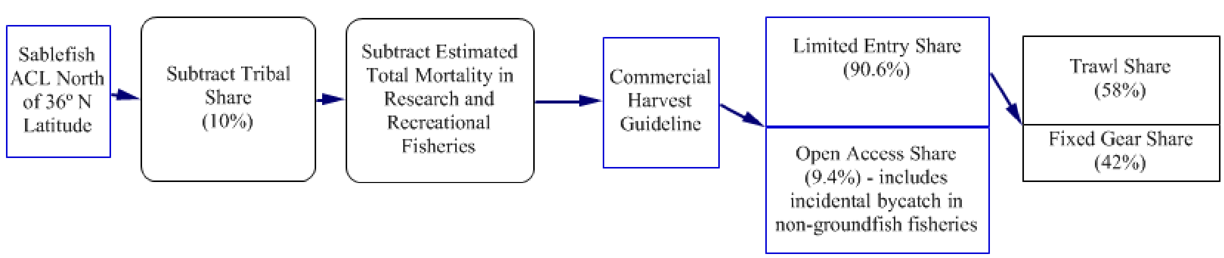


Figure 1-3. Fixed intersector allocations of sablefish north of 36° N. lat.

Pacific Whiting

Pacific whiting allocations for non-tribal sectors apply after a yield amount is set aside to accommodate tribal whiting fisheries and other non-tribal non-directed fishing activities (e.g., pink shrimp and research). The non-tribal commercial share of whiting is allocated 42 percent shoreside whiting sector, 24 percent at-sea mothership whiting sector, and 34 percent at-sea catcher-processor sector.

Amendment 21 Allocations

Formal sector allocations for 19 important target stocks (arrowtooth flounder, chilipepper rockfish south of 40°10' N. lat., darkblotched rockfish, Dover sole, English sole, lingcod, longspine thornyhead north of 34°27' N. lat., longspine thornyhead south of 34°27' N. lat., Pacific cod, Pacific ocean perch, petrale sole, sablefish N of 36° N. lat., sablefish south of 36° N. lat., shortspine thornyhead north of 34°27' N. lat., shortspine thornyhead south of 34°27' N. lat., splitnose S of 40°10' N. lat., starry flounder, widow rockfish, and yellowtail rockfish north of 40°10' N. lat.) and three stock complexes (other flatfish and the slope rockfish complexes north and south of 40°10' N. lat.) were established under Amendment 21 and implemented in 2011 coincident with the trawl catch share program. Under Amendment 29, formal allocations for canary rockfish, lingcod S of 40°10' N. lat., slope rockfish complex south of 40°10' N. lat. including blackgill rockfish, petrale sole, and widow rockfish were transitioned to biennial allocations in 2021. Shortspine thornyhead was transitioned to a biennial allocation in 2025 under Amendment 33 The formal allocations prescribed in the FMP through Amendments 21 are shown in Table 1-1.

Table 1-1. Formal non-treaty trawl/non-trawl allocation percentages (%) specified for FMP groundfish stocks and stock complexes (most percentages based on average 2003-05 total catch by sector).

Stock or Complex	All Non-Treaty LE Trawl Sectors	All Non-Treaty Non-Trawl Sectors
Arrowtooth flounder	95%	5%
Chilipepper rockfish S of 40°10' N. lat.	75%	25%
Darkblotched rockfish	95%	5%
Dover sole	95%	5%
English sole	95%	5%
Lingcod N of 40°10' N. lat.	45%	55%
Longspine thornyhead N of 34°27' N. lat.	95%	5%
Pacific cod	95%	5%
Pacific ocean perch	95%	5%
Sablefish S of 36° N. lat.	42%	58%
Splitnose rockfish S of 40°10' N. lat.	95%	5%
Starry flounder	50%	50%
Yellowtail rockfish N of 40°10' N. lat.	88%	12%
Other Flatfish Complex	90%	10%
Slope Rockfish Complex N of 40°10’ N. lat.	81%	19%

1.6.2 Biennial Allocations

Biennial allocations are those that can be modified each biennium without an FMP Amendment. These allocations are often referred to as informal allocations. The allocations are shown in Table 1-2.

Table 1-2. Biennial non-treaty trawl/non-trawl allocation percentages (%) for FMP groundfish stocks and stock complexes.

Stock or Complex	Trawl Sector	Non-Trawl Sector
Big Skate	95%	5%
Bocaccio	39.04%	60.96%
Canary Rockfish	72.3%	27.7%
Cowcod	95%	5%
Lingcod south of 40°10' N. lat	36%	64%
Longnose Skate	90%	10%
Petrale Sole	Remaining yield	30
Shortspine Thornyhead	64%/71%	36%/29%
Widow Rockfish	Remaining yield	300mt
Yelloweye Rockfish	8%	92%
Shelf Rockfish Complex N of 40°10' N. lat.	60.2%	39.8%
Shelf Rockfish Complex S of 40°10' N. lat.	12.2%	87.8%
Slope Rockfish Complex S of 40°10' N. lat.	63%	37%

a/ The shortspine thornyhead trawl/non-trawl allocation changes during the 2025-26 biennium. 2025 allocation is 64:36 and the 2026 allocation is 71:29.

Harvest Guidelines/Sharing Agreements

Harvest guidelines (HG) can be developed for specific sectors for single stocks and/or for stocks within a complex. The Council has developed HGs for stocks within complexes and state sharing agreements. HGs are a discretionary AM that do not require action if exceeded (FMP §2.2). Sharing agreements are generally an informal method of apportioning an HG to sub-sectors, e.g., commercial and recreational fisheries within the non-trawl sector. They are helpful in understanding sector, or state, specific impacts on a stock and/or a stock complex.

Boccacio South of 40°10′ N. lat.

Boccacio South of 40°10′ N. lat. has an informal, within non-trawl allocation/sharing agreement. The non-trawl allocation is parsed to the commercial and recreational sector as 69.1 percent commercial and 30.9 percent California recreational.

Canary Rockfish

Canary rockfish has an informal within non-trawl allocation/sharing agreement. The non-trawl allocation is parsed to the commercial and recreational sector as 36 percent commercial, 12.3

percent Washington recreational, 18.5 percent Oregon recreational, and 33.2 percent California recreational.

Cowcod

Cowcod south of 40°10′ N. lat. is allocated to the trawl/non-trawl fishery at 36 percent to 64 percent, respectively. The non-trawl sector is managed under a 50:50 percent commercial/recreational sharing agreement

Slope rockfish south of 40° 10′ N. lat. and blackgill rockfish

The goal of this informal allocation is to informally allocate blackgill rockfish south of 40°10′ N. lat. within the slope rockfish complex south of 40°10′ N. lat. to improve utilization of the stock in equitable manner between the trawl/non-trawl sectors. In this process, the blackgill rockfish south of 40°10′ N. lat. ACL is split 41 percent trawl to 59 percent non-trawl. The slope rockfish complex south of 40°10′ N. lat. is split 91 percent trawl to 9 percent non-trawl. These amounts are summed by sector. The percent of total share is calculated as total of trawl/non-trawl amount divided by each sector specific amount then multiplied by 100 to calculate the percentage. Any set-asides are proportionally removed from each sector. This final calculation results in the final biennial allocation. See § 1.5.2 in Agenda Item F.6, Attachment 2, June 2024.

Yelloweye Rockfish

Yelloweye rockfish has an allocation structure of 8 percent trawl to 92 percent non-trawl. The non-trawl allocation is informally shared. The sharing structure is 20.9 percent non-trawl, 25.6 percent Washington recreational, 23.3 percent Oregon recreational, and 30.2 percent California recreational.

2. Groundfish Stocks, Their Status, and Description of the Management System

The Council actively manages 86 groundfish species, of which 20 stocks have been defined.[1] At present, nine species and two families are considered ecosystem component species (ECS). The managed species include over 61 species of rockfish, two thornyheads, one scorpionfish, six roundfish species, 12 flatfish species, two sharks, and two skates. Table 2-1 depicts the latitudinal and depth distributions of groundfish species managed under the groundfish FMP and Figure 1-1 depicts management area divisions.

The following sections contain information on the life histories of a subset of the groundfish managed under the groundfish FMP. While reading these sections, it is important to keep in mind how certain life history traits of the species have important implications on how the stocks are sustainably managed.

In contrast to the highly variable, and often volatile, population cycles of many coastal pelagic and invertebrate populations in the California Current, many of the resident groundfish in the California Current have evolved entirely different life history approaches to coping with environmental variability. Sablefish, Dover sole, spiny dogfish, and a large number of rockfish (*Sebastes* and *Sebastolobus*) species have life spans that typically span decades, and in some extreme examples may reach ages of 100 or greater (Beamish*, et al.* 2006; Love*, et al.* 2002). Although large initial catches of many rockfish had given the impression that these stocks were also highly productive, a growing body of scientific evidence soon made it clear that many of these species were incapable of sustaining high intensity fishing pressure using modern fishing methods (Francis 1986; Gunderson 1977; Gunderson 1984; Leaman and Beamish 1984).

Among the concerns raised in some of the early research and analyses were that the large standing stocks of older individuals were simply maintaining themselves within the dynamic bounds of their ecosystem, and that the failure to consider the role of such longevity in Northeast Pacific groundfish could lead to management challenges. Factors such as extreme longevity, low natural mortality, increasing fecundity with age, and infrequent reproductive success (recruitment) were explicitly considered when initial harvest rate strategies were developed for the Council (Clark 1991). However, the paucity of data and magnitude of some of these factors as related to the low productivity of many species were not fully appreciated in many early studies, and are now known to be important considerations in developing harvest rate guidelines and management policies (Clark 2002; Dorn 2002a). Consequently, harvest rates for many species have been reduced repeatedly in recent years to account for the improved knowledge regarding the overall productivity of these stocks. As new information continues to emerge regarding the significance of diverse age structures and other factors in sustaining groundfish resources (Berkeley 2004; Berkeley*, et al.* 2004; Bobko and Berkeley 2004), such information continues to be evaluated

[1] The Council is undertaking a process at present to define stocks of species in need of conservation and management. This process may reduce the number of species managed.

and incorporated into the stock assessment and assessment review processes that provide the scientific basis upon which management decisions are made.

Management of these groundfish species is based on principles outlined in the MSA, groundfish FMP, and National Standard Guidelines, which provide guidance on the ten national standards in the MSA. Stock assessments are based on resource surveys, catch trends in West Coast fisheries, and other data sources.

Table 2-1. Latitudinal and depth distributions of groundfish species (adults) managed under the Pacific Coast Groundfish Fishery Management Plan. [a/]

Common Name	Scientific Name	Latitudinal Distribution		Depth Distribution (fm)	
		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
Rockfish Species [b/]					
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
Brown rockfish	*Sebastes auriculatus*	Coastwide	S 40° N. lat.	0-70	0-50

Common Name	Scientific Name	Latitudinal Distribution		Depth Distribution (fm)	
		Overall	Highest Density	Overall	Highest Density
Calico rockfish	*Sebastes dallii*	S 38° N. lat.	S 33° N. lat.	10-140	33-50
California scorpionfish	*Scorpaena gutatta*	S 37° N. lat.	S 34°27' N. lat.	0-100	0-100
Canary rockfish	*Sebastes pinniger*	Coastwide	Coastwide	27-460	50-100
Chameleon rockfish	*Sebastes phillipsi*	37°-33° N.	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
Longspine thornyhead	*Sebastolobus altivelis*	Coastwide	Coastwide	167-	320-550
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.	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

Common Name	Scientific Name	Latitudinal Distribution		Depth Distribution (fm)	
		Overall	Highest Density	Overall	Highest Density
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
Shortbelly rockfish	*Sebastes jordani*	Coastwide	S 46° N. lat.	50-175	50-155
Shortraker rockfish	*Sebastes borealis*	N 39°30' N.	N 44° N. lat.	110-	110-220
Shortspine thornyhead	*Sebastolobus alascanus*	Coastwide	Coastwide	14-	55-550
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
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					
Cabezon	*Scorpaenichthys marmoratus*	Coastwide	Coastwide	0-60	0-27
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					
Aleutian skate	*Bathyraja aleutica*	N of 40°10' N. lat.	N of 40°10' N. lat.	8-876	50-120
Bering/sandpaper skate	*Bathyraja interrupta*	N of 32°30' N. lat.	N of 32°30' N. lat.	13-820	30-750
Big skate	*Beringraja binoculata*	Coastwide	N 34°27' N. lat.	2-440	2-60

Common Name	Scientific Name	Latitudinal Distribution		Depth Distribution (fm)	
		Overall	Highest Density	Overa ll	Highest Density
California skate	*Raja inornata*	Coastwide	S 39° N. lat.	0-367	0-10
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
All other skates	Endemic species in the family *Arhynchobatidae*				
Ratfish	*Hydrolagus colliei*	Coastwide	Coastwide	0-499	55-82
Roughtail/black skate	*Bathyraja trachura*	Coastwide	Coastwide	116-1,394	400-1,090
Soupfin shark	*Galeorhinus zyopterus*	Coastwide	Coastwide	0-225	0-225
Spiny dogfish	*Squalus suckleyi*	Coastwide	Coastwide	0-	0-190
Other Species					
Finescale codling	*Antimora microlepis*	Coastwide	N 38° N. lat.	190-1,588	190-470
Giant grenadier	*Coryphaenoides pectoralis*	Coastwide	Coastwide	77-1,914	383-601
Pacific grenadier	*Coryphaenoides acrolepis*	Coastwide	N 38° N. lat.	85-1,350	500-1,350
All other grenadiers	Endemic species in the family *Macrouridae*				

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)).

The passage of the SFA in 1996 and the reauthorization of the MSA in 2006 incorporated the current conservation and rebuilding mandates into the MSA. These mandates, including abundance-based standard reference points for declaring the status of a stock (overfished/rebuilding; in a "precautionary" status; or at levels that can support MSY (healthy or "rebuilt")), were subsequently incorporated in the groundfish FMP with adoption of Amendments 11, 12, and 23. These reference points are determined relative to an estimate of the "virgin" or unexploited spawning biomass of the stock, denoted as B_0, which is defined as the average equilibrium abundance of a stock's spawning biomass before it is affected by fishing-related mortality.[2] B_0 is then used to estimate MSY, as identified in the MSA and National Standard Guidelines. MSY represents a theoretical maximum surplus production from a population of constant size; National Standard Guidelines define it as "the largest long-term

[2] The current abundance of a stock relative to its unfished level is commonly written as a percentage or a proportion; this value represents the stock's depletion level. In addition to using a comparison between current spawning biomass and unfished spawning biomass to determine this reference point, some stock assessment authors compare current and unfished levels of spawning output or of total stock biomass, depending on the information that is available.

average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions." For a given population and set of ecological conditions, there is a biomass that produces MSY (denoted as B_{MSY}), which is less than the equilibrium size in the absence of fishing (B_0)[3]. The harvest rate used to achieve or sustain B_{MSY} is referred to as the Maximum Fishing Mortality Threshold (MFMT, denoted as F_{MSY}). Three harvest specification reference points defined in the groundfish FMP provide guidance in setting the harvest rate: an OFL, an ABC, and an ACL (see section 5 for more information on harvest specifications). The Council identifies the ACL as the management target for each species or species complex. When the stock biomass is determined to be lower than B_{MSY}, the ACL is set to an adequately low level to rebuild the stock to a healthy level in a timely fashion.

The biomass level that produces MSY (i.e., B_{MSY}) is generally unknown and assumed to be variable over time due to long-term fluctuations in ocean conditions, so that no single value is appropriate. Furthermore, F_{MSY} is tightly linked to an assumed level of density dependence in recruitment, and there is insufficient information to determine that level for many West Coast groundfish stocks. Therefore, the use of approximations or proxies is necessary; absent a more accurate determination of F_{MSY}, the Council applies default MSY proxies (see section 5 for more details). The Council adopts management actions aimed to maintain abundance of each stock at or above the specified B_{MSY} target. The threshold for declaring a stock overfished is when the stock's spawning biomass declines to less than the specified Minimum Stock Size Threshold or MSST (i.e., 12.5 percent of B_0 or $B_{12.5\%}$ for assessed flatfish stocks and $B_{25\%}$ for all other groundfish stocks). A rebuilding plan that specifies how total fishing-related mortality is constrained to achieve an MSY abundance level within the legally allowed time is required by the MSA and groundfish FMP when a stock is declared overfished.

Only a portion of the species in the FMP are individually managed; the remaining species are managed and accounted for in stock complexes (see section 2.5). The Council has also decided to continue to manage some assessed stocks in complexes to avoid management complications such as disruption to the trawl rationalization program. Catch-based and other data-limited methods described in Chapter 3 are used to set OFLs for unassessed stocks. Additionally, there is a category of stocks that are incidentally caught in groundfish fisheries for which no harvest limits are specified. This category of stocks, termed Ecosystem Component (EC) species, are not considered to be in the fishery and are neither targeted nor generally retained for sale or personal use. EC species are determined not to likely become subject to overfishing or to be overfished in the absence of conservation and management measures. There is a monitoring requirement for species designated as EC species to the extent that any new pertinent scientific information becomes available (e.g., catch trends, vulnerability, etc.) to determine changes in their status or their vulnerability to the fishery. The Council has specified an EC designation for some species currently managed in the FMP (see section 2.5.9).

When the total fishing mortality (i.e., landed catch plus dead discards) of a West Coast groundfish stock or stock complex exceeds the specified OFL for that stock or complex, the stock is

[3] Generally, population sizes above B_{MSY} are assumed to be less productive because of competition for resources or other density-dependent factors.

considered to be subject to overfishing. Total mortality is estimated by the NMFS Northwest Fisheries Science Center and reported for all managed West Coast stocks and complexes in total mortality reports. Summaries of the status of West Coast groundfish stocks and complexes (and the other federally-managed stocks and complexes nationally), are provided by the NMFS Fish Stock Sustainability Index (FSSI).

2.1 Productivity and Susceptibility Assessment of Stocks to Overfishing

The vulnerability to potential overfishing of a stock to the fishery for each groundfish stock in the FMP was determined as a first step in assisting with two specific tasks set forth in the FMP: 1) to define species as either "in the fishery" or as an "ecosystem component," and 2) identify stock complexes. In addition, the vulnerability scores were considered when prioritizing stock assessments and determining data collection needs.

The Productivity-Susceptibility Assessment (PSA) approach of Patrick et al. (2009) was used to characterize vulnerability and has two components: 1) productivity as defined by life history traits, and 2) susceptibility to current fishing practices (Cope*, et al.* 2011). Each vulnerability component is comprised of several attributes (10 productivity and 12 susceptibility attributes) and the weighted mean score of all attributes defines the overall productivity and susceptibility score. Table 2-2 includes the vulnerability scores for all species in the FMP relative to the current fishery. Table 2-3 shows the vulnerability scores for currently overfished or rebuilding rockfish species relative to the fishery circa 1998. Scores are presented in two dimensions, with productivity on the x-axis and susceptibility on the y-axis (Figure 2-1). Cope et al. (2011) established vulnerability reference points of assessed and unassessed West Coast groundfish stocks to determine vulnerability groups as follows:

- $V \geq 2.2$ indicate species of major concern.
- $2.0 \leq V < 2.2$ indicate species of high concern.
- $1.8 \leq V < 2.0$ indicate species of medium concern.
- $V < 1.8$ indicate species of low concern.

Rockfish and elasmobranchs showed the highest vulnerabilities (>2.0), with the deepest-residing members of those groups often the most vulnerable, though there were several species of nearshore rockfish (China, quillback, and copper rockfish) with some of the highest scored vulnerabilities. Flatfishes in general showed the lowest vulnerabilities.

In addition to scoring each productivity and susceptibility attribute, the quality of the data used for each score was also recorded (Table 2-2, Table 2-3, and Figure 2-2). Data quality is scored for each productivity and susceptibility attribute, with the overall data quality score calculated as the weighted mean of all attributes. A scoring scale of 1-5 was used, with the best data score being 5.

Recording the data quality can highlight vulnerability scores that can be improved with additional data or that should be interpreted with caution because of questionable data contribution. Data quality scores can also be used to justify future data collection on particular attributes.

In general, susceptibility was harder to score (lower data quality) than productivity. Flatfishes as a group had the least informed species, but elasmobranchs and several rockfish species also showed low-quality data informing vulnerability scores (Table 2-2 and Figure 2-2).

PSA analyses are anticipated to be re-done periodically. Productivity scores are not expected to vary much over time since they are based on life history traits. However, susceptibility scores may vary based on changes in fishing practices and/or management, as well as an updated understanding of the stock's interaction with the fishery. As susceptibility scores change, so do the vulnerability scores.

Table 2-2. Overall scores and results of the Productivity and Susceptibility Assessment (PSA) ranked from most to least vulnerable to overfishing relative to the current West Coast fishery (Cope et al. 2011).

Stock ID	Stock Name	Productivity	Susceptibility	Vulnerability
21	Copper rockfish	1.95	1.60	2.27
67	Rougheye rockfish	1.17	2.33	2.27
72	Shortraker rockfish	1.22	2.38	2.25
20	China rockfish	1.33	2.29	2.23
58	Quillback rockfish	1.31	2.43	2.22
61	Redstripe rockfish	1.31	2.33	2.16
22	Cowcod	1.25	2.00	2.13
77	Spiny dogfish	1.11	1.98	2.13
10	Bronzespotted rockfish	1.37	2.14	2.12
16	California skate	1.33	2.00	2.12
35	Greenblotched rockfish	1.28	2.24	2.12
2	Aurora rockfish	1.89	2.29	2.10
76	Speckled rockfish	1.33	2.29	2.10
65	Rosethorn rockfish	1.19	2.05	2.09
81	Starry rockfish	1.25	2.14	2.09
7	Blackgill rockfish	1.22	2.08	2.08
84	Tiger rockfish	1.25	2.10	2.06
70	Sharpchin rockfish	1.36	2.24	2.05
86	Vermilion rockfish	1.22	2.02	2.05
87	Widow rockfish	1.31	2.16	2.05
18	Chameleon rockfish	1.39	2.20	2.03
3	Bank rockfish	1.28	1.88	2.02
55	Pink rockfish	1.33	2.14	2.02
60	Redbanded rockfish	1.28	2.05	2.02
74	Silvergray rockfish	1.22	1.95	2.02
75	Soupfin shark	1.11	1.71	2.02
8	Blue rockfish	1.22	2.16	2.01

Stock ID	Stock Name	Productivity	Susceptibility	Vulnerability
17	Canary rockfish	1.61	2.43	2.01
43	Leopard shark	1.26	2.00	2.00
88	Yelloweye rockfish	1.22	1.92	2.00
4	Big skate	2.45	2.05	1.99
11	Brown rockfish	1.72	2.08	1.99
26	Dusky rockfish	1.75	1.76	1.99
36	Greenspotted rockfish	1.39	2.14	1.98
30	Flag rockfish	1.83	1.80	1.97
40	Honeycomb rockfish	1.36	2.10	1.97
89	Yellowmouth rockfish	1.61	2.38	1.96
5	Black rockfish	1.21	2.14	1.94
39	Harlequin rockfish	1.31	1.95	1.94
54	Petrale sole	1.70	2.44	1.94
83	Swordspine rockfish	1.33	2.00	1.94
9	Bocaccio	1.28	2.04	1.93
24	Darkblotched rockfish	1.39	2.24	1.92
34	Grass rockfish	1.61	2.29	1.89
66	Rosy rockfish	1.61	2.29	1.89
37	Greenstriped rockfish	1.28	1.76	1.88
90	Yellowtail rockfish	1.33	1.88	1.88
48	Olive rockfish	1.69	2.33	1.87
79	Squarespot rockfish	1.61	2.24	1.86
51	Pacific grenadier	1.44	1.95	1.82
56	Pinkrose rockfish	1.31	1.67	1.82
78	Splitnose rockfish	1.28	1.60	1.82
47	Mexican rockfish	1.50	2.00	1.80
73	Shortspine thornyhead	1.33	1.68	1.80
82	Stripetail rockfish	1.39	1.81	1.80
63	Rock greenling	1.78	2.29	1.77
33	Gopher rockfish	1.56	2.00	1.76
85	Treefish	1.67	2.10	1.73
59	Ratfish	1.63	2.05	1.72
6	Black-and-yellow rockfish	1.83	1.68	1.70
50	Pacific ocean perch	1.44	1.67	1.69
53	Pacific whiting	2.00	2.36	1.69
13	Cabezon	1.33	2.48	1.68

Stock ID	Stock Name	Productivity	Susceptibility	Vulnerability
45	Longnose skate	1.53	1.80	1.68
68	Sablefish	1.61	1.88	1.64
42	Kelp rockfish	1.83	2.12	1.62
41	Kelp greenling	1.83	2.04	1.56
44	Lingcod	1.75	1.92	1.55
25	Dover sole	1.36	2.57	1.54
27	Dwarf-red rockfish	1.06	1.88	1.54
46	Longspine thornyhead	1.47	1.16	1.54
29	Finescale codling	2.45	2.10	1.48
14	Calico rockfish	1.39	2.04	1.46
32	Freckled rockfish	1.80	1.96	1.44
57	Pygmy rockfish	1.78	1.71	1.42
64	Rock sole	1.95	1.95	1.42
15	California scorpionfish	1.28	0.00	1.41
19	Chilipepper	1.83	0.00	1.35
49	Pacific cod	2.11	2.00	1.34
62	Rex sole	2.05	1.86	1.28
31	Flathead sole	2.25	1.92	1.26
38	Halfbanded rockfish	2.00	1.76	1.26
52	Pacific sanddab	2.40	2.10	1.25
23	Curlfin sole	1.72	1.75	1.23
69	Sand sole	2.35	2.05	1.23
1	Arrowtooth flounder	1.33	2.05	1.21
28	English sole	2.30	2.05	1.19
12	Butter sole	1.78	1.76	1.18
71	Shortbelly rockfish	1.94	1.40	1.13
80	Starry flounder	2.15	1.60	1.04

Table 2-3. Retrospective Productivity and Susceptibility Assessment (PSA) vulnerability scores of currently overfished or rebuilding rockfish relative to the fishery circa 1998. California quillback rockfish retrospective PSA (*) is unknown as it was not a stock under rebuilding in Cope et al. 2011.

Stock Name	Stock ID	Susceptibility	Vulnerability
Yelloweye rockfish	18_H	2.80	2.53
California quillback rockfish	*	*	*

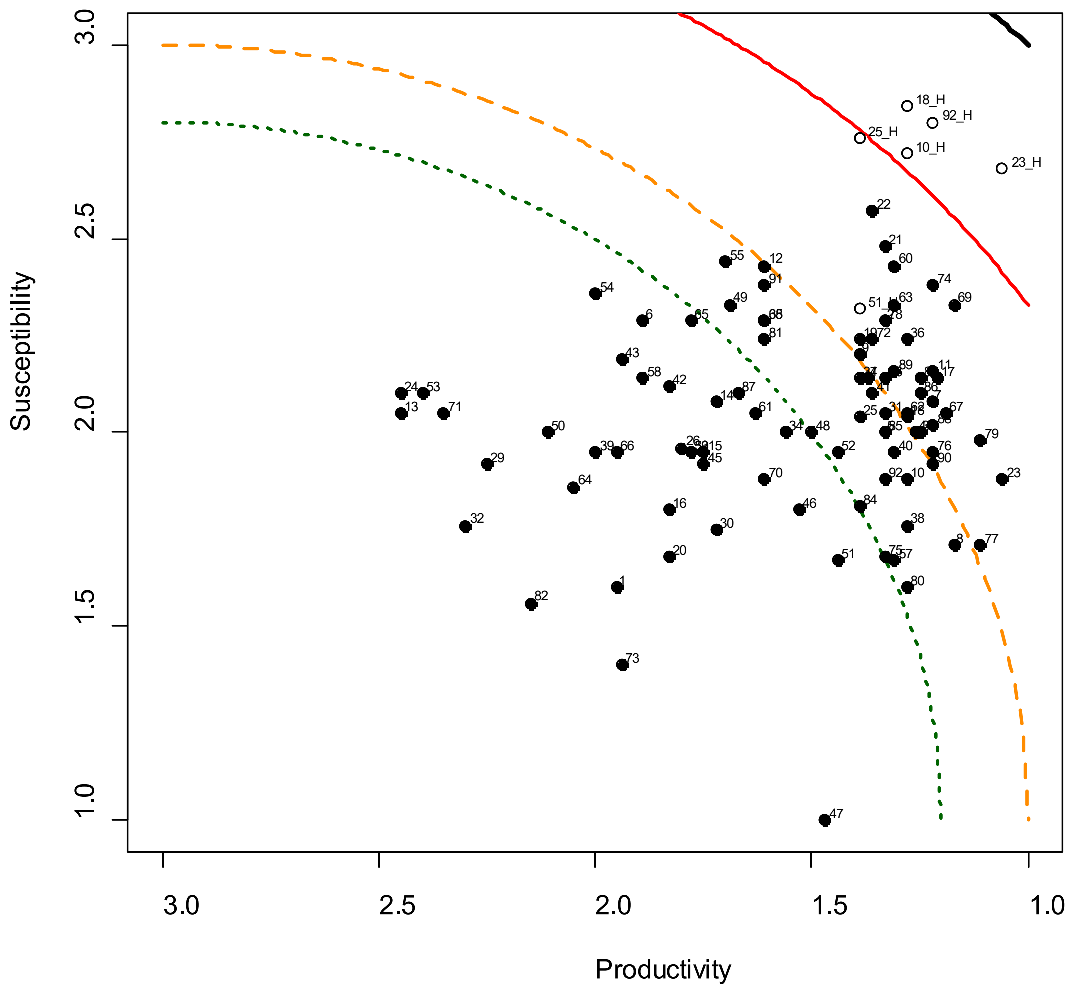


Figure 2-1. Productivity and Susceptibility Analysis (PSA) plot for species in the West Coast groundfish FMP. Contours delineate areas of relative vulnerability (V, i.e., distance from the origin), with the highest vulnerability above the solid red line (V = 2.2), high vulnerability above the orange broken line (V=2), medium vulnerability above the green dotted line (V=1.8), and the lowest vulnerability below the green dotted line. The maximum vulnerability (V=2.8) is indicated with the solid black line. Solid circles are based on current PSA scores. Open circles are based on PSA scores circa 1998. Numbers refer to the Stock ID in Table 2-2 and Table 2-3.

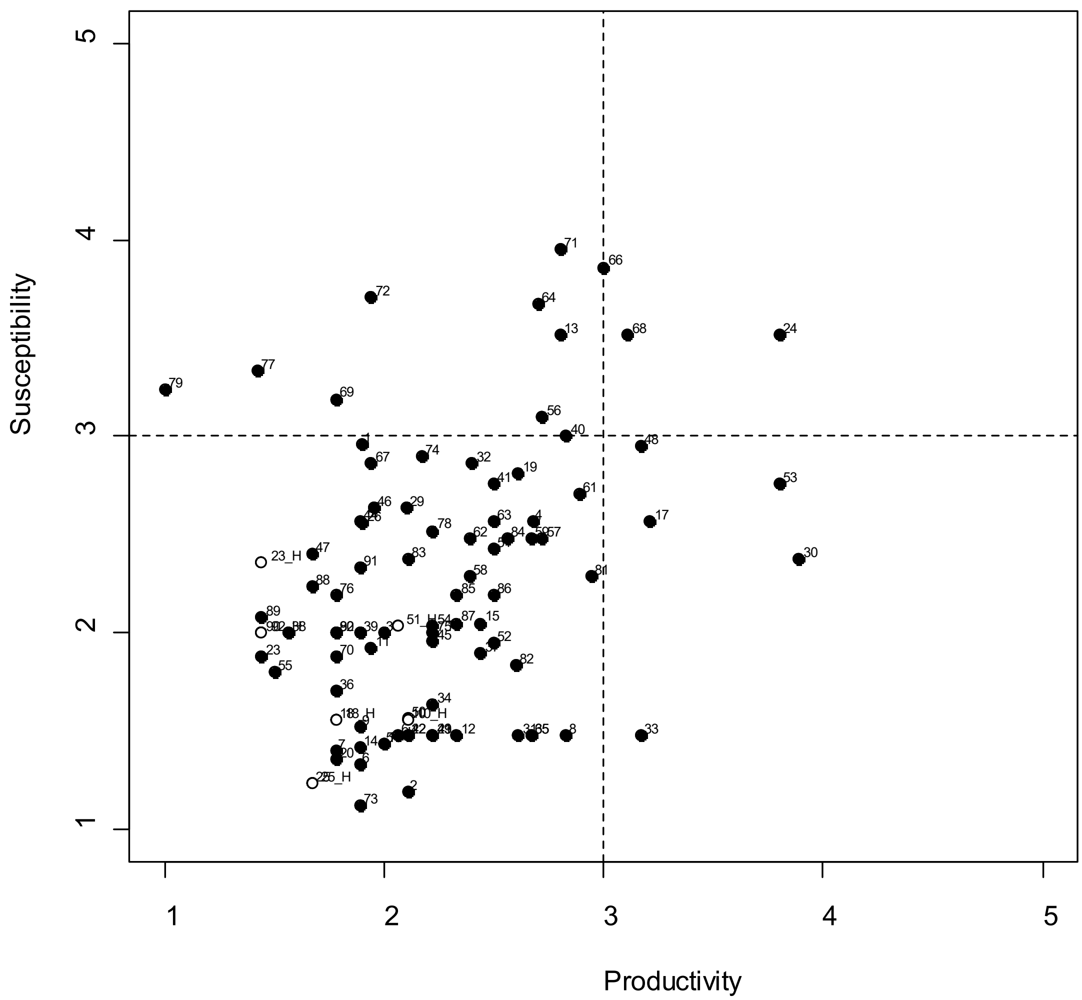


Figure 2-2. Data quality plots for the productivity and susceptibility scores in the PSA for each species (represented numerically in Table 2-2 and Table 2-3) in the West Coast groundfish FMP. Higher scores indicate lower data quality. Vertical and horizontal lines provide a general guide to relative data quality with values above 3 on either axis considered data-limited.

2.2 *Stock Assessments and Rebuilding Analyses Used to Estimate Stock Status and Inform Management Decisions*

Stock assessments are used for setting harvest specifications by providing estimates of MSY, OFL, the MFMT, the minimum stock size threshold (MSST), and ABC. Stock assessments are also used to determine the status of a fish population or subpopulation (stock) in terms of estimating population size, reproductive status (e.g., spawning biomass, fecundity, etc.), fishing mortality, and whether current catches are sustainable. In the terms of the Groundfish FMP, stock assessments provide: 1) an estimate of the current biomass and reproductive potential (generally expressed as spawning biomass or spawning output), 2) an estimate of F_{MSY} (the harvest rate estimated to produce MSY) or proxy thereof translated into exploitation rate or spawning potential ratio (SPR; see section 3.1.1 for a description of SPR), 3) the estimated biomass corresponding to MSY (B_{MSY}), or a proxy thereof, 4) estimated unfished biomass (B_0), and 5) the estimated variance (or a confidence interval) for the estimate of current biomass. With the exception of Pacific whiting, which is assessed annually as specified in the Agreement with Canada on Pacific Hake/Whiting, groundfish stock assessments are conducted on a two-year cycle. Given the large number of groundfish species and limited state and Federal resources, a subset of all groundfish stocks are assessed in each stock assessment cycle. Overfished species' stock assessments are typically conducted every two years, although a catch report can be substituted for an assessment to monitor compliance with adopted rebuilding plans. The process for setting groundfish specifications involves the adoption of new and updated stock assessments. During the biennial specification process, the Council's Scientific and Statistical Committee (SSC) reviews stock assessments and rebuilding analyses for overfished/rebuilding species and makes recommendations to the Council relative to the standards of the best available science and the soundness of the scientific information relative to management decisions. The Council then approves all or a portion of the stock assessments or recommends further analysis.

The perception of stock status and productivity may change substantially between stock assessments. Such changes can result from technical changes in the assessment model, including how a given assessment model is structured, the assumptions used to fix or estimate key parameters (i.e., whether parameters such as natural mortality and steepness are fixed, estimated freely, or estimated with an informative prior), and the evolution of methods for developing data time series and estimates of uncertainty from different sources of raw data. The population dynamics of target species themselves are responsive to a mix of complex (and often poorly understood) biological, oceanographic, and interspecies interactions. New data sources (e.g., new data types, extensions of existing data sets, incorporation of environmental factors into assessments) can result in changes in parameter estimates and model outputs.

All stock assessments are subject to a peer review process, consistent with the MSA (§302(g)(1)(E)). The process considers components of the assessments starting with data collection and continuing through to scientific recommendations and information presented to the Council and its advisors. The terms of reference for the groundfish stock assessment review process defines the expectations and responsibilities for various participants in the groundfish stock assessment review (STAR) process and outlines the guidelines and procedures for a peer review process. The STAR process is a key element in an overall process designed to review the technical merits of stock assessments and other scientific information used by the SSC. This process allows the Council to make timely use of new fishery and survey data, to analyze and understand these data as completely as possible, to provide opportunity for public comment, and to assure that the results are as accurate and error-free as possible.

Harvest specifications and the science used as the basis for management decision-making are derived from the most recent assessments and/or rebuilding analyses prepared for those stocks that are informed by an assessment. The newest assessments were those prepared and adopted in 2019 and the oldest assessments informing management decisions for fisheries in 2021 and beyond were updated from a few stock assessments conducted and adopted in 2007 by re-running the projections from old assessments using actual catches since the assessment was conducted. Table 2-4 presents a summary of the management quantities estimated by the base models of the most recent assessments informing management in 2021 and beyond. Table 2-5 lists life history parameters from the stocks assessed since 2005, excluding those conducted using Extended Depletion-based Stock Reduction Analysis (XDB-SRA); steepness of the spawner-recruitment curve (h), recruitment variability (sigma-r), the von Bertalanffy Equation growth constant (k), and natural mortality (M) are each important contributors to the understanding of the productivity and resiliency of these stocks. Table 2-6 lists life history parameters from the stocks assessed in 2013 using XDB-SRA; B_{MSY}, F_{MSY}, M, B_{MSY}/B_0, and F_{MSY}/M inform the relative productivity and resiliency of these stocks.

All stock assessments, STAR panel reports, and rebuilding analyses used to inform management decisions on West Coast groundfish stocks and fisheries can be found on the Council's web site at https://www.pcouncil.org/stock-assessments-star-reports-stat-reports-rebuilding-analyses-terms-of-reference/groundfish-stock-assessment-documents/.

2.2.1 Types of Assessments Used in Managing Groundfish Stocks

The Council uses various types of assessments that range from data-rich full assessments (also known as benchmark assessments) to data-limited methods used to only estimate an OFL. The Council decides which groundfish stocks will be assessed and based on SSC recommendations, what type of assessment will be used (i.e., full, update, data-moderate, data-limited) each cycle. These stock assessment priorities are decided in even years and assessments are conducted, reviewed, and adopted in odd years. Results from these assessments are used to inform management decisions for the following biennial cycle, which begins in the next odd year. The SSC reviews all assessments and recommends to the Council if they represent the best scientific information available for the stock, and whether and how they can be used to inform Council decisions.

The SSC categorizes stocks based on the type of assessment and the quality of data informing that assessment. The FMP harvest specification framework calls for increasing uncertainty buffers translated into lower ABCs (and ACLs) for stocks informed by less certain assessments (see section 3.1.2). Stock categories range from category 1, characterized by stocks informed by full assessments with reasonably good estimates of year class strength, to category 3 stocks where there is only a data-limited estimate of the OFL. A more detailed description of the assessment models used in current groundfish management follows.

Data-Limited Assessments

Data-limited assessments employ catch-based or other (e.g., trawl survey biomass * M) statistics to estimate an OFL for a stock. Stock status cannot be determined using these types of assessment since there are no time series of survey or other abundance indices used in a data-limited assessment. The most rudimentary data-limited assessment is simply setting the OFL to a proportion of the average historical catch. However, there is great uncertainty whether that is a "true" OFL since the historical catch used to compute the average could have been unsustainably high. Therefore, the SSC categorizes stocks informed by a data-limited assessment as category 3 stocks, thus mandating a higher buffer to determine the ABC. While data-limited methods are characterized as "assessments" here, stocks with OFLs informed with data-limited methods are considered unassessed since there is no estimate of relative depletion or status. Other approved data-limited methods (Depletion-Corrected Average Catch (DCAC), Depletion-Based Stock Reduction Analysis (DB-SRA), and Simple Stock Synthesis), more sophisticated than average catch, are described below.

Depletion-Corrected Average Catch

The DCAC method provides an estimate of the OFL for data-limited stocks of uncertain status (MacCall 2009). DCAC adjusts historical average catch to account for one-time "windfall" catches that are the result of stock depletion, producing an estimate of yield that was likely to be sustainable over the same period. Advantages of the DCAC approach for determining sustainable yield for data-limited stocks include: 1) relatively minimal data requirements (i.e., an historical catch time series), 2) biologically-based adjustment to catch-based yield proxies with transparent assumptions about relative changes in abundance (e.g., a production function with compensation exists for the stock), and 3) simplicity in computing.

Depletion-Based Stock Reduction Analysis

The DB-SRA method extends the DCAC method by 1) restoring the temporal link between production and biomass, and 2) evaluating and integrating alternative hypotheses regarding changes in abundance during the historical catch period (Dick and MacCall 2011). This method combines DCAC's distributional assumptions regarding life history characteristics and stock status with the dynamic models and simulation approach of stochastic stock reduction analysis.

Simple Stock Synthesis

A similar approach to DB-SRA, or Simple Stock Synthesis (SSS) can also be conducted in Stock Synthesis (Cope 2013).

Data-Moderate Assessments

Data-moderate assessments are less complicated than full assessments and can therefore be reviewed more expeditiously. Unlike a full assessment, which is reviewed by a STAR panel and the SSC, only the SSC reviews a data-moderate assessment[4].

[4] While this is technically true, the SSC and Council elected to do a more rigorous review of data-moderate

Data-moderate assessments combine catch-based methods with a time series of relative abundance estimates from one or more surveys or other types of abundance indices (e.g., catch per unit of effort (CPUE) time series). This type of assessment represents the minimal structure of an assessment used to determine stock status according to the NMFS National Stock Assessment Improvement plan (Mace*, et al.* 2001). These assessments exclude compositional age and length data, which are used to determine survey and/or fishery selectivities and to estimate other parameters in a full assessment model. The addition of compositional data complicates an assessment, requiring more review time to understand what data are driving model results. Data-moderate assessments were therefore developed to increase the number of groundfish stocks assessed given the resources available to conduct and review assessments each cycle. There are two data-moderate assessment models in current use that have been reviewed and recommended by the SSC: Extended Simple Stock Synthesis (exSSS) and XDB-SRA. These are described in more detail below.

Since data-moderate assessments are less informative than full assessments, the SSC categorizes stocks informed with such an assessment as category 2 stocks.

Extended Simple Stock Synthesis

ExSSS is based on sampling parameters (steepness, natural mortality, and depletion) from prior distributions and using Stock Synthesis to solve for virgin recruitment (R_0) given inputs for selectivity, growth, and fecundity. ExSSS extends Simple Stock Synthesis, originally a data-limited method reviewed by the SSC, by allowing index data (and potentially length and age data) to be used for parameter estimation using the Stock Synthesis platform. Parameter estimation for exSSS is based on the Adaptive Importance Sampling (AIS) methods (Cope*, et al.* 2015b; Wetzel and Punt 2015). ExSSS assumes that recruitment is related deterministically to the stock-recruitment relationship. The outputs from exSSS include biomass trajectories, as well as estimates of (and measures of uncertainty for) the OFL. The prior for depletion is based on the results of a regression of depletion on the PSA vulnerability score (see section 2.1 and (Cope*, et al.* 2015b)).

ExSSS was used in the 2013 data-moderate assessments of English sole, rex sole, sharpchin rockfish, stripetail rockfish, and yellowtail rockfish north of 40°10’ N. lat. and the 2019 assessment of cabezon off Washington,

Extended Depletion-Based Stock Reduction Analysis

XDB-SRA, an extension of DB-SRA, is an assessment method approved by the SSC for use in data-moderate assessments. XDB-SRA can be implemented within a Bayesian framework, with the priors for the parameters updated based on index data. The additional parameters in XDB-SRA compared with DB-SRA include the catchability coefficient (q) for each index of abundance, and the extent of observation variance additional to that inferred from sampling error (a). The priors for these parameters have a weakly informative log-normal and a uniform

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assessments in a STAR panel in 2013, the first year data-moderate assessments were conducted on the West Coast.

distribution, respectively. While XDB-SRA is an approved data-moderate assessment model, it can also be parameterized to incorporate compositional data.

XDB-SRA was used in the 2013 data-moderate assessments of brown, China, and copper rockfish, as well as the 2013 full assessment of cowcod in the Southern California Bight.

SS-CL and SS-CL+Index

New data-moderate assessment methods were adopted and used in 2021 - Stock Synthesis with Catches and Lengths (SS-CL) and Stock Synthesis with Catches and Lengths informed with one or more fishery-independent abundance indices (SS-CL+Index). These length-based assessment methods do not use age composition data or fishery dependent abundance indices since the use of these data require more extensive evaluation during review. Reviews of assessments using these methods are done more expeditiously by the SSC. These methods are robust to full assessments when there are length-composition data only and there were at least 20 years of data as discussed in the SSC's evaluation of these methods. Length-based methods are deemed particularly useful for assessments where age data are sparse. These methods were used in 2021 assessments of copper rockfish, quillback rockfish, and squarespot rockfish.

Full Stock Assessments

Full, or benchmark, stock assessments are those where Stock Assessment Teams (STATs) can propose new models and explore new data to determine the status and dynamics of a fish stock. The Council has a rigorous process for first determining those stocks that will be assessed and, once determined, how they will be reviewed (the process is codified in the Stock Assessment and Review Terms of Reference, which is updated every other year). Full assessments are more rigorously reviewed than other types of assessments since they are inherently more complicated. A week-long STAR panel meeting occurs with STATs presenting assessment models to a panel of experts (typically comprised of one SSC Groundfish Subcommittee member who chairs the meeting, one West Coast groundfish assessment expert, and two independent reviewers from the Center of Independent Experts). Additionally, one Groundfish Management Team (GMT) representative, one Groundfish Advisory Subpanel representative, and a member of the Council staff attends STAR panel meetings as advisors. The STAR panel prepares a report recommending whether the assessment is robust enough to be used in management, along with other detailed recommendations on how to interpret assessment results and how to improve the assessment next time it is conducted. STAR panel reports also detail the model and data explorations that occurred during the review. The draft assessment and STAR panel report are then reviewed by the SSC. The assessment is only adopted for use in management decision-making if recommended by the SSC.

Stocks assessed with SSC-endorsed full assessments are categorized either as category 1 or category 2 depending on the quality of data informing the assessment, relative uncertainty of model estimates, and/or whether individual year class strength (i.e., recruitment) is estimated.

Stock Synthesis

Most of the groundfish assessments on the U.S. West Coast currently used to inform management decisions have been conducted using Stock Synthesis. Stock Synthesis provides a statistical framework for calibration of a population dynamics model using a diversity of fishery and survey data. It is designed to accommodate both age and size structure in the population and with multiple stock sub-areas. Selectivity can be cast as age-specific only, size-specific in the observations only, or size-specific with the ability to capture the major effect of size-specific survivorship. The overall model contains subcomponents which simulate the population dynamics of the stock and fisheries, derive the expected values for the various observed data, and quantify the magnitude of difference between observed and expected data. Some SS features include ageing error, growth estimation, spawner-recruitment relationship, and movement between areas. SS is most flexible in its ability to utilize a wide diversity of age, size, and aggregate data from fisheries and surveys. The ADMB C++ software in which SS is written searches for the set of parameter values that maximize the goodness-of-fit, then calculates the variance of these parameters using inverse Hessian and Markov Chain Monte Carlo (MCMC) methods. A management layer is also included in the model allowing uncertainty in estimated parameters to be propagated to the management quantities, thus facilitating a description of the risk of various possible management scenarios, including forecasts of possible ACLs. The structure of Stock Synthesis allows for the building of simple to complex models depending upon the data available.

Update Assessments

An update assessment uses the model structure of the stock's last full, SSC-endorsed assessment, but is generally restricted to the addition of new data that have become available since the last full assessment. It must carry forward the fundamental structure of the last full assessment reviewed and endorsed by a STAR panel, the SSC, and the Council. Assessment structure here refers to the population dynamics model, data sources used as inputs to the model, the statistical platform used to fit the model to the data, and how the management quantities used to set harvest specifications are calculated. Particularly when an update assessment is developed, no substantial changes should be made to 1) the sources of data used (data sources can be updated to correct data entry errors), 2) the software used in programming the assessment (newer versions of assessment software can be used), 3) the assumptions and structure of the population dynamics model underlying the stock assessment, 4) the statistical framework for fitting the model to the data and determining goodness of fit, and 5) the analytical treatment of model outputs in determining management reference points.

Major changes to the assessment should be postponed until the next full assessment. Minor alterations to the input data and the assessment can be considered as long as the update assessment clearly documents and justifies the need for such changes. A step-by-step transition (via sensitivity analysis) from the last full assessment to an update assessment under review should be provided. Minor alterations can be considered under only two circumstances: first, when the addition of new data reveals an unanticipated sensitivity of the model, and second, when there are clear and straightforward improvements in the input data and how it is processed and analyzed for use in the model. Examples of minor alterations include: 1) changes in how compositional data are pooled across sampling strata, 2) the weighting of the various data components (including the use of methods for tuning the variances of the data components), 3) changes in the time periods for the selectivity blocks, 4) correcting data entry errors, and 5) bug fixes in software programming. This list is not meant to be exhaustive, and other alterations can be considered if warranted. Ideally, improved data or methods used to process and analyze data would be reviewed by the SSC prior to being used in assessments.

The SSC reviews all update assessments; a STAR panel review is not needed since the assessment only updates the last full, STAR panel-reviewed assessment.

Rebuilding Analyses

Rebuilding analyses use the results of stock assessments and project stock rebuilding periods under alternative harvest control rules in a stochastic fashion. In other words, a rebuilding analysis involves projecting the status of the overfished/rebuilding resource into the future under a variety of alternative harvest strategies to determine the probability of recovery to B_{MSY} (or its proxy) within a pre-specified timeframe. Rebuilding analyses are used to develop new rebuilding plans or in consideration for modifying existing rebuilding plans; rebuilding plans dictate the target year to rebuild a stock, the harvest control rules for rebuilding the stock, and any other special management measures designed to foster rebuilding. Rebuilding analyses are also used to determine the OFLs and ACLs for overfished/rebuilding stocks. The Terms of Reference for Groundfish Rebuilding Analysis provide the required projections and outputs in a rebuilding analysis.

A rebuilding analysis consists of 1) estimation of B_0 (and hence B_{MSY} or its proxy), 2) selection of a method to generate future recruitment, 3) specification of the mean generation time (defined as the predicted time it would take for a mature female in the population to replace herself), 4) calculation of the minimum and maximum times to recovery, and 5) identification and analysis of alternative harvest strategies and rebuilding times. Most rebuilding analyses are done using software developed by Dr. André Punt from the University of Washington.[5]

The Puntalyzer uses a "Monte Carlo simulation" to derive a probability estimate for a given rebuilding strategy. This method projects population growth many times in separate simulations. It accounts for possible variability by randomly choosing the value of a key variable, generally the deviation in recruitment about the stock-recruitment relationship, but also allows for uncertainty in the estimated parameters of the stock assessment. Because of this variability in a key input value, each simulation will show a different pattern of population growth. As a result, a modeled population may reach the target biomass that defines a rebuilt stock (B_{MSY}) in a different year in each of the simulations.

This technique is first used to calculate minimal time to rebuild a stock given its level of depletion and productivity from the time of implementing the first rebuilding plan (T_{MIN}) in probabilistic terms, which is defined as the time needed to reach the target biomass in the absence of fishing with a 50 percent probability. In other words, in half the simulations, the target biomass was reached in some year up to and including the computed T_{MIN}. Given T_{MIN}, the maximum legal time to rebuild (T_{MAX}) is computed as 10 years or by adding the value of one mean generation time to T_{MIN}, if T_{MIN} is greater than or equal to 10 years. In cases where there is consideration for modifying an existing rebuilding plan, the shortest time to rebuild is calculated as the biological limit for the stock to rebuild in the absence of fishing beginning in the year the modified rebuilding plan is implemented; this limit is denoted, "$T_{F=0}$".

[5] Available at http://puntlab.washington.edu/software/.

A target rebuilding year, T_{TARGET}, is set as a year at T_{MIN} (or $T_{F=0}$) or greater, which does not exceed T_{MAX}, and which is as short as possible, taking into account the status and biology of the stock, the needs of fishing communities, recommendations by international organizations in which the U.S. participates, and the interaction of the stock of fish within the marine ecosystem. Prior to Amendment 16-4, the Council set T_{TARGET} in part by considering the probability of rebuilding the stock by T_{MAX}. The Council may continue to review the probability of rebuilding the stock by T_{MAX} given differing harvest control rules, a reference parameter known as "P_{MAX}."

It is important to recognize that some of the terms introduced and described above represent policy decisions at the national level and the Council **does not have a choice** in setting their values. The dates for T_{MIN} and T_{MAX} are determined based on guidelines established at the national level. Mean generation time is a biological characteristic that cannot be chosen by policymakers. Thus, the Council cannot choose these values and then use them as a basis for management. Defined in national guidelines, T_{MIN} is a consequence of the productivity of the fish stock and is calculated by fishery biologists based on information they estimate for a particular stock. Similarly, T_{MAX}, which is calculated from T_{MIN}, does not represent a Council choice.

Policy flexibility comes into play in determining T_{TARGET}, or the time by which the stock is projected to rebuild. When developing a management strategy, the Council can choose a fishing mortality rate and corresponding annual level of fishing. However, when rebuilding overfished/rebuilding species, the choice of the harvest control rule is based on the value of T_{TARGET}, keeping in mind that these values cannot be chosen independently of one another. In other words, the Council may choose one value and derive the other from it, but they cannot choose these values independently of the other.

Table 2-4. Management quantities estimated from the most recent stock assessments informing management in 2025 and beyond.

Stock	Year of Most Recent Assessment	Est. Depletion a/	Initial Spawning Biomass (B_0)	Current Spawning Biomass a/	Current Total Biomass a/	Spawning Biomass at MSY	Harvest Rate at MSY	MSY	MSY Basis
Arrowtooth flounder	2017	0.87	65,448 mt	56,710 mt	97,118 mt	18,355 mt	0.184	6,635 mt	$F_{30\%}$
Aurora rockfish	2013	0.64	2,626 mt	1,673 mt	4,366 mt	1,213 mt	0.025	67 mt	$F_{50\%}$
Big skate	2019	0.79	2,525 mt	1,999 mt	25,339 mt	505 mt	0.071	590 mt	$F_{50\%}$
Black rockfish (CA North – N of Pt. Arena)	2023	0.36	1,126 B eggs	410 B eggs	3,109 mt	502 B eggs	0.137	265 mt	$F_{50\%}$
Black rockfish (CA Central – S of Pt. Arena)	2023	0.42	324 B eggs	136 B eggs	930 mt	145 B eggs	0.114	65 mt	$F_{50\%}$
Black rockfish (OR)	2023	0.45	1,490 B eggs	674 B eggs	6,049 mt	665 B eggs	0.07	422 mt	$F_{50\%}$
Black rockfish (WA)	2023	0.45	944 B eggs	426 B eggs mt	5,281 mt	421 B eggs mt	0.05	276 mt	$F_{50\%}$
Blackgill rockfish	2017	0.39	2,064 B larvae	812 B larvae	7,917 mt	919 B larvae	0.022	178 mt	$F_{50\%}$
Blue & Deacon rockfishes (CA N of Pt. Con.)	2017	0.37	2,178 M eggs	812 M eggs	6,654 mt	871 M eggs	0.045	306 mt	$F_{50\%}$
Blue & Deacon rockfishes (OR)	2017	0.69	431 M eggs	296 M eggs	1,773 mt	192 M eggs	0.056	78 mt	$F_{50\%}$
Bocaccio b/	2017	0.49	7,411 M larvae	3,603 M larvae	25,293 mt	3,302 M larvae	0.082	1,857 mt	$F_{50\%}$
Brown rockfish	2013	0.42	1,794 mt	727 mt	1,454 mt	718 mt	0.102	149 mt	$B_{40\%}$
Cabezon (CA S of Pt. Con.)	2019	0.49	205 mt	101 mt	208 mt	79 mt	0.129	17 mt	$F_{45\%}$
Cabezon (CA N of Pt. Con.)	2019	0.65	986 mt	643 mt	1,317 mt	379 mt	0.14	118 mt	$F_{45\%}$
Cabezon (OR)	2019	0.53	335 mt	177 mt	358 mt	128.6 mt	0.161	46.4 mt	$F_{45\%}$
California scorpionfish	2017	0.54	1,624 mt	882 mt	1,915 mt	724 mt	0.1502	232 mt	$F_{50\%}$
Canary rockfish	2023	0.35	8,009 M eggs	2,809 M eggs	28,077 mt	3,573 M eggs	0.03	1,094 mt	$F_{50\%}$

Stock	Year of Most Recent Assessment	Est. Depletion a/	Initial Spawning Biomass (B_0)	Current Spawning Biomass a/	Current Total Biomass a/	Spawning Biomass at MSY	Harvest Rate at MSY	MSY	MSY Basis
Chilipepper rockfish	2015	0.64	7,042 M larvae	4,502 M larvae	35,039 M larvae	2,133 mt	0.095	2,165 mt	$F_{50\%}$
China rockfish (S of 40°10’ N. lat.)	2015	0.30	66.5 B eggs	18.565 B eggs	446.54 mt	30.6 B eggs	0.0476	19.5 mt	$F_{50\%}$
China rockfish (40°10’ N. lat. – 46°16’ N. lat.)	2015	0.62	65.1 B eggs	40.033 B eggs	496.73 mt	30 B eggs	0.0484	14.5 mt	$F_{50\%}$
China rockfish (N of 46° 16’ N. lat.)	2015	0.73	24.4 B eggs	17.950 B eggs	207.26 mt	11.3 B eggs	0.0458	5.8 mt	$F_{50\%}$
Copper rockfish (CA - S of 34°27' N. lat.)	2023	0.16	201.06 B eggs	32.06 B eggs	343.79 mt	80.43 B eggs	0.06	49.99 mt	$B_{40\%}$
Copper rockfish (CA - N of 34°27' N. lat.)	2023	0.46	456.05 B eggs	208.74 B eggs	2,328.87 mt	182.42 B eggs	0.06	121.92 mt	$B_{40\%}$
Copper rockfish (OR)	2021	0.74	38.75 M eggs	28.51 M eggs	281.30 mt	15.50 M eggs	0.08	12.46 mt	$B_{40\%}$
Copper rockfish (WA)	2021	0.42	7.65 M eggs	3.203 M eggs	34.65 mt	3.06 M eggs	0.072	2.347 mt	$B_{40\%}$
Cowcod	2019	0.57	285 B eggs	163 B eggs	2,494 mt	127 B eggs	0.043	73 mt	$F_{50\%}$
Darkblotched rockfish	2017	0.40	3,544 M eggs	1,419 M eggs	20,718 mt	2,166 M eggs	0.019	477 mt	$F_{50\%}$
Dover sole	2021	0.79	294,070 mt	232,065 mt	481,200 mt	74,498 mt	0.12	22,891 mt	$F_{30\%}$
English sole	2013	0.88	29,238 mt	25,719 mt	46,968 mt	7,833 mt	0.404	3,875 mt	$F_{30\%}$
Gopher & black-and-yellow rockfishes (S of 40°10’ N. lat.)	2019	0.44	1,261 M eggs	553 M eggs	1,281 mt	563 M eggs	0.111	134 mt	$F_{50\%}$
Greenspotted rockfish	2011	0.35	1,357.8 B eggs	449.9 B eggs	3,110 mt	621 B eggs	.034 N; .024 S	95.6 mt	$F_{50\%}$
Greenstriped rockfish	2009	0.81	7,090 M eggs	5,736 M eggs	29,391 mt	3,101 M eggs	0.044	738 mt	$F_{50\%}$

Stock	Year of Most Recent Assessment	Est. Depletion a/	Initial Spawning Biomass (B_0)	Current Spawning Biomass a/	Current Total Biomass a/	Spawning Biomass at MSY	Harvest Rate at MSY	MSY	MSY Basis
Kelp greenling (OR)	2015	0.80	397 mt	316 mt	1,131 mt	152 mt	0.18	130 mt	$F_{45\%}$
Lingcod (S of 40°10’ N lat.)	2021	0.39	26,443.6 mt	10,415 mt	13,594 mt	7,093.73 mt	0.0874	810.758 mt	$F_{45\%}$
Lingcod (N of 40°10’ N lat.)	2021	0.64	17,159.8 mt	11,010.2 mt	24,989 mt	7,098.53 mt	0.2224	3,644.93 mt	$F_{45\%}$
Longnose skate	2019	0.57	12,252 mt	6,923 mt	51,447 mt	2,450 mt	0.039	860 mt	$F_{50\%}$
Longspine thornyhead	2013	0.75	39,134 mt	29,436 mt	68,131 mt	15,654 mt	0.060	2,487 mt	$F_{50\%}$
Pacific ocean perch	2017	0.77	6,889 M eggs	5,280 M eggs	129,191 mt	2,296 M eggs	0.033	1,823 mt	$F_{50\%}$
Pacific sanddabs	2013	0.96	c/	c/	c/	c/	c/	c/	c/
Pacific whiting	2021	0.59	1,658,000 mt	981,000 mt	1,789,000 mt	332,000 mt	0.183	148,000 mt	$F_{40\%}$
Petrale sole	2023	0.34	22.91 T eggs	7.69 T eggs	16,196 mt	5.80 T eggs	0.17	2,479 mt	$F_{30\%}$
Quillback rockfish (CA)	2021	0.14	55.08 M eggs	7.75 M eggs	70.6 mt	22.03 M eggs	0.05	8.8 mt	$B_{40\%}$
Quillback rockfish (OR)	2021	0.47	19.71 M eggs	9.21 M eggs	79.06 mt	7.88 M eggs	0.05	3.24 mt	$B_{40\%}$
Quillback rockfish (WA)	2021	0.39	17.19 M eggs	6.64 M eggs	34.65 mt	7.67 M eggs	0.04	2.86 mt	$F_{50\%}$
Rex sole	2023	0.76	1,199 M eggs	913 M eggs	24,277 mt	259 M eggs	0.651	1,658 mt	$F_{30\%}$
Rougheye & blackspotted rockfishes	2013	0.47	5,394 mt	2,552 mt	8,176 mt	2,491 mt	0.027	194 mt	$F_{50\%}$
Sablefish	2023	0.63	186,534 mt	117,519 mt	525.277 mt	71,629 mt	0.045	9,641 mt	$F_{45\%}$
Sharpchin rockfish	2013	0.68	7,887 mt	4,947 mt	12,767 mt	3,482 mt	0.050	270 mt	$F_{50\%}$
Shortspine thornyhead	2023	0.39	22,145 B eggs	8,717 B eggs	95,328 mt	9,880 B eggs	0.010	1,108 mt	$F_{50\%}$

Stock	Year of Most Recent Assessment	Est. Depletion a/	Initial Spawning Biomass (B_0)	Current Spawning Biomass a/	Current Total Biomass a/	Spawning Biomass at MSY	Harvest Rate at MSY	MSY	MSY Basis
Spiny dogfish	2021	0.42	32.57 M pups	13.61 M pups	255,616 mt	13.03 M pups	0.003	358 mt	$B_{40\%}$
Splitnose rockfish	2009	0.66	12,853 M eggs	8,426 M eggs	74,772 mt	5,006 M eggs	0.033	1,244 mt	$F_{50\%}$
Squarespot rockfish (CA)	2021	0.37	20.64 M eggs	7.73 M eggs	116.2 mt	8.26 M eggs	0.26	9.67 mt	$B_{40\%}$
Starry flounder	2005	0.50	7,158 mt	3,566 mt	7,638 mt	1,830 mt	0.229	1,848 mt	$F_{30\%}$
Stripetail rockfish	2013	>0.775	c/	c/	c/	c/	c/	c/	c/
Vermilion & sunset rockfishes (S of 34°27’ N lat.)	2021	0.48	977.834 M eggs	471.178 M eggs	3,665.87 mt	391.134 M eggs	0.139	155.76 mt	$B_{40\%}$
Vermilion & sunset rockfishes (CA N of 34°27’ N lat.)	2021	0.43	1,145.18 M eggs	489.439 M eggs	3,564.4 mt	458.073 M eggs	0.071	145.61 mt	$B_{40\%}$
Vermilion rockfish (OR)	2021	0.73	29.24 M eggs	21.35 M eggs	377.77 mt	11.7 M eggs	0.06	8.32 mt	$B_{40\%}$
Vermilion rockfish (WA)	2021	0.56	2.75 M eggs	1.55 M eggs	23.22 mt	1.10 M eggs	0.06	0.81 mt	$B_{40\%}$
Widow rockfish	2019	0.92	87,995 mt	80,910 mt	189,576 mt	39,259 mt	0.084	7,240 mt	$F_{50\%}$
Yelloweye rockfish	2017	0.28	1,139 M eggs	323 M eggs	3,569 mt	508 M eggs	0.022	105 mt	$F_{50\%}$
Yellowtail rockfish (N of 40°10’ N. lat.)	2017	0.75	15 T eggs	11.278 T eggs	130,219 mt	6.7 T eggs	0.051	5,115 mt	$F_{50\%}$

a/ Estimates pertain to the most recent assessment year.

b/ Bocaccio biomass and MSY estimates are reduced by 7.4 percent from the values reported in the 2015 assessment since the assessment applies to the West Coast population south of Cape Blanco at 43° N. lat. and the stock is managed for the area south of 40°10’ N. lat. The proportional reduction is based on historical catches by area.

c/ The assessment results were only used for informing status since the scale of the population could not be adequately determined.

Table 2-5. Parameters estimated and/or assumed in base models in the most recent West Coast groundfish stock assessments, excluding those done using XDB-SRA.

Stock	ln(R0)	Steepness (h)		Sigma R	von-Bertalanffy Growth Coefficient (k)		Natural Mortality (M)		
		value	est. ?		F	M	F	M	est.?
Arrowtooth flounder	10.83	0.90	N	0.8	0.17	0.36	0.216	0.300	N
Aurora rockfish	6.64	0.78	N	0.5	0.09	0.09	0.035	0.037	a/
Big skate	8.90	0.40	N	0.3	b/	b/	0.449	0.449	Y for Females Males assumed equal to Females
Black rockfish (CA Central - S of Pt Arena)	6.47	0.72	N	0.6	0.145	0.248	0.21	0.20	N (Fixed = value from North)
Black rockfish (CA North – N of Pt Arena)	7.72	0.72	N	0.6	0.148	0.309	0.21	0.20	Y
Black rockfish (OR)	8.14	0.72	N	0.6	0.184	0.209	0.19	0.17	N
Black rockfish (WA)	7.58	0.72	N	0.6	0.118	0.14	0.17	0.152	N
Blackgill rockfish (S of 40°10’ N. lat.)	7.85	0.718	N	0.5	0.023	0.04	0.063	0.065	N
Blue & deacon rockfishes (CA N of Pt. Con.)	8.44	0.645	Y	0.5	0.118	0.115	0.119	0.315	Y
Blue & deacon rockfishes (OR)	7.04	0.718	N	0.5	0.203	0.487	0.159	0.159	N
Bocaccio	8.83	0.718	N	1.0	0.226	0.311	0.180	0.180	Y
Cabezon (CA S of Pt. Con.)	5.21	0.70	N	0.5	0.21	0.33	0.26	0.35	Y
Cabezon (CA N of Pt. Con.)	6.57	0.70	N	0.5	0.21	0.33	0.24	0.28	Y
Cabezon (OR)	4.68	0.70	N	0.5	0.329	0.178	0.24	0.154	a/
California scorpionfish	8.19	0.718	N	0.6	0.292	0.212	0.235	0.235	Y
Canary rockfish	8.22	0.72	N	0.5	0.139	0.163	0.078	0.064	Y
Chilipepper rockfish	10.64	0.57	N	1.0	0.17- 0.24 c/	0.17- 0.24 c/	0.160	0.200	N
China rockfish (S of 40°10’ N. lat.)	5.04	0.773	N	0.5	0.144	0.144	0.070	0.070	N
China rockfish (40°10’ N. lat. – 46° 16’ N. lat.)	4.27	0.773	N	0.5	0.159	0.159	0.070	0.070	N
China rockfish (N of 46° 16’ N. lat.)	3.53	0.773	N	0.5	0.147	0.147	0.070	0.070	N
Copper rockfish (CA - S of 34°27’ N lat.)	5.49	0.72	N	0.6	0.194	0.218	0.108	0.108	N
Copper rockfish (CA - N of 34°27’ N lat.)	6.28	0.72	N	0.5	0.153	0.194	0.108	0.108	N
Copper rockfish (OR)	3.66	0.72	N	0.6	0.206	0.231	0.108	0.108	N

Stock	ln(R0)	Steepness (h)		Sigma R	von-Bertalanffy Growth Coefficient (k)		Natural Mortality (M)		
		value	est. ?		F	M	F	M	est.?
Copper rockfish (WA)	2.03	0.72	N	0.6	0.206	0.231	0.108	0.108	N
Cowcod (S of 40°10' N. lat.)	5.19	0.72	N	e/	0.055	0.055	0.088	0.088	Y
Darkblotched rockfish	8.01	0.72	N	0.75	0.19	0.24	0.054	0.069	a/
Dover sole	12.27	0.80	N	0.35	0.13	0.14	0.108	0.114	N
English sole	11.45 d/	0.87 d/	Y	e/	0.36	0.48	0.24 d/	0.27 d/	Y
Gopher & black-and-yellow rockfishes (S of 40°10' N. lat.)	8.05	0.72	N	0.5	0.107	0.107	0.193	0.193	N
Greenspotted rockfish (CA N of Pt. Con.)	6.15	0.76	N	0.7	0.057	0.057	0.065	0.065	N
Greenspotted rockfish (CA S of Pt. Con.)	6.65	0.76	N	0.7	0.042	0.042	0.065	0.065	N
Greenstriped rockfish	9.62	0.69	N	0.84	0.11	0.15	0.080	0.080	N
Kelp greenling (OR)	7.28	0.70	N	0.65	0.26	0.26	0.360	0.318	N
Lingcod (S of 40°10' N lat.)	7.72	0.502	Y	0.6	0.136	0.401	0.17	0.22	Y
Lingcod (N of 40°10' N lat.)	9.73	0.801	Y	0.6	0.152	0.282	0.42	0.41	Y
Longnose skate	9.47	0.40	N	0.3	0.04	0.04	0.22	0.22	N
Longspine thornyhead	11.82	0.60	N	0.6	0.109	0.109	0.111	0.111	N
Pacific ocean perch	9.40	0.50	N	0.7	0.167	0.198	0.054	0.054	N
Pacific whiting	14.63	0.807	Y	1.4	f/	f/	0.230	0.230	Y
Petrale sole	9.64	0.8	N	0.5	0.193	0.246	0.142	0.155	Y
Quillback rockfish (CA)	3.17	0.72	N	0.6	0.20	0.20	0.06	0.06	N
Quillback rockfish (OR)	2.14	0.72	N	0.6	0.20	0.20	0.06	0.06	N
Quillback rockfish (WA)	2.00	0.72	N	0.6	0.20	0.20	0.06	0.06	N
Rex sole	11.079	0.70	N	0.5	0.247	0.224	0.186d /	0.186 d/	N
Rougheye & blackspotted rockfishes	6.19	0.78	N	0.4	0.081	0.081	0.042	0.042	Y
Sablefish	9.88	0.70	N	1.4	0.367	0.381	0.071	0.059	Y

Stock	ln(R0)	Steepness (h)		Sigma R	von-Bertalanffy Growth Coefficient (k)		Natural Mortality (M)		
		value	est.?		F	M	F	M	est.?
Sharpchin rockfish	8.23 d/	0.77 d/	Y	e/	0.17	0.20	0.07 d/	0.07 d/	Y
Shortspine thornyhead	9.44	0.72	N	0.5	0.0099	0.0168	0.04	0.04	N
Spiny dogfish	9.87	2.83 g/	Y	0.2	0.028	0.368	0.065	0.065	N
Splitnose rockfish	9.54	0.58	N	1.0	0.156	0.165	0.048	0.048	N
Squarespot rockfish (CA)	5.94	0.72	N	0.7	0.12	0.25	0.13	0.13	N
Starry flounder (OR & WA)	7.96	0.80	N	1.0	0.251	0.426	0.510	0.760	N
Starry flounder (CA)	7.23	0.80	N	1.0	0.251	0.426	0.510	0.760	N
Vermilion & sunset rockfishes (S of 34°27’ N lat.)	6.70	0.73	Y	0.5	0.156	0.137	0.130	0.130	Y; Male M fixed to Fem M
Vermilion & sunset rockfishes (CA N of 34°27’ N lat.)	6.04	0.72	N	0.5	0.147	0.199	0.086	0.080	Y
Vermilion rockfish (OR)	2.79	0.72	N	0.6	0.146	0.180	0.080	0.073	Y
Vermilion rockfish (WA)	0.91	0.72	N	0.6	0.093	0.109	0.085	0.087	Y
Widow rockfish	10.81	0.72	N	0.85	0.1719	0.2361	0.1444	0.1549	Y
Yelloweye rockfish	5.39	0.718	N	0.5	0.06	0.06	0.044	0.044	N
Yellowtail rockfish (N of 40°10’ N. lat.)	10.83	0.72	N	0.5	0.140	0.352	0.174	0.025	Y

a/ Female M was fixed and male M was estimated as an offset to female M.

b/ Growth was modeled using the Growth Cessation model (Maunder, et al. 2018).

c/ The base case model allowed growth for each sex to differ between blocks of time, based on freely estimating the K parameter.

d/ This value is the median of the posterior distribution of estimates for this parameter (Hamel and Cope 2022).

e/ Recruitment variability (sigma-r) not estimated.

f/ The 2021 Pacific whiting assessment uses weight-at-age, thus there is no estimate of growth. Weight-at-age varies between years; therefore, growth is time-varying.

g/ While steepness was not estimated or assumed in the conventional sense of a Beverton-Holt stock-recruitment relationship, a value for steepness (defined as recruitment relative to R_0 at a spawning depletion level of 0.2) can be derived from the parameters above according to the relationship provided by Gertseva et al. (2021).

Table 2-6. Population parameters estimated and/or derived in base models in 2013 West Coast groundfish stock assessments using XDB-SRA.

Stock	B_0	Estimated Parameters				B_{MSY}	F_{MSY}
		M	F_{MSY}/M	B_{MSY}/B_0	$Delta_{2000}$		
Brown rockfish	3588	0.133	0.971	0.399	0.698	1,383.4	0.130

2.3 Overfished and Rebuilding Groundfish Stocks

The NMFS reports the status of stocks managed under rebuilding plans as "overfished" if the current stock status is below the MSST and as "rebuilding" if over the MSST but not yet at or above the target B_{MSY} threshold (i.e., rebuilt).

Yelloweye rockfish and California quillback rockfish are two currently rebuilding stocks on the U.S. West Coast.

2.3.1 Yelloweye Rockfish

Distribution and Life History

Yelloweye rockfish (*Sebastes ruberrimus*) range from the Aleutian Islands, Alaska, to northern Baja California, Mexico, and are common from Central California northward to the Gulf of Alaska (Eschmeyer*, et al.* 1983; Hart 1988; Love*, et al.* 2002; Miller and Lea 1972; O'Connell and Funk 1986). The stock occurs in water 25 m to 550 m deep with 95 percent of survey catches occurring from 50 m to 400 m (Allen and Smith 1988). Yelloweye rockfish are bottom dwelling, generally solitary, rocky reef fish, found either on or just over reefs (Eschmeyer*, et al.* 1983; Hart 1988; Love*, et al.* 2002; Miller and Lea 1972; O'Connell and Funk 1986). Boulder areas in deep water (>180 m) are the most densely-populated habitat type, and juveniles prefer shallow-zone broken-rock habitat (O'Connell and Carlile 1993). They also reportedly occur around steep cliffs and offshore pinnacles (Rosenthal*, et al.* 1982). The presence of refuge spaces is an important factor affecting their occurrence (O'Connell and Carlile 1993).

Yelloweye rockfish are ovoviviparous and give birth to live young in June off Washington (Hart 1988). The age of first maturity is estimated at six years and all are estimated to be mature by eight years (Wyllie Echeverria 1987). They can grow to 91 cm (Eschmeyer*, et al.* 1983; Hart 1988) and males and females probably grow at the same rates (Love 1996; O'Connell and Funk 1986). The growth rate levels off at approximately 30 years of age (O'Connell and Funk 1986) and the maximum reported age is 147 years (Love 2011). Yelloweye rockfish are a large predatory reef fish that usually feeds close to the bottom (Rosenthal*, et al.* 1982). They have a widely varied diet, including fish, crabs, shrimps and snails, rockfish, cods, sand lances, and herring (Love*, et al.* 2002). Yelloweye rockfish have been observed underwater capturing smaller rockfish with rapid bursts of speed and agility. Major food items of yelloweye rockfish include cancroid crabs, cottids, righteye flounders, adult rockfishes, and pandalid shrimps (Steiner 1978). Quillback and yelloweye rockfish have many trophic features in common (Rosenthal*, et al.* 1982).

Stock Status and Management History

The first yelloweye rockfish stock assessment on the U.S. West Coast was conducted in 2001 (Wallace 2002). This assessment incorporated two area assessments: one off Northern California using CPUE indices constructed from Marine Recreational Fisheries Statistical Survey (MRFSS) sample data and California Department of Fish and Game (CDFG; now California Department of Fish and Wildlife) data collected on board CPFVs, and the other off Oregon using Oregon Department of Fish and Wildlife (ODFW) sampling data. The assessment concluded yelloweye rockfish stock biomass in 2001 was at about seven percent of unexploited biomass in Northern California and 13 percent of unexploited biomass in Oregon. The assessment revealed a 30-year declining biomass trend in both areas with the last above-average recruitment occurring in the late

1980s. The assessment's conclusion that yelloweye rockfish biomass was well below the 25 percent of unexploited biomass threshold for overfished stocks led to this stock being declared overfished in 2002. Until 2002, yelloweye rockfish was listed in the "Remaining Rockfish" complex on the shelf in the Vancouver, Columbia, and Eureka INPFC[6] areas and the "Other Rockfish" complex on the shelf in the Monterey and Conception areas. Since then, yelloweye rockfish harvest is now tracked separately and managed against a species-specific ACL.

In June 2002, the SSC recommended that managers should conduct a new assessment incorporating Washington catch and age data. This recommendation was based on evidence that the biomass distribution of yelloweye rockfish on the West Coast was centered in waters off Washington and that useable data from Washington were available. Based on that testimony, the Council recommended completing a new assessment in the summer of 2002, before a final decision was made on 2003 management measures. Methot et al. (Methot*, et al.* 2003) did the assessment, which confirmed the overfished status (24 percent of unfished biomass) and provided evidence of higher stock productivity than originally assumed. The assessment also treated the stock as a coastwide assemblage. The 2002 rebuilding analysis (Methot and Piner 2002a) informed the yelloweye rockfish rebuilding plan adopted under FMP Amendment 16-3 in 2004. The rebuilding plan established a target rebuilding year of 2058 and a harvest control rule of F = 0.0153.

A coastwide 2006 yelloweye rockfish assessment estimated a stock depletion of 17.7 percent of the unfished level at the start of 2006 (Wallace*, et al.* 2006). New data sources in the assessment included the Washington Department of Fish and Wildlife (WDFW) 2002 submersible survey and the International Pacific Halibut Commission (IPHC) annual longline survey. Further revisions in the assessment included reducing natural mortality from 0.045 to 0.036 and increasing steepness from 0.437 to 0.45.

The 2006 rebuilding analysis (Tsou and Wallace 2006) was used to inform a revision of the yelloweye rockfish rebuilding plan under FMP Amendment 16-4. Given the significant negative socioeconomic impacts associated with the projected OYs under the constant harvest rate modeled in the rebuilding analysis, the Council elected to gradually ramp down the harvest rate beginning in 2007 before resuming a constant harvest rate rebuilding strategy in 2011. The harvest rate ramp-down strategy, which projected annual OYs of 23 mt, 20 mt, 17 mt, and 14 mt, respectively in 2007-2011, was projected to extend rebuilding by less than one year relative to the more conservative constant harvest rate strategy analyzed. The ramp-down strategy afforded more time to consider new Yelloweye rockfish Conservation Areas and other management measures designed to reduce the harvest rate to prescribed levels. Therefore, the Amendment 16-4 rebuilding plan incorporated the ramp-down strategy before resuming a constant harvest rate (SPR = 71.9 percent) in 2011. The rebuilding plan also specified a target rebuilding year of 2084.

[6] The International North Pacific Fisheries Commission (INPFC) was established by the International Convention for the High Seas Fisheries of the North Pacific Ocean in 1952, and comprised Canada, Japan, and the United States of America as members. The INPFC contributed significantly to the understanding of the life history and distribution of anadromous species, groundfish, crab, and marine mammals in the North Pacific Ocean and Bering Sea. The INPFC dissolved when the North Pacific Anadromous Fish Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean came into effect on February 16, 1993.

The 2007 updated stock assessment for yelloweye rockfish estimated a stock depletion of 16.4 percent of initial, unfished biomass (Wallace 2008a). The long-term biomass trajectory in the 2007 updated assessment was very similar to that in the 2006 assessment. The 2007 rebuilding analysis (Wallace 2008b) indicated rebuilding progress was on track under the ramp-down strategy; therefore, no revisions were made to the rebuilding plan.

The full 2009 yelloweye rockfish assessment estimated a stock depletion of 20.3 percent of initial, unfished biomass at the start of 2009 (Stewart, *et al.* 2009). The resource was modeled as a single stock, but with three explicit spatial areas: Washington, Oregon, and California. Each area was modeled simultaneously with its own unique catch history and fishing fleets (recreational and commercial), with the stocks linked via a common stock-recruit relationship with negligible adult movement among areas. The assumed level of historical removals and estimated steepness were identified as the main axes of uncertainty.

The 2009 yelloweye rockfish rebuilding analysis (Stewart 2009b) was used to inform a revised rebuilding plan that was implemented under FMP Amendment 16-5. The revised rebuilding plan implemented in 2011 specified a constant harvest rate (SPR = 76 percent) strategy (the ramp-down strategy was abandoned) and a target year to rebuild the stock of 2074.

The 2011 yelloweye rockfish assessment (Taylor and Wetzel 2011), an update of the 2009 assessment, estimated stock depletion at 21.4 percent of initial, unfished biomass at the start of 2011 (Figure 2-3). The update assessment results were very similar to those in the previous assessment. The 2011 yelloweye rockfish rebuilding analysis (Taylor 2011) indicated rebuilding progress was on schedule, and no revisions were made to the rebuilding plan.

A full yelloweye rockfish assessment was conducted in 2017 indicating the stock was at a 28.4 percent depletion at the start of 2017 (Gertseva and Cope 2017b). Yelloweye rockfish was again modeled as a single stock with a shared stock-recruitment relationship, but between two rather than three assessment areas. Oregon and Washington were combined in a single area due to difficulties separating the catch and compositional data of fish caught in one state but landed in the other, with California as a second area. A comparison to a single area assessment showed no appreciable differences in outcomes. A state-specific assessment with three areas was not evaluated, but the results from the two-area base model showed close correspondence to the results from the 2011 update assessment.

This assessment was the first for yelloweye rockfish to combine sexes due to similar growth parameters. The assessment period was extended back to 1889 as a result of updates to the historical catch series. Indices of abundance from fishery-dependent and fishery-independent data sources were found to be uninformative (although they were retained) with the catch, age, and length composition data driving the results of the assessment. Steepness was fixed at 0.718 based on the meta-analysis for rockfish species. The previous assessment allowed natural mortality and steepness to be estimated, while this assessment fixed both of these key parameters, which allowed recruitment deviations to be estimated for this species. The assessment was sensitive to steepness and whether selectivity was allowed to be freely estimated. There is continued uncertainty regarding the differences in age assignments from reading otoliths between institutions, which has implication for estimates of natural mortality. Additional uncertainty results from uninformative indices of abundance and assumed values of steepness. The SSC upgraded the stock to a category 1 since recruitment deviations were estimated.

The Council adopted a new yelloweye rockfish rebuilding plan that was implemented in 2019. The harvest rate was increased from an SPR harvest rate (see Section 3.1.3 for a description and definition of the spawning potential ratio) of 76 percent to an SPR of 65 percent and the target rebuilding year was changed from 2074 to 2029. The more optimistic rebuilding projections in the 2017 yelloweye rockfish rebuilding analysis (Gertseva and Cope 2017a) prompted this change to ease some of the constraints to commercial and recreational fisheries brought about by the very low available harvest of yelloweye rockfish under the previous rebuilding plan. While the higher ACLs of 48 and 49 mt in 2019 and 2020, respectively, are specified under the SPR harvest rate of 65 percent, the Council adopted more conservative management measures designed to maintain a lower impact (e.g., sector-specific ACTs based on an SPR harvest rate of 70 percent).

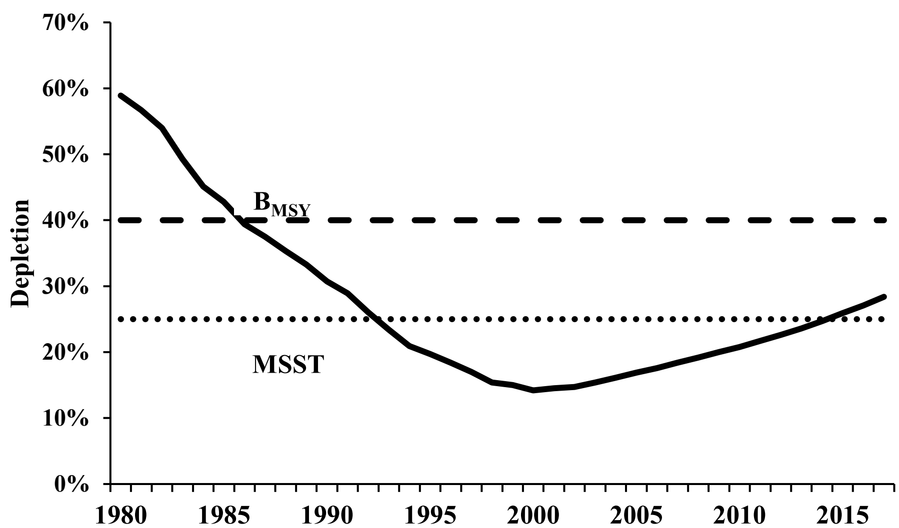

Figure 2-3. Relative depletion of yelloweye rockfish from 1980 to 2017 based on the 2017 stock assessment.

Stock Productivity Relative to Rebuilding Success

Recruitment dynamics in the 2017 assessment are assumed to follow Beverton-Holt stock-recruit function that includes an updated value of the steepness parameter (h). The steepness parameter was inestimable, and, therefore, it is fixed at the value of 0.718, which is the mean of the steepness prior probability distribution, derived from the 2017 meta-analysis of category 1 rockfish assessments. R_0 is estimated to inform the magnitude of the initial stock size. 'Main' recruitment deviations were estimated for modeled years that had information about recruitment, between 1980 and 2015. Peak recruitment events were estimated in years 1982-1984, 2002, 2008-2010 (Figure 2-4).

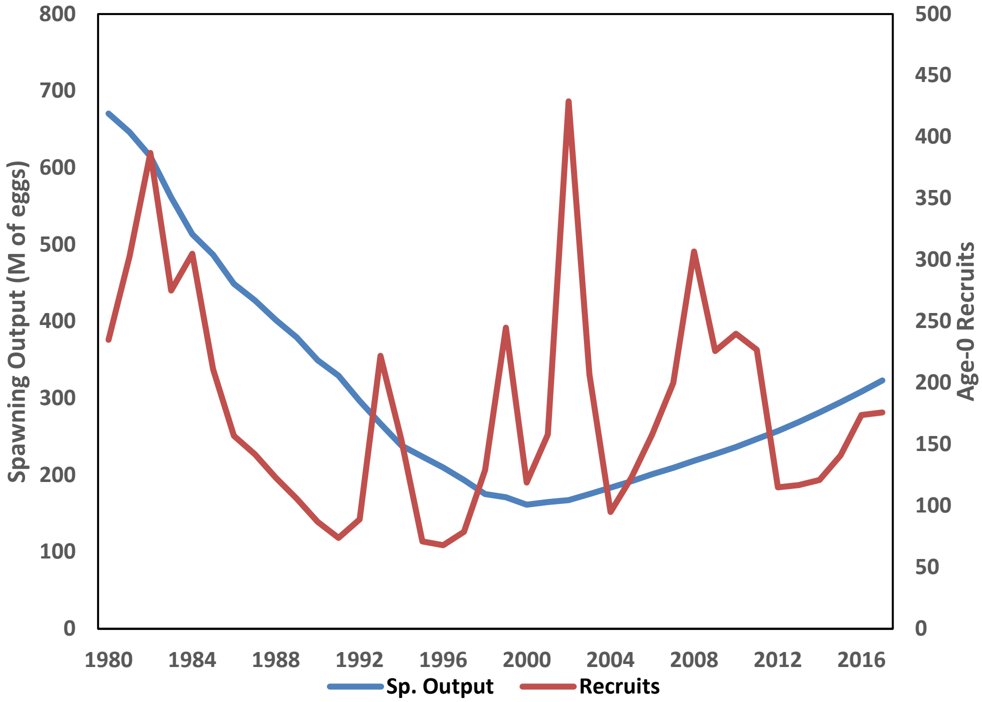

Figure 2-4. Time series of estimated yelloweye rockfish spawning output and recruitments for the base-case model in the 2017 assessment (Gertseva and Cope 2017b).

Fishing Mortality

Yelloweye rockfish are caught coastwide in all sectors of the fishery. Yelloweye rockfish are particularly vulnerable to hook and line gears, which are effective in the high relief habitats they reside. The current non-trawl RCA and the recreational depth closures are primarily configured based on yelloweye rockfish distribution and projected impacts in these hook and line fisheries. Small footrope trawls, including selective flatfish trawls, do not have the rollers and anti-chafing protection needed to fish in high relief habitats. Mandating these gears for trawl efforts on the shelf shoreward of the trawl RCA, the configuration of the trawl RCA, and a small IFQ allocation of yelloweye rockfish are the primary strategies currently used to minimize trawl impacts on yelloweye rockfish. Yelloweye rockfish are also a bycatch species in the Pacific halibut fishery (Love*, et al.* 2002).

Yelloweye rockfish are mostly encountered north of 36° N. lat. Yelloweye rockfish occur in depths from 25 to 475 m and are most commonly found at depths from 91 to 180 m (Love*, et al.* 2002).

Fishing mortality rates estimated in the 2017 assessment have been in excess of the current F_{MSY} harvest rate for rockfish (SPR = 50 percent) from 1977 through 2001 (Figure 2-5). Relative exploitation rates (catch/biomass of age-8 and older fish) are estimated to have peaked at 14.3 percent in 1997 but have been at or less than 0.8 percent after 2001. The F_{MSY} exploitation rate assuming the proxy SPR of 50 percent is 2.2 percent. Annual yelloweye rockfish harvest rates in the 1977-2001 period averaged over five times the estimated F_{MSY}, and spawning biomass declined rapidly during that period.

The commercial RCAs substantially reduce yelloweye rockfish impacts. North of 40°10’ N. lat., the highest bycatch rates of yelloweye rockfish occur in waters less than 100 fm. Yelloweye rockfish have a patchy distribution and, as such, using fleetwide bycatch rates over a large area (north and south of 40°10’ N. lat.) may misrepresent actual catch rates. North of Cape Alava, yelloweye rockfish bycatch rates are lowest inside of the 60 fm line; bycatch rates would increase substantially if shoreward RCAs were moved from the 60 fm line to the 75 fm line. The seaward boundary of the non-trawl RCA extends out to 150 fm year-round south of 40°10’ N. lat. The seaward boundary of the non-trawl RCA north of 40°10’ N. lat. is at 100 fm year-round.

Area closures and a prohibition on retention are the main strategies used to minimize recreational yelloweye rockfish impacts. The California recreational fishery is subject to depth restrictions that are more restrictive in the northern management areas where yelloweye rockfish are more prevalent. The California Department of Fish and Wildlife (CDFW) evaluated and has available four potential yelloweye rockfish conservation areas (YRCAs), which include habitat in both state and Federal waters where high yelloweye rockfish encounter rates have been documented. If implemented, YRCAs are anticipated to reduce yelloweye rockfish impacts during the open fishing seasons in both the Northern Groundfish Management Area and the North-Central North of Pt. Arena Groundfish Management Area, possibly allowing for a longer fishing season. To date, these YRCAs have not been implemented but would remain available management measures that can be routinely implemented inseason if needed.

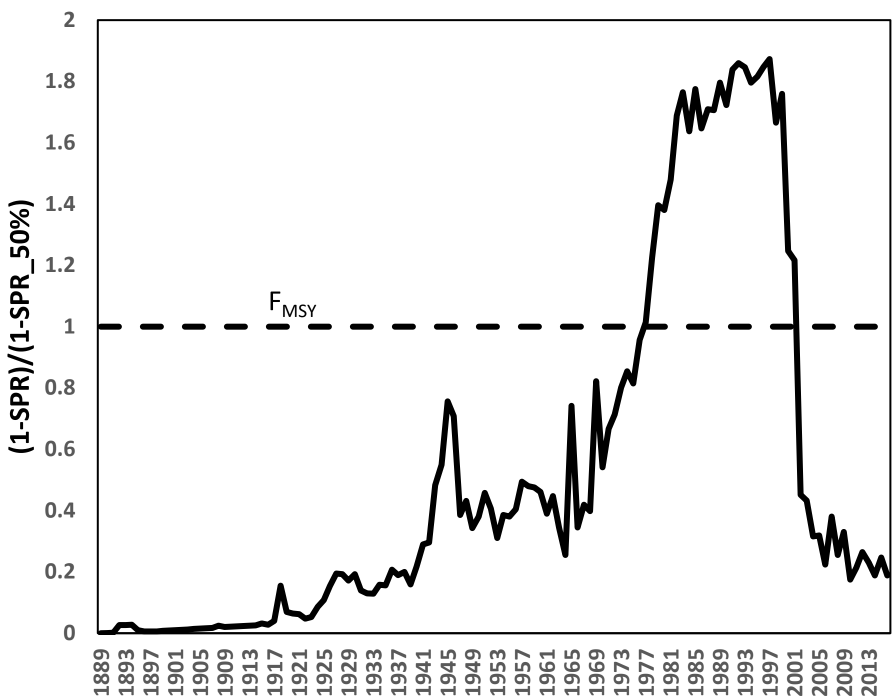

Figure 2-5. Time series of estimated relative exploitation rates (catch/biomass of age-8 and older fish) relative to the F_{MSY} target of yelloweye rockfish, 1889-2016 (Gertseva and Cope 2017b).

Catch monitoring uncertainty is high, given the relatively small contribution of yelloweye rockfish to rockfish market categories and the relatively large scale of recreational removals. In addition, since 2001, management restrictions have required nearly all yelloweye rockfish caught by recreational and commercial fishermen to be discarded at sea. Precisely tracking recreational catch inseason, especially in the California recreational fishery, has been a challenge.

Rebuilding Duration and Probabilities

The SSC evaluated progress to rebuilding in 2017 when they endorsed the new rebuilding analysis (Gertseva and Cope 2017a). Catches have been less than ACLs, and the stock is rebuilding faster than anticipated from the previous rebuilding analysis. The SSC concluded that rebuilding progress has been adequate.

The probability of rebuilding changed from 0 to 100 percent over a single year (2027). This is an unexpected result, but for yelloweye rockfish this occurs because a sequence of good year classes that spawned from 2007 to 2011 will join the spawning population starting around 2020 such that the projected spawning biomass will exceed the target biomass by 2027. The results of the rebuilding analysis do not depend strongly on forecasted recruitment. The rapid change in rebuilding probability is a consequence of this rebuilding analysis not accounting for uncertainty about starting biomass and age-structure, which is acceptable under the Terms of Reference for Groundfish Rebuilding Analyses.

A catch-only rebuilding projection update was conducted in 2023 for yelloweye rockfish, based on the 2017 rebuilding analysis (Wallace 2023). When a fish stock is under rebuilding, the rebuilding plan provides guidance on future catches and hence the rebuilding analysis is updated with observed catches in lieu of updating the stock assessment forecasting. Updated catches for the years 2017-2022 were incorporated and projected catch for 2023 and 2024 were provided by the Groundfish Management Team. For the years 2025 and beyond, the rebuilding model projected catches were assumed equal to the SPR of 65% estimated removals. Scientific uncertainty buffers based on the number of years since the last assessment were also utilized. The rebuilding projection update predicted a greater than 50% chance of rebuilding by 2028 (one year later than the 2017 analysis), given ACL catches from 2025 forward.

2.3.2 California Quillback Rockfish

Distribution and Life History

Quillback rockfish is a long-lived nearshore rockfish, which can live up to 95 years and is late to mature (Yamanako and Lacko, 2001; Love et al., 2002). The range of this species is from Kodiak Island, Alaska to Anacapa Island, California, though it is most common from southeast Alaska to central California (Love et al., 2002). Off of California, adult quillback rockfish are generally found in waters between 20-50 fathoms in nearshore kelp forests and rocky habitat (Love et al., 2002; Love, 2011).

In 2010, a productivity and susceptibility analysis conducted at a coastwide scale estimated quillback rockfish to have a vulnerability of major concern (V = 2.22, Cope et al., 2011). This analysis calculated species-specific vulnerability scores based on two dimensions: productivity characterized by life history and susceptibility characterized by how the stock is likely affected by fisheries.

Stock Status and Management History

Quillback rockfish was assessed in 2021 using a length-based data-moderate method, which is included by reference (Langseth et al., 2021). The Scientific and Statistical Committee (SSC) reviewed the assessment in June 2021 and endorsed it as the best scientific information available (BSIA) and suitable to inform management (Agenda Item G.5.a, Supplemental SSC Report 1, June 2021). The SSC noted the estimated stock size of California quillback rockfish to be below the MSST (Agenda Item G.5.a Supplemental SSC Report 1, June 2021), indicating it appeared to be overfished. A rebuilding analysis was conducted and submitted to the Council at the September 2021 meeting under Agenda Item G.5, Attachment 10, June 2021 and recommended by the SSC (Agenda Item C.6.a Supplemental SSC Report 1, September 2021). The Council referred the assessment to the Groundfish Subcommittee (GFSC) of the SSC for further review in September 2021. The SSC determined the results of the rebuilding analysis, per the recommendations of the GFSC, to be technically correct (Agenda Item E.2.a. Supplemental SSC Report 1, November 2021). The Council then adopted the stock assessment and the rebuilding analysis at their November 2021 meeting.

The next step was for NMFS to determine the status of quillback rockfish based on the stock assessment results. In March 2021, the Council was informed by NMFS that it needed to correct the FMP to define stocks of managed groundfish species (Agenda Item E.3.a, NMFS Report 1, March 2022). Briefly, the FMP at that time did not define stocks of managed species. Therefore, the status could not be determined until the stock was defined in the FMP, which Amendment 31 accomplished.

Despite not being declared overfished, the Council took precautionary measures to reduce impacts on California quillback rockfish for the 2023-24 biennium. The Council adopted Alternative 1 California quillback rockfish harvest specifications at their June 2022 meeting under Agenda Item F.6. as their final preferred alternative (FPA) to inform the contribution of California quillback rockfish to the nearshore rockfish complexes north and south of 40° 10′ N. lat. (refer to Informational Report 2, September 2022). The OFL for California quillback rockfish, within the nearshore complexes, were projected using a 50% SPR harvest rate from the 2021 assessment of quillback rockfish in CA, with 49.6% of the OFL apportioned north of 40°10' N lat. and 50.4% of the OFL apportioned south of 40°10' N lat. based on the estimated average 2002-2020 total catch by area based on the estimated average 2002-2020 total catch by area. The ACL were based on the an SPR55% harvest rate projected from the rebuilding analysis.

Additionally, for waters off of California, the Council implemented an annual catch target (ACT) set equal to the combined statewide ACL contributions to the nearshore rockfish complexes (Table 2-8). The Council also adopted a 75 lbs. bimonthly trip limit for the fixed gear commercial fishery and a 1 fish bag limit for the recreational fishery. These harvest specifications and management measures are detailed in Informational Report 2, September 2022.

Table 2-7. The 2023-24 estimated and summed No Action California quillback rockfish contributions (ACL contribution SPR 0.55 < ABC P* = 0.45) and ACTs (ACT = ACL contribution) to the nearshore rockfish complexes north and south of 40° 10′ N. lat.

Specification a/	**2023 (mt)**	**2024 (mt)**
OFL	2.11	2.32

ABC	1.85	2.01
ACL Contribution	1.76	1.93
ACT	1.76	1.93

Amendment 31 defined quillback rockfish as state-specific stocks in Washington, Oregon, and California, which allowed NMFS to determine status of these stock units. In December 2023, the status of California quillback rockfish was determined to be overfished (Agenda Item F.2, Attachment 2, March 2024).

At the September 2023 meeting, the Council was informed by the California Department of Fish and Wildlife (CDFW) that the 2023 California quillback rockfish ACT was exceeded (Agenda Item G.8.a, CDFW Report 1, September 2023) and that the state had implemented actions to reduce impacts to the stock (Agenda Item G.8.a, Supplemental CDFW Report 2, September 2023). Following analysis by the Groundfish Management Team (GMT; Agenda Item G.8.a, Supplemental Report 5, September 2023), the Council adopted inseason actions for federal waters off of California that were consistent to CDFW actions (Agenda Item G.8.a, Supplemental Report 5, September 2023). In brief, these actions reduced the commercial trip limit and recreational bag limit to zero. Further, recreational groundfish fishing shoreward of the 50 fathom non-trawl rockfish conservation area (RCA) was prohibited and area-based gear-specific trip limit restrictions were placed on the fixed gear commercial fishery.

In September 2023, under Agenda Item G.6 Initial Harvest Specifications and Management Measures Actions for 2025-26, the Council expressed concerns regarding the assumed removals for 2023 and 2024 applied in the updated rebuilding analysis. The GMT's recommended removal assumption for 2024 in the rebuilding analysis was 10.62 mt, which was based on the 2023 Groundfish Multiyear Report (GEMM, Agenda Item G.1.b, NWFSC Report 1, September 2023; Agenda Item E.2.a, Supplemental GMT Report 2, November 2023). The methodology used to develop this value is described in Agenda Item E.2, Supplemental GMT Report 1, November 2023. At that time, additional inseason actions were being considered in response to the ACT being exceeded for California quillback rockfish – actions that were expected to reduce mortality for the remainder of 2023 and for 2024. Given these concerns, CDFW recommended a removal assumption of 6.32 mt in 2024 (Agenda Item G.6, Supplemental CDFW Report 1, September 2023). In response, the Council recommended the Northwest Fishery Science Center (NWFSC) complete an alternate run of the rebuilding analysis using an alternate quillback rockfish removal assumption based on expected inseason actions, i.e., the CDFW removal assumption.

In November 2023, the Council reviewed the draft 2023 California quillback rockfish rebuilding analysis (Langseth 2023), with the alternate rebuilding removal assumption (i.e., the CDFW removal assumptions) included as a separate appendix (Agenda Item E.2, Attachment 1, November 2023). The SSC endorsed the rebuilding analysis as BSIA and concurred with the GFSC that the analysis was conducted in accordance with the Terms of Reference (TOR) for Groundfish Rebuilding Analysis (Agenda Item E.2.a, Supplemental SSC Report 1, November 2023). However, the SSC did not make recommendations on the removal assumptions. The Council postponed adoption of the 2023 rebuilding analysis (based on the 2021 assessment) and requested an additional SSC review of the public comments submitted by Dr. Ray Hilborn and Dr. Mark Maunder [via a letter submitted by J.T. Hobbs] regarding the 2021 stock assessment.

Also in November 2023, as part of developing the range of 2025-26 harvest specifications and management measures, CDFW recommended the Council consider managing California quillback rockfish contributions to the nearshore rockfish complexes north and south of 40° 10′ N. lat. with a 2025 OFL specification of 8.41 mt and a category 3 buffer using a P*=0.40 to obtain an ABC of 5.06 mt [ABC = 8.41*0.602 = 5.06] (Agenda Item E.2, Supplemental CDFW Report 2, November 2023). CDFW recommended this be added to the range of HCRs. Thus, a range of four action alternatives[7] for the 2025-26 California quillback rockfish OFL, ABC, and ACL values were:

- Alternative 1 - ACL SPR = 0.55 < ABC P* 0.45,
- Alternative 2 - the ABC rule, P* 0.45,
- Alternative 3 - CDFW alternative, and
- Alternative 4 - F = 0.

In November 2023, the Council adopted inseason adjustments by extending the duration of several measures implemented through the September 2023 (G.8.a. Supplemental GMT Report 2, September 2023) inseason action, with the goal of minimizing the mortality of California quillback rockfish (detailed in E.9.a, Supplemental GMT Report 1, November 2023) in limited entry (LE) and open access (OA) groundfish fisheries in 2024. The majority of the management measures implemented through the 2023 inseason actions are for the area between 42° N. latitude and 36° N. latitude within the area of the non-trawl RCA. In November 2023, the inseason action expanded the RCA to include all federal waters shoreward of 75 fathoms. Based on analysis conducted by the GMT at the November 2023 meeting (E.9.a. Supplemental GMT Report 1, November 2023), the Council recommended revising some of the measures implemented through the September 2023 inseason action to reduce discard mortality of California quillback rockfish while further narrowing the scope of restrictions and minimizing the economic impact to fishing communities to the extent possible (88 FR 90127, January 1, 2024).

In January 2024, the SSC GFSC conducted a review of the public comments submitted by Dr. Ray Hilborn and Dr. Mark Maunder, as requested by the Council in November. A TOR was specifically developed for this review meeting to provide the Council with further guidance on using the existing 2021 assessment of California quillback rockfish and corresponding 2023 rebuilding analysis for decision-making. This additional GFSC review did not raise new information that had either not been considered by the GFSC and SSC during its past reviews, or for which the approach taken by the stock assessment team did not follow the TOR and accepted practices guidelines, or for which there are data that could have been included in the assessment at the time it was conducted (SSC GFSC report, March 2024).

At the March 2024 Council meeting, the GFSC and the SSC again recommend use of the 2021 stock assessment and adoption of the 2023 rebuilding analysis for California quillback rockfish (Agenda Item F.7.a, Supplemental SSC Report 1, March 2024). The Council adopted the 2023 rebuilding analysis for California quillback rockfish, as described in Agenda Item F.2, Attachment 1, March 2024, with the original GMT removal assumptions. The Council also affirmed the range

[7] Table 5 and 4, Agenda Item E.2, Attachment 1, November 2023 and Agenda Item E.2.a, Supplemental CDFW Report 2, November 2023

of 2025-26 harvest specifications to be included in analysis based on the range developed in November (see Table 1 in Agenda Item E.7.a, Supplemental GMT Report 1 November 2023.

In April 2024, the Council adopted the ABC rule (Alternative 2) as a preliminary preferred alternative for their rebuilding strategy and removed the default HCR (Alternative 1) and the CDFW proposal (Alternative 3) from further analysis. The Council took final action on California quillback rockfish harvest specifications for 2025-26 and the associated rebuilding plan was adopted in June 2024. The adopted rebuilding plan will apply the ABC Rule harvest specifications for California quillback rockfish as the rebuilding strategy. The ABC rule results in 2025 and 2026 annual catch limits (ACL) of 1.3 mt and 1.5 mt, respectively. The ABC Rule results in a rebuilding target (T_{Target}) of 2061, with a maximum rebuilding timeline (T_{max}) of 2070. The Council also removed this stock from the nearshore rockfish complexes off California and will manage it as an individual stock.

Stock Productivity Relative to Rebuilding Success

Quillback rockfish was first assessed in 2010 using Depletion-Based Stock Reduction Analysis (DB-SRA) to provide estimates of coastwide OFLs (Dick and MacCall, 2010). The coastwide OFL was then apportioned to each management area based on the proportion of historical catches north and south of 40° 10′ N. lat. It is important to note, the application of DB-SRA did not estimate a stock status, but rather assumed that depletion at that time was distributed around the management target (i.e., 40 percent of unfished spawning output). The 2010 assessment found there was a 52 percent probability that quillback rockfish was experiencing overfishing, as recent coastwide catches were greater than the estimated median coastwide OFL estimate from that analysis (Dick and MacCall, 2010).

The 2021 assessment of California quillback rockfish used a length-based data-moderate methodology (Langseth et al., 2021). This assessment was a single-sex model that included two fishing fleets (a recreational fleet and a commercial fleet), externally estimated biological relationships (length-weight, length-at-age, natural mortality, fecundity, and maturity), estimated asymptotic selectivity for each fishing fleet, assumed a Beverton-Holt stock recruitment relationship with fixed productivity (i.e., steepness of 0.72), and estimated annual recruitment deviations (Agenda Item G.5.a, Supplemental SSC Report 1, June 2021). Assumed biological parameters are provided below in Table 2-8. There was substantial uncertainty in the California model given sensitivity to assumed mortality parameters and the limited data in California. The assessment was assigned a category 2 designation (i.e., sigma = 1.0). The assessment of California quillback rockfish estimated 2021 depletion (i.e., fraction of unfished spawning output) of 14 percent, below the MSST for rockfish (25 percent).

The SSC reviewed the 2021 assessment and endorsed it as BSIA for use in management and the Council adopted the assessment after considering several discussions presented in SSC statements and GFSC reports that are reflected in the record for Council meetings in June 2021 (Agenda Item G.5.a Supplemental SSC Report 1), September 2021 (Agenda Item C.6.a Supplemental SSC Report 1), and November 2021 (Agenda Item E.2.a Supplemental SSC Report 1). Those reports characterize the SSC's conclusions about the assumptions, strengths, and limitations of the 2021 assessment. An additional review meeting conducted in January 2024 also clarifies SSC conclusions (SSC GFSC report, March 2024).

Table 2-8. Summary of key parameters in the 2021 assessment for California quillback rockfish.

Parameter	Value	Estimated or Fixed
Natural mortality yr^{-1}	0.057	Fixed
Length at age (cm)		
von Bertalanffy k yr^{-1}	0.199	Fixed
Asymptotic length (cm)	43.04	Fixed
Weight at length (kg)		
Coefficient	1.963 e-05	Fixed
Exponent	3.016	Fixed
Maturity at length (cm)		
Inflection (cm)	29.23	Fixed
Slope	-0.80	Fixed
Fecundity at length (cm)		
Inflection	3.93e-07	Fixed
Slope	3.702	Fixed
Stock-recruitment		
$Ln(R_0)$	3.17	Estimated
Steepness (h)	0.72	Fixed
Variation in Recruitment (σ_R)	0.60	Fixed
Recruitment deviations	Annual deviations from the stock-recruitment curve	Estimated
Start Year for Early Deviations	1940	Fixed
Start Year for Main Deviations	1978	Fixed
End year for Deviations	2017	Fixed
Maximum Bias Adjustment	0.35	Fixed

Model Sensitivity to Stock-Recruit Steepness

The steepness of the stock-recruitment relationship, which determines the productivity of a fish population, is one of the key parameters for understanding the dynamics of the stock and determining projected rebuilding. The stock-recruit steepness represents the proportion of average unfished recruitment achieved at 20 percent of unfished spawning output and ranges from 0.2 to 1.0 (the higher value indicates the higher productivity of the stock). Reliable estimation of this parameter is dependent on long, contrasting time-series of stock-recruit data that are often not available (Hilborn and Walters, 1992; Conn et al., 2010). To date, the majority of groundfish assessments lack sufficient data to estimate steepness reliably, resulting in the parameter being fixed at an assumed value. Similar to other groundfish assessments, the assessment of California quillback rockfish was unable to reliably estimate this parameter due to the short time-series of data, which are primarily available after the estimated large declines in spawning output, and due to the continuous downward trajectory of the stock abundance. Therefore, steepness in the assessment model was fixed at the value of 0.72, which is the mean of the rockfish prior defined in the groundfish stock assessment TOR (applicable version to 2021 assessment; December 2020).

The impact to the assumed value of steepness was explored in the 2021 assessment through analysis of model sensitivity to alternative values, and through likelihood profile analyses. The likelihood profile for steepness from the 2021 assessment for California quillback rockfish is shown in Figure 2-6. The estimated negative log-likelihood declines indicate improved fits to the data with increasing values of steepness with the best fit to the data found with a value of 1.0, which is considered to be implausible for a slow-growing rockfish, implying that this parameter is unable to be estimated given the available data. The change in the estimated fraction of unfished spawning output across a range of steepness values is shown in Figure 2-6.

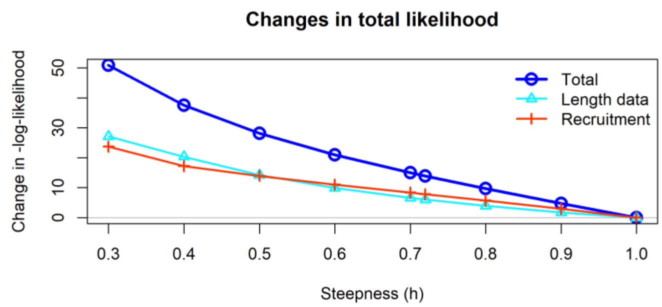

Figure 2-6. Negative log-likelihood profile in total and for each data type over the range of steepness from 0.3 to 1.0 by increments of 0.1 (from Langseth et al., 2021).

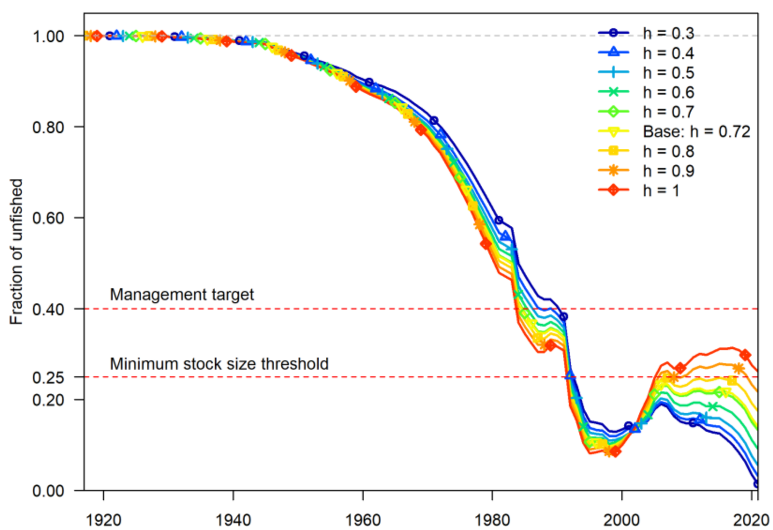

Figure 2-7. Time series of the estimated fraction of unfished spawning output associated with values of steepness ranging from 0.3 to 1.0 by increments of 0.1 (from Langseth et al., 2021).

Similar to steepness, natural mortality is often difficult to estimate based on available data and is often fixed within groundfish assessments. Quillback rockfish are a long-lived rockfish that are thought to live up to 95 years of age (Yamanako and Lacko, 2001; Love et al., 2002). Across the U.S West Coast there are limited age data for quillback rockfish with the majority of these samples being collected in recent years, well after the peaks of high historical catches. Natural mortality was fixed in the model based on literature values of a maximum age of 95, resulting in an assumed natural mortality of 0.057 yr^{-1}. A likelihood profile and model sensitivities over natural mortality values were conducted in the 2021 assessment (Langseth et al., 2021). The likelihood profile over natural mortality supported higher values (i.e., a lower maximum age, Figure 2-8). This information is being informed primarily by the length data and the estimates of annual recruitments which would be expected to contain limited data on natural mortality, particularly compared to age data which were not included in the base model. The estimated fraction unfished was also highly sensitive to assumptions about natural mortality (Figure 2-9).

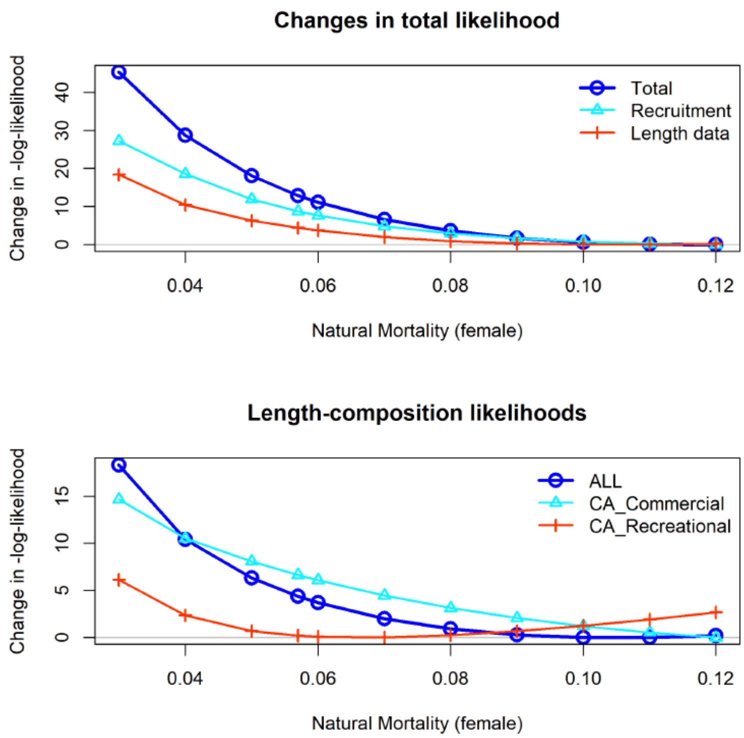

Figure 2-8. Negative log-likelihood profile in total and for each data type over a range of natural mortality values (from Langseth et al., 2021).

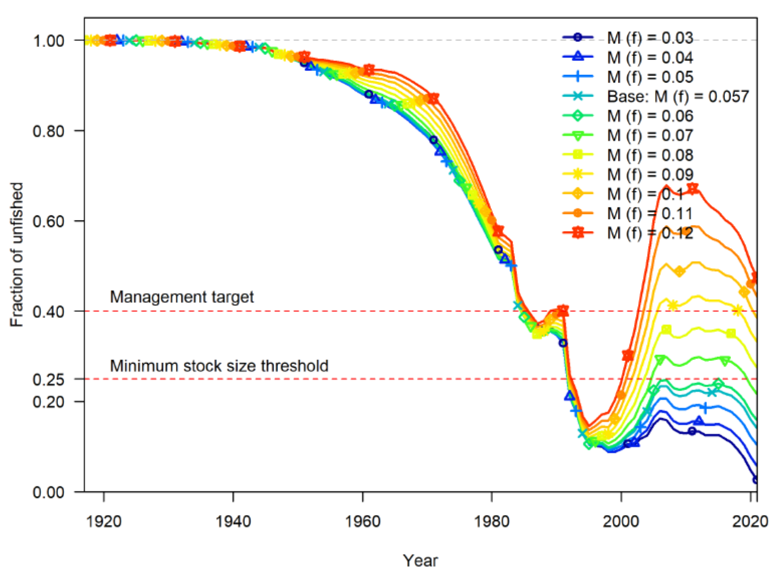

Figure 2-9. Time series of the estimated fraction of unfished spawning output associated with a range of natural mortality values (from Langseth et al., 2021).

Fishing Mortality

Historically, California quillback rockfish mortality has been higher in the recreational sector than in the commercial sectors (Table 2-9, Figure 2-10). Prior to the overfished declaration, California quillback rockfish were targeted and retained by a small group of commercial limited entry state-issued deeper nearshore permitees. Commercial open access and limited entry participants without a deeper nearshore permit also incidentally encounter quillback rockfish while targeting other species and must discard that catch at sea (Agenda Item G.8.a, Supplemental GMT Report 2, September 2023, Agenda Item G.8.a, Supplemental GMT Report 5, September 2023, Agenda Item E.9.a, Supplemental GMT Report 1, November 2023).

The adopted rebuilding plan is specific to the groundfish FMP and can only restrict targeted groundfish fisheries. Historically there have been some small incidental catch from fisheries not managed under the Groundfish FMP (Table 2-9) [8]. These fisheries are not subject to the California quillback rockfish rebuilding plan. All California quillback rockfish mortality counts against the ACL. These non-groundfish fisheries include, but are not limited to, directed Pacific halibut, open access California halibut, and pink shrimp trawl. Additionally, mortality from research is estimated. Figure 2-10 displays the same information as Table 2-9, but as a visual representation.[9] Figure 2-10 shows the California quillback rockfish mortality by management area used to manage the nearshore rockfish complex.[10]

Table 2-9. Preliminary estimates of quillback rockfish mortality (mt) off California by sector, 2013-2022. Incidental open access (IOA) includes directed Pacific halibut, open access California halibut, pink shrimp trawl, and research. Note that research values represent coastwide estimates and are not specific to California.

YEAR	Directed Groundfish Fisheries					Other		Total (mt)
	California Recreational (mt)	Shoreside Trawl (mt)	LE Fixed Gear - Hook & Line (mt)	Nearshore (mt)	OA Fixed Gear - Hook & Line (mt)	Research (mt)	IOA (mt)	
2013	2.9	0	0	0.67	0	0.01	0	3.58
2014	2.53	0	0	0.45	0	0.03	0	3.01
2015	7.43	0	0	1.09	0.01	0.08	0	8.61
2016	8.48	0	0.03	0.96	0.02	0.17	0	9.66
2017	9.76	0	0.77	1.74	0.01	0.09	0.03	12.4
2018	10.11	0	0	2.62	0.01	0.04	0	12.78

[8] These values were provided by the Fisheries Observation Program and were produced using the methods outlined in Somers et al. 2022b. These estimates are in a pre-review, pre-decisional state and should not be formally cited. They are to be considered provisional and do not represent any final determination or policy of NOAA or the Department of Commerce. Incidental open access (IOA) includes directed Pacific halibut, open access California halibut, pink shrimp trawl, and incidental mortality. Limited entry (LE) fixed gear hook and line includes both sablefish-endorsed and non-sablefish-endorsed sectors. Research mortality was not estimated by state, and coastwide values are shown here for reference.

[9] *Id.*

[10] *Id.*

YEAR	Directed Groundfish Fisheries					Other		Total (mt)
	California Recreational (mt)	Shoreside Trawl (mt)	LE Fixed Gear - Hook & Line (mt)	Nearshore (mt)	OA Fixed Gear - Hook & Line (mt)	Research (mt)	IOA (mt)	
2019	11.46	0	0	3.89	0	0.03	0.8	16.18
2020	7.8	0	0	4.1	0.12	0	0	12.02
2021	10.55	0	0	4.76	0	0.02	0.01	15.34
2022	9.23	0.01	0	1.86	6.75	0.06	0.01	17.92

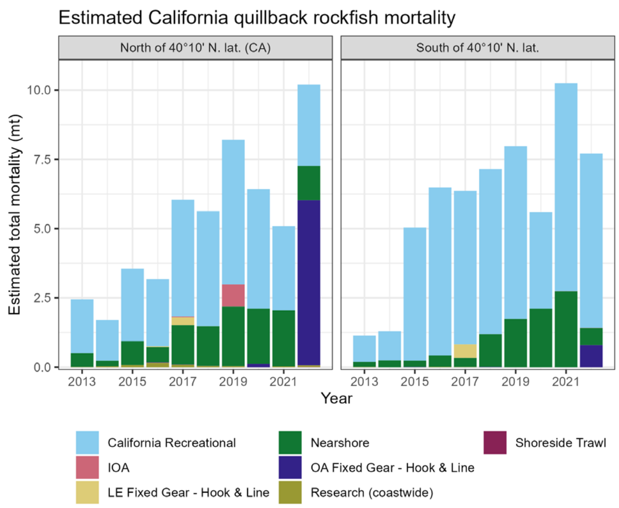

Figure 2-10. Preliminary estimates of California quillback rockfish mortality by sector from 2013-2022. Incidental open access (IOA) includes directed Pacific halibut, open access California halibut, pink shrimp trawl, and incidental mortality. Note that research values represent coastwide estimates and are not specific to California.

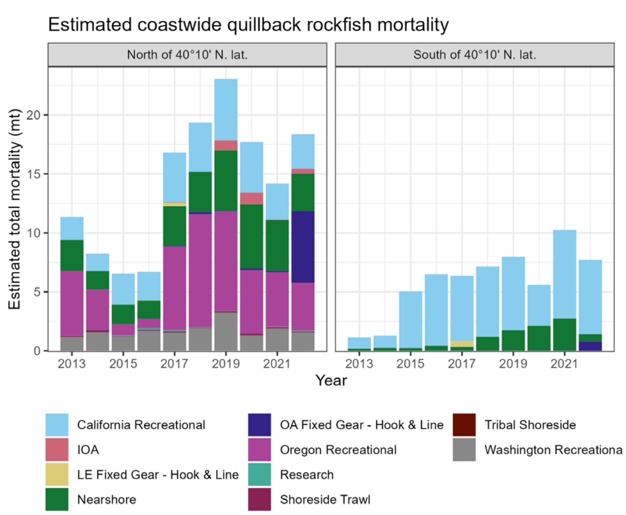

Figure 2-11. Estimated coastwide quillback rockfish fishing mortality north and south of 40° 10′ N. lat by sector from 2013-2022. Incidental open access (IOA) includes directed Pacific halibut, open access California halibut, pink shrimp trawl, and incidental mortality. Data from Somers et al. 2022b.

Rebuilding Duration and Probabilities

The adopted rebuilding plan, with the ABC rule rebuilding strategy, with T_{target} = 2060 and T_{max} = 2071 (based on values in Table 3; Langseth 2023) projects a 73.6 percent probability of rebuilding the stock by T_{max} by 2071 and a T_{target} of 2060. Probabilities represent the proportion of rebuilding analysis simulations that reach the target spawning output by the specified year.

2.4 Non-Overfished Groundfish Stocks

2.4.1 Arrowtooth flounder

Distribution and Life History

Arrowtooth flounder (*Atheresthes stomias*) range from the southern coast of Kamchatka in Russia to the northwest Bering Sea and Aleutian Islands to San Simeon, California. Arrowtooth flounder is the dominant flounder species on the outer continental shelf from the western Gulf of Alaska to Oregon. They are members of the family Pleuronectidae, the right-eyed flounders. Arrowtooth flounder reach sizes of nearly 90 cm and can live to 27 years. Eggs and larvae are pelagic; juveniles and adults are demersal (Garrison and Miller 1982; NOAA 1990). Juveniles and adults are commonly found on sand or sandy gravel substrates, but occasionally occur over low-relief rock-sponge bottoms. Arrowtooth flounder exhibit a strong migration from shallow water summer feeding grounds on the continental shelf to deep water spawning grounds over the continental slope (NOAA 1990). Depth distribution may vary from as little as 50 m in summer to more than 500 m in the winter (Garrison and Miller 1982; NOAA 1990; Rickey 1995).

Arrowtooth flounder are oviparous with external fertilization, and eggs are about 2.5 mm in diameter. Spawning may occur deeper than 500 m off Washington (Rickey 1995). Arrowtooth flounder are batch spawners (Rickey 1995). They spawn in the deeper continental shelf waters (>200 m) in the late fall through early spring and appear to move inshore during the summer (Zimmerman and Goddard 1996). The larvae spend approximately four weeks in the upper 100 m of the water column (Fargo and Starr 2001) and settle to the bottom in the late winter and early spring. Larvae eat copepods, their eggs, and copepod nauplii (Yang 1995; Yang and Livingston 1985). Juveniles and adults feed on crustaceans (mainly ocean pink shrimp and krill) and fish (mainly gadids, herring, and pollock) (Hart 1988; NOAA 1990).

Arrowtooth flounder exhibit two feeding peaks, at noon and midnight. Arrowtooth flounder are piscivorous, but they also eat shrimp, worms, and euphausiids (Love 1996). Buckley et al. (1999) analyzed 380 arrowtooth flounder stomachs that were collected in 1989 and 1992 from Oregon and Washington and found that hake (*Merluccius productus*) and unidentified gadids dominate their stomach contents (45 percent and 22 percent, respectively) followed by herring (19 percent; *Clupea pallasi*), mesopelagics (0.5 percent), rex sole (1 percent; *Glyptocephalus zachirus*), slender sole (*Lyopsetta exilis*) and other small flatfish (3 percent), other arrowtooth flounder (1.5 percent), other unidentified flatfish (1 percent), pandalid shrimp (~3 percent), and euphausiids (3 percent).

Yang (1995) analyzed 1,144 stomachs from arrowtooth flounder collected in the Gulf of Alaska, and found that walleye pollock (*Theragra chalcogramma*) composed 66 percent of the arrowtooth flounder diet, although arrowtooth flounder smaller than 40 cm primarily feed on capelin (*Mallotus villosus*), herring, and shrimp. Gotshall (1969) examined 425 arrowtooth flounder stomachs from northern California throughout the 1960s and found that pandalid shrimp made up nearly 40 percent of the prey by volume, along with other shrimps, crabs, euphausiids, Pacific sanddabs (*Citharichthys sordidus*), and slender sole. However, Gotshall's samples were taken directly from shrimp beds, so higher concentrations of shrimp would be expected. It is clear that arrowtooth flounder have a broad diet, consuming most of the common fish and invertebrates found on soft bottom substrate and in the water column.

Predators of juvenile arrowtooth flounder include skates, dogfish, shortspine thornyhead, halibut, coastal sharks, orcas, toothed whales, and harbor seals (Field*, et al.* 2006). Adult arrowtooth flounder are likely to be vulnerable only to the largest of these predators.

Female arrowtooth flounder off Oregon reach 50 percent maturity at 8 years of age, and males at 4 years (Hosie 1976). Rickey (1995) found that arrowtooth flounder reach 50 percent maturity at lengths of 36.8 cm for females and 28 cm for males off Washington, and 44 cm for females and 29 cm for males off Oregon. As a comparison, female length at 50 percent maturity is 47 cm in the Gulf of Alaska (Turnock*, et al.* 2005) and 38 cm in British Columbia (Fargo and Starr 2001).

Stock Status and Management History

Arrowtooth flounder are commonly caught by trawl fleets off Washington and Oregon, but they are frequently discarded due to low flesh quality. For this reason, the market for arrowtooth flounder has been fairly limited over the last 50 years. It is likely that the stock off the U.S. West Coast is linked to the population off British Columbia and, possibly, to the stock in the Gulf of Alaska. However, for assessment purposes it is assumed that the U.S. West Coast population is a unit stock.

The West Coast stock of arrowtooth flounder was assessed in 1993 (Rickey 1993), and a full stock assessment was done in 2007 (Kaplan and Helser 2008). Three components of the arrowtooth flounder fishery were used in modeling: the mink food fishery in the 1950s-1970s, a targeted fillet/headed-and-gutted fishery that began around 1981, and a "bycatch fleet" that represents West Coast trawl effort with arrowtooth flounder bycatch but no landings. Estimates of historical catch are highly uncertain. The model contains assumed fixed values for natural mortality and steepness of the stock-recruitment relationship. Likelihood profiles suggest that the estimates of biomass and depletion are not sensitive to values of steepness. Assumed values of natural mortality have a small effect on estimated depletion, but strongly influence the estimates of absolute biomass.

The base model shows a period of moderate depletion through the 1950s and 1960s, followed by a rebuilding of the stock beginning in the late 1970s. Strong year classes, in particular the 1999 year class, have led to an increase in the stock since the late 1990s. The spawning biomass at the beginning of 2007 was estimated to be 63,302 mt and 79 percent of the estimated unfished spawning biomass. Total biomass at the start of 2007 was estimated to be 85,175 mt. The 2007 stock assessment estimated that the arrowtooth flounder stock has never fallen below the overfished threshold.

An update of the full 2007 assessment of arrowtooth flounder was prepared in 2017 (Sampson*, et al.* 2017). Changes from the 2007 assessment included use of updated pre-2007 landings, discards, and composition data; updated abundance indices; updated natural mortality estimates; and the addition of 10 years of catch, composition, and Northwest Fisheries Science Center (NWFSC) slope-shelf survey data. Large recruitments that occurred in 2011-2013, coupled with declining fishing mortality, have resulted in an upward trend in biomass. The assessment update estimates spawning biomass of almost 57,000 mt, with a depletion of 87 percent in 2017, which is much higher than the B_{MSY} proxy of $B_{25\%}$ for Council managed flatfish species. Biomass trajectories prior to 2007 were substantially different compared to the previous assessment.

The Council maintained the default harvest control rules of ACL = ABC (cat. 2 sigma; P* = 0.4) for 2021 and beyond. A catch-only projection update of the 2017 update assessment inform harvest specifications for 2023 and beyond.

Stock Productivity

Arrowtooth flounder are a very productive stock with high growth rates, high natural mortality rates, and a high stock-recruitment steepness. A mean flatfish steepness of 0.8 was determined in a 2010 meta-analysis conducted by the SSC and described in the 2011-2012 specifications Final Environmental Impact Statement (FEIS) (PFMC and NMFS 2011). A steepness of 0.902 was assumed in the 2007 arrowtooth flounder assessment based on a flatfish meta-analysis conducted by Dorn (2002a) and the same value was assumed in the 2017 update. Arrowtooth flounder received a relatively high productivity score of 1.95 in the PSA analysis (Table 2-2).

The 2017 assessment estimated strong recent recruitments in 1999 and 2011 to 2013.

Fishing Mortality

The target F_{MSY} SPR harvest rate for arrowtooth flounder is 30 percent. The 2017 assessment estimated annual SPR harvest rates between 2007 and 2016 of 41-81 percent, substantially lower than the target. Exploitation of arrowtooth flounder has remained below the F_{MSY} target throughout the entire assessment period and the ACL has never been exceeded.

Arrowtooth flounder are a trawl-dominant species and are not particularly valuable. Given that arrowtooth flounder are caught on the northern shelf where Pacific halibut and yelloweye rockfish are caught incidentally to arrowtooth flounder, this is not a species with a high attainment, since valuable quota for these highly constraining species would have to be invested to target arrowtooth flounder. Management uncertainty is low with 100 percent observer coverage for the trawl fleet under trawl rationalization. The PSA vulnerability score of 1.21 indicates a low concern of overfishing.

2.4.2 Big Skate

Distribution and Life History

Big skate (*Raja binoculata*) are the largest skate species in North America with a documented maximum length of 244 cm total length and a maximum weight of 91 kg (Eschmeyer*, et al.* 1983). The species name “binoculata” (two-eyed) refers to the prominent ocellus at the base of each pectoral fin. Big skate range from the Bering Sea to Cedros Island in Baja California but are uncommon south of Pt. Conception. Big skate occur in coastal bays, estuaries, and over the continental shelf, usually on sandy or muddy bottoms, but occasionally on low strands of kelp.

Big skate have a shallow depth distribution of 3-800 m but are most common in the 3-110 m depth zone. It frequents progressively shallower water in the northern parts of its range.

Skates are the largest and most widely distributed group of batoid fish with approximately 245 species ascribed to two families (Ebert and Compagno 2007; McEachran 1990). Skates are benthic fish that are found in all coastal waters but are most common in cold temperatures and polar waters (Ebert and Compagno 2007).

There are about eleven species of skates from either of three genera (*Amblyraja*, *Bathyraja*, and *Raja*) present in the Northeast Pacific Ocean off California, Oregon and Washington (Ebert 2003). Of that number, just three species (longnose skate, *Raja rhina*; big skate, *Raja binoculata*; and sandpaper skate, *Bathyraja interrupta*) make up over 95 percent of survey catches in terms of biomass and numbers, with the longnose skate leading in both categories (62 percent of biomass and 56 percent of numbers).

Mating has been observed with distinct pairing and embrace. Big skate are oviparous and lay horned egg cases up to a foot in length with up to seven embryos per egg case (Eschmeyer*, et al.* 1983). The female deposits her eggs in pairs on sandy or muddy flats; there is no discrete breeding season and egg-laying occurs year-round (Ebert 2003). Females may use discrete spawning beds, as large numbers of egg cases have been found in certain localized areas (IUCN/SSC Shark Specialist Group 2005). The young emerge after 9 months and measure 18–23 cm (7–9 in). Female big skates mature at 1.3–1.4 m (4 ft 3 in–4 ft 7 in) long and 12–13 years old, while males mature at 0.9–1.1 m (2 ft 11 in–3 ft 7 in) long and seven to eight years old (Bester 2009). The growth rate of big skates in the Gulf of Alaska are comparable to those off California but differ from those off British Columbia. The lifespans of big skates off Alaska are up to 15 years, while those off British Columbia are up to 26 years.

Big skates are usually seen buried in sediment with only their eyes showing. They feed on polychaete worms, mollusks, crustaceans, and small benthic fishes. Polychaetes and mollusks comprise a slightly greater percentage of the diet of younger individuals. A known predator of big skates is the broadnose sevengill shark (*Notorhynchus cepedianus*); the eyespots on the skates' wings are believed to serve as decoys to confuse predators. Juvenile northern elephant seals (*Mirounga angustirostris*) are known to consume the egg cases of the big skate. Known parasites of the big skate include the copepod *Lepeophtheirus cuneifer*.

Stock Status and Management History

Big skate are caught in commercial and recreational fisheries on the West Coast using line and trawl gears. Big skate are commercially utilized to a limited extent by removing the pectoral fins (skate wings) for sale in fresh fish markets.

Big skate were managed in the Other Fish complex until 2015 when they were designated an EC species. When the Council considered designating all skates except longnose skate as EC species, the GMT estimated that catches of big skate averaged 95 mt from 2007–2011 with large landings of Unspecified Skate (see Table 4-33 in the 2015-2016 Harvest Specifications and Management Measures Final Environmental Impact Statement). Subsequent analysis of Oregon port sampling data not available when the Council considered the EC designation indicated about 98 percent of the recent Unspecified Skate landings in Oregon were comprised of big skate. The GMT revised the total mortality estimates of big skate coastwide using these new data. Such large landings indicate targeting of big skate has occurred and an EC designation was not warranted. Based on this evidence, the Council decided to redesignate big skate as an actively managed species in the fishery. Big skate were managed with stock-specific harvest specifications starting in 2017.

The SSC-endorsed OFL of 541 mt for 2017-2020 is calculated by applying approximate MSY harvest rates to estimates of stock biomass from the NWFSC West Coast Bottom Trawl Survey (see Agenda Item H.6.a, Supplemental Attachment 6, November 2013). The survey-based biomass estimate is likely underestimated since big skate are distributed to the shore and no West Coast trawl surveys have been conducted shallower than 55 m. This adds a level of precaution to the management of big skate with stock-specific management reducing management uncertainty and the risk of overfishing the stock. There was consideration for managing big skate in a complex with longnose skate, the other actively managed West Coast skate species, but the two species have disparate distributions and fishery interactions (longnose is much more deeply distributed than big skate) and that option was not endorsed. The Council chose to set the ACL equal to the ABC with a P* of 0.45.

The first full assessment of big skate was conducted in 2019, which estimated big skate to be healthy with an estimated depletion of 79 percent at the start of 2019 (Taylor, *et al.* 2019). The retrospective estimates of stock status indicate the stock has not been highly exploited and has maintained a high level of abundance in the last 100 years (Figure 2-12). Strong assumptions were required to estimate historical discards (and dead catches), as big skate have only been sorted from other skate species since 2015. The data provide little information about the scale of the population, necessitating the use of a new prior for the NMFS bottom trawl survey catchability (q) developed by the STAT during the STAR Panel review to maintain stable model results. The prior was updated from the one developed in the 2007 longnose skate stock assessment (Gertseva and Schirripa 2008) to better account for big skate occurrences in shallower water than the surveyed region. The assessment model provided weak support for the assumed steepness of 0.4. As in longnose skate, the major axis of uncertainty in the decision table was q of the trawl survey.

The SSC endorsed the big skate assessment as a category 2 assessment since recruitment deviations were not estimated. The Council selected the default harvest control rule for big skate where the ACL equals the ABC under a P* of 0.45.

Table 2-10. 2010-2015 total mortality (mt) of big skate by sector in West Coast fisheries.

Sector	2010	2011	2012	2013	2014	2015
Incidental OA						
Landings	3.0	5.2	1.1	3.8	2.0	3.8
Discards	0.0	0.6	0.1	0.0	0.0	0.0
Total	3.0	5.7	1.1	3.8	2.1	3.8
Non-Trawl						
Landings	16.2	9.7	3.3	6.4	8.9	3.3
Discards	1.6	2.7	6.7	5.1	3.3	3.3
Total	17.8	12.4	10.1	11.5	12.2	6.6
Trawl						
Landings	173.2	236.1	227.7	123.6	354.3	276.7
Discards	28.8	35.9	30.6	36.5	43.8	43.8
Total	202.0	272.0	258.3	160.1	398.1	320.4
Tribal						
Landings	3.8	5.5	12.4	10.3	9.7	16.9
Discards	0.1	0.1	0.0	0.0	0.0	0.0
Total	3.8	5.5	12.4	10.3	9.7	16.9
Total All Sectors	226.6	295.7	281.8	185.8	422.1	347.8

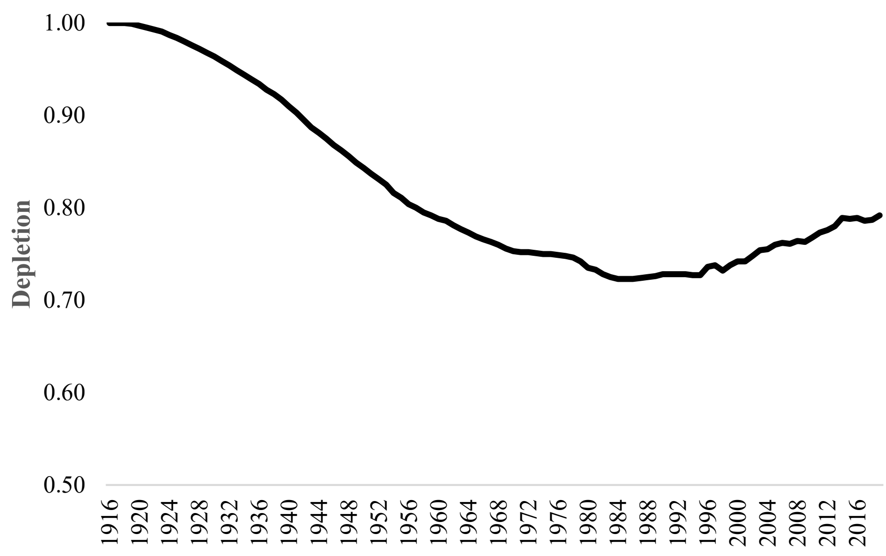

Figure 2-12. Relative depletion of big skate from 1916 to 2019 based on the 2019 stock assessment.

Stock Productivity

In general, elasmobranchs have relatively low productivity given the K-type reproductive strategy of producing few eggs per female with a significant parental energy investment to increase survival of those few eggs (e.g., production of egg cases and relatively large yolk masses). A relatively low Beverton-Holt steepness of 0.4 was assumed in the 2019 big skate assessment.

Fishing Mortality

Historically, skates in general have not been high-priced fishery products. They are taken mostly as bycatch in other commercially important fisheries (Bonfil 1994). Although skates are caught in almost all demersal fisheries and areas off the U.S. West Coast, the vast majority (almost 97 percent) are caught with trawl gear.

Landing records indicate that skates have been retained on the U.S. Pacific Coast at least since 1916 (Martin and Zorzi 1993). Little is known about the species composition of West Coast skate fisheries, particularly prior to 1990. With few exceptions, big skate landings have been reported, along with other skate species, under the market category "Unspecified Skates."

Historically, only the skinned pectoral fins or "wings" were sold, although a small portion of catch would be marketed in the round (whole). The wings were cut onboard the boat and the remainder discarded. Currently, West Coast skates are marketed both whole and as wings. Skates wings are sold fresh or fresh-frozen, as well as dried or salted and dehydrated, for sale predominantly in Asian markets (Bonfil 1994; Martin and Zorzi 1993). It appears that the demand for whole skates did increase greatly during the mid-1990s, as evidenced by the increase in the number of trips where skates were landed. While skates were encountered predominantly as bycatch previously, landings data from this period reveal greater targeting of skates by some vessels. After a few years, the whole-skate market cooled due to downturns in Asian financial markets (Peter Leipzig, Fishermen's Marketing Association, pers. com. as cited by Gertseva and Schirripa (2008)).

Harvest rates estimated by the base model indicate catch levels have been below the 100 percent relative fishing intensity upper limit defined as 50 percent SPR (0.5 1-SPR in Figure 2-13). SPR is calculated as the lifetime spawning potential per recruit at a given fishing level relative to the lifetime spawning potential per recruit with no fishing. The annual exploitation rate of age 2+ fish has been below 2 percent over the recent 10-year period.

A vulnerability score of 1.99 indicates a medium concern for overfishing the stock.

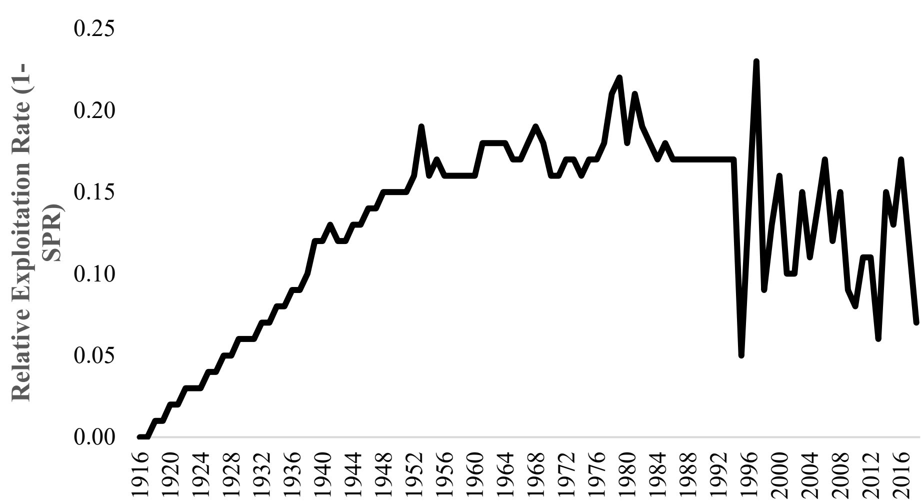

Figure 2-13. Relative exploitation rate of big skate, 1916-2018, from the 2019 stock assessment.

2.4.3 Black Rockfish off California

Distribution and Life History

Black rockfish (*Sebastes melanops*) are found from Southern California (San Miguel Island) to the Aleutian Islands (Amchitka Island) and they occur most commonly from San Francisco northward (Hart 1988; Miller and Lea 1972; Phillips 1957; Stein and Hassler 1989). Black rockfish occur from the surface to greater than 366 m; however, they are most abundant at depths less than 54 m (Stein and Hassler 1989). Off California, black rockfish are found along with the blue, olive, kelp, black-and-yellow, and gopher rockfishes (Hallacher and Roberts 1985). The abundance of black rockfish in shallow water declines in the winter and increases in the summer (Stein and Hassler 1989). Densities of black rockfish decrease with depth during both the upwelling and non-upwelling seasons (Hallacher and Roberts 1985). Off Oregon, larger fish seem to be found in deeper water (20 m to 50 m) (Stein and Hassler 1989).

Although tagging studies have documented some individuals moving long distances (several hundreds of miles), the vast majority of recaptured individuals were found close to the areas of initial capture and tagging (Culver 1987; Ayres 1988; Starr and Green 2007; Wallace et al. 2010). Movement displayed by black rockfish off the northern Oregon coast is primarily northward to the Columbia River (Culver 1986). Results from a 2004-2005 study off Newport, Oregon of 42 black rockfish implanted with acoustic tags indicated that all but seven fish remained within range of a 3 x 5 km array of acoustic receivers during one full year of monitoring and had relatively small home ranges that did not vary seasonally (Parker et al. 1995). Green and Starr (2011) report similar findings from a study in Carmel Bay, California of 23 acoustically tagged black rockfish. The extensive Washington state tagging study also supported low movements for most individuals, with some exceptional movements recorded (Wallace et al. 2010).

Black rockfish form mixed sex, midwater schools, especially in shallow water (Hart 1988; Stein and Hassler 1989). Black rockfish larvae and young juveniles (<40 mm to 50 mm) are pelagic, but are benthic at larger sizes (Laroche and Richardson 1980).

Black rockfish have internal fertilization and annual spawning (Stein and Hassler 1989). Parturition occurs from February through April off British Columbia, January through March off Oregon, and January through May off California (Stein and Hassler 1989). Spawning areas are unknown, but spawning may occur in offshore waters because gravid (egg-carrying) females have been caught well offshore (Dunn and Hitz 1969; Hart 1988; Stein and Hassler 1989). Black rockfish can live to be more than 20 years in age. The maximum length attained by the black rockfish is 60 cm (Hart 1988; Stein and Hassler 1989). Off Oregon, black rockfish primarily prey on pelagic nekton (anchovies and smelt) and zooplankton such as salps, mysids, and crab megalops. Off Central California, juveniles eat copepods and zoea, while adults prey on juvenile rockfish, euphausiids, and amphipods during upwelling periods. During periods without upwelling, they primarily consume invertebrates. Black rockfish feed almost exclusively in the water column (Culver 1986). Black rockfish are known to be eaten by lingcod and yelloweye rockfish (Stein and Hassler 1989).

Stock Status and Management History

A black rockfish assessment was completed in 2003 and pertained to the portion of the coastwide stock occurring off the coasts of Oregon and California (Ralston and Dick 2003) or the southern stock unit. Alternative harvest levels in the 2003 assessment were ranged to capture the major uncertainty of historical landings prior to 1978. Black rockfish catches prior to 1945 were assumed to be zero in the assessment. Many gaps in historical landings of black rockfish since 1945 were evident, and these landings were reconstructed using a variety of data sources. The base model assumed cumulative landings of black rockfish from all fisheries was 17,100 mt from 1945 to 1977. The 2003 assessment concluded the southern California-Oregon stock of black rockfish was in healthy condition with a 2002 spawning output estimated to be at 49 percent of its unexploited level.

The southern stock of black rockfish was again assessed in 2007 (Sampson 2008) using a similar approach and structure as the 2003 assessment, but included historical catch series that extended back to 1916 with relatively large catches of black rockfish in California during World War II. The 2007 assessment estimated the southern stock was at 70 percent of its unfished level at the start of 2007. The 2007 assessment was structured into six fisheries: a set of trawl, commercial non-trawl, and recreational fisheries for Oregon and California, respectively. The fisheries for each state were based on fish capture location rather than where they were landed and therefore represented separate geographic areas. The model in the 2007 assessment did not include any underlying spatial structure in the population dynamics. Like the previous southern stock assessment, abundance indices for tuning the assessment were based on recreational CPUE data with two independent indices available for each state. The standard research trawl surveys along the U.S. West Coast do not operate in shallow enough water to catch appreciable numbers of black rockfish and therefore do not provide any fishery independent index of stock biomass for black rockfish. The 2007 assessment had two additional abundance indices that were not available for the previous assessment: a black rockfish pre-recruit index for 2001-2006 and estimates from a tag-recapture study of exploitable black rockfish abundance off Newport, Oregon for 2003-2005. The 2007 assessment for the southern stock of black rockfish used the same sex- and age-specific formulation for natural mortality (M) that was used in the assessment for northern black rockfish, but there is little evidence to confirm that the assumed formulation is correct. The 2003 assessment for southern black rockfish used much smaller values for M that were more consistent with observed values for the maximum age of southern black rockfish.

A full assessment of black rockfish in waters off California was conducted in 2015 (Cope*, et al.* 2015a). It was the first assessment ever of the California black rockfish stock in isolation. Cope et al. (2015a) estimated the California black rockfish stock was at a 33 percent depletion at the start of 2015, which was below the biomass target and in the precautionary zone, but the assessment estimated the stock had been increasing in abundance in the last 20 years. The stock was projected to be above the biomass target by the start of 2017 due to the strength of very strong year classes in 2008 and 2009.

The 2015 California black rockfish assessment modeled four fleets (trawl fishery, non-trawl dead-landed fish commercial fishery, non-trawl live fish commercial fishery, and the recreational fishery) and four surveys (onboard CPFV survey (1988-1999), onboard CPFV survey (2000-2014), research samples, and dockside CPUE survey). All life history parameters were modeled as sex-specific, including natural mortality. Steepness was fixed at the meta-analysis prior.

A full assessment of the black rockfish stock in waters off California was again conducted in 2023 (Dick, et al. 2023), with two independent sub-area models, one northern model from Point Arena

(38° 57.5’ N. lat.) to the California-Oregon border, and one central model from Point Arena to the U.S./Mexico border. Two separate models were needed to approximate spatial and temporal variation in factors affecting stock dynamics, due to regional differences in size, trend and exploitation history. Spawning output in the northern area is roughly three times larger than the central area. All life history parameters were modeled as sex-specific, with a prior distribution for female natural mortality and male as an offset with no prior. The steepness stock recruitment parameter was fixed at the prior mean (0.72) from the meta-analysis approach.

Under Amendment 31 to the FMP, the stock is defined at the state-wide level and thus model results are combined for stock status, etc. The California black rockfish stock was estimated at a 37.7 percent depletion at the start of 2023 (Figure 2-14), which remained below the biomass target and in the precautionary zone. The relative spawning output trajectory was very similar to that estimated in the 2015 assessment and has shown recent increases.

The primary challenge for the black rockfish assessment in all three states is the absence of larger, older female black rockfish in fisheries catches, a phenomenon that has long been a challenge in developing plausible assessments for black rockfish and other species that exhibit this tendency. Past modeling approaches have explored both “hiding” larger, older females (e.g., applying dome-shaped selectivity to fisheries, which often results in what are considered to be implausibly high “cryptic” biomass levels of large, old, unavailable fish) or “killing” off larger, older females (one common formulation being a ramp up in natural mortality rates with age) in order to fit the observed data. Natural mortality is the primary source of uncertainty in the 2023 California black rockfish assessment.

The SSC categorized both sub-area assessment models for black rockfish off California as category 1 (default sigma=0.5). The Council adopted the default harvest control rule for black rockfish off California in 2025 and beyond of ACL = ABC with a P* of 0.45.

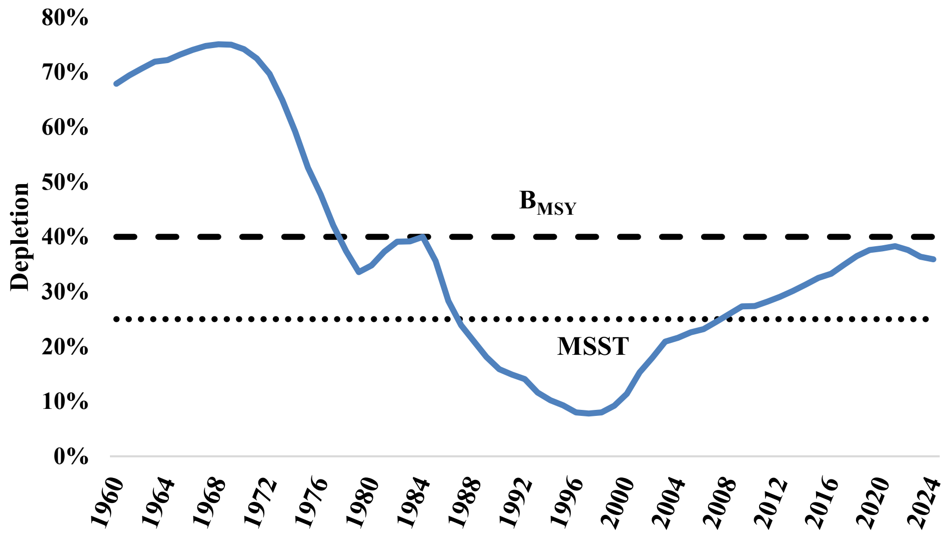

Figure 2-14a. Relative depletion of black rockfish off northern California from 1960 to 2024 based on the 2023 northern area stock assessment (Point Arena (38° 57.5' N. lat.) to the California-Oregon border (based on Dick, et al. 2023).

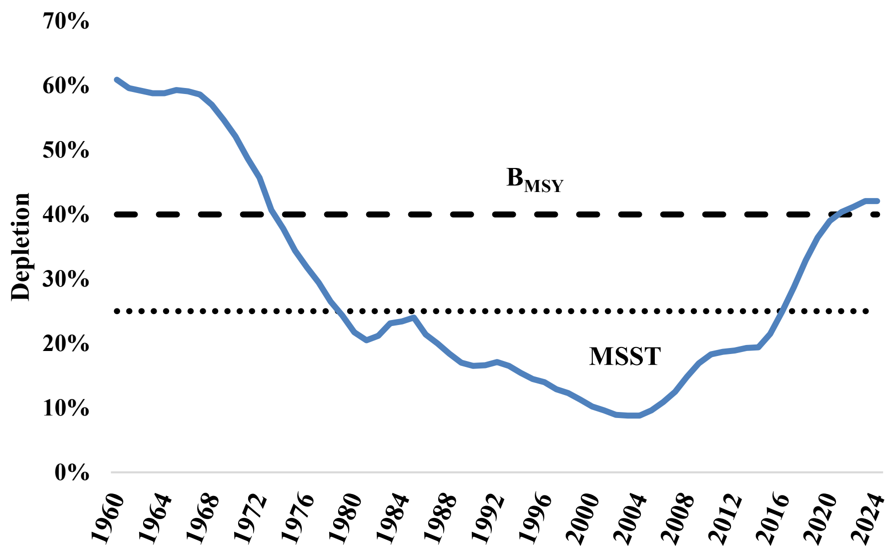

Figure 2-15b. Relative depletion of black rockfish off central California from 1960 to 2024 based on the 2023 central area stock assessment (Point Arena (38° 57.5' N. lat.) to the California-Mexico border (based on Dick, et al. 2023).

Stock Productivity

The 2023 California black rockfish assessment assumed a stock recruit steepness of 0.72 based on the meta-analysis of rockfish steepness. The PSA productivity score of 1.33 indicates a stock of moderate productivity.

From the 2023 California black rockfish assessments, estimates of year-class strength in the northern model are largest, in absolute terms, in 1973-74, 1976-77, and 1995 (Figure 2-15a).

Estimates of year-class strength in the central model are largest, in absolute terms, in 2008, 2010, and 1976 (Figure2-15b).

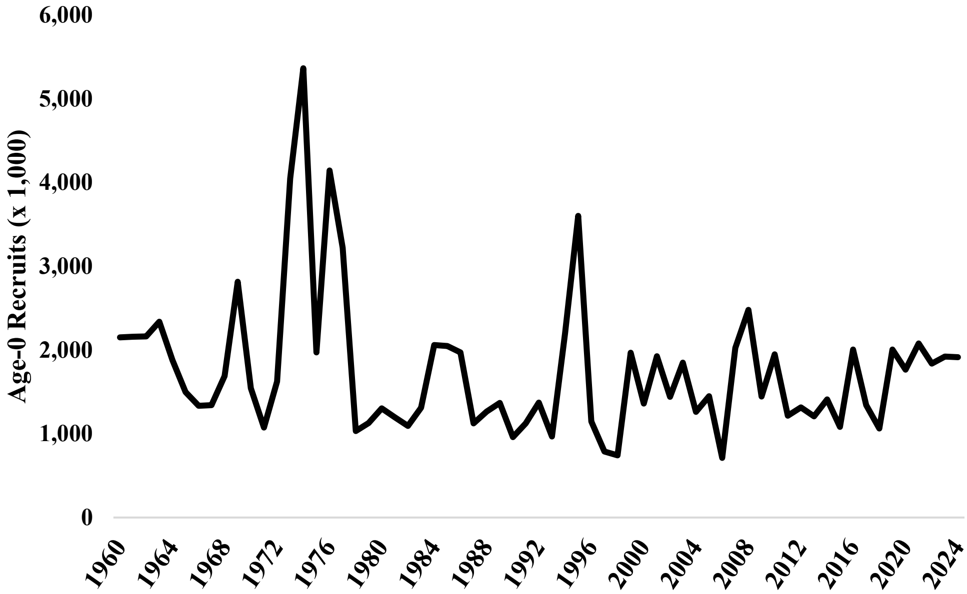

Figure 2-16a. Estimated recruitments of black rockfish off northern California, 1960-2024, based on the 2023 northern area stock assessment (Point Arena (38° 57.5' N. lat.) to the California-Oregon border (based on Dick, et al. 2023).

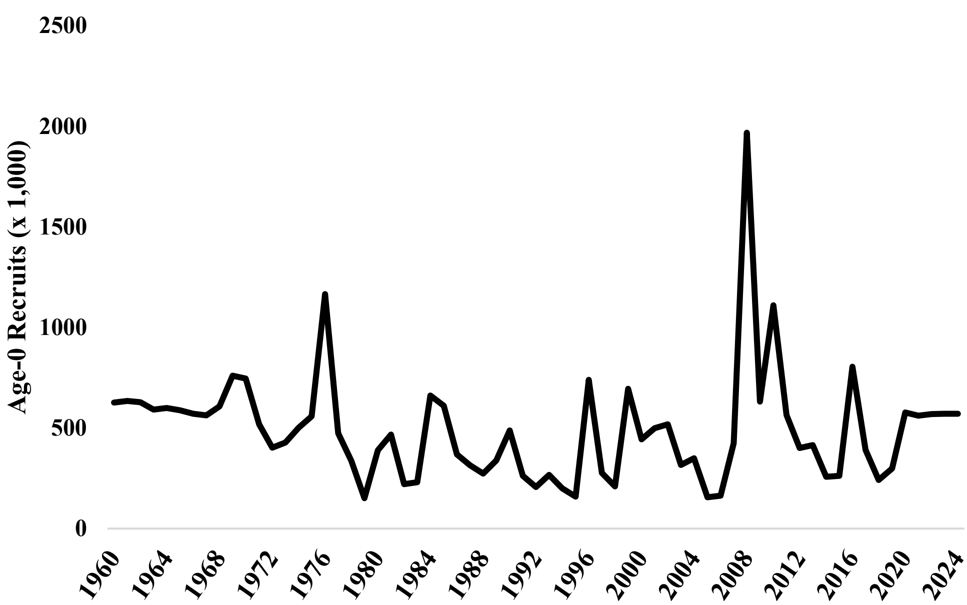

Figure 2-17b. Estimated recruitments of black rockfish off central California, 1960-2024, based on the 2023 central area stock assessment (Point Arena (38° 57.5' N. lat.) to the California-Mexico border (based on Dick, et al. 2023).

Fishing Mortality

The nearshore commercial and recreational fisheries that take black rockfish are managed well in California and ACLs/OYs have not been exceeded. The PSA vulnerability score of 1.94 indicates a stock of medium concern for overfishing.

While black rockfish off California have been well managed with no years when total mortality has exceeded specified harvest limits, exploitation rates have routinely exceeded the newly calculated F_{MSY} rate since 1970 in retrospect (Figure 2-16).

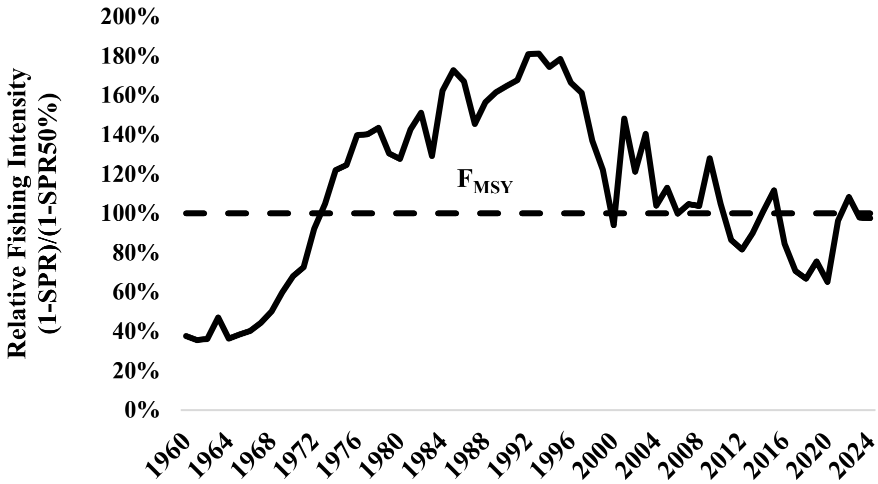

Figure 2-18a. Time series of estimated relative fishing intensity (1-SPR)/(1-SPR 50%) of black rockfish off northern California, 1960-2024, based on the 2023 northern area stock assessment (Point Arena (38° 57.5' N. lat.) to the California-Oregon border (based on Dick, et al. 2023). One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis.

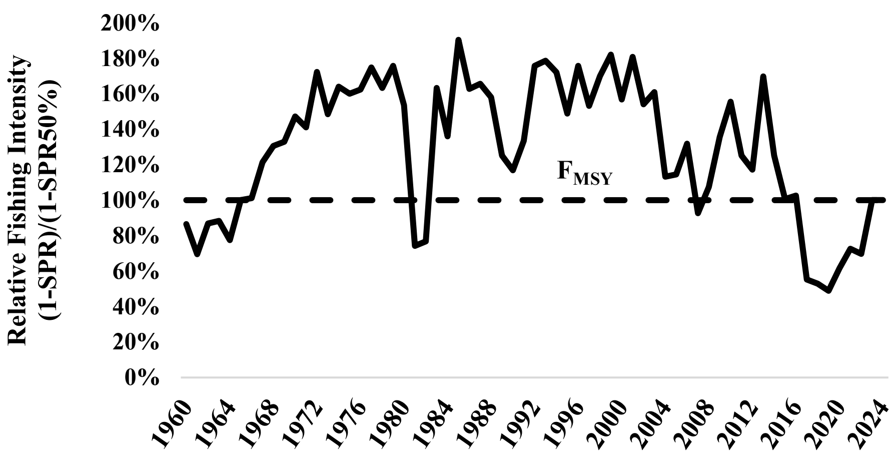

Figure 2-19b. Time series of estimated relative fishing intensity (1-SPR)/(1-SPR 50%) of black rockfish off central California, 1960-2024, based on the 2023 central area stock assessment (Point Arena (38° 57.5' N. lat.) to the California-Mexico border (based on Dick, et al. 2023). One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis.

2.4.4 Black Rockfish off Washington

Distribution and Life History

See the description of black rockfish distribution and life history in section 2.4.3.

Stock Status and Management History

The black rockfish stock found between Cape Falcon, Oregon and the U.S. Canadian border was first assessed in 1994 (Wallace and Tagart 1994). Estimated biomass was 60 percent of the unfished level and female egg production was estimated to be 43 percent of the unfished level. A harvest guideline of 517 mt for this area was specified beginning in 1995 based on assessment results. Catches remained well below the harvest guideline in the years after the assessment.

The 1999 assessment of the black rockfish stock north of Cape Falcon, Oregon determined the stock was at 45 percent of the unfished level (Wallace, *et al.* 1999). The population was regarded as healthy, and stock abundance was estimated to be slightly increasing after a period of low abundance in the late 1980s and early 1990s.

An assessment of the northern stock was done in 2007, which estimated a depletion of 53.4 percent of the unfished level (Wallace, *et al.* 2008). The base model for the 2007 assessment assumed a female natural mortality rate to be age-specific using age at first and full maturity for inflections (10 and 15). A constant natural mortality rate of 0.16 was assumed for males and young females (< 10 years of age), and a rate of 0.2 was assumed for old females (>=15 years of age). Model sensitivity analysis showed that model configurations using higher natural mortality for older females provided better overall fits to the data. In the model, spawning biomass and age 3+ biomass reached the lowest levels in 1995, following poor recruitment and intense fishing in the late 1980s. The population trajectory remained just above minimum stock size threshold, and the model indicated that the stock is currently well above the management target of $B_{40\%}$.

A full assessment of black rockfish in waters off Washington was conducted in 2015 (Cope, *et al.* 2015a). This assessment changed the boundaries of the assessment from Cape Falcon, Oregon to the state's southern border at the Columbia River. The assessment modeled three fleets (trawl fishery, non-trawl dead-landed fish commercial fishery, and the recreational fishery) and two surveys (a dockside CPUE survey and a tagging CPUE survey). All life history parameters were modeled as sex-specific, including M. Steepness was fixed at the meta-analysis prior. The Washington black rockfish stock was estimated at a 43 percent depletion at the start of 2015.

The most recent assessment for Washington black rockfish was conducted in 2023 (Cope, et al. 2023). Currently, the stock is estimated at 45% depletion, which is above the management target relative to unfished (40%) and is estimated to have reached the B_{MSY} target only recently due to several years of above average recruitment (Figure 2-17).

The major changes in 2023 from the previous 2015 assessment included changes in the estimation of some parameters, changes in the removal history, the addition and stratification of various survey data sources. The model was informed by catch data from two commercial fleets and one recreational fleet, six abundance indices, length composition data from commercial, recreational, and surveys, and conditional age-at-length compositions from the commercial and recreational fisheries. Life history parameters were sex-specific (i.e., a two-sex model) with natural mortality fixed at estimates from the previous assessment (but rationalized through life history theory) and most growth and recruitment parameters estimated. The model was sensitive to specifications for natural mortality.

For the 2023 state-specific black rockfish assessment, the commercially caught black rockfish were apportioned to assessment region based on the port of landing, with the exception of trawl caught fish landed into Astoria, OR. Most of these fish were found to have been caught off Washington and most of the trawl landings into Astoria were therefore included with the catch history for the Washington assessment. This approach was refined in the current assessment to allow for state-specific species compositions to be applied to aggregated trawl landings.

The primary challenge for the black rockfish assessment in all three states is the absence of larger, older female black rockfish in fisheries catches, a phenomenon that has long been a challenge in developing plausible assessments for black rockfish and other species that exhibit this tendency. Past modeling approaches have explored both "hiding" larger, older females (e.g., applying dome-shaped selectivity to fisheries, which often results in what are considered to be implausibly high "cryptic" biomass levels of large, old, unavailable fish) or "killing" off larger, older females (one common formulation being a ramp up in natural mortality rates with age) in order to fit the observed data. Complex sex-specific growth and mortality dynamics are captured in the Washington assessment through sex-specific parameterizations. In particular, observations of older females are lacking in the available data and is addressed by allowing for higher female natural mortality relative to males (a fixed value in the 2023 assessment).

The SSC categorized black rockfish off Washington as a category 1 stock. The Council adopted the default harvest control rule for black rockfish off Washington in 2025 and beyond of ACL equal to ABC with a P* of 0.45.

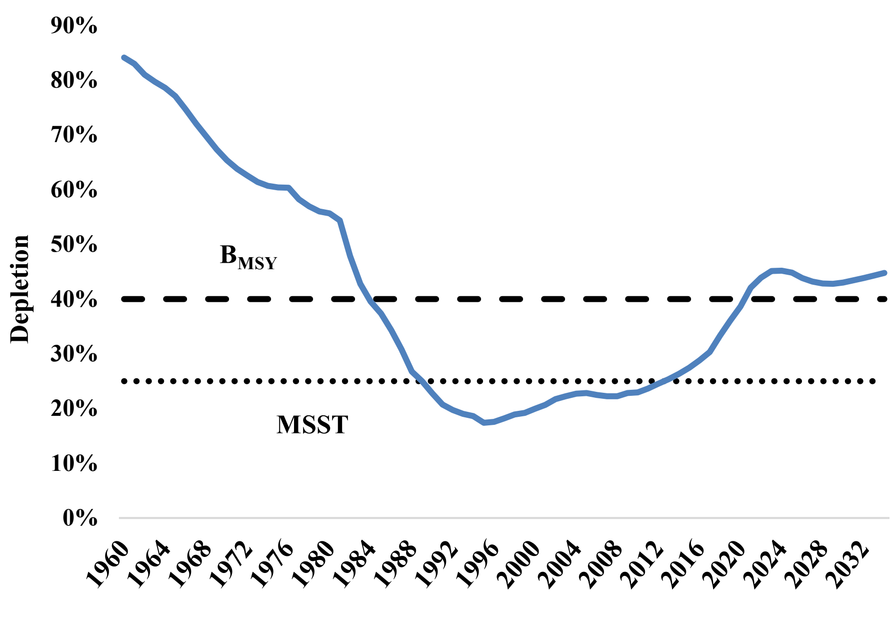

Figure 2-20. Relative depletion of black rockfish off Washington from 1960 to 2034 based on the 2023 stock assessment (Cope et al. 2023).

Stock Productivity

The 2023 Washington black rockfish assessment assumed a steepness of 0.72 based on the meta-analysis of rockfish steepness. The PSA productivity score of 1.33 indicates a stock of moderate productivity.

The large 2008 and 2011 year classes, as well as several above average year classes in the mid-2000s to early 2010s, contributed to the recent increase in Black Rockfish biomass (Figure 2-18). Recruitment is informed mostly by the composition data in the 2023 assessment. While the stock has been reduced to levels that theoretically would provide some information on how recruitment compensation changes across spawning biomass levels (i.e., inform the steepness parameter), the assessment model could not adequately estimate a reasonable steepness parameter given that most of the data was collected after the major decline in the spawning output and/or did not show much contrast. Thus, recruitment is based on a fixed assumption about steepness (h = 0.72) and recruitment variability (σR = 0.6).

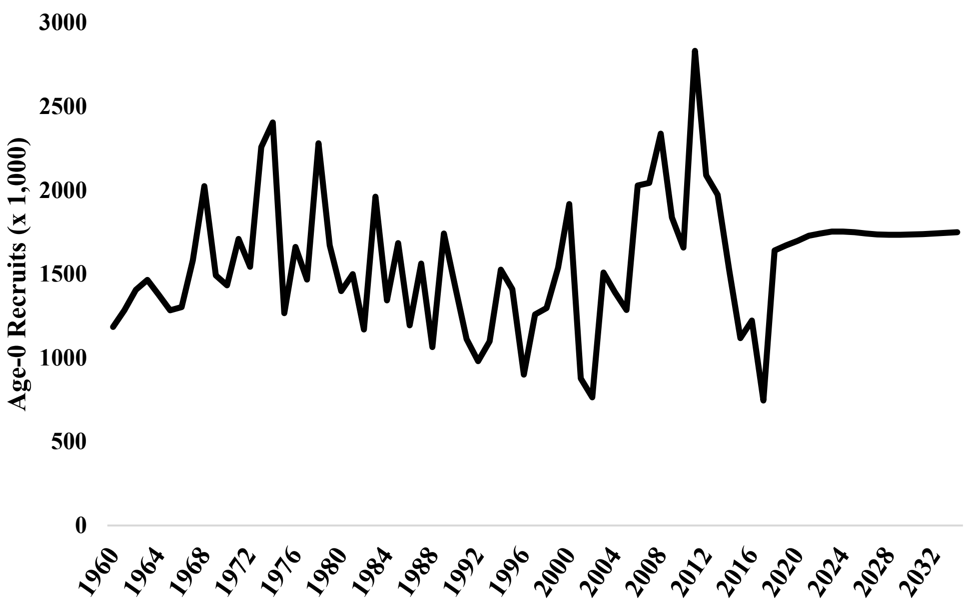

Figure 2-21. Estimated recruitments of black rockfish off Washington (1960-2034) based on the 2023 stock assessment (Cope, et al. 2023).

Fishing Mortality

Overall, spawning output declined with the onset of commercial fishing, further decreasing with the increasing recreational removals in the 1980s and continued to decline until the commercial fisheries were shut down in the late 1990s. The nearshore recreational fishery that catches black rockfish is actively managed in Washington and ACLs/OYs have not been exceeded. The PSA vulnerability score of 1.94 indicates a stock of medium concern for overfishing.

Fishing intensity has been above the estimated SPR rate fishing intensity target of 0.50 (1 - $SPR_{50\%}$) since the 1980s and only recently dropped below the target (Figure 2-19). The Black Rockfish population in Washington at the start of 2023 is estimated to be above the target biomass, and fishing intensity during 2022 is estimated to be below the fishing intensity target.

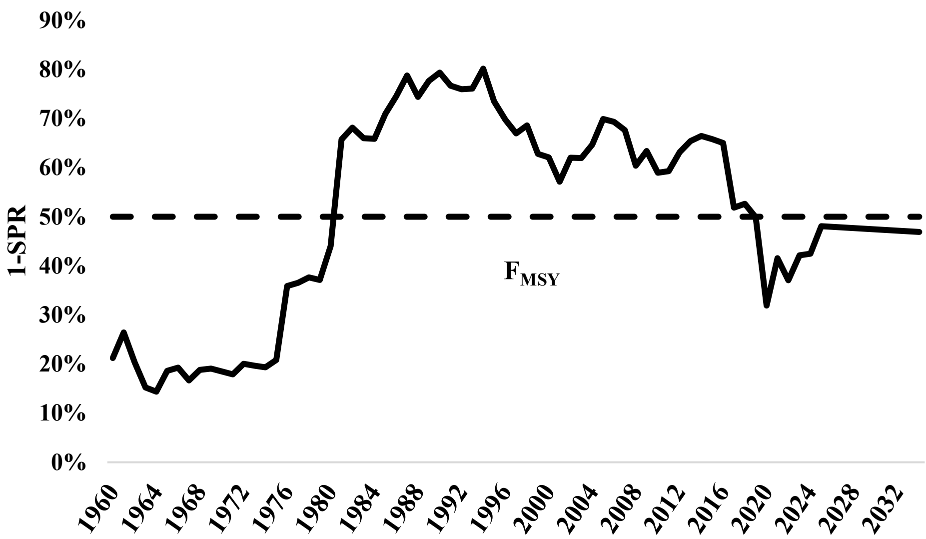

Figure 2-22. Time series of estimated SPR harvest rates of black rockfish off Washington (1960-2034) based on the 2023 stock assessment (Cope et al. 2023). One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis.

2.4.5 Bocaccio

Distribution and Life History

Bocaccio (*Sebastes paucispinis*) is a rockfish species that ranges from Stepovak Bay on the Alaskan Peninsula (as well as Kodiak Island, Alaska) to Punta Blanca, Baja California, Mexico (Hart 1988; Miller and Lea 1972). Love, et al. (2002) and Thomas and MacCall (2001) describe bocaccio distribution and life history. Bocaccio are historically most abundant in waters off central and southern California. The southern bocaccio stock is most prevalent in the 54-82 fm depth zone (Casillas*, et al.* 1998).

Bocaccio are found in a wide variety of habitats, often on or near bottom features, but sometimes over muddy bottoms. They are found both nearshore and offshore (Sakuma and Ralston 1995). Larvae and small juveniles are pelagic (Garrison and Miller 1982) and are commonly found in the upper 100 m of the water column, often far from shore (MBC 1987). Large juveniles and adults are semi-demersal and are most often found in shallow coastal waters over rocky bottoms associated with algae (Sakuma and Ralston 1995). Adults are commonly found in eelgrass beds, or congregated around floating kelp beds love (Love*, et al.* 1990; Sakuma and Ralston 1995). Young and adult bocaccio also occur around artificial structures, such as piers and oil platforms (MBC 1987). Although juveniles and adults are usually found around vertical relief, adult aggregations also occur over firm sand-mud bottoms (MBC 1987). Bocaccio move into shallow waters during their first year of life (Hart 1988), then move into deeper water with increased size and age (Garrison and Miller 1982).

Bocaccio are ovoviviparous (live young are produced from eggs that hatch within the female's body) (Garrison and Miller 1982; Hart 1988). Love et al. (1990) reported the spawning season to last nearly an entire year (>10 months). Parturition occurs during January to April off Washington, November to March off Northern and Central California, and October to March off Southern California (MBC 1987). Fecundity ranges from 20,000 to 2,300,000 eggs. In California, two or more broods may be born per year (Love, *et al.* 1990). The spawning season is not well-known in northern waters. Males mature at three to seven years, with about half maturing in four to five years. Females mature at three to eight years, with about half maturing in four to six years (MBC 1987).

Maximum age of bocaccio was radiometrically determined to be at least 40 years, and perhaps more than 50 years. Bocaccio are difficult to age, and stock assessments used length measurement data and growth curves to estimate the age composition of the stock (Ralston and Ianelli 1998). New techniques were developed for ageing bocaccio, and age data were therefore used for the first time in the 2015 assessment (He, *et al.* 2015).

Larval bocaccio eat diatoms, dinoflagellates, tintinnids, and cladocerans (Sumida and Moser 1984). Copepods and euphausiids of all life stages (adults, nauplii and egg masses) are common prey for juveniles (Sumida and Moser 1984). Both Phillips (1964) and Love et al. (2002) described bocaccio rockfish as almost exclusively piscivorous, and include other rockfish, Pacific whiting, sablefish, anchovy, mesopelagic fishes and squid as the key prey for large juvenile and adult bocaccio. Bocaccio are eaten by sharks, salmon, other rockfishes, lingcod, albacore, sea lions, porpoises, and whales (MBC 1987). Adult bocaccio are often caught with chilipepper rockfish and have been observed schooling with speckled, vermilion, widow, and yellowtail rockfish (Love, *et al.* 2002). As pelagic juveniles, they may compete with chilipepper, widow, yellowtail, shortbelly rockfish, and other pelagic juvenile rockfishes for both food and habitat (Reilly, *et al.* 1992).

Stock Productivity

He and Field (2018; 2015) fixed steepness at its prior mean of 0.718. This prior was estimated using a likelihood profile approximation to a maximum marginal likelihood mixed-effect model for steepness from ten category 1 rockfish species off the U.S. West Coast (Pacific ocean perch, bocaccio, canary rockfish, chilipepper, black, darkblotched rockfish, gopher, splitnose, widow, and yellowtail rockfish). This likelihood profile model is intended to synthesize observation-level data from assessed species, while avoiding the use of model output and thus improving upon previous meta-analyses (Dorn 2002a; Forrest, *et al.* 2010). This methodology has been simulation tested and has been recommended by the SSC for use in stock assessments.

Recruitment for bocaccio is highly variable, with a small number of year classes tending to dominate the catch in any given fishery or region. Recruitment appears to have been at very low levels throughout most of the 1990s, but several recent year classes (1999, 2010, and 2013) have been relatively strong, given the decline in spawner abundance, and have resulted in an increase in abundance and spawning output. The 2013 recruitment is among the highest observed for bocaccio in the past two decades, which is expected to lead to high biomass levels over the next few years (Figure 2-20).

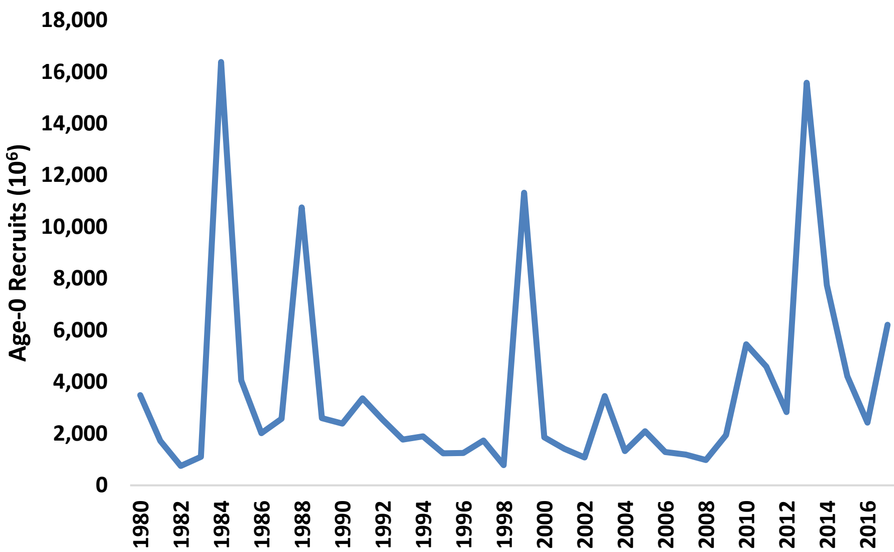

Figure 2-23. Estimated bocaccio recruitments, 1980-2017 (from He and Field 2018).

Stock Status and Management History

Bocaccio are managed as two separate West Coast populations. The southern stock exists south of Cape Mendocino and the northern stock north of Cape Mendocino (the northern stock density is limited south of 48° N. lat. with increasing abundance off Cape Flattery, Washington and points north). It is unclear whether this stock separation implies stock structure. The distribution of the two populations and evidence of lack of genetic intermixing suggests stock structure, although MacCall (2002) reported some evidence for limited genetic mixing of the two populations. Nonetheless, assessment scientists and managers have treated the two populations as independent stocks north and south of Cape Mendocino.

Bocaccio have long been an important component of California rockfish fisheries. Catches increased to high levels in the 1970s and early 1980s as relatively strong year-classes recruited to the stock. The Council began to recommend increasingly restrictive regulations after an assessment of the southern stock in 1990 (Bence and Hightower 1990) indicated that fishing rates were too high. The southern stock suffered poor recruitment during the warm water conditions that prevailed off Southern California beginning in the late 1980s. The 1996 assessment (Ralston, *et al.* 1996) indicated the stock was in severe decline. NMFS formally declared the stock overfished in March 1999 after the groundfish FMP was amended to incorporate the tenets of the Sustainable Fisheries Act. MacCall et al. (1999) confirmed the overfished status of bocaccio and estimated spawning output of the southern stock to be 2.1 percent of its unfished biomass.

In the 2002 assessment (MacCall 2002) relative abundance increased slightly from the previous assessment (4.8 percent of unfished biomass), potential productivity (as evidenced from the steepness of the spawner/recruit relationship, which reflects the level of compensatory production at low stock sizes) appeared lower than previously thought, making for a more pessimistic outlook. Furthermore, the 2002 assessment revealed that although the 1999 year class was the strongest in several years, it was weak relative to the range of possibilities considered in the 1999 assessment. The 2002 rebuilding analysis (MacCall and He 2002) predicted the stock would not rebuild within maximum time legally possible (T_{MAX}) even with no fishing-related mortality. Total mortality in 2003 fisheries was restricted to less than 20 mt as a means of conserving the stock while minimizing adverse socioeconomic impacts to communities.

The 2003 bocaccio assessment (MacCall 2003b) estimated a higher stock biomass (7.4 percent depletion) relative to the 2002 assessment. The instantaneous rate of natural mortality was changed from 0.2 to 0.15. Additional CalCOFI data indicated an increasing abundance trend due to recruitment of the 1999 year class. This was corroborated by a dramatic increase in recreational CPUE, which was at a record high level in central California north of Pt. Conception. The 2003 rebuilding analysis suggested the stock could rebuild to B_{MSY} within 25 years while sustaining an OY of approximately 300 mt in 2004 (MacCall 2003a).

The 2003 assessment was updated in 2005 and 2007 (MacCall 2006b; MacCall 2008b) using the original 2003 base model (i.e., STATc) in SS1. These assessments were used to establish annual specifications and management measures consistent with a strategy of a higher OY than the impacts anticipated under the suite of management measures adopted. This strategy was designed to buffer the effects of a large recruitment event like that observed for the 1999 year class. Such effects include disruption to fisheries as experienced in previous years when fisheries closed early to avoid young bocaccio. This buffer strategy, which addressed the large, episodic recruitment pattern inherent in the stock's dynamics, became a tenet of the bocaccio rebuilding plan.

A bocaccio rebuilding plan was adopted by the Council in 2004 under Amendment 16-3 (PFMC 2004). The rebuilding plan established a target rebuilding year of 2023 and a harvest control rule of F = 0.0498. (It was later clarified in the 2005 rebuilding analysis (MacCall 2006a) that the target rebuilding year had been incorrectly stated in the rebuilding plan to be 2023 since the 2003 rebuilding analysis indicated that a 50 percent probability rebuilding would require 23 years, and that this assumed a beginning date of 2004 (the first simulated year). Therefore, the Council amended the rebuilding plan's target year to 2026.

A new rebuilding analysis was conducted in 2007 (MacCall 2008a) based on the results of the 2007 stock assessment (MacCall 2008b). The 2007 bocaccio rebuilding analysis showed a similar rebuilding trajectory to that adopted in Amendment 16-4, and the rebuilding plan was maintained for the 2009-2010 management cycle.

A new bocaccio assessment (Field*, et al.* 2009) and rebuilding analysis (Field and He 2009) were prepared in 2009. Field et al. (2009) extended the assessment north of Cape Mendocino to Cape Blanco, Oregon; the U.S. West Coast stock north of this point has not been assessed. Indications of strong 2009 and 2010 year classes were projected to result in increased abundance. Depletion in 2011 was estimated at 26 percent (18.7 -33.1 percent), with the stock projected to be rebuilt by 2019. Based on these analyses, the Council changed the target year for rebuilding bocaccio from 2026 to 2022; the amended rebuilding plan was implemented in 2011.

A bocaccio stock assessment update (Field 2011b) and rebuilding analysis (Field 2011a) were prepared in 2011. The 2011 bocaccio assessment was originally scheduled to be an update of the 2009 full assessment; however, the STAT had some limited changes in the 2009 model structure since a strict update estimated that the 2010 year class was extraordinarily and unrealistically strong, based on length frequency data collected in the 2010 NMFS trawl survey. The modified update was ultimately reviewed, endorsed by the SSC, and adopted for use in management decision-making. The 2011 bocaccio rebuilding analysis indicated rebuilding progress was well ahead of schedule with a predicted median year to rebuild of 2021 or one year earlier than the target rebuilding year (Field 2011a). The Council elected to maintain the revised rebuilding plan implemented in 2011.

An update of the 2011 bocaccio assessment model was prepared in 2013, which confirmed the 2009 and 2010 year classes were indeed strong (Field 2013). The assessment estimated a depletion of 31.4 percent at the start of 2013 (Figure 2-21) and predicted the stock would rebuild by 2015. The SSC recommended maintaining the current rebuilding plan for the 2015-2016 management cycle and a full assessment be done in 2015 to confirm this prediction. The SSC further recommended against preparing a rebuilding analysis in 2013.

A full assessment of bocaccio in 2015 indicated the stock was at 36.8 percent of initial, unfished spawning biomass at the start of 2015 or just under the biomass target of 40 percent (He*, et al.* 2015). Data inputs and model structure generally followed those of the 2009 assessment, with the exceptions that age data for bocaccio were included for the first time, natural mortality was estimated rather than fixed, and the steepness of the stock-recruitment curve was set to 0.773 rather than estimated. Strong recruitment was estimated for 2010 and 2011, although it was not estimated to be as strong as it was in previous assessments. There were early indications of strong recruitment for 2013. Results were sensitive to the choice of data-weighting. The 2015 assessment was conducted for the portion of the West Coast population south of Cape Blanco at 43° N. lat. Since the rebuilding plan is for the portion of the stock south of 40°10' N. lat., the biomass estimates in the assessment were reduced by 7.4 percent based on historical catches by area.

A 2017 update to the 2015 assessment was conducted (He and Field 2018), which estimated a depletion in 2017 of 48.6 percent, which is above the B_{MSY} proxy of $B_{40\%}$, in large part due to recent strong recruitment events (1999, 2010, and 2013 year classes). Minor changes to the 2015 assessment included updated catches for the commercial and recreational fisheries, updated indices of abundance, new fishery and survey length composition data, and the recently updated priors on steepness and natural mortality. In addition, the method used to estimate the juvenile index was changed to correct a methodological error but there was little impact on the results. The SSC endorsed the new assessment as a category 1 assessment and the stock was declared rebuilt in June 2017.

The default harvest control rule for stocks that are declared rebuilt is ACL = ABC under the previously specified P* value used to decide the ABC. In this case, the P* is 0.45 and the 2019 and 2020 ABCs and ACLs for bocaccio south of 40°10' N. lat. are 2,097 mt and 2,011 mt, respectively.

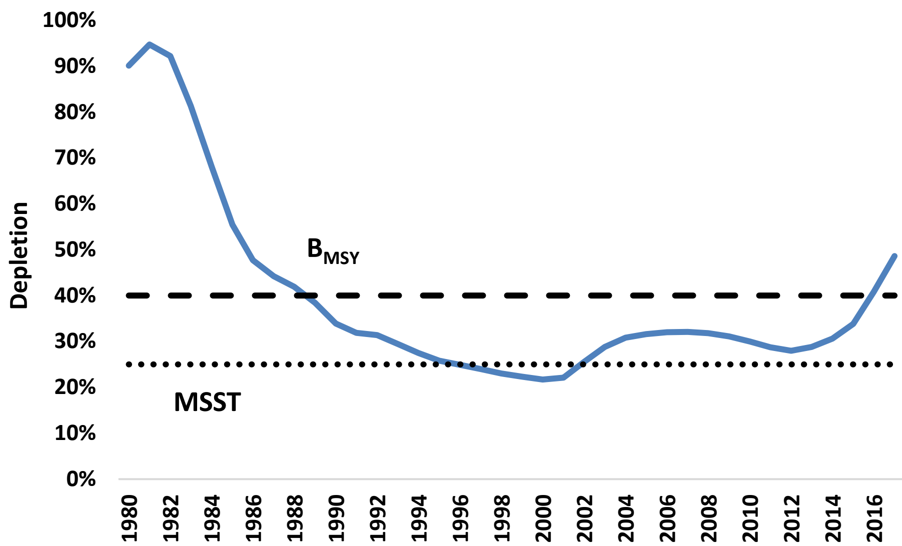

Figure 2-24. Relative depletion of bocaccio south of 40°10' N. lat. from 1980 to 2017 based on the 2017 stock assessment update.

Fishing Mortality

The presence of banner 2010 and 2013 year classes in the bocaccio stock is not entirely unexpected. Bocaccio stock production is characterized by high episodic recruitment and relatively rapid juvenile growth rates Field, et al. 2009. Juvenile bocaccio also recruit to shallow waters and are consequently caught in nearshore recreational fisheries as evidenced by dramatic spikes in both catch rates and the percentage of the total southern California rockfish catch that is bocaccio following strong recruitment events. Unlike most rockfish species where recruitment to fisheries usually takes several years due to low growth rates, juvenile bocaccio can recruit to nearshore fisheries in California within a year or two of parturition.

Given the bocaccio stock is now considered healthy with a spawning output above the B_{MSY} target, the harvest control rule reverts from the SPR harvest rate of 77.7 percent specified in the rebuilding plan to ACL = ABC under the default P* of 0.45. This rule will be implemented starting in 2019.

2.4.6 Cabezon off California

Distribution and Life History

Cabezon (*Scorpaenichthys marmoratus*) are distributed along the entire West Coast of the continental United States. They range from central Baja California north to Sitka, Alaska (Love 1996; Miller and Lea 1972). Cabezon are primarily a nearshore species found intertidally and among jetty rocks, out to depths of greater than 100 m (Love 1996; Miller and Lea 1972).

Cabezon are known to spawn in recesses of natural and manmade objects, and males are reported to show nest-guarding behavior (Garrison and Miller 1982). Spawning is protracted, and there appears to be a seasonal progression of spawning that begins off California in winter and proceeds northward to Washington by spring. Spawning off California peaks in January and February (O'Connell 1953) while spawning in Puget Sound (Washington State) occurs for up to 10 months (November-August), peaking in March–April (Lauth 1987). Laid eggs are sticky and adhere to the surface where deposited. After hatching, the young-of-the-year spend 3–4 months as pelagic larvae and juveniles. Settlement takes place after the young fish have attained 3–5 cm in length (Lauth 1987; O'Connell 1953). It is apparent that females lay multiple batches in different nests, but whether these eggs are temporally distinct enough to qualify for separate spawning events is not understood (Lauth 1987; O'Connell 1953).

Stock Status and Management History

Cabezon in California waters was first assessed in 2003; depletion was estimated at 34.7 percent at the start of 2003 (Cope*, et al.* 2004). The assessment delineated two stocks (north and south) at the Oregon-California border, a distinction based on differences in the catch history, CPUE trends, and biological parameters (mainly growth) between the two areas. Due to the lack of data for the northern population, the assessment focused on only the southern population. As with most nearshore groundfish stocks, this assessment lacked a fishery-independent index of abundance, and consequently relied on recreational CPUE indices and information about larval abundance.

The 2005 assessment modeled two California substocks north and south of Point Conception (Cope and Punt 2006). Historically, the recreational fishery had been the primary source of removals of cabezon in California; however, commercial catches had become a major source of removals in the ten years preceding the assessment because of the developing live-fish fishery. Removals were reconstructed back to 1916, when the commercial fishery began. The estimated stock depletions of the northern and southern substocks of cabezon at the start of 2005 were 40.1 percent and 28.3 percent, respectively.

The 2009 full assessment estimated a stock depletion of 48.3 percent of unfished biomass at the start of 2009 (Cope and Key 2009). The 2009 assessment modeled two California substocks and evaluated the population as a coastwide California stock. The SSC recommended combining the results of the area models for the two California substocks of cabezon for use in deciding statewide harvest specifications.

New full assessments of cabezon stocks in California and Oregon were conducted in 2019 (Cope*, et al.* 2019). The 2019 assessment again modeled two California stocks north and south of Pt. Conception at 34°27’ N. lat. The southern California substock (SCS) was estimated to be at a 49 percent depletion (Figure 2-22) and the northern California substock (NCS) was estimated to be at a 65 percent depletion (Figure 2-23) at the start of 2019. Model structure and data were modestly changed from the 2009 assessment in the California models. Changes include the addition of the California Collaborative Fisheries Research Program (CCFRP) survey index and use of informative priors for natural mortality (M) and the growth coefficient (k) in the NCS model. Due to a lack of age data, the SCS model fixes growth at the NCS model estimates, constraining the model’s ability to estimate uncertainty and natural mortality. Major uncertainties include M and growth for the California models, which are informed by little (NCS) or no (SCS) age data. The SSC recommended both assessments be designated category 1 and model results should again be summed to determine harvest specifications for cabezon in California waters.

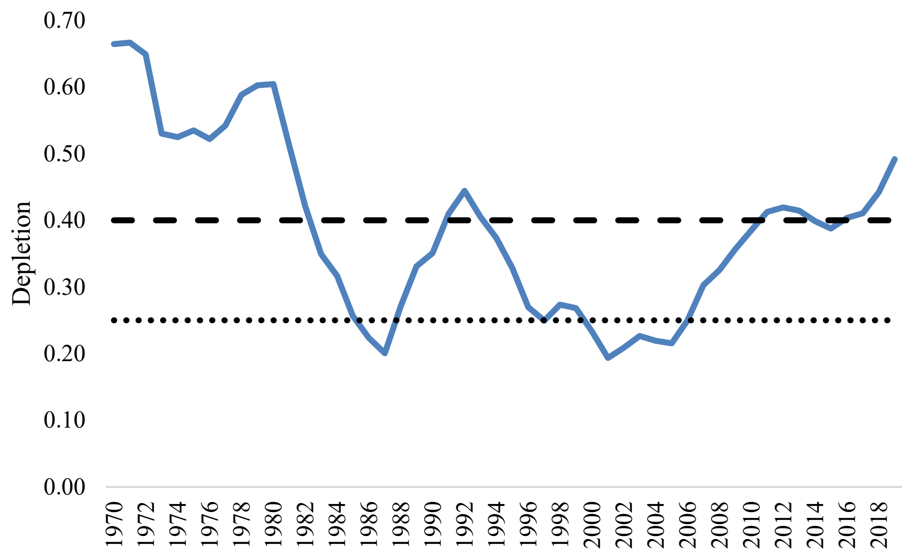

Figure 2-25. Relative depletion of cabezon south of Pt. Conception from 1970 to 2019 based on the 2019 stock assessment update.

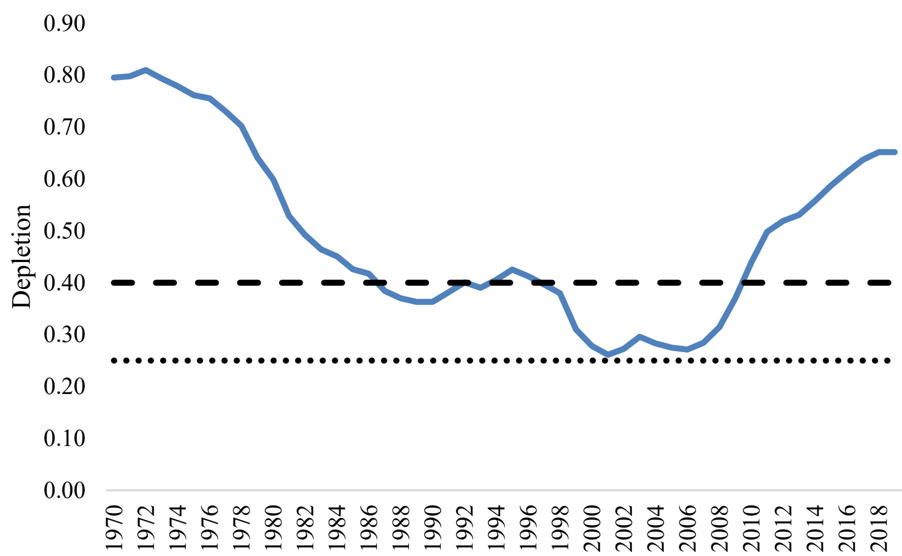

Figure 2-26. Relative depletion of cabezon north of Pt. Conception from 1970 to 2019 based on the 2019 stock assessment.

Stock Productivity

The 2019 cabezon assessment assumed a steepness of 0.7 for all models. The PSA productivity score of 1.72 indicates a stock of relatively high productivity.

Recruitment deviations were estimated from 1970-2016 for both of the assessed substocks. Recruitment patterns are distinctly different for the substocks occurring north and south of Pt. Conception at 34°27' N. lat. (Figure 2-24 and Figure 2-25). Large recruitment events in the 1970s and 1990s in the north and the south have increased spawning biomass to healthy levels. Interannual variation in recruitment is greater in the north. Large recruitments in the southern substock were estimated immediately after major El Niño events (e.g., 1984 and 1994 recruitments).

Since strong recruitment events in the late 1990s and early 2000s for the southern California substock, recent recruitment has been mostly lower or around average (Figure 2-24). This recruitment is informed mostly by length composition data, but removal history also influences the estimates. The 2009 stock assessment also suggested similar recruitment dynamics. Despite the drop in relative stock status to levels around the limit reference point in the early 1980s and the large spike in recruitment during that same time, there is not enough information in the assessment to estimate recruitment compensation (steepness), thus all recruitment is based on a fixed assumption of steepness (0.7) and recruitment variability (0.5).

Recruitment patterns for the northern California substock are much different from that estimated in southern California. Recent recruitment is a mix of positive and negative recruitments, with a very large recruitment detected in 2016, the last year a recruitment deviation was estimated (Figure 2-25). Recruitment estimation uncertainty is high, and recruitment is informed mostly by length composition data, with some contribution from the survey index and removal history. Recruitments are much more muted compared to the 2009 stock assessment, though with similar peaks. These lower in magnitude recruitments lead to a steeper drop in the population biomass at the peak of the live-fish fishery before the more recent recruitments allow for a rapid population increase. Despite these fluctuations in biomass, there is not enough information in the assessment to estimate recruitment compensation (steepness), thus all recruitment is based on a fixed assumption of steepness (0.7) and recruitment variability (0.5).

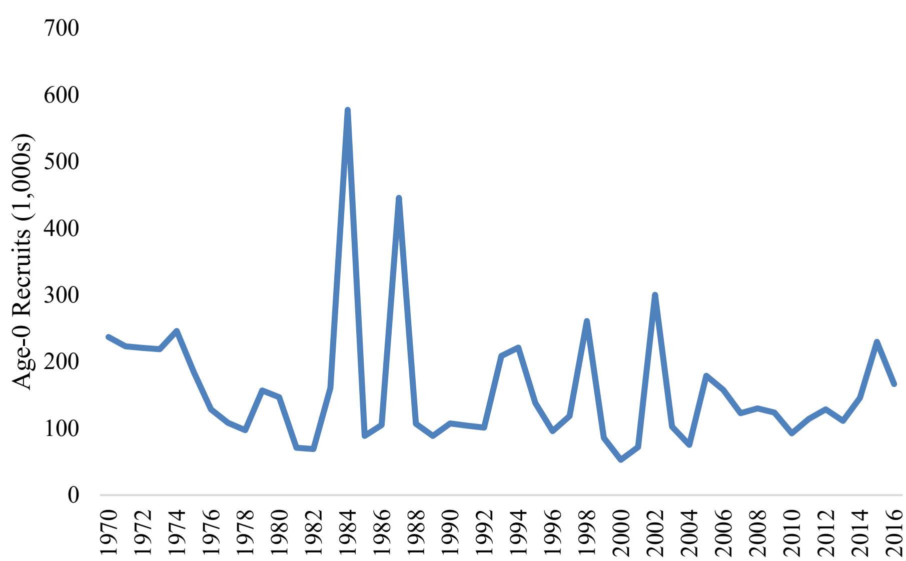

Figure 2-27. Estimated recruitments of cabezon in California south of Pt. Conception, 1970-2016.

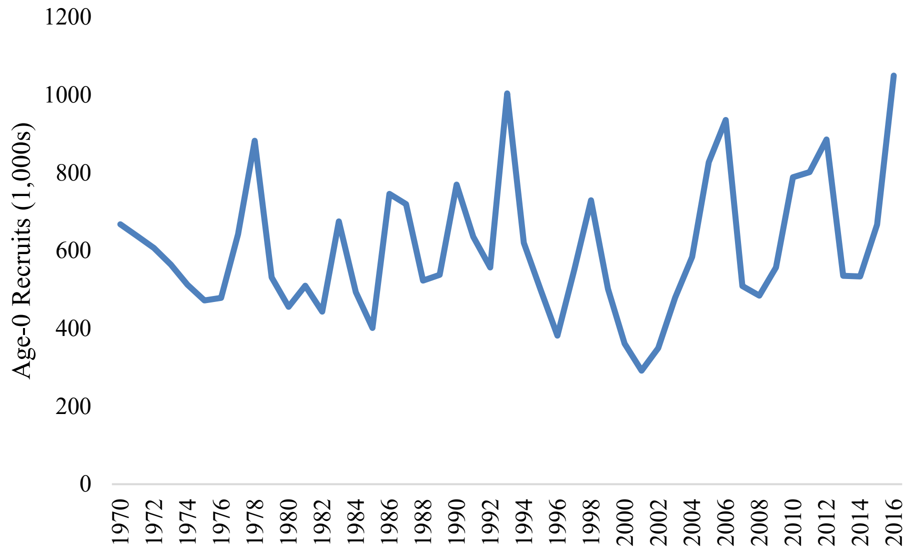

Figure 2-28. Estimated recruitments of cabezon in California north of Pt. Conception, 1970-2016.

Fishing Mortality

SCS fishing intensity showed a steady increase from the 1960s to peak levels in the 1980s through the mid-1990s (Figure 2-26). From that time fishing intensity steadily declined to the low levels seen in the early 1960s. The maximum relative fishing rate ((1-SPR)/(1-SPR45 percent)) was 1.46 in 1986, well above the target level. Current relative fishing rates are much lower and generally decreasing, fluctuating around 0.50.

NCS fishing intensity showed a steady increase from the 1950s to a distinct peak in 1998, then steadily declined to the low levels seen in the early 1970s (Figure 2-27). The maximum relative fishing rate ((1-SPR)/ (1-SPR45 percent)) was 1.39 in 1998, well above the target level. The current relative fishing rates are much lower, fluctuating around 0.60.

The PSA vulnerability score of 1.68 indicates a low risk of overfishing.

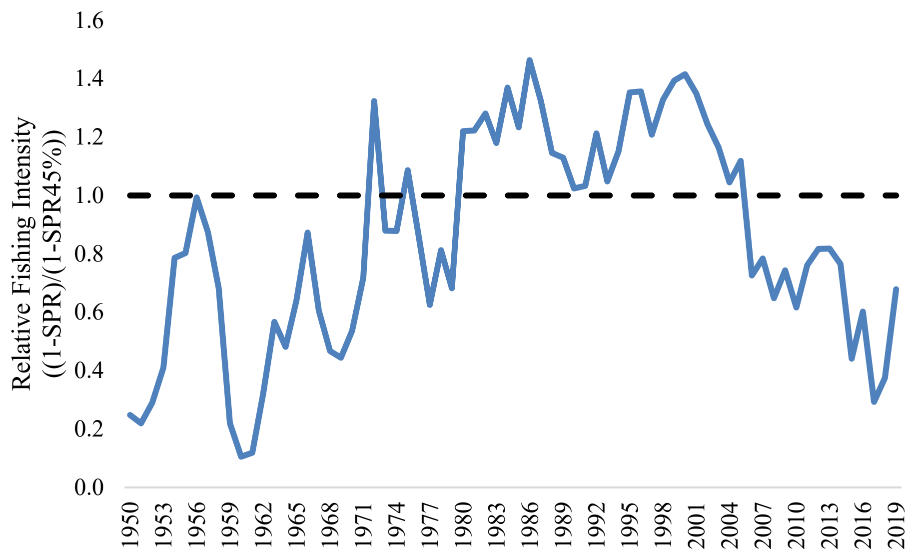

Figure 2-29. Relative fishing intensity of cabezon in California south of Pt. Conception, 1950-2018.

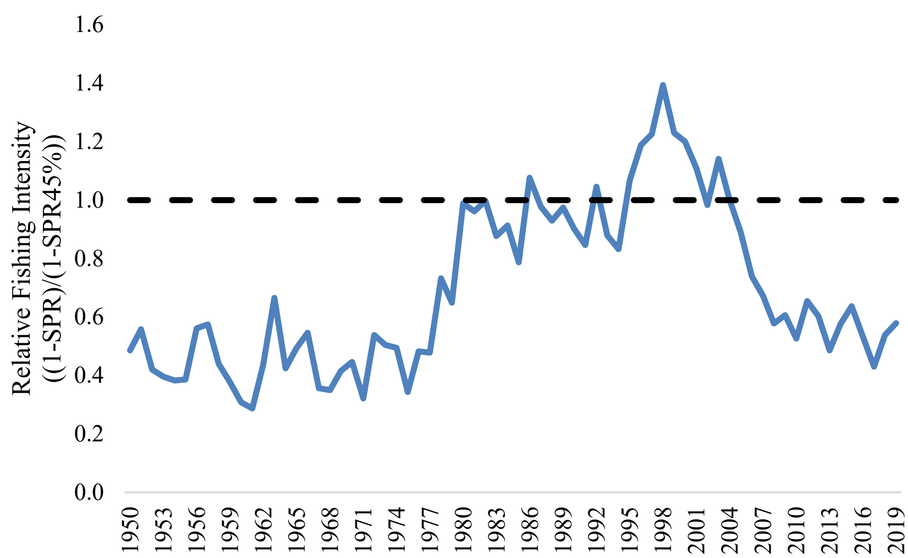

Figure 2-30. Relative fishing intensity of cabezon in California north of Pt. Conception, 1950-2018.

2.4.7 California Scorpionfish South of 34°27' N. Lat.

Distribution and Life History

California scorpionfish (*Scorpaena guttata*), also known locally as sculpin, is a generally benthic species found from central California to the Gulf of California in depths between the inter-tidal and about 170 m (Eschmeyer*, et al.* 1983; Love*, et al.* 1987). California scorpionfish generally inhabits rocky reefs, but in certain areas and seasons they aggregate over sandy or muddy substrate (Frey 1971; Love*, et al.* 1987). Catch rate analysis and tagging studies show that most, but not all, California scorpionfish migrate to deeper water to spawn during May-September (Love*, et al.* 1987). Tagging data suggest that they return to the same spawning site (Love*, et al.* 1987), but information is not available on non-spawning season site fidelity. California scorpionfish are quite mobile and may not be permanently tied to a particular reef (Love*, et al.* 1987).

California scorpionfish spawn from May through August, peaking in July (Love*, et al.* 1987). The species is oviparous, producing floating, gelatinous egg masses in which the eggs are embedded in a single layer (Orton 1955). California scorpionfish utilize the "explosive breeding assemblage" reproductive mode in which fish migrate to, and aggregate at traditional spawning sites for brief periods (Love*, et al.* 1987). These spawning aggregations have been targeted by fishermen. Few California scorpionfish are mature at one year of age, but over 50 percent are mature by age two and most are mature by age three (Love*, et al.* 1987).

The species feeds on a wide variety of foods, including crabs, fishes, octopi, isopods and shrimp, but juvenile Cancer crabs are the most important prey (Limbaugh 1955; Love*, et al.* 1987).

Stock Status and Management History

California scorpionfish were assessed in 2005 (Maunder*, et al.* 2006) in the southern California Bight south of Point Conception at 34°27' N. lat. to the U.S.-Mexico border. The stock assessment indicated the California scorpionfish stock was healthy with an estimated spawning stock biomass of 79.8 percent of its initial, unfished biomass in 2005.

In most years, 99 percent or more of the landings occur in the southern California ports. The California nearshore FMP includes California scorpionfish. The stock is managed by the state under provisions for improved fishery monitoring and research data collection.

A catch-only update of the 2005 assessment was prepared in 2015 to inform harvest specifications in 2017 and beyond. The California scorpionfish OFLs adopted for 2017 and 2018 were from projections in the catch-only update assuming the Expected Catch scenario for future removals. The SSC downgraded the California scorpionfish stock to a category 2 from a category 1 stock based on the age of the assessment.

A new full assessment of California scorpionfish was conducted in 2017 and indicated the stock was healthy with a depletion of 54.3 percent at the start of 2017 (Monk*, et al.* 2018) (Figure 2-28). The 2017 assessment updated catches back to 1916, used a more disaggregated fleet structure, included additional indices of abundance, and added conditional age-at-length data. Indices of abundance as well as composition data were derived from 1) Publicly Owned Treatment Works (POTW) trawl surveys, 2) the NWFSC trawl survey, 3) the Southern California Bight regional monitoring program trawl survey, and 4) the onboard observer survey for retained catch.

Additional composition data was derived from a nuclear power generating station impingement survey. The SSC determined the 2017 assessment as a category 1 stock assessment.

The Council adopted a new harvest control rule for California scorpionfish of ACL = ABC under a P* of 0.45 starting in 2019 based on projections indicating the stock would remain healthy in the next ten years under this harvest control rule. The 2019 and 2020 ABCs and ACLs for California scorpionfish are 313 mt and 307 mt, respectively.

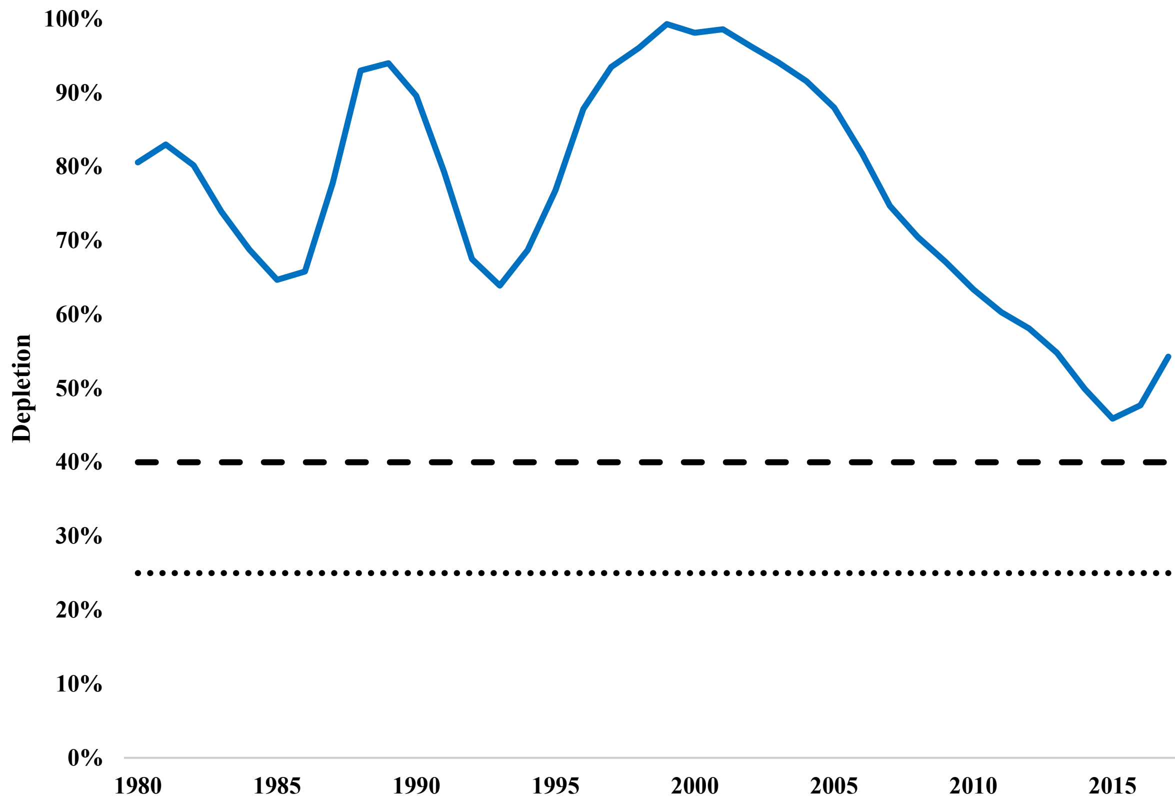

Figure 2-31. Relative depletion of California scorpionfish from 1980 to 2017 based on the 2017 stock assessment.

Stock Productivity

A steepness value of 0.718 was assumed for California scorpionfish in the 2017 assessment. The PSA productivity score of 1.83 indicates a stock of relatively high productivity.

Recruitment deviations were estimated from 1965-2016 in the 2017 assessment. Historically, there are estimates of large recruitment from 1975-1977, 1984-1985, and in 1993 and 1996 (Figure 2-29). There is early evidence of a strong recruitment in 2013. The four lowest recruitments estimated within the model (in ascending order) occurred in 2012, 2011, 1989, and 1988.

The nearly sinusoidal pattern in biomass (Figure 2-28) and recruitments (Figure 2-29) was found to be moderately correlated with water temperature (the CalCOFI temperature index), indicating that the patterns in recruitment are at least partially driven by environmental factors.

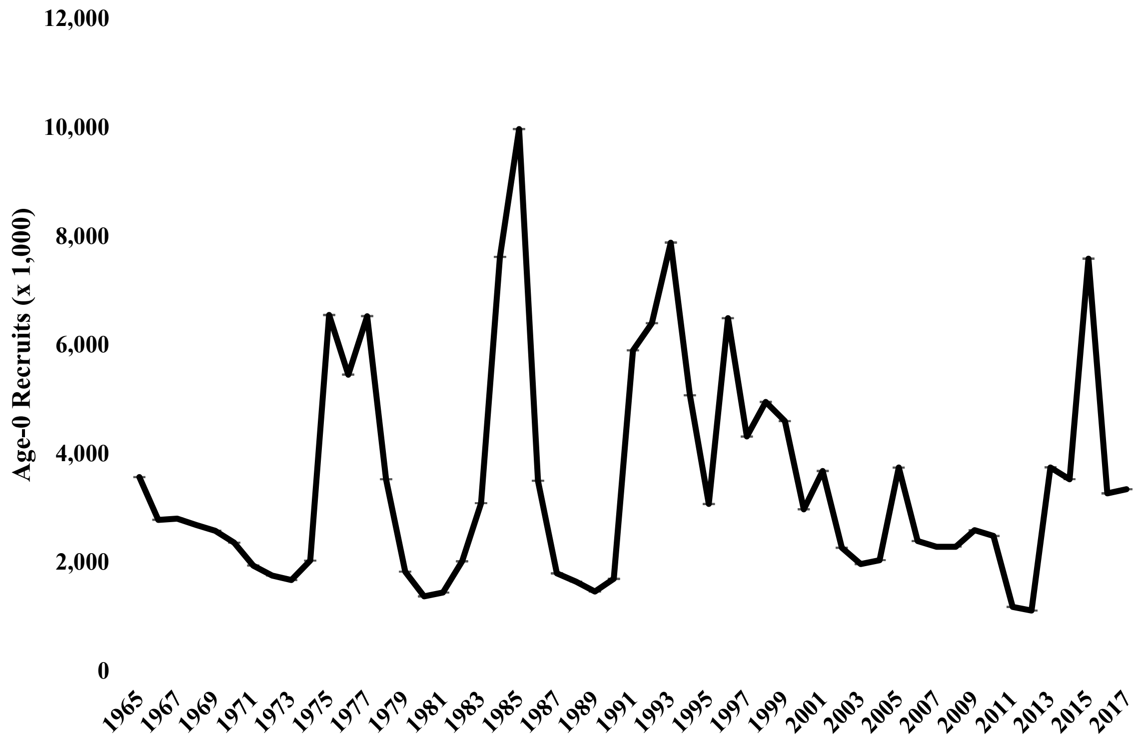

Figure 2-32. Estimated California scorpionfish recruitments, 1965-2017 (from Monk et al. 2017).

Fishing Mortality

A substantial but unknown portion of the stock occurs in Mexican waters. The exploitation of the stock in Mexican waters is unknown and the connectivity of that stock with the U.S. stock in the Southern California Bight is also unknown.

Commercial catch records for scorpionfish were available beginning in 1916. Commercial catches were the dominant removals until the 1960s when the recreational catch became dominant. Harvest rates estimated in the base model of the 2017 assessment have never exceeded management target levels. The estimated relative depletion is currently greater than the 40 percent unfished spawning output target. Recent exploitation rates on California scorpionfish were predicted to be significantly below target levels.

A short, but sharp decline in spawning stock biomass occurred between 1965 and 1985, followed by a period of cyclical variation in spawning biomass, and then a decline from 2000 to 2015. The stock showed increases in stock size in 2015 due to a combination of strong recruitment and smaller catches in 2015 and 2016.

The PSA vulnerability score of 1.41 indicates a low risk of overfishing.

2.4.8 Canary Rockfish

Distribution and Life History

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 (Hart 1988; Love*, et al.* 2002; Miller and Lea 1972). Adults are primarily found along the continental shelf shallower than 300 m, although they are occasionally observed in deeper waters. Juvenile canary rockfish are found in shallow and intertidal areas (Love*, et al.* 2002).

Canary rockfish spawn in the winter, producing pelagic larvae and juveniles that remain in the upper water column for 3-4 months (Love*, et al.* 2002). These 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. The mean size of individuals captured in the trawl survey shows a characteristic ontogenetic shift to deeper water with increasing body size. The degree to which this ontogenetic shift may be accompanied by a component of latitudinal dispersal from shallow rocky reefs is unknown. Canary rockfish are a medium to large-bodied rockfish, achieving a maximum size of around 70 cm. Female canary rockfish reach slightly larger sizes than males.

Adult canary rockfish primarily inhabit areas in and around rocky habitat. They form very dense schools, leading to an extremely patchy population distribution that is reflected in both fishery and survey encounter rates.

Canary rockfish are relatively long-lived, with a maximum observed age of 95 years; however, only males are commonly observed above the age of 50, while females tend to be rare above age 30. The degree to which this pattern reflects behavioral differences translating to reduced availability to fishery and survey fishing gear, or an increase in relative mortality for older females has been the focus of much discussion and remains unclear. A similar pattern has been observed for black rockfish (*Sebastes melanops*) and yellowtail rockfish (*Sebastes flavidus*), closely related, but more pelagic species with a similar distribution (Cope*, et al.* 2015a; Wallace and Lai 2006).

Canary rockfish off the West Coast exhibit a protracted spawning period from September through March, probably peaking in December and January off Washington and Oregon (Hart 1988; Johnson*, et al.* 1982). Female canary rockfish reach sexual maturity at roughly eight years of age. Like many members of Sebastes, canary rockfish are ovoviviparous, whereby eggs are internally fertilized within females, and hatched eggs are released as live young (Bond 1979; Golden and Demory 1984; Kendall and Lenarz 1986). Canary rockfish are a relatively fecund species, with egg production being correlated with size (e.g., a 49-cm female can produce roughly 0.8 million eggs, and a female that has realized maximum length (approximately 60 cm) produces approximately 1.5 million eggs (Gunderson 1971).

Very little is known about the early life history strategies of canary rockfish. The limited research that has been conducted indicates that larvae are strictly pelagic (near the ocean surface) for a short period of time and begin to migrate to demersal waters during the summer of their first year of life. Larvae develop into juveniles around nearshore rocky reefs, where they may congregate for up to three years (Boehlert 1980; Sampson 1996). Evaluations of length distributions by depth demonstrate an increasing trend in mean size of fish with depth (Methot and Stewart 2006). From

1990 through the 2011 update assessment, stock assessments have assumed a base natural mortality rate of 0.06 (94 percent adult annual survival when there is no fishing mortality). The natural mortality rate prior was updated in the 2015 assessment (Thorson and Wetzel 2015) to 0.0521 based on a maximum age of 84 years (Love*, et al.* 2002). Due to the rarity of old females in both survey and catch data, female canary rockfish have long been assumed to have increasing natural mortality rates with age (Golden and Wood 1990).

Little is known about ecological relationships between canary rockfish and other organisms. Adult canary rockfish are often caught with bocaccio, sharpchin, yelloweye rockfish, and yellowtail rockfishes, and lingcod. Researchers have also observed canary rockfish associated with silvergray and widow rockfish. Young-of-the-year feed on copepods, amphipods, and young stages of euphausiids. Adult canary rockfish feed primarily on euphausiids, as well as pelagic shrimp, cephalopods, mesopelagic fishes and other prey (Brodeur and Percy 1984; Lee 2002; Phillips 1964). Small canary rockfish are consumed by seabirds, Chinook salmon, lingcod, and marine mammals.

Stock Status and Management History

Canary rockfish have long been an important component of rockfish fisheries. The Council began to recommend increasingly restrictive regulations after an assessment in 1994 (Sampson and Stewart 1994) indicated that fishing rates were too high. Prior to passage of the Sustainable Fisheries Act of 1996, there was no requirement for stock assessments to estimate biomass status; and until 1997 the Council's default target rate for fishing mortality corresponded to an SPR of 35 percent. Thorson and Wetzel (2015) estimated that the abundance of the canary rockfish stock dropped below B_{MSY} ($B_{40\%}$) in 1983 and below the MSST in 1990, at which time the annual catch was more than double the current estimate of the MSY level. Harvest rates in excess of the current fishing mortality target for rockfish (SPR = 50 percent) is estimated to have begun in the late 1970s and persisted through 1999. Recent management actions appear to have curtailed the rate of removal such that overfishing has not occurred since 1999, and recent SPR values are in excess of 90 percent.

A 1999 stock assessment showed the stock had declined to 6.6 percent of unfished biomass in the northern area (Columbia and U.S. Vancouver management areas) (Crone*, et al.* 1999) and in the southern area (Conception, Monterey, and Eureka areas) (Williams*, et al.* 1999). The stock was declared overfished in January 2000. The first rebuilding analysis (Methot 2000) used results from the northern area assessment to project rates of potential stock recovery. The stock was found to have extremely low productivity, defined as production of recruits in excess of the level necessary to maintain the stock at its current, low level. Rates of recovery were highly dependent upon the level of recent recruitment, which could not be estimated with high certainty. The initial rebuilding OY for 2001 and 2002 was set at 93 mt based upon a 50 percent probability of rebuilding by the year 2057, a medium level for these recent recruitments, and maintaining a constant annual catch of 93 mt through 2002.

A coastwide 2002 canary rockfish assessment estimated stock depletion to be 7.9 percent at the start of 2002 (Methot and Piner 2002b). A canary rockfish rebuilding plan was adopted in 2003 under Amendment 16-2 based on the results of the 2002 rebuilding analysis (Methot and Piner 2002a). The rebuilding plan established a target rebuilding year of 2074 and the harvest control rule of F = 0.022 (with a P_{MAX} of 60 percent).

A full canary rockfish assessment was done in 2005 indicating a stock depletion of 9.0 percent at the start of 2005 (Methot and Stewart 2006). The assessment was based on two equally plausible models; one with differential male and female gear selectivities and one without gender-specific selectivities. A critical uncertainty in canary rockfish assessments was the lack of older, mature females in surveys and other assessment indices. There were two competing explanations for this observation. Older females could have a higher natural mortality rate, resulting in their disproportionate disappearance from the population. Alternatively, survey and fishing gears may be less effective at catching them, perhaps because older females are associated with habitat inaccessible to most trawl gear. If this is the case, then these fish (which, because of their higher spawning output, may make an important contribution to future recruitment) are part of the population, but remain poorly sampled. Methot and Stewart (2006) assumed a linear increase in female natural mortality from 0.06 at age 6 to approximately 0.09 at age 14. In the base model (differential male-female selectivity) B_0 was estimated to be 34,798 mt, resulting in a depletion level of 5.7 percent. In the alternate model (no difference in selectivity) B_0 was estimated to be 33,872 mt, with a depletion level of 11.3 percent. The steepness of the spawner-recruitment relationship, which largely determines the rate of increase in recruitment as the stock rebuilds, was estimated to be 0.33 in the base model, and 0.45 in the alternate model. The approved canary rockfish rebuilding analysis (Methot 2006) blended the two models by alternately re-sampling between the two input parameter sets.

The 2005 canary rockfish rebuilding analysis (Methot 2006) was used to inform the revised canary rockfish rebuilding plan adopted under Amendment 16-4, which specified a target rebuilding year of 2063 and a constant harvest strategy (SPR = 88.7 percent). Amendment 16-4 rebuilding plans were implemented in 2007.

The 2007 canary rockfish assessment estimated relative depletion level was 32.4 percent at the start of 2007 (Stewart 2008b). This was a significant departure from the previous assessment and largely driven by a higher assumed steepness (h = 0.51) relative to past assessments. The 2007 assessment was unable to estimate steepness as had been done in the 2005 assessment, largely because the 2007 assessment treated the triennial bottom trawl survey as two separate indices due to changes between the 1992 and 1995 surveys in the seasonal timing. The 2007 canary rockfish rebuilding analysis (Stewart 2008a) predicted the SPR harvest rate in the rebuilding plan (88.7 percent) would rebuild 42 years earlier (2021) than the originally estimated rebuilding schedule (2063). A modification of the Amendment 16-4 canary rockfish rebuilding plan specifying a target rebuilding year of 2021 while maintaining the SPR harvest rate of 88.7 percent was implemented in 2009.

The 2009 canary rockfish assessment (Stewart 2009c), an update of the 2007 assessment, estimated stock depletion at 23.7 percent at the start of 2009. This change in stock status was due to a lower estimate of initial, unfished biomass (B_0) largely attributable to the inclusion of revised historical California catches from a formal reconstruction of 1916-1980 California catch data (Ralston*, et al.* 2010). The 2009 canary rockfish rebuilding analysis (Stewart 2009a) predicted the stock would not rebuild to the target year of 2021 with at least a 50 percent probability even in the absence of fishing-related mortality starting in 2011 ($T_{F=0}$). The rebuilding plan was revised by changing the target to rebuild the stock to 2027 while maintaining the 88.7 percent SPR harvest rate; the revised rebuilding plan was implemented in 2011.

Another update assessment was prepared in 2011 (Wallace and Cope 2011), which estimated stock depletion was 23.2 percent at the start of 2011. This change in stock status was due to a lower estimate of initial, unfished biomass (B_0) largely attributable to the inclusion of revised historical Oregon catches from a formal reconstruction of Oregon catch data. For the period 2000-2011, the spawning biomass was estimated to have increased from 11.2 percent to 23.2 percent of the unfished biomass level.

The 2011 canary rockfish rebuilding analysis (Wallace 2011) predicted the stock would not rebuild to the target year of 2027 with at least a 50 percent probability. The rebuilding plan was revised slightly by changing the target to rebuild the stock to 2030 while maintaining the 88.7 percent SPR harvest rate; the revised rebuilding plan was implemented in 2013.

A full assessment of canary rockfish was conducted in 2015 (Thorson and Wetzel 2015), which indicated the stock was rebuilt with a depletion of 56 percent at the start of 2015. A number of revisions were made to the data used for stock assessment, including: 1) a new method of index standardization for NWFSC trawl survey using a geo-statistical delta-generalized linear mixed model (GLMM), 2) a new steepness value (0.773) based on an updated meta-analysis of steepness, 3) a re-estimated relationship for maturity, 4) new ageing error tables, and 5) a re-estimated length-weight relationship. Ageing data based on surface otolith reads were added to the assessment using an ageing-error table appropriate to surface reads. This added about 10 years of historical ageing data to the model. The primary factors driving the improvement in stock status are the use of a higher steepness value, the reduction in harvest due to the rebuilding plan, and above average recruitments in 2001-2003, and in 2007 and 2010. The SSC explained the relatively strong effect of steepness on estimated stock status is a reason for concern about the reliability of model results since steepness is a relatively uncertain parameter value. However, it should be noted that even a relatively low steepness of 0.6 (e.g., the low state of nature in the steepness decision table) results in a biomass estimate above the rebuilding target.

Another full assessment of canary rockfish was conducted in 2023 (Langseth et al. 2023) with a coastwide population model. Major changes compared to the previous 2015 benchmark assessment were estimating separate female and male natural mortality rates that were constant across ages, and separate selectivity by sex for larger fish. This is in contrast to the 2015 model, which estimated separate natural mortality only for older females, and assumed the same selectivity between sexes. The 2023 model also estimated coastwide recruitment deviations, whereas the 2015 assessment had estimated additional spatial recruitment deviations by state. The 2023 model estimated separate selectivity curves for fishing fleets by state versus assuming selectivity was the same along the coast in the prior assessment model.

The 2023 assessment model estimates recovery from the population's low abundance in 1995 to be slower than was estimated in the 2015 assessment, but more similar to estimates from earlier assessments. The change from the 2015 model is primarily due to different assumptions regarding natural mortality and current data weighting practices on the updated data. Current depletion (spawning output relative to unfished spawning output) in 2023 was 35.1% and is in the "precautionary zone" between the management target of 40% and the minimum stock size threshold of 25% (Figure 2-30).

The Council adopted harvest specifications based on a 40-10 harvest control rule of ACL<ABC due to the population being in the precautionary zone, under a P* of 0.45 to inform harvest specifications in 2025 and beyond.

A recent assessment for canary rockfish in Canada shows a similar decline and subsequent rebuilding of the stock in Canadian waters, where the magnitude of decline and the timing of the commencement of rebuilding are generally similar to the current 2023 U.S. stock assessment (DFO 2023).

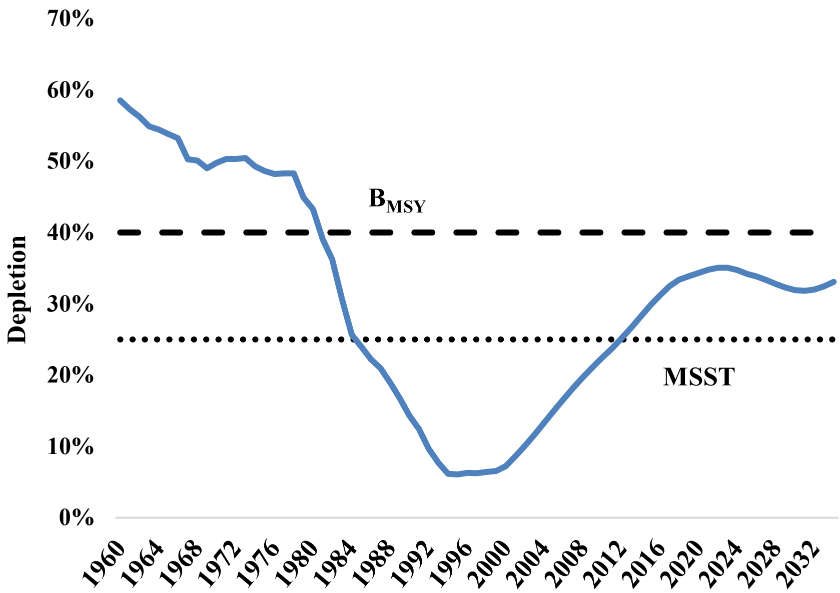

Figure 2-33. Relative depletion of canary rockfish from 1960 to 2034 based on the 2023 stock assessment.

Stock Productivity

The 2023 canary rockfish assessment assumed a steepness of 0.72 based on the meta-analysis of rockfish steepness. The PSA productivity score of 1.61 indicates a stock of moderate productivity.

Years with the highest recruitment deviations were estimated to have occurred in the 1960s and continued through around 1990 (Figure 2-31). Starting around 2005 recruitment deviations became more consistently negative. Much of this period corresponds to a period of relatively sparse composition data. Deviations have increased closer to average levels since 2018 but these deviations are more uncertain given the few years available to sample these age classes (Langseth et al. 2023).

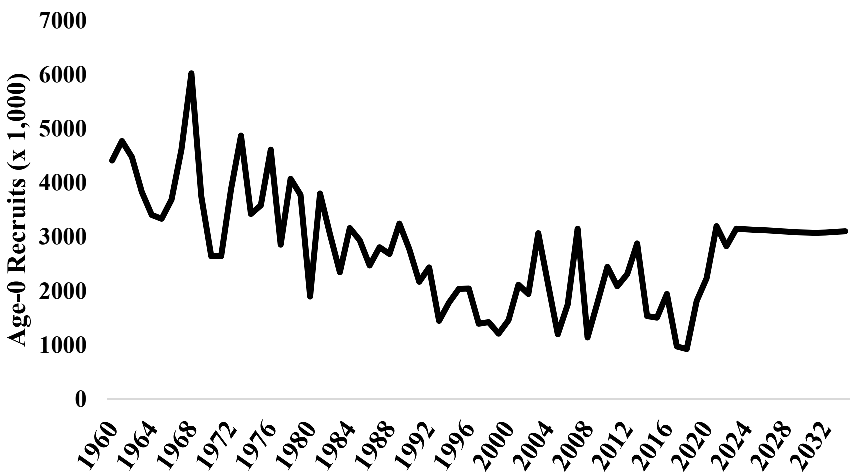

Figure 2-34. Estimated canary rockfish recruitments from 1960 to 2034 based on the 2023 stock assessment.

Fishing Mortality

Rockfishes in the California Current are managed to have a target SPR of 50 percent of its equilibrium value in a population given current fishing. Population trajectories for canary rockfish in the 2023 assessment track the patterns in fishing intensity, where fishing intensity was steadily above a fishing mortality that would produce an SPR of 50% starting in the 1960s and lasting nearly four decades (Figure 2-32). Fishing intensity has been low since 2000 but has recently increased to a fishing mortality corresponding to an SPR of near 50%. The estimate of recent fishing intensity (measured as 1-spawning potential ratio) in 2022 is 0.469 and is close to the target reference point of 0.5.

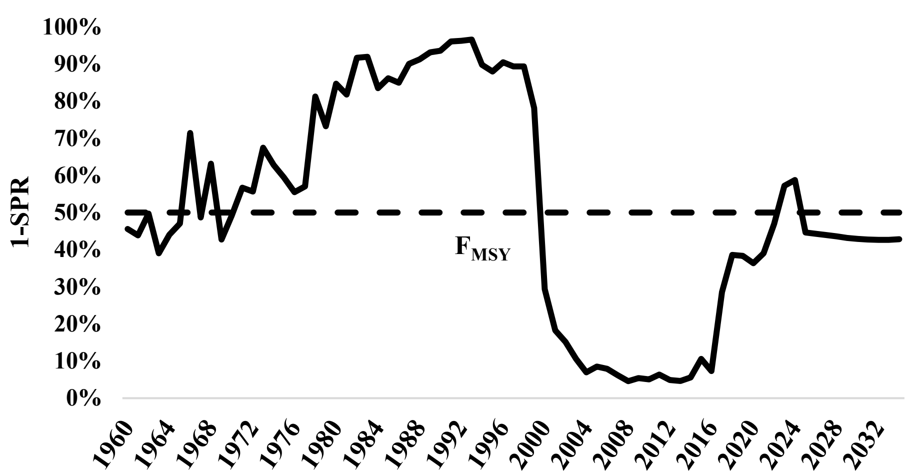

Figure 2-35. Estimated spawning potential ratio (SPR) of canary rockfish relative to the current F_{MSY}, 1960-2034 based on the 2023 stock assessment. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis.

2.4.9 Chilipepper Rockfish

Distribution and Life History

Chilipepper rockfish (*Sebastes goodei*) are found from Magdalena Bay, Baja California, Mexico, to as far north as the northwest Coast of Vancouver Island, British Columbia (Allen 1982; Hart 1988; Miller and Lea 1972). The region of greatest abundance is found between Point Conception and Cape Mendocino, California. Chilipepper have been taken as deep as 425 m, but nearly all in survey catches were taken between 50 and 350 m (Allen and Smith 1988). Adults and older juveniles usually occur over the shelf and slope; larvae and small juveniles are generally found near the surface. In California, chilipepper are most commonly found associated with deep, high relief rocky areas and along cliff drop-offs (Love*, et al.* 1990), as well as on sand and mud bottoms (MBC 1987). They are occasionally found over flat, hard substrates (Love*, et al.* 1990). Love (1996) does not consider this to be a migratory species. Chilipepper may travel as far as 45 m off the bottom during the day to feed (Love 1996). Chilipepper rockfish are described as an elongate fish with reduced head spines similar in appearance to both shortbelly rockfish (at smaller sizes, although shortbelly rockfish tend to be slimmer) and bocaccio rockfish (bocaccio tend to have larger mouths).

Chilipeppers are ovoviviparous and eggs are fertilized internally (Reilly*, et al.* 1992). Chilipepper school by sex just prior to spawning (MBC 1987). In California, fertilization of eggs begins in October and spawning occurs from September to April (Oda 1992) with the peak occurring during December to January (Love*, et al.* 2002). Chilipepper may spawn multiple broods in a single season (Love*, et al.* 2002). Females of the species are significantly larger, reaching lengths of up to 56 cm (Hart 1988). Males are usually smaller than 40 cm (Dark and Wilkins 1994). Males mature at two years to six years of age, and 50 percent are mature at three years to four years. Females mature at two years to five years with 50 percent mature at three years to four years (MBC 1987). Females may attain an age of about 27 years, whereas the maximum age for males is about 12 years (MBC 1987).

Larval and juvenile chilipepper eat all life stages of copepods and euphausiids, and are considered to be somewhat opportunistic feeders (Reilly*, et al.* 1992). In California, adults prey on large euphausiids, squid, and small fishes such as anchovies, lanternfish, and young Pacific whiting (Hart 1988; Love*, et al.* 2002). Chilipepper are found with widow rockfish, greenspotted rockfish, and swordspine rockfish (Love*, et al.* 2002). Juvenile chilipepper compete for food with bocaccio, yellowtail rockfish, and shortbelly rockfish (Reilly*, et al.* 1992). Pelagic juveniles are preyed upon by a wide range of predators, including seabirds, salmon, lingcod, and marine mammals. Larger piscivorous fishes, marine mammals, and in recent years jumbo squid are among the predators of larger adults.

Stock Status and Management History

Chilipepper have been one of the most important commercial target species in California waters since the 1880s and were historically an important recreational target in Southern California waters. With the exception of excluding foreign fishing effort from the U.S. EEZ in the late 1970s, management actions were modest (and usually general to all rockfish and other groundfish) prior to the implementation of the Groundfish FMP in 1982. When the FMP was implemented, management for the groundfish trawl fishery was based on individual vessel trip limits, which were set at 40,000 lbs per trip on the *Sebastes* (all rockfish species) complex. These limits were maintained until 1991, when they were reduced to 25,000; in 1993 the trip limit system was revised from daily to biweekly trip limits, which were set at 50,000 lbs (south of Cape Mendocino). The trip limit regime continued to evolve in its absolute amounts and temporal duration (monthly, bimonthly) throughout the 1990s, with a general trend towards lower limits as conservation concerns arose for other rockfish species (particularly bocaccio rockfish in the region south of Mendocino). The chilipepper catch in the bottom trawl fishery has been managed under an IFQ system since 2011.

Chilipepper rockfish were assessed in 1998 (Ralston*, et al.* 1998), at which time the stock south of 40°10' N. lat. was estimated to be at 46 percent to 61 percent of unfished biomass.

A full chilipepper assessment for the stock in waters off California and Oregon was conducted in 2007 (Field 2008). The 2007 assessment estimated a substantial increase in the spawning biomass of chilipepper rockfish in recent years, due to a strong 1999 year class as well as greatly reduced harvest rates in commercial and recreational fisheries. The 2007 assessment's base model result suggests a spawning biomass of 23,889 mt in 2006, corresponding to approximately 70 percent of the unfished spawning biomass of 33,390 mt and representing a near tripling of spawning biomass from the estimated low of 8,696 mt (26 percent of unfished) in 1999. The strong 1999 year class represents the largest estimated historical recruitment and is the primary cause for the current population trajectory. Several strong year classes have been observed in recent years (2009-2010, 2013-2014) and these recent recruitments are already leading to a fast rate of increase in abundance and larval production.

The 2007 assessment was first used in 2008 to decide 2009 and 2010 chilipepper harvest specifications. The Council consideration for 2011 and 2012 was whether or not to remove chilipepper rockfish from the Shelf Rockfish North complex and manage it coastwide. Chilipepper rockfish are predominantly found south of 40°10' N. lat. Prior to 2007 they were only assessed in the area south of 40°10' N. lat. To date, chilipepper rockfish have been managed with stock-specific harvest specifications south of 40°10' N. lat. and within the Shelf Rockfish North complex north of 40°10' N. lat. When the stock assessment area was extended for the 2007 chilipepper stock assessment, it was extended to the stock's entire West Coast range through waters off Oregon (chilipepper rockfish are not believed to occur in waters off Washington). However, it was decided to continue to manage chilipepper rockfish south of 40°10' N. lat. with stock-specific harvest specifications and as part of the Shelf Rockfish complex north of 40°10' N. lat.

An update of the 2007 assessment of chilipepper rockfish south of 40°10' N. lat. was conducted in 2015 (Field*, et al.* 2015), which indicated the stock was at 64 percent of its unfished biomass at the start of 2015 (Figure 2-33). Changes from the 2007 assessment include using an updated version of the Stock Synthesis model, which results in better treatment of time-varying growth; updated historical catch estimates; a new 2003-2014 time block to account for changes in recreational fishery selectivity; updated maturity and fecundity relationships; updated ageing error estimates; and 8 additional years of data.

The SSC designated chilipepper as a category 1 stock and recommended that the next assessment be a full assessment due to the length of time since the last full assessment.

The relative biomass apportioned to the stock south of 40°10’ N. lat. was estimated to be 93 percent of the coastwide biomass based on average historical landings. A catch-only projection update was conducted in 2023 to provide harvest specifications for 2025-2026 fishery management.

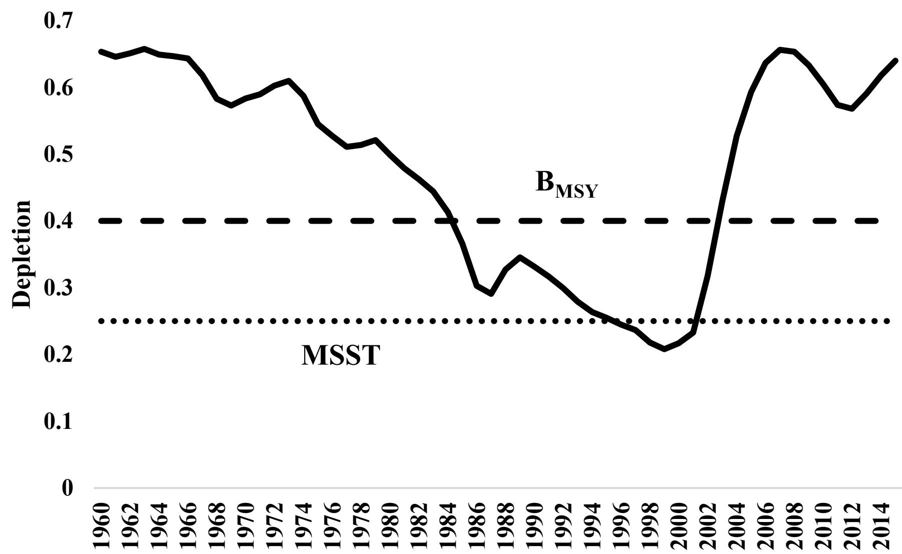

Figure 2-36. Relative depletion of chilipepper rockfish from 1960 to 2015 based on the 2015 stock assessment update.

Stock Productivity

Steepness in the 2007 assessment and 2015 update was fixed at 0.57, which was the mean of the prior probability distribution in the rockfish meta-analysis available in 2007. Since steepness was thought to be poorly specified in the model, this parameter was chosen as the major axis of uncertainty. The decision table projected outcomes for a low productivity and a high productivity model using steepness values of 0.34 and 0.81, respectively. The PSA productivity score of 1.83 indicates a stock of relatively high productivity, especially for a rockfish.

Recruitment for chilipepper rockfish is highly variable, with a small number of year classes tending to dominate the catch in any given fishery or region. As age and length data are only available for the late 1970s onward, estimates of year class strength are most informative from the 1970s to the present. The 1984 and 1999 year classes were among the strongest in that time period; however, several very strong year classes have been observed in recent years (2009-2010, 2013-2014) and are already leading to a fast rate of increase in abundance and larval production (Figure 2-34).

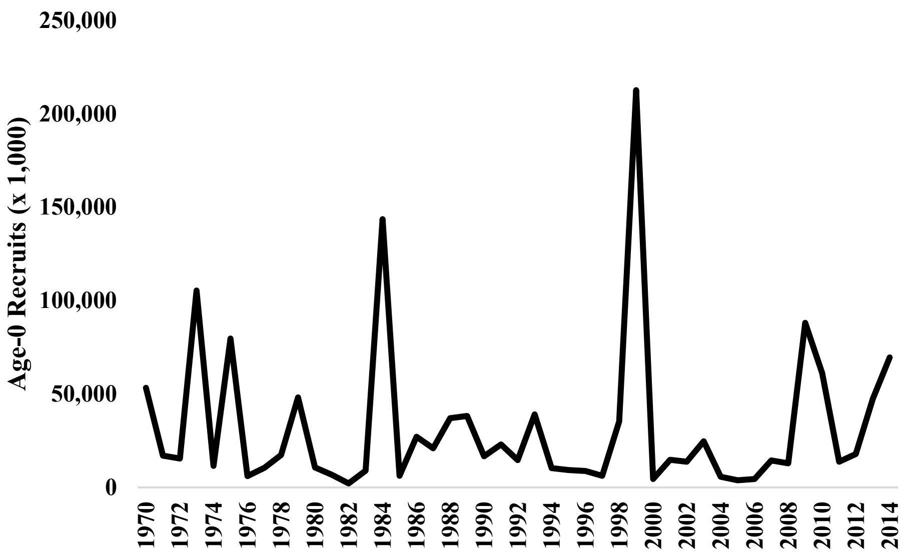

Figure 2-37. Estimated chilipepper rockfish recruitments, 1970-2014 (from Field, *et al.* 2015).

Fishing Mortality

Chilipepper rockfish have been one of the most important commercial target species in California since the late 1800s and was also a recreational target in southern California waters. Catches and exploitation rate have declined substantially since the early 1990s. While chilipepper has always been an important target species in California, the exploitation rate has rarely exceeded the F_{MSY} target of a 50 percent SPR. Exploitation rates declined substantially since the late 1990s with the implementation of more restrictive management measures to rebuild depleted stocks.

Throughout most of the past three decades, domestic landings have ranged between approximately 2,000 and 3,000 mt; however, since 2002 landings have averaged less than 100 mt per year. The highest exploitation rates occurred from the late 1980s through the mid-1990s, when they were above target levels and the stock was approaching its lowest estimated historical levels. From the late 1990s through the present, exploitation rates have been declining significantly down to incidental levels, as a result of management measures implemented to rebuild co-occurring depleted rockfish species (particularly bocaccio, but including canary rockfish, widow, cowcod and yelloweye rockfish). Discards are assumed to be negligible in the historical period; however, regulatory discards have been substantial in recent years, more than doubling the total catch relative to landings since 2002. Trawl discards have been negligible since implementation of the IFQ program in 2011.

The PSA vulnerability score of 1.35 indicates a low risk of overfishing.

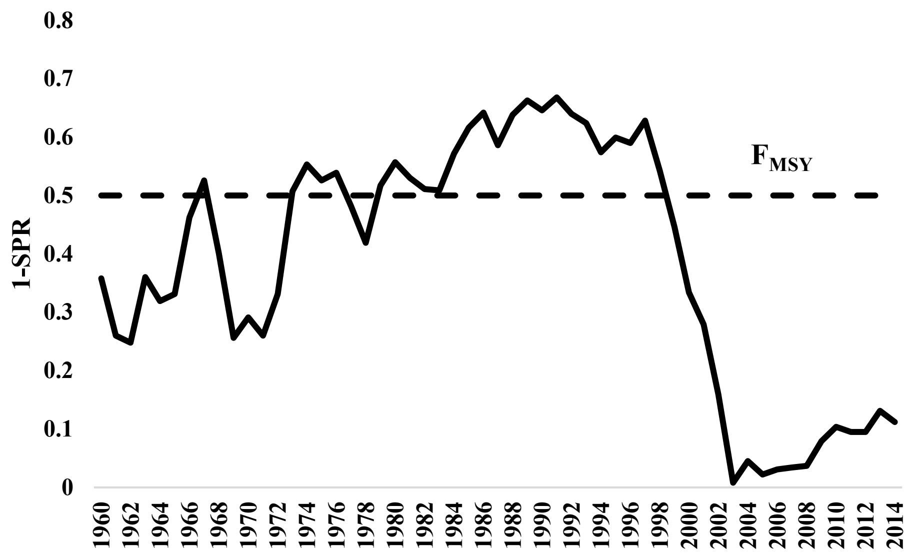

Figure 2-38. Estimated spawning potential ratio (SPR) of chilipepper rockfish relative to the current F_{MSY}, 1960-2014. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis.

2.4.10 Cowcod

Distribution and Life History

Cowcod (*Sebastes levis*) is a species of large rockfish with a distribution from Newport, Oregon, to central Baja California, Mexico (Love et al., 2002). They are most common from Cape Mendocino (California) to northern Baja California, in depths from 50-300 m. Hess et al. (2014) recently used genetic and otolith microchemistry tools to study cowcod population structure from California to Oregon. Specifically, they tested the hypothesis that a phylogeographic boundary exists at Point Conception. Their results supported a hypothesis of two primary lineages with a geographic boundary falling south of, rather than at Point Conception. Both lineages co-occur in the Southern California Bight (SCB), with no clear pattern of depth stratification or spatial structure within the Bight. Within lineages, there is evidence for considerable gene flow across the Point Conception boundary. Cowcod found north of Point Conception consist primarily of a single lineage, also found in northern areas of the SCB.

Cowcod are easily identified at all life stages, including larvae. Adults are piscivorous, with a diet consisting mainly of fishes, squids, and octopi. Cowcod are considered to be parademersal (transitional between a midwater pelagic and benthic species). Larvae develop into a pelagic juvenile stage, settling to benthic habitats after about 3 months. Juvenile cowcod were once thought to associate primarily with soft sediments, but Love and Yoklavich (2008), using visual surveys, found juveniles mainly associate with low-relief, hard substrate. Young-of-the-year were observed over a wide depth range (52-277 m), with juveniles slightly deeper, and adults mainly deeper than 150 m. Larger juveniles increasingly associate with high-relief, complex rocky substrate, the primary habitat for adult cowcod. Adult cowcod are generally solitary, but occasionally aggregate (Love*, et al.* 1990). Although cowcod are generally not migratory, they may move, to some extent, to follow food (Love 1996).

Cowcod are a long-lived, slow-growing species that require a decade or more to reach sexual maturity. Fertilization is internal, with females giving birth to planktonic larvae mainly during winter months. Spawning peaks in January in the SCB (MacGregor 1986) and large females may produce up to three broods per season (Love*, et al.* 1990). Larvae emerge at about 5.0 mm (MacGregor 1986).

Cowcod are a highly fecund species, with large females producing 2 million eggs (fecundity is dependent on size and ranges from 181,000 to 1,925,000 eggs) (Love*, et al.* 2002). Dick et al. (2009) found no evidence of increasing weight-specific fecundity (i.e., spawning output is roughly proportional to spawning biomass).

Maximum observed age for cowcod is 55 years (Love*, et al.* 2002). Dick et al. (2007) estimated the natural mortality rate (M) using three methods, reporting a range of values from 0.027 to 0.064 based on Beverton's (1992) method, a range of total mortality (Z) estimates from 0.038 to 0.072 based on catch curve analysis, and Hoenig's geometric mean regression. Females reach 90 percent of their maximum expected size by 42 years.

Little is known about ecological relationships between cowcod and other organisms. Small cowcod feed on planktonic organisms such as copepods. Juveniles eat shrimp and crabs, and adults eat fish, octopus, and squid (Allen 1982). Adults consume a wide range of prey items, but are primarily piscivorous (Love*, et al.* 2002).

Stock Status and Management History

While cowcod are not a major component of the groundfish fishery, they are highly desired by both recreational and commercial fishers because of their bright color and large size. The cowcod stock in the Conception area was first assessed in 1998 (Butler*, et al.* 1999b). Abundance indices decreased approximately tenfold between the 1960s and the 1990s, based on CPFV logs (Butler*, et al.* 1999b). Recreational and commercial catch also declined substantially from peaks in the 1970s and 1980s, respectively.

NMFS declared cowcod in the Conception and Monterey management areas overfished in January 2000, after Butler et al. (1999b) estimated the 1998 spawning biomass to be at 7 percent of B_0, well below the 25 percent minimum stock size threshold. Because cowcod is a fairly sedentary species, closed areas were established in 2001 to reduce cowcod mortality. Two Cowcod Conservation Areas (CCAs), in the SCB, were selected due to their high density of cowcod. The larger of the two areas (CCA West) is a 4,200 square mile area west of Santa Catalina and San Clemente Islands. A smaller area (CCA East) is about 40 miles offshore of San Diego and covers about 100 square miles. Bottom fishing is prohibited deeper than 20 fm within the CCAs.

A cowcod rebuilding analysis was completed in 2003 which validated the assumption that non-retention regulations and area closures had been effective in constraining cowcod fishing mortality (Butler*, et al.* 2003). These encouraging results were based on cowcod fishery-related landings in recreational and commercial fisheries, although the assessment included discard information only with respect to CPFV observations (which indicated negligible discards in that sector). This rebuilding review pointed out a common problem among the analyses of overfished species:

reliance on landings (fishery-dependent) data for providing relative abundance values becomes increasingly difficult as the allowable catch is decreased and fishery observer data remains low. Monitoring stock status and recovery thus becomes increasingly difficult in the absence of fishery-independent surveys.

As in the 1999 assessment, the 2005 cowcod assessment (Piner*, et al.* 2006) considered only the cowcod population in SCB (from the U.S.-Mexico border north to Point Conception) population, as this is the area in which cowcod are most abundant, adult habitat is most common, and catches are highest. The 2005 assessment used only two data sources, the CPFV time series and the visual survey estimate data (Yoklavich*, et al.* 2007). The model was developed in Stock Synthesis 2, and although the base model estimated only three parameters (two of which were "nuisance parameters," the other was equilibrium recruitment), the STAR Panel determined that this simplicity was appropriate given the paucity of data. The assessment provided a set of results corresponding to three different values for assumed steepness (h), the key parameter in the stock-recruitment relationship (h=0.4, 0.5, and 0.6) and one the key uncertainties in the assessment. The assessment estimated that the 2005 spawning biomass was 18 percent of unfished levels and within a range of 14 to 21 percent depending on the value assumed for steepness, a considerably more optimistic result than the 1999 assessment. The corresponding 2005 cowcod rebuilding analysis (Piner 2006) was used to develop the cowcod rebuilding plan adopted in the groundfish FMP under Amendment 16-4. The rebuilding plan established a target rebuilding year of 2039 and an SPR of 90 percent.

A full cowcod assessment was conducted in 2007, which estimated spawning biomass to be 3.8 percent of its unfished level at the start of 2007 (Dick*, et al.* 2007). The 2007 cowcod assessment was an age-structured production model assuming a Beverton-Holt stock-recruitment function with deterministic recruitment, fit to the aggregated CPFV logbook index and the 2002 visual survey biomass estimate (Yoklavich*, et al.* 2007). Productivity parameters were fixed (steepness = 0.6, natural mortality = 0.055), leaving only R_0 to be estimated. Spawning biomass in 2007 was estimated to be between 3.4 percent and 16.3 percent of the unfished level. The poor precision of this estimate was due to 1) a lack of data to inform estimates of stock productivity, and 2) conflicting information from fishery-dependent and fishery–independent data. However, even the most optimistic model, which assumed a high-productivity stock and ignored declines in CPFV catch rates, suggested that spawning biomass was below 25 percent since 1980. Since retention of cowcod was prohibited and bycatch was thought to be minimal, it was considered unlikely that overfishing was an issue. It is likely that the 2007 base model underestimated the uncertainty about stock status given steepness and the natural mortality rate were treated as fixed and known in the model.

The 2007 assessment was originally prepared as an "update" stock assessment; however, while preparing the update, an error was discovered in the previous assessment's specification of the selectivity curve. Several revisions were proposed, including new estimates of historical landings, a corrected growth curve, and a two-fishery model. The 2007 assessment used Stock Synthesis 2, revised estimates of historical commercial catch, contained corrections to gear selectivity curves, utilized a revised growth curve, and separated the catch into commercial (all gears) and recreational fisheries rather than a single fishery. Recreational catches in the 2007 assessment were identical to those in the previous assessment, but estimates of commercial catches had been updated to reflect three additional data sources: 1) recovered port samples from Southern

California (1983-1985), 2) regional summaries of total rockfish landings (1928-1968) provided by the NMFS Southwest Fisheries Science Center (SWFSC) Environmental Research Division, and 3) California rockfish landings by region (1916-1927), published in CDF&G Fish Bulletin No. 105 (1958).

The 2007 rebuilding analysis (Dick and Ralston 2007) estimated a new T_{MAX} of 2098, 24 years later than the date estimated by Piner (2006), due in part to the corrections described above, but only 1 year earlier than the 2099 date estimated previously (Butler*, et al.* 2003). It was noted in the rebuilding analysis that rebuilding scenarios were extremely uncertain for this data-limited species, particularly with respect to steepness. Moreover, there was widespread concern about the ability to monitor the stock, and consequently to evaluate progress towards rebuilding in the future. The 2007 rebuilding analysis projections indicated that it would not be possible to rebuild the cowcod stock by 2039, even if all the catches are eliminated, and the estimated time to rebuild under the current harvest rate (SPR = 90 percent) was 26 years greater than the target year of 2039 adopted under Amendment 16-4. Therefore, a modification of the Amendment 16-4 cowcod rebuilding plan was implemented in 2007 which prescribed a target year of 2072 and an SPR harvest rate of 82.1 percent.

The 2007 cowcod assessment was updated in 2009, with stock depletion estimated to be 4.5 percent of its unfished level at the start of 2009 (Dick*, et al.* 2009). Estimates of female spawning stock biomass in 2009 were highly uncertain. Spawning biomass had declined from an unfished biomass of 2,101-2,461 mt to 93-441 mt in 2009. The 2009 cowcod rebuilding analysis (Dick*, et al.* 2009) was used to reconsider the cowcod rebuilding plan adopted under Amendment 16-4 as mandated in a legal challenge (*NRDC v. Locke*). The revised rebuilding plan, implemented in 2011, prescribed a target year of 2068 and an SPR harvest rate 82.7 percent.

The 2013 cowcod assessment estimated stock depletion to be 33.9 percent of unfished spawning biomass at the start of 2013 (Dick and MacCall 2013). The 2013 assessment suggested that cowcod in the SCB constitute a smaller, but more productive stock than was estimated from previous assessments. The 2013 assessment used the XDB-SRA modeling platform to estimate stock status, scale, and productivity. Dick et al. (2013) fit five fishery-independent data sources: four time series of relative abundance (CalCOFI larval abundance survey, Sanitation District trawl surveys, NWFSC trawl survey, and NWFSC hook and line survey), and the 2002 Yoklavich et al. (2007) visual survey estimate of absolute abundance.

A new cowcod assessment was conducted in 2019 indicating the stock was rebuilt with a depletion of 57 percent at the start of 2019 (Dick and He 2019). NMFS declared the stock rebuilt in September 2019 based on the results of the new assessment. The 2019 used the Stock Synthesis model rather than the Bayesian surplus production model (XDB-SRA) used in the 2013 assessment. The new assessment includes indices from six fishery-independent data sources (most of which were also included in the 2013 model), as well as length and age composition data. A major contributor of uncertainty with the cowcod assessment is the lack of adequate data (particularly age data) for estimating growth, natural mortality, and recruitment.

The base model estimates that spawning output has been steadily increasing since the late 1980s when the stock was estimated to be at 9 percent of unfished level (Figure 2-36). The current depletion estimate is 57 percent of unfished spawning output in 2019. Sensitivity analyses demonstrate that when the lower productivity assumptions associated with the 2013 model are applied to the current model (e.g., lower steepness and M), the model results are very comparable to those of the 2013 model. Uncertainty in current stock status and productivity is greatly underestimated by the base model due to lack of sufficient information in estimating natural mortality, the form and parameters of the stock recruitment relationship, recruitment variability, and historical fishery selectivity. Catch uncertainty affects the precision of population scale (and therefore yield) and is not accounted for in the current assessment. Therefore, the STAT recommended that target yields be set well below the MSY proxy until data become available to better inform stock productivity and status.

The SSC endorsed the cowcod stock assessment as a category 2 assessment since recruitment deviations were not estimated. The Council selected a new harvest control rule where ACL equals ABC under a P* of 0.4 for 2021 and beyond

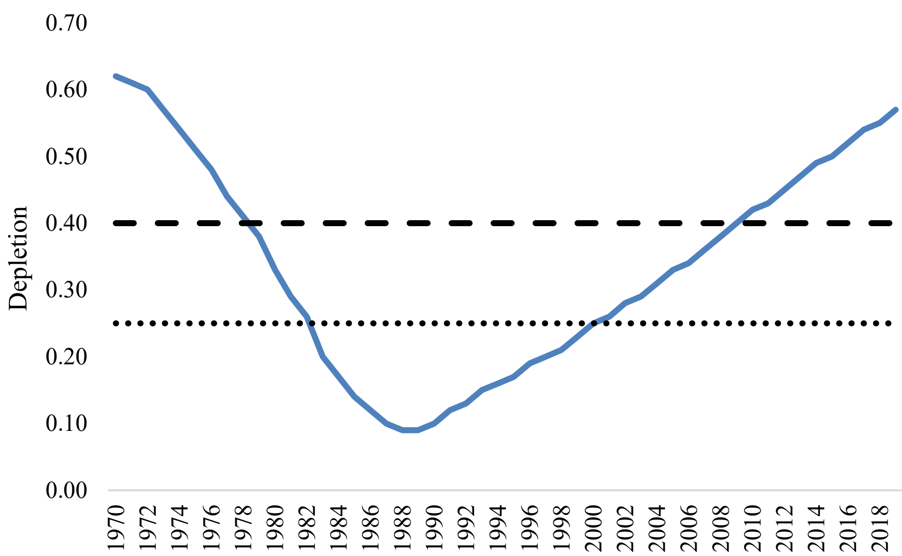

Figure 2-39. Relative depletion of cowcod south of 40°10’ N. lat. from 1970 to 2019 based on the 2019 stock assessment.

Stock Productivity

As in the previous assessment, production in the 2013 assessment is assumed to be a deterministic function of spawning biomass. Recruitment pulses may be evident in the abundance indices, but insufficient information is available to reliably estimate the relative strength of individual year classes. A Beverton-Holt steepness of 0.72 based on the rockfish meta-analysis prior was assumed in the 2019 assessment.

Fishing Mortality

The annual (equilibrium) SPR harvest rate (1-SPR) for cowcod has been less than 4 percent of target for over a decade (Figure 2-37). Historically, the SPR harvest rate reached target levels by 1920-1930, and later regularly exceeded the target for roughly 30 years, from the mid-1960s to the mid-1990s. As a percentage of age-10+ biomass (i.e., exploitation rate), harvest rates peaked at around 40 percent in the 1980s, but have declined to levels below 1 percent since retention of cowcod was prohibited in 2001. Exploitation history relative to the target SPR harvest rate (0.5) and the target spawning output (40 percent of unfished spawning output) is shown in Figure 2-37. The estimated $SPR_{50\%}$-based proxy for MSY is 73 mt per year, which corresponds to an annual harvest rate of roughly 4 percent of age 10+ biomass.

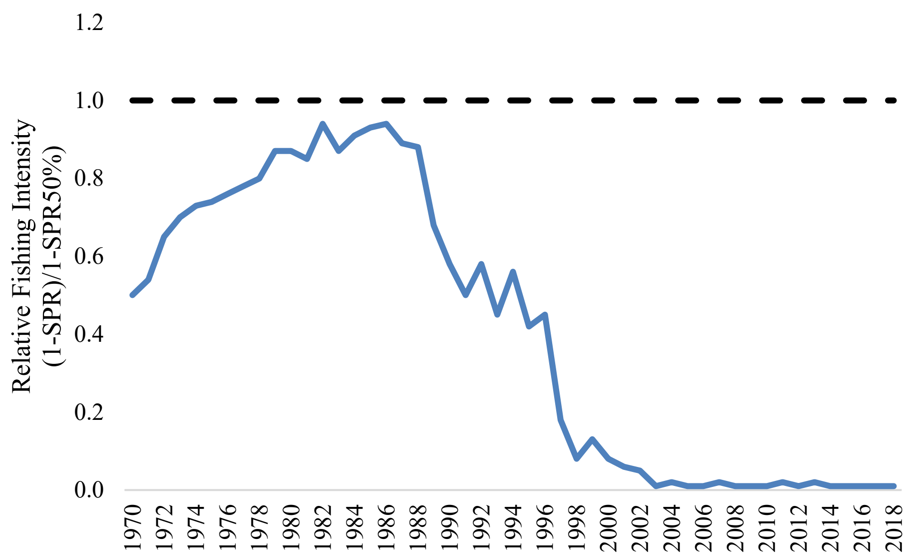

Figure 2-40. Relative fishing intensity of cowcod south of Pt. Conception, 1970-2018.

2.4.11 Darkblotched Rockfish

Distribution and Life History

Darkblotched rockfish (*Sebastes crameri*) are found from Santa Catalina Island off Southern California to the Bering Sea (Miller and Lea 1972; Richardson and Laroche 1979). They are most abundant from Oregon to British Columbia. Darkblotched rockfish primarily occur on the outer shelf and upper slope off Oregon, Washington, and British Columbia (Richardson and Laroche 1979). Based upon genetic information and the absence of large-scale gaps in catches, there are no clear stock delineations for darkblotched rockfish in U.S. waters. This does not mean there are not more fine scale groupings to be found, and in fact, darkblotched rockfish catches are characterized by infrequent large tows of larger fish. Distinct population groups have been found off the Oregon coast between 44°30' N. lat. and 45°20' N. lat. (Richardson and Laroche 1979). This species co-occurs with an assemblage of slope rockfish, including Pacific ocean perch (*Sebastes alutus*), splitnose rockfish (*Sebastes diploproa*), yellowmouth rockfish (*Sebastes reedi*), and sharpchin rockfish (*Sebastes zacentrus*).

Darkblotched rockfish mate from August to December, eggs are fertilized from October through March, and larvae are released from November through April (Love*, et al.* 2002). Older larvae and pelagic juvenile darkblotched rockfish are found closer to the surface than many other rockfish species. Pelagic juvenile settle at 4 to 6 cm in length in about 55 to 200 m (Love*, et al.* 2002). As many other Sebastes, this species exhibits ontogenetic movement, with fish migrating to deeper waters as they mature and increase in size and age (Lenarz 1993; Nichol 1990).

Darkblotched rockfish are among the longer living rockfish; the data used in the most recent assessment (Gertseva*, et al.* 2015) includes individuals that have been aged to be 98 years old. The maximum reported age of darkblotched rockfish is 105 years (Love*, et al.* 2002). As with many other *Sebastes* species, darkblotched rockfish exhibit sexually dimorphic growth; females reach larger sizes than males, while males attain maximum length earlier than females (Love*, et al.* 2002; Nichol 1990; Rogers*, et al.* 2000).

Darkblotched rockfish are ovoviviparous (Nichol and Pikitch 1994). Insemination of female darkblotched rockfish occurs from August to December, and fertilization and parturition occur from December to March off Oregon and California, and primarily in February off Oregon and Washington (Hart 1988; Nichol and Pikitch 1994; Richardson and Laroche 1979). Fecundity is dependent on size and ranges from 20,000 to 610,000 eggs.

Little is known about ecological relationships between darkblotched rockfish and other organisms. Pelagic juveniles feed on planktonic organisms such as copepods. Adults are often caught with other fish such as Pacific ocean perch and splitnose rockfish. Mid-water animals such as euphausiids and amphipods dominate the diet of adult fish. Albacore and Chinook salmon consume pelagic juveniles (Hart 1988). Little is known about predation of adults.

Stock Status and Management History

Darkblotched rockfish are caught primarily with commercial trawl gear, as part of a complex of slope rockfish, which includes Pacific ocean perch (*Sebastes alutus*), splitnose rockfish (*Sebastes diploproa*), yellowmouth rockfish (*Sebastes reedi*), and sharpchin rockfish (*Sebastes zacentrus*). Catches of darkblotched rockfish first became significant in the mid-to-late 1940s due to increased demand for fish protein during World War II. During the mid-1960s to mid-1970s darkblotched rockfish were caught by both domestic and foreign fleets (Rogers 2003b). Domestic landings rose from the late 1970s until the late 1980s, although limits on rockfish catch were first instituted in 1983, when darkblotched rockfish was managed as part of a group of around 50 species (designated as the Sebastes complex) (Rogers*, et al.* 2000). During the 2000s, progressive steps have been taken to reduce the catch of darkblotched rockfish, following the declaration of its overfished status in 2001.

The first full assessment of the darkblotched rockfish stock was conducted in 2000, which estimated stock depletion at 14–31 percent of its unfished level, depending on assumptions regarding the historic catch of darkblotched rockfish in the foreign fishery from 1965-1978 (Rogers, *et al.* 2000). The base model assumed 10 percent of foreign catch was comprised of darkblotched rockfish, leading to the conclusion that the spawning stock biomass was at 22 percent of its unfished level. NMFS declared darkblotched rockfish to be overfished in 2001 based on these results.

The 2001 rebuilding analysis for the stock (Methot and Rogers 2001) incorporated results of the 2000 Alaska Fisheries Science Center (AFSC) triennial slope trawl survey and modeled a more recent time series of recruitments. Incorporating these data resulted in a downward revision of the estimated recruitment and abundance throughout the time series compared to what had been used in the Rogers et al. (2000) assessment. This led to a revised estimate of spawning stock biomass at the beginning of 2002 of 14 percent of its unfished level and a longer projected rebuilding period.

A 2003 assessment and rebuilding update for darkblotched rockfish (Rogers 2003a) estimated a lower depletion ($B_{11\%}$), but provided evidence of strong recent recruitment not yet recruited to the spawning population. This analysis was used to inform the darkblotched rockfish rebuilding plan adopted under Amendment 16-2, which established a target rebuilding year of 2030 and a fishing mortality rate of F = 0.027. A revised darkblotched rockfish rebuilding plan was implemented in 2004 that specified a higher harvest rate (F = 0.032) to avoid negative socioeconomic impacts.

The 2005 full darkblotched rockfish assessment estimated a spawning stock depletion of 16 percent of unfished biomass at the start of 2005 (Rogers 2005a). The assessment estimated strong recruitment of the 1999 and 2000 year classes. The 2005 rebuilding analysis (Rogers 2005b) was used to inform a revised rebuilding plan adopted under Amendment 16-4 and implemented in 2007. The revised rebuilding plan specified a target year of 2011 and a constant harvest rate strategy (SPR = 60.7 percent).

The 2007 darkblotched rockfish assessment estimated a stock depletion of 22.7 percent at the start of 2007 (Hamel 2008c). The 2007 darkblotched rockfish rebuilding analysis (Hamel 2008a) predicted the median time to rebuild would be 19 years later than the target year of 2011 under the SPR harvest rate adopted under Amendment 16-4. The Council revised the Amendment 16-4 rebuilding plan by specifying a target year to rebuild the stock of 2028 and decreasing the harvest rate (SPR = 62.1 percent).

The 2007 darkblotched rockfish assessment was updated in 2009 and 2011. The 2009 stock assessment update estimated a stock depletion of 27.5 percent at the start of 2009 (Wallace and Hamel 2009). The 2009 darkblotched rockfish rebuilding analysis (Wallace 2009) was used to inform a revised rebuilding plan, which was implemented in 2011 The revised rebuilding plan specified a target year to rebuild the stock of 2025 and decreased the harvest rate to SPR = 64.9 percent. The 2011 stock assessment update estimated a stock depletion of 30.2 percent at the start of 2009 (Stephens, *et al.* 2011). No revisions to the rebuilding plan were made based on the 2011 assessment update and accompanying rebuilding plan (Stephens 2011).

A full darkblotched rockfish stock assessment in 2013 (Gertseva and Thorson 2013) estimated a stock depletion of 36 percent at the start of 2013 (Figure 2-38). The assessment also predicted the stock would be rebuilt by the start of 2015. The improved stock status and rebuilding outlook were largely attributed to 1) reduced fishing mortality under the rebuilding program; 2) inferences that follow from more favorable perceptions of steepness, fecundity, and age at maturity of the stock; and 3) length and age data indicating relatively large recruitments in 1999, 2000, and 2008.

A full assessment of darkblotched rockfish conducted in 2015 (Gertseva*, et al.* 2015) estimated a stock depletion of 39 percent at the start of 2015 or just under the 40 percent target. Revisions that were made to the data used for stock assessment included 1) a new method of index standardization for NWFSC trawl survey using a geo-statistical delta-GLMM, 2) a new steepness value based on an updated meta-analysis of steepness, 3) a new value for natural mortality, 4) an updated maturity at length relationship, 5) a re-estimated length-weight relationship, and 6) additional ageing data. Changes to the assessment model were relatively minor but included a change from two fleets to three fleets, with the at-sea hake fishery now modeled as a separate fishery, and a change from asymptotic selectivity for the shore-based fishery to dome-shaped selectivity.

A 2017 update to the 2015 full assessment of darkblotched rockfish was conducted (Wallace and Gertseva 2018), which estimated stock depletion at 40.03 percent at the start of 2017 or over the B_{MSY} proxy of $B_{40\%}$. Changes to the model include revision of the historical catch estimates, new length and age data, and an updated prior on steepness. The SSC endorsed the update assessment as a category 1 assessment.

The Council adopted the default harvest control rule of ACL = ABC (P* = 0.45) for darkblotched rockfish to inform harvest specifications in 2019 and beyond. A catch only-projection of darkblotched rockfish was provided to inform harvest specifications for 2023 and beyond.

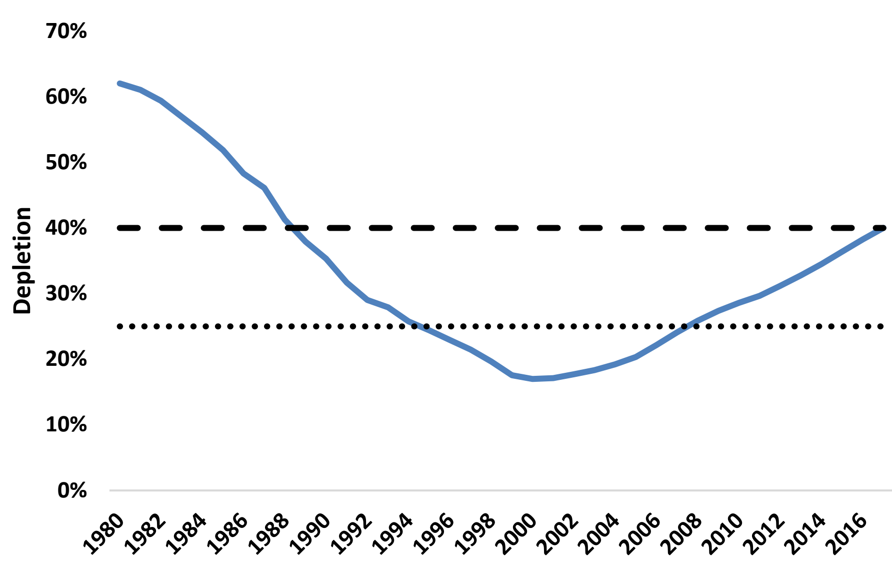

Figure 2-41. Relative depletion of darkblotched rockfish from 1980 to 2017 based on the 2017 stock assessment update.

Stock Productivity

Wallace and Gertseva (2018) fixed steepness at its prior mean of 0.72. This prior was estimated using a likelihood profile approximation to a maximum marginal likelihood mixed-effect model for steepness from ten category 1 rockfish species off the U.S. West Coast (Pacific ocean perch, bocaccio, canary rockfish, chilipepper, black, darkblotched rockfish, gopher, splitnose, widow, and yellowtail rockfish). This likelihood profile model is intended to synthesize observation-level data from assessed species, while avoiding the use of model output and thus improving upon previous meta-analyses (Dorn 2002a; Forrest*, et al.* 2010). This methodology has been simulation tested and has been recommended by the SSC for use in stock assessments.

Recruitment was modeled in the 2017 assessment assuming a Beverton-Holt relationship and recruitment deviations were informed by data from 1960 to 2013. Recent strong year classes include 1999, 2008, and 2013 with 2013 being the largest estimated in the time series (Figure 2-39). Stock abundance is predicted to continue to increase as these cohorts recruit into the fishery and spawning population.

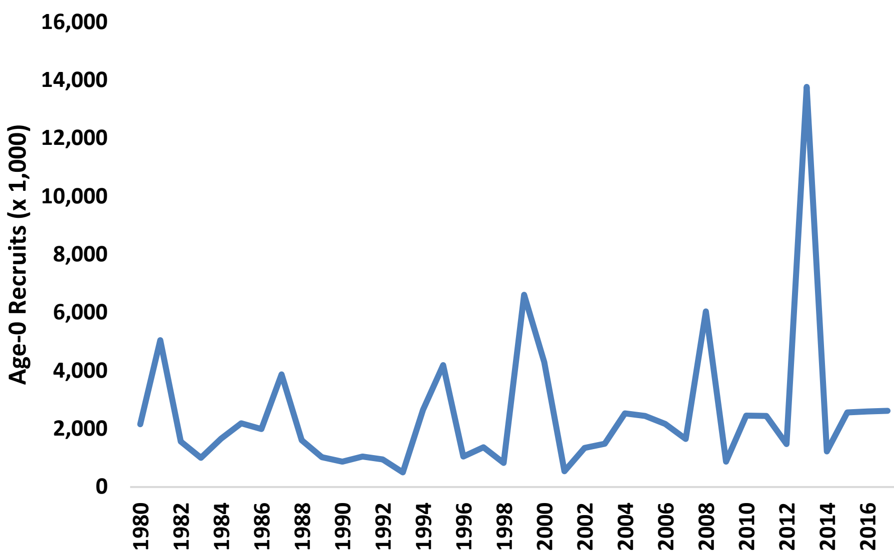

Figure 2-42. Estimated recruitments of darkblotched rockfish, 1980-2017.

Fishing Mortality

Historically, the darkblotched rockfish was fished beyond the F_{MSY} threshold of $F_{50\%}$ between 1966 and 1968, during the peak years of the Pacific ocean perch fishery, in 1973, and for a prolonged period between from 1981 and 2000 (Figure 2-40). The spawning output of darkblotched rockfish dropped below the B_{MSY} target for the first time in 1989, as a result of intense fishing by foreign and domestic fleets (Figure 2-38). It continued to decline and reached the level of 17 percent of its unfished output in 2000. Since 2000, when the stock was declared overfished, the spawning output slowly increased primarily due to management regulations implemented for the stock. The 2017 assessment indicated the stock had attained the B_{MSY} target of $B_{40\%}$ by the start of 2017 and the stock was declared rebuilt in June 2017.

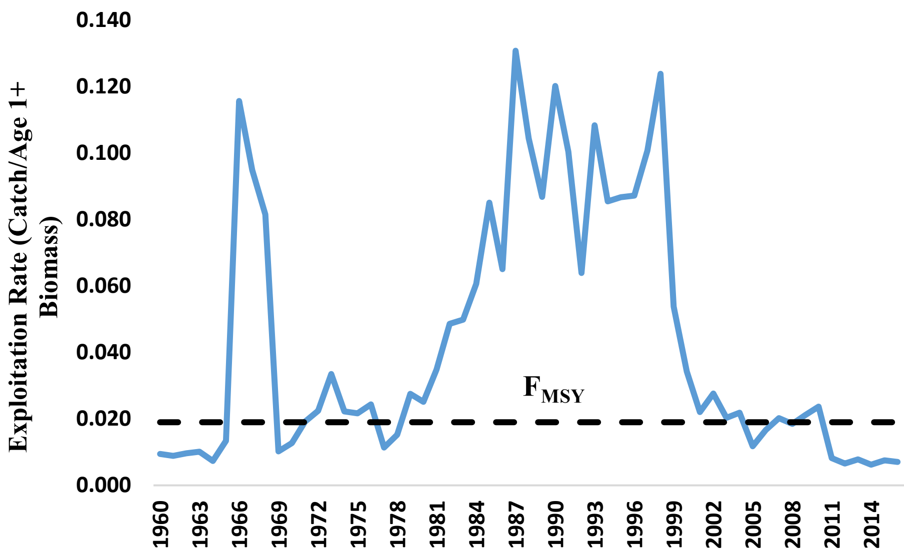

Figure 2-43. Time series of estimated exploitation rates (catch/age 1+ biomass) of darkblotched rockfish, 1960-2016 relative to the exploitation rate corresponding to F_{MSY} (SPR = 50%).

2.4.12 Dover Sole

Distribution and Life History

Dover sole (*Microstomus pacificus*) are distributed from the Navarin Canyon in the northwest Bering Sea and westernmost Aleutian Islands to San Cristobal Bay, Baja California, Mexico (Hagerman 1952; Hart 1988; NOAA 1990). Dover sole are a dominant flatfish on the continental shelf and slope from Washington to Southern California. Adults are demersal and are found from 9 m to 1,450 m, with highest abundance below 200 m to 300 m (Allen and Smith 1988). Adults and juveniles show a high affinity toward soft bottoms of fine sand and mud. Juveniles are often found in deep nearshore waters. Dover sole are considered to be a migratory species. In the summer and fall, mature adults and juveniles can be found in shallow feeding grounds, as shallow as 55 m off British Columbia (Westrheim and Morgan 1963). By late fall, Dover sole begin moving offshore into deep waters (400 m or more) to spawn. Although there is an inshore-offshore seasonal migration, little north-south coastal migration occurs (Westrheim and Morgan 1963).

Spawning occurs from November through April off Oregon and California in waters 80 m to 550 m depth at or near the bottom (Hagerman 1952; Hart 1988; NOAA 1990; Pearcy*, et al.* 1977). Dover sole are oviparous and fertilization is external. Larvae are planktonic and are transported to offshore nursery areas by ocean currents and winds for up to two years. Settlement to benthic living occurs mid-autumn to early spring off Oregon, and February through July off California (Markle*, et al.* 1992). Juvenile fish move into deeper water with age and begin seasonal spawning and feeding migrations upon reaching maturity.

Dover sole larvae eat copepods, eggs, and nauplii, as well as other plankton. Juveniles and adults eat polychaetes, bivalves, brittle stars, and small benthic crustaceans. Dover sole feed diurnally by sight and smell (Dark and Wilkins 1994; Gabriel and Pearcy 1981; Hart 1988; NOAA 1990). Dover sole larvae are eaten by pelagic fishes like albacore, jack mackerel and tuna, as well as sea birds. Juveniles and adults are preyed upon by sharks, demersally feeding marine mammals, and to some extent by sablefish (NOAA 1990). Dover sole compete with various eelpout species, rex sole, English sole, and other fishes of the mixed species flatfish assemblage (NOAA 1990).

Stock Status and Management History

Dover sole have been the target of trawl operations along the West Coast of North America since World War II and were almost certainly caught prior to the war as incidental take in directed fisheries for English sole and petrale sole. Almost all of the harvests have been taken by groundfish trawl, and in particular as part of the Dover sole, shortspine thornyhead, longspine thornyhead, and sablefish (DTS) trawl strategy. Annual landings from U.S. waters averaged 6,700 mt during the 1960s, 12,800 mt during the 1970s, 18,400 mt during the 1980s, 12,400 mt during the 1990s, and 7,200 mt since 2000.

The 1997 Dover sole stock assessment (Brodziak*, et al.* 1997) treated the entire population from the Monterey area through the U.S.-Vancouver area as a single stock based on research addressing the genetic structure of the population. Under a range of harvest policies and recruitment scenarios, the 1997 model projected that spawning biomass would increase from the estimated year-end level in 1997 through the year 2000 due to growth of the exceptionally large 1991 year class and to the lower catches observed in the fishery since 1991.

Dover sole were next assessed in 2001, resulting in an estimated spawning stock size of 29 percent of the unexploited biomass (Sampson and Wood 2001). The unexploited spawning stock biomass was estimated to be 176,500 mt and the stock steadily declined from the 1950s until the mid-1990s with little subsequent variation. The 1991 year class was the last strong one estimated in that assessment, consistent with the 1997 assessment.

The 2005 Dover sole assessment indicated the stock was above target levels and had an increasing abundance and biomass trend since the late 1990s (Sampson 2005). The final base model estimated the unexploited spawning stock biomass to be slightly less than 300,000 mt and spawning biomass at the start of 2005 was estimated to be about 189,000 mt, equivalent to 63 percent of the unexploited level. Spawning biomass and age 5+ biomass (roughly corresponding to the exploitable biomass) were estimated to have reached their lowest points in the mid-1990s and rose steadily since. The estimated increases in biomass since the mid-1990s were due primarily to strong year classes in 1990 and 1991, and exceptionally strong year classes in 1997 and 2000.

A new Dover sole assessment was done in 2011, which indicated the stock was healthy with a 2011 spawning stock biomass depletion of 83.7 percent of unfished biomass (Hicks and Wetzel 2011). The assessment was based on the length- and age-structured model developed in SS. The data included fishery landings, length and age data, as well as abundance indices from the NMFS AFSC triennial slope surveys, and from the NWFSC slope and shelf/slope surveys. The extension of the NWFSC shelf/slope survey was new to this assessment and added a considerable amount of information, including age data, which were fit in the model as conditional age-at-length vectors. Also, recent data on discarding collected by the West Coast Groundfish Observer Program

(WCGOP), including length data, were used to determine retention curves and selectivity for the commercial fleets.

A major difference between the 2011 and 2005 assessments is that the current estimate of annual natural mortality is 0.117 for males and 0.114 for females, as opposed to 0.09 for both in the last assessment. These estimates made use of a prior probability distribution developed by Dr. Owen Hamel. A lognormal distribution was used to characterize the variability of length-at-age. In addition, selectivity curves for the slope surveys were modeled using cubic splines which allows for a greater possibility of shapes. Lastly, the female selectivity curves were not forced to asymptote at one, allowing for the possibility of differential sex selection.

A new assessment of Dover sole in 2021 estimated a depletion of 79 percent at the start of 2021 (Wetzel 2021; Figure 2-41). Results from this assessment were consistent with those from the 2011 assessment. Model estimates show that the scale of the spawning biomass is uncertain and that the stock size is well above the target reference point and has been above the target reference point throughout the duration of the fishery. The scale of the estimates of stock size are lower than from the 2011 assessment, driven by improved parameterization of survey selectivity (double normal and sex-specific). There are several sources of uncertainty in the model, including the level of recruitment variability, sensitivity to the treatment of natural mortality (M), and sensitivity to alternative selectivity parameterizations.

The default harvest control rule for Dover Sole is ABC based on a category 1 sigma and a P* of 0.45 and an ACL of 50,000 mt. An annual catch of 50,000 mt can be sustained through 2024. The harvest control rule defaulted to ACL = ABC (P* = 0.45) beginning in 2025 since the ABC is predicted to be less than 50,000 mt.

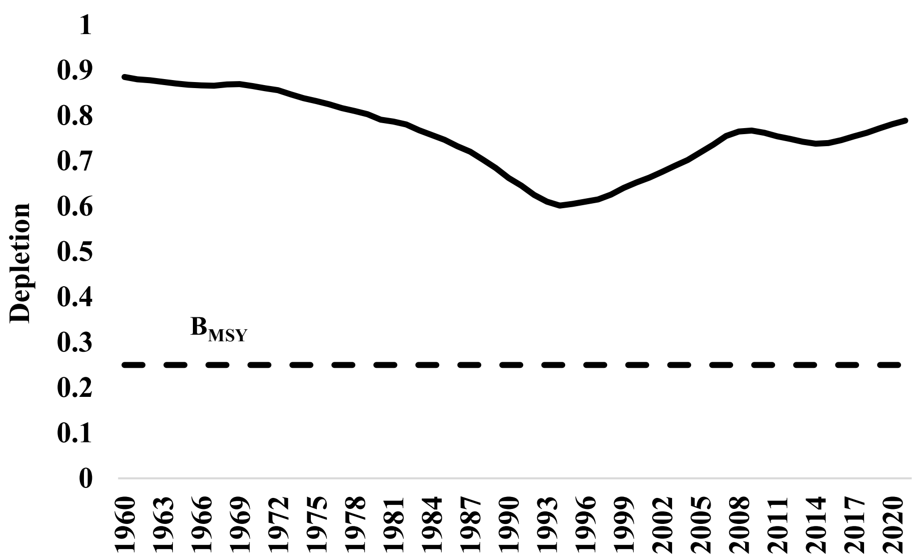

Figure 2-44. Relative depletion of Dover sole from 1960 to 2021 based on the 2021 stock assessment.

Stock Productivity

Steepness in the 2021 Dover sole assessment was fixed at 0.8, the mean steepness estimated in the SSC's 2010 meta-analysis of flatfish productivity (PFMC and NMFS 2011). While the 2021 assessment was considered data-rich, estimates of steepness are uncertain partly because the stock has not been fished to low levels to understand potential recruitment at low spawning biomass. The PSA productivity score of 1.8 indicates a stock of relatively high productivity.

Recruitment deviations were estimated to be above average in the late 1990s, below average in the early 2000s, and then generally above average between 2008-2012 (Figure 2-42). Years with the highest recruitment deviations were estimated to have occurred in 2000 and 2009 with the lowest between 2003 - 2005. The stock is predicted to have never fallen to low enough levels that the effects of steepness are obvious.

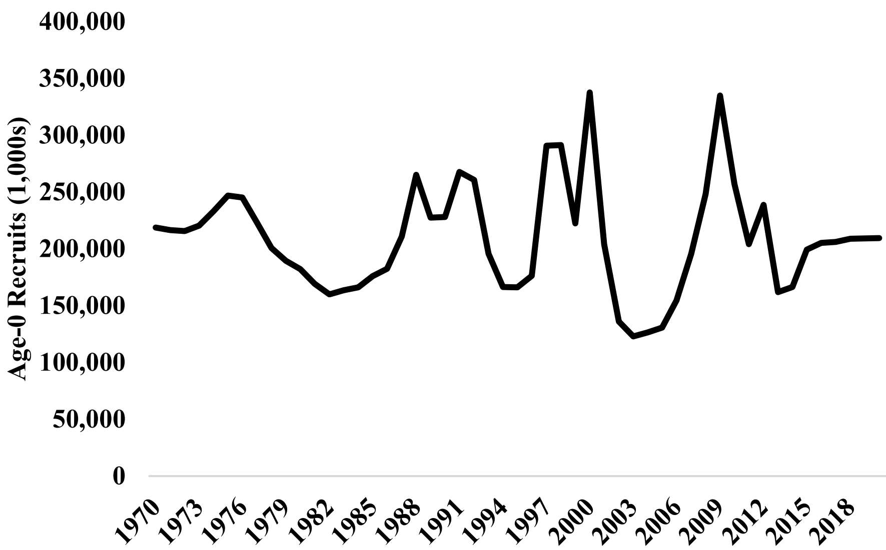

Figure 2-45. Estimated recruitments of Dover sole, 1970-2020.

Fishing Mortality

The spawning biomass of Dover sole reached a low in the mid-1990s before beginning to increase throughout the last decade. The estimated depletion has remained above the 25 percent biomass target and it is unlikely that the stock has ever fallen below this threshold. Throughout the 1970s, 1980s, and 1990s the exploitation rate and SPR generally increased, but never exceeded the SPR 30 percent F_{MSY} target (Figure 2-43). Recent exploitation rates on Dover sole have been much lower than F_{MSY}, even after management increased catch levels in 2007.

Sablefish quota is needed to target Dover sole and the other DTS species using trawl gear. Sablefish IFQ quota is also used in a single-species target fishery using fixed gears. The competition and price for sablefish quota are affected by Asian sablefish demand and supply from north Pacific fisheries outside the West Coast EEZ (e.g., BC and the Gulf of Alaska fisheries). It may be the case that the supply and demand of West Coast Dover sole will remain limited until there is an increased harvestable surplus of sablefish above recent levels.

Dover sole are caught primarily by bottom trawls and are managed using IFQs in the rationalized fishery. Despite Dover sole being an important target species, an average of 15 percent of the annual quota has been attained on average (2011-2019) in the IFQ fishery.

The PSA vulnerability score of 1.54 indicates a low risk of overfishing.

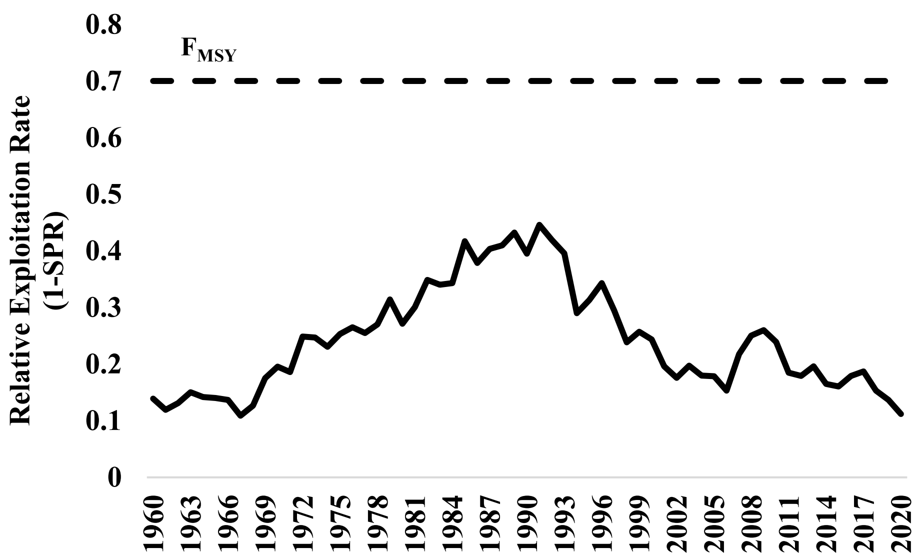

Figure 2-46. Estimated annual relative exploitation rate of West Coast Dover sole relative to the current proxy F_{MSY} target, 1960-2020.

2.4.13 English Sole

Distribution and Life History

English sole (*Parophrys vetulus*) are found from Nunivak Island in the southeast Bering Sea and Agattu Island in the Aleutian Islands, to San Cristobal Bay, Baja California Sur, Mexico (Allen and Smith 1988). In research survey data, nearly all occurred at depths greater than 250 m (Allen and Smith 1988). Adults and juveniles prefer soft bottoms composed of fine sands and mud (Ketchen 1956), but also occur in eelgrass habitats (Pearson and Owen 1992). English sole use nearshore coastal and estuarine waters as nursery areas (Krygier and Pearcy 1986; Rogers*, et al.* 1988). Adults make limited migrations. Those off Washington show a northward post-spawning migration in the spring on their way to summer feeding grounds and a southerly movement in the fall (Garrison and Miller 1982). Tagging studies have identified separate stocks based on this species' limited movements and meristic characteristics (Jow 1969).

Spawning occurs over soft-bottom mud substrates (Ketchen 1956) from winter to early spring, depending on the stock. Eggs are neritic and buoyant, but sink just before hatching (Hart 1988); juveniles and adults are demersal (Garrison and Miller 1982). Small juveniles settle in the estuarine and shallow nearshore areas all along the coast, but are less common in southerly areas, particularly south of Point Conception. Large juveniles commonly occur up to depths of 150 m. Although many post larvae may settle outside of estuaries, most will enter estuaries during some part of their first year of life (Gunderson, et al. 1990). Some females mature as three-year-olds (26 cm), but all females over 35 cm long are mature. Males mature at two years (21 cm). Females attain much larger sizes than males. Landings by the fishery are composed primarily of female fish, but at-sea discards of small fish include large numbers of male English sole.

Larvae are planktivorous. Juveniles and adults are carnivorous, eating copepods, amphipods, cumaceans, mysids, polychaetes, small bivalves, clam siphons, and other benthic invertebrates (Allen 1982; Becker 1984; Hogue and Carey 1982; Simenstad, *et al.* 1979). English sole feed primarily by day, using sight and smell, and sometimes dig for prey (Allen 1982; Hulberg and Oliver 1979). A juvenile English sole's main predators are piscivorous birds such as great blue heron (*Ardia herodias*), larger fishes, and marine mammals. Adults may be eaten by marine mammals, sharks, and other large fishes.

Stock Status and Management History

English sole have been captured by the bottom trawl fishery operating off the western coast of North America for over a century. Stewart (2006) found that peak catches from the southern area occurred in the 1920s with a maximum of 3,976 mt of English sole landed in 1929, and peak catches from the northern area occurred in the 1940s to the 1960s with a maximum of 4,008 mt landed in 1948. Landings from both areas have generally declined since the mid-1960s and have been at nearly historical lows in recent years.

The first English sole stock assessment was conducted in the INPFC Columbia and U.S. Vancouver areas and used Virtual Population Analysis (Golden, *et al.* 1986). This model covered only the years 1966 to 1983. A dynamic pool model was used to get an estimate of MSY based on the recruitments produced by the cohort analysis. Many previous studies using cohort analysis and CPUE statistics have been conducted. Of note from these analyses was that they identified a very large year class in 1961 (Hayman, *et al.* 1980).

The next West Coast assessment of English sole was conducted in 1993 (Sampson and Stewart 1993). That assessment considered the female portion of the stock off Oregon and Washington during the years 1977-1993 because the landings were dominated by females (greater that 90 percent by weight). The English sole spawning biomass was found to be increasing and it was concluded that the fishery was sustainable at (then) contemporary harvest levels.

The 2005 assessment of English sole (Stewart 2006) modeled a single coastwide stock, although both commercial and fishery independent data sources were treated separately for a southern (INPFC Conception and Monterey) and a northern (INPFC Eureka, Columbia and U.S. Vancouver) area. The assessment found that English sole spawning biomass had increased rapidly over the last decade after a period of poor recruitments from the mid-1970s to the mid-1990s, which left the stock at nearly historically low levels. Strong year classes were estimated for 1995, 1996, and 1999. The data indicated that the 1999 year class may be the largest in the time-series. There was substantial uncertainty related to certain parameters in the assessment, specifically biomass, recruitment, and relative depletion, as indicated by the wide confidence intervals for those parameters. Nevertheless, sensitivity analyses indicated that the conclusion that current spawning biomass exceeds the target level ($B_{40\%}$) was robust to all three of these sources of uncertainty. The spawning biomass at the beginning of 2005 was estimated to be 31,379 mt, which corresponds to 91.5 percent of the unexploited equilibrium level.

The 2007 update assessment (Stewart 2008c) confirmed the magnitude of increased biomass through a large quantity of age data through 2006, which became available. The 2007 assessment also included data on fishery length and age (primarily from Washington) that was previously unavailable. These new data provided substantially improved information regarding recent year class strengths and current stock status. The spawning biomass at the beginning of 2007 was estimated to be 41,906 mt, which corresponded to 116 percent of the unexploited equilibrium level.

Cope et al. (2014) assessed English sole using the data-moderate exSSS model platform. The English sole assessment was conducted for a coastwide stock and stock depletion was estimated to be 88 percent at the start of 2013 (Table 2-4). The current spawning biomass was estimated to be 25,719 mt. Since the new English sole assessment was conducting using data-moderate methods, the stock was downgraded from a category 1 to a category 2 stock.

The Council adopted the default harvest control rule of ACL = ABC (P* = 0.45) for English sole in 2019-2020. The 2019 and 2020 English sole ABCs and ACLs are 10,090 mt and 10,135 mt, respectively.

Stock Productivity

There is little evidence for a strong stock-recruitment relationship, with some of the largest recruitments occurring at moderate levels of spawning biomass. This corresponds to the relatively high estimate of steepness of 0.8-0.87 in recent assessments. In general, recruitment deviations are well-informed by the data between 1940 and 2000.

Following two decades of low recruitments, strong year classes were estimated for 1995, 1998-2000, and 2002. The data indicate that the 1999 year class was the largest in the time-series.

The PSA productivity score of 2.25 indicates a very productive stock, which is true for most nearshore and shelf flatfishes.

Fishing Mortality

The estimated SPR for English sole has never been below the proxy target of 30 percent for flatfish. Exploitation rates were highest from the late 1940s to the early 1990s. Since 1992, the intensity of exploitation has been substantially less, resulting in higher SPR levels. This corresponds to a relative exploitation rate (catch/biomass of age 3 and older fish) history that is high from the late 1940s to the early 1990s, and steadily declining to very low levels over the last 15 years.

English sole are primarily caught by groundfish bottom trawls. Management uncertainty is low with the 100 percent observer coverage for the groundfish trawl fleet under trawl rationalization. Very small amounts of English sole were landed in the 2011 IFQ fishery with only 1 percent of the quota attained. This is due to low trawl effort on the shelf since such efforts require investment of limited quota for Pacific halibut, darkblotched rockfish, and yelloweye rockfish.

The PSA vulnerability score of 1.19 shows a very low concern of overfishing on the stock.

2.4.14 Lingcod North and South of 40°10' N. Lat.

Distribution and Life History

Lingcod (*Ophiodon elongatus*), a top order predator of the family *Hexagrammidae*, ranges from Baja California, Mexico, to Kodiak Island in the Gulf of Alaska. Lingcod are demersal at all life stages (Allen and Smith 1988; NOAA 1990; Shaw and Hassler 1989). Adult lingcod prefer two main habitat types: slopes of submerged banks 10 m to 70 m below the surface with seaweed, kelp, and eelgrass beds and channels with swift currents that flow around rocky reefs (Emmett*, et al.* 1991; Giorgi and Congleton 1984; NOAA 1990; Shaw and Hassler 1989). Juveniles prefer sandy substrates in estuaries and shallow subtidal zones (Emmett*, et al.* 1991; Hart 1988; NOAA 1990). As the juveniles grow, they move to deeper waters. Adult lingcod are considered a relatively sedentary species, but there are reports of migrations of greater than 100 km by sexually immature fish (Jagielo 1990; Mathews and LaRiviere 1987; Matthews 1992; Smith*, et al.* 1990).

Mature females live in deeper water than males and move from deep water to shallow water in the winter to spawn (Forrester 1969; Hart 1988; Jagielo 1990; LaRiviere*, et al.* 1980; Mathews and LaRiviere 1987; Matthews 1992; Smith*, et al.* 1990). Mature males may live their whole lives associated with a single rock reef, possibly out of fidelity to a prime spawning or feeding area (Allen and Smith 1988; LaRiviere*, et al.* 1980; Shaw and Hassler 1989). Spawning generally occurs over rocky reefs in areas of swift current (Adams 1986; Adams and Hardwick 1992; Giorgi and Congleton 1984; LaRiviere*, et al.* 1980). After the females leave the spawning grounds, the males remain in nearshore areas to guard the nests until the eggs hatch. Hatching occurs in April off Washington, but as early as January and as late as June at the geographic extremes of the lingcod range. Males begin maturing at about two years (50 cm), whereas females mature at three plus years (76 cm). In the northern extent of their range, fish mature at an older age and larger size (Emmett*, et al.* 1991 Adams, 1992 #438; Hart 1988; Mathews and LaRiviere 1987; Miller and Geibel 1973; Shaw and Hassler 1989). The maximum age for lingcod is about 20 years (Adams and Hardwick 1992).

Lingcod are a visual predator, feeding primarily by day. Larvae are zooplanktivores (NOAA 1990). Small demersal juveniles prey upon copepods, shrimps, and other small crustaceans. Larger juveniles shift to clupeids and other small fishes (Emmett*, et al.* 1991; NOAA 1990). Adults feed primarily on demersal fishes (including smaller lingcod), squids, octopi, and crabs (Hart 1988; Miller and Geibel 1973; Shaw and Hassler 1989). Lingcod eggs are eaten by gastropods, crabs, echinoderms, spiny dogfish, and cabezon. Juveniles and adults are eaten by marine mammals, sharks, and larger lingcod (Miller and Geibel 1973; NOAA 1990).

Stock Status and Management History

Lingcod have been a target of commercial fisheries since the early 1900s in California, and since the late 1930s in Oregon and Washington waters. Recreational fishermen have targeted lingcod since the 1920s in California. A smaller recreational fishery has taken place in Washington and Oregon since at least the 1970s. Although historically the catches of lingcod have been greater in the commercial sector than in the recreational sector, this pattern has been reversed since the late 1990s.

In 1997, Jagielo, et al. (1997) assessed the size and condition of the portion of the stock in the Columbia and Vancouver areas (including the Canadian portion of the Vancouver management area), and concluded the stock had fallen to below ten percent of its unfished size at 8.8 percent of its unfished biomass. The Council responded by imposing substantial harvest reductions coastwide, reducing the harvest targets for the Eureka, Monterey, and Conception areas by the same percentage as in the north.

In 1999, Adams, et al. (1999) assessed the southern portion of the stock and concluded the condition of the southern stock was similar to the northern stock with a depletion of $B_{15\%}$, thus confirming the Council had taken appropriate action to reduce harvest coastwide. Based on these assessments, the lingcod stock was declared overfished in 1999. A rebuilding plan establishing a target year of 2009 and harvest rates of F = 0.0531 and F = 0.0610 for fisheries in the northern and southern areas, respectively was adopted and implemented in 2000.

Jagielo et al. (2000) conducted a coastwide lingcod assessment and determined the total biomass increased from 6,500 mt in the mid-1990s to about 8,900 mt in 2000. In the south, the population had also increased slightly from 5,600 mt in 1998 to 6,200 mt in 2000. In addition, the assessment concluded previous aging methods portrayed an older population, whereas new aging efforts showed the stock to be younger and more productive. Therefore, the ABC and OY were increased in 2001 on the basis of the new assessment. A revised rebuilding analysis of coastwide lingcod (Jagielo and Hastie 2001) confirmed the major conclusions of the 2000 assessment and rebuilding analysis, but slightly modified recruitment projections to stay on the rebuilding trajectory to reach target biomass in 2009.

The lingcod rebuilding plan was formally adopted by the Council and incorporated into the FMP under Amendment 16-2. The rebuilding plan established a target rebuilding year of 2009 and the harvest control rule of F = 0.0531 for fisheries in the northern areas and F = 0.0610 for fisheries in the southern areas (with a P_{MAX} of 60 percent). Depth-based restrictions and a winter season fishing closure to protect nest-guarding males were also implemented as part of the rebuilding plan.

Jagielo et al. (2004) conducted a coastwide assessment for lingcod in 2003 that indicated the lingcod stock had achieved the rebuilding objective of $B_{40\%}$ in the north with a 68 percent depletion, but was at a 31 percent depletion in the south. The Council's SSC, working in concert with the lead assessment author, recalculated the coastwide lingcod stock status in March 2004 using actual 2003 harvests (the assessment, which was completed during 2003, assumed harvest would be equal to the specified OY in 2003). Their calculations indicated that the spawning biomass at the start of 2004 was within 99.3 percent of B_{MSY} ($B_{40\%}$) on a coastwide basis. The harvest control rule was recalculated to be F = 0.17 for fisheries in the northern areas and F = 0.15 for fisheries in the southern areas.

The 2005 coastwide assessment (Jagielo and Wallace 2006) again modeled two populations of lingcod north and south of 40°10’ N. lat. On a coastwide basis, the lingcod population was concluded to be fully rebuilt, with the spawning biomass in 2005 estimated to be 64 percent of its unfished level. Within the separate area models, current biomass was estimated to be closer to unfished biomass in the north ($B_{87\%}$) than in the south ($B_{24\%}$). Given that the lingcod stock is managed on a coastwide basis, the Council announced the lingcod stock to be fully rebuilt in 2005, which is four years earlier than the target rebuilding year established in the rebuilding plan.

The 2009 lingcod assessment modeled two populations north and south of the California-Oregon border at 42° N. lat. (Hamel*, et al.* 2009). Both populations were healthy with stock depletion estimated at 62 and 74 percent for the north and south, respectively.

The Council and NMFS elected to maintain the management line for lingcod at 40°10' N. lat. by specifying separate ACLs north and south of that line. This action was intended to not overly encumber the commercial fishing industry, which is required to fish within a single management area within one trip. Specifying the lingcod management line at 42° N. lat. would create two management areas stratified at 40°10' N. lat. and 42° N. lat. This would especially burden vessels home ported out of Brookings, Crescent City, Eureka, and Ft. Bragg since they would have to restructure their current fishing practices to avoid a violation of the management line crossover provisions. It is stated in the 2009 assessment that a management break at Cape Mendocino would likely be more biologically accurate than stratifying the assessment north and south of 42° N. lat. In general, given the crossover provisions and the other regulations that foster area management strategies, the fewer latitudinal management lines there are, the less burdened the offshore commercial fishery will be. Two major biogeographic breaks occur on the West Coast at Pt. Conception at 34°27' N. lat. and Cape Mendocino approximately at 40°10' N. lat., and many stocks show differences north and south of these latitudes. These biogeographic breaks are probably the more appropriate latitudes to specify management lines, given how north-south physical processes such as current patterns tend to be different, creating stock differences for species affected by these different physical processes.

The lingcod STAT evaluated the swept area biomass estimates calculated annually (2003-2010) from the NMFS NWFSC trawl survey, which indicated that 48 percent of the lingcod biomass for the stock south of 42° N. lat. occurred between 40°10' N. lat. and 42° N. lat. Therefore, 48 percent of the 2013 and 2014 OFLs projected in the 2009 lingcod assessment for the southern lingcod stock were added to OFLs proposed for the stock north of 40°10' N. lat. Likewise, 48 percent of the projected OFLs for the southern stock were subtracted from the OFLs proposed for the stock south of 40°10' N. lat. Given that the trawl survey is the main fishery-independent tuning index of biomass in the assessment, using swept area biomass from the trawl survey to estimate relative biomass north and south of 40°10' N. lat. was considered appropriate.

New full assessments of lingcod were conducted in 2017 with northern (Washington and Oregon) and southern (California) stock assessments (Haltuch*, et al.* 2018). The 2017 assessments indicated the stock was healthy in the north with a depletion of 57.9 percent and in the precautionary zone in the south with a depletion of 32.9 percent at the start of 2017. A number of revisions relative to the previous assessment were made to the data used for these stock assessments including: 1) shifting the start of the assessment to 1889, 2) splitting the commercial fleet into trawl and fixed gear components and the northern recreational fleet into Oregon and Washington components, 3) re-analysis of commercial fishery CPUE data and the Alaska Fisheries Science Center Triennial survey index using vector autoregressive spatial temporal (VAST) software, 4) addition of three fishery-dependent and one fishery-independent CPUE indices, 5) updating length-weight relationships and the prior on natural mortality, 6) new maturity relationship based on recent data collections, 7) re-estimating ageing error from double read age data, and 8) updating landings and composition data. The main model structure changes from the last assessment were the addition of selectivity parameters for fleets that were split by gear or geographic area, altering the plus and minus groups for length and age composition bins, and constructing a broader set of time blocks for selectivity. Also, conditional age-at-length composition data were directly incorporated into the model. The SSC endorsed these assessments as category 1 assessments in both areas.

The 2019 and 2020 harvest specifications were projected from the 2017 assessment. The relative biomass of lingcod (and subsequently the OFLs, ABCs, and ACLs) were reapportioned from the assessment area stratification north and south of 42° N. lat. to the management area stratification north and south of 40°10’ N. lat. by using the most recent 5-year (2012-2016) average percentage of trawl survey lingcod biomass in California occurring north of 40°10’ N. lat. The analysis indicated 21.31 percent of the average survey biomass in California occurred north of 40°10’ N. lat. Therefore, 21.31 percent of the projected harvest specifications from the southern assessment area were apportioned to the lingcod north of 40°10’ N. lat. harvest specifications.

New assessments for lingcod north and south of 40°10’ N. lat. were conducted in 2021. The northern lingcod assessment estimates the stock has never been overfished and currently at a depletion of 61 percent of unfished biomass (Figure 2-44, Taylor, 2021). The southern lingcod assessment estimates the stock declined below target levels from the late 1980s to early 2000s but increased since then due to a series of strong recruitment year-classes and was just below the management target with 39 percent depletion at the start of 2021 (Figure 2-45, Johnson, 2021).

In terms of differences between northern and southern models, estimated natural mortality (M) rates were 0.42/year and 0.41/year for females and males in the northern model whereas M values for the southern model were 0.17/year and 0.22/year for females and males, respectively. Steepness was also estimated and varied between northern and southern models, with higher estimates in the northern model at 0.80. While both models fit relative abundance indices well, there was considerable tension among many data sources, particularly between age and length composition data. The SSC designated both assessments category 2 and recommended full assessments be conducted the next time.

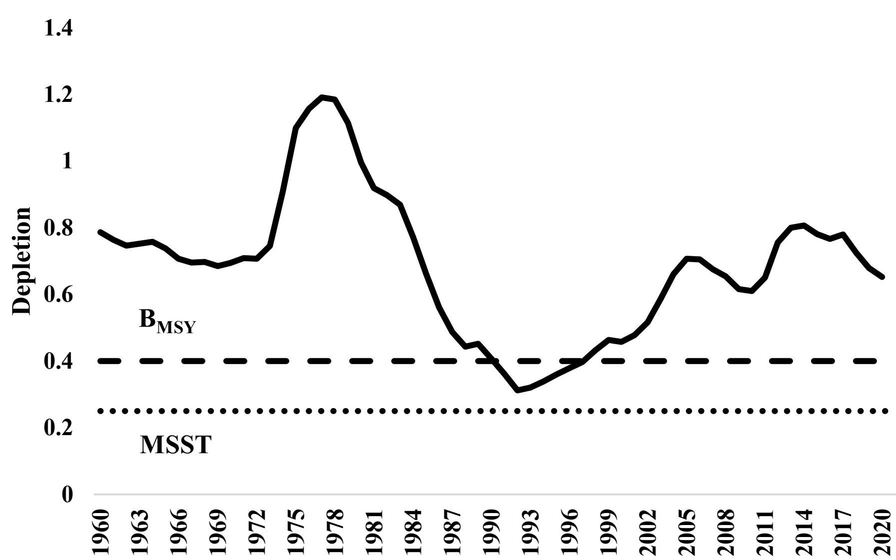

Figure 2-47. Relative depletion of lingcod north of 40°10’ N lat. from 1960 to 2021 based on the 2021 stock assessment.

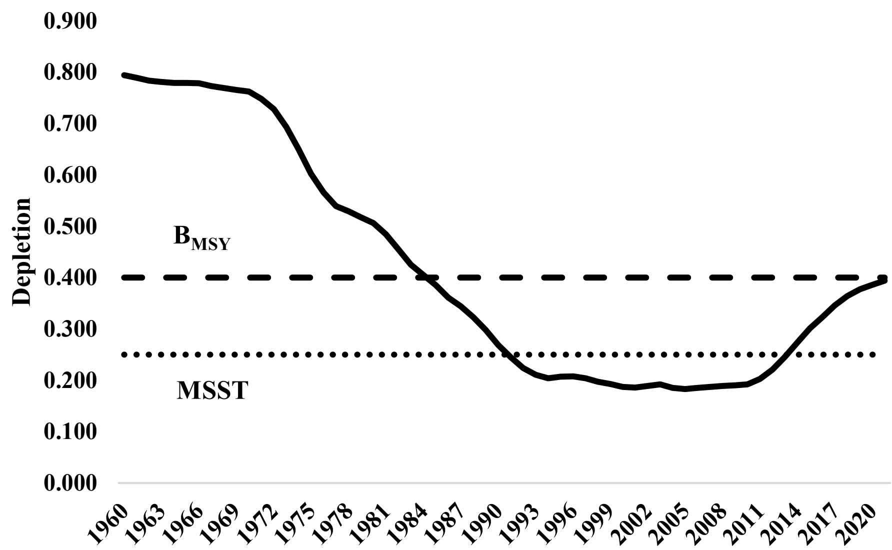

Figure 2-48. Relative depletion of lingcod south of 40°10’ N lat. from 1960 to 2021 based on the 2021 stock assessment.

Stock Productivity

Steepness and natural mortality were estimated using informed priors in the 2021 lingcod assessments. Estimates of key productivity parameters (i.e., M and h) differ significantly among the two areas, indicating that the southern stock is less productive than the northern stock (Table 2-5). Additionally, the north model estimates almost equal M for females and males (0.418 and 0.414 respectively), whereas the south model has a lower estimate of female M than male M (0.17 and 0.222). The M estimates are uncertain in both models, although more so in the south than the north. The PSA productivity score of 1.75 indicates a stock of relatively high productivity.

Lingcod appear to have moderate variability in estimates of recruitment with recruitment variability (σR) fixed at 0.6. Given the pandemic and the lack of recent survey information, there was little information in the data to estimate recruitment in 2019. The last large recruitment event for both the northern and southern lingcod stocks occurred in 2013 and a smaller event may have also occurred within the last half-decade though its magnitude is more uncertain (Figure 2-46 and Figure 2-47).

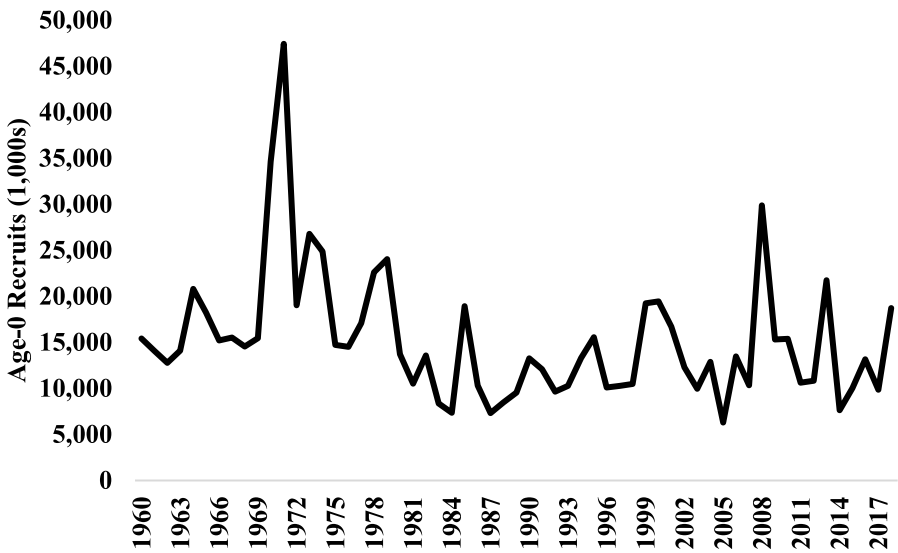

Figure 2-49. Estimated recruitments of lingcod north of 40°10' N lat., 1960-2018 from the 2021 assessment.

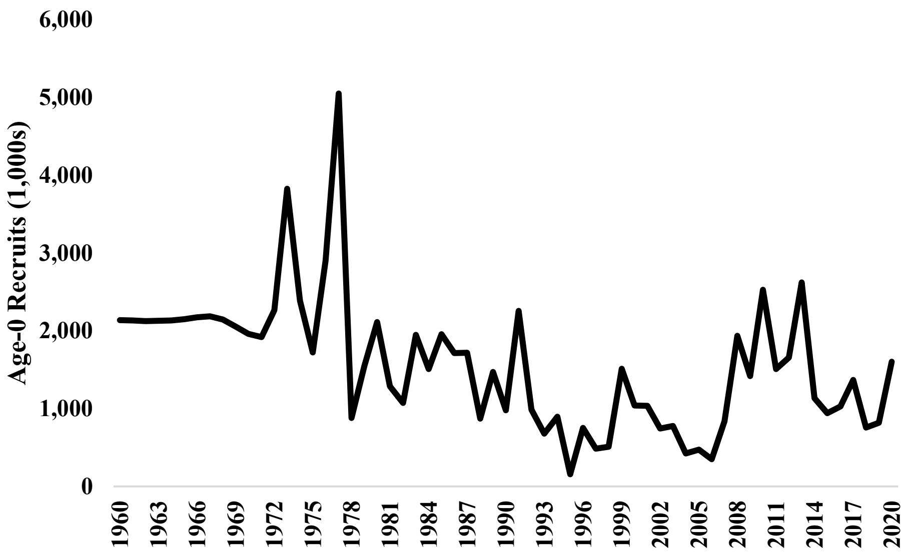

Figure 2-50. Estimated recruitments of lingcod south of 40°10' N lat., 1960-2018 from the 2021 assessment.

Fishing Mortality

The harvest rate in the north was estimated to have never been above the target proxy harvest rate (Figure 2-48). Recent estimates of fishing intensity indicate stability within the fishery and are close to pre-1950 estimates. The relative fishing intensity is estimated to have peaked in 1991.

The southern stock was estimated to have been harvested above the target proxy harvest rate from the 1970s to approximately the late 1990s and again in the early 2000s (Figure 2-49). The relative fishing intensity is estimated to have peaked in 1989. Recent estimates of harvest have all been below the target proxy harvest rate and the estimate of fishing intensity for the terminal year was the lowest estimated since 2011.

The PSA vulnerability score for lingcod is 1.55, indicating a low risk of overfishing of the stock.

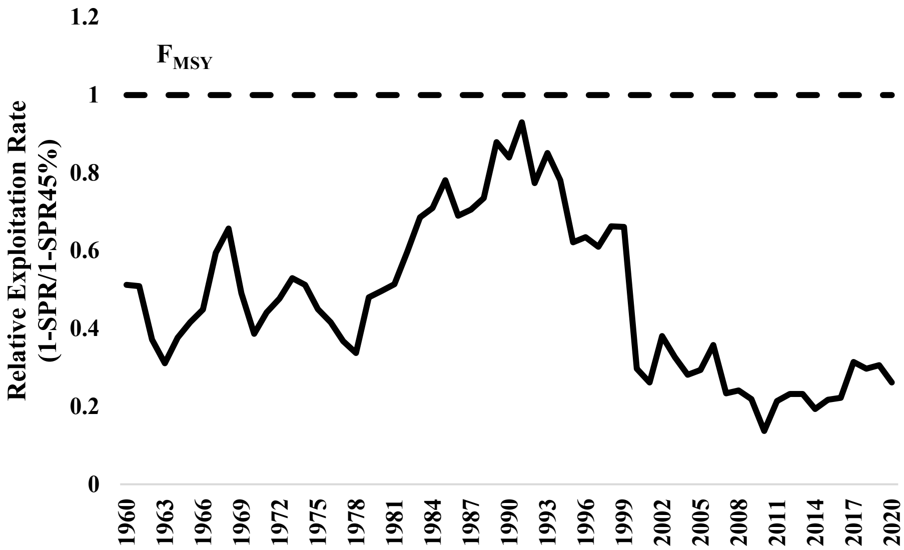

Figure 2-51. Estimated annual relative exploitation rate of lingcod north of 40°10’ N lat. relative to the current proxy F_{MSY} target, 1960-2020.

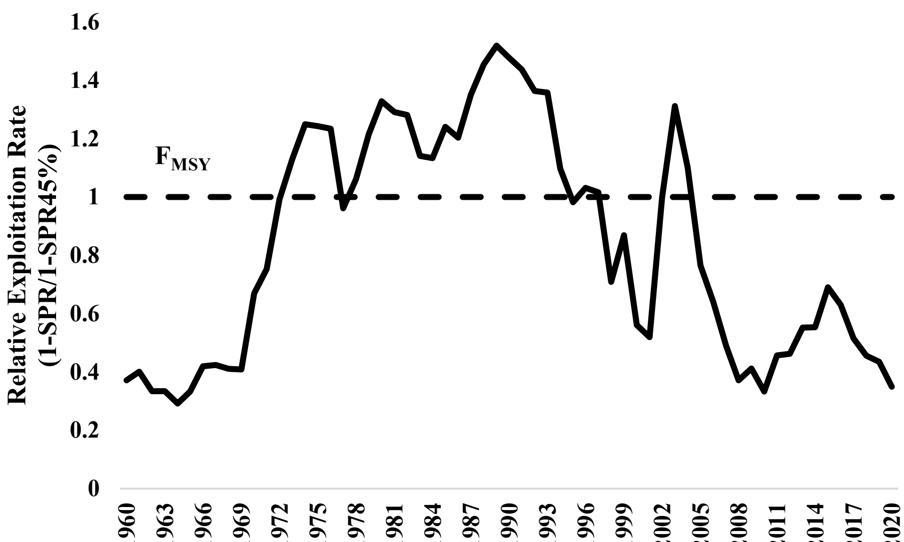

Figure 2-52. Estimated annual relative exploitation rate of lingcod south of 40°10’ N lat. relative to the current proxy F_{MSY} target, 1960-2020.

2.4.15 Longnose Skate

Distribution and Life History

Skates are the largest and most widely distributed group of batoid fish with approximately 245 species ascribed to two families (Ebert and Compagno 2007; McEachran 1990). Skates are benthic fish that are found in all coastal waters but are most common in cold temperatures and polar waters (Ebert and Compagno 2007).

There are about eleven species of skates from either of three genera (*Amblyraja*, *Bathyraja*, and *Raja*) present in the Northeast Pacific Ocean off California, Oregon, and Washington (Ebert 2003). Of that number, just three species (longnose skate *Beringraja rhina*, big skate *B. binoculata*, and sandpaper skate *Bathyraja interrupta*) make up over 95 percent of survey catches in terms of biomass and numbers, with the longnose skate leading in both categories (62 percent of biomass and 56 percent of numbers). Species compositions of fishery landings also show that longnose skate are the predominant skates in commercial catches. On average, longnose skate represents 75 percent of total skate landings in Oregon for the last 20 years and 45 percent in Washington for the last 10 years. There are no species composition data available for commercial landings in California, but anecdotal evidence suggests that the majority of skates landed there are longnose skates.

The distribution of the longnose skate is limited to the eastern Pacific Ocean. It is found from the southeastern Bering Sea to just below Punta San Juanico, southern Baja California, and Gulf of California at depths of 9-1,069 m (Love*, et al.* 2005). Longnose skates do not exhibit a size-specific pattern in distribution relative to bottom depth; average fish size does not vary greatly with depth.

Currently, there is no information available that indicates the existence of multiple breeding units in the Northeast Pacific Ocean. Several tagging studies have found that elasmobranchs, such as sharks and skates, can undertake extensive migrations within their geographic range (Martin and Zorzi 1993; McFarlane and King 2003). This behavior suggests the likelihood that there is a high degree of genetic mixing within the population, across its range. As a result, the longnose skate population off California, Oregon and Washington is modeled in this assessment as a single stock.

The life history of skates is characterized by late maturity, low fecundity and slow growth to large body size (King and McFarlane 2003; Moyle and Cech 1996; Walker and Hislop 1998). Skates invest considerable energy in developing a few large, well-protected embryos. These characteristics are associated with a K-type reproductive strategy, as opposed to r-type strategy, wherein reproductive success is achieved by high productivity and early maturity (Hoenig and Gruber 1990).

Longnose skate are oviparous. After fertilization, the female forms tough, but permeable egg cases that surround eggs and then deposits these egg cases onto the sea floor at daily to weekly intervals for a period of several months or longer (Hamlett and Koob 1999). The eggs within egg cases incubate for several months in a benthic habitat. Inside the egg cases, the embryos develop with nourishment provided by yolk. The longnose skate is known to have only a single embryo per egg case (David Ebert, Moss Landing Marine Laboratories, pers. com. as cited by Gertseva and Schirripa (2008)). When the yolk is depleted and the juvenile is fully formed, it exits the egg case. Once hatched, the young skate is similar in appearance to an adult, but smaller in size. Upon reaching maturity, skates enter the reproductive stage, which lasts for the remainder of their lives (Frisk*, et al.* 2002; Pratt and Casey 1990). On average off the continental U.S. Pacific Coast, female longnose skates mature between 11-18 years, which corresponds to 75-125 cm in total length (Thompson 2006). The life span of the longnose skate is not well known, although individuals up to 23 years of age have been found (Thompson 2006). Longnose skates attain a maximum length of about 145 cm, although individuals as large as 180 cm have been reported off the U.S. West Coast (Thompson 2006).

The reproductive cycle of oviparous skates has been observed for a few species but not for longnose skate. These studies indicate that egg production generally occurs throughout the year although there have been some instances where seasonality in egg laying was observed (Hamlett and Koob 1999). Information on fecundity of longnose skate is extremely limited. Holden (1974) found that species of the family *Rajidae* are the most fecund of all elasmobranchs and can lay 100 egg cases per year, although eggs may not be produced every year. Frisk et al. (2002) estimated that annual fecundity for skates similar in size with longnose may be less than 50 eggs per year; however, those eggs exhibit high survival rates due to the large parental investment. Overall, little is known about breeding frequency, egg survival, hatching success and other early life history characteristics of longnose skate.

Stock Status and Management History

Longnose skate was managed in a complex of dissimilar species, the Other Fish complex, from 1982, when the Groundfish FMP was implemented through 2008. In 2009, longnose skate was removed from the Other Fish complex and managed with stock-specific harvest specifications.

Gertseva and Schirripa (2008) assessed the West Coast longnose skate stock in 2007. The spawning stock biomass was estimated to be at 66 percent of its unfished biomass at the start of 2007. Based on that assessment, a constant catch strategy (OY = 1,349 mt) was implemented in 2009 based on a 50 percent increase in the average 2004-2006 landings and discard mortality. The constant catch strategy was revised in 2013 by implementing an ACL of 2,000 mt to provide greater access to the stock and to limit disruption of current fisheries. This level of harvest was projected to maintain the population at a healthy level as projected in the 10-year forecast for longnose skate in the 2007 assessment (Gertseva and Schirripa 2008).

The SSC recommended changing the proxy F_{MSY} rate for longnose skate and other elasmobranchs from an SPR of 45 percent to an SPR of 50 percent beginning in 2015. This recommendation, driven primarily by conservation concerns for spiny dogfish (see section 2.4.23), was adopted to determine OFLs in 2017 and beyond consistent with this lower harvest rate.

A new longnose skate assessment conducted in 2019 estimated stock depletion at 57 percent at the start of 2019 (Gertseva*, et al.* 2019). The assessment includes considerable improvements to landings and discard estimates relative to those in the 2007 assessment, a particular challenge for skate stocks given that landings were not routinely recorded to the species level prior to 2009. Natural mortality and the West Coast Groundfish Bottom Trawl (WCGBT) Survey catchability coefficient (q) are estimated using informative priors. The catchability of the WCGBT survey is used to set the low and high states of nature in the decision table.

The 2019 assessment estimates longnose skate spawning biomass has slowly declined from unfished levels at the start of the assessment in 1916, with a relatively flat trend from the early 2000s to present (Figure 2-50).

The SSC designated longnose skate as a category 2 stock given the lack of recruitment deviations in the assessment model, the model's inability to fit the indices, and the weak information content of the available data. The SSC recommended the next assessment could be an update, provided future fishing removals remain well below the OFL.

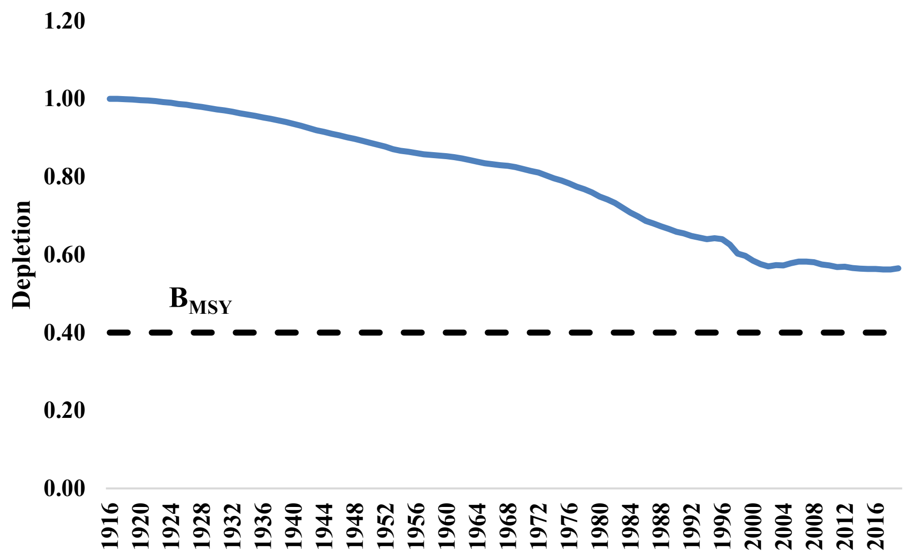

Figure 2-53. Relative depletion of longnose skate from 1916 to 2019 based on the 2019 stock assessment.

Stock Productivity

Steepness of the stock-recruitment curve was fixed at a value of 0.4 in the 2019 assessment to reflect the K-type reproductive strategy of the longnose skate. Recruitments were deterministically provided using this steepness value and a Beverton-Holt stock-recruitment relationship since the data in the 2019 assessment was not informative of relative year-class strength. In general, elasmobranchs have relatively low productivity given the K-type reproductive strategy of producing few eggs per female with a significant parental energy investment to increase survival of those few eggs (e.g., production of egg cases and relatively large yolk masses).

Fishing Mortality

Historically, skates in general, and longnose skate in particular, have not been high-priced fishery products. They are taken mostly as bycatch in other commercially important fisheries (Bonfil 1994). Although skates are caught in almost all demersal fisheries and areas off the U.S. West Coast, the vast majority (almost 97 percent) are caught with trawl gear.

Landing records indicate that skates have been retained on the U.S. Pacific Coast at least since 1916 (Martin and Zorzi 1993). Little is known about the species composition of West Coast skate fisheries, particularly prior to 1990. With few exceptions, longnose skate landings have been reported, along with other skate species, under the market category "Unspecified Skates", until 2009 when a sorting requirement for longnose skate was required.

Historically, only the skinned pectoral fins or "wings" were sold, although a small portion of catch would be marketed in the round (whole). The wings were cut onboard the boat and the remainder discarded. Currently, West Coast skates are marketed both whole and as wings. Skates wings are sold fresh or fresh-frozen, as well as dried or salted and dehydrated, for sale predominantly in Asian markets (Bonfil 1994; Martin and Zorzi 1993). It appears that the demand for whole skates did increase greatly during the mid-1990s, as evidenced by the increase in the number of trips where skates were landed. While skates were encountered predominantly as bycatch previously, landings data from this period reveal greater targeting of skates by some vessels. After a few years, the whole-skate market cooled due to downturns in Asian financial markets (Peter Leipzig, Fishermen's Marketing Association, pers. com. as cited by Gertseva and Schirripa (2008)).

Historically, the exploitation rate for the longnose skate has been low. Relative exploitation rates (calculated as dead catch/biomass of age-2 and older fish) are estimated to have been below one percent during the last decade. For the recent and historical period, the assessment estimates that longnose skate was fished at a rate below the relative SPR target (calculated as $1\text{-SPR}/1\text{-SPR}_{50\%}$) (Figure 2-51). Relative SPR for 2018 is estimated to be 48 percent, which is below SPR target.

A vulnerability score of 1.68 indicates a low concern for overfishing the stock.

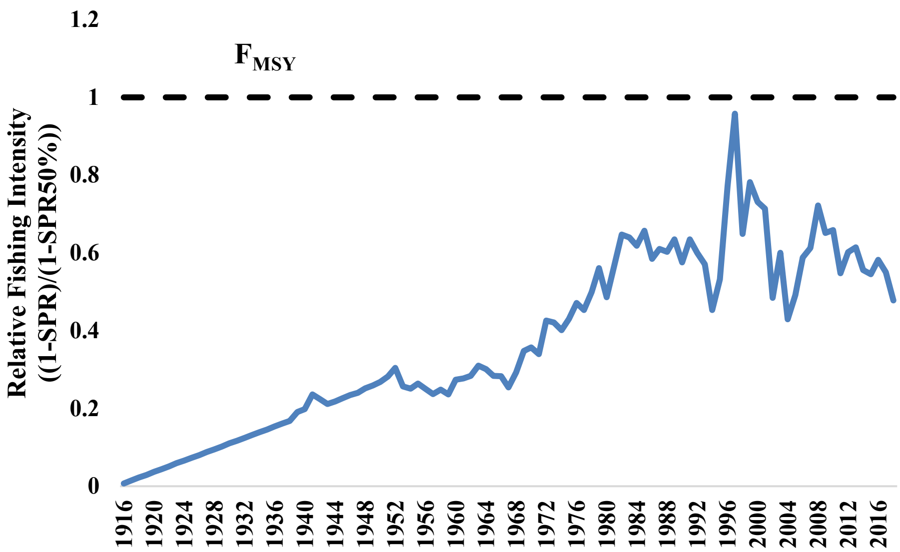

Figure 2-54. Relative fishing intensity of longnose skate, 1916-2018.

2.4.16 Longspine Thornyhead

Distribution and Life History

Longspine thornyhead (*Sebastolobus altivelis*) occur from the southern tip of Baja, California, to the Aleutian Islands (Jacobson and Vetter 1996; Orr, *et al.* 1998). There appears to be no distinct geographic breaks in stock abundance along the West Coast (Fay 2006; Rogers, *et al.* 1997). Adult longspine thornyhead are bottom dwellers and inhabit the deep waters of the continental slope throughout their range.

Longspine thornyhead occur at depths greater between 201 and 1,756 m, most typically between 500 and 1,300 m (Love*, et al.* 2002), and a peak in abundance and spawning biomass in the oxygen minimum zone (OMZ) at about 1,000 m depth (Jacobson and Vetter 1996; Wakefield 1990). Longspine thornyhead are better adapted to deep water than shortspine thornyhead (Siebenaller 1978; Siebenaller and Somero 1982). Wakefield (1990) estimated that in Central California, 83 percent of the longspine thornyhead population resides within an area of the continental slope bounded by 600 and 1,000 m depth.

Unlike shortspine thornyhead, the mean size of longspine thornyhead is similar throughout the depth range of the species (Jacobson and Vetter 1996). Camera sled observations indicate that longspine thornyheads do not school or aggregate, and are distributed relatively evenly over soft sediments (Wakefield 1990). Differences in density of individuals at depth do occur with lat., with higher densities of longspine thornyhead in deep water (1,000-1,400 m) off Oregon than off central California (Jacobson and Vetter 1996).

The strong relationship between depth and size found in shortspine thornyhead (Jacobson and Vetter 1996) is not observed for longspine thornyhead, with the distribution of longspine thornyhead being relatively uniform with depth (Rogers*, et al.* 1997). Unlike shortspine thornyhead, longspine thornyhead do not undergo an ontogenetic migration to deeper waters (Wakefield 1990).

Longspine thornyhead prefer muddy or soft sand bottoms in deep-water environments characterized by high pressure and low oxygen concentrations. These are low productivity (Vetter and Lynn 1997) and low diversity (Haigh and Schnute 2003) habitats where food availability is limited. Longspine thornyhead have adapted to this environment with an extremely slow metabolism that allows it to wait up to 180 days between feedings (Vetter and Lynn 1997). They are not territorial, and do not school. They have no swim bladders; instead, oil in the bones and spines provides floatation. Video observations from submersibles and remotely operated vehicles indicate that thornyhead are sit-and-wait predators that rest on the bottom and remain motionless for extended periods (John Butler, NOAA Fisheries, Southwest Fisheries Science Center, CA, as cited in Jacobson and Vetter (1996)).

The spawning season for longspine thornyhead appears to be extended, and occurs over several months during February, March, and April (Best 1964; Moser 1974; Pearcy 1962; Wakefield and Smith 1990). Both thornyhead species produce a bi-lobed jellied egg mass that is fertilized at depth and which then floats to the surface where final development and hatching occur (Pearcy 1962). An extended larval and pelagic juvenile phase follows, which is thought to be 18-20 months long (Jacobson and Vetter 1996; Moser 1974; Wakefield 1990). Juvenile longspine thornyhead settle on the continental slope at depths between 600 and 1,200 m (Wakefield 1990). Moser (1974) reports a mean length at settlement of 4.2-6.0 cm, although pelagic juveniles up to 69 mm in length have been collected in midwater trawls off Oregon (J. Siebenaller unpublished data, as cited in Wakefield and Smith (1990)).

Following settlement, longspine thornyhead are strictly benthic (Jacobson and Vetter 1996). No apparent pulse in recruitment during the year was observed by Wakefield and Smith (1990), perhaps due to the long (4-5 months) spawning season, variation in growth rates, and variation in the duration of the pelagic period (Wakefield and Smith 1990). There is potential for cannibalism because juveniles settle directly on to the adult habitat (Jacobson and Vetter 1996).

Adult females release between 20,000 and 450,000 eggs over a 4-5 month period (Best 1964; Moser 1974). Wakefield (1990) and Cooper et al. (2005) both found linear relationships between fecundity and somatic weight. The data analyzed by Cooper et al. (2005) indicated that fecundity of longspine thornyhead between 20 and 30 cm in length ranged from 20,000 to 50,000 eggs.

There is considerable uncertainty regarding age and growth of thornyheads (Jacobson and Vetter 1996), although data indicate that longspine thornyhead are long lived. Age estimates of over 40 years have been obtained from otoliths using thin-section and break- and-burn techniques (Ianelli*, et al.* 1994). High frequencies of large longspine thornyhead may be due to a strongly asymptotic growth pattern, with accumulation of many age groups in the largest size-classes (Jacobson and Vetter 1996).

Size-at-age data (Ianelli*, et al.* 1994) indicate that longspine thornyhead grow to a maximum size of about 30 cm total length at ages of about 25-45 years, with little or no sexual dimorphism in length at age – longspine thornyhead in British Columbia, Canada also display no sexual dimorphism (Starr and Haigh 2000). Orr et al. (1998) report a maximum length for longspine thornyhead of 38 cm, although individuals of this size are rare in both trawl surveys and commercial landings. Growth increments on otoliths suggest that juveniles reach 80 mm after 1 year of life as demersal juveniles (Wakefield unpublished data, as cited in (Wakefield and Smith 1990)), which would correspond to an age of 2.5 - 3 years old.

Longspine thornyhead are ambush predators (Jacobson and Vetter 1996). They consume fish fragments, crustaceans, bivalves, and polychaetes and occupy a tertiary consumer level in the food web. Pelagic juveniles prey largely on herbivorous euphausiids and occupy a secondary consumer level in the food web (Love 1996; Smith and Brown 1983). Sablefish and shortspine thornyhead commonly prey on longspine thornyhead (Buckley*, et al.* 1999).

Stock Status and Management History

Longspine thornyhead are exploited in the limited entry deep-water trawl fishery operating on the continental slope that also targets shortspine thornyhead, Dover sole and sablefish (i.e., the DTS fishery). A very small proportion of longspine thornyhead landings is due to non-trawl gears (gillnets, hook and line). Longspine thornyhead and shortspine thornyhead make up a single market category; however, they have been managed under separate harvest specifications since 1992. Beginning in 2011, trawl catches of longspine thornyhead north of 34°27’ N. lat. have been managed using individual fishing quotas.

The thornyhead fishery developed in Northern California during the 1960s. The fishery then expanded north and south, and the majority of the landings of longspine thornyhead have since been in the Monterey, Eureka, and Columbia INPFC areas, with some increase in landings from the Conception (southern CA) and Vancouver (northern WA) INPFC areas in recent years (Fay 2006).

The most recent stock assessment of West Coast longspine thornyhead was done in 2013. This was the fifth assessment done for longspine thornyhead, but only the second in which it was assessed individually (earlier assessments were of longspine thornyhead and shortspine thornyhead in combination). Previous assessments were conducted by Jacobson (Jacobson 1990; 1991), Ianelli et al. (1994), Rogers et al. (1997), and Fay (2006). The 1990 and 1991 assessments were very similar. Important features included reviews of available biological data, and analyses of trends in mean lengths from port samples and catch rates calculated from logbook data. Swept-area and video biomass estimates were used to estimate average biomass levels and exploitation rates in the Monterey to U.S.-Vancouver management areas. The available data were used to conduct per-recruit analyses of yield, revenue, and spawning biomass, and to develop estimates of the then target level of $F_{35\%}$.

Ianelli et al. (1994) assessed the coastwide abundance of longspine thornyhead and shortspine thornyhead based on slope survey data, an updated analysis of the logbook data, and fishery length-composition data to estimate the parameters of length-based Stock Synthesis models, under different assumptions regarding discarding practices.

The Rogers et al. (1997) assessment used a length-based version of Stock Synthesis 1 to fit an age-structured model to data for the Monterey, Eureka, Columbia and Vancouver INPFC areas. Models were fitted to biomass estimates and length data from the AFSC slope surveys (1988-1996), a logbook CPUE index, discarded proportions by year, and length composition data from California and Oregon. Sensitivity to discard rates based on changes in prices and minimum size were explored.

The 2005 assessment of longspine thornyhead estimated spawning biomass in 2005 was approximately 71 percent of unfished spawning biomass (Fay 2006). The model assumed one coastwide stock with one coastwide trawl fishery. Results from the base model suggested that the length compositions from the slope surveys were influencing recruitment in the model, such that the model estimated slightly higher recruitment in the early 1990s, which then declined in the mid to late 1990s.

The 2013 longspine thornyhead assessment indicated a stock depletion of 75 percent at the start of 2013 (Stephens and Taylor 2013). The assessment was highly uncertain with respect to 1) important fishery data (historical catches and discards) and key population vital rates (maturity, age and growth) are highly uncertain, 2) the surveys did not cover the entire depth distributions of the species, 3) key parameters (e.g., M and h) are fixed, and 4) models are sensitive to small changes in assumptions. R_0 was used to bracket uncertainty. The SSC categorized the stock as a category 2 stock given relatively high assessment uncertainty.

The Council adopted the default harvest control rule for longspine thornyhead of ACL equal to 76 percent of the coastwide ABC with a P* of 0.4 for the stock north of 34°27' N. lat. and 24 percent of the coastwide ABC for the stock south of 34°27' N. lat. The apportionment of coastwide OFLs and ABCs is based on the 2003-2012 average swept area biomass estimated north and south of Pt. Conception at 34°27' N. lat. in the NWFSC trawl survey. A catch only-projection of longspine thornyhead was provided to inform harvest specifications for 2021 and beyond.

Stock Productivity

Stephens and Taylor (2013) estimated annual longspine thornyhead recruitment using a Beverton-Holt stock-recruitment function and assuming a steepness value of 0.6. Most 2013 rockfish assessments used a steepness prior of 0.779, estimated from a meta-analysis of rockfish assessment results. This value might be expected in the 2013 longspine thornyhead assessment; however, rockfish ecology and reproduction are quite different from those of thornyheads, which (for example) do not give birth to live young but rather spawn floating egg masses.

Steepness in the shortspine thornyhead assessment was fixed at 0.6 both in the 2005 and 2013 models (Hamel 2006c; Taylor and Stephens 2013). This value was justified based on consistency between the modeling approach and management targets, in addition to being within a range of biologically reasonable values. For consistency, steepness for the longspine thornyhead model was also fixed at 0.6.

Annual deviations about this stock-recruitment curve were estimated for the years 1944 through 2012. Estimated recruitments do not show high variability, and the uncertainty in each estimate is greater than the variability between estimates. The 2013 longspine thornyhead assessment is relatively uninformative of relative year class strength since ages were not used in the model (thornyheads are notoriously difficult to age). Therefore, a length-based assessment with an assumed steepness is used to determine recruitment.

Fishing Mortality

The estimated exploitation rate of longspine thornyhead was above the current F_{MSY} harvest rate through much of the 1990s and, in hindsight, given the current target harvest rate, overfishing was occurring. However, stock biomass was estimated to have never dropped below the target B_{MSY} level. There is very little risk of overexploitation of longspine thornyhead given their deep distribution beyond the 700 fm limit to West Coast bottom trawling implemented under Amendment 19.

The PSA vulnerability score of 1.54 for longspine thornyhead also indicates a low concern for potential overfishing of the stock.

2.4.17 Pacific Cod

Distribution and Life History

Pacific cod (*Gadus macrocephalus*) are widely distributed in the coastal north Pacific, from the Bering Sea to Southern California in the east, and to the Sea of Japan in the west. Adult Pacific cod occur as deep as 875 m (Allen and Smith 1988), but the vast majority occurs between 50 m and 300 m (Allen and Smith 1988; Love 1996; NOAA 1990). Along the West Coast, Pacific cod prefer shallow, soft-bottom habitats in marine and estuarine environments (Garrison and Miller 1982), although adults have been found associated with coarse sand and gravel substrates (Garrison and Miller 1982; Palsson 1990). Larvae and small juveniles are pelagic; large juveniles and adults are parademersal (Dunn and Matarese 1987) NOAA 1990). Adult Pacific cod are not considered to be a migratory species. There is, however, a seasonal bathymetric movement from deep spawning areas of the outer shelf and upper slope in fall and winter to shallow middle-upper shelf feeding grounds in the spring (Dunn and Matarese 1987).

Pacific cod have external fertilization (Hart 1988; NOAA 1990) with spawning occurring from late fall to early spring. Their eggs are demersal. Larvae may be transported to nursery areas by tidal currents (Garrison and Miller 1982). Half of females are mature by three years (55 cm) and half of males are mature by two years (45 cm) (Dunn and Matarese 1987). Juveniles and adults are carnivorous and feed at night (Allen and Smith 1988; Palsson 1990) with the main part of the adult Pacific cod diet being whatever prey species is most abundant (Kihara and Shimada 1988; Klovach*, et al.* 1995). Larval feeding is poorly understood. Pelagic fish and sea birds eat Pacific cod larvae, while juveniles are eaten by larger demersal fish, including Pacific cod. Adults are preyed upon by toothed whales, Pacific halibut, salmon shark, and larger Pacific cod (Hart 1988; Love 1996; NOAA 1990; Palsson 1990). The closest competitor of the Pacific cod for resources is the sablefish (Allen 1982).

Stock Status and Management History

The West Coast population of Pacific cod has never been formally assessed. Targetable amounts of Pacific cod occur off northern Washington infrequently since the West Coast EEZ is at the southern limit of their distribution. The Pacific cod OFL has been set at the highest annual historical catch observed for the stock (in 1985) and ACLs/OYs have been set at half that amount. The SSC rates Pacific cod as a category 3 stock since the OFL is based on such a data-limited method.

The Council adopted the default harvest control rule for Pacific cod with the 2019 and 2020 ACL of 1,600 mt based on half the 3,200 mt OFL. The ABC is based on a P* of 0.4.

Stock Productivity

The PSA productivity score of 2.11 indicates a relatively high productivity and the vulnerability score of 1.34 for Pacific cod indicates a low concern for potential overfishing of the stock.

Fishing Mortality

Pacific cod occur periodically in targetable amounts off northern Washington. In some years they are targeted because the abundance of this fringe population (in the context of the species' distribution off the West Coast) is large enough to be targeted and, in some years, they are not available. The annual total mortality of Pacific cod has ranged from 39 mt (2008) to 1,415 mt (2004) during 2002-2012. The ACL of 1,600 mt has never been exceeded.

2.4.18 Pacific Ocean Perch

Distribution and Life History

Pacific ocean perch (POP, *Sebastes alutus*) are most abundant in the Gulf of Alaska, and have been observed off of Japan, in the Bering Sea, and south to Baja California, although they are sparse south of Oregon and rare in southern California (Eschmeyer*, et al.* 1983; Gunderson 1971; Miller and Lea 1972). They primarily inhabit waters of the upper continental slope (Dark and Wilkins 1994) and are found along the edge of the continental shelf (Archibald*, et al.* 1983). Pacific ocean perch occur as deep as 825 m, but usually are at 200 m to 450 m and along submarine canyons and depressions (Love*, et al.* 2002). Throughout their range, POP are generally associated with gravel, rocky, or boulder type substrate (Ito*, et al.* 1986). Larvae and juveniles are pelagic; subadults and adults are benthopelagic (living and feeding on the bottom and in the water column). Adults form large schools 30 m wide, to 80 m deep, and as much as 1,300 m long (NOAA 1990). They also form spawning schools (Gunderson 1971). Juvenile POP form ball-shaped schools near the surface or hide in rocks (NOAA 1990).

Pacific ocean perch winter and spawn in deeper water (>275 m). In the summer (June through August) they move to feeding grounds in shallower water (180 m to 220 m) to allow gonads to ripen (Archibald, *et al.* 1983; Gunderson 1971; NOAA 1990). They are slow-growing and long-lived; the maximum age has been estimated at about 98 years (Heifetz, *et al.* 2000). They can grow up to about 54 cm and 2 kg (Archibald, *et al.* 1983; Beamish 1979; Gunderson 1971; Ito, *et al.* 1986; Mulligan and Leaman 1992; NOAA 1990). POP are carnivorous. Larvae eat small zooplankton. Small juveniles eat copepods, and larger juveniles feed on euphausiids (krill). Adults eat euphausiids, shrimps, squids, and small fish. Immature fish feed throughout the year, but adults feed only seasonally, mostly April through August (NOAA 1990). POP predators include sablefish and Pacific halibut.

Stock Status and Management History

POP were harvested exclusively by U.S. and Canadian vessels in the Columbia and Vancouver INPFC areas prior to 1966. Large Soviet and Japanese factory trawlers began fishing for POP in 1965 in the Vancouver area and in the Columbia area a year later. Intense fishing pressure by these foreign fleets occurred from 1966 to 1975. The mandates of the MSA, passed by Congress in 1976, eventually ended foreign fishing within 200 miles of the United States coast.

The POP resource off the West Coast was and was estimated to have been overfished before implementation of the groundfish FMP in 1982, and Council actions to conserve the resource likewise predate the FMP. Large removals of POP in the foreign trawl fishery, followed by significant declines in catch and abundance, led the Council to limit harvest beginning in 1979. A 20–year rebuilding plan for POP was adopted in 1981. Rebuilding under this original plan was largely influenced by a cohort analysis of 1966-1976 catch and age composition data (Gunderson 1979), updated with 1977-1980 data (Gunderson 1981), and an evaluation of trip limits as a management tool (Tagart, *et al.* 1980). This was the first time trip limits were used by the Council to discourage targeting and overharvest of an overfished stock, and it remains a management strategy in use today in the West Coast groundfish fishery. In addition to trip limits, the Council significantly lowered the OY for POP. After twenty years of rebuilding under the original plan, the stock stabilized at a lower equilibrium than estimated in the pre-fishing condition. While continuing stock decline was abated, rebuilding was not achieved as the stock failed to increase in abundance to B_{MSY}.

Ianelli and Zimmerman (1998) estimated POP female spawning biomass in 1997 to be at 13 percent of its unfished level, thereby confirming that the stock was overfished. NMFS formally declared POP overfished in March 1999 after the groundfish FMP was amended to incorporate the tenets of the Sustainable Fisheries Act. The Council adopted and NMFS enacted more conservative management measures in 1999 as part of a redoubled rebuilding effort.

A 2000 POP assessment suggested the stock was more productive than originally thought (Ianelli, *et al.* 2000). A revised POP rebuilding analysis was completed and adopted by the Council in 2001 (Punt and Ianelli 2001). This analysis estimated a T_{MIN} of 12 years and a T_{MAX} of 42 years. It was noted in the rebuilding analysis that the ongoing retrospective analysis of historic foreign fleet catches was likely to change projections of POP rebuilding.

The 2003 POP assessment (Hamel, *et al.* 2003) incorporated updated survey and fishery data including the retrospective of foreign fleet catches (Rogers 2003b). The assessment covered areas from southern Oregon to the U.S. border with Canada, the southern extent of POP distribution. The overall conclusion was that the stock was relatively stable at approximately 28 percent of its unfished biomass ($B_{28\%}$). Of all the changes and additions to the data, the historical catch estimates had the greatest effect, resulting in lower estimates of both equilibrium unfished biomass (B_0) and MSY.

A POP rebuilding plan was adopted in 2003 under Amendment 16-2. The rebuilding plan was informed by a revised rebuilding analysis based on the 2000 assessment and conducted in 2001 (Punt and Ianelli 2001). The rebuilding plan established a target rebuilding year of 2027 and a harvest control rule of F = 0.0082 (with a P_{MAX} of 70 percent).

The 2003 assessment estimated a stock depletion of 28 percent at the start of 2003 (Hamel*, et al.* 2003). The 2003 rebuilding analysis (Punt*, et al.* 2003) was used to amend the harvest control rule and set annual POP OYs for the 2004-2006 period. The amended harvest control rule was F = 0.0257.

The 2003 POP assessment was updated in 2005, 2007, and 2009. The 2005 update assessment estimated a stock depletion of 23.4 percent of its unfished level at the start of 2005 (Hamel 2006b). The 2005 POP rebuilding analysis (Hamel 2006a) was used to inform revisions to the POP rebuilding plan. The revised rebuilding plan, which was adopted under Amendment 16-4, specified a target rebuilding year of 2017 and a constant harvest rate strategy (SPR = 86.4 percent).

The 2007 POP assessment update estimated a stock depletion of 27.5 percent at the start of 2007 (Hamel 2008d). The 2007 rebuilding analysis indicated rebuilding was progressing ahead of schedule (Hamel 2008b). No modifications to the rebuilding plan were made.

The 2009 POP assessment estimated a stock depletion of 28.6 percent at the start of 2009 (Hamel 2009b). The 2009 POP rebuilding analysis (Hamel 2009a) predicted rebuilding would not occur by the target year of 2017 with at least a 50 percent probability even in the absence of fishing-related mortality beginning in 2011 (i.e., $T_{F=0}$). Therefore, the rebuilding plan was revised by changing the target rebuilding year to 2020 while maintaining the constant SPR harvest rate of 86.4 percent.

A full assessment in 2011 estimated a stock depletion of 19.1 percent at the start of 2011 (Hamel and Ono 2011). The significant decrease in the estimated depletion of the stock was largely due to a much higher estimate of initial, unfished biomass (B_0). Previous assessments assumed a large recruitment in the late 1950s provided the higher biomass to support the estimated removals by the foreign fleets without any data to support that assumption. The assumption in the 2011 assessment is that the large foreign fleet catch fished the biomass down to critical levels, thus resulting in a substantially larger B_0 estimate. The 2011 assessment also estimated a longer sequence of higher recruitment based on fitting to the data available for early years of the assessment period. The 2011 rebuilding analysis (Hamel 2011) predicted rebuilding would not occur by the target year of 2020 with at least a 50 percent probability even in the absence of fishing-related mortality beginning in 2013 (i.e., $T_{F=0}$). Therefore, the rebuilding plan was revised by changing the target rebuilding year to 2051 while maintaining the constant SPR harvest rate of 86.4 percent.

A 2017 full assessment of POP indicated the stock was successfully rebuilt with an estimated depletion of 76.6 percent (above the target of 40 percent) at the start of 2017 (Wetzel*, et al.* 2017).

Unlike past assessments, the 2017 assessment estimated the stock was never overfished and was in the precautionary zone with a depletion between 37 and 39 percent during 1971-1995 (Figure 2-52).

Similar to the 2011 assessment, the 2017 assessment models the population as a single stock off of the U.S. West Coast from northern California to the Canadian border. A number of revisions were made to the data used for the 2017 stock assessment including: 1) disaggregating the one combined fleet used in 2011 to four component fleets, 2) using new historical catch reconstruction landings for Washington, 3) starting the model in 1918, 4) re-analyzing all of the fishery-independent indices using VAST, 5) dropping the fishery CPUE logbook index, 6) dropping the Triennial survey index, 7) updating maturity and fecundity relationships, and 8) updating landings and composition data.

There remains considerable uncertainty associated with the steepness parameter, which is the main driver of the large change in status and scale between the 2011 assessment and the 2017 assessment. It was concluded that the available data in the 2017 assessment was insufficient to estimate steepness. It is usual in this situation to base the assessment on the mean of the prior for steepness, but this value led to an unrealistically low estimate of survey catchability. Therefore, the assumed steepness was set equal to 0.5 in the assessment.

The SSC recommended the next assessment be a full assessment given the considerable uncertainty associated with the 2017 assessment. They also recommended the next assessment should reconsider the Triennial survey. The SSC recommended that the POP assessment be assigned to category 2 owing to the extreme sensitivity of the model outputs to changes to the specifications of the model.

The Council adopted the default harvest control rule of setting the ACL equal to the ABC under the previous P* (0.45) for a newly rebuilt stock for 2019 and beyond.

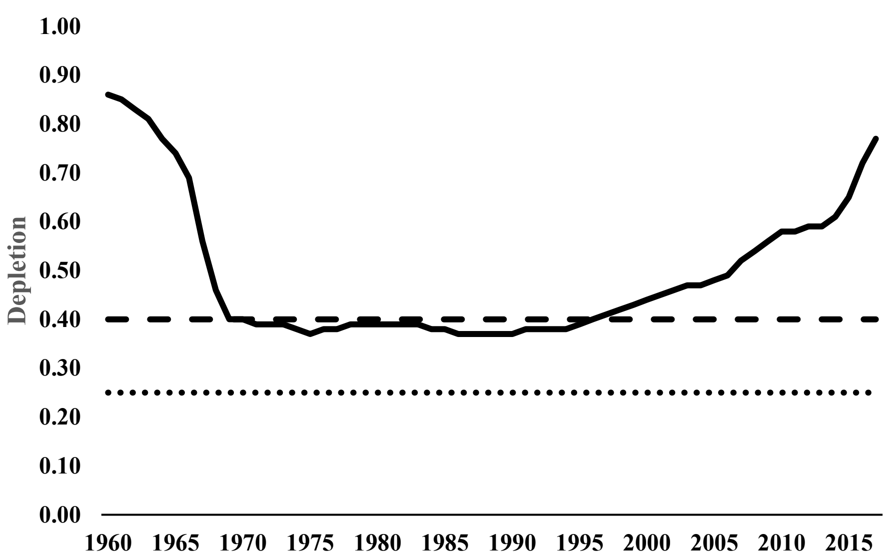

Figure 2-55. Relative depletion of Pacific ocean perch from 1960 to 2017 based on the 2017 stock assessment.

Stock Productivity

Stock-recruitment steepness was assumed to be 0.5 in the 2017 POP stock assessment base model. The 2017 assessment assumed no connectivity with the other assessed POP stocks in Canada and Alaska. POP off the U.S. West Coast (mostly Washington and Oregon) are at the southern end of the range where there are enough POP to be commercially important, and the numbers seen are likely related to movement across the Canadian border, as well as reproductive success (recruitment), stock status, and fishing mortality north of the border. The actual productivity of the West Coast POP stock may be higher than implied by the 2017 steepness assumption; however, assuming the mean prior of steepness in the most recent meta-analysis of category 1 assessments (h = 0.718) led to an unrealistically low estimate of survey catchability. Such model uncertainties led to the stock being downgraded to a category 2 assessment.

Recruitment deviations were estimated for the entire assessment period. There is little information regarding recruitment prior to 1965, and the uncertainty in these estimates is expressed in the model. Past assessments estimated large recruitments in 1999 and 2000. In recent years, a recruitment of unprecedented size is estimated to have occurred in 2008 (Figure 2-53). Additionally, there is early evidence of a strong recruitment in 2013. The four lowest recruitments estimated within the model (in ascending order) occurred in 2012, 2003, 2005, and 2007 (Figure 2-53).

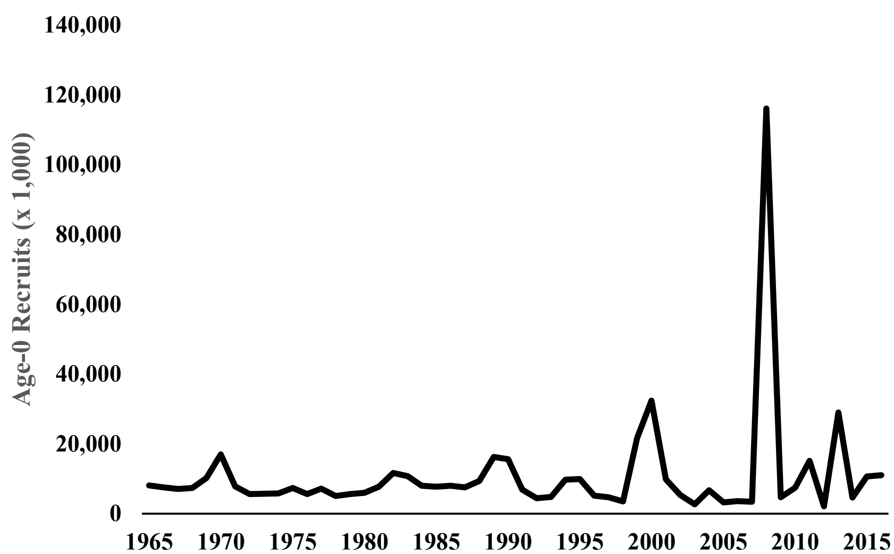

Figure 2-56. Time series of estimated (age-0) Pacific ocean perch recruitments, 1965-2016 from the 2017 assessment.

Fishing Mortality

Historically, the West Coast was severely overfished by the foreign trawl fisheries in the mid-1960s. POP are caught almost exclusively by groundfish trawl gear and predominantly bottom trawls operating on the outer continental shelf and slope north of 43° N. lat. POP are distributed from 30-350 fm, with the core distribution between 110-220 fm.

The spawning output of POP reached a low in 1989 (Figure 2-52). Landings for POP decreased significantly in 2000 compared to previous years with implementation of the POP rebuilding plan. The estimated relative depletion was possibly below the target biomass level between the 1970s and 1990s, but has likely remained above the target otherwise, and currently is significantly greater than the 40 percent unfished spawning output target. Throughout the late 1960s and the early 1970s the exploitation rate and values of relative spawning potential (1-SPR) were mostly above target levels (Figure 2-54). Recent exploitation rates on POP were predicted to be significantly below target levels.

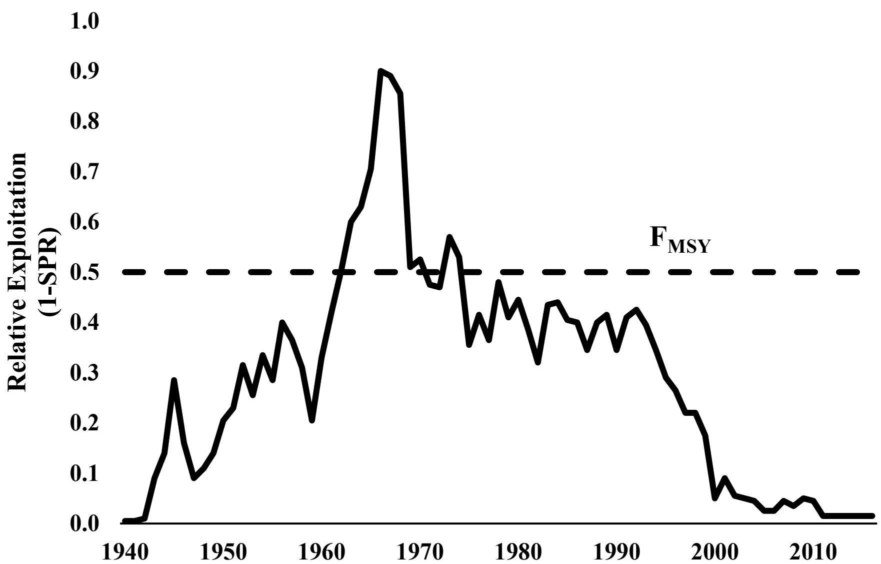

Figure 2-57. Estimated annual relative exploitation rate of West Coast Pacific ocean perch relative to the current proxy F_{MSY} target, 1940-2016.

2.4.19 Pacific Whiting

Distribution and Life History

Pacific whiting (*Merluccius productus*), also referred to as Pacific hake, is a semi-pelagic schooling species distributed along the West Coast of North America generally ranging from 25° N. lat. to 55° N. lat. It is among 18 species of hake from four genera (being the majority of the family *Merluccidae*), which are found in both hemispheres of the Atlantic and Pacific Oceans (Alheit and Pitcher 1995; Lloris*, et al.* 2005). The coastal stock of Pacific whiting is currently the most abundant groundfish population in the California Current system. Smaller populations of this species occur in the major inlets of the Northeast Pacific Ocean, including the Strait of Georgia, Puget Sound, and the Gulf of California. Genetic studies indicate that the Strait of Georgia and the Puget Sound populations are genetically distinct from the coastal population (Iwamoto*, et al.* 2004; King*, et al.* 2012). Genetic differences have also been found between the coastal population and hake off the West Coast of Baja California (Vrooman and Paloma 1977). The coastal stock is also distinguished from the inshore populations by larger body size and seasonal migratory behavior.

The coastal stock of Pacific whiting typically ranges from the waters off southern California to northern British Columbia and in some years to southern Alaska, with the northern boundary related to fluctuations in annual migration. In spring, adult Pacific whiting migrate onshore and northward to feed along the continental shelf and slope from northern California to Vancouver Island. In summer, Pacific whiting often form extensive midwater aggregations in association with the continental shelf break, with highest densities located over bottom depths of 200–300 m (Dorn and Methot 1991; Dorn and Methot 1992).

Older Pacific whiting exhibit the greatest northward migration each season, with two- and three-year old fish rarely observed in Canadian waters north of southern Vancouver Island. During El Niño events (warm ocean conditions, such as occurred in 1998), a larger proportion of the stock migrates into Canadian waters, apparently due to intensified northward transport during the period of active migration (Agostini*, et al.* 2006; Dorn 1995). In contrast, La Niña conditions (colder water, such as occurred in 2001) result in a southward shift in the stock's distribution, with a much smaller proportion of the population found in Canadian waters, as seen in the 2001 survey.

Spawning occurs from December through March, peaking in late January (Smith 1995). Pacific whiting are oviparous with external fertilization. Eggs of the Pacific whiting are neritic and float to neutral buoyancy (Bailey 1982; Bailey*, et al.* 1982; NOAA 1990). Hatching occurs in five days to six days, and within three months to four months juveniles are typically 35 mm (Hollowed 1992). Juveniles move to deeper water as they get older (NOAA 1990). Females mature at three years to four years (34 cm to 40 cm) and nearly all males are mature by three years (28 cm). Females grow more rapidly than males after four years; growth ceases for both sexes at 10 to 13 years (Bailey*, et al.* 1982).

All life stages feed near the surface late at night and early in the morning (Sumida and Moser 1984). Larvae eat calanoid copepods, as well as their eggs and nauplii (McFarlane and Beamish 1986; Sumida and Moser 1984). Juveniles and small adults feed chiefly on euphausiids (NOAA 1990). Large adults also eat amphipods, squid, herring, smelt, crabs, and sometimes juvenile whiting (Bailey 1982; Dark and Wilkins 1994; McFarlane and Beamish 1986). Eggs and larvae of Pacific whiting are eaten by pollock, herring, invertebrates, and sometimes Pacific whiting. Juveniles are eaten by lingcod, Pacific cod, and rockfish species. Adults are preyed on by sablefish, albacore, pollock, Pacific cod, marine mammals, soupfin sharks, and spiny dogfish (Fiscus 1979; McFarlane and Beamish 1986).

Stock Status and Management History

The history of the coastal whiting fishery is characterized by rapid changes brought about by the development of foreign fisheries in 1966, joint-venture fisheries in the early 1980s, and domestic fisheries in 1990s. Since implementation of the Magnuson-Stevens Fishery Conservation and

Management Act in the U.S. and the declaration of a 200-mile fishery conservation zone in the U.S. and Canada in the late 1970s, annual quotas (or catch targets) have been used to limit the catch of Pacific hake in both zones by foreign and domestic fisheries. Scientists from both countries historically collaborated through the Technical Subcommittee of the Canada-U.S. Groundfish Committee (TSC), and there were informal agreements on the adoption of annual fishing policies. During the 1990s, disagreements between the U.S. and Canada on the allotment of the catch limits between U.S. and Canadian fisheries led to quota overruns; 1991-1992 quotas summed to 128 percent of the limit, while the 1993-1999 combined quotas were 107 percent of the limit on average. In 2003, a bilateral Pacific whiting management agreement was signed by both countries that created formal allocations of the harvestable surplus, as well as an international process for assessing and managing the stock. This international process was fully implemented in 2012.

Pacific whiting is managed consistent with the Agreement with Canada on Pacific Hake/Whiting. Annual catch limits, now called TACs (total allowable catches), for Pacific whiting are adopted on an annual basis after a stock assessment is completed by a Joint Technical Committee (JTC) and reviewed in February by an international Scientific Review Group (SRG). In March, the JTC and SRG present the assessment to the Joint Management Committee (JMC), the international decision-making body. The JMC presents their TAC recommendations to their respective government officials before these TACs are implemented in regulations. The coastwide TAC for the U.S. West Coast and Canada is allocated 26.12 percent to Canada and 73.88 percent to the U.S. under Article III (2) of the Agreement.

A 2022 stock assessment for Pacific whiting has been conducted (Edwards, *et al.* 2022) and endorsed by the SRG in the U.S./Canada Pacific Whiting Treaty Process. The 2022 whiting assessment indicates the median estimate of the 2022 relative spawning biomass (depletion) is 65 percent. The median relative spawning biomass has progressively declined since 2019, due to the aging large cohorts (2010, 2014, and 2016) and relatively high catches. Based on limited data, the 2020 cohort looks likely to be large.

The 2021 coastwide TAC for Pacific whiting was not decided by the JMC given an impasse in the U.S.-Canada treaty process. The U.S.-adjusted TAC decided by NMFS is 369,400 mt for the 2021 fishery.

A 2023 stock assessment for Pacific whiting has been completed (Berger, et al. 2023) and endorsed by the SRG in the U.S./Canada Pacific Whiting Treaty Process. The structure of the 2023 assessment model is similar to that of the 2022 model. The 2023 whiting assessment estimates a spawning biomass that is 104% of the unfished equilibrium level (B0), with a wide 95% credible interval of 42% to 300%. There is a 0.1% joint probability that the stock is both below B40% at the beginning of 2023 and above a level of fishing intensity equivalent to the default harvest rate of F40% in 2022. Total exploitable stock biomass (age 2+, males and females) at the beginning of 2023 is estimated to be 4.514 Mt, with a 95% credible interval of 1.753 to 13.669 Mt. This estimate is a 35% increase relative to the 2022 median estimate, due largely to the big 2020 year-class.

Stock Productivity

Pacific whiting exhibit high relative productivity as evidenced by fast growth, a high natural mortality rate (M), and high steepness in the Beverton-Holt stock-recruitment function. The prior for steepness in the 2021 Pacific whiting assessment is based on the median (0.79), 20th (0.67) and 80th (0.87) percentiles from the Myers et al. (1999) meta-analysis of the family *Gadidae*, and has been used in previous U.S. assessments since 2007.

Pacific Hake appear to have low recruitment with occasional large year-classes. Very large year classes in 1980, 1984, and 1999 supported much of the commercial catch from the 1980s to the mid-2000s. From 2000 to 2007, estimated recruitment was at some of the lowest values in the time series, but this was followed by an above average 2008 year class. Current estimates continue to indicate a very strong 2010 year class comprising 64 percent of the coast-wide commercial catch in 2014, 33 percent of the 2016 catch, 23 percent of the 2018 catch, and 15 percent of the 2020 catch. The decline from 2014 to 2016 was due to the large influx of the 2014 year class (50 percent of the 2016 catch was age-2 fish from the 2014 year class; this was larger than the proportion of age-2 fish, 41 percent, from the 2010 year class in 2012). The median estimate of the 2010 year class is just below the highest ever (for 1980), with a 46 percent probability that the 2010 year class is larger than the 1980 year class. The model currently estimates small 2011, 2013, 2015, and 2018 year classes (median recruitment well below the mean of all median recruitments).

The PSA productivity score for Pacific whiting (P = 2.00) is relatively high and the low vulnerability score (V = 1.69) indicates a low concern for potential overfishing.

Fishing Mortality

Median relative fishing intensity on the stock is estimated to have been below the target of 1.0 for all years. Median exploitation fraction (catch divided by biomass of fish of age-2 and above) peaked in 1999 and then reached similar levels in 2006 and 2008. Over the last five years, the exploitation fraction was the highest in 2017. Median relative fishing intensity is estimated to have declined from 92.7 percent in 2010 to 45.5 percent in 2015, and then it leveled off around 75 percent from 2016 to 2019 before dropping to 65.9 percent in 2020. The exploitation fraction has increased from a recent low of 0.05 in 2012 to 0.13 in 2017 and has remained relatively stable since then (dropping no further than 0.11).

2.4.20 Petrale Sole

Distribution and Life History

Petrale sole (*Eopsetta jordani*) is a right-eyed flounder in the family Pleuronectidae ranging from the western Gulf of Alaska to the Coronado Islands, northern Baja California, (Hart 1988; Kramer and O'Connell 1995; Love*, et al.* 2002) with a preference for soft substrates at depths ranging from 0-550 m (Love*, et al.* 2002). In northern and central California petrale sole are mostly found on the middle and outer continental shelf (Allen*, et al.* 2006).

There is little information regarding the stock structure of petrale sole off the U.S. Pacific coast. Tagging studies show adult petrale sole can move up to 350-390 miles, having the ability to be highly migratory with the possibility for homing ability (Alverson and Chatwin 1957; MBC 1987). Juveniles show little coastwide or bathymetric movement while 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; Love 1996; MBC 1987). Adult petrale sole can tolerate a wide range of bottom temperatures (Perry*, et al.* 1994).

Mixing of fish from multiple deep water spawning grounds likely occurs during the spring and summer when petrale sole are feeding on the continental shelf. Fish that were captured, tagged, and released off the northwest Coast of Washington during May and September were subsequently recaptured during winter from spawning grounds off Vancouver Island (British Columbia, 1 fish), Heceta Bank (central Oregon, 2 fish), Eureka (northern California, 2 fish), and Halfmoon Bay (central California, 2 fish) (Pederson 1975). Fish tagged south of Fort Bragg (central California) during July 1964 were later recaptured off Oregon (11 fish), Washington (6 fish), and Swiftsure Bank (southwestern tip of Vancouver Island, 1 fish) (D. Thomas, California Department of Fish and Game, Menlo Park, CA, cited by Sampson and Lee (1999)).

The highest densities of spawning adults off of British Columbia, as well as of eggs, larvae, and juveniles are found in the waters around Vancouver Island. Adults may utilize nearshore areas as summer feeding grounds and non-migrating adults may stay there during winter (Starr and Fargo 2004).

Petrale sole spawn during the winter at several discrete deep water sites (270-460 m) off the U.S. West Coast, from November to April, with peak spawning taking place from December to February (Best 1960; Casillas*, et al.* 1998; Castillo 1995; Castillo*, et al.* 1993; Garrison and Miller 1982; Gregory and Jow 1976; Harry 1959; Love 1996; Moser 1996; Reilly*, et al.* 1994). Females spawn once each year and fecundity varies with fish size, with one large female laying as many as 1.5 million eggs (Porter 1964). Petrale sole eggs are planktonic, ranging in size from 1.2 to 1.3 mm, and are found in deep water habitats at water temperatures of 4–10 degrees C and salinities of 25–30 ppt (Alderdice and Forrester 1971; Best 1960; Gregory and Jow 1976; Ketchen and Forrester 1966). The duration of the egg stage can range from approximately 6 to 14 days (Alderdice and Forrester 1971; Casillas*, et al.* 1998; Hart 1988; Love 1996).

Petrale sole larvae are planktonic, ranging in size from approximately 3 to 20 mm, and are found up to 150 km offshore foraging upon copepod eggs and nauplii (Casillas*, et al.* 1998; Hart 1988; MBC 1987; Moser 1996). The larval duration, including the egg stage, spans approximately 6 months with larvae settling at about 2.2 cm in length on the inner continental shelf (Pearcy*, et al.*

1977). Juveniles are benthic and found on sandy or sand-mud bottoms (Eschmeyer, *et al.* 1983; MBC 1987) and range in size from approximately 2.2 cm to the size at maturity, 50 percent of the population is mature at approximately 38 cm and 41 cm for males and females, respectively (Casillas, *et al.* 1998). No specific areas have been identified as nursery grounds for juvenile petrale sole. In the waters off British Columbia, Canada larvae are usually found in the upper 50 m far offshore, juveniles at 19–82 m and large juveniles at 25–125 m (Starr and Fargo 2004).

Adult petrale sole achieve a maximum size of around 50 cm and 63 cm for males and females, respectively (Best 1963; Pedersen 1975). The maximum length reported for petrale sole is 70 cm (Eschmeyer, *et al.* 1983; Hart 1988; Love, *et al.* 2002) while the maximum observed break and burn age is 31 years (Haltuch, *et al.* 2013).

Petrale sole juveniles are carnivorous, foraging on annelid worms, clams, brittle star, mysids, sculpin, amphipods, and other juvenile flatfish (Casillas, *et al.* 1998; Ford 1965; Pearsall and Fargo 2007). Predators of juvenile petrale sole include adult petrale sole as well as other larger fish (Casillas, *et al.* 1998; Ford 1965) while adults are preyed upon by marine mammals, sharks, and larger fishes (Casillas, *et al.* 1998; Love 1996; Trumble 1995).

One of the ambushing flatfishes, adult petrale sole have diverse diets that become more piscivorous at larger sizes (Allen, *et al.* 2006). Adult petrale sole are found on sandy and sand-mud bottoms (Eschmeyer, *et al.* 1983) foraging for a variety of invertebrates including, crab, octopi, squid, euphausiids, and shrimp, as well as anchovies, hake, herring, sand lance, and other smaller rockfish and flatfish (Birtwell, *et al.* 1984; Casillas, *et al.* 1998; Ford 1965; Kravitz, *et al.* 1977; Love 1996; Pearsall and Fargo 2007; Reilly, *et al.* 1994). On the continental shelf petrale sole generally co-occur with English sole, rex sole, Pacific sanddab, and rock sole (Kravitz, *et al.* 1977).

Castillo (1992) and Castillo et al. (1995) suggest that density-independent survival of early life stages is low and show that offshore Ekman transportation of eggs and larvae may be an important source of variation in year class strength in the Columbia INPFC area. The effects of the Pacific Decadal Oscillation (PDO) on California current temperature and productivity (Mantua, *et al.* 1997) may also contribute to non-stationary recruitment dynamics for petrale sole. The prevalence of strong late 1990s-year classes for many U.S. West Coast groundfish species suggest that environmentally driven recruitment variation may be correlated among species with relatively diverse life history strategies.

Stock Status and Management History

Early stock assessments only assessed petrale sole in the combined U.S.-Vancouver and Columbia INPFC areas (i.e., petrale in these areas were treated as a unit stock, using time series of data that began during the 1970s) (Demory 1984; Turnock, *et al.* 1993). The first assessment used stock reduction analysis and the second assessment used the length-based Stock Synthesis model. The third petrale sole assessment utilized the hybrid length-and-age-based Stock Synthesis 1 model, using data from 1977–1998 (Sampson and Lee 1999), and structured the data into separate seasonal fisheries - one for the winter spawning ground fishery that harvests larger fish and another for the rest of the year. Sampson and Lee (1999) estimated petrale sole stock depletion at 42 percent of unfished biomass at the start of 1999.

The 2005 petrale sole assessment (Lai*, et al.* 2006) was conducted assuming two separate stocks: the northern stock encompassing the U.S. Vancouver and Columbia INPFC areas and the southern stock including the Eureka, Monterey, and Conception INPFC areas. Petrale sole in the north was estimated to be at 34 percent of unfished spawning stock biomass in 2005. In the south, the stock was estimated to be at 29 percent of unfished spawning stock biomass. Biomass trends were qualitatively similar in both areas, and also showed consistency with petrale sole trends in Canadian waters. Both stocks were estimated to have been below the Council's MSST of $B_{25\%}$[11] from the mid-1970s until very recently. Estimated harvest rates were in excess of the target fishing mortality rate of $F_{40\%}$[12] during this period as well. Petrale sole in both areas showed large recent increases in stock size, which was consistent with the strong upward trend in the shelf survey biomass index. In 2005, the STAR panel noted that the petrale sole stock trends were similar in both northern and southern areas in spite of the different modeling choices made for each area, and that a single coastwide assessment should be considered (Dorn*, et al.* 2006).

The 2009 petrale assessment estimated a stock depletion of 11.6 percent of its unfished biomass at the start of 2009 (Haltuch and Hicks 2009b). That result compelled NMFS to declare the stock overfished in 2010. The 2009 assessment treated petrale sole as a single coastwide stock, with the fleets and landings structured by state (WA, OR, CA) area of catch. The data series for historical catches was extended back to 1876, the first year of estimated exploitation for the stock.

New proxy management reference points used to manage FMP flatfish stocks, such as petrale sole, were implemented in 2011 under FMP Amendment 16-5 (also referred to as Secretarial Amendment 1) (PFMC and NMFS 2011). The proxy F_{MSY} harvest rate or MFMT of $F_{40\%}$, which is applied to the estimated exploitable biomass to determine the OFL, was changed to $F_{30\%}$; the B_{MSY} target of $B_{40\%}$ was changed to $B_{25\%}$; and the MSST of $B_{25\%}$, was changed to $B_{12.5\%}$. The SSC recommended these new proxy reference points to manage flatfish stocks based on a meta-analysis of the relative productivity of assessed U.S. West Coast flatfish species and other assessed Pleuronectid species internationally. The precautionary ACL harvest control rule, referred to as the 25-5 rule and analogous to the 40-10 rule for other groundfish stocks (see Figure 3-2 and section 3.1.3 for more detail on these ACL harvest control rules), was also adopted for flatfish stocks under Amendment 16-5.

The 2009 rebuilding analysis (Haltuch and Hicks 2009a) was used to consider a petrale sole rebuilding plan for petrale sole, which was implemented under FMP Amendment 16-5. The rebuilding plan specified a target year of 2016 and the strategy of using the 25-5 harvest control rule after 2011 to set harvest levels (the 2011 ACL was set equal to the ABC to avoid unnecessary negative socioeconomic impacts). An emergency rule was implemented to reduce the 2010 petrale OY to 1,200 mt.

[11] $B_{25\%}$ was the MSST or overfished threshold for all groundfish stocks from the implementation of Amendment 12 in 1998 through 2010.

[12] $F_{40\%}$ was the F_{MSY} proxy harvest rate for all flatfish stocks from 1997-2011. Prior to 1997, the proxy F_{MSY} harvest rate was $F_{35\%}$.

The 2011 petrale assessment estimated a stock depletion of 18 percent of its unfished biomass at the start of 2011 (Haltuch*, et al.* 2011). The assessment indicated an increasing spawning biomass trend with above average year classes recruiting into the spawning biomass. The 2011 rebuilding analysis (Haltuch 2011) indicated rebuilding was ahead of schedule and predicted spawning biomass would likely attain the B_{MSY} target of $B_{25\%}$ by the start of 2013. No modifications were made to the rebuilding plan based on this result.

The 2013 petrale assessment (Haltuch*, et al.* 2013) estimated a stock depletion of 22.3 percent of its unfished biomass at the start of 2013 and short of the prediction from the 2011 rebuilding analysis; spawning biomass is predicted to reach the B_{MSY} target by the start of 2014. The 2013 stock assessment continued with the coastwide stock assessment but was restructured to summarize petrale sole landings by the port of landing and combined Washington and Oregon into a single fleet but structured seasonally based on winter (November to February) and summer (March to October) fishing seasons. The down-weighting of the trawl CPUE index used in the 2011 assessment was largely responsible for the more pessimistic result and the one-year lag in rebuilding relative to the previous assessment. However, the estimation of recent recruitments indicated two very strong year classes (2007 and 2008; Figure 2-56) recruiting into the spawning population, which increases the likelihood of imminent success in rebuilding this stock.

An update of the 2013 full petrale sole assessment was conducted in 2015 (Stawitz*, et al.* 2015). The update assessment indicated the coastwide petrale sole stock was successfully rebuilt with a depletion of 31 percent at the start of 2015. Improvement in the estimated stock status (relative to the 2013 model projection) is attributed to greater strength of the 2006-2008 year classes, and a consistent increasing trend in the NWFSC trawl survey index. The SSC noted the NWFSC trawl survey appears to be an excellent indicator of petrale sole trends and should be monitored to evaluate the need for a new assessment in the future.

An update assessment of petrale sole in 2019 indicated a depletion of 39 percent at the start of 2019 (Wetzel 2019). The most influential new information was the updated NWFSC groundfish bottom trawl survey index, which initially continued the sharply increasing trend observed in the 2011-2014 period, with indications of a leveling off and a downturn in the latest year (2018). Landings had increased in the last four years (2015-2018) relative to the previous four years (2011-2014), consistent with the stock being rebuilt and continuing to increase in abundance. The trajectory of the stock was forecast to decline as the large 2006-2008 cohorts were fished down, as recent recruitments (2010-2016) were below average.

A full benchmark assessment was conducted in 2023, with an extended data series and substantial changes to the time series of historical catch landed in Washington (Taylor et al. 2023). The assessment was structured with two fleets (North for fish landed in Washington and Oregon ports; South for California), and modeled males and females separately. The estimate of depletion for 2023 is 33.6 percent, which is above the B_{MSY} target of $B_{25\%}$. However, the biomass is estimated to be declining due to below-average recruitments in recent years (Figure 2-55). This decline is due to poor recruitment in recent years, which contrasts with the high recruitment event from 2006-2008 that resulted in rebuilding of the stock from overfished conditions. In general, the data on petrale sole are informative due to large sample sizes of length and age data from fisheries and surveys, high frequency of occurrence in the bottom trawl survey, and strong contrast in the data caused by fishing down the stock to a low level followed by rapid rebuilding. The Council adopted the default harvest control rule of ACL = ABC (P* = 0.45) for petrale sole for 2025 and beyond.

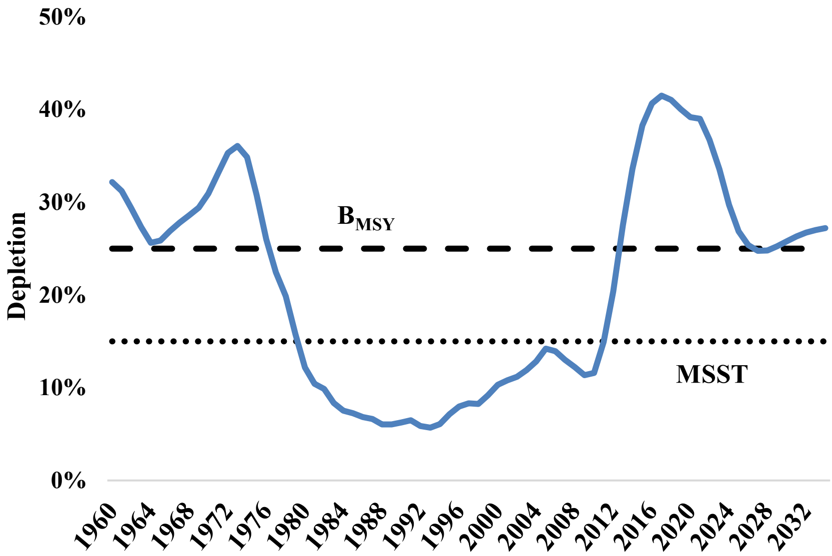

Figure 2-58. Relative depletion trend from 1960 to 2034 for petrale sole based on the 2023 full benchmark stock assessment.

Stock Productivity

Petrale have high stock productivity with the stock-recruitment steepness fixed at a value of 0.8 in the most recent 2023 assessment, derived from a meta-analysis of flatfish species in the family *Pleuronectidae* (Myers, *et al.* 1999). The time-series of estimated recruitments shows a relationship with the decline in spawning biomass, punctuated by larger recruitments in 2006, 2007, and 2008 (Figure 2-56). However, recruitment in recent years is estimated to be less than the expected mean recruitment indicating an absence of strong incoming recruitment.

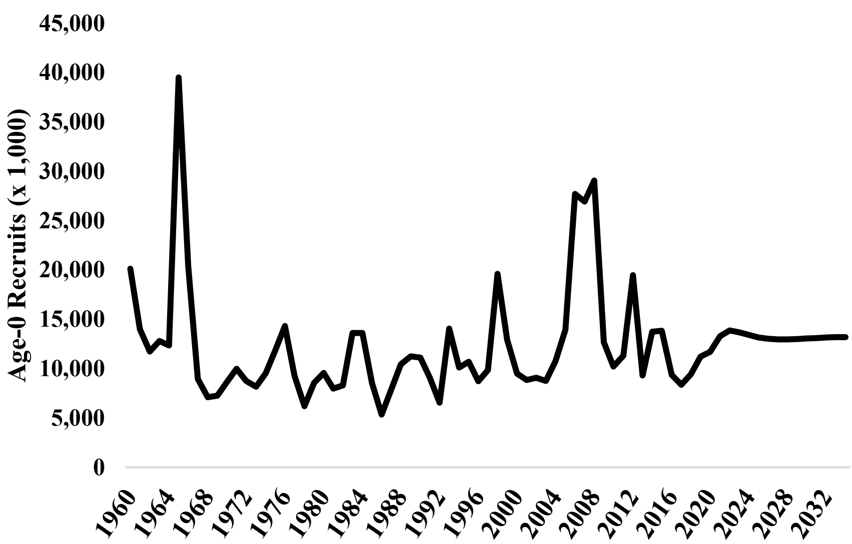

Figure 2-59. Time series of estimated (age-0) petrale sole recruitments (1960-2034), based on the 2023 full benchmark stock assessment.

Fishing Mortality

Most of the petrale sole catch is made by deep-water demersal trawls at depths of 164-252 fm. Since discovery of petrale spawning grounds during the 1950s and 1960s, petrale sole catch statistics have exhibited marked seasonal variation, with substantial portions of the annual harvest taken from the spawning grounds in December and January. From the inception of the fishery in 1876 through the mid-1940s, the majority of catches occurred between March and October (the summer fishery), when the stock is dispersed over the continental shelf. The post-World War II period witnessed a steady decline in the amount and proportion of annual catches occurring during the summer months (March-October). Conversely, petrale catch during the winter season (November–February), when the fishery targets spawning aggregations, has exhibited a steadily increasing trend since the 1950s. Since the mid-1980s, catches during the winter months have been roughly equivalent to or exceeded catches throughout the remainder of the year. In 2009, catches of petrale sole began to be restricted due to declining stock size.

Petrale sole exhibit distinct seasonal depth migrations with higher abundance on the shelf during summer months and higher abundance in distinct spawning areas during winter months. Hence, RCA structures for this species could vary seasonally if RCA management is needed to control fishing mortality. The general pattern for petrale sole is a shallower depth distribution during the summer months and a deeper depth distribution during the winter months.

Petrale sole are caught almost exclusively by bottom trawl gears. Discarding has historically been low (less than 5%), with most of the discarding due to small sizes. The uncertainty in catch monitoring and accounting is low, given the mandatory 100 percent observer coverage and near real-time reporting of total catches in the rationalized groundfish trawl fisheries.

Estimates of recent fishing intensity have been slightly below the limit reference point (Figure 2-57). Fishing intensity is defined here as 1 - SPR, where SPR is the equilibrium spawning output at a given combination of F and selectivity relative to spawning output at unfished equilibrium. Using the units of 1-SPR means that more intense fishing is associated with a higher value. The value of 1-SPR in the absence of fishing is 0 and the maximum is 1.0 if all spawning fish are being killed before spawning. The PFMC has chosen an SPR target of 30 percent for petrale sole so harvest which leads to SPR below 30 percent, or fishing intensity (1-SPR) greater than 70 percent would be overfishing.

The estimated time series shows an accelerating increase in fishing intensity with a peak around 1990 and the overfishing declaration in 2009 led to a dramatic decrease in catch in 2010, when 1-SPR fell below the management reference point. The fishing intensity has increased since that time due to the stock rebuilding but is estimated to have remained below the reference point in the years since.

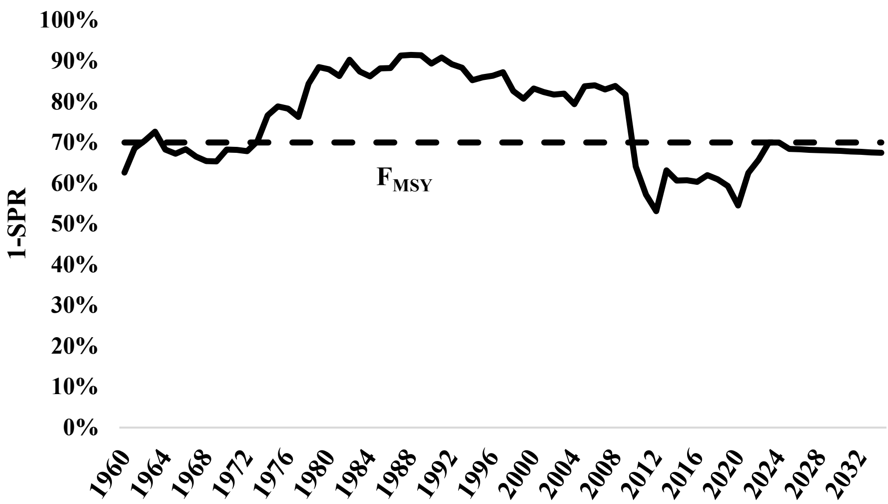

Figure 2-60. Fishing intensity (1-SPR) of petrale sole (1960-2034), based on the 2023 full benchmark stock assessment.

2.4.21 Sablefish

Distribution and Life History

Sablefish, or 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 stock 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 (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 1983a). Large adults are uncommon south of Point Conception (Hart 1988; Love 1996; McFarlane and Beamish 1983b; NOAA 1990). Adults are found as deep as 1,900 m, but are most abundant between 200 m and 1,000 m (Beamish and McFarlane 1988; Kendall and Matarese 1987; Mason*, et al.* 1983). Off southern California, sablefish are abundant to depths of 1,500 m (MBC 1987). Adults and large juveniles commonly occur over sand and mud (McFarlane and Beamish 1983a; NOAA 1990) in deep marine waters. They were also reported on hard-packed mud and clay bottoms in the vicinity of submarine canyons (MBC 1987).

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. Estimates indicate that 50 percent of females are mature at five years to six years (24 inches) and 50 percent of males are mature at five years (20 inches).

Sablefish larvae prey on copepods and copepod nauplii. Pelagic juveniles feed on small fishes and cephalopods—mainly squids (Hart 1988; Mason*, et al.* 1983). Demersal juveniles eat small demersal fishes, amphipods, and krill (NOAA 1990). Adult sablefish feed on fishes like rockfishes and octopus (Hart 1988; McFarlane and Beamish 1983a). Larvae and pelagic juvenile sablefish are heavily preyed upon by seabirds and pelagic fishes. Juveniles are eaten by Pacific cod, Pacific halibut, lingcod, spiny dogfish, and marine mammals, such as Orca whales (Cailliet*, et al.* 1988; Hart 1988; Love 1996; Mason*, et al.* 1983; NOAA 1990). Sablefish compete with many other co-occurring species for food, mainly Pacific cod and spiny dogfish (Allen 1982).

Stock Status and Management History

Formal stock assessments of sablefish began in 1984. The first coastwide assessment established regulations on the sablefish fishery off the U.S. Pacific coast which were implemented as trip limits in October 1982. Since 1982, the sablefish fishery has been managed intensively, with limited entry and open access programs used in various manners to limit catches.

In 2001, two assessments were completed and reviewed by a STAR Panel: one by NMFS (Schirripa and Methot 2001) and one by the Pacific Groundfish Conservation Trust (Hilborn*, et al.* 2001). The two assessments were in agreement, and the Council adopted the NMFS assessment for management purposes. Schirripa and Methot (2001) focused on evaluating the sensitivity of the model and the outcomes to changes in the survey data. These changes included the combining of the AFSC slope survey data and the NWFSC Industry Co-operative Survey data using a statistical Generalized Linear Models (GLM) procedure. This analysis made it possible to extend the southern boundary of the assessment south to Point Conception at 34°27' N. lat. rather than 36° N. lat. used in previous assessments. The assessment indicated a normal decline in biomass since the late 1970s due to the fishing down of the unfished stock and an unexpected decline in recruitment during the early 1990s. It introduced for the first time, the possibility that sablefish recruitment may be linked to environmental factors. A seemingly meaningful relationship was demonstrated between changes in northern and southern copepod abundances and sablefish recruitment. Conditions and projections in the model considered two competing “states of nature” to calculate the mean virgin recruitment: a “density-dependent” state that used the average of 1975-1991 recruitments, and a “regime shift” state that used the 1975-2000 recruitments. To account for this uncertainty, the Council adopted a 2002 ABC based on the proxy harvest rate ($F_{45\%}$) adjusted to reflect the distribution north and south of 36° N. lat. This was done because a plan amendment would be needed to change the management area since Groundfish FMP Amendment 14 specified only the area north of 36° N. lat.

The Council also wanted to verify industry reports of a large abundance of juvenile sablefish, an observation that was confirmed to some extent by preliminary results from the 2001 NMFS slope survey. Based on these considerations, the Council recommended a new expedited assessment be done in 2002. This update assessment (Schirripa 2002), by definition, sought to document changes in the estimates of the status of the stock by only considering newly available data for 2001 while not considering any new changes in the model structure or model assumptions. The expedited assessment confirmed fishermen's anecdotal reports of a large 1999 year class, which was also apparent in the preliminary results of the 2001 slope survey.

The 2005 sablefish assessment estimated stock depletion at 34.3 percent of unfished biomass (Schirripa and Colbert 2006). The assessment fit a relationship between sea level and recruitment deviations for the period 1973-2003 and used that relationship to hindcast recruitment variability back to 1925. The 2005 assessment found that spawning stock biomass had steadily declined since 1900 and suggested that there was little evidence that recruitment from 2001-2005 was as high as that for the strong 1999 and 2000 year classes. As a result, the assessment's biomass projections indicate a short-term increase, followed by a continued decline.

The 2007 updated sablefish assessment estimated spawning depletion to be 38.3 percent of unfished biomass at the start of 2007 (Schirripa 2008). This increase from 2005 was attributed in part to the continued recruitment of the strong 1999 and 2000 year classes into the spawning stock biomass. The assessment also estimated a series of poor recruitments in the mid- to late-1990s, and if fished at the full OY level, depletion was forecasted to decrease for the next five years.

The 2011 sablefish assessment estimated spawning stock biomass to be at 33 percent of its unfished biomass at the beginning of 2011 (Stewart*, et al.* 2011). The resource was modeled as a single stock; however, there is some dispersal to and from offshore seamounts and along the coastal waters of the continental U.S., Canada, Alaska, and across the Aleutian Islands to the western Pacific which was not explicitly accounted for in this analysis. Environmental time-series including both sea-surface height (used in previous sablefish assessments) and zooplankton abundance were also investigated. These environmental indices were not used in the 2011 assessment in the interest of parsimony since they did not affect results.

An update of the 2011 sablefish assessment was conducted in 2015 (Johnson*, et al.* 2015), which indicated spawning biomass to be 34.5 percent of its unfished level. There were only minor changes to the 2011 assessment when updating to the new version of Stock Synthesis. All data inputs were updated, additional corrections to data were made (e.g., discards), and new software was used to generate survey indices using delta-GLMMs. The SSC recommended a more thorough review is needed of standardized procedures and new software used to produce fishery size and age compositions, used for the first time in the current assessment cycle, especially in the context of sablefish. Port sampling data for sablefish are more complicated than for other groundfish species because there is a complex set of size-graded market categories for sablefish and many of the fish are landed in dressed condition.

A new full assessment of sablefish conducted in 2019 (Haltuch*, et al.* 2019) indicated the stock was at 39 percent of unfished biomass at the start of 2019. Major changes in the 2019 assessment include pooling of hook and line and pot gear into a single fixed gear fishery, the exclusion of all the length composition data (except data associated with the NMFS trawl survey) due to tensions among data sources in the model, a change in the fixed steepness value from 0.60 to 0.70, and the inclusion of a recruitment index based on the environmental time series of sea level. In addition to tension between length and age data, other major uncertainties were associated with spatial and temporal variability in growth, spatial stock structure, and the modeling of retention curves. Despite these uncertainties, the NMFS trawl survey index and compositional data are informative with respect to both abundance trends and recruitment variability. Spawning output has been relatively stable over the past decade with depletion close to the management target level during that time. In 2019, the sablefish stock was estimated to be at 39 percent of unfished spawning output.

A 2021 update of the 2019 sablefish assessment indicated the 2021 depletion was 57.9 percent of the unfished level (Kapur 2021). Catch projections indicated that catch attainment consistent with harvest policies would result in the stock declining from 57.9 percent of the unfished level in 2021 to approximately 50 percent of the unfished level in 2031.

A limited update assessment was conducted in 2023 (Johnson et al. 2023), which did not utilize new age readings from fishery collections. This species was added (Spring 2023) to the list of species scheduled for assessment in 2023 due to observations in 2021 and 2022 West Coast groundfish bottom trawl surveys that included above-average recruitment success for sablefish, which raised concerns about sablefish bycatch in non-target fisheries. All externally estimated model parameters, weight-length relationship, maturity schedule, and fecundity relationships, remained unchanged from the 2019 benchmark assessment. As in previous assessments, growth and natural mortality were estimated using sex-specific relationships. The estimated trajectory of relative spawning biomass across the times series is highly variable, with the population increasing to near unfished levels in the 1970s; declining to near the target relative biomass of 40 percent around 2000; and then increasing at the end of the modeled period (Figure 2-58). The estimated fraction unfished in 2023 is 63 percent, well above the management target.

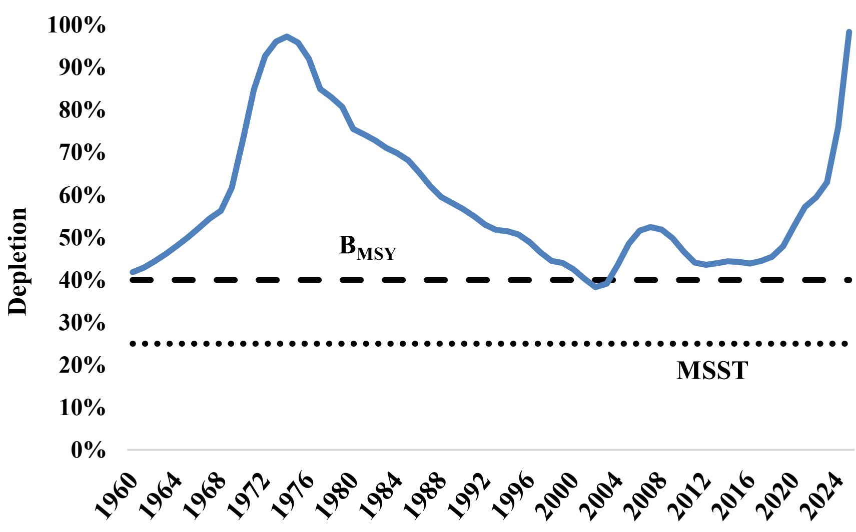

Figure 2-61. Relative depletion of sablefish (1960-2025), based on the 2023 limited update stock assessment.

Stock Productivity

Sablefish recruitment is estimated to be quite variable with large amounts of uncertainty in individual recruitment events. A period with generally higher frequencies of strong recruitments spans from the early 1950s through the 1970s, followed by a lower frequency of large recruitments during 1980 forward, contributing to stock declines, with some recent larger recruitments pushing the population higher in the past few years (Figure 2-59). The period with a higher frequency of high recruitments contributed to a large increase in stock biomass that subsequently declined throughout much of the 1970s forward. Less frequent large recruitments during the mid-1980s through 1990 slowed the rate of stock decline, with another series of large recruitments during 1999 and 2000 leading to a leveling off in the stock decline. The above-average cohorts starting in 2008 and onward, especially those recently observed in 2021 and 2022, are contributing to an increasing spawning stock size.

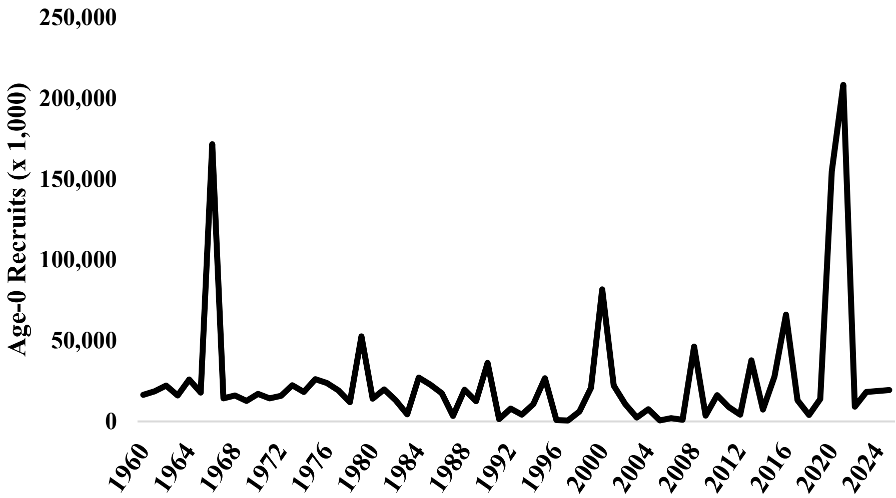

Figure 2-62. Estimated sablefish recruitments (1960-2025), based on the 2023 limited update stock assessment.

Fishing Mortality

Sablefish is one of the most important groundfish stocks on the West Coast and the most commercially valuable groundfish stock on a per pound basis. Sablefish is a major target species in commercial trawl and non-trawl fisheries and is readily caught with trawls, longlines, and sablefish pots/traps on the shelf and slope.

During the first half of the 20th century, it is estimated that sablefish were exploited at relatively modest levels. Relative fishing intensity of sablefish was above the proxy F_{MSY} harvest rate ($SPR_{45\%}$) during nearly half of the years from 1976 through 2000, has been below the target since (Figure 2-60).

The PSA vulnerability score of 1.64 indicates a relatively low concern for potential overfishing.

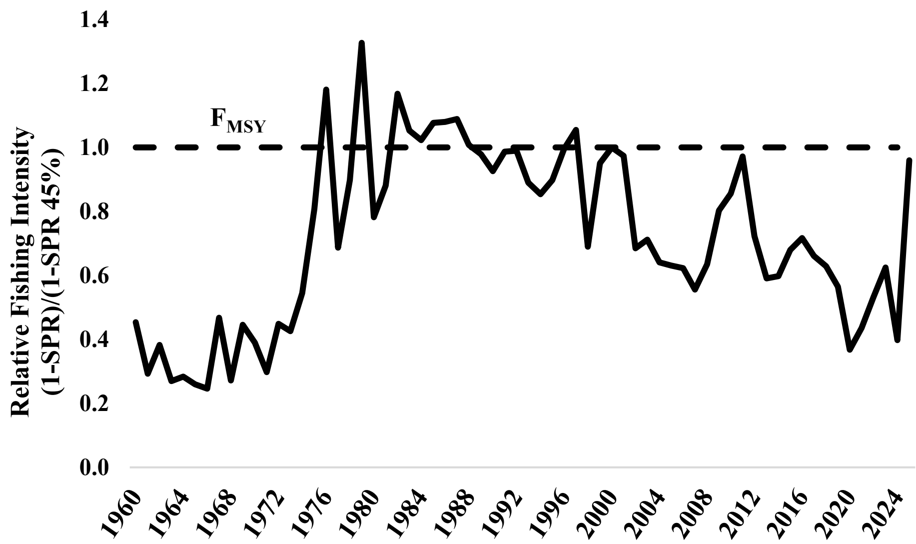

Figure 2-63. Relative fishing intensity of sablefish (1960-2025), based on the 2023 limited update stock assessment.

2.4.22 Shortspine Thornyhead

Distribution and Life History

Shortspine thornyhead (*Sebastolobus alascanus*) are found in the waters off of the West Coast of the United States from northern Baja California to the Bering Sea. They are found from 20 to over 1,500 m in depth. The majority of the spawning biomass occurs in the oxygen minimum zone between 600 and 1,400 m, where longspine thornyhead are most abundant (Bradburn*, et al.* 2011; Jacobson and Vetter 1996). The distribution of the smallest shortspine thornyhead suggests that they tend to settle at around 100–400 m and are believed to have ontogenetic migration down the slope, although large individuals are found across the depth range.

Shortspine thornyhead do not appear to be distributed evenly across the West Coast, with higher densities of thornyheads in shallower areas (under 500 m) off of Oregon and Washington, and higher densities in deeper areas off of California. The mean latitude of the largest shortspine thornyhead is slightly further north than of the medium sizes, suggesting the possibility of either a J-shaped migration, differential patterns of recruitment, or regional differences in exploitation history.

Although their densities vary, shortspine thornyhead are present in almost all trawlable areas below 500 m. They are caught in 91 percent of the trawl survey hauls below 500 m and 94 percent of the commercial bottom trawl hauls below 500 m. In camera tows, thornyheads are seen to be spaced randomly across the sea floor (Wakefield 1990), indicating a lack of both schooling and territoriality.

Genetic studies of stock structure do not suggest separate stocks along the West Coast. Siebenaller (1978) and Stepien (1995) found few genetic differences among shortspine thornyhead along the Pacific coast. Stepien (1995) suggested there may be a separate population of shortspine thornyhead in the isolated area around Cortes Bank off San Diego, California. Stepien (1995) also suggested that 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. lat.

Stepien et al. (2000), using a more discerning genetic material (mtDNA), found evidence of a pattern of genetic divergence corresponding to geographic distance. However, this study, which included samples collected from southern California to Alaska, did not identify a clear difference between stocks even at the extremes of the range. No such pattern was seen in longspine thornyhead, which suggests that the shorter pelagic stage (~1 yr vs. ~2 yrs) of shortspine thornyhead may contribute to an increased genetic separation with distance.

Shortspine thornyhead along the West Coast spawn pelagic, gelatinous masses between December and May (Erickson and Pikitch 1993; Pearson and Gunderson 2003; Wakefield 1990). Juveniles settle at around 1 year of age (22- 27 mm in length), likely in the range of 100-200 m (Vetter and Lynn 1997), and migrate down the slope with age and size, although large individuals are found across the depth range.

Shortspine thornyhead grow very slowly, but may continue growing throughout their lives, reaching maximum lengths of over 70 cm. Females appear to reach larger sizes than do males. Maturity in females has been estimated as occurring near 18 cm, at 8-10 years of age (Pearson and Gunderson 2003), although new information suggests that patterns of maturity may be more complex.

Shortspine thornyhead and longspine thornyhead have historically been caught with each other and with Dover sole and sablefish, making up the DTS fishery. Other groundfish species that frequently co-occur in these deep waters include a complex of slope rockfishes, rex sole, longnose skate, roughtail skate, Pacific grenadier, giant grenadier, Pacific flatnose as well as non-groundfish species such as Pacific hagfish and a diverse complex of eelpouts. Shortspine thornyhead typically occur in shallower water than the shallowest longspine thornyhead and migrate to deeper water as they age. When shortspine thornyhead have reached a depth where they overlap with longspine thornyhead, they are typically larger than the largest longspine thornyhead. Shortspine thornyhead stomachs have been found to include longspine thornyhead, suggesting a predator-prey linkage between the two species.

Thornyheads spawn gelatinous masses of eggs which float to the surface. This may represent a significant portion of the upward movement of organic carbon from the deep ocean (Wakefield 1990). Thornyheads have been observed in towed cameras beyond the 1,280 m limit of the current fishery and survey, but their distribution, abundance, and ecosystem interactions in these deep waters are relatively unknown.

Stock Status and Management History

Beginning in 1989, both thornyhead species were managed as part of the deep water complex with sablefish and Dover sole (DTS). In 1991, the Council first adopted separate ABC levels for thornyheads and catch limits were imposed on the thornyhead group. Harvest guidelines were instituted in 1992 along with an increase in the minimum mesh size for bottom trawl fisheries. In 1995 separate landing limits were placed on shortspine thornyhead and longspine thornyhead and trip limits became more restrictive. Trip limits (predominantly 2-month limits on cumulative vessel landings) have often been adjusted during the year since 1995 in order to not exceed the HG or OY for that year. At first, the HG for shortspine thornyhead was set higher than the ABC to allow a greater catch of longspine thornyhead, which was considered a relatively underutilized and healthy stock.

Ianelli et al. (Ianelli*, et al.* 1994) assessed the coastwide abundance of longspine thornyhead and shortspine thornyhead based on slope survey data, an updated analysis of the logbook data, and fishery length-composition data to estimate the parameters of length-based Stock Synthesis models, under different assumptions regarding discarding practices.

The assessment of thornyheads in 1997 covered the area from Central California at 36° N. lat. to the U.S.-Canada border (Rogers*, et al.* 1997). The STAR Panel expressed concern that management requires more detailed information on thornyheads than could be obtained from the available data. In 1998, two separate stock assessments covering the area north of 36° N. lat. were prepared and accepted by the Council (NMFS and OT 1998; Rogers*, et al.* 1998). A synthesis of these two assessments was used to set the harvest specifications for 1999 and 2000. Given that the synthesis estimated 1999 depletion at 32 percent of virgin biomass, the Council used the precautionary 40-10 harvest control rule policy to set the OYs for those two years.

There were a range of uncertainties in the 2001 assessment of shortspine thornyhead, not the least of which was the estimated biomass (Piner and Methot 2001). The assessment was extended south to Point Conception (in contrast to past surveys, which were limited to stocks north of the 36° N. lat. management area boundary). The authors concluded the 2001 spawning biomass ranged between 25 percent and 50 percent of unexploited spawning biomass. As was also the case in the 1998 assessment, the uncertainty in abundance largely revolved around the uncertainty in recruitment and survey q, or catchability, of shortspine thornyhead in slope surveys. The authors also concluded that the trend in stock biomass was increasing and the stock was not depleted. Based on estimated biomass and application of the GMT-recommended F=0.75M principle (which approximated an $F_{50\%}$ proxy harvest rate for shortspine thornyhead), the assessment authors and GMT recommended a slight increase in the ABC and OY for 2002. They also recommended that the harvest specifications be set for two areas divided by Point Conception at 34°27' N. lat., rather than the previous policy to separate the management areas at the Conception-Monterey border (36° N. lat.). Despite the uncertainty in biomass estimates and determination of whether shortspine thornyhead should be treated as a "precautionary zone" stock, these recommendations did treat the stock as such by applying the 40-10 harvest control rule adjustment.

The 2005 stock assessment estimated the shortspine thornyhead spawning stock biomass to be at 62.9 percent of its initial, unfished biomass in 2005 (Hamel 2006c). The 2005 assessment extended the southern border of the assessment area from Point Conception to the Mexican border (32.5° N. lat.). Including the entire Conception area resulted in a larger basis for unfished biomass, given that this area was estimated to contain nearly half of the stock's total West Coast biomass. It was noted that there could be regional management concerns with this stock because while the assessment OY was coastwide, there are differences in historic exploitation rates north and south of Point Conception. It was also noted that the biomass estimate south of Pt. Conception was more uncertain than that in the north.

The 2013 stock assessment estimated the shortspine thornyhead spawning stock biomass to be at 74.2 percent of its initial, unfished biomass in 2013 (Taylor and Stephens 2013). A longer time series of the coastwide NWFSC trawl survey biomass estimates were included in this assessment relative to the 2005 assessment. Therefore, the STAT concluded there was no greater uncertainty in the biomass south of Pt. Conception relative to estimates for the rest of the coast. As in the previous assessment, no age data were used in the 2013 assessment and growth parameters were fixed at the same values used in 2005.

A data-moderate stock assessment for shortspine thornyhead was conducted in 2023 (Zahner et al. 2023). A coastwide two-sex, length-based age-structured model utilized a three fishery fleet and three survey structure, and most data used in the 2013 assessment were reanalyzed. New maturity analyses were available for this assessment with broader spatial coverage and larger sample sizes, in which fish mature at much larger sizes and thus older ages. A new fecundity relationship (i.e. fecundity increases with body size) and updated growth curves were also used.

In the 2023 assessment, spawning output was estimated to have remained stable until the early-1970s before beginning to decline near linearly through the present day. The estimated spawning output in 2023 is 8.717 billion eggs, which represents a depletion of 39.4 percent and falls below the 40 percent management target and in the precautionary zone (i.e. between management target and the minimum stock size threshold). Also based on the 2023 assessment, the depletion in 2013 was estimated to be 43.5%, a large decrease from what was estimated by the 2013 assessment for that year (~75%). The stock status is estimated to have only fallen below the management target starting in 2020.

The Council adopted a harvest control rule for shortspine thornyhead with an ACL less than the ABC due to the stock being in the precautionary zone, with the 40-10 harvest control rule applied, and a P* of 0.45. The apportionment of the coastwide ABC to ACLs for the stock north (70.6%) and south (29.4%) of 34°27' N. lat. is based on a 5 year rolling average of biomass estimates north and south of Pt. Conception at 34°27' N. lat. in the NWFSC WCGBT survey.

Stock Productivity

The 2023 data moderate stock assessment assumed a Beverton-Holt stock-recruitment relationship and used a fixed steepness value of 0.72 as recommended by Thorson et al. (2019), slightly higher than was assumed in previous assessments for shortspine thornyheads Steepness in the shortspine thornyhead assessment was fixed at 0.6 both in the 2005 and 2013 models (Hamel 2006c; Taylor and Stephens 2013). Results from the 2023 assessment model were found to be largely insensitive to the assumed steepness value.

Annual deviations about this stock-recruitment curve were estimated for the years 1901 through 2034. Recruitment in 2003 was estimated to be substantially larger than other years. As in the 2013 assessment, the uncertainty in each estimate is greater than the variability between estimates.

Fishing Mortality

Landings of shortspine thornyhead were estimated to have risen to a peak of 4,815 mt in 1989, followed by a sharp decline during a period of trip limits and other management measures imposed in the 1990s. Since the institution of separate trip limits for shortspine thornyhead and longspine thornyhead, the fishery had more moderate removals of between 1,000 and 2,000 mt per year from 1995 through 1998. Landings fell below 1,000 mt per year from 1999 through 2006, then rose to 1,531 in 2009 and have declined since that time.

Based on the 2023 stock assessment, the estimated relative fishing intensity has been above the F_{MSY} target starting in the early 1970's, and consistently exceeded the $SPR_{50\%}$ target from 1980-2018, but dropped below that point around 2020 and onward.

2.4.23 Spiny Dogfish

Distribution and Life History

In the Northeast 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. They are extremely abundant in waters off British Columbia and Washington, but decline in abundance southward along the Oregon and California coasts (Ebert 2003; Ebert*, et al.* 2010).

The U.S. West Coast spiny dogfish stock likely has interaction and overlap with dogfish observed off British Columbia. About 1,300 dogfish were tagged along the coast of Washington from 1942-1946, during the period of the strong directed fishery for dogfish. Only 50 of these fish were recaptured and had tags returned (4 percent), of which 54 percent were recaptured within U.S. coastal waters, while 32 percent were recaptured in coastal Canada and 12 percent in the inside waters of Puget Sound and the Strait of Georgia. One fish was recaptured in coastal Japanese waters (7 years after being tagged). Because many of the releases were close to the U.S.-Canada border and the fractions do not take into account the relative fishing pressure within each area, this study is of limited use in providing reliable information about dogfish movement rates.

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 percent per year between the U.S. coastal sub-population of dogfish and that found along the West Coast of Vancouver Island in Canada. The model also estimated movement rates of less than 1 percent per year between the U.S. coastal sub-population of dogfish and that in the Puget Sound.

These sharks appear to prefer areas in which the water temperature ranges from 5 to 15° C, often making latitudinal and depth migrations to follow this optimal temperature gradient (Brodeur*, et al.* 2009). There is also evidence of seasonal movement along the coast based on both tagging data and timing of historical fisheries (Ketchen 1986). One estimate of the seasonal movement along the Pacific coast is a North-South shift of about 600 km from winter to summer (Taylor 2008). This seasonal pattern is not as extreme as that found among spiny dogfish in Atlantic waters of the U.S., which are likely due to larger fluctuations in temperature. Dogfish have also been captured in high-seas salmon gillnets across the North Pacific between about 40° and 50° N. lat. (Nakano and Nagasawa 1996), but the extent of these wide-ranging pelagic movements is poorly understood.

The biology and life history of spiny dogfish are relatively well studied (Campana*, et al.* 2009; Di Giacomo*, et al.* 2009; Taylor 2008; Tribuzio 2009; Tribuzio*, et al.* 2009; Tribuzio*, et al.* 2010; Vega*, et al.* 2009). This species is an opportunistic feeder that consumes a wide range of prey (whatever is abundant). Schooling pelagic fish, such as herring, make up the majority of its diet. They also feed on invertebrates such as shrimp, crab, and squid. In turn, dogfish are preyed upon by larger cod, hake, and other spiny dogfish (Beamish*, et al.* 1992; Brodeur*, et al.* 2009; Tanasichuk*, et al.* 1991). Larger species of sharks, as well as seals and killer whales, also feed on dogfish.

Spiny dogfish have internal fertilization and ovoviviparous development. The internal development takes place over 22-24 months, the longest gestation period known for sharks. The number of pups in each litter ranges between 5 and 15 individuals depending on the size of the female (larger females bearing more pups). The size at birth is generally between 20 and 30 cm for both genders. Male spiny dogfish are reported to grow faster than females, but females reach larger sizes. This species is the latest maturing (with 50 percent female maturity reported at 35.5 years) and longest lived of all elasmobranchs (Cortes 2002; Saunders and McFarlane 1993; Smith*, et al.* 1998; Taylor 2008). Life history traits of spiny dogfish make the species highly susceptible to overfishing and slow to recover from stock depletion since its slow growth, late maturation, and low fecundity are directly related to recruitment and spawning stock biomass (Holden 1974; King and McFarlane 2003).

Stock Status and Management History

Spiny dogfish on the U.S. West Coast have been utilized for almost a thousand years, with those in Puget Sound first used by Native Americans (Bargmann 2009). The exploitation of spiny dogfish in coastal waters started in the 20th century. Even though the history of spiny dogfish utilization on the U.S. West Coast included a brief but intense commercial fishery in the 1940s, in general this species is not highly prized and is mostly taken as bycatch in other fisheries.

Prior to 1936, coastal catches of spiny dogfish were extremely minimal, but in 1936, shortly after it was discovered that livers of spiny dogfish have high level of vitamin A, a large-scale fishery for dogfish developed in the Pacific Northwest. Before World War II, Northeast Pacific dogfish livers could not compete with the cheaper and more potent sources of vitamin A from Europe. But when World War II started and European supplies were cut, dogfish shark livers became the major source of vitamin A in the United States, and the spiny dogfish fishery grew rapidly along the Pacific coast. The processed liver oils were used in pharmaceuticals, food processing, and animal feed (Bargmann 2009; Ketchen 1986).

During the liver fishery, dogfish were targeted by three major gear groups, including setlines, set nets, and bottom trawls. The timing of the dogfish liver fishery coincided with the development of bottom trawling in the U.S. Northwest, and though at the onset of the fishery the catches by trawl were low, by the mid-1940s trawling was the dominant type of fishing for dogfish.

In 1945, a sharp decline in spiny dogfish catches began. This decline occurred despite continued strong demand for vitamin A and high prices for dogfish livers, but because of decreased availability of the species in the Northeast Pacific (Bargmann 2009; Ketchen 1986). In 1950, with the advent of synthetic vitamins, demand for spiny dogfish livers declined and catches in the Northeast Pacific virtually ended.

Between 1950 and 1974, the landings of spiny dogfish remained minimal. By the late 1950s it was reported that species availability had increased. Also, in the late 1950s-early 1960s, dogfish earned a bad reputation among fishermen. They were blamed for driving off commercially valuable species such as herring and mackerel, while consuming large numbers of them. Spiny dogfish have also been observed biting through nets to get to their fish prey, releasing many of them and damaging fishing gear in the process. They were also reported damaging gear when become entangled in commercial nets. As a result, fishermen were trying to avoid areas with higher densities of dogfish (such as soft bottoms, for example) to prevent encountering dogfish and potentially damaging their gear.

A market opportunity for dogfish developed in the mid-1970s. In Europe, spiny dogfish has long been used an inexpensive source of human food, for fish and chips in particular. A decline in the European dogfish supply provided an opportunity for developing an export dogfish food fishery on the U.S. West Coast. Also, during the late 1970s, shark cartilage started to be used in cancer treatment, and a portion of spiny dogfish catches have since been sold for medical research and treatment (Gregory Lippert, WDFW, pers. com. as cited by Gertseva and Taylor (2011)). As before, three types of gear were involved in catching dogfish (bottom trawl, setlines, and sunken gill nets), but since the mid-1980s catches by gillnets have been minimal.

Spiny dogfish is a common bycatch species, often caught in other fisheries and largely discarded. For instance, it has long been incidentally caught in the hake fishery, which is almost exclusively conducted with midwater trawls. Large-scale harvesting of Pacific hake in the U.S. began in 1966, when factory trawlers from the Soviet Union and other countries began targeting this stock. After the 200-mile U.S. EEZ was declared in 1977, a joint-venture fishery was initiated between U.S. trawlers and Soviet factory trawlers acting as motherships (larger, slower ships for fish processing and storage while at sea). By 1989 the U.S. fleet capacity had grown to a level sufficient to harvest the entire quota, and no further foreign fishing was allowed. The Pacific hake fishery is currently 100 percent observed at sea and data on bycatch species, including spiny dogfish, is being routinely collected.

Spiny dogfish on the U.S. West Coast has been managed under the Other Fish complex since implementation of the Groundfish FMP by the Council in 1982. In 2005, reduction in the Other Fish ABC was implemented due to removal of the California substock of cabezon from the Other Fish complex. The same year, a 50 percent precautionary OY reduction was implemented to accommodate uncertainty associated with managing unassessed stocks. In 2006, a trip limit for spiny dogfish was imposed for U.S. West Coast waters which varied between 45 and 91 mt per two months for all gears. In 2009, another ABC reduction was implemented due to removal of longnose skate from the Other Fish complex and the 50 percent OY reduction was maintained.

Gertseva and Taylor (2011) estimated the spawning stock output of spiny dogfish to be 44,660 thousands of fish (95 percent confidence interval: 8,937-80,383), which represents 63 percent of the unfished spawning output level. While this depletion level indicates the stock is currently healthy, fishing at the target SPR of 45 percent was expected to severely reduce the spawning output over the long term because of the extremely low productivity and other reproductive characteristics of the stock. The Council partially addressed this by setting a more conservative spiny dogfish ABC for 2013 by specifying a P* of 0.3.

The Council further decided to manage spiny dogfish with stock-specific harvest specifications beginning in 2015. The SSC also investigated establishing a more conservative F_{MSY} harvest rate for spiny dogfish and other elasmobranchs in recognition of their lower productivity. The SSC recommended and the Council adopted a more conservative proxy 50 percent SPR harvest rate as an interim measure for elasmobranchs. The 50 percent SPR was based on an SSC meta-analysis of *Chondrichthyes* species using the posterior distribution for F_{MSY}/M values as reported by Zhou et al. (2012). The SSC said they may further investigate sustainable harvest rates for Council-managed elasmobranchs as more information becomes available in the future.

A new stock assessment for spiny dogfish conducted in 2021 indicates the stock is just over the management target at 41.8 percent of unfished biomass (Figure 2-61, Gertseva 2021). The estimated spawning output in 2021 under the new assessment decreased from 18,354,000 pups projected in the previous assessment to 13,613,000 pups. Bridging analyses adding and updating data indicated that the scale of the assessment had changed as a result of 1) revised estimates for catchability (*q*) for the Northwest Fisheries Science Center (NWFSC) West Coast Bottom Trawl Survey (WCBTS) changing from 0.27 to 0.43, 2) new WCBTS composition data, and 3) new research indicating a gestation period of two years rather than one reducing fecundity estimates to half that assumed previously contributing to the change to the perception of stock status and harvest levels.

Improvements from the 2011 assessment included updated fisheries and survey-related data, abundance indices estimated using the VAST modeling approach, revised historical discard estimates, updated selectivity assumptions from asymptotic to dome-shaped with sex-specific offset, updated biological parameters, and updated tuning for age data. The magnitude of historical discards remains one of the main concerns in assessment data. Age determination is another unresolved issue for female dogfish, which has impacts on the growth parameters and the assumed natural mortality rate.

The West Coast Groundfish Survey *q* was fixed at 0.43 in the final base model, though it is subject to considerable uncertainty due to lack of contrast in the data included in the assessment and an inability to qualify 1) seasonal migrations (of up to 600 km) during the summer relative to the timing of the survey that operated from April through October that likely affects availability, 2) potential net avoidance given strong swimming abilities, 3) the distribution of a portion of the stock shoreward of the survey area, and 4) availability to the net itself given their semi-pelagic habits. The relatively flat likelihood profile for *q* implies that the data are uninformative about this parameter even though it is influential on the scale and depletion in the assessment. Catchability is listed as the major axis of uncertainty in decision tables and the best estimate determines the lower and upper bounds. The uncertainty in *q* is problematic since it affects the estimates of key parameters including natural mortality (*M*) and growth, creating tension in the model between these variables. There is a tradeoff between *M* and *q*, and the model fit improved when *M* was lower and *q* was higher.

The estimate of steepness for spiny dogfish is among the lowest values reported for marine fish stocks. The F_{MSY} of 0.003yr-1 corresponds to an SPR harvest rate of 90 percent while an SPR of 88.3 percent corresponds to $B_{40\%}$ given the value for steepness. The current $SPR_{50\%}$ F_{MSY} harvest rate proxy appears inconsistent with the biology if these results are correct. The SSC highlighted the SPR proxy is significantly higher than the SPR estimated to correspond to MSY and the stock is predicted to collapse if it is fished at a SPR of 50 percent. While a spawner-recruitment relationship meta-analysis might help inform a more ideal HCR, such an analysis is unlikely to be possible given the limited number of species with this life history.

The stock was designated category 2 since recruitment deviations are not estimated and data do not inform scale well. The SSC recommended the next assessment of spiny dogfish be a full assessment due to the technical issues discussed in the assessment and STAR panel report.

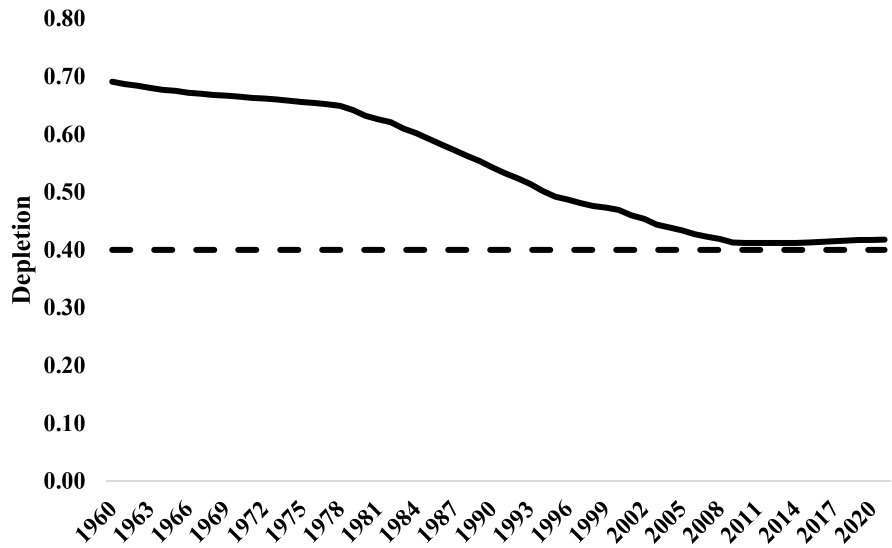

Figure 2-64. Relative depletion of spiny dogfish from 1960 to 2021 based on the 2021 stock assessment.

Stock Productivity

Spiny dogfish have a relatively low stock productivity due to slow growth, late maturation, and low fecundity. The fecundity of dogfish in the Northeast Pacific Ocean has been well studied, with pregnant females having relatively few pups per litter (5 to 15) and with relatively little variability among individuals. Unlike fish producing millions of eggs, the low fecundity of dogfish suggests both low productivity in general and a more direct connection between spawning output and recruitment than for many species.

Gertseva et al. (2021) modeled the spiny dogfish spawner-recruit relationship using a functional form which allowed a more explicit modeling of pre-recruit survival between the stage during which embryos can be counted in pregnant females to their recruitment as age-0 dogfish. The recruits were taken deterministically from the stock-recruit curve since the relatively large size of dogfish pups at birth (20-30cm) suggest that variability in recruitment would be lower than for a species with a larval stage, which is subject to higher mortality rates.

While steepness was not estimated or assumed in the conventional sense of a Beverton-Holt stock-recruitment relationship, a value for steepness (defined as recruitment relative to R_0 at a spawning depletion level of 0.2) can be derived from the parameters above according to the relationship provided by Gertseva et al. (2021). The calculated value of steepness is 0.283, indicating a great degree of compensation or density-dependent recruitment.

Fishing Mortality

Spiny dogfish catches have exceeded the proxy F_{MSY} harvest rate during the vitamin A fishery in the 1940s and during multiple periods in the last 40 years, most recently in 2008 (Figure 2-62).

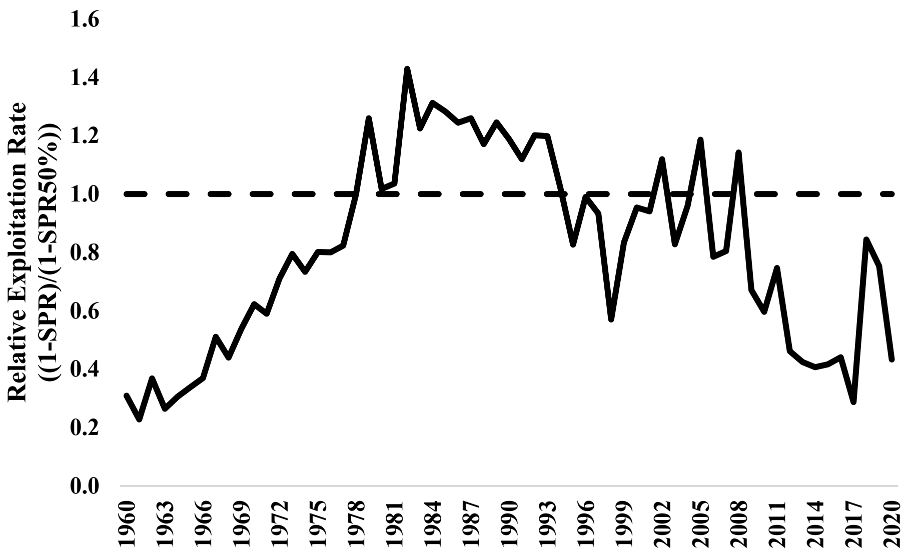

Figure 2-65. Estimated annual relative exploitation rate of spiny dogfish relative to the current proxy F_{MSY} target, 1960-2020.

2.4.24 Splitnose Rockfish South of 40°10′ N. Lat.

Distribution and Life History

Splitnose rockfish (*Sebastes diploproa*) are distributed from the northern Gulf of Alaska (Prince William Sound) to central Baja California and occur at depths between 91-795 meters. Adults are the most abundant between British Columbia and southern California at depths from 215 to 350 meters (Alverson*, et al.* 1964; Gunderson and Sample 1980; Love*, et al.* 2002). The species is distinguished by having a deeply notched upper jaw, which inspired its Greek name diploproa, meaning “double prow”. Splitnose rockfish are commonly seen on low-relief mud fields of the continental shelf and upper slope, often near isolated rock, cobble, or shell debris. Solitary individuals are often found resting on the seafloor, although they occasionally form schools that move more than 100 meters in the water column (Love*, et al.* 2002; Rogers 1994).

Splitnose rockfish co-occur with an assemblage of slope rockfish, including Pacific ocean perch (*Sebastes alutus*), darkblotched rockfish (*Sebastes crameri*), yellowmouth rockfish (*Sebastes reedi*), and sharpchin rockfish (*Sebastes zacentrus*) off Washington and Oregon, and stripetail rockfish (*Sebastes saxicola*), darkblotched rockfish and shortspine thornyhead (*Sebastolobus alascanus*) off central California. Pacific ocean perch and darkblotched rockfish are the most abundant members of that assemblage off the coasts of Oregon and Washington, but splitnose rockfish and darkblotched rockfish dominate off the northern coast of California. Lesser amounts of splitnose have also been noted in the deep water DTS assemblage and with shrimp catch (Rogers 1994; Rogers and Pikitch 1992; Weinberg 1994).

There are no clear stock delineations for splitnose rockfish in the U.S. waters. No molecular markers have yet been developed for this species, and no genetic data are currently available to suggest the presence of stock structure (Waples*, et al.* 2008). No distinct breaks are seen in the fishery landings and catch distributions. Survey catches imply a continuous distribution. The spatial dynamic cluster analysis of the NWFSC survey abundance indices (Cope and Punt 2009) provided no evidence of spatial stock structure for splitnose rockfish off Washington, Oregon, and California.

Splitnose rockfish are documented in the literature to live to at least 86 years (Bennett*, et al.* 1982), although a fish encountered in a NMFS survey was aged at 103 years old. This is a small species – the maximum size reported in the literature is 46 cm (Love*, et al.* 2002); the vast majority of individuals caught in NMFS surveys were under 44 cm in fork length, although a few fish larger than this were caught.

Splitnose rockfish exhibit sexual dimorphism in growth. Although the males grow to their maximum lengths earlier than females, females reach larger sizes than males (Boehlert 1980; Love*, et al.* 2002). It was hypothesized that life history characteristics may vary with lat., but that is uncertain. Boehlert and Kappenman (1980) detected greater size-at-age with increasing lat. and suggested more rapid growth of fish in the northern end of their range. Analysis of the NWFSC shelf-slope survey data did not show a distinct gradient in growth rate between north and south, although the asymptotic length (Linf) exhibits a latitudinal gradient (Gertseva*, et al.* 2009). Growth of splitnose rockfish was found to correlate with climate and environmental variables, including sea surface temperature, the (ENSO) index, and the PDO (Black 2009; Black*, et al.* 2008); more information is needed to develop climate-growth relationships for stock assessment purposes.

Female splitnose rockfish off California mature at 6-9 years old (18-23 cm long) (Echeverria 1987), and their fecundity increases with size (Phillips 1964). Splitnose rockfish mature somewhat later off British Columbia - both males and females reach 50 percent maturity at size of 27 cm (Westrheim 1975). Like other rockfishes, splitnose utilize internal fertilization and bear live young (Love*, et al.* 2002). This species can exhibit a long reproductive season, with young larvae found in all months off southern California, from January to September off central California, from March to September in Oregon, and in July off Washington (Love*, et al.* 2002; Moser*, et al.* 2000).

Young juveniles live at the surface for several months, then go through a transitory midwater residence, and finally settle to benthic habitats near the end of their first year of life (Love*, et al.* 2002). During their first year, splitnose have been found living among drifting vegetation in Puget Sound and southern California, and under floating objects in Queen Charlotte Sound, British Columbia (Shaffer*, et al.* 1995). Pelagic juvenile splitnose feed on calanoid copepods and amphipods (Shaffer*, et al.* 1995), while benthic juveniles and adults eat krill, copepods, sergestid shrimps and amphipods. Splitnose are prey of Steller sea lions and other pinnipeds (Love*, et al.* 2002).

Size-composition data for splitnose rockfish show a strong gradient of body size with depth, with smaller fish in shallow waters, suggesting ontogenetic movements of splitnose rockfish to deeper waters with increasing size and age, a common phenomenon in the genus *Sebastes* (Boehlert 1980).

Stock Status and Management History

Limits on domestic rockfish catches were first instituted in 1983, with splitnose rockfish managed as a part of the *Sebastes* complex, which included around 50 species. The ABC for the *Sebastes* complex was estimated for each INPFC area along the coast based on historic landings. In 1994, the *Sebastes* complex was divided into southern and northern management areas, and harvest guidelines were established for the complex in each area. The southern area included the Conception, Monterey and Eureka INPFC areas, and the northern area included the Columbia and U.S.-Vancouver INPFC areas.

In response to a concern that deep water species off Oregon and Washington might have been overharvested, Rogers (1994) conducted a preliminary assessment of splitnose rockfish, which focused on compiling and reviewing the available data. However, since the data were sparse and no evident trends in biomass or mean size were detected, the results were inconclusive. In 1996 the status of several rockfish species, which were part of the *Sebastes* complex, were assessed (Rogers*, et al.* 1996), and ABCs for splitnose rockfish in the southern area were calculated to be 868 mt for the southern management area and 274 mt for the northern management area. These amounts were not specified individually but included in the total ABCs for the *Sebastes* complex.

In 1998, unusually high splitnose rockfish landings drove *Sebastes* complex harvests in the southern management area sharply upward. In 1999, for the first time, splitnose rockfish were individually separated from the southern *Sebastes* complex. Individual ABCs and OYs for splitnose rockfish in that area have been specified along with splitnose-specific trip limits since then. The ABC for the southern management area was set at 868 mt, as estimated in the 1996 assessment of the remaining rockfish in the *Sebastes* complex (Rogers*, et al.* 1996).

Additionally, in 1999, the general *Sebastes* complex was divided into nearshore, shelf, and slope assemblages, and the dividing line between the northern and southern management areas was shifted southward to 40°10’ N. lat., near Cape Mendocino. Since that time, in the northern area, splitnose has been managed under trip limits for slope rockfish. In 2000, harvest specifications for splitnose rockfish were set for the Conception and Monterey areas only, and 48 mt for the Eureka area were added to the northern rockfish ABC. Also, a precautionary adjustment of the OY (reduced from the ABC by 25 percent) was specified to account for the limited nature of the assessment. In 2000, the ABC and OY for splitnose rockfish south of 40°10’ N. lat. were reduced based on the revised F_{MSY} harvest rate policy. During the last 10 years, the coastwide landings and total catch of splitnose rockfish were relatively low, and the limits established for the area south of 40°10’ N. lat. have not been exceeded.

Gertseva et al. (2009) assessed splitnose rockfish coastwide and determined the stock was healthy with a depletion of 66 percent at the start of 2009. Since 1999, the splitnose spawning output was estimated to have been increasing in response to below-average removals and above-average recruitment during the last decade. At the beginning of 2009 the estimated spawning stock output was 8,426 million eggs. Uncertainty in the model was explored though asymptotic variance estimates and sensitivity analyses. Asymptotic confidence intervals were estimated within the model and reported throughout the assessment for key model parameters and management quantities. Uncertainty in recent recruitment was used to define alternative states of nature and develop the decision table.

The Council adopted the default harvest control rule of ACL = ABC (P* = 0.45) for splitnose rockfish for 2019 and beyond. Splitnose rockfish are managed with stock-specific harvest specifications south of 40°10' N. lat. and within the Slope Rockfish complex north of 40°10' N. lat. The projected coastwide OFLs, ABCs, and ACLs for splitnose rockfish are apportioned north and south of 40°10' N. lat. using average historical (1916-2008) landings with 64.2 percent apportioned south of 40°10' N. lat.

Stock Productivity

Steepness of the stock-recruitment curve was fixed at a value of 0.58 in the 2009 splitnose rockfish assessment, as estimated by a meta-analysis for unassessed rockfish. Recruitment deviations were estimated for each year between 1960 and 2006, which was the period best informed by the data based on evaluation of the variance of the recruitment deviations. Prior to 1960 and after 2006, recruits were taken deterministically from the stock-recruit curve. The model estimated above-average recruitments in the most recent years beginning 1999, which along with low catches during the last decade determine a population increase in recent and early forecast years. Uncertainty in recent recruitment was used to define alternative states of nature and develop the decision table.

Fishing Mortality

Splitnose rockfish have been taken incidentally in fisheries such as the trawl fisheries targeting POP, mixed slope rockfish, and other deep water targets, but have not been a commercial target species. Splitnose rockfish were lightly exploited until the 1940s, when the trawl fishery for rockfish first became important. With the development of the POP fishery (a species with which splitnose rockfish co-occur), spawning output of splitnose rockfish began to decline. A sharp drop in the 1960s was associated with large harvests of POP by foreign trawl fleets operating in the U.S. EEZ. Another drop occurred in 1998 when the increased availability of splitnose rockfish led to high removals off California. Since 1999, the splitnose spawning output was estimated to have been increasing in response to below-average removals and above-average recruitment during the last decade.

It was decided to continue management of splitnose rockfish with stock-specific specifications south of 40°10' N. lat. and under the Slope Rockfish complex north of 40°10' N. lat. when the coastwide splitnose rockfish assessment was first used to inform management in 2011. A north-south apportionment based on the average 1916-2008 assessed area catch resulted in 64.2 percent of the stock-specific specifications in the southern area and 35.8 percent for the contribution of splitnose rockfish to the Slope Rockfish North complex being used to apportion harvest specifications since 2011. The Council recommended continuing this management strategy largely due to the implications of determining the uncertain catch history by trawl permit to initially allocate trawl splitnose quota shares (QS) under Amendment 20. Since splitnose rockfish are not targeted and predominantly discarded at sea, little data would be available to determine catch history.

2.4.25 Starry Flounder

Distribution and Life History

Starry flounder (*Platichthys stellatus*) have a very broad geographic distribution around the rim of the North Pacific Ocean and have been recorded from Los Angeles to the Aleutian Islands, although they are rare south of Point Conception (Kramer and O'Connell 1995; Orcutt 1950). Off the U.S. West Coast starry flounder are found commonly in nearshore waters, especially in the vicinity of estuaries (Baxter 1999; Kimmerer 2002; NOAA 1990; Orcutt 1950; Pearson 1989; Sopher 1974). It has quite a shallow bathymetric distribution, with most individuals occurring in waters less than 80 m, although specimens have been collected off the continental shelf in excess of 350 m (Kramer and O'Connell 1995; Orcutt 1950). They are most often found on gravel, clean shifting sand, hard stable sand, and mud substrates.

Spawning occurs primarily during the winter months of December and January, at least in central California (Orcutt 1950); it may occur somewhat later in the year (February-April) off British Columbia and Washington (Hart 1988; Love 1996). Egg/larval development apparently takes about 2-3 months to occur. Offspring principally remain within the estuaries until age two, when many have migrated to the adjacent ocean habitats (Baxter 1999; Kimmerer 2002; Orcutt 1950). Reproductive maturity occurs at age two years for males and age three years for females, when the fish are 28 cm and 35 cm, respectively. Tagging studies have shown that fish are relatively sedentary and move little during their adult lives (Love 1996); however, there is little information on regional variation in stock structure.

Starry flounder consume crabs, shrimps, worms, clams and clam siphons, other small mollusks, small fish, nemertean worms, and brittle stars (Hart 1988).

Stock Status and Management History

The U.S. West Coast starry flounder stock was assessed in 2005 (Ralston 2006). The assessment was based on the assumption of separate biological populations north and south of the California-Oregon border. The assessment used catch data, relative abundance indices derived from trawl logbook data, and an index of age-1 abundance from trawl surveys in the San Francisco Bay and Sacramento-San Joaquin River estuary. Unlike most other groundfish stock assessments, no age- or length-composition data were directly used in the assessment. Both the northern and southern populations were estimated to be above the target level of 40 percent of virgin spawning biomass (44 percent in Washington-Oregon and 62 percent in California), although the status of this data-limited species remained fairly uncertain compared to that of many other groundfish species. One of the most significant areas of uncertainty in the assessment was the estimate of natural mortality rate, which was quite high (0.30 for females and 0.45 for males).

Starry flounder were managed in the Other Flatfish complex until 2007, when the stock was removed from the complex and managed with stock-specific specifications determined from the assessment. Starry flounder have never been overfished or subject to overfishing.

A new starry flounder assessment was not conducted in 2015 and the 2005 assessment was out of date for informing harvest specifications in 2017 and beyond. A DB-SRA assessment of starry flounder was conducted, reviewed, and approved in 2017 to inform harvest specifications in 2019 and beyond. The OFL of 652 mt is the sum of estimated California and Oregon OFLs of 354 mt and 298 mt, respectively. Harvest specifications in 2019 and beyond are based on the default harvest control rule of ACL equal to ABC with a P* of 0.4. The starry flounder stock has consistently been harvested at about 2 percent of the allowable harvest and there are no conservation concerns for this under-utilized stock.

Stock Productivity

Recruitment deviations were estimated in both the northern and southern starry flounder assessment models, although selectivity patterns were fixed external to the model after analysis of trawl length composition information from the Pacific Fisheries Information Network (PacFIN)-Biological Data System (BDS) database and sport length composition information from the Recreational Fisheries Information Network (RecFIN) database. Growth and other life history parameters were also fixed, largely based on a detailed study of starry flounder by Orcutt (1950). Finally, spawner-recruit steepness (h = 0.80) and recruitment variability (σr = 1.00) were also held constant.

Starry flounder is a relatively productive stock with a PSA productivity score of 2.15. They are also not vulnerable to potential overfishing (V = 1.04).

Fishing Mortality

Starry flounder are mostly caught in nearshore recreational fisheries. Historically, they were also caught in nearshore trawl efforts; however, this catch is rare today given that Washington and California have closed their state nearshore waters to trawling. Both the northern and southern stocks were estimated to be well above the $B_{25\%}$ B_{MSY} threshold ($B_{44\%}$ in Washington-Oregon and $B_{62\%}$ in California). In addition, recent exploitation rates have been well below the F_{MSY} proxy for flatfish.

2.4.26 Widow Rockfish

Distribution and Life History

Widow rockfish (*Sebastes entomelas*) range from Albatross Bank off Kodiak Island to Todos Santos Bay, Baja California, Mexico (Eschmeyer*, et al.* 1983; Miller and Lea 1972; NOAA 1990). They occur over hard bottoms along the continental shelf (NOAA 1990) and prefer rocky banks, seamounts, ridges near canyons, headlands, and muddy bottoms near rocks. Large widow rockfish concentrations occur off headlands such as Cape Blanco, Cape Mendocino, Point Reyes, and Point Sur. Adults form dense, irregular, midwater and semi-demersal schools deeper than 100 m at night and disperse during the day (Eschmeyer*, et al.* 1983; NOAA 1990; Wilkins 1986). All life stages are pelagic, but older juveniles and adults are often associated with the bottom (NOAA 1990). All life stages are fairly common from Washington to California (NOAA 1990). Pelagic larvae and juveniles co-occur with yellowtail rockfish, chilipepper, shortbelly rockfish, and bocaccio larvae and juveniles off Central California (Reilly*, et al.* 1992).

Widow rockfish are ovoviviparous, have internal fertilization, and brood their eggs until released as larvae (NOAA 1990; Reilly*, et al.* 1992). Mating occurs from late fall-early winter. Larval release occurs from December through February off California, and from February through March off Oregon. Juveniles are 21 mm to 31 mm at metamorphosis, and they grow to 25 cm to 26 cm over three years. Age and size at sexual maturity varies by region and sex, generally increasing northward and at older ages and larger sizes for females. Some mature in three years (25 cm to 26 cm), 50 percent are mature by four years to five years (25 cm to 35 cm), and most are mature in eight years (39 cm to 40 cm) (NOAA 1990). The maximum age of widow rockfish is 28 years, but rarely over 20 years for females and 15 years for males (NOAA 1990). The largest size is 53 cm and about 2.1 kg (Eschmeyer*, et al.* 1983; NOAA 1990).

Widow rockfish are carnivorous. Adults feed on small pelagic crustaceans, midwater fishes (such as age-one or younger Pacific whiting), salps, caridean shrimp, and small squids (Adams 1987; NOAA 1990). During spring, the most important prey item is salps, during the fall fish are more important, and during the winter widow rockfish primarily eat sergestid shrimp (Adams 1987). Feeding is most intense in the spring after spawning (NOAA 1990). Pelagic juveniles are opportunistic feeders, and their prey consists of various life stages of calanoid copepods, and euphausiids (Reilly*, et al.* 1992).

Stock Status and Management History

Widow rockfish are an important commercial species from British Columbia to central California, particularly since 1979, when Oregon trawl fisherman demonstrated the ability to make large catches at night using midwater trawl gear. Many additional participants entered the fishery resulting in a rapid increase in landings of widow rockfish (Love*, et al.* 2002). Widow rockfish are a minor component of the recreational groundfish fisheries.

The first West Coast assessments for widow rockfish were performed in 1988, 1990, 1993, and 1997 (Hightower and Lenarz 1990; Lenarz and Hightower 1988; Ralston and Pearson 1997; Rogers and Lenarz 1993). In 1988 the assessment involved the use of cohort analysis and the stock synthesis program. In 1993 and 1997, the age-based version of the stock synthesis program was used to assess the status of widow rockfish.

Williams et al. (2000) assessed the coastwide stock of widow rockfish in 2000. The spawning output level (8,223 million eggs), based on that assessment and a revised rebuilding analysis (Punt and MacCall 2002) adopted by the Council in June 2001, indicated the stock was at 23.6 percent of the unfished level (33,490 million eggs) in 1999. The widow rockfish stock was declared overfished in 2001 based on this assessment result.

It was concluded in the 2003 assessment (He*, et al.* 2003) that the widow rockfish stock size was at 24.7 percent of the unfished biomass and that stock productivity was considerably lower than previously thought. Results from the 2003 widow rockfish rebuilding analysis were used to develop the first widow rockfish rebuilding plan, which was adopted in April 2004 under Amendment 16-3 to the groundfish FMP. The rebuilding plan established a target rebuilding year of 2038 and a harvest control rule of F = 0.0093.

A full assessment was completed in 2005 for widow rockfish (He*, et al.* 2006a). The base model estimated that spawning biomass declined steadily since the early 1980s and that spawning output in 2004 was 31 percent of the unexploited level, above the Council's overfished threshold. Further, spawning output in the base model was estimated to have never dropped below the 25 percent overfished threshold. The 2005 rebuilding analysis indicated that the stock was much closer to reaching a rebuilt biomass than previously estimated: under the 2005 rebuilding analysis (He*, et al.* 2006b), T_{MIN} was estimated to be 2013, compared to a T_{MIN} of 2026 in the 2003 analysis (He*, et al.* 2003). This rebuilding analysis was used to modify the widow rockfish rebuilding plan, which was adopted under Amendment 16-4 in 2006. The target rebuilding year under the modified rebuilding plan was 2015 and the harvest control rule was an SPR harvest rate of 95 percent.

An updated assessment was done in 2007 (He*, et al.* 2008) using the same age-based model (written in ADMB) and data compiling procedures used in the previous assessment. The estimated total biomass in 2006 was 120,132 mt and the estimated depletion rate was 35.5 percent of the unfished spawning output. The population was projected to recover to the target in 2009, which was six years earlier than the target year in the rebuilding plan. Based on these results, the SSC recommended no changes to the rebuilding plan.

A full assessment of widow rockfish was conducted in 2009 (He*, et al.* 2009), which indicated the stock was at 38.5 percent of its unfished spawning output at the start of 2009. The 2009 assessment differed from the previous assessment in several respects: a) the assessment used Stock Synthesis 3 (SS3) rather than a custom-designed model, b) the catch history was revised and extended back to 1916, c) catch, age, and survey data were updated with data from 2007 and 2008, and d) data from the NWFSC trawl survey were included in the assessment. Widow rockfish were modeled as a single stock with two areas and four fisheries.

A full assessment of widow rockfish was conducted in 2011 (He*, et al.* 2011), which indicated the spawning stock biomass was successfully rebuilt with a depletion of 51 percent at the start of 2011. However, there was considerable uncertainty regarding the stock assessment's finding that the stock had rebuilt. Productivity and status of this stock were highly uncertain because the available biomass indices were not informative. Nonetheless, the SSC considered the base model of the new widow rockfish assessment to be the best available science.

A new full assessment of widow rockfish was conducted in 2015 (Hicks and Wetzel 2015), which indicated the stock was at 75.1 percent depletion at the start of 2015 (Figure 2-63). A number of revisions were made to the data used for the 2015 stock assessment, including: 1) a new method of index standardization for NWFSC groundfish bottom trawl survey using a geo-statistical delta-GLMM model, 2) a new steepness value (0.798) based on an updated meta-analysis of steepness (the prior distribution on steepness in the meta-analysis was recalculated without the widow values), 3) a prior distribution developed for the natural mortality parameter from an analysis of a maximum age of 54 years, 4) updated methods of expanding fishery length and age composition, and survey conditional age at length, and 5) new ageing error tables. For this assessment, there was a more thorough investigation of available age and length data, increasing the amount of these data relative to previous assessments. In addition, Washington historical landings were reconstructed. Other changes from the last assessment included how fisheries were structured and how selectivity was modeled. The index was split based on a shift in the Q value in a single fleet rather than have two separate fleets as was done in previous assessments.

An update of the 2015 assessment of widow rockfish was conducted in 2019, which indicated the stock was at 92 percent depletion at the start of 2019 (Adams*, et al.* 2019). The updated data and time series include a notable (albeit noisy) upward trend over most of the last few years that was fit reasonably well by the model and driven by several recent strong year classes (2008, 2010, 2013, and 2014). The revised depletion estimate was slightly lower than what was projected in the 2015 assessment, but maintains the ongoing increase in abundance, such that the model estimated a 2019 depletion of 92 percent. The axis of uncertainty for the decision table was a combination of natural mortality, steepness, and the strength of the 2013 recruitment.

The Council adopted the default harvest control rule for widow rockfish where the ACL equals the ABC under a P* of 0.45 for 2019 and beyond. A catch-only projection of the 2019 update assessment was conducted in 2023 to provide harvest specifications for 2025-2026 fishery management.

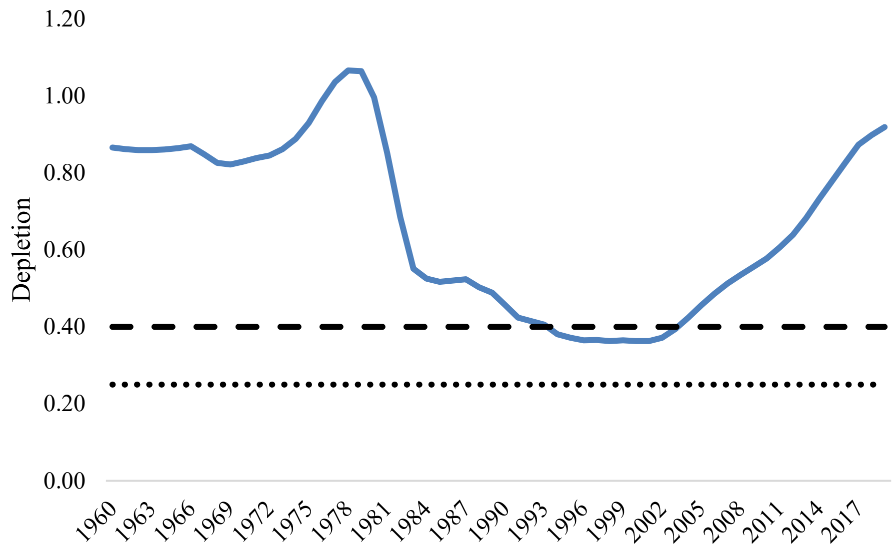

Figure 2-66. Relative depletion of widow rockfish from 1960 to 2019 based on the 2019 stock assessment update.

Stock Productivity

The 2019 widow rockfish assessment assumed a steepness of 0.72 based on a meta-analysis of rockfish steepness. The PSA productivity score of 1.31 indicates a stock of moderate productivity.

Recruitment deviations were estimated in the 2019 assessment for the entire time series modeled. Recruitment deviations were estimated for the entire time series modeled. There is little information regarding recruitment prior to 1965, and the uncertainty in these estimates is expressed in the model. There are very large, but uncertain, estimates of recruitment in 2013, 1970, 2008, and 1971 (Figure 2-64). Other large recruitment events (in descending order of magnitude) occurred in 1978, 2014, 1981, 2010, and 1991. The five lowest recruitments (in ascending order) occurred in 2012, 2011, 1976, 2007, and 1973. Estimates of recruitment appear to be episodic and characterized by periods of low recruitment. Two of the four largest estimated recruitments happened in the last 11 years.

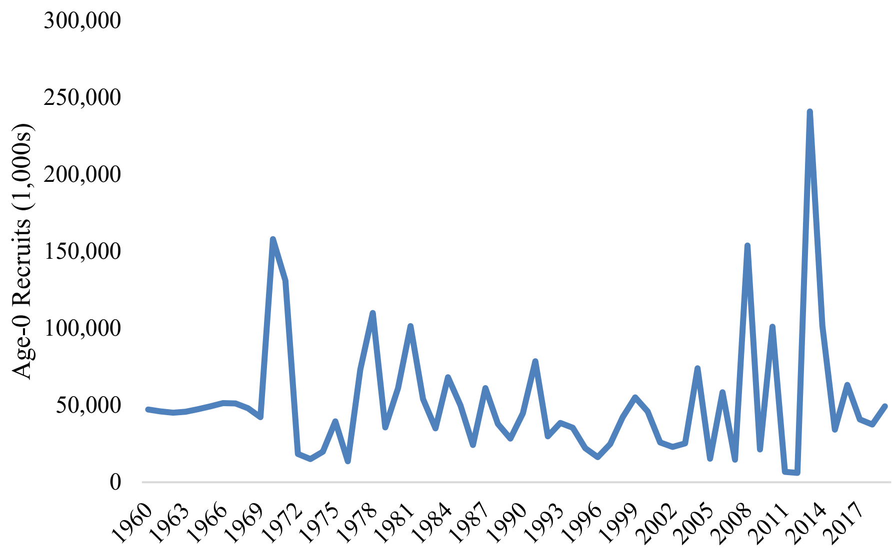

Figure 2-67. Estimated widow rockfish recruitments, 1960-2019 (from Adams et al. 2019).

Fishing Mortality

Widow rockfish are caught mostly in midwater trawls used to target Pacific whiting and, before 2002 (and increasingly after 2011), used to target widow and yellowtail rockfish. The spawning biomass of widow rockfish reached a low in 2001 before increasing due to low catch levels (Figure 2-63). The lower 95 percent confidence interval of the estimated depletion dipped below the overfished threshold in the very late 1990s and early 2000s, but has remained above that level otherwise, and currently the depletion estimate is significantly greater than the spawning biomass target. Throughout the 1980s and 1990s the exploitation rate and (1-SPR) were mostly above target levels (Figure 2-65). Exploitation rates between 2001 and 2016 on widow rockfish are estimated to have been substantially below target levels, however, have increased in the last two years (2017-2018).

Management uncertainty is low since widow rockfish is a trawl-dominant species and there is mandatory 100 percent observer coverage in trawl fisheries.

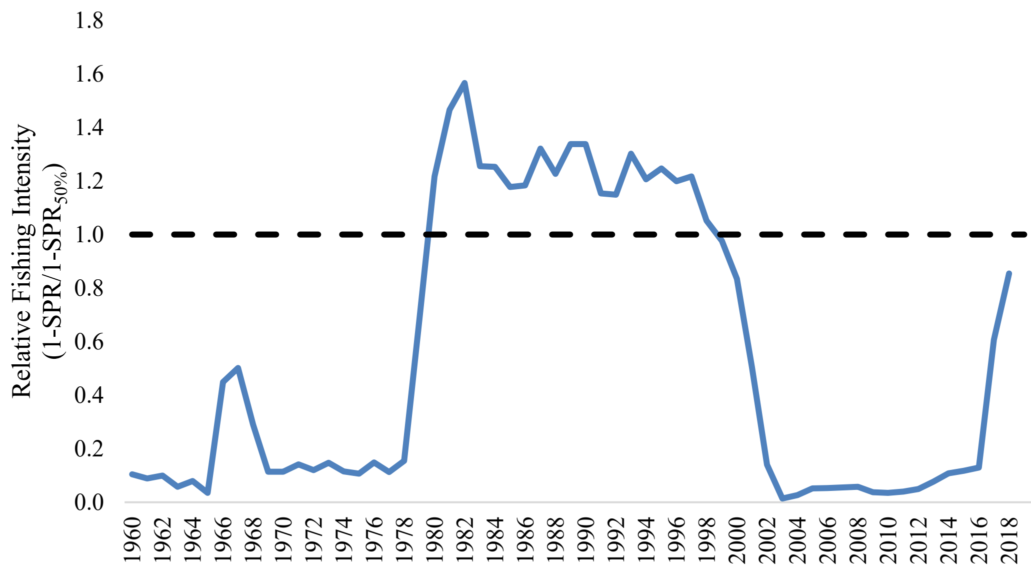

Figure 2-68. Relative fishing intensity of widow rockfish, 1960-2018.

2.4.27 Yellowtail Rockfish North of 40°10' N. Lat.

Distribution and Life History

Yellowtail rockfish (*Sebastes flavidus*) range from San Diego, California, to Kodiak Island, Alaska (Fraidenburg 1980; Gotshall 1981; Lorz*, et al.* 1983; Love*, et al.* 2002; Miller and Lea 1972; Norton and MacFarlane 1995). The center of yellowtail rockfish abundance is from Oregon to British Columbia (Fraidenburg 1980). Yellowtail rockfish are a common species abundant over the middle shelf (Carlson and Haight 1972; Fraidenburg 1980; Tagart 1991; Weinberg 1994). Yellowtail rockfish are most common near the bottom, but not on the bottom (Love*, et al.* 2002; Stanley*, et al.* 1994). Yellowtail rockfish adults are considered semi-pelagic (Stanley*, et al.* 1994; Stein*, et al.* 1992) or pelagic, which allows them to range over wider areas than benthic rockfish (Pearcy 1992). Adult yellowtail rockfish occur along steeply sloping shores or above rocky reefs (Love*, et al.* 2002). They can be found above mud with cobble, boulder and rock ridges, and sand habitats; they are not, however, found on mud, mud with boulder, or flat rock (Love*, et al.* 2002; Stein*, et al.* 1992). Yellowtail rockfish form large (sometimes greater than 1,000 fish) schools and can be found alone or in association with other rockfishes (Love*, et al.* 2002; Pearcy 1992; Rosenthal*, et al.* 1982; Stein*, et al.* 1992; Tagart 1991). These schools may persist at the same location for many years (Pearcy 1992).

Yellowtail rockfish are viviparous (Norton and MacFarlane 1995) and mate from October to December. Parturition peaks in February and March and from November to March off California (Westrheim 1975). Young-of-the-year pelagic juveniles often appear in kelp beds beginning in April and live in and around kelp in midwater during the day, descending to the bottom at night (Love*, et al.* 2002; Tagart 1991). Male yellowtail rockfish are 34 cm to 41 cm in length (five years to nine years) at 50 percent maturity, females are 37 cm to 45 cm (six years to ten years) (Tagart 1991). Yellowtail rockfish are long-lived and slow-growing; the oldest recorded individual was 64 years old (Fraidenburg 1980; Tagart 1991). Yellowtail rockfish have a high growth rate relative to other rockfish species (Tagart 1991). They reach a maximum size of about 55 cm in approximately 15 years (Tagart 1991). Yellowtail rockfish feed mainly on pelagic animals, but are opportunistic, occasionally eating benthic animals as well (Lorz*, et al.* 1983). Large juveniles and adults eat fish (small Pacific whiting, Pacific herring, smelt, anchovies, lanternfishes, and others), along with squid, krill, and other planktonic organisms (euphausiids, salps, and pyrosomes) (Love*, et al.* 2002; Phillips 1964; Rosenthal*, et al.* 1982; Tagart 1991).

Stock Status and Management History

Until late 2002, yellowtail rockfish were harvested as part of a directed midwater trawl fishery. Yellowtail rockfish are common in both commercial and recreational fisheries throughout its range, and commonly occur with canary rockfish and widow rockfishes (Cope and Haltuch 2012). Despite its popularity in commercial and recreational fisheries, its association with those highly regulated species has greatly decreased removals over the last decade. From the end of 2002 through 2010, implementation of the RCAs and small landings limits designed to only accommodate incidental bycatch eliminated directed midwater fishing opportunities for yellowtail rockfish in non-tribal trawl fisheries. A limited opportunity to target yellowtail rockfish in the trawl fishery has been available since 2011 under the trawl rationalization program, yet low quotas for widow rockfish, canary rockfish, and for other constraining stocks had limited midwater targeting of yellowtail rockfish. With the improved status of widow and canary rockfish, the industry is developing a strategy to better target their allocations of yellowtail and widow rockfish.

Yellowtail rockfish are currently managed with stock-specific harvest specifications north of 40°10’ N. lat. and within the southern Shelf Rockfish complex south of 40°10’ N. lat. There has never been an assessment of the southern stock and the OFL contribution of yellowtail rockfish to the southern Shelf Rockfish complex is based on a DB-SRA estimate.

Yellowtail rockfish on the U.S. West Coast north of 40°10’ N. lat. were assessed in 1984 (Weinberg*, et al.* 1984), 1986 (Coleman 1986), 1988 (Tagart 1988), 1993 (Tagart 1993), 1996 (Tagart and Wallace 1996), and 1997 (Tagart*, et al.* 1997) to determine harvest specifications for the stock. A full assessment in 2000 (Tagart*, et al.* 2000) was the first that estimated stock status with an estimated depletion of 60.5 percent at the start of 2000. Lai et al. (2003) updated the 2000 assessment and estimated stock depletion was 46 percent at the start of 2003. Another assessment update was prepared in 2005 (Wallace and Lai 2006) with an estimated depletion of 55 percent at the start of 2005.

A data-moderate assessment of yellowtail rockfish north of 40°10’ N. lat. was conducted in 2013 (Cope*, et al.* 2014). The estimated depletion at the start of 2013 was 67 percent and the spawning biomass was estimated to be 50,043 mt. This was a large biomass increase relative to previous estimates and can be attributed to the low removals in the last 10 years.

A full assessment of yellowtail rockfish north of 40°10’ N. lat. was conducted using Stock Synthesis in 2017, which indicated the stock was healthy with a 75 percent depletion at the start of 2017 (Stephens and Taylor 2017) (Figure 2-66). The estimate of natural mortality of females for the northern model was 0.174, and that for males was 0.15. Steepness was fixed at the mean of the prior (0.718). The final base model is heavily reliant on compositional data, although fishery-independent survey indices are somewhat informative. Then SSC categorized the 2017 yellowtail rockfish assessment as a category 1 assessment.

The Council adopted the default harvest control rule of ACL equal to the ABC with a P* of 0.45 for 2019 and beyond. A catch-only projection of the 2017 assessment was conducted in 2023 to provide harvest specifications for 2025-2026 fishery management.

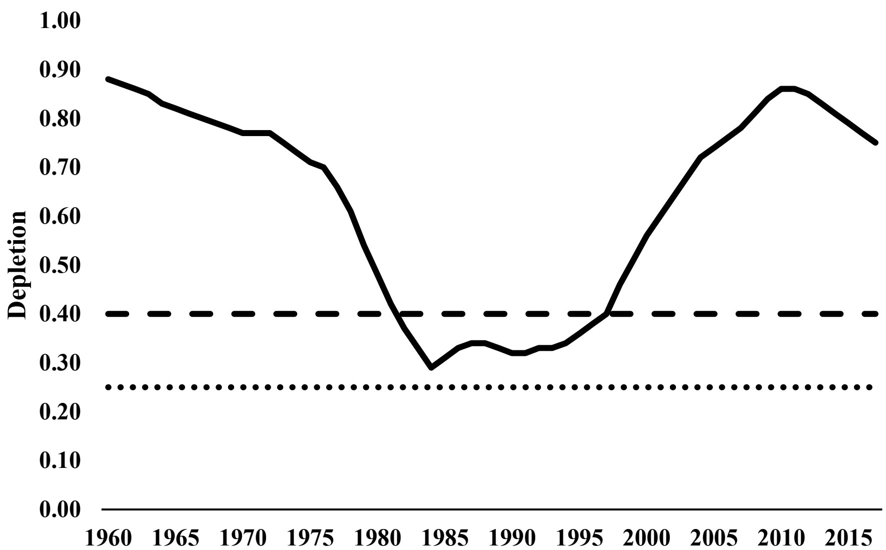

Figure 2-69. Relative depletion of yellowtail rockfish north of 40°10' N. lat. from 1960 to 2017 based on the 2017 stock assessment.

Stock Productivity

Steepness was fixed at the mean of the prior (0.718) of the most recent meta-analysis of rockfish steepness. Due to the low susceptibility of yellowtail rockfish to fisheries removals, the vulnerability to overfishing of yellowtail rockfish is relatively low (V = 1.88), though the productivity of this species is also relatively low (P = 1.33) based on other life history traits, including a longevity to almost 70 years.

Recruitments of yellowtail rockfish north of 40°10' N. lat. have ranged from roughly 17.5 million to 88 million since 1989 with particularly large year classes in 1989-1991, 1998-2000, 2006, 2008, and 2010 (Figure 2-67).

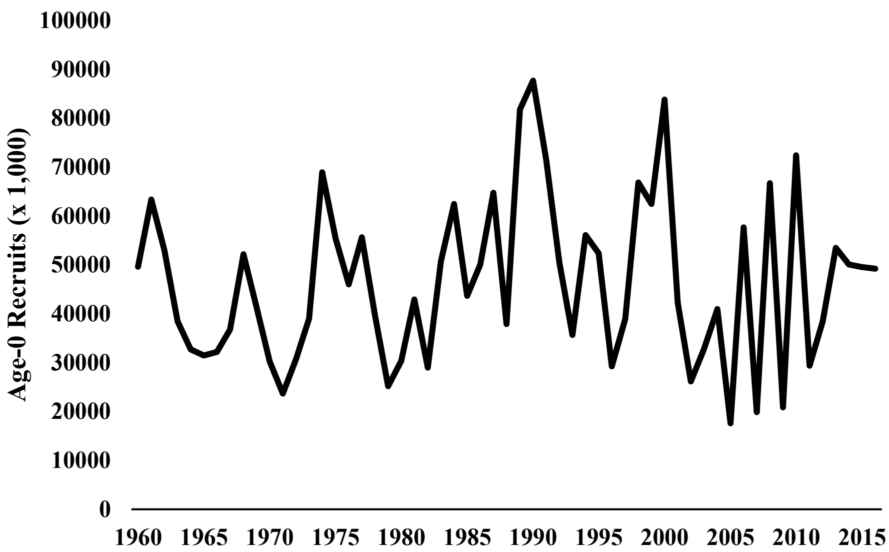

Figure 2-70. Estimated recruitments of yellowtail rockfish north of 40°10’ N. lat., 1960-2016 (from Stephens and Taylor 2017).

Fishing Mortality

Fishing mortality of yellowtail rockfish north of 40°10’ N. lat. was relatively high and the stock experienced overfishing relative to the current SPR-based harvest rate limit ($F_{50\%}$) in the 1980s and 1990s with direct targeting by midwater trawl gear of yellowtail and widow rockfish (Figure 2-68). The elimination of that fishery in 2003 to reduce impacts on widow rockfish (and canary rockfish to some degree), coupled with RCA implementation, significantly reduced fishing mortality of yellowtail rockfish. Fishing intensity has been well within the management limits in recent years and exploitation rates (catch divided by age 4+ biomass) are estimated to have been less than 2 percent per year.

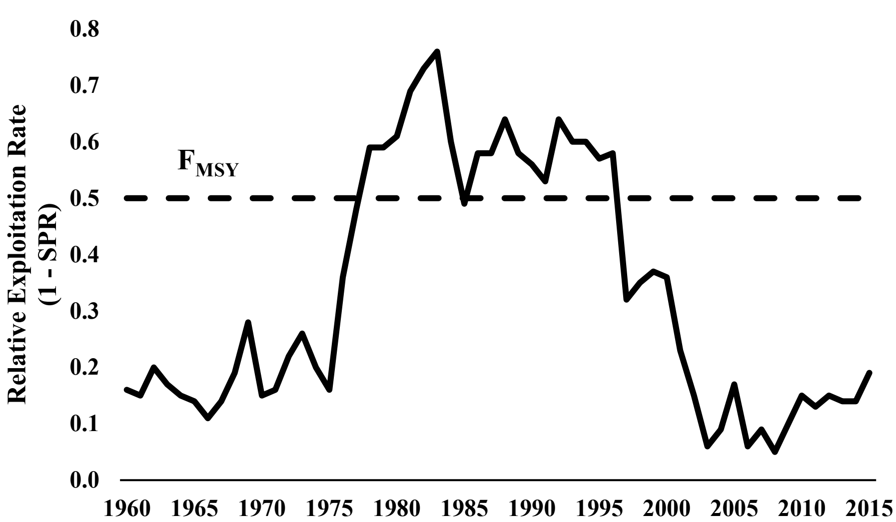

Figure 2-71. Estimated spawning potential ratio (SPR) of yellowtail rockfish north of 40°10’ N. lat. relative to the current F_{MSY}, 1960-2015. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis.

2.5 *Groundfish Stock Complexes*

There are eleven stock complexes for which ACLs were specified through the 2023-2024 management cycle. These complexes are the Nearshore, Shelf, and Slope Rockfish complexes north and south of 40°10' N. lat., the Other Flatfish, the Other Fish, the Oregon Black/Blue/Deacon Rockfish, the Oregon Cabezon/Kelp Greenling, and the Washington Cabezon/Kelp Greenling complexes. The Oregon Black/Blue/Deacon Rockfish, the Oregon Cabezon/Kelp Greenling, and the Washington Cabezon/Kelp Greenling complexes were newly specified stock complexes in 2019.

Most of the component stocks comprising the stock complexes are unassessed category 3 stocks with OFLs that are determined using data-limited methods such as DB-SRA, DCAC, or average historical catch (see Section 3.1.1). In cases where assessments were used to inform OFLs for component stocks managed in stock complexes, the OFLs were projected from those assessments using proxy F_{MSY} harvest rates. A more detailed description of the assessed stocks managed in stock complexes follows.

These complexes are the status quo management structure for these stocks as described in Federal regulations. In March 2022, NMFS notified the Council they would not make any status determinations for any of the stocks assessed in 2021, including quillback rockfish, pending an FMP amendment that specifies stocks in need of conservation and management (i.e., actively managed stocks), defines stock delineations and management boundaries for purposes of making status determinations, and stock complexes that align better with National Standard 1 guidelines. Status determinations would then be made after such an FMP amendment is approved by NMFS. While status determinations have not been officially made for the stocks/species assessed in 2021, those assessments are considered the best scientific information available and will inform management in 2023 and beyond.

It is anticipated the Council will continue to manage West Coast fisheries under the stock structure described in this SAFE document in 2023-24 and consider stock complex restructuring in an FMP amendment process in the interim. New stock definitions and stock complex structures are anticipated for managing fisheries in 2025 and beyond. If quillback rockfish in California and other stocks assessed in 2021 (or 2023) and subsequently defined in the FMP are considered to be below the MSST, rebuilding plans will be developed in time for implementation in 2025.

2.5.1 Nearshore Rockfish North and South of 40°10' N. Lat.

The nearshore rockfish complexes north and south of 40°10' N. lat. are comprised of both assessed and unassessed species. Of the stocks managed in the nearshore rockfish complexes, only blue and deacon rockfishes north of Pt. Conception, brown rockfish, China rockfish, copper rockfish, gopher and black-and-yellow rockfishes in California north of Pt. Conception, and quillback rockfish have been assessed. The following section defines these complexes in terms of their component stocks and provides further detail on those component stocks that have been assessed.

The Nearshore Rockfish complex north of 40°10' N. lat. is composed of the following species: black-and-yellow rockfish (*Sebastes chrysomelas*), blue rockfish (*S. mystinus*) off northern California and Washington, brown rockfish (*S. auriculatus*), calico rockfish (*S. dalli*), China rockfish (*S. nebulosus*), copper rockfish (*S. caurinus*), deacon rockfish (*S. diaconus*) off northern

California and Washington, gopher rockfish (*S. carnatus*), grass rockfish (*S. rastrelliger*), kelp rockfish (*S. atrovirens*), olive rockfish (*S. serranoides*), quillback rockfish (*S. maliger*), and treefish (*S. serriceps*).

The Nearshore Rockfish complex south of 40°10' N. lat. is further subdivided into the following management categories: 1) shallow nearshore rockfish [comprised of black-and-yellow rockfish (*Sebastes chrysomelas*), China rockfish (*S. nebulosus*), gopher rockfish (*S. carnatus*), grass rockfish (*S. rastrelliger*), and kelp rockfish (*S. atrovirens*)], and 2) deeper nearshore rockfish [comprised of blue rockfish (*S. mystinus*), brown rockfish (*S. auriculatus*), calico rockfish (*S. dalli*), copper rockfish (*S. caurinus*), deacon rockfish (*S. diaconus*), olive rockfish (*S. serranoides*), quillback rockfish (*S. maliger*), and treefish (*S. serriceps*)].

Blue and Deacon Rockfish off California

Distribution and Life History

Blue rockfish (*Sebastes mystinus*), now known to include deacon rockfish (*S. diaconus*), range from Baja California Sur, Mexico to British Columbia, Canada, although they are most commonly found between Oregon and central California (Love 2011). The two species were assessed as a complex in 2017 (see the next section; Dick*, et al.* 2017). Deacon rockfish was formally separated from blue rockfish based on morphometric and microsatellite genetic analyses by Frable et al. (2015). Thus, the 2017 blue and deacon rockfishes (BDR) assessment was done as a complex of the two species because almost all of the historical data available consist of mixed BDR in unknown proportions. While genetic studies have found that, at least in recent decades, deacon rockfish are more common north of Monterey Bay, and blue rockfish more common to the south, catch and index data were separated at the Oregon/California border due to management history. The two species appear to be mixed to some degree throughout the entire range of the two areas assessed.

BDR inhabit kelp forests and rocky reefs in relatively shallow depths usually to about 90 meters (50 fm) (Miller and Lea 1972; Reilly 2001), but have been landed as deep as 549 meters (300 fm) (Love*, et al.* 2002). These two species are sympatric from northern California to central Oregon (Frable*, et al.* 2015). BDR can occupy depths from the shallow intertidal zones out to 149 m at Stonewall Banks (Hannah and Blume 2016), but are also found 500 km west of Washington at Cobb seamount where depths range from 33 – 820 m (Douglas 2011). However, these fish are most commonly encountered in depths from 0 – 55 m (Love 2011) as schools can surface feed. BDR are schooling semi-pelagic species commonly found aggregating with black rockfish, canary rockfish, widow rockfish, yellowtail rockfish, olive rockfish, and blacksmiths. BDR are residential, with their movements restricted to a small area, usually near the kelp canopy or pinnacles for shelter and spatial orientation (Jorgensen*, et al.* 2006; Lea*, et al.* 1999; Miller and Geibel 1973).

BDR are primarily "selective opportunity" planktivores (Gotshall*, et al.* 1965; Love and Ebeling 1978). As juveniles, they feed on planktonic crustacea, hydroids, and algae (Miller and Geibel 1973). Adults also consume fish, squid, tunicates, scyphozoids, bull kelp nori, and pelagic gastropods (Hobson*, et al.* 1996; Lea*, et al.* 1999; Love*, et al.* 2002). Many of these prey items are made available from the relaxation of upwelling or southerly winds, explaining high blue rockfish numbers in the summer off central and northern California, where these conditions are well developed (Hobson and Chess 1988; Love*, et al.* 2002). Due to their great abundance in kelp forests, blue rockfish juveniles are recognized as a key species in the piscivore trophic web of these ecosystems (Hallacher and Roberts 1985).

Stock Status and Management History

The blue rockfish stock in California waters north of Pt. Conception was assessed in 2007 and the stock's depletion was estimated to be 29.7 percent of its unfished spawning output at the start of 2007 (Key*, et al.* 2008); therefore, the stock was considered to be in the precautionary zone. Blue rockfish were not a highly sought species historically, but an increase in catches in the 1970s resulted in a continuous decline in spawning biomass through the early 1990s. The abundance of blue rockfish was at the management target ($B_{40\%}$) in 1980 and at the overfished threshold in 1982. Spawning biomass reached a minimum (10 percent of unexploited) in 1994 and 1995; however, there has been a constant increase since then.

During the 2009 and 2010 biennial specifications process, the Council contemplated removing blue rockfish from the Nearshore Rockfish complexes. Blue rockfish was managed within the Nearshore Rockfish complexes because of scientific uncertainty and management needs, given the interaction of blue rockfish with other nearshore species. When blue rockfish occur offshore, they can be targeted separately from other nearshore rockfish, but those that occur inshore mix with other nearshore rockfish stocks. Blue rockfish are managed under California's Nearshore Fishery Management Plan which has mandatory sorting requirements for landed catch. Landings are routinely tracked and monitored, thereby reducing management uncertainty.

The Council had implemented precautionary management of the California population of blue rockfish since 2009 by setting a harvest guideline for California fisheries based on the sum of the 40-10 adjusted ACL contribution north of Pt. Conception and the ABC contribution south of Pt. Conception. This HG had not been exceeded. Beginning in 2019, there is no blue rockfish harvest guideline for the population occurring off California since the stock was projected to be healthy starting in 2019.

A new assessment of BDR, assessed as a complex of the two species, was conducted in 2017 for the populations of these two species off California north of Pt. Conception and Oregon (Dick*, et al.* 2017). The California assessment estimates that the BDR population reached a low depletion level of 15.6 percent in 2007, and had recovered nearly to the target level, being at 37.3 percent of the unfished spawning output in 2017 (Figure 2-69). A strong 2013 year class appears to be entering the population.

While genetic studies have found that, at least in recent decades, deacon rockfish are more common north of Monterey Bay, and blue rockfish more common to the south, catch and index data were separated at the Oregon/California border due to management history. The two species appear to be mixed to some degree throughout the entire range of the two areas assessed.

The 2017 BDR assessment for California is generally consistent with the results of the 2007 assessment. The scale of the stock is similar, and proxy ($SPR_{50\%}$) estimates of MSY are similar (275 mt per the 2007 assessment and 306 mt per the 2017 assessment). However, estimates of recent stock size based on the 2017 assessment are imprecise, which results in imprecise forecasts of yield. The California assessment includes several fishery-dependent and –independent sources, though no comprehensive survey of adults. There is a general lack of recent age data, and the assessment is sensitive to the inclusion or exclusion of age information in the form of conditional age-at-length data from relatively recent research projects.

Steepness and natural mortality were both estimated in the 2017 California BDR assessment. While estimation of steepness is unusual, especially for a species without a strong fishery-independent index, the “two-way trip” pattern of depletion history may provide more information on steepness, and the estimation of steepness and natural mortality provides for more realistic quantification of uncertainty coming out of the assessment for use in the decision table. The estimated value of steepness, 0.65, is close to the mean of the prior distribution for rockfish, 0.72. Similar to natural mortality, uncertainty in the Beverton-Holt steepness parameter contributes to the imprecision of recent BDR biomass. However, population scale (unfished spawning output) in the California model is robust to changes in these parameters, relative to the Oregon model (see Stock Status and Management History of Oregon BDR in Section 2.5.2). Catches of blue and deacon rockfish are strongly skewed toward females. The current assessment accounts for this through gender-specific growth and natural mortality. An alternative (or parallel) hypothesis is that males are less vulnerable to the fishery (i.e., have a gender-specific selectivity). The California BDR model was not able to estimate gender-specific selectivity curves given the available data.

The SSC endorsed the use of the California BDR stock assessment as the best scientific information available for status determination and management as a category 2 assessment due to BDR being a complex of two species. The sigma value derived from the decision table for the California assessment is larger than the category 2 sigma of 0.72 (0.783) and this value was used in calculating the scientific uncertainty buffer used to determine ABCs.

The Council adopted default harvest specifications (ACL = ABC with a P* of 0.45) for the California BDR contribution to the Nearshore Rockfish complexes north and south of 40°10’ N. lat. Without a 40-10 adjustment to the 2019 and beyond ACLs since the stock is projected to be above the B_{MSY} target of 40 percent depletion beginning in 2019 (projected depletion in 2019 is 42.1 percent). The California harvest specifications were apportioned north and south of 40°10’ N. lat. Based on an approach that combines existing habitat information with a catch-per-unit-effort proxy for fish density (see Appendix D in the 2017 BDR assessment). This approach estimated a relative biomass of California BDR north of 40°10’ N. lat. Of 10 percent and the harvest specifications were apportioned accordingly. A catch only-projection of BDR in California was provided to inform harvest specifications for 2021 and beyond.

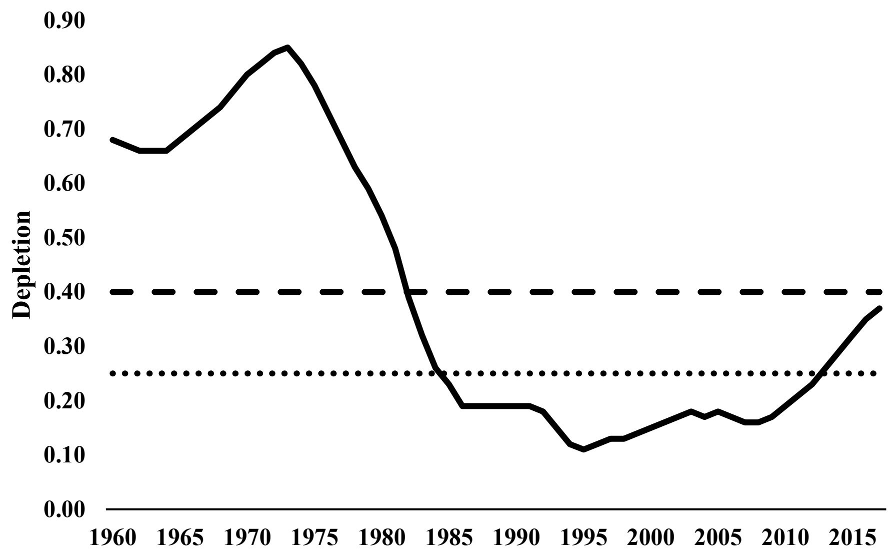

Figure 2-72. Relative depletion of blue and deacon rockfish off California from 1960 to 2017 based on the 2017 stock assessment.

Stock Productivity

A Beverton-Holt steepness of 0.65 was estimated in the 2017 California BDR assessment, which is close to the median steepness of 0.718 in the current rockfish meta-analysis. The GMT's PSA analysis indicates a relatively high vulnerability to potential overfishing (V = 2.01) due partly to a relatively low relative productivity (P = 1.22) (Table 2-2).

A recent, strong recruitment in 2013 has contributed to the recent increase in BDR biomass in California (Figure 2-70). This recruitment is informed by several independent data sets, was observed by multiple juvenile rockfish surveys, and is also supported by length composition data in the 2017 California assessment model. Above-average recruitments in 2008 and 2009 are largely driven by recent age data covering the years 2010-2011, but the 2007 recruitment appears to be supported by multiple data sources, as well.

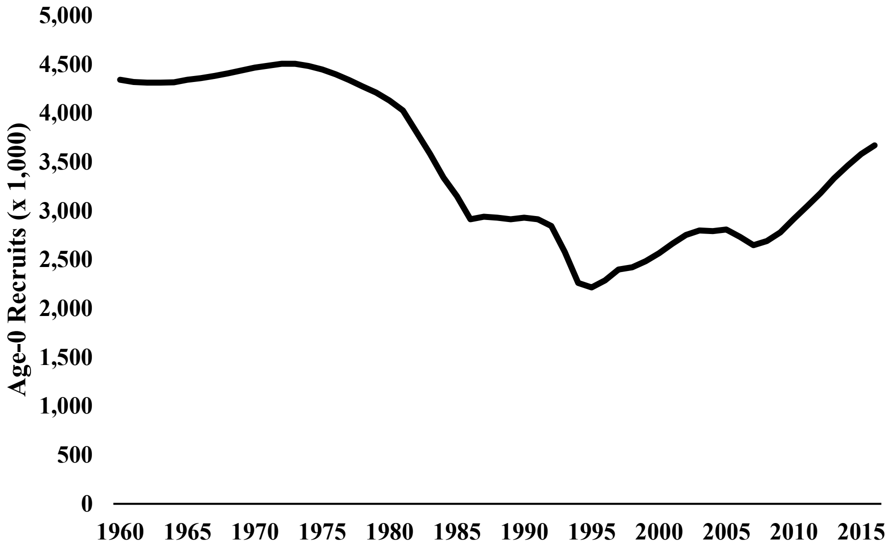

Figure 2-73. Estimated recruitments of blue and deacon rockfishes off California, 1960-2016 (from Dick et al. 2017).

Fishing Mortality

BDR have been an important part of the recreational fishery in California since the late 1950s (Mason 1998; Reilly*, et al.* 1993; Wilson-Vandenberg*, et al.* 1996). Commonly taken by Commercial Passenger Fishing Vessels (CPFVs, aka partyboats), skiffs, and divers, it is among the most frequently caught species north of Point Conception (Karpov*, et al.* 1995). However, since the mid-1980s the California recreational catch has declined significantly, especially in the south. This may be a result of overfishing from the more heavily populated southern coast (Love*, et al.* 1998), where there is more angling opportunity due to more favorable access and ocean conditions (Bennett*, et al.* 2004); poor recruitment resulting from a long-term shift away from preferred cold, productive waters (Jarvis*, et al.* 2004; Love*, et al.* 2002); or the effect of increasingly strict fishing regulations.

The California BDR catch has played a relatively minor role in the commercial fishery compared to the recreational fishery. This has remained true, even with the advent of the live-fish fishery in the late 1980s, although the contribution of blue rockfish has been increasing in recent years. Since the preferred dinner plate-sized catch for this fishery results in immature fish being targeted in many cases, there is concern over the potential implications of the increasing effort in this fishery. Selection of younger, smaller individuals has led to lower lifetime egg production and consequently, threatened population viability (O'Farrell and Botsford 2005; O'Farrell and Botsford 2006).

The annual (equilibrium) SPR harvest rate for BDR in California has been below target since 2008 (Figure 2-71). Prior to 2008, the harvest rate exceeded the target for over 30 years, regularly reaching levels 50 percent above target in the 1980s and 1990s. As a percentage of total biomass (ages 0+), California harvest rates peaked at 15-20 percent in the 1980s and 1990s but have since declined to levels below 3 percent for the past decade. Harvest rates in California are currently below target, and the stock is approaching the proxy target biomass (Figure 2-71). Estimates of MSY for the California portion of the stock are 3 to 4 times larger than the Oregon stock.

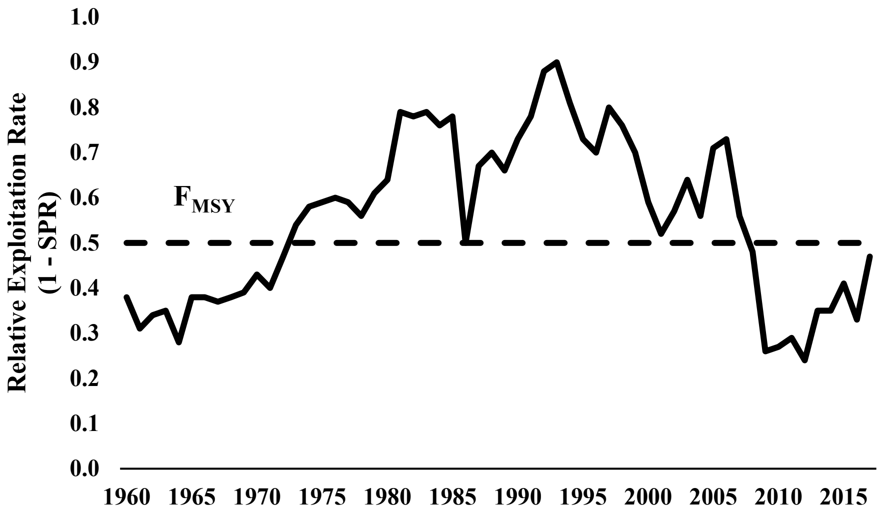

Figure 2-74. Estimated spawning potential ratio (SPR) of blue and deacon rockfish off California relative to the current F_{MSY}, 1960-2016. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis.

Brown Rockfish

Distribution and Life History

Brown rockfish (*Sebastes auriculatus*) are distributed from Prince William Sound to southern Baja California in Mexico, but are most abundant on the U.S. West Coast south of Bodega Bay, California (Love*, et al.* 2002). They occur from very shallow inshore waters out to 135 m (74 fm). Brown rockfish are a sedentary rockfish found in shallow water and bays (Eschmeyer*, et al.* 1983), among sheltering weed-covered rocks or around pilings (Lamb and Edgell 1986). Brown rockfish show distinct genetic differentiation by distance in coastal populations off California (Buonaccoursi*, et al.* 2005), though no distinct break is obvious to define substocks. Life history information is not spatially resolved. While coastwide populations may be subject to localized depletion because of reef-specific associations and small home ranges, no subpopulations have been distinguished.

Brown rockfish have been aged to 34 years (Love*, et al.* 2002).

Stock Status and Management History

Brown rockfish are managed in the northern and southern Nearshore Rockfish complexes. A single coastwide data-moderate assessment of brown rockfish was conducted in 2013 (Cope*, et al.* 2014). The assessment estimated the brown rockfish stock to be healthy with a depletion of 42 percent of its unfished biomass at the start of 2013. The brown rockfish assessment used two CPUE indices of the California recreational fisheries derived from dockside intercept surveys during 1980-2003 (north and south of Point Conception). The assessment also used two observer-based recreational CPUE indices from CPFV during 1999-2011 south of Point Conception and during 1988-2011 between Point Conception and Cape Mendocino. No indices were constructed for north of 40°10’ N. lat. Since this is a rare species north of Cape Mendocino. While coastwide landings were used in the assessment, only about 1 percent of the cumulative coastwide landings of brown rockfish were from fisheries north of 40°10' N. lat. Based on the proportion of cumulative removals during 1916-2012. It was assumed that the population in the north followed the same trends as the southern population and this apportionment was used to parse harvest specifications to the Nearshore Rockfish complexes north and south of 40°10' N. lat.

Projections of harvest specifications for brown rockfish for 2017 and beyond using the base model in the 2013 data-moderate assessment were provided in 2015 (Agenda Item I.4, Attachment 4, November 2015) since long term projections were inadvertently omitted from the 2013 assessment.

The Council adopted the default harvest control rule of ACL equal to the ABC with a P* of 0.45 for 2019 and 2020 harvest specifications. The 2019 and 2020 ABC and ACL contribution of brown rockfish to the Nearshore Rockfish complex north of 40°10' N. lat. Is 1.9 mt. The 2019 and 2020 ABC and ACL contributions of brown rockfish to the Nearshore Rockfish complex south of 40°10' N. lat. Are 162.4 mt and 166.1 mt, respectively.

Stock Productivity

Brown rockfish has a notably elevated vulnerability to overfishing (V = 1.99) but a relatively high productivity score for a rockfish (P = 1.72) in the GMT's PSA analysis (Table 2-2).

Fishing Mortality

Estimated exploitation rates for brown rockfish were at or above the MSY harvest level during most years between 1973 and 2003, but have remained below the MSY harvest level since then (Cope*, et al.* 2014). Median spawning biomass declined rapidly during the 1970s and 1980s but has shown an increasing trend since the mid-1990s. The fishing mortality rate in 2012 was estimated to be 63 percent of F_{MSY}.

China Rockfish

Distribution and Life History

China rockfish (*Sebastes nebulosus*) range from Kachemak Bay in the Gulf of Alaska to Redondo Beach and Nicholas Island in the Southern California Bight but are most abundant from Prince William Sound to northern California (Love*, et al.* 2002). They occur primarily in nearshore and shelf waters in depths ranging from 3 to 128 m. China rockfish are a solitary species associated with high relief habitats, especially boulder fields with many crevices. They are territorial and a study off Vancouver Island indicates that individuals are likely to move 10 m or less within their territories.

China rockfish are long-lived with the oldest age reported at 79 years (Love*, et al.* 2002). Males and females mature at about the same size and age with some fish mature at 26 cm and all fish mature at 30 cm. The maximum size is reported to be 45 cm. Larval release occurs off California from January to June peaking in January. Larvae are released later in the season in the Gulf of Alaska during April to August with peak release in May.

China rockfish prey on benthic organisms including brittle stars, crabs, shrimps, chitons, and small fishes. Nudribranchs, octopi, snails, and red abalone were observed prey for China rockfish off central and northern California.

Stock Status and Management History

China rockfish are managed in the northern and southern Nearshore Rockfish complexes. Separate data-moderate assessments of China rockfish north and south of 40°10' N. lat.[13] Were conducted in 2013 (Cope*, et al.* 2014). The China rockfish population south of 40°10' N. lat. Was estimated to be healthy with a depletion of 66 percent of its unfished biomass at the start of 2013. However, the population north of 40°10' N. lat. Was estimated to be more depleted and in the precautionary zone with a depletion ratio of 37 percent at the start of 2013. The southern China rockfish assessment used a CPUE index of the California recreational fisheries derived from dockside intercept surveys during 1980-2003, as well as an observer-based recreational CPUE index from CPFVs during 1988-2011 as indices of abundance. The northern China rockfish assessment used a CPUE index of the Oregon and northern California recreational fisheries derived from dockside intercept surveys during 1980-2003 and an Oregon onboard charter boat index during 2001-2012 as indices of abundance and assumed the population off Washington followed the same trends. The Council decided to continue to manage China rockfish in the Nearshore Rockfish complexes in 2015-2016.

A full assessment of China rockfish was conducted in 2015 using the Stock Synthesis 3 modeling platform (Dick*, et al.* 2015). The Northern area from the 2013 assessment was split into Northern and Central areas for the 2015 assessment, and models were developed for three separate areas: Washington, Oregon plus California north of Cape Mendocino, and California south of Cape Mendocino. Differences in growth, size-composition data, exploitation history, and biogeographic boundaries formed the basis to split the assessment into separate areas along the coast. New data for the 2015 assessment included length and age compositions starting as early as the 1970s. The models included seven fishery-dependent indices of abundance (three indices for each of the Southern and Central areas, and one for the Northern area). Maturity and fecundity relationships were also updated. Steepness was fixed in all models at 0.773, and the natural mortality rate was estimated for the Northern and Southern areas and fixed at the estimated value, 0.07, for all areas. The Northern assessment modeled years from 1967 (when catch began) to 2015, whereas the other two areas covered the period 1900-2015. For the Southern area model, discard data were modeled as a separate fleet. For all models, the selectivity of landings was asymptotic, and growth was estimated. Recruitment deviations were not estimated, so recruitment is assumed to be that from the stock-recruitment curve in each area for each year. The SSC designated China rockfish a category 2 stock since recruitment deviations were not estimated.

The spawning stock biomass for China rockfish is estimated to be above the B_{MSY} proxy of $B_{40\%}$ in the Northern and Central areas ($B_{73.4\%}$ and $B_{61.5\%}$, respectively at the start of 2015) and in the

[13] Separate China rockfish data-moderate assessments were also conducted north and south of the California-Oregon border at 42º N lat. at the Council's request. The SSC recommended the Council's choice of a management line for China rockfish should dictate which assessments should be used to set harvest specifications. The Council's decision to continue to manage the stock within the Nearshore Rockfish complexes north and south of 40º10' N lat. in 2015 and beyond rendered the second set of assessments stratified at 42º N lat. moot.

precautionary zone ($B_{29.6\%}$ at the start of 2015) in the Southern area, while increasing in recent years (Figure 2-72, Figure 2-73, and Figure 2-74).

The Council adopted the default harvest control rule of ACL equal to the ABC with a P* of 0.45 for 2019 and beyond. A catch only-projection of China rockfish was provided to inform harvest specifications for 2021 and beyond.

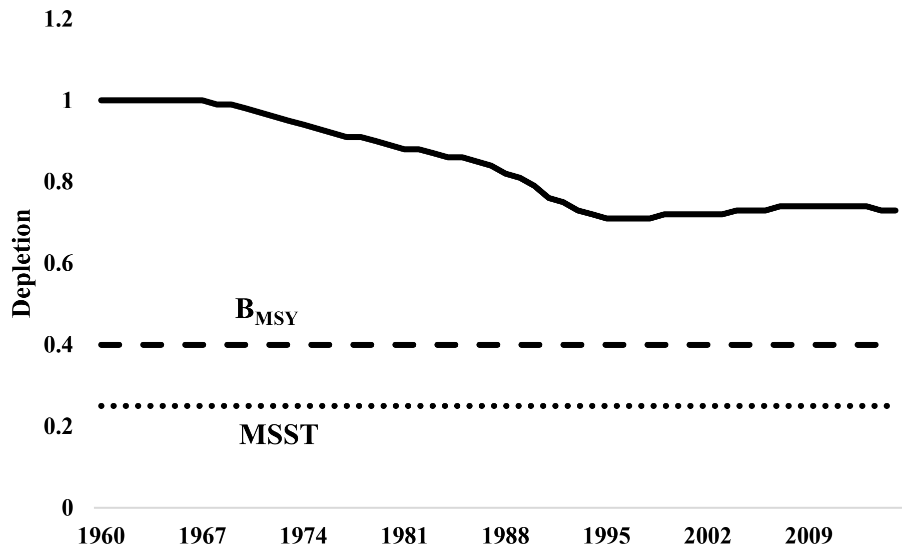

Figure 2-75. Relative depletion of China rockfish in the Northern assessment area (off Washington) from 1960 to 2015 based on the 2015 stock assessment.

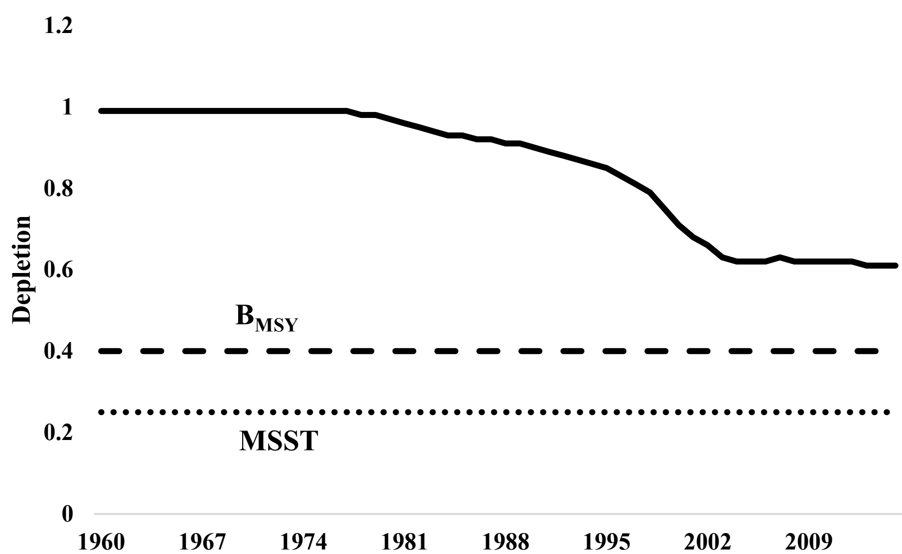

Figure 2-76. Relative depletion of China rockfish in the Central assessment area (off Oregon and California north of 40°10' N. lat.) from 1960 to 2015 based on the 2015 stock assessment.

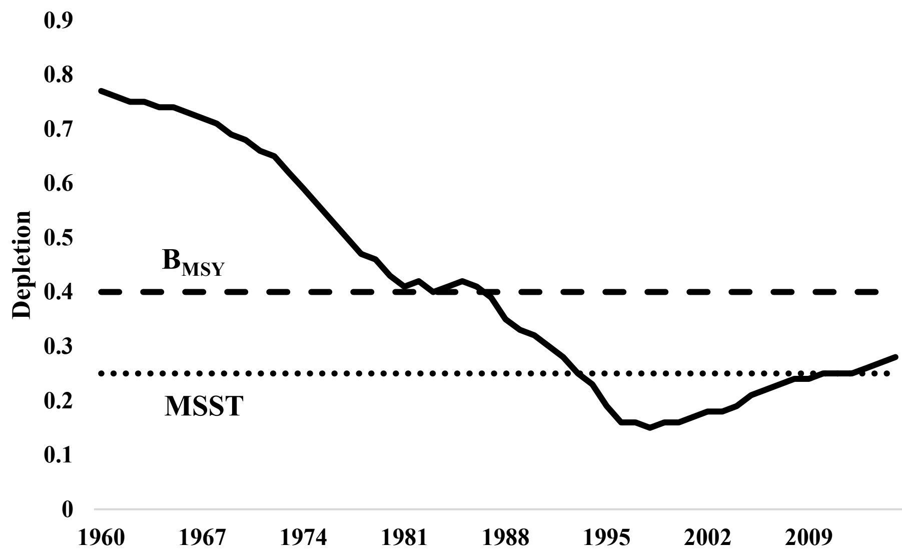

Figure 2-77. Relative depletion of China rockfish in the Southern assessment area (south of 40°10' N. lat.) from 1960 to 2015 based on the 2015 stock assessment.

Stock Productivity

The 2015 China rockfish assessments assumed a steepness of 0.773 based on the meta-analysis of rockfish steepness in 2015. The productivity score for China rockfish is relatively low (P = 1.33) and there is a major vulnerability to potential overfishing (V = 2.23).

Fishing Mortality

China rockfish are an important species in the nearshore recreational and commercial fisheries on the West Coast. They are particularly valuable in the commercial live-fish fishery where their unique coloration and high-quality flesh commands the highest prices for rockfish delivered as a live product on the West Coast. California and Oregon allow nearshore commercial fisheries while Washington does not.

Harvest rates estimated by the northern area model for Washington have never exceeded management target levels (Figure 2-75). Model results for the central area suggest that harvest rates have briefly exceeded the current proxy MSY value around 2000 but have remained below the management target in the last decade (Figure 2-76). Historical harvest rates for China rockfish rose steadily in the southern management area until the mid-1990s and exceeded the target SPR harvest rate for several decades and is just below the target harvest rate as of 2013 (Figure 2-77).

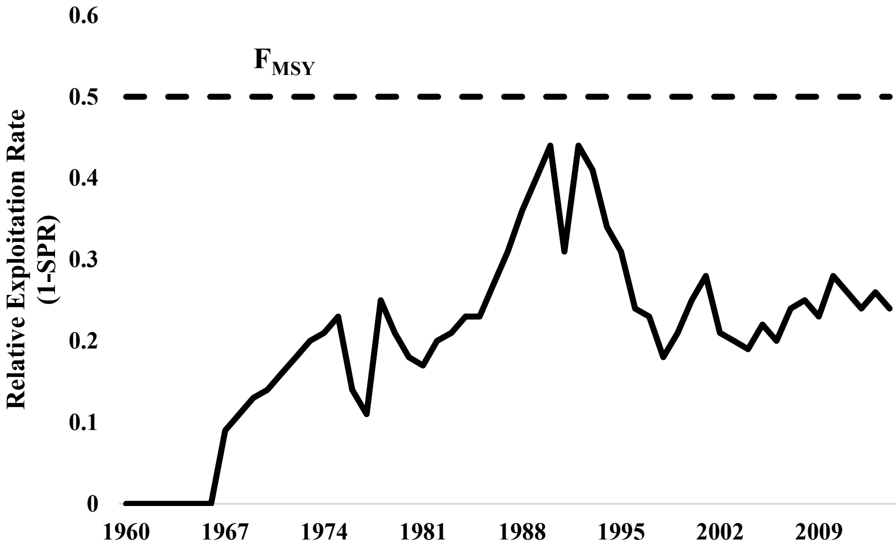

Figure 2-78. Estimated relative exploitation rate of China rockfish in the Northern assessment area (off Washington) relative to the current F_{MSY}, 1960-2014. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis.

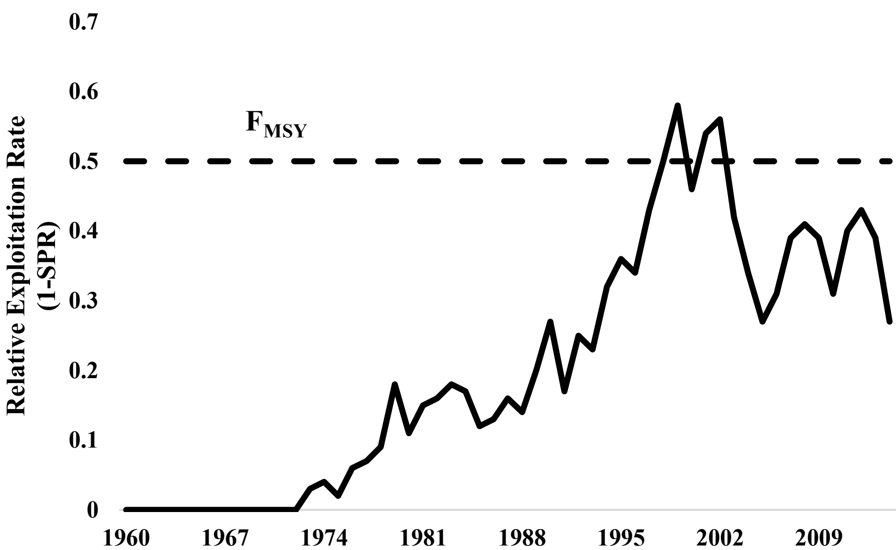

Figure 2-79. Estimated relative exploitation rate of China rockfish in the Central assessment area (off Oregon and California north of 40°10' N. lat.) relative to the current F_{MSY}, 1960-2014. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis.

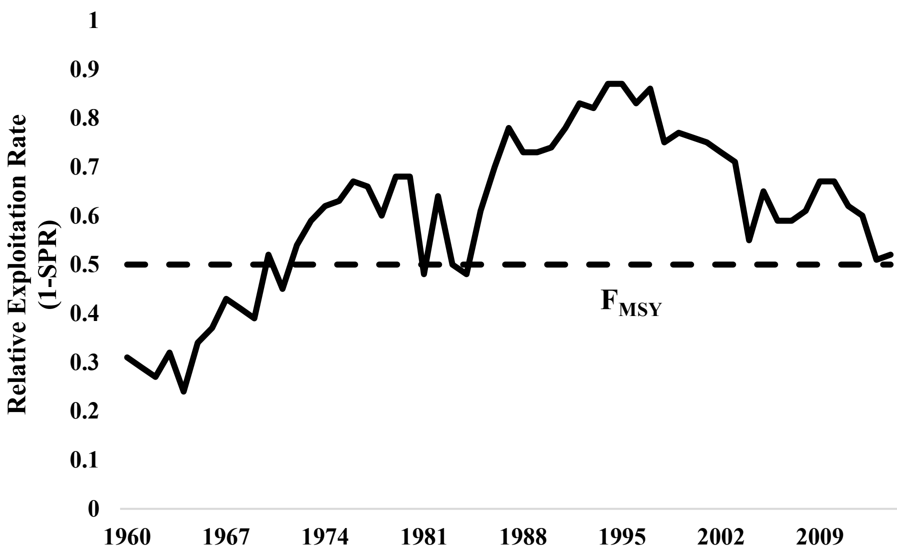

Figure 2-80. Estimated relative exploitation rate of China rockfish in the Southern assessment area (south of 40°10' N. lat.) relative to the current F_{MSY}, 1960-2014.

Copper Rockfish

Distribution and Life History

Copper rockfish (*Sebastes caurinus*) is a relatively long-lived rockfish estimated to live at least 50 years (Love 1996). They are a medium- to large-sized nearshore rockfish found from Mexico to Alaska. The core range is comparatively large, from northern Baja Mexico to the Gulf of Alaska, as well as in Puget Sound. Copper rockfish have historically been a part of both commercial and recreational fisheries throughout its range.

Copper rockfish are commonly found in waters less than 130 meters in depth in nearshore kelp forests and rocky habitat (Love 1996). The diets of copper rockfish consist primarily of crustaceans, mollusks, and fish (Bizzarro*, et al.* 2017; Lea*, et al.* 1999). The body coloring of copper rockfish varies across the coast with northern fish often exhibiting dark brown to olive with southern fish exhibiting yellow to olive-pink variations in color (Miller and Lea 1972), which initially led to them being designated as two separate species (*S. caurinus* and *S. vexillaris*).

Subadult and adult copper rockfish are found primarily in boulder fields and over high relief rocks, although they also inhabit low relief rock substrata. They perch on the substrata or hover a few meters above the bottom in aggregations and as solitary individuals (Love*, et al.* 2002). Depending on the habitat and the geographic location, copper rockfish are often found with vermilion, brown, black, dusky, silvergray, yelloweye rockfish, quillback, or tiger rockfishes. Copper rockfish have small home ranges in high relief habitats (<10 m^2) and large home ranges in low relief habitats (<4,000 m^2).

Numerous genetic studies have been performed looking for genetic variation in copper rockfish with variable outcomes. Genetic work has revealed significant differences between Puget Sound and coastal stocks (Dick*, et al.* 2014). Stocks along the U.S. West Coast have not been determined to be genetically distinct populations but significant population subdivision has been detected, indicating limited oceanographic exchange among geographically proximate locations (Buonaccorsi*, et al.* 2002; Johansson*, et al.* 2008). A specific study examining copper rockfish populations off the coast of Santa Barbara and Monterey California identified a genetic break between the north and south with moderate differentiation (Sivasundar and Palumbi 2010).

Stock Status and Management History

Copper rockfish are managed in the northern and southern Nearshore Rockfish complexes. Separate data-moderate assessments of copper rockfish north and south of 34°27' N. lat. were conducted in 2013 (Cope*, et al.* 2014). Both copper rockfish populations were estimated to be healthy with depletions of 76 percent and 48 percent of unfished biomass at the start of 2013 for the southern and northern populations, respectively. The southern copper rockfish assessment used a CPUE index of the California recreational fisheries derived from dockside intercept surveys during 1980-2003, as well as an observer-based recreational CPUE index from CPFVs during 1999-2011 as indices of abundance. The northern copper rockfish assessment used a CPUE index of the California recreational fisheries derived from dockside intercept surveys during 1980-2003, an observer-based recreational CPUE index from CPFVs during 1988-2011, and an Oregon onboard charter boat index during 2001-2012 as indices of abundance. The northern copper rockfish assessment assumed the population off Washington followed the same trends.

While coastwide landings were used in the 2013 assessment, only about 4.9 percent of the cumulative coastwide landings of copper rockfish were from fisheries north of 40°10' N. lat. based on the proportion of cumulative removals during 1916-2012. It was assumed that the population in the north followed the same trends as the southern population and this apportionment was used to parse 2015-2022 harvest specifications to the Nearshore Rockfish complexes north and south of 40°10' N. latitude.

New data-moderate stock assessments were conducted in 2021 for copper rockfish south of Pt. Conception (Wetzel*, et al.* 2021b), north of Pt. Conception in California (Wetzel*, et al.* 2021a), Oregon (Wetzel*, et al.* 2021d), and Washington (Wetzel*, et al.* 2021c). The assessments estimated depletion in the year 2021 of 18.1 percent (Figure 2-78), 39.3 percent (Figure 2-79), 73.6 percent (Figure 2-80), and 42 percent (Figure 2-81) for the stocks in California south of Point Conception, California north of Pt. Conception, Oregon, and Washington, respectively. The SSC's Groundfish Subcommittee recommended the California assessments could be combined for making a status determination of copper rockfish statewide since there was little evidence of stock structure north and south of Pt. Conception. The estimated depletion of copper rockfish in California is 31.7 percent of unfished biomass. However, formal status determinations were not made pending an FMP amendment to define groundfish stocks in the FMP.

While the 2021 assessments provided justification for the modeled areas, there is considerable uncertainty in stock structure. All models relied primarily on length-composition data, most of which came from recreational fleets. There were retrospective patterns in these assessments. All four assessments had reduced data availability from 2020 due to COVID-19 impacts on data collection agencies. Age-length estimates (and hence the growth curve) for northern California may not be representative because they rely on data from Oregon and Washington where water temperatures are different and growth may differ as a result. The SSC recommended a category 2 designation for all the 2021 copper rockfish assessments for informing harvest specifications in 2023 and beyond.

In 2023, full benchmark stock assessments were conducted for copper rockfish south of Pt. Conception (Wetzel*, et al.* 2023) and north of Pt. Conception in California (34°27’ N. lat.) (Monk, *et al.* 2023). Each assessment model captured distinct inter-stock dynamics by area and were combined to obtain an overall stock status for the waters off California, per the copper rockfish stock definition adopted by the Council under the groundfish FMP Amendment 31.

New data sources were included in the 2023 California assessments compared to the 2021 assessments. One fishery-independent data source was added to these assessments, the California Collaborative Fisheries Research Program (CCFRP) Hook and Line survey. The CCFRP Hook and Line survey data (indices, lengths, and ages) have been included in other nearshore assessments in the past (e.g., vermilion rockfish). These assessments also include fishery-dependent indices of abundance from the CPFV and PR fleets, north and south of Point Conception, that were not included in the 2021 assessments. Finally, these are the first assessments for California copper rockfish to include age composition data to support estimates of growth and population dynamics within the base models.

Across California, the stock for copper rockfish has a combined relative spawning output of 36.6 percent, which is estimated to be in the “precautionary zone” below the management target of 40% unfished, but above the minimum stock size threshold of 25% at the start of 2023.

The spawning output declined for each sub-area from the early 1970s through the mid-1990s. South of Point Conception, the population remained at very low levels until the early 2000s at which point the population began slowly increasing up until 2019, with the spawning output declining in the final years of the time series (Figure 2-78). In contrast, the portion of the stock north of Point Conception has been continually increasing since the sub-area low point in spawning output in the 1990s (Figure 2-79).

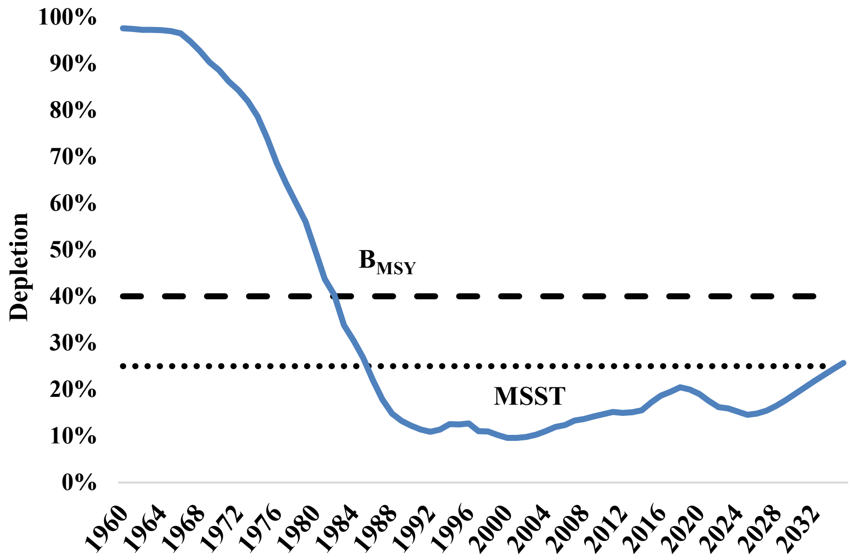

Figure 2-81. Estimated depletion of copper rockfish in California south of 34°27' N lat. relative to management reference points, 1960-2035, based on the 2023 stock assessment.

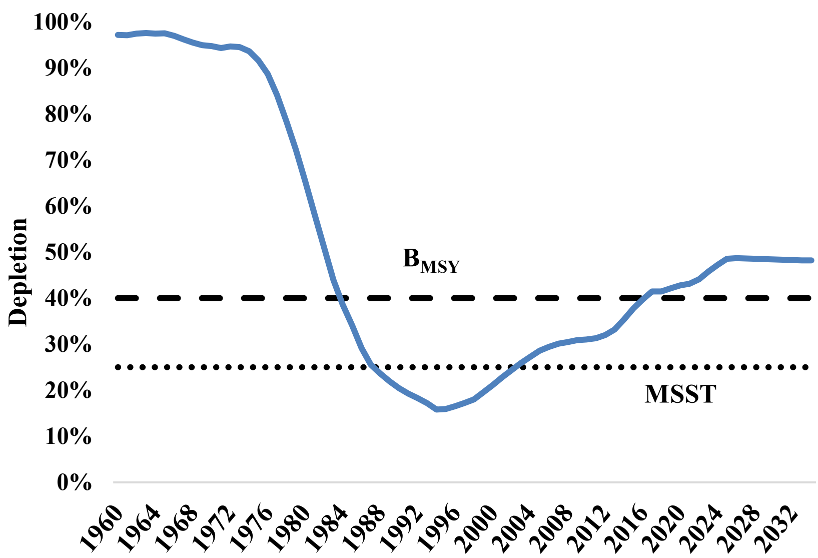

Figure 2-82. Estimated depletion of copper rockfish in California north of 34°27' N lat. relative to the management target, 1960-2034, based on the 2023 stock assessment.

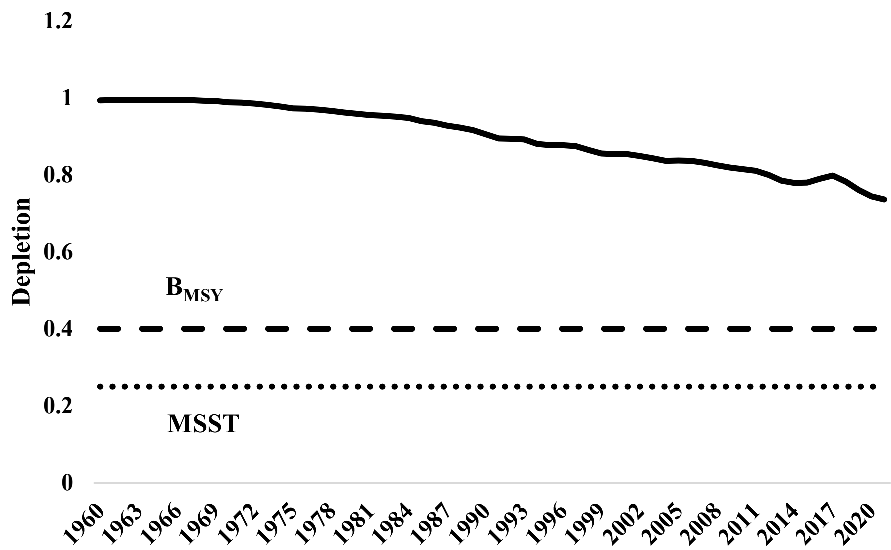

Figure 2-83. Estimated depletion of copper rockfish in Oregon relative to the management target, 1960-2021, based on the 2021 stock assessment.

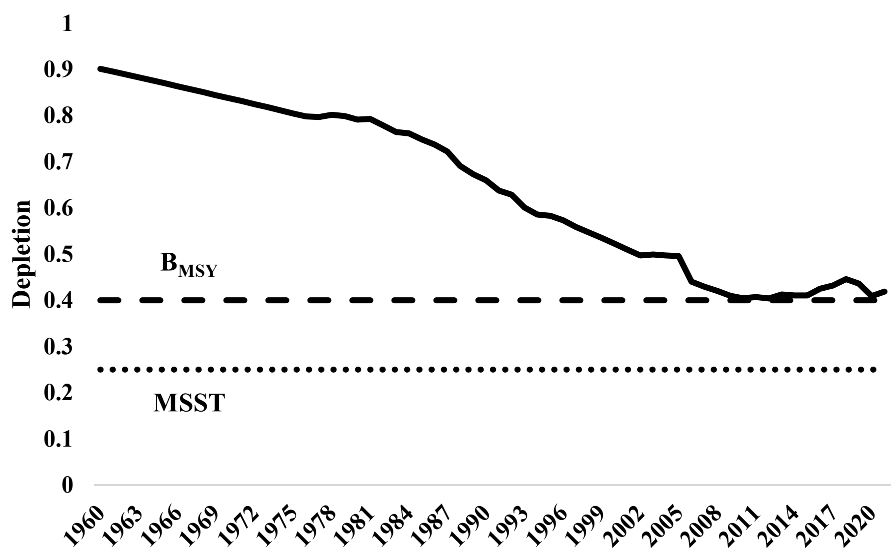

Figure 2-84. Estimated depletion of copper rockfish in Washington relative to the management target, 1960-2021, based on the 2021 stock assessment.

Stock Productivity

The PSA productivity score of 1.95 for copper rockfish indicates a high relative productivity among rockfish species. There is a relatively major vulnerability of potential overfishing (V = 2.27) for the stock, which ranks as the highest vulnerability score in the GMT's analysis of species managed under the Groundfish FMP (tied with rougheye rockfish; Table 2-2).

For California copper rockfish, the previous 2021 data-moderate assessment south of Point Conception model was unable to estimate annual recruitment deviations due to lack of information in the data. The 2023 southern assessment model included additional data sources including available age data that supported the estimation of annual recruitment. The base model south of

Point Conception estimated strong recruitment in 2009, 2010, and 2013 with multiple poor recruitment years at the end of the time series (Figure 2-82a). A steepness of 0.72 was assumed in the stock-recruitment relationship modeled in 2023.

Recruitment deviations were estimated for the north of Point Conception model in 2023 as well. The northern model estimated the largest recent recruitment deviations in 2007, 2009, and 2017 with a series of poor recruitment occurring in the late 1990s and early 2000s (Figure 2-82b). The magnitude of overall estimated relative recruitment variation, highs and lows, was greater in the area south of Point Conception compared to the area north of Point Conception.

Annual recruitment deviations were not estimated in the Oregon or Washington assessments and a steepness of 0.72 was assumed in the deterministic stock-recruitment relationships modeled in the 2021 assessments.

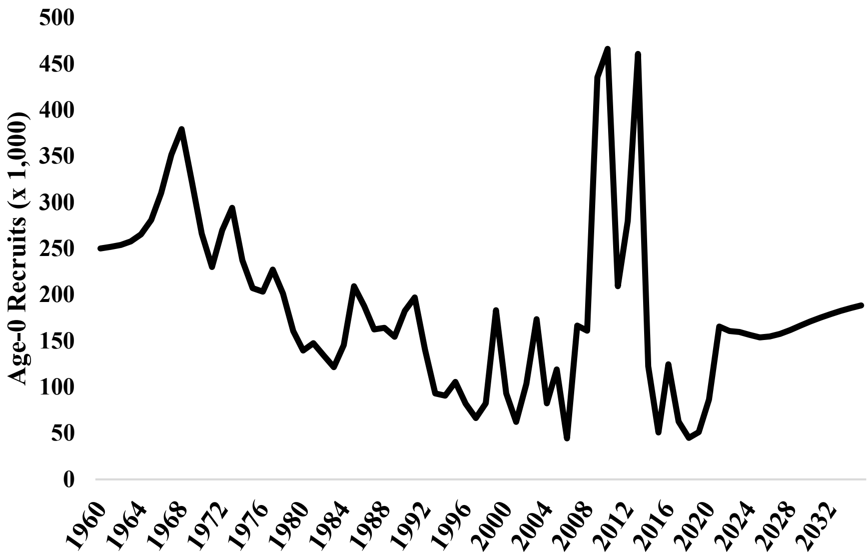

Figure 2-85a. Estimated recruitment of copper rockfish in California south of 34°27' N lat., 1960-2035, based on the 2023 stock assessment.

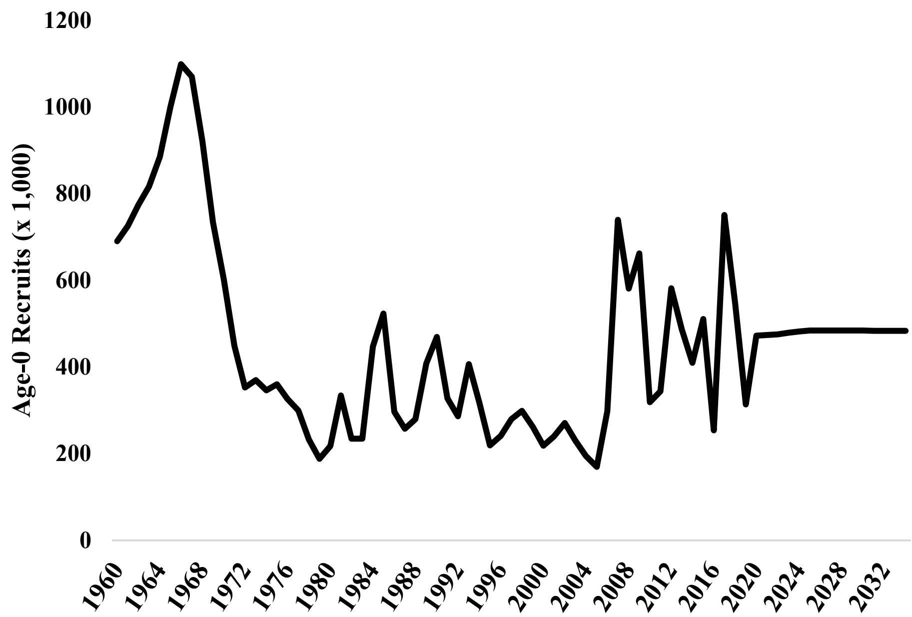

Figure 2-86b. Estimated recruitment of copper rockfish in California north of 34°27' N lat., 1960-2034, based on the 2023 stock assessment.

Fishing Mortality

Copper rockfish are caught in both commercial and recreational fisheries off the coast of California. Recreational removals have been the largest source of fishing mortality of copper rockfish. Commercial catch of copper rockfish increased with the advent of the live fish market in the 1980s. The proportion of copper rockfish being landed live vs. dead since 2000 by California commercial fleets ranges between 50 to greater than 70 percent in the southern and northern areas, respectively.

Based on the 2023 California copper rockfish assessments, trends in fishing intensity for both sub-areas dramatically increased in the 1970s, exceeded the management target SPR of 50%, and remained high until at least the late 1990s. The fishing intensity south of Point Conception declined in the early 2000s but remained above the target for the rest of the time series except for 2006 (Figure 2-83). The fishing intensity sharply decreased around 2000 north of Point Conception with fishing intensity remaining below the management target since, excluding a recent spike in 2017 (Figure 2-84). Statewide harvest rates declined in 2022 based on inseason management actions by the California Department of Fish and Wildlife (CDFW).

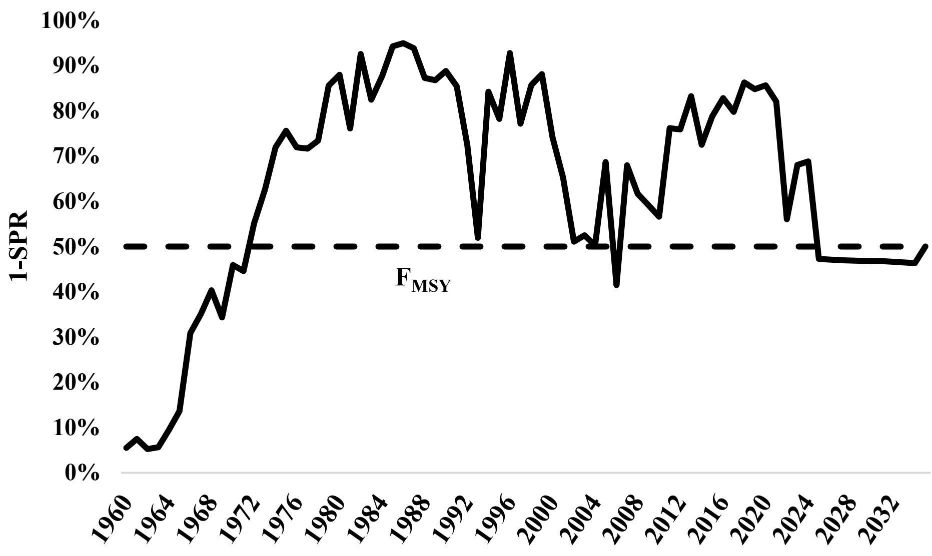

Figure 2-87. Estimated annual relative exploitation rate of copper rockfish in California south of 34°27' N lat. relative to the current proxy F_{MSY} target, 1960-2035, based on the 2023 stock assessment.

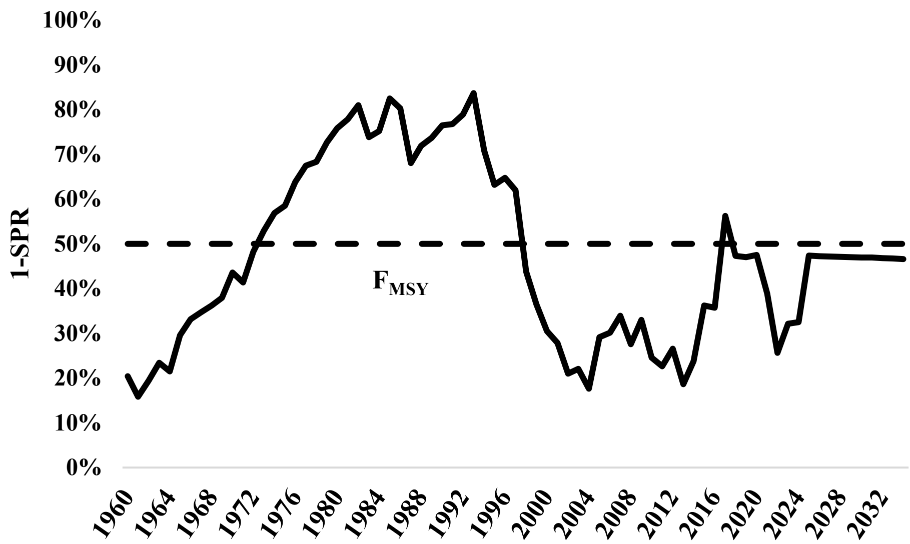

Figure 2-88. Estimated annual relative exploitation rate of copper rockfish in California north of 34°27' N lat. relative to the current proxy F_{MSY} target, 1960-2034, based on the 2023 stock assessment.

Copper rockfish are caught in both commercial and recreational fisheries in Oregon. While most of the catch from the late-1960s through the early-1980s was from the commercial fishery, the recreational fishery has taken the largest proportion of the catch since then averaging 72 percent from 1980-2020. Currently, the commercial fishery is centered on the southern Oregon coast and copper rockfish are primarily landed live with some landings made to the fresh market.

The 2021 assessment estimates relative exploitation rates have progressively increased since the late-1960s and have never exceeded the F_{MSY} proxy (Figure 2-85).

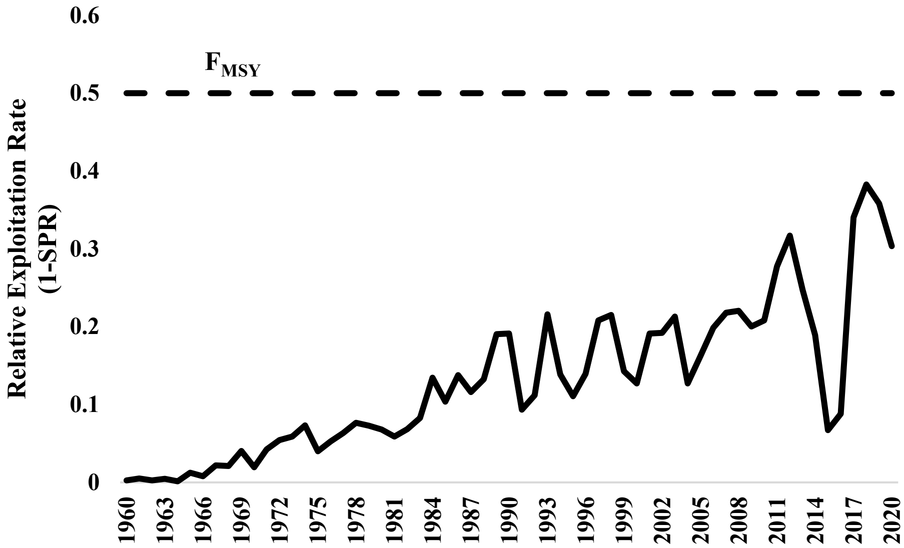

Figure 2-89. Estimated annual relative exploitation rate of copper rockfish in Oregon relative to the current proxy F_{MSY} target, 1960-2020, based on the 2021 stock assessment.

Copper rockfish is primarily caught off Washington in the recreational fishery with very little mortality from commercial fishing off the coast of Washington. Copper rockfish has not been targeted by commercial fisheries in Washington waters; commercial fixed gears and trawls were banned in state waters in 1995 and 1999. Copper rockfish has been a target of recreational fishing starting as early as 1935, with catches stabilizing around 2,500 – 3,000 fish per year starting around 1980 with the exception of select years with high (2005) or low catches (2015).

The relative exploitation rate has been above and below the F_{MSY} proxy in recent years (Figure 2-86).

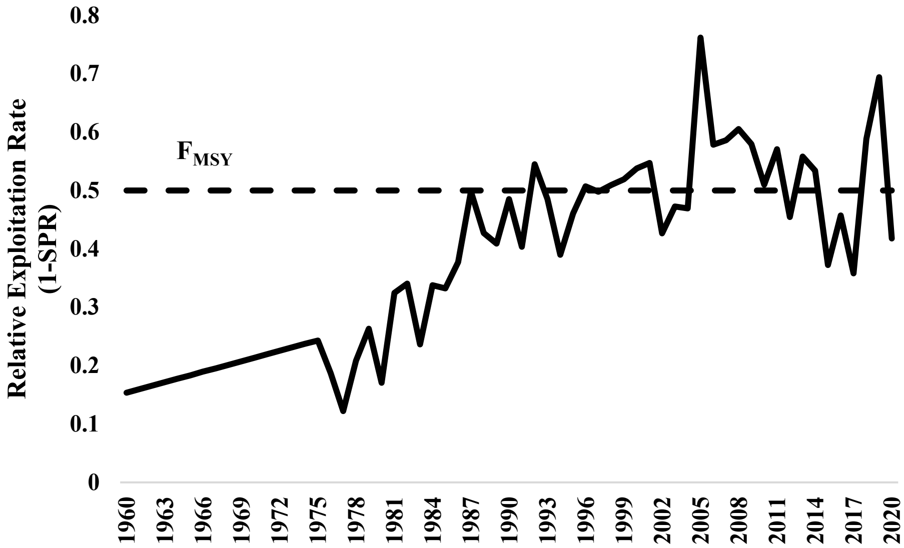

Figure 2-90. Estimated annual relative exploitation rate of copper rockfish in Washington relative to the current proxy F_{MSY} target, 1960-2020, based on the 2021 stock assessment.

Gopher Rockfish

Distribution and Life History

Gopher rockfish (*Sebastes carnatus*) range from Eureka, California, to San Roque, central Baja California (Miller and Lea 1972), but are most common from Mendocino County to Santa Monica Bay, California (Love 1996). Gopher rockfish is a residential and demersal species, associated with kelp beds or rocky reefs, from the intertidal to about 264 ft (80 m), most commonly between 30 and 120 ft (9-37 m) (Eschmeyer, *et al.* 1983; Love 1996; Love, *et al.* 2002). One tagging study off central California (Lea*, et al.* 1999) revealed that gopher rockfish exhibit minor patterns of movement (<1.5 nm, 2.8 km) with all fish being recaptured on the same reef system where they were tagged. Another study, conducted by Matthews (1986), reported movements up to 1.2 km (0.65 nm) by gopher rockfish that traveled from a low-relief natural reef to a high-relief artificial reef. The change in substrate type may have been a factor in the movement in the Matthews study.

Gopher rockfish settle out of the plankton as large larvae (2 cm. or less in length) primarily in the canopies of giant and bull kelp (*Macrocystis pyrifera* and *Nereocystis luetkeana*, respectively) where they remain close to the fronds (Love, *et al.* 2002). Settlement occurs primarily in June and July. With growth, older individuals move down the kelp stipes to the bottom where they take up residence in rocks and crevices. They are largely territorial with home ranges of 10-12 m^2 (Love, *et al.* 2002).

Gopher rockfish are closely related to black-and-yellow rockfish (*Sebastes chrysomelas*) and kelp rockfish (*Sebastes atrovirens*). Gopher and black-and-yellow rockfish are distinct morphologically by color and inhabit different depth ranges (gopher have a deeper depth range) but cannot be distinguished genetically (Love, *et al.* 2002). This presents an interesting phenomenon in how speciation in rockfish may occur. There are theories that interbreeding may be lessened by individuals only breeding with others of the same color. If it is determined the two species are actually one, then the name *S. carnatus* will prevail since it was described first (Love, *et al.* 2002).

Stock Status and Management History

Gopher rockfish was assessed for the first time in 2005 and estimated stock depletion under the base model was 97 percent of its unfished biomass at the start of 2005 (Key*, et al.* 2006). Although the distribution of gopher rockfish extends south into the Southern California Bight, the assessment was restricted to the stock north of Point Conception. The assessment is based on landings and length composition data from commercial and recreational fisheries (primarily hook and line gear) and an index of relative abundance (CPUE) from the CPFV Sportfish Survey database. These data sources were used to estimate population trends from 1965 to 2004. There are no fishery-independent indices of stock biomass for gopher rockfish. Assessment results indicate an upward trend in gopher rockfish biomass since the 1980s and estimates of 2005 abundance ranged between 60 percent and 110 percent of average unfished stock size; this range of depletion levels is the result of alternative emphases in the model given to the CPFV in the CPUE index, a data element identified as a major source of uncertainty.

During the 2007-2008 biennial specifications process, the Council decided to continue managing gopher rockfish within the Nearshore Rockfish South complex since there was adequate resource protection under the California Nearshore Fishery Management Plan and managing gopher rockfish with stock-specific harvest specifications could disrupt that plan.

The OFL contribution of gopher rockfish to the Nearshore Rockfish complex south of 40°10' N. lat. and north of 34°27' N. lat. Is based on the equilibrium MSY proxy estimated in the 2005 assessment of 101 mt. The OFL contribution for the population occurring south of 34°27' N. lat. is based on a 2011 DCAC estimate. These data-poor methods for determining OFLs were used since the 2005 assessment was considered out of date and the SSC did not recommend a catch-only update of that assessment. These data-poor methods also compelled the SSC to rate gopher rockfish as a category 3 stock. The historical catches of gopher rockfish are so minimal there is no OFL contribution to the Nearshore Rockfish complex north of 40°10' N. Lat.

New genetic evidence suggests that gopher rockfish and black-and-yellow rockfish are the same species. A full assessment of gopher rockfish and black-and-yellow rockfish as a complex of the two previously-described species south of 40°10' N. lat. Was conducted in 2019 (Monk and He 2019). Spawning output has been steadily decreasing since the mid-2000s when the stock was estimated to be at 77 percent of unfished spawning output, the highest level since the early-1970s, to a current depletion estimate of 44 percent of the unfished level (Figure 2-87).

The current assessment includes information from landings, discards, age and length composition data, and six sources of fishery-dependent and fishery-independent abundance indices, including indices and age data from the CCFRP. Major sources of uncertainty are the potential for spatial and species-specific differences in life history parameters (e.g., growth) and that the abundance indices were not fit well in the model. Steepness and M were fixed in the base model, while recruitment deviations and growth were estimated.

The SSC designated the 2019 assessment of gopher and black-and-yellow rockfishes as category 2, largely due to the fact that this assessment is for a species complex. The SSC recommended that the next assessment be a full assessment if there are substantial increases in information (i.e., improved information on growth, or an improved age-0 index); otherwise, it could be an update assessment.

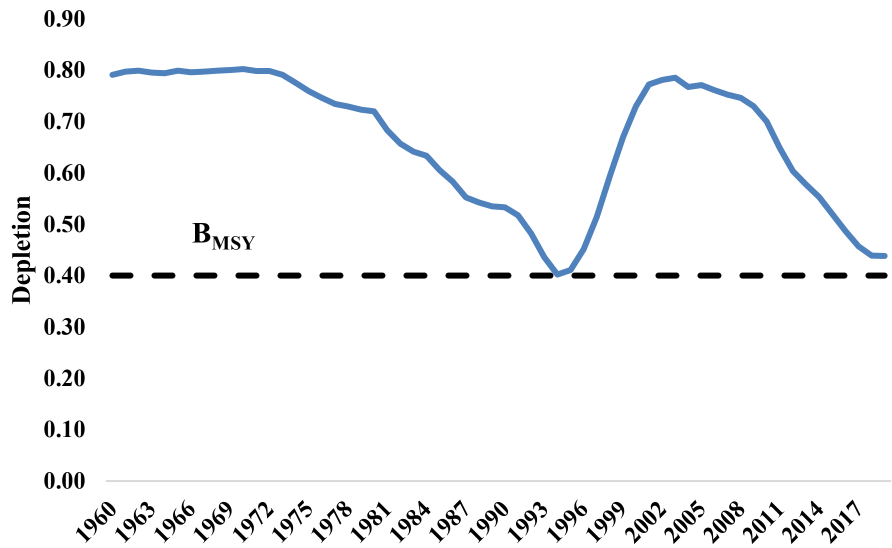

Figure 2-91. Relative depletion of gopher and black-and-yellow rockfishes off California south of 40°10' N. lat. From 1960 to 2019 based on the 2019 stock assessment.

Stock Productivity

Recruitments were modeled in the 2019 assessment assuming a Beverton-Holt relationship, with an assumed steepness of 0.72 based on the current meta-analysis of rockfish steepness. Recruitment variability was fixed at sigma r = 0.5. Recruitment deviations were estimated from 1979-2018 (Figure 2-88). There are estimates of very strong recruitment in 1991, with high recruitment pulses for a number of other years including 1994-1995 and 2014-2015.

The PSA productivity score of 1.56 for gopher rockfish indicates a moderate relative productivity among rockfish species. There is a relatively low vulnerability of potential overfishing (V = 1.76) for the stock.

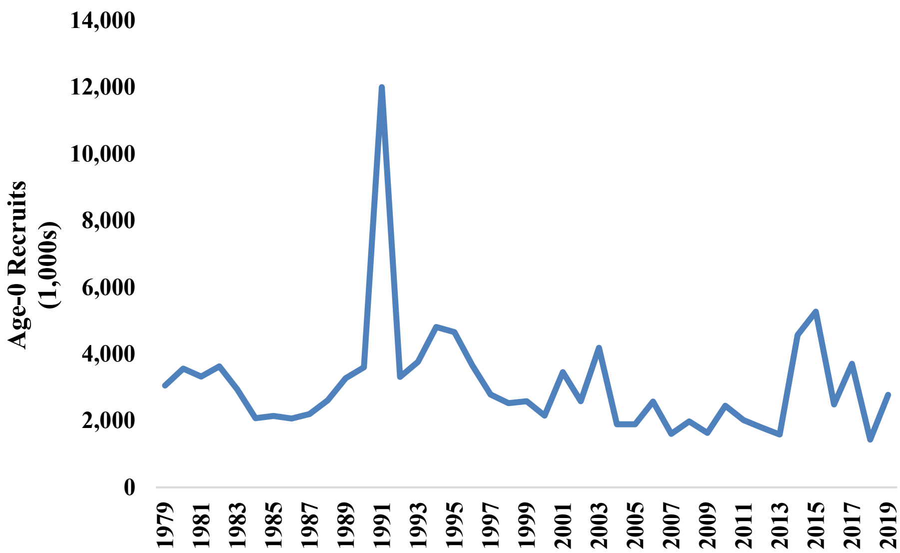

Figure 2-92. Estimated recruitments of gopher and black-and-yellow rockfishes south of 40°10' N. lat., 1979-2019.

Fishing Mortality

Gopher and black-and-yellow (referred to from hereon as GBYR when discussing the complex) rockfish have been a minor component of the commercial and recreational rockfish fishery since at least the late 1960s. The commercial catch histories of the two species cannot easily be separated; from 1916-1936 only black-and-yellow rockfish were reported in the landings, and an average of 0.04 mt of black-and-yellow rockfish are reported from 1937-1983. Black-and-yellow rockfish reappear in the landings in 1984 with 7.2 mt landed commercially. From 1985-1988 the trend switches and only black-and-yellow rockfish appear in the commercial landings, with gopher rockfish averaging 0.1 mt landed, and 0 mt reported in 1987. From 1988 and on, the landings are dominated by gopher rockfish, and both species are represented in the commercial landings. The landings from south of Point Conception are minor throughout the time period, with peaks in the 1950s and 1960s for gopher rockfish. Black-and-yellow rockfish are rare south of Point Conception and it is therefore expected that these catches are minimal.

The live fish fishery began in the early 1990s, with the first reported commercial landings of live gopher rockfish in 1993, and black-and-yellow rockfish a year later. By 1995, over half (57 percent; 39 mt) of the commercial landings were from the live fish fishery. This increased quickly over the next few years and has been on average 84 percent of the landed gopher and black-and-yellow rockfish since 2000. The majority of the landings are from gopher rockfish north of Point Conception. Landings of live GBYR south of Point Conception were higher in the late 1990s, (max. 3.2 mt in 1999), and have been averaging 0.4 mt since 2003.

The ex-vessel value of GBYR increased from less than $40,000 in 1984 and peaked at $680,452

in 1996. The ex-vessel revenue has been fairly stable at around $500,000 a year since 2007. Prior to the live fish fishery in 1994, the average price per pound for either species was around $2 a pound. The live fish fishery increased the value of both species to an average of $6-$8 a pound, with maximum reported value of either a gopher or black-and-yellow rockfish was $20 a pound in 2003.

The recreational GBYR fishery for California is most prominent north of Point Conception throughout the entire catch history from 1928 to 1980.

Harvest rates estimated by the base model in the 2019 assessment indicate catch levels have been below the limits that would be associated with the SPR = 50 percent limit (corresponding to a relative fishing intensity of 100 percent) (Figure 2-89). The relative inverse SPR increased over the last decade from a low period from 2004-2008, ranged from 0.64 to 0.77 of the F_{MSY} limit from 2009-2015, and ranged from 0.80 to 0.82 from 2016-2018 (Figure 2-89).

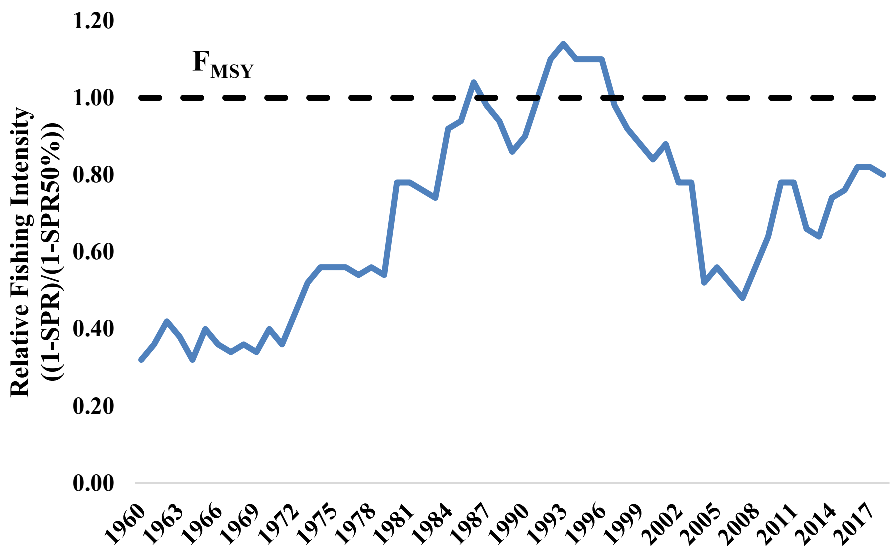

Figure 2-93. Relative fishing intensity of gopher and black-and-yellow rockfishes in California south of 40°10’ N. lat., 1960-2018.

Quillback Rockfish

Distribution and Life History

Quillback rockfish (*Sebastes maliger*) are a medium- to large-sized nearshore rockfish found from southern California to the Gulf of Alaska (Love*, et al.* 2002). Off the U.S. West Coast quillback rockfish are primarily located north of central California, with few observations south of Point Conception. Quillback rockfish have historically been part of both commercial and recreational fisheries throughout their range.

Quillback rockfish are found in waters less than 274 meters in depth in nearshore kelp forests and rocky habitat (Love*, et al.* 2002). The diets of quillback rockfish consist primarily of benthic and pelagic crustaceans and fish (Murie 1995). The body coloring of adult quillback rockfish is brown with yellow to orange blotching and light-colored dorsal saddle patches (Love*, et al.* 2002). As their name suggests, quillback rockfish have long dorsal fin spines.

Limited studies have evaluated genetic variation in quillback rockfish across the U.S. West Coast. Genetic work has revealed significant differences between Puget Sound and coastal stocks of quillback rockfish (Seeb 1998; Stout*, et al.* 2001); however, Seeb (1998) did not find significant differentiation in populations of quillback rockfish between coastal Washington and Alaska. Significant population sub-division along the U.S. West Coast has been detected for the closely related, and more well-studied copper rockfish (*S. caurinus*), indicating limited oceanographic exchange among geographically proximate locations (Buonaccorsi*, et al.* 2002; Johansson*, et al.* 2008; Seeb 1998). High site-fidelity (Hannah and Rankin 2011) and relatively small home ranges (Tolimieri*, et al.* 2009) for quillback rockfish suggests patterns of isolation-by-distance as found for other rockfish.

Stock Status and Management History

Quillback rockfish are managed in the northern and southern Nearshore Rockfish complexes. New data-moderate assessments were conducted in 2021 for quillback rockfish in California, Oregon, and Washington. The California stock was estimated to be below the MSST with a 14 percent depletion at the start of 2021 (Figure 2-90) (Langseth*, et al.* 2021a). The Oregon and Washington stock depletions were estimated to be 47 percent (Figure 2-91) (Langseth*, et al.* 2021c) and 39 percent (Figure 2-92) (Langseth*, et al.* 2021b) in Oregon and Washington, respectively at the start of 2021. However, formal status determinations were notmade until Amendment 31 defined the stocks in the FMP. See section 2.3 Overfished and Rebuilding Groundfish Stocks, and 2.3.2 California Quillback Rockfish for more information.

The data-moderate quillback assessments were modeled using the SS-CL framework and relied primarily on length composition data, most of which came from the recreational fleet. These assessments included two fleets (a recreational fleet and a commercial fleet), externally estimated biological relationships (length-weight, length-age, natural mortality, fecundity, and maturity), double-normal selectivity, and the stock-recruitment relationship was Beverton-Holt (h = 0.72). Recruitment deviations were estimated for California and Oregon, and the model for Washington assumed deterministic recruitment.

The stock off the California coast was assessed as a separate stock from other populations off the U.S. West Coast based on the fairly sedentary nature of quillback rockfish (Hannah and Rankin 2011; Tolimieri*, et al.* 2009), which likely limits movement of fish between California and Oregon. Additionally, the exploitation history and magnitude of removals off the California coast differ from those in Oregon. Although the population of quillback rockfish in California is assessed statewide, given the range of quillback rockfish, this assessment is primarily of quillback rockfish north of Point Conception. Catches of quillback rockfish south of Point Conception were rare.

There was substantial uncertainty in the California model given sensitivity to assumed growth and mortality parameters. The use of growth from fish sampled in Oregon and Washington, applied in the California assessment presents an unresolved uncertainty, since California is subject to higher water temperatures that can affect growth rates making them potentially unrepresentative.

For the Oregon model, the key sensitivities are whether annual recruitment deviation should be estimated, which has an effect on the model scale in 2021, and assuming asymptotic recreational selectivity, which reduces the fraction of unfished spawning biomass. In the Washington model, there was more variability in model estimates, and sensitivity to estimating parameters (*M*, CV of larger individuals, and L infinity), as well as sensitivities around recruitment, and estimation of recruitment deviations.

The SSC recommended a category 2 designation for the California and Oregon stocks and a category 3 designation for the Washington stock for informing harvest specifications in 2023 and beyond. The OFL for Washington quillback is the MSY under the proxy F_{MSY} harvest rate of $SPR_{50\%}$.

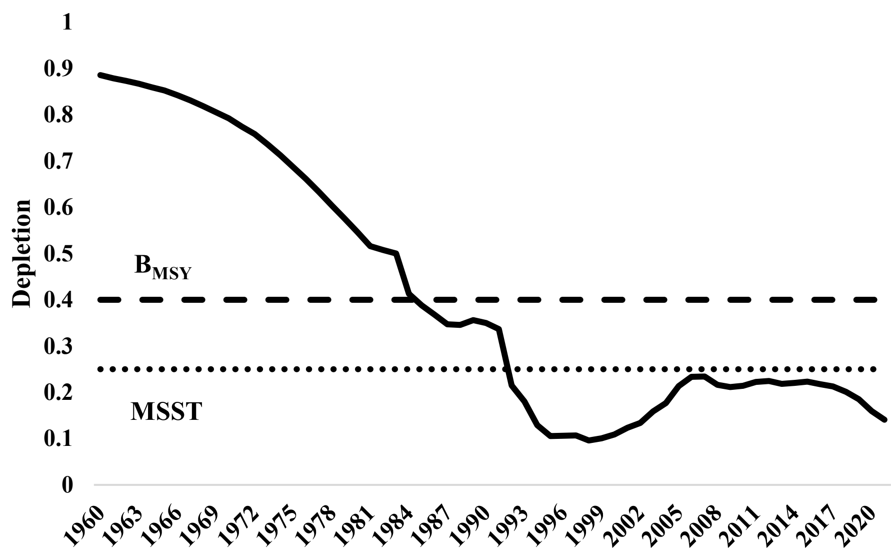

Figure 2-94. Estimated depletion of quillback rockfish in California relative to the management target, 1960-2021.

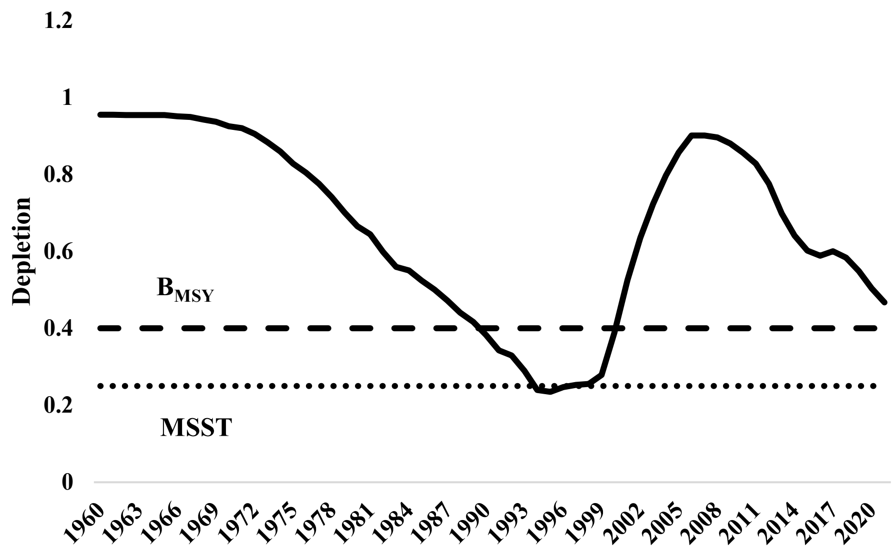

Figure 2-95. Estimated depletion of quillback rockfish in Oregon relative to the management target, 1960-2021.

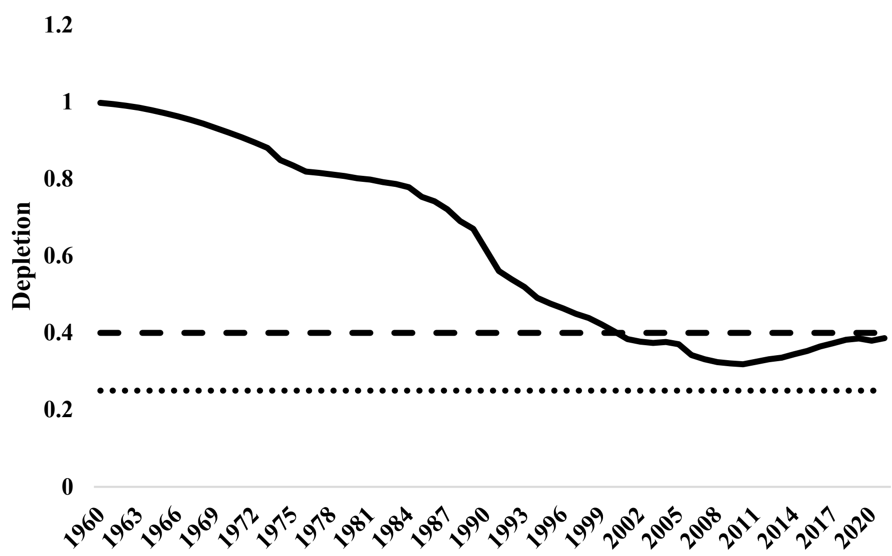

Figure 2-96. Estimated depletion of quillback rockfish in Washington relative to the management target, 1960-2021.

Stock Productivity

The PSA productivity score of 1.31 for quillback rockfish indicates a moderate relative productivity among rockfish species. There is a relatively major vulnerability of potential overfishing (V = 2.22; Table 2-2).

Strong recruitment events were estimated for the California stock prior to 2000 and in 2011. Recruitment deviations in 1987, 1996, and 1999 were particularly strong (Figure 2-93) and resulted in an increase in biomass during the early 2000s. While the largest recruitment deviations were estimated to have occurred in these three specific years, the surrounding years in the 1980s and 1990s also have above average recruitment estimated. Below average recruitment was estimated in all years since 2000, with the exception of 2011.

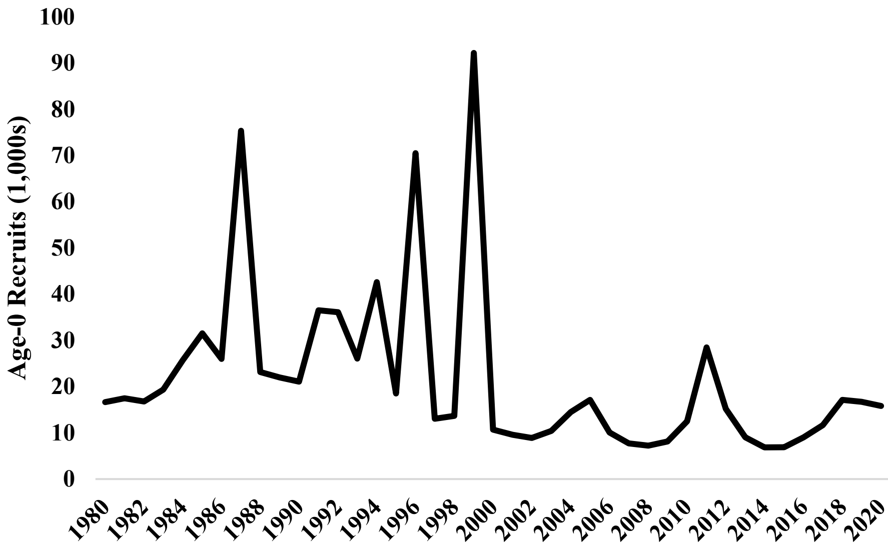

Figure 2-97. Estimated recruitment of quillback rockfish in California, 1980-2020.

Strong recruitment events were estimated for the Oregon stock to have occurred in 1993, 1995, 1999, and 2012 which resulted in a substantial increase in biomass during the late 1990s and early- to mid-2000s (Figure 2-94). While the largest recruitment deviations were estimated to have occurred in these four specific years, the surrounding years in the 1990s also have above average recruitment estimated, whereas the surrounding years in the 2000s have lower than average recruitment estimated.

The Washington stock-recruitment relationship is deterministic and recruitment deviations were not estimated due to extreme model sensitivity to recruitment estimation.

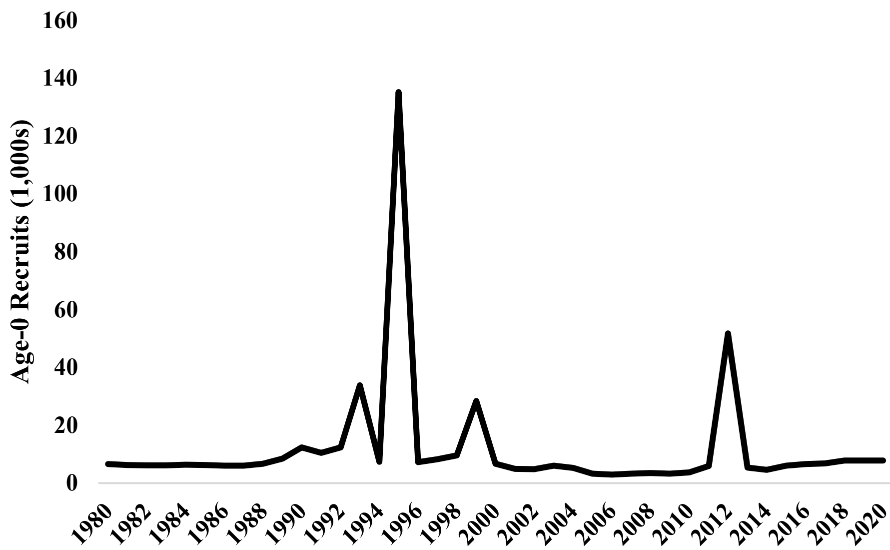

Figure 2-98. Estimated recruitment of quillback rockfish in Oregon, 1980-2020.

Fishing Mortality

Quillback rockfish off the coast of California are caught in both the recreational and commercial fisheries. Recreational removals are the largest source of fishing mortality and represent approximately 70 percent of the total removals of quillback rockfish across all years in the 2021 assessment. The majority of the commercial landings for quillback rockfish occurred between 1990 and 2008 with the advent of the live fish market in the 1980s, and apart from 1945-1946, in 1984, and in the last four years, commercial landings for quillback rockfish have been less than 2 mt per year. From 2003 to 2020, total removals from all fishing fleets have averaged 9.85 mt annually.

The relative exploitation rate of California quillback has been above the proxy F_{MSY} harvest rate in most years since the mid-1970s according to the 2021 assessment (Figure 2-95).

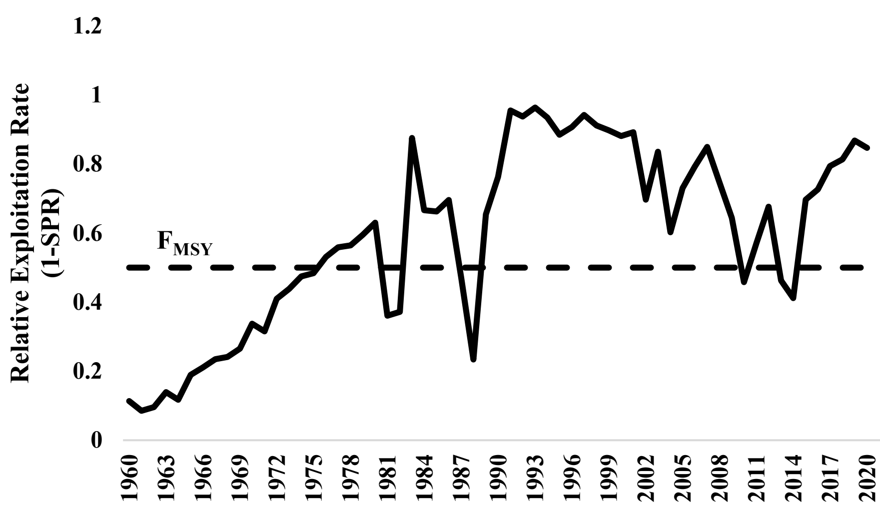

Figure 2-99. Estimated annual relative exploitation rate of quillback rockfish in California relative to the current proxy F_{MSY} target, 1960-2020.

Quillback rockfish off the coast of Oregon are caught in both the recreational and commercial fisheries. Recreational removals are the largest source of fishing mortality and represent approximately 59 percent of the total removals of quillback rockfish across all years in the 2021 assessment. Quillback rockfish is one of several rockfish species targeted by a nearshore, primarily live-fish fixed gear fishery centered on Oregon's southern coast. Quillback rockfish have been landed primarily with hook and line gear, though a substantial portion have been landed with bottom longline gear as well. Overall, 94.2 percent of quillback rockfish landings are from these two gear types (2000 – 2020). In the most recent years, longline landings have eclipsed hook and line landings. Landings from other gear types, including fish pot and trawl, are sporadic and minimal relative to hook and line and longline gears. Commercial landings for quillback rockfish increased from the mid-1960s to 1974 and have since fluctuated between approximately 0.4 and 4.5 mt annually. From 2003 to 2020, total removals from all fishing fleets have averaged 6.6 mt annually.

The relative exploitation rate of Oregon quillback has been above the proxy F_{MSY} harvest rate in most years since the mid-1970s according to the new assessment (Figure 2-96).

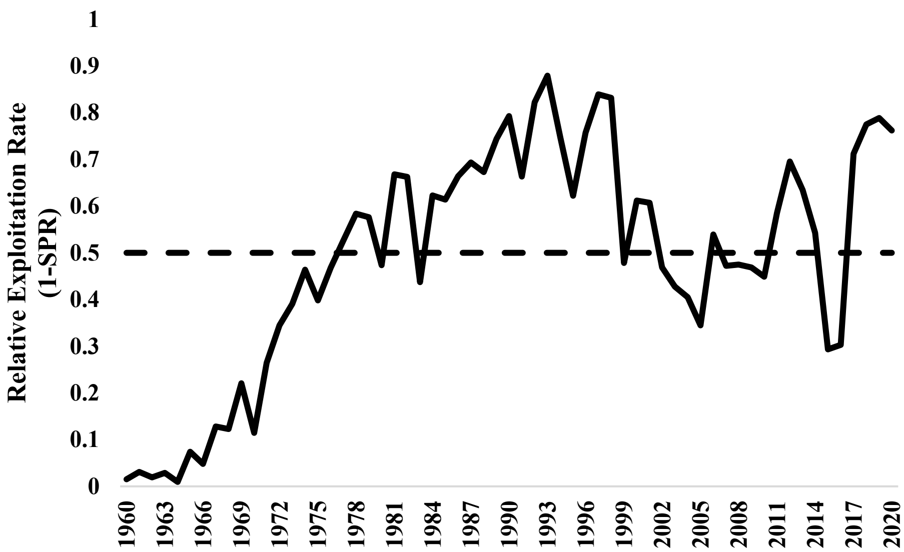

Figure 2-100. Estimated annual relative exploitation rate of quillback rockfish in Oregon relative to the current proxy F_{MSY} target, 1960-2020.

Off the Washington coast, quillback rockfish is primarily caught in the recreational fishery, and in general, is not targeted by either commercial or recreational fleets. Washington state waters, which mostly encompass the depths preferred by quillback rockfish, were closed to commercial fixed gears in 1995 and to trawling in 1999. In response to the development of the live-fish fishery in California and Oregon, Washington took preemptive action in 1999 by prohibiting the landing of live fish. There are four treaty tribes along the Washington coast that continue to fish under separate commercial rules and are not subject to the state water closure. These tribes occasionally land small amounts of quillback rockfish. Recreational removals are the largest source of fishing mortality and represent approximately 94 percent of the total removals of quillback rockfish across all years in the assessment. From 2003 to 2020, total removals from all fishing fleets have averaged 3.0 mt annually.

The relative exploitation rate of Washington quillback has been above the proxy F_{MSY} harvest rate in most years since 1987 according to the 2021 assessment (Figure 2-97).

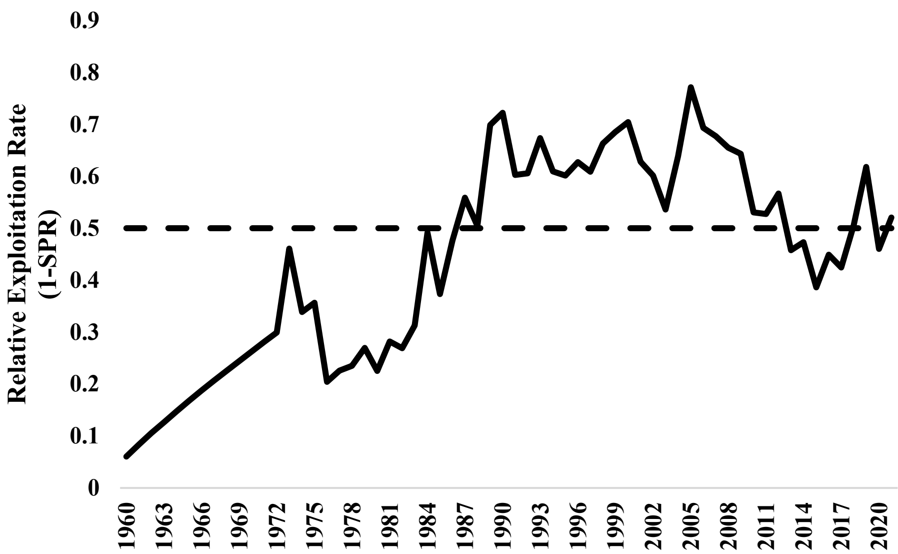

Figure 2-101. Estimated annual relative exploitation rate of quillback rockfish in Washington relative to the current proxy F_{MSY} target, 1960-2020.

2.5.2 Oregon Black/Blue/Deacon Rockfishes

Black Rockfish off Oregon

Distribution and Life History

See the description of black rockfish distribution and life history in section 2.9.3.

Stock Status and Management History

The stock status and management history of the Oregon black rockfish stock is provided in the previous section (see Section 2.9.3) since one assessment was done for California and Oregon stocks together prior to 2015.

A full assessment of black rockfish in waters off Oregon was conducted in 2015 (Cope*, et al.* 2015a). This was the first assessment ever of the Oregon black rockfish stock in isolation. Cope et al. (2015a) estimated the Oregon black rockfish stock was at a 61 percent depletion at the start of 2015 and the stock had never fallen below the B_{MSY} target. The Oregon model had five fisheries (three commercial and two recreational) and considered five surveys.

The most recent assessment for black rockfish in waters off Oregon was conducted in 2023 (Cope, et al. 2023). Currently, the stock is estimated at 43% depletion, which is above the management target relative to unfished (40%) and is estimated to have remained above the target since 2014 (Figure 2-98).

The model had four fisheries (two commercial and two recreational) and considered three fishery-dependent and three fishery-independent indices of abundance. The addition of a new coastwide acoustic-visual survey (conducted in 2021) was incorporated into the reference model to provide direct information on overall population scale and to anchor related information on scale from earlier (2005-2013) tagging data. Besides the additional data and changes in the estimation of some parameters, the biggest changes to the past assessment were the addition of and fixing to the acoustic visual survey, estimation of recruitment, female mortality no longer a step but a constant value, length-based selectivity only, and dome-shaped selectivity for the ocean boat fisheries, use of an updated functional maturity relationship, changes in the removal history, and composition data were not constrained to inform the sex ratio.

In Oregon, accounting for location of capture is problematic for historic commercially caught fish, primarily for trawl gear types, which was the predominant gear type during the 1940s to 1970s. For state-specific assessments, the commercially caught Black Rockfish were apportioned to assessment region based on the port of landing, with the exception of trawl caught fish landed into Astoria, OR. Most of these fish were found to have been caught off Washington and most of the trawl landings into Astoria were therefore included with the catch history for the Washington assessment. This approach was refined in the current assessment to allow for state-specific species compositions to be applied to aggregated trawl landings.

A primary challenge for the black rockfish assessment in all three states is the absence of larger, older female black rockfish in fisheries catches, a phenomenon that has long been a challenge in developing plausible assessments for black rockfish and other species that exhibit this tendency. Past modeling approaches have explored both "hiding" larger, older females (e.g., applying dome-shaped selectivity to fisheries, which often results in what are considered to be implausibly high "cryptic" biomass levels of large, old, unavailable fish) or "killing" off larger, older females (one common formulation being a ramp up in natural mortality rates with age) in order to fit the observed data. Complex sex-specific growth and mortality dynamics are captured in the Oregon assessment through sex-specific parameterizations. In particular, observations of older females are lacking in the available data and is addressed by allowing for higher female natural mortality (a fixed value in the 2023 assessment).

The SSC categorized black rockfish off Oregon as a category 1 stock based on the 2023 assessment. The Council adopted the default harvest control rule of ACL equal to the ABC with a P* of 0.45 for 2025 and 2026 harvest specifications.

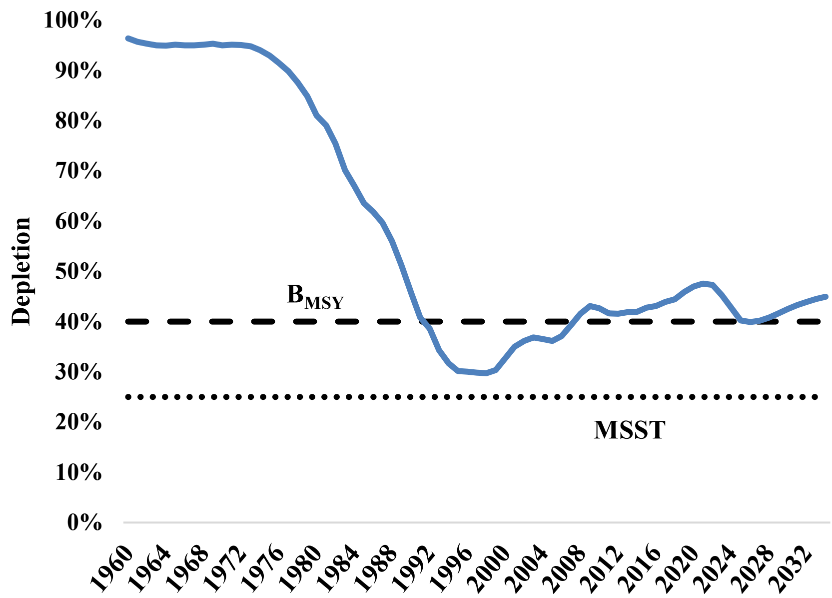

Figure 2-102. Relative depletion of black rockfish off Oregon from 1960 to 2034 based on the 2023 stock assessment.

Stock Productivity

The 2023 Oregon black rockfish assessment assumed a fixed steepness of 0.72 based on the meta-analysis of rockfish steepness. The PSA productivity score of 1.33 indicates a stock of moderate productivity.

The 2015 stock assessment did not estimate deviations from the stock-recruitment curve. While the stock has been reduced to levels that theoretically would provide some information on how recruitment compensation changes across spawning output levels (i.e., inform the steepness parameter), the 2023 assessment model could not adequately estimate a reasonable steepness parameter. Thus, recruitment was based on a fixed assumption about steepness (h = 0.72) and recruitment variability (σR = 0.6).

Fishing Mortality

The nearshore commercial and recreational fisheries that take black rockfish are actively managed in Oregon, and ACLs/OYs have not been exceeded. The PSA vulnerability score of 1.94 indicates a stock of medium concern for overfishing.

Fishing intensity over the past several decades has ranged above and below the 50 percent SPR target fishing rate and has come down since the time series high of 0.12 in 1992. Current estimates indicate that Oregon black rockfish spawning output is greater than the target biomass level, though fishing intensity remains above the target F_{MSY} proxy harvest rate of 1 - SPR50% (Figure 2-99).

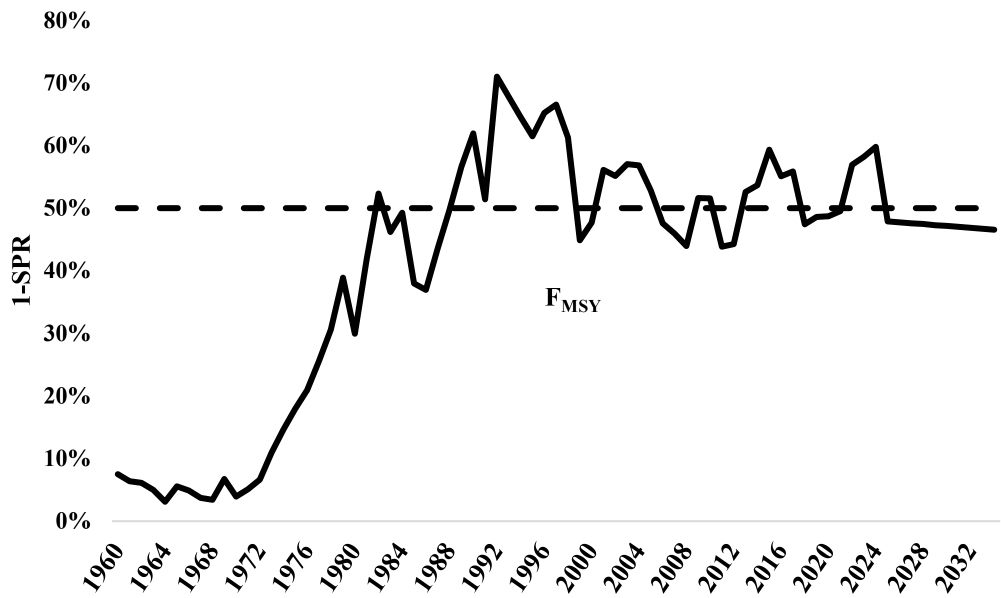

Figure 2-103. Time series of estimated SPR harvest rates of black rockfish off Oregon (1960-2034) based on the 2023 stock assessment. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis.

Blue and Deacon Rockfish off Oregon

Distribution and Life History

See Distribution and Life History of Blue and Deacon Rockfish in Section 2.10.1.

Stock Status and Management History

A new assessment of BDR, assessed as a complex of the two species, was conducted in 2017 for the populations of these two species off Oregon (Dick*, et al.* 2017). The Oregon BDR population is estimated to have been relatively lightly exploited, and to be healthy yet at a historically low level of depletion, 68.6 percent of the unfished spawning output in 2017 (Figure 2-100). The 2013 year class is estimated to be strong in Oregon waters, as in California.

The most significant uncertainty for the Oregon BDR model is the size of population scale, the treatment and value of natural mortality, and gender-specific selectivity. The development of a comprehensive fishery-independent index of abundance will help to resolve uncertainty in population scale. The treatment of selectivity and natural mortality was a major structural consideration that was explored in the development of the base case model. In particular, alternative approaches to estimating female and male natural mortality and gender specific selectivity were evaluated to account for differences in male selectivity (gear retention for the slower growing males) and availability (for sex-ratio reasons other than that attributed to natural mortality) relative to females in the catch. There was little information in the data to estimate gender-specific selectivity patterns, and most modeling attempts resulted in non-convergence or unrealistic results. The catch history for recreational fishing modes in years prior to 1979 and for the shore (and estuary) mode in recent years (2006-2014) is quite uncertain. In this assessment, historical catch reconstructions for these fleets included using a simple linear ramp, proportional fishing license sales ramp, and an extrapolation based on information available in the time series. The Oregon BDR assessment does not display a two-way trip like the California assessment and is based on fewer and shorter indices. Thus, both steepness and natural mortality are fixed in the base model.

The SSC endorsed the use of the Oregon BDR stock assessment as the best scientific information available for status determination and management as a category 2 assessment due to BDR being a complex of two species. The sigma value derived from the decision table for the Oregon assessment is larger than the category 2 sigma of 0.72 (0.803) and this value was used in calculating the scientific uncertainty buffer used to determine ABCs.

The Council adopted default harvest specifications (ACL = ABC with a P* of 0.45) for the Oregon BDR contribution to the new Oregon Black/Blue/Deacon Rockfish complex. The 2019 and 2020 ABC and ACL contributions of Oregon BDR to the Oregon Black/Blue/Deacon Rockfish complex are 101.5 mt and 98.4 mt, respectively.

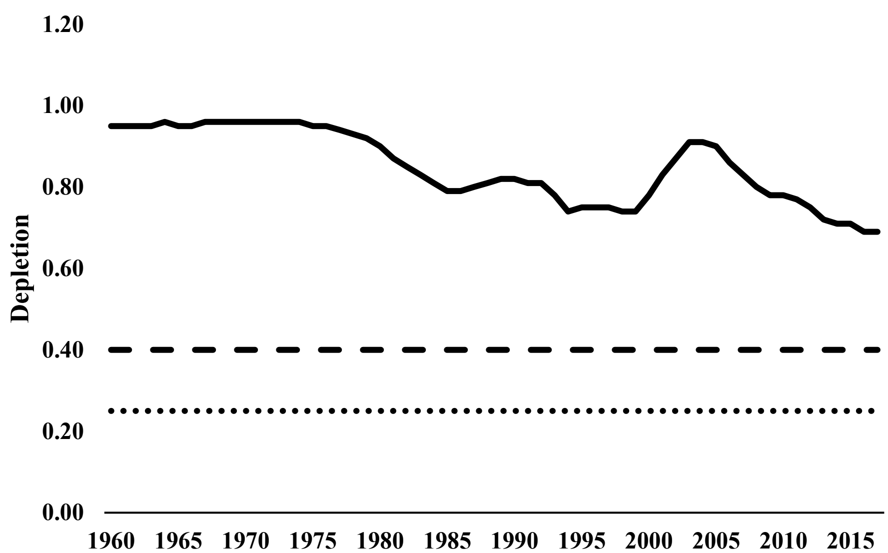

Figure 2-104. Relative depletion of blue and deacon rockfish off Oregon from 1960 to 2017 based on the 2017 stock assessment.

Stock Productivity

A Beverton-Holt steepness of 0.718 was assumed in the Oregon BDR model based on the mean of the prior distribution of the most recent meta-analysis of rockfish steepness. There was an attempt to estimate steepness in the Oregon BDR model, but a lack of contrast in exploitation lead to little information about steepness.

Recruitment variability was dynamic for BDR (Figure 2-101) and indicated well above average recruitment in 2013. Other years with relatively high estimates of recruitment were 1993, 1994, and 1995. The BDR stock in Oregon has not been depleted to levels that would provide information on how recruitment changes with spawning output at low spawning output levels (i.e., inform the steepness parameter).

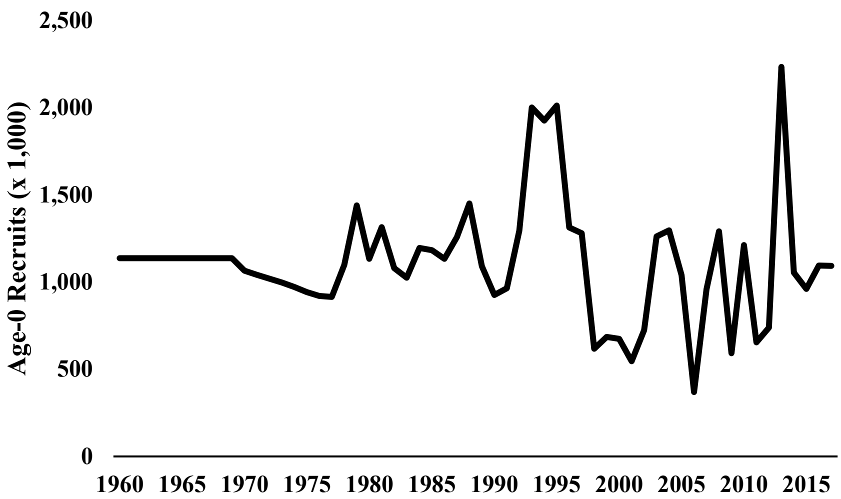

Figure 2-105. Estimated recruitments of blue and deacon rockfishes off Oregon, 1960-2016 (from Dick et al. 2017).

Fishing Mortality

Harvest rates in Oregon have generally increased through time until the mid-1990s when harvest was reduced to a relatively stable level beginning in the 2000s (Figure 2-102). The maximum relative harvest rate was 0.92 in 1993 (or 92 percent of the target level) before declining again to around 0.40 in recent years (Figure 2-102). Summary fishing mortality rates have been around 0.02 in recent years. Fishing intensity is estimated to have been below the target throughout the time series [(1-SPR) / (1-$SPR_{50\%}$) < 1]. In 2016, Oregon BDR biomass is estimated to have been 1.73 times higher than the target biomass level, and fishing intensity remains lower than the SPR fishing intensity target. The equilibrium curve is shifted left, as expected from the high fixed steepness, showing a more productive stock than the $SPR_{50\%}$ reference point would suggest.

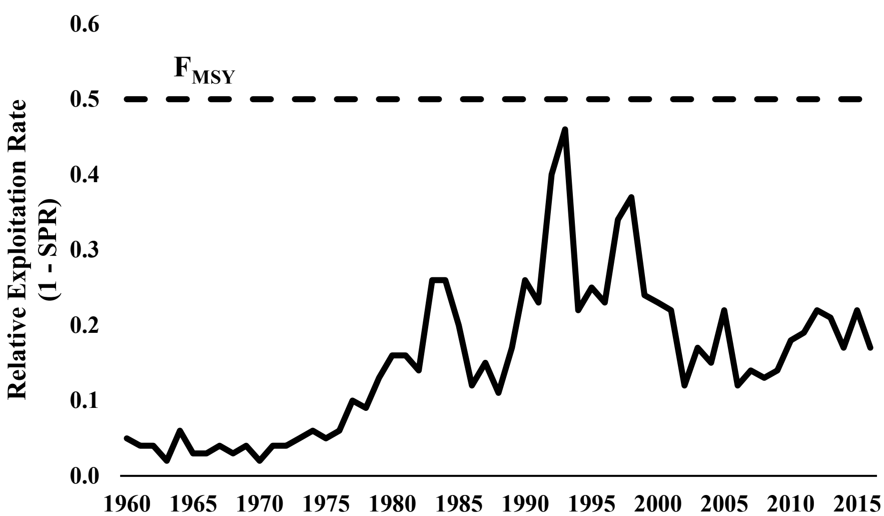

Figure 2-106. Estimated spawning potential ratio (SPR) of blue and deacon rockfish off Oregon relative to the current F_{MSY}, 1960-2016. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis.

2.5.3 Shelf Rockfish North and South of 40°10' N. Lat.

The shelf rockfish complexes north and south of 40°10' N. lat. Are comprised of both assessed and unassessed species. Of the stocks managed in the shelf rockfish complexes, chilipepper rockfish north of 40°10' N. lat. (the assessment for the northern stock only covers the area from 40°10' N. lat. To Cape Blanco, OR at 43° N. lat. – see section 2.9.9 for more details), greenspotted rockfish, greenstriped rockfish, and stripetail rockfish have been assessed. The following section defines these complexes in terms of their component stocks and provides further detail on those component stocks that have been assessed.

The Shelf Rockfish complex north of 40°10' N. lat. Is comprised of the following species: bronzespotted rockfish (*Sebastes gilli*); bocaccio (*Sebastes paucispinis*); chameleon rockfish (*S. phillipsi*); cowcod (*S. levis*); dusky rockfish (*S. ciliatus*); dwarf-red rockfish (*S. rufianus*); flag rockfish (*S. rubrivinctus*); freckled rockfish (*S. lentiginosus*); greenblotched rockfish (*S. rosenblatti*); greenspotted rockfish (*S. chlorostictus*); greenstriped rockfish (*S. elongatus*); halfbanded rockfish (*S. semicinctus*); harlequin rockfish (*S. variegatus*); honeycomb rockfish (*S. umbrosus*); Mexican rockfish (*S. macdonaldi*); pink rockfish (*S. eos*); pinkrose rockfish (*S. simulator*); pygmy rockfish (*S. wilsoni*); redstripe rockfish (*S. proriger*); rosethorn rockfish (*S. helvomaculatus*); rosy rockfish (*S. rosaceus*); silvergray rockfish (*S. brevispinis*); speckled rockfish (*S. ovalis*); squarespot rockfish (*S. hopkinsi*); starry rockfish (*S. constellatus*); stripetail rockfish (*S. saxicola*); sunset rockfish (*S. crocotulus*); swordspine rockfish (*S. ensifer*); tiger rockfish (*S. nigrocinctus*); and vermilion rockfish (*S. miniatus*).

The Shelf Rockfish complex south of 40°10' N. lat. Is composed of the following species: bronzespotted rockfish (*Sebastes gilli*); chameleon rockfish (*S. phillipsi*); dusky rockfish (*S. ciliatus*); dwarf-red rockfish (*S. rufianus*); flag rockfish (*S. rubrivinctus*); freckled rockfish (*S. lentiginosus*); greenblotched rockfish (*S. rosenblatti*); greenspotted rockfish (*S. chlorostictus*); greenstriped rockfish (*S. elongatus*); halfbanded rockfish (*S. semicinctus*); harlequin rockfish (*S. variegatus*); honeycomb rockfish (*S. umbrosus*); Mexican rockfish (*S. macdonaldi*); pink rockfish (*S. eos*); pinkrose rockfish (*S. simulator*); pygmy rockfish (*S. wilsoni*); redstripe rockfish (*S. proriger*); rosethorn rockfish (*S. helvomaculatus*); rosy rockfish (*S. rosaceus*); silvergray rockfish (*S. brevispinis*); speckled rockfish (*S. ovalis*); squarespot rockfish (*S. hopkinsi*); starry rockfish (*S. constellatus*); stripetail rockfish (*S. saxicola*); sunset rockfish (*S. crocotulus*); swordspine rockfish (*S. ensifer*); tiger rockfish (*S. nigrocinctus*); vermilion rockfish (*S. miniatus*); and yellowtail rockfish (*S. flavidus*).

Greenspotted Rockfish

Distribution and Life History

Greenspotted rockfish (*Sebastes chlorostictus*) are found in waters off the West Coast of North America, ranging from Copalis Head, Washington to Isla Cedros, Baja California (approximately 25° to 47° N. lat.). Abundance of this species is greatest from northern Baja California to Mendocino County in California. Greenspotted rockfish associate with several benthic habitat types between depths of 30-363 m, although adults are most common between 60 and 240 m (Love*, et al.* 2002).

Greenspotted rockfish are a long-lived and slow growing species, with sedentary adults associated with a wide variety of benthic habitats. Maximum reported age is 51 years (Benet*, et al.* 2009).

Estimates of maximum length for greenspotted rockfish are in the vicinity of 50 cm. Benet et al. (2009) report maximum fork length as 48 cm for central California. Miller and Gotshall (1965) report 51 cm total length for the same area, but did not attempt to distinguish between greenspotted rockfish and pink rockfish (*Sebastes eos*), which grow to 56 cm (Love*, et al.* 2002). Commercial port samplers in California have reported individuals larger than 50 cm fork length (up to 57 cm), although fish of this size appear to be rare (CALCOM, 2011). In southern California, Love et al. (1990) report maximum length as 50 cm total length. Sexual dimorphism is not apparent in greenspotted rockfish (Benet*, et al.* 2009; Lenarz and Wyllie Echeverria 1991; Mason 1998), although latitudinal differences in weight-at-length, length-at-age, and size-at-maturity have been observed.

Seasonal maturation and size at maturity vary with lat., a trend commonly seen in rockfishes (Benet*, et al.* 2009; Love*, et al.* 1990). In central and northern California, spawning months have been reported from March to September, with peak parturition from April to June (Benet*, et al.* 2009; Wyllie Echeverria 1987). In southern California spawning months begin in February and extend through July, with peak parturition in April (Love*, et al.* 1990). Benet et al. (2009) estimate length at 50 percent maturity for female greenspotted as 26 cm, consistent with a previous estimate of 27 cm (Wyllie Echeverria 1987) based on females from the same area. In southern California, Love et al. (1990) report length at 50 percent maturity as 22 cm (converted to fork length from total length). Love et al. (1990) detected evidence of multiple broods in females from southern California (ovaries containing eyed larvae and large numbers of fertilized or unfertilized eggs). No evidence of multiple broods was found in studies of greenspotted rockfish north of Point Conception (Benet*, et al.* 2009; Wyllie Echeverria 1987).

Several studies have reported on habitat associations for greenspotted rockfish. Yoklavich et al. (2000) quantified deep, rocky habitat in Monterey Bay. They observed smaller greenspotted rockfish in shallow depths (75-174 m) and reported strong associations with heterogeneous habitats (cobble-mud, mud-boulder, rock-mud, and rock-ridge). Laidig et al. (2009) studied habitat associations of demersal fishes from a manned submersible in central California, observing 809 greenspotted rockfish. They mainly encountered immature individuals (86 percent of greenspotted were <25 cm), identifying positive associations with all habitat types (boulder, brachiopod beds, cobble) other than mud. The predominance of juvenile rockfish in the study area suggests that the areas and depths surveyed may be nursery grounds for juvenile rockfish and/or transitional zones as individuals move toward adult habitats (Laidig*, et al.* 2009). Juvenile greenspotted rockfish are commonly seen in traps targeting spot prawn in Monterey Bay, usually in low-relief habitats (Dick*, et al.* 2011).

Adult greenspotted rockfish are generally sedentary, and associate with a wide range of habitat types. Yoklavich et al. (2000) observed 426 greenspotted rockfish (fourth highest abundance of observed species) in Monterey Bay, noting that adults were common near rocky outcrops, ridges, caves, and overhangs. Anderson et al. (2009) described greenspotted rockfish as characteristic of transition zones between hard and soft sediments, based on in situ observations across Cordell Bank in central California. They classified habitat for greenspotted rockfish over a range of spatial scales. At the finest scale (1-10s of m), greenspotted were found to have weak associations with four of five possible categories: mud, boulders, cobbles, and rock (sand being the fifth category). At intermediate scales (10-100s of m) Anderson et al. (2009) characterized greenspotted habitat as depths between 100-300 m and soft and mixed sediment types.

Movements of greenspotted rockfish have been monitored using acoustic tagging experiments. Starr et al. (2002) implanted acoustic tags in six adults in Monterey Bay, finding that adults exhibit limited horizontal movement and almost no vertical movement. They also identified two movement patterns. In the first pattern, 94 percent of time was spent within a 0.58 km2 area. The second pattern involved larger movements, with excursions up to 3 km, but 60 percent of time was spent within the 1.6 km^2 study area. Lowe et al. (2009) monitored 4 adult greenspotted rockfish near oil platforms in southern California using acoustic tags. Probabilities of detection near the release sites dropped by 14 percent in one year of monitoring. Two individuals returned to their release sites after a 7-month absence.

Williams and Ralston (2002) studied the distribution and co-occurrence of rockfishes over continental shelf and slope habitats using fishery-independent trawl survey data. Greenspotted rockfish were consistently caught (>80 percent co-occurrence) with bocaccio, chilipepper, stripetail (*S. saxicola*), and shortbelly rockfish. Williams and Ralston (2002) proposed species assemblages for management purposes, including greenspotted in a "southern shelf" assemblage along with bocaccio, chilipepper, shortbelly rockfish, stripetail, greenstriped, and cowcod. Since greenspotted rockfish is not a primary target of commercial fisheries, its association with other desirable shelf rockfish species (e.g., bocaccio and chilipepper) is likely a driving force behind historical exploitation of this species.

Molecular systematic studies (Hyde and Vetter 2007) report that greenspotted rockfish are closely related to pink rockfish and greenblotched rockfish (*S. rosenblatti*). Greenspotted rockfish can be distinguished from pink and greenblotched rockfishes by a smooth lower jaw, lacking scales found on the lower mandibles of the other two species (Love*, et al.* 2002).

Stock Status and Management History

The 2011 greenspotted rockfish assessment conducted for the portion of the stock off California was modeled as two area assessments north and south of Point Conception at 34°27' N. lat. The assessment indicates the stock is in the precautionary zone with spawning biomass depletions of 30.6 percent and 37.4 percent for the stocks north and south of Point Conception, respectively. The stocks have shown substantial biomass increases since implementation of the RCAs in 2003. Shelf rockfish are particularly well protected by the RCAs, and greenspotted rockfish catches have been negligible since 2003. The Council recommended continuing to manage greenspotted rockfish within the Shelf Rockfish complexes since catch histories were too uncertain to allocate QS in the IFQ fishery.

The OFL contribution of greenspotted rockfish to the Shelf Rockfish North complex was based on apportioning 22.2 percent of the projected OFLs from the assessment for the stock north of Point Conception, which is the average estimated catch proportion in the assessment for the stock occurring in the area between 40°10' N. lat. And the California-Oregon border at 42° N. lat. The OFL contribution for the portion of the stock occurring north of 42° N. lat. Was derived using DB-SRA. The SSC categorized the assessed portion of the stock as a category 2 stock since recruitments were not estimated. The unassessed portion of the stock was categorized as a category 3 stock.

The Council adopted the default harvest control rule of ACL equal to the ABC With a P* of 0.45 with the 40-10 adjustment to the ACL (since the stock is in the precautionary zone). The OFL and

ABC values for greenspotted rockfish have been based on the 2011 assessment, but year-specific projections were not available for 2025 and 2026 harvest specifications. Thus, the SSC recommended and the Council adopted rolling over 2024 values for the OFL and ABC in both 2025 and 2026 fishery management (see September 2023 Council meeting).

Stock Productivity

Length and age composition data available for the 2011 greenspotted rockfish assessment contained insufficient information to reliably resolve year-class strength. Both base models assumed that recruitment followed a deterministic Beverton-Holt stock-recruitment relationship, so trends in recruitment reflected trends in estimated spawning output.

While the productivity score for greenspotted rockfish is relatively low (P = 1.39), the susceptibility score is sufficiently low to estimate a medium vulnerability to potential overfishing (V = 1.98).

Fishing Mortality

Greenspotted rockfish are not usually a primary target of commercial or recreational fisheries. Regulations affecting this species are typically intended to alter fishing mortality of primary targets and/or overfished/rebuilding species. For example, implementation of RCAs statewide and CCAs in southern California has greatly reduced fishing mortality for greenspotted rockfish in the past decade.

Historical harvest rates for greenspotted rockfish peaked in the mid-1980s in southern California but continued to rise in northern California until about a decade later. SPR harvest rates exceeded the current proxy MSY value in northern California from 1973-2000, and from 1969-1998 in southern California. Biomass in both regions is currently below target (<40 percent unfished spawning output), but above the MSST, and equilibrium SPR harvest rates have been below the proxy MSY level since 2001 in the north and since 1999 in the south.

Greenstriped Rockfish

Distribution and Life History

Greenstriped rockfish (*Sebastes elongatus*) can be found in abundance from British Columbia to Northern Baja California, but range from Chirikof Island in the Aleutian Islands (Gulf of Alaska) to central Baja California (Love*, et al.* 2002). Adults may inhabit depths between 12 and 500 meters, but are more commonly found between 100 and 250 m, and adults typically move to deeper water as they mature (Love*, et al.* 2002; Shaw and Gunderson 2006). This species of rockfish is found with other congeners or alone in a wide range of habitats, which include rocky outcroppings. However, unlike most other species of rockfish they seem to prefer mud or sand bottoms (Love*, et al.* 2002; Shaw and Gunderson 2006).

A genetic study of greenstriped rockfish was recently undertaken by Jon Hess (pers. Comm., NWFSC, NOAA as cited in by Hicks et al. (2009)) to study the stock structure of greenstriped rockfish. The genetic variability was remarkably low and showed less variability than most other rockfish species, even when including samples from Puget Sound. However, latitudinal differences in life-history traits have been observed.

Typical of other species of the genus *Sebastes*, greenstriped rockfish are long-lived with maximum observed ages greater than 50 years (Love*, et al.* 2002). Females grow larger than males, but typically mature at about the same length, between 18 and 24 cm, which corresponds to an age between 7 and 10 years. A latitudinal cline in maturity has been observed with fish maturing at a smaller size in the southern areas (Wyllie Echeverria 1987).

Greenstriped rockfish give birth to live young and the fecundity of a 0.5 kilogram female is on average around 200,000 eggs (Dick 2009), although a wide range of fecundity has been reported (Love*, et al.* 2002). The reproductive development of males and females is slightly offset with mating occurring in December through February, fertilization occurring in early spring, and parturition occurring about a month later in late spring (Shaw and Gunderson 2006). Females have the ability to store sperm during the time between copulation and fertilization to ensure the availability of spermatozoa when oocyte maturation has occurred (Shaw and Gunderson 2006). However, in southern latitudes, parturition may occur from January to July and females in Southern California may release two broods during this time (Love*, et al.* 2002). Juveniles settle to the bottom at about 3 cm in length in autumn and are commonly found along the interface of fine sand and clay. Maturing adults typically move to deeper water (Love*, et al.* 2002).

A wide range of prey items make up the diet of greenstriped rockfish. They will feed from the water column or the bottom on such things as fish, krill, shrimps, copepods, amphipods, and squid. Other fish species may prey on greenstriped rockfish. They have been found in the stomachs of king salmon (Love*, et al.* 2002). Reefs with small numbers of piscivorous rockfish had much higher numbers of small rockfish, such as greenstriped rockfish, than reefs with high numbers of piscivorous rockfish (PFMC 2006).

Stock Status and Management History

Greenstriped rockfish are a bycatch species with little market value mainly due to its small size, and it has been reported that fillets from this species have a short shelf life (Love*, et al.* 2002). As a result, there has not been a long-term directed fishery for this species. However, greenstriped rockfish are often observed in landings from various fisheries, although in small proportions. The most common occurrence of greenstriped rockfish is in trawl fisheries, but they are often caught in recreational fisheries, especially when fishing vessels drift off of the rocks.

After many attempts to start trawl fisheries off the West Coast of the United States in the late 1800s, the availability of the otter trawl and the diesel engine in the mid-1920s helped the trawl fisheries expand (Douglas 1998). The trawl fisheries really became established during World War II when demand increased for shark livers and bottomfish. A mink food fishery also developed during World War II (Jones and Harry 1960). Foreign fleets began fishing for rockfish in the mid-1960s until the EEZ was implemented in 1977 (Rogers 2003b). Since 1977, landings of rockfish were high until management restrictions were implemented in 2000.

Greenstriped rockfish are often caught in bottom trawls, but a long-term directed fishery has not occurred for this species and historical discarding rates are not well known. There have been many reports of greenstriped rockfish occurring in various fisheries, even as early as 1884 (Goode 1884). Fishermen report that greenstriped rockfish are ubiquitous and are rarely if ever caught in great numbers.

A coastwide assessment of greenstriped rockfish was done in 2009, which indicated stock depletion was at 81 percent of its unfished biomass at the start of 2009 (Hicks*, et al.* 2009). The coastwide greenstriped harvest specifications were apportioned beginning in 2011 using the mean of the 2003-2008 swept area biomass estimates north of 40°10' N. lat. (84.5 percent) from the NMFS trawl survey. This stock has continued to be managed within the Shelf Rockfish complexes due to the complications associated with managing this species with IFQs. Species pulled out of a complex managed with IFQs must be converted into an IFQ management unit under the Amendment 20 rules. Greenstriped rockfish is a trawl-dominant bycatch species that is rarely landed due to their diminutive size and low market desirability. An initial allocation of quota share for greenstriped would be less than straightforward given the unreliable catch history. The SSC rated the greenstriped stock as category 2 on the basis of the very uncertain catch history in the 2009 assessment that prevented the estimation of discrete year classes.

The SSC downgraded greenstriped rockfish to a category 3 species in 2021 given the age of the assessment. They recommended the OFL for 2023 and beyond be set at the estimated MSY under the F_{MSY} proxy (SPR of 50 percent) of 738 mt. The status quo apportionment of the coastwide OFL of 84.5 percent to the north of 40°10' N. lat. was maintained.

Stock Productivity

Recruitment deviations were estimated in the 2009 assessment starting in 1970. The estimates showed that recruitment was highly variable for greenstriped rockfish with high values in 1971, 1984, 1993, and 1998, and low estimates of recruitment in the 1990s, early 1970s, and 2006. The age data from the NWFSC trawl survey were very consistent with these estimates and precisely showed a very strong 1993 cohort.

While the greenstriped productivity score is relatively low (P = 1.28), the susceptibility to high exploitation was also low leading to a medium vulnerability to potential overfishing (V = 1.88).

Fishing Mortality

The spawning output of greenstriped rockfish reached a low in the late 1990s before beginning to increase throughout the last decade. The estimated depletion has remained above the 40 percent of unfished spawning output target and it is unlikely that the stock has ever fallen below this threshold. Throughout the 1970s, 1980s, and 1990s the exploitation rate and SPR have generally increased and occasionally exceeded current estimates of the harvest rate limit (SPR = 50 percent). Recent exploitation rates on greenstriped rockfish have been very small, which is primarily due to management actions in the late 1990s and early 2000s to rebuild other species.

Squarespot Rockfish

Distribution and Life History

Squarespot rockfish (*Sebastes hopkinsi*) is a dwarf species of rockfish commonly found in depths between 60 – 123 m (33-68 fm), hovering over or sheltering in rocky reef habitat and aggregating with other smaller rockfishes (Love*, et al.* 2002). Squarespot rockfish are yellow-brown, brown, or tan on the back and sides with lighter colored bellies. Squarespot rockfish has sex-specific growth with females reaching larger sizes (29 cm) than males (23 cm).

Stock Status and Management History

Squarespot rockfish are managed in the northern and southern Shelf Rockfish complexes, although they are rare north of 40°10' N. lat. With 0.3 percent of average annual landings occurring in northern California. Squarespot rockfish are generally undesirable in the recreational and commercial fishery due to their small size. Females grow larger than males, and only nearing their maximum length do they reach a size that is marginally acceptable to anglers, thus the landings are primarily composed of older females.

A length-based data-moderate stock assessment was conducted for squarespot rockfish in California in 2021, which indicated the stock was at 37 percent of unfished biomass at the start of 2021 {Figure 2-103; Cope, 2021 #1300}. There are no prior assessments for this species, and since 2010, the DCAC method has been used to set annual catch limits, based on assuming a relative depletion of 40 percent. This species is treated as one stock in the assessment as there is no evidence of population structure. Due to its small size, squarespot rockfish are not targeted by the recreational or commercial fisheries. Catches mostly consist of large females. Thus, the fishery mainly affects spawning biomass. The assessment model did not fit the NWFSC Hook and Line Survey index and associated length compositions.

The SSC designated the squarespot rockfish assessment as category 2, the default for data-moderate assessments. The SSC recommended the next squarespot rockfish assessment be a data-moderate assessment.

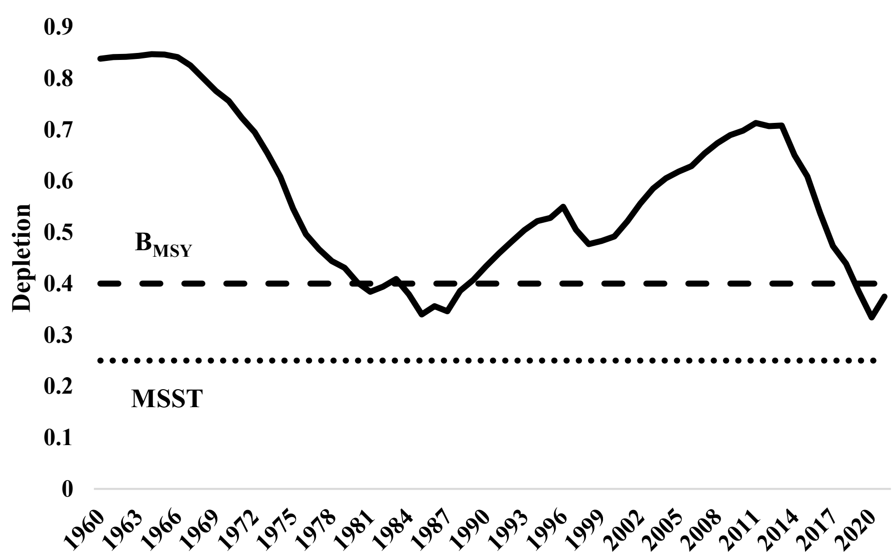

Figure 2-107. Estimated depletion of squarespot rockfish in California relative to the management target, 1960-2021.

Stock Productivity

Stock-recruitment steepness for squarespot rockfish was fixed at the prior of 0.72 in the 2021 assessment and treated as deterministic. Therefore, recruitment deviations were not estimated.

Fishing Mortality

The relative exploitation rate of squarespot rockfish was above the F_{MSY} proxy harvest rate between the 1970s and early 1980s, below the target for much of the time from the mid-1980s to early 2010s, and most of the recent several years have exceeded the target (Figure 2-104).

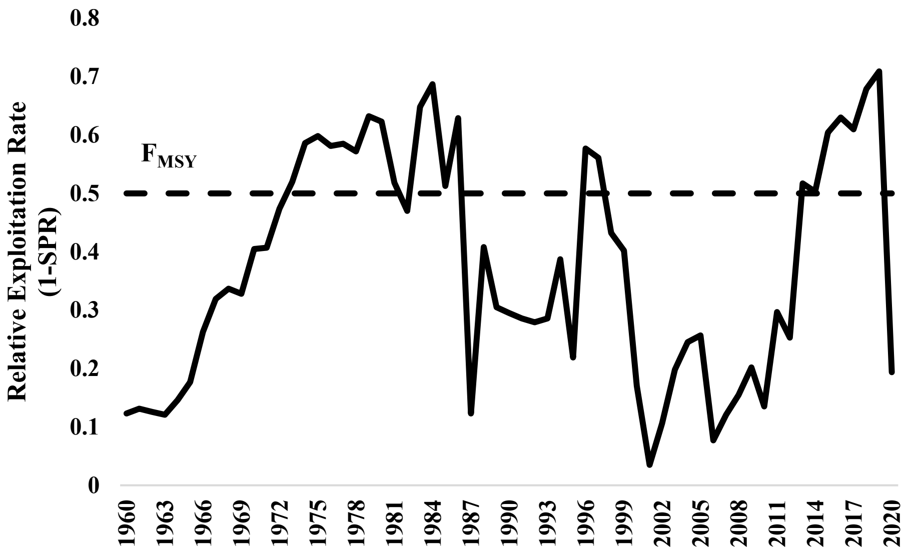

Figure 2-108. Estimated annual relative exploitation rate of squarespot rockfish in California relative to the current proxy F_{MSY} target, 1960-2020.

Stripetail Rockfish

Distribution and Life History

Stripetail rockfish (*Sebastes saxicola*) are found from Yakutat Bay in the eastern Gulf of Alaska to Bahia Sebastian Vizcaino in central Baja California, but are more common from coastal British Columbia to southern California (Love*, et al.* 2002). They occur in depths ranging from 25 to 547 m but are most abundant between 100 and 200 m. Adult stripetail are benthically oriented and are most often associated with mud, sand, and other low relief habitats. Stripetails are found in the same habitats as splitnose rockfish, greenstriped rockfish, Dover sole, and thornyheads.

Stripetail rockfish live at least 38 years and females grow faster (after reaching maturity) and achieve a larger size than males. Stripetail rockfish are relatively small-sized rockfish with a maximum size of 41 cm and 1 kg (Love*, et al.* 2002). Female stripetails along the California coast are mature by 18 cm or about 9 years of age. Off California, larval release occurs from November to March with peak release occurring off central and northern California in February and in December in the Southern California Bight (Love*, et al.* 2002). Females produce between 15,000 and 230,000 eggs.

Stripetails are primarily water column planktivores feeding mainly on krill and copepods. They are preyed on by a number of predators including Chinook salmon.

Stock Status and Management History

Stripetail rockfish are managed in the northern and southern Shelf Rockfish complexes. They are a relatively minor component stock to these complexes since stripetail are not targeted nor landed in large amounts.

A new data-moderate assessment of stripetail rockfish was conducted in 2013, which indicated the stock was healthy with a depletion exceeding 77.5 percent (Cope*, et al.* 2014). The 2013 assessment did not produce a reliable estimate of the scale of the stock's biomass; therefore, the SSC did not recommend using the OFL estimates in the assessment. However, the SSC did recommend the available data in the assessment provided strong evidence that the stock was well above the target B_{MSY} and that the assessment results could be used for status determination. Given that the assessment-based OFLs were not endorsed by the SSC, the OFL continues to be based on a DB-SRA methodology and the stock is therefore categorized as a category 3 stock.

The Council adopted the default harvest control rule of ACL equal to the ABC with a P* of 0.45 for 2019 and 2020 harvest specifications. The 2019 and 2020 ACL contribution of stripetail rockfish to the Shelf Rockfish complex north of 40°10' N. lat. Is 33.7 mt. The 2019 and 2020 ACL contribution of stripetail rockfish to the Shelf Rockfish complex south of 40°10' N. lat. Is 19.7 mt.

Stock Productivity

Two recruitment events reported in trawl studies off California from 1973-1993 occurred during El Niños (Love*, et al.* 2002). It is not clear from the literature whether this is a representative recruitment pattern for the stock.

The PSA productivity score of 1.39 for stripetail rockfish indicates a relatively low productivity among rockfish species. There is a moderate vulnerability of potential overfishing (V = 1.8) for the stock.

Fishing Mortality

Stripetail rockfish are not targeted in commercial or recreational fisheries due to their small size. However, they are caught incidentally in bottom trawl fisheries due to their occurrence in low relief, trawlable habitats. They are rarely landed in current trawl fisheries although they were frequently landed and sold for animal food in the 1950s and 1960s. The stock has never experienced overfishing with the exploitation rate remaining well below the proxy SPR = 50 percent F_{MSY} harvest rate for rockfish.

Vermilion and Sunset Rockfishes

Distribution and Life History

Vermilion rockfish (*Sebastes miniatus*) range from Prince William Sound, Alaska, to central Baja California at depths of 6 m to 436 m (Love*, et al.* 2002). However, they are most commonly found from central Oregon to Punta Baja, Mexico at depths of 50 m to 150 m (Hyde and Vetter 2009). Hyde and Vetter (2009) describe vermilion rockfish as residents of shallower depths (<100 m) than their sibling species, sunset rockfish (*Sebastes crocotulus*). Adult fish tend to cluster on high relief rocky outcrops and kelp forests. North of Point Conception, California, some adults reside in shallower water, living in caves and cracks (Love*, et al.* 2002). Vermilion rockfish have shown high site fidelity (Hannah and Rankin 2011 (only tagged one vermilion rockfish), (Lea*, et al.*

1999), and low to average larval dispersal distance (Hyde and Vetter 2009). Lowe et al. (2009) suggested that vermilion rockfish have a lower site fidelity than previously believed but acknowledged that their observations of movements to different depths may have been due to differences in depth distribution between the species. Vermilion rockfish have been aged to over 80 years, but few fish have been aged above 60 years, with females growing larger than their male counterparts. Fifty percent of females are mature at 5 years and about 37 cm, with males likely maturing at shorter lengths than females (Love*, et al.* 2002).

Vermilion rockfish are viviparous, and females produce an estimated 63,000 to 2,600,000 eggs

per brood, with larger fish releasing a substantially larger number of larvae. In southern California, vermilion rockfish larvae are released between July and March. In central and northern California, this release occurs in September, December, and April-June (Love*, et al.* 2002). Hyde and Vetter (Hyde and Vetter) suggest that low larval dispersal may be due to weak poleward flow of nearshore waters corresponding with peak vermilion rockfish larval release.

Young-of-the-year vermilion rockfish settle out of the water column during two primary recruitment periods per year, first from February to April and a second from August to October, and settlement has been observed in May off southern California (Love*, et al.* 2002). Young-of-the-year vermilion and sunset rockfish are both mottled brown with areas of black, and older juveniles turn a mottled orange or red color (Love*, et al.* 2002). Larvae measure about 4.3 mm and juvenile fish are found in depths of 6-36 m, living near sand and structure. After two months, juveniles travel deeper and live on low relief rocky outcrops and other structures (Love*, et al.* 2002). Adult vermilion rockfish predominantly eat smaller fish, though sometimes they pursue euphausiids and other various macroplankton (Phillips 1964). Love et al. (2002) noted their diet includes octopuses, salps, shrimps, and pelagic red crabs.

Stock Status and Management History

Vermilion rockfish are managed in the northern and southern Shelf Rockfish complexes. Prior to the identification of sunset rockfish as a separate species (Hyde*, et al.* 2008), historical studies of "vermilion" rockfish, particularly those conducted south of Point Conception, California, could have included a mixture of both species. Also, many current studies and data sets (e.g., landing statistics) do not distinguish between the species.

Two assessments of vermilion rockfish in California north and south of Pt. conception were conducted in 2005 but were not endorsed by the SSC to inform management. Vermilion assessments were again conducted in 2013 but were not reviewed at the designated STAR panel due to lack of time.

Stock assessments for vermilion and sunset rockfishes were conducted in 2021 for California south of Pt. Conception, California north of Pt. Conception, Oregon, and Washington. This spatial structure reflects the distribution of this cryptic species complex, with vermilion rockfish found throughout the region, most sunset rockfish found south of Point Conception, with a small but uncertain proportion of sunset rockfish north of Point Conception. The models for all regions estimated stocks as being above management targets in 2021, with depletions of 48.2 percent in southern California (Figure 2-105), 42.7 percent in northern California (Figure 2-106), 73 percent in Oregon (Figure 2-107), and 56 percent of unfished biomass in Washington (Figure 2-108).

However, formal status determinations were not made pending an FMP amendment to define stocks in the FMP.

Model complexity decreased from south to north as fewer data sources were available and sample sizes declined with distance from the center of the species' primary distribution in central/southern California. This is also consistent with the diminishing relative abundance of sunset rockfish from central California. All area models had data on catch, length, age, and conditional age-at length, estimate growth and recruitment deviations, and use Francis weighting. Natural mortality is estimated separately for males and females using the Hamel prior with a median of 0.1, though fixed to be the same for both genders in the southern California model. Steepness was fixed at 0.72 in all model areas except for southern California, where it is estimated at 0.73.

The SSC designated the assessments in southern California and Washington as category 2 and category 1 in northern California and Oregon. The category 2 designation in southern California reflects the mixed stock complex in that region. The category 2 designation in Washington reflects the data limitations and wider confidence bounds on the stock status estimates in that region. The category 1 designations in northern California and Oregon are because those regions are predominantly comprised of vermilion rockfish. The SSC recommended full assessments for all regions next time these species are assessed.

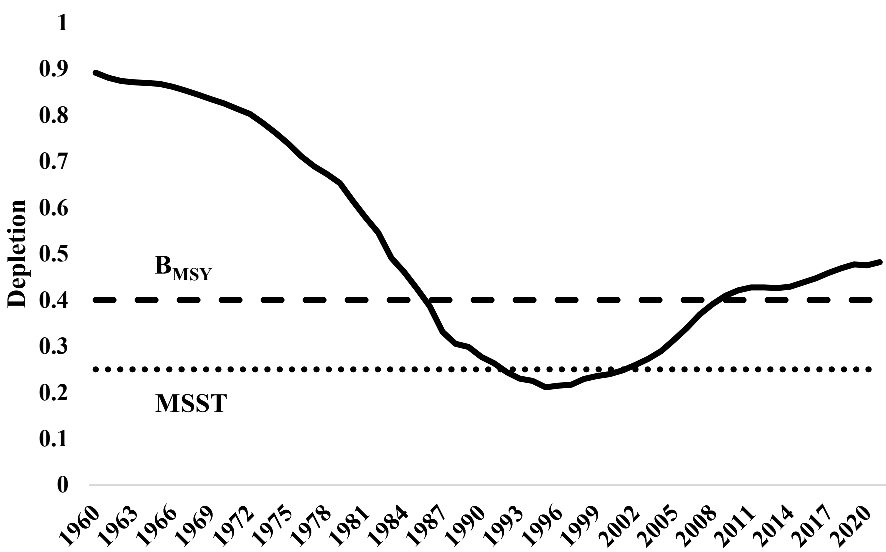

Figure 2-109. Estimated depletion of vermilion and sunset rockfishes in California south of 34°27' N lat. Relative to the management target, 1960-2021.

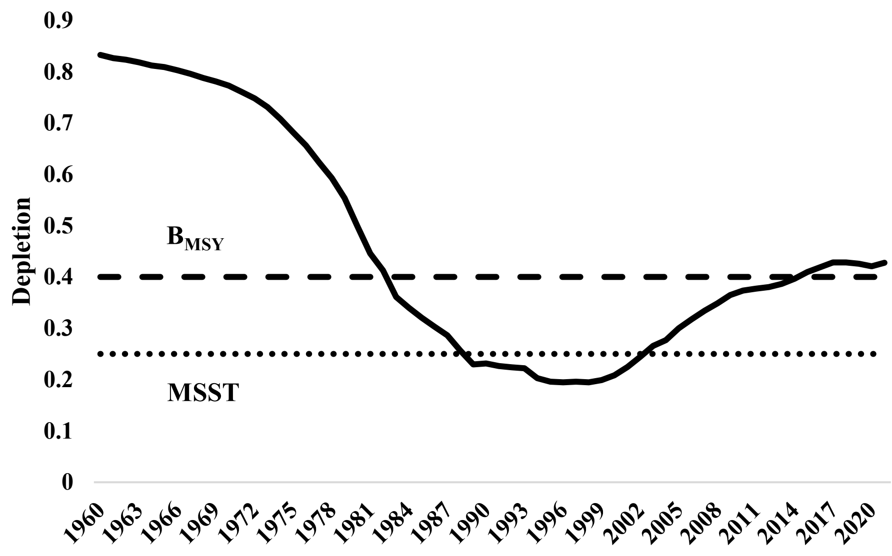

Figure 2-110. Estimated depletion of vermilion and sunset rockfishes in California north of 34°27’ N lat. Relative to the management target, 1960-2021.

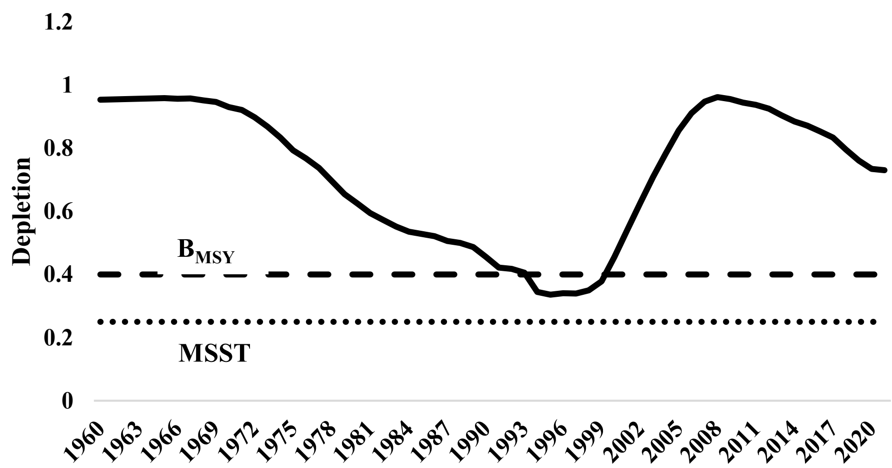

Figure 2-111. Estimated depletion of vermilion rockfish in Oregon relative to the management target, 1960-2021.

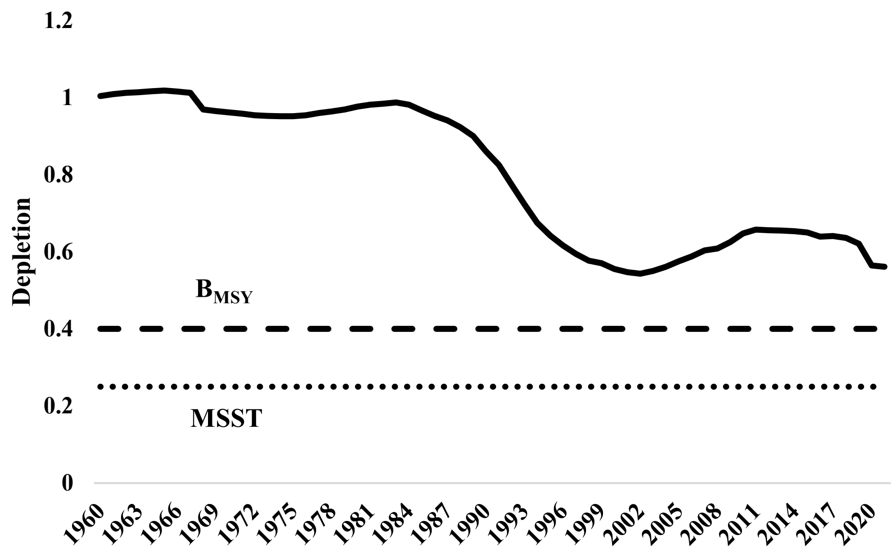

Figure 2-112. Estimated depletion of vermilion rockfish in Washington relative to the management target, 1960-2021.

Stock Productivity

A Beverton-Holt steepness of 0.72 (the meta-analytical prior) was assumed in the vermilion assessments in northern California, Oregon, and Washington. A steepness of 0.73 was estimated using the prior in the southern California assessment.

The PSA productivity score of 1.22 for vermilion rockfish indicates a relatively low productivity among rockfish species. There is a moderate vulnerability of potential overfishing (V = 2.05) for the stock.

Major recruitments in southern California were consistently estimated by both primary sources of age data (NWFSC hook and line and trawl surveys), with a strong 1999 year class estimated even when either data set was removed (Figure 2-109). Other years with relatively high estimates of recruitment were 1983-84, 1999, and 2016. These are consistent with estimates of strong year classes in other rockfish stock assessments. Recent recruitments (2011-2020) have been above average in most years that are well-informed by data, although extended periods of below-average recruitment (e.g., 2001-2006) have also occurred and future trends in recruitment are highly uncertain.

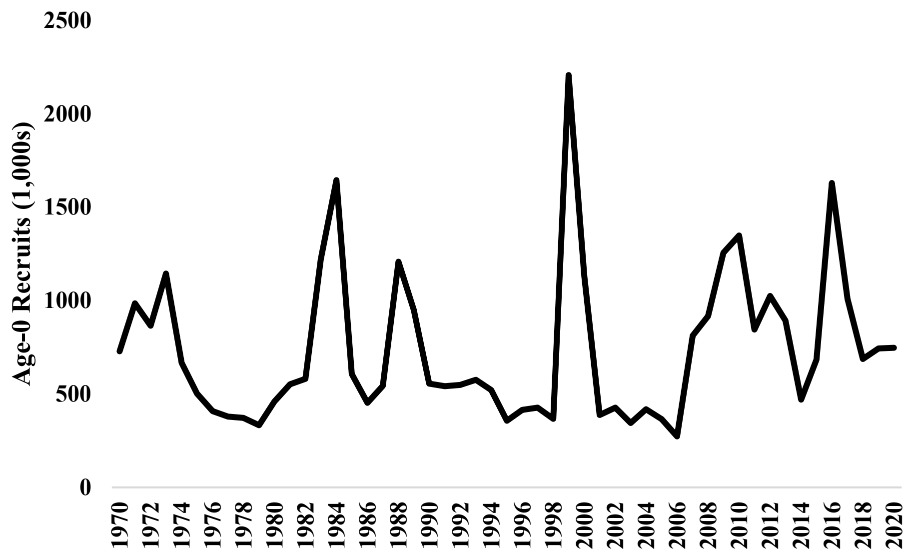

Figure 2-113. Estimated recruitment of vermilion and sunset rockfishes in California south of 34°27' N lat., 1970-2020.

Recruitment deviations were estimated from 1970-2020 with a recent, strong recruitment in 2016 that has contributed to the recent increase in vermilion rockfish biomass in northern California (Figure 2-110). The second highest estimated recruitment occurred in 1985 and is more certain than the estimated 2016 recruitment.

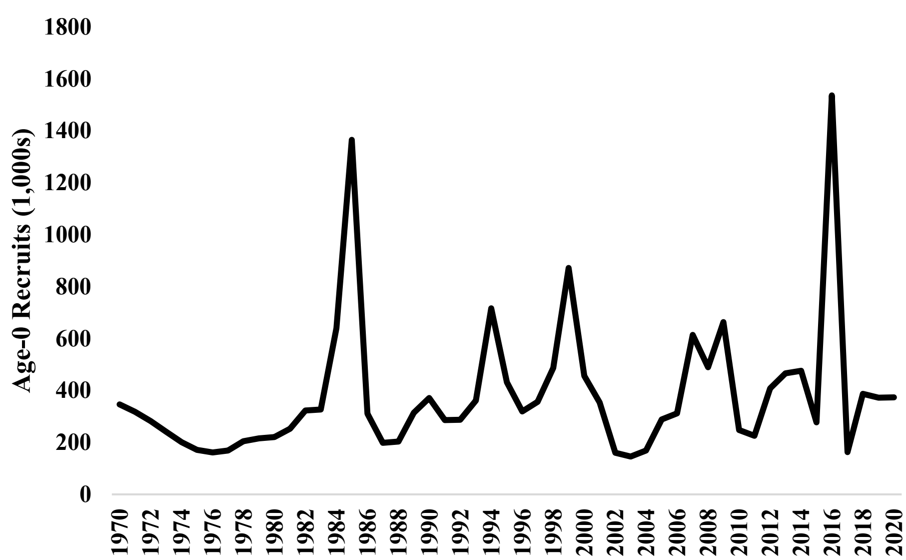

Figure 2-114. Estimated recruitment of vermilion and sunset rockfishes in California north of 34°27' N lat., 1970-2020.

Data informing recruitment of vermilion rockfish in Oregon were most informative from the 1990s to the mid-2010s. Peak years of recruitments are found in years 1993, 1994, 1998, 2005, and 2015 (Figure 2-111).

Figure 2-115. Estimated recruitment of vermilion rockfish in Oregon, 1970-2020.

Recruitment information is weak for the Washington vermilion assessment; informative recruitments start to appear in the 1980s and peak in early 2000s. Data were most informative from the 1990s to the mid-2010s. Peak years of recruitments are found in years 1995-1996, 1999-2000, 2006, and 2011 (Figure 2-112).

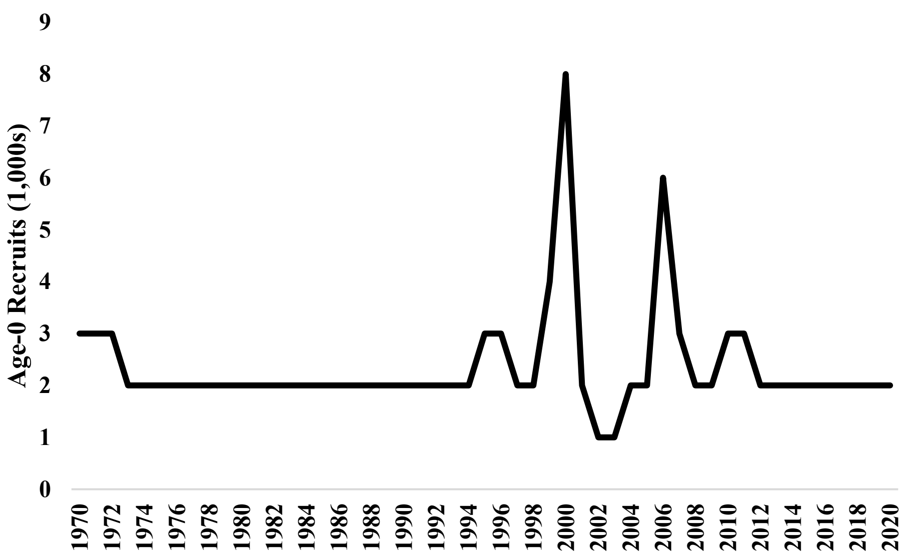

Figure 2-116. Estimated recruitment of vermilion rockfish in Washington, 1970-2020.

Fishing Mortality

The annual (equilibrium) SPR harvest rate for vermilion rockfish in southern California has fluctuated around the management target for the past decade, with a recent spike in 2019 (Figure 2-113). Prior to 2011, fishing intensity exceeded the target for a number of years in the 1980s and 1990s, regularly reaching levels 50 percent above target. As with current estimates of spawning output, recent estimates of equilibrium SPR are highly uncertain, ranging from 45 percent to 104 percent of target in 2020, and 102 percent to 172 percent of target in 2019. As a percentage of biomass (ages 4+), southern California harvest rates peaked in the 1980s and 1990s but have since declined to near-target levels for the past decade.

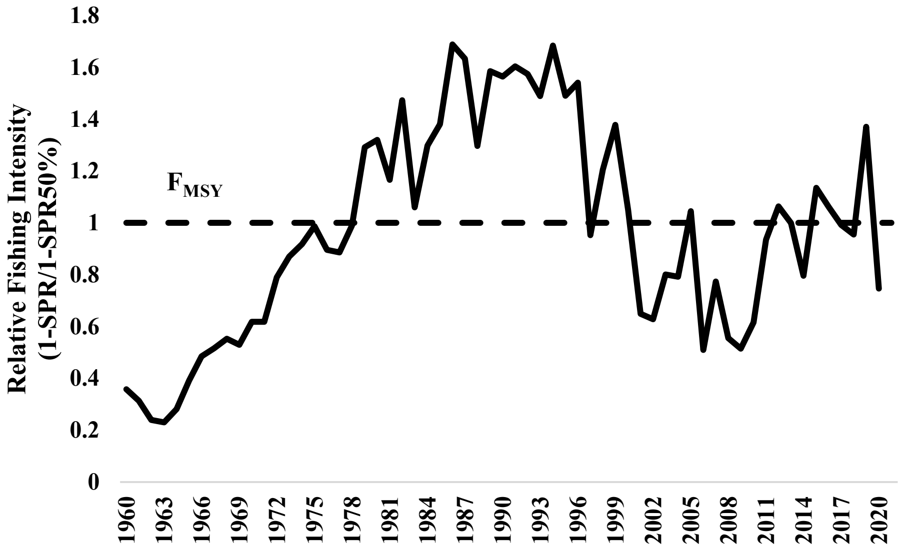

Figure 2-117. Estimated annual relative fishing intensity of vermilion and sunset rockfishes in California south of 34°27' N lat. Relative to the current proxy F_{MSY} target, 1960-2020.

The annual (equilibrium) SPR for vermilion rockfish was above target from 2017-2019 (Figure 2-114). Prior to 2011, the fishing intensity exceeded the target for a number of years, regularly reaching levels 50 percent above target in the 1980s and 1990s. As with current estimates of spawning output, recent estimates of equilibrium SPR are highly uncertain, ranging from 68 percent to 129 percent of target in 2020. As a percentage of total biomass (ages 4+), California harvest rates peaked in the 1980s and 1990s, but have since declined to levels below 10 percent for the past decade. Harvest rates in northern California were near target in 2020, but above target in the three previous years.

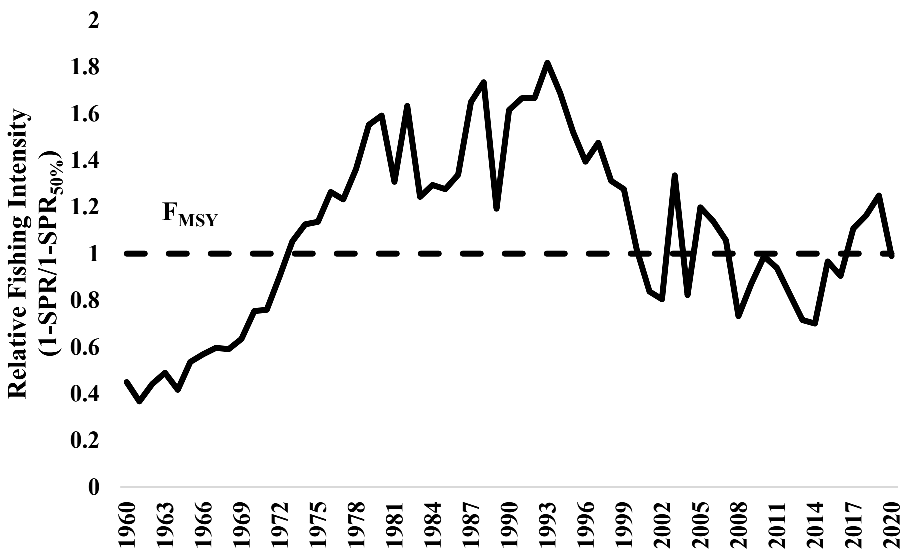

Figure 2-118. Estimated annual relative fishing intensity of vermilion and sunset rockfishes in California north of 34°27’ N lat. Relative to the current proxy F_{MSY} target, 1960-2020.

Trends in fishing intensity largely mirrored that of landings until the 1990s when recruitment pulses overcame the catches to lower overall fishing intensity. The maximum fishing intensity was 0.84 in 1993, above the target SPR-based harvest rate of 0.50 (Figure 2-115). Current levels of 0.47 for 2020 are near the fishing limit. Fishing intensity over the past decade has ranged between 0.27 and 0.51 and the exploitation rate has been high.

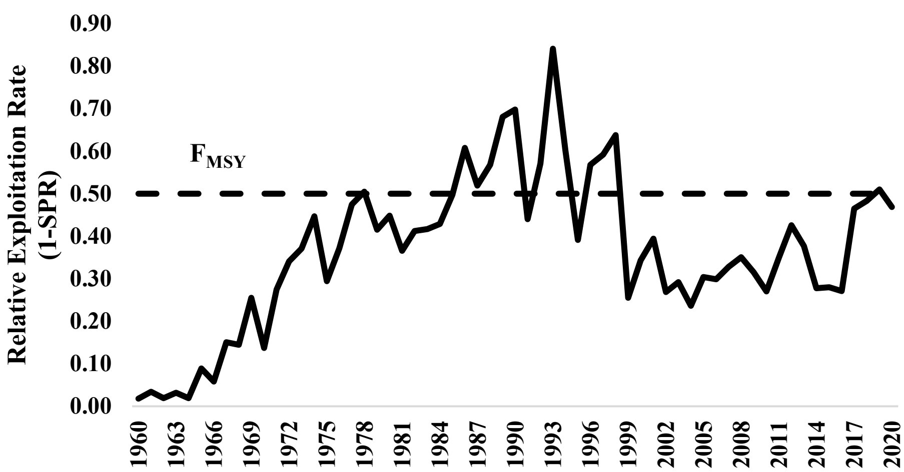

Figure 2-119. Estimated annual relative exploitation rate of vermilion rockfish in Oregon relative to the current proxy F_{MSY} target, 1960-2020.

Trends in fishing intensity largely mirrored that of landings. The maximum fishing intensity was 0.75 in 2019, above the target SPR-based harvest rate of 0.50 (Figure 2-116). Current levels of 0.4 for 2020 are below the retrospectively estimated fishing limit, but 2019 was the highest on record. Fishing intensity over the past decade has ranged between 0.4 and 0.75 and the exploitation rate has been moderate.

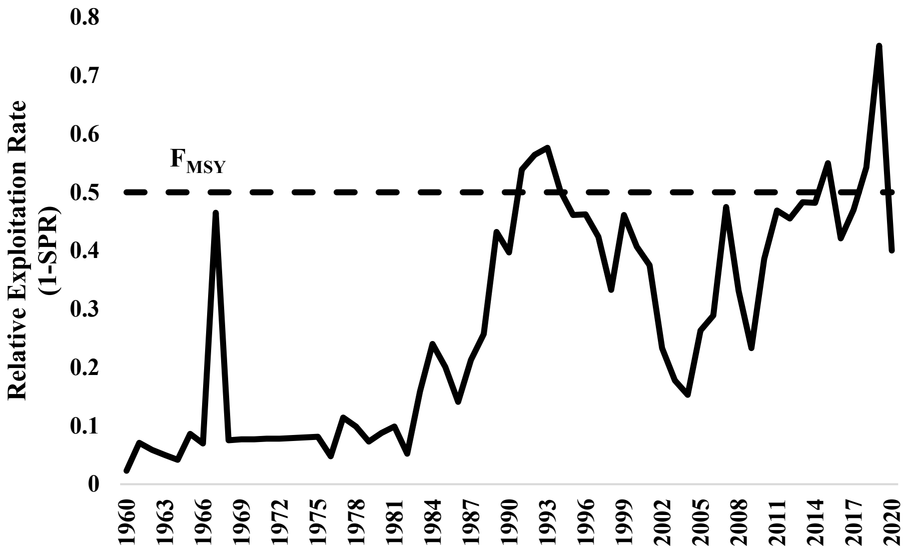

Figure 2-120. Estimated annual relative exploitation rate of vermilion rockfish in Washington relative to the current proxy F_{MSY} target, 1960-2020.

2.5.4 Slope Rockfish North and South of 40°10' N. Lat.

The slope rockfish complexes north and south of 40°10' N. lat. Are comprised of both assessed and unassessed species. Of the stocks managed in the slope rockfish complexes, aurora rockfish, blackgill rockfish south of 40°10' N. lat., rougheye rockfish (and blackspotted rockfish), and sharpchin rockfish have been assessed. There is an older assessment of bank rockfish that was done in 2000 (Piner*, et al.* 2000) that was limited in area and is not used in current management. The following section defines these complexes in terms of their component stocks and provides further detail on those component stocks that have been assessed.

The Slope Rockfish complex north of 40°10' N. lat. Is comprised of the following species: aurora rockfish (*Sebastes aurora*); bank rockfish (*S. rufus*); blackgill rockfish (*S. melanostomus*); blackspotted rockfish (*S. melanostictus*); redbanded rockfish (*S. babcocki*); rougheye rockfish (*S. aleutianus*); sharpchin rockfish (*S. zacentrus*); shortraker rockfish (*S. borealis*); splitnose rockfish (*S. diploproa*); and yellowmouth rockfish (*S. reedi*).

The Slope Rockfish complex south of 40°10' N. lat. Is composed of the following species: aurora rockfish (*Sebastes aurora*), bank rockfish (*S. rufus*), blackgill rockfish (*S. melanostomus*), Pacific ocean perch (*S. alutus*), redbanded rockfish (*S. babcocki*), rougheye rockfish (*S. aleutianus*), sharpchin rockfish (*S. zacentrus*), shortraker rockfish (*S. borealis*), and yellowmouth rockfish (*S. reedi*).

Aurora Rockfish

Distribution and Life History

Aurora rockfish (*Sebastes aurora*) are encountered between the Queen Charlotte Islands (British Columbia, Canada) south to mid-Baja California (Mexico). Off of the United States, they are common from northern Oregon to southern California, and are most abundant in the area around Point Conception, California. They occur at depths from 200 to 700 m (~100 to 400 fm) with the median depth increasing to the south, such that they are most abundant from 350 to 550 m in the north and 400 to 600 m in the south.

While there are areas of greater abundance off of northern Oregon and especially off of Point Conception, California, the population appears continuous over the entire coast, so that there is no clear point for stock delineation. Survey catches exhibit a continuous distribution along the entire coast, though with areas of higher and lower abundances along the coast.

Aurora rockfish is a long-lived rockfish species, with maximum observed age of 125 years on the U.S. West Coast based upon otoliths aged in the 2013 assessment (Hamel*, et al.* 2013). This is slightly greater than the maximum of 118 years seen by Thompson and Hannah (2010) and consistent with a maximum age greater than 75 as reported by Love et al. (2002). As with many rockfish species, aurora rockfish exhibit both spatially varying and sexually dimorphic growth, with females reaching a slightly larger size than males. Off of Oregon, females reached an asymptotic length of 36.9 cm, while males reached only 33.6 cm (Thompson and Hannah 2010). Asymptotic size and size at age decreases with lat., and since the bulk of the stock is south of Oregon, the average asymptotic lengths are quite a bit lower than those reported above.

Thompson and Hannah (2010) found the age at 50 percent maturity for female aurora rockfish to be 12.56 years and the length at 50 percent maturity to be 25.54 cm. Maturity data collected coastwide during the 2012 NWFSC trawl survey found similar values, though with more evidence of atresia in older and larger fish than observed in the Thomson and Hannah study.

Aurora rockfish larvae have been collected off of California in months ranging from November to August, with abundance peaking in May and June, corresponding to the observation of females with developed embryos from March to May off of California and in May in Oregon (Love*, et al.* 2002). Thompson and Hannah (2010) also found that parturition peaked in May off of Oregon. Auroras settle on the bottom when they reach a length of about 3.3 cm (Love*, et al.* 2002).

Aurora rockfish display ontogenetic movement, with smaller fish found in shallower waters (below 400-450 m). They are distributed over both hard and soft substrates (Love*, et al.* 2002).

Aurora rockfish co-occurs with many prominent groundfish targets such as Dover sole, sablefish, thornyheads, and hake, though are most reported in the catch of splitnose rockfish. Aurora rockfish contributes to the overall California Current ecosystem as both predator on crustaceans and small fishes, and as prey to larger fishes, marine mammals, and large squid. Juvenile aurora rockfishes are preyed on by salmon, birds, and other fishes (Love 2011).

Several aspects of aurora rockfish population biology are affected by the ecosystem. The recruitment of many species of rockfish appears to be high in 1999, suggesting that environmental conditions influence the spawning success and survival of larvae and juvenile rockfish, including aurora rockfish. The mechanism behind this observation is not well understood, but zooplankton abundance, changes in water temperature and currents, distribution of prey and predators, and amount and timing of upwelling are all possible linkages. Changes in the environment may also directly influence age-at-maturity, fecundity, growth, and survival, which can affect stock status determination and its susceptibility to fishing. Thompson and Hannah (2010) found variations in growth corresponding to individual years based upon dendrochronological techniques and otoliths, and found a correlation between an observed growth anomaly in otoliths and sea level in individual years.

Stock Status and Management History

Aurora rockfish reside in deep waters below 200 m. The primary gear type that has been used to catch aurora rockfish and other deep water rockfish has been trawl gear. The use of trawls off the West Coast of the United States dates to the late 1800s, though there was little fishery expansion until the availability of the otter trawl and the diesel engine in the mid-1920s (Douglas 1998). Trawl fisheries were mainly conducted on the shelf and became more established during World War II when demand increased for groundfish. Mink farms were also a major destination of groundfish removals in the 1940s and 1950s (Jones and Harry 1960). Foreign fleets began fishing for rockfish, including deeper waters of the slope, in the mid-1960s, with declining participation until the 200-mile EEZ was implemented in 1977 (Rogers 2003b). Peaks in the foreign catch have typically been seen in the mid-1960s for rockfishes, but for aurora rockfish, the largest catches were taken in the early 1970s. Foreign fishing was limited in the northern regions by 1970, shifting effort southward and more into aurora rockfish habitat. After 1977, domestic landings of rockfish increased rapidly until about 1990. Subsequent declines in rockfish landings were driven by declining biomass levels and the implementation of new, more restrictive management practices, particularly between 1997 and 2002.

Documented and estimated removals of aurora rockfish do not reach consistently large levels until the 1980s. Aurora rockfish are and have been historically most commonly taken from central California to Oregon, tightly coupled with catches of splitnose rockfish. The term "rosefish" was often used to describe either splitnose or aurora rockfish and has been used as a reporting category in California since 1982. Aurora rockfish remains largely a non-targeted member of the slope rockfish complexes.

Limits on select rockfishes, which included the co-occurring species splitnose, were established in 1982. The first imposed catch limits on a coastwide *Sebastes* complex (aurora being one of the 50 rockfishes in the complex) were instituted in 1983. This complex was divided into two management areas north and south of 43° N. lat. (separating the Eureka and Columbia INPFC areas) in 1994. Ongoing concern that shelf and slope rockfishes may be undergoing overfishing led the attempt by Rogers et al. (1996) to describe the status of most rockfishes contained in the *Sebastes* complex. Aurora rockfish information content was low, so only estimates of exploitation rates were provided, indicating the stock was undergoing very high exploitation rates relative to biomass estimates in both management areas.

The *Sebastes* complex was subsequently divided into nearshore, shelf, and slope complexes effective in the year 2000 and the dividing line between the northern and southern management areas was shifted to 40°10' N. lat. Aurora rockfish has been managed under trip limits for the slope rockfish complexes in both the north and south management areas from 2000-2010.

Beginning in 2011, bottom trawl catches of slope rockfish north and south of 40°10’ N. lat. Have been managed under an IFQ system.

The first assessment of the West Coast stock of aurora rockfish was conducted in 2013 (Hamel*, et al.* 2013); the assessment estimated stock depletion was at 64 percent of its unfished equilibrium at the start of 2013 and had never dropped below its B_{MSY} target (Figure 2-117). The assessment was an age-based full assessment with natural mortality identified as the major axis of uncertainty. The SSC categorized aurora rockfish as a category 1 stock based on the assessment. However, the uncertainty in estimated biomass in the 2013 assessment was greater than for other category 1 assessments resulting in a higher sigma value ($\sigma = 0.39$) for defining the ABC buffer (see section 0 for more details).

Coastwide OFLs of aurora rockfish are apportioned north (19 percent) and south (81 percent) of 40°10’ N. lat. Based on average trawl survey biomass. The Council adopted the default harvest control rule of ACL equal to the ABC with a P* of 0.45 for 2019 and 2020 harvest specifications. The 2019 and 2020 ACL contribution of aurora rockfish to the Slope Rockfish complex north of 40°10’ N. lat. Is 16.7 mt. The 2019 and 2020 ACL contribution of aurora rockfish to the Slope Rockfish complex south of 40°10’ N. lat. Is 71.0 mt.

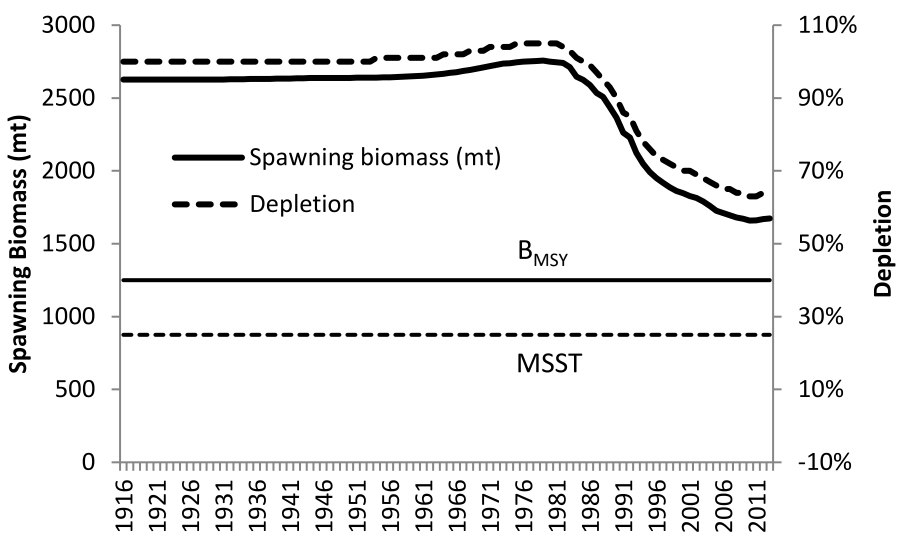

Figure 2-121. Time series of estimated spawning biomass and depletion of aurora rockfish, 1916-2013.

Stock Productivity

Steepness was fixed to the mean of the most recent rockfish steepness prior ($h = 0.779$; Thorson, 2013) in the 2013 assessment. Recruitment deviations were estimated from 1916 (the beginning of the modeling period), with a ramp towards bias correction beginning in 1962, full-bias adjustment beginning in 1970 and ending in 2008, and a ramping back down to no bias correction in 2012. Two of the largest contemporary recruitment events are found in 1999 and 2007 (Figure 2-118). Despite the inclusion of estimated ageing error, discerning individual year classes remains difficult and significant correlation exists between the estimated strength of adjacent year classes, which may be primarily due to ageing error rather than actual correlation in recruitment strength.

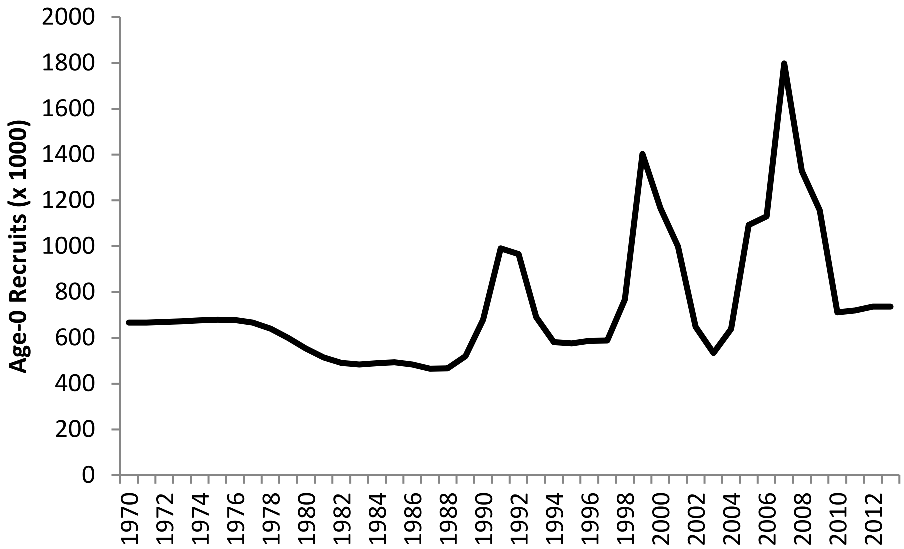

Figure 2-122. Time series of estimated age-0 recruits of aurora rockfish on the U.S. West Coast, 1970-2013.

Fishing Mortality

Hamel et al. (2013) estimated that exploitation of aurora rockfish has been relatively low, with total catch estimated to have exceeded the current management harvest rate limits in 7 years (1983, 1988-1990, and 1992-1994), during the early peak in trawl catches (Figure 2-119). Recent levels of removals have remained moderate. There seems to be very low risk that current removals are causing overfishing.

While stock-specific OFLs/ABCs were not historically set for aurora rockfish specifically, the reauthorized Magnuson-Stevens Act of 2006 and FMP Amendment 23 required OFLs for all species in a management plan, including those managed in stock complexes. The first OFL contributions were calculated using DB-SRA and provided in 2011. The 2015 and beyond OFLs are projected from the 2013 assessment. Recent catches since 2002 have been below the 2015 OFL and ABC.

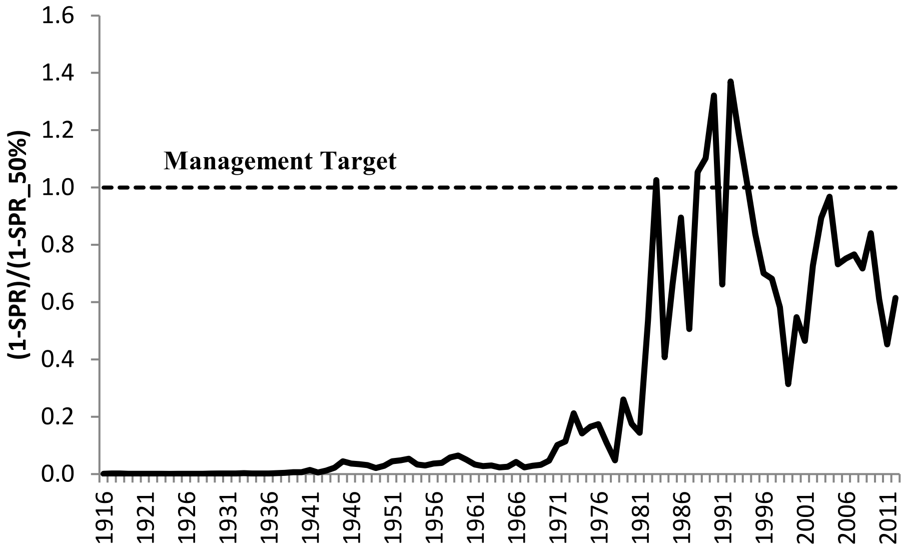

Figure 2-123. Time series of estimated relative spawning potential ratio (1-SPR/1-SPR(Target=0.50)) for aurora rockfish, 1916-2012. Values of relative SPR above 1.0 reflect harvests in excess of the current overfishing proxy.

Blackgill rockfish

Distribution and Life History

Blackgill rockfish (*Sebastes melanostomus*), also known at times as blackmouth rockfish or deepsea rockfish, range from at least central Vancouver Island to central Baja California (Love*, et al.* 2002). However, the species is relatively uncommon north of Cape Mendocino and occurs in the greatest densities in the Southern California Bight (SCB). The name very accurately describes the most identifying characteristic of adult blackgill rockfish, in that they have black pigmentation on the rear edge of their gill cover, as well as in the fold above the upper jaw and inside of the mouth. The rest of the fish appears pink with brown and white blotches underwater, or reddish with distinct brown saddles upon capture. It is a medium-sized (to about 62 cm maximum length) and deep bodied species. Additional descriptions and meristics can be found in Love et al. (2002) for adults and Moser (1996) for larvae and juveniles.

Hyde and Vetter (2007) did not find any evidence for close molecular or evolutionary relationships between blackgill rockfish and other rockfish species. Blackgill rockfish were found to be moderately related with several other slope or deep shelf species (*S. aurora*, *S. phillipsi*, *S. gilli*, *S. diploproa*, and *S. melanosema*) as well to a suite of mostly rare and poorly known species from the Gulf of California (*S. sinensis*, *S. peduncularis*, and *S. cortezi*) or southern California.

Blackgill rockfish are a slope rockfish species and are generally rare in waters less than 100 meters and most abundant in waters between 300 and 500 meters depth. Love et al. (2002) report a depth distribution of 87 to 768 meters; however, from ten years of data from the NWFSC combined trawl survey, only one haul greater than 600 meters encountered blackgill rockfish (that tow was at 647 meters) and the shallowest fish was encountered at 133 meters. Survey data suggest that smaller fish tend to be encountered in shallower water and larger fish in deeper water; survey data also suggest few small fish in waters north of Cape Mendocino. Juveniles are often seen over soft bottom habitats with low relief. Adults are usually associated with high relief rocky outcrops, canyons or deep rock pinnacles, although fishermen often report taking them in midwater (Kronman 1999; Love*, et al.* 2002).

Little is known about the population structure of blackgill rockfish. Like most rockfish, larvae and juveniles circulate in the plankton for 3-4 months. Love et al. (2002) report that some juveniles may be pelagic for up to 7 months; however, this may be atypical. Thus, like most shelf and slope species, blackgill rockfish likely disperse over long distances before settling to the bottom. Abundance south of the U.S./Mexico border is uncertain, but there appear to be substantial numbers and catches of blackgill rockfish in many areas, and pelagic juveniles have been found as far south as Punta Abreojos, in southern Baja California (Moser and Ahlstrom 1978). The CalCOFI Ichthyoplankton survey has been used to develop or explore indices of relative abundance for several rockfish species for which larvae can be morphologically identified to species (Moser*, et al.* 2000), and such indices have been used as relative abundance indices for assessments of bocaccio (Field*, et al.* 2009) and shortbelly rockfish (Field*, et al.* 2008) as well as northern anchovy (Jacobson and Lo 1994), Pacific sardine (Hill*, et al.* 2008), and California sheephead (Alonzo*, et al.* 2008). Unfortunately, blackgill rockfish is not among the species that have been historically sorted to the species level using morphological methods, although recent developments have led to the potential to use genetic methods to identify historical and contemporary *Sebastes* from the ichthyoplankton archives (e.g., (Taylor*, et al.* 2004), J. Hyde, FRD/SWFSC, unpublished data). Thus, it is possible that these collections could provide relative abundance information from past and contemporary monitoring programs.

Moser and Ahlstrom also found that blackgill rockfish represented approximately 16 percent of the total number of rockfish specimens encountered in a series of midwater trawls for late larvae and juvenile stage rockfish done in the early 1970s (prior to most historical exploitation). By contrast, from ongoing pelagic juvenile surveys run by the Fisheries Ecology Division used to develop juvenile (pre-recruit) indices for some species, blackgill rockfish comprised only about 3 percent of juveniles collected from the southern California region from 2004 through 2010 (K. Sakuma and J. Field, unpublished data as cited in Field and Pearson (2011)). However, these results are not likely to be comparable unless seasonal and depth of survey efforts are accounted for; the Moser and Ahlstrom (1978) study in particular fished depths ranging from 0 to 600 meters using an Isaacs-Kidd midwater trawl, while the FED survey uses a considerably larger (modified Cobb) midwater trawl and typically only fishes at 30 meters headrope depth. There is at least some potential to consider relative abundance indices of age-0 juveniles from the FED/SWFSC survey in the future, although given the very slow growth and difficulty in ageing of blackgill rockfish, it is unlikely that validation of survey indices or improved understandings of high frequency variation in year class strength will be of substantial near term benefit to the model.

Nearly two-thirds of all U.S. landings are from waters south of Point Conception, for which blackgill rockfish accounted for as much as 20 to 30 percent of total *Sebastes* landings in the SCB during the 1980s, when deep water fixed gear fisheries rapidly expanded (more details in catch history section). Nearly all of the remaining landings took place between Conception and Cape Mendocino, such that less than 1.3 percent of historical California landings have come from waters north of Cape Mendocino. Landings in Oregon waters are even less, and only trace landings of blackgill rockfish are reported from Washington waters. Trawl survey abundance data (discussed later in the document) are consistent with these results, although they represent the period following the greatest extent of exploitation: surveys that took place from the 1970s through the late 1990s had virtually no coverage in southern waters where blackgill rockfish are the most abundant.

Blackgill rockfish have among the deepest distribution of all of the California Current *Sebastes* (although the three *Sebastolobus* species are common at considerably greater depths) and live at the edge of the low oxygen (hypoxic) conditions that characterize the slope waters of the California Current. Below these depths, species diversity declines to a smaller suite of species that have adapted to cope with low oxygen waters, notably the DTS complex species (Dover sole, thornyheads and sablefish), which have evolved a range of adaptive strategies including metabolic suppression, slow growth rates, late ages at maturity, and ambush (rather than active searching) predation methods (Childress and Seibel 1998; Jacobson and Vetter 1996; Koslow*, et al.* 2000; Vetter and Lynn 1997). These low oxygen waters, known as the oxygen minimum zone (OMZ), are a natural feature of the Eastern Pacific Rim and other regions characterized by high surface productivity and/or the upwelling of oxygen-poor source waters (Helly and Levin 2004). The California Current has a relatively deeper OMZ than the Equatorial Eastern Tropical Pacific or the Humboldt Current (Helly and Levin 2004), with the zone starting at approximately 500 to 600 meters depth in the waters off of southern and central California. The observation that blackgill rockfish are likely the most deeply distributed medium-size *Sebastes* (at least in southern California Current waters) suggests that they have adapted to live on the edge of the OMZ, where oxygen availability is rapidly declining relative to shelf waters, although no *Sebastes* species appears able to tolerate the very low oxygen conditions within the OMZ itself.

Seibel (2011) describes two oxygen thresholds that are temperature dependent (as opposed to species or situation-specific), one in which virtually all species are capable are of physiologically adjusting or adapting to declining oxygen availability, and a second for which no further adjustment or adaptation in aerobic oxygen utilization is possible. Seibel (2011) describes this latter threshold as one at which "organisms that are not specifically adapted to low oxygen will suffer physiological stress and eventual death." Importantly, this threshold falls just below the currently observed oxygen levels throughout the slope waters of much of the California Current, implying that any expansion of the OMZ in this region is likely to have tremendous impacts on the vertical distribution of populations and the species composition of ecosystems. Equally importantly, there is already some evidence of a shoaling (shallowing) of the depth of the OMZ throughout the California Current (Bograd*, et al.* 2008; Whitney*, et al.* 2007), with Bograd et al. (2008) reporting oxygen declines of 20-30 percent at depths of approximately 300 to 500 meters in the waters of the Southern California Bight, the region in which most of the blackgill rockfish biomass resides. A shoaling of the OMZ has been predicted to be a likely or plausible response to global climate change due to the fact that oxygen is less soluble in warmer waters, and warming is also expected to increase stratification in the upper ocean, which will both reduce oxygen supply and increase oxygen demand at depth (Keeling*, et al.* 2010; Sarmiento*, et al.* 1998; Seibel 2011).

For blackgill rockfish, it is the shoaling of the OMZ at depth that is likely to be the greatest long-term threat, as such a shoaling would likely represent a severe compression of the available habitat for this species. McClatchie et al. (2010) evaluated potential scenarios for hypoxia to impact the habitat of cowcod, a rebuilding shelf species that is a focus of management in the SCB. They found that as much as 37 percent of deep (240-350 m) cowcod habitat is currently affected by hypoxia, but that if the current trends of a shoaling OMZ continue for 20 years, this could increase to 55 percent of deep habitat, as well as an additional 18 percent of habitat in the 180 to 240 m depth range. These numbers would presumably differ substantially for blackgill rockfish, which have a very different (considerably deeper) distribution; due to their proximity to the OMZ, they may be at considerably greater risk to the longer-term impacts of shoaling. Moreover, changes in the characteristics and dynamics of the OMZ could lead to changes in the forage base for blackgill rockfish, which are described as foraging primarily on mesopelagic fishes which undergo dial migrations from the edge of the OMZ to surface waters in order to feed.

Blackgill rockfish feed on small mesopelagic fishes, such as myctophids and bathylagids (Love*, et al.* 2002). Isaacs and Schwartzlose (1965), Genin et al. (1988), Koslow (2000) and Genin (2004) describe the mechanisms by which vertical migrants, such as zooplankton and mesopelagic fishes, become trapped by topographic features. High densities of deep water adapted resident species are consequently found in the relatively small, confined areas where these diurnally migrating prey become aggregated. Such observations are consistent with the reports by fishermen of isolated deep banks, pinnacles, or other habitat features often hosting very large numbers of fish over a relatively small spatial range, such that vertical hook and line gear (which can be more precisely targeted at small habitat features) is the gear of choice for targeting these species (as opposed to horizontal, or set, hook and line gear often used to target species in deeper slope waters, such as sablefish and thornyheads, which tend to be more widely dispersed).

With respect to predators and predation mortality, it is likely that sablefish and shortspine thornyhead are among the most important predators of blackgill rockfish. Both species are large (up to 100 and 75 cm, respectively, although individuals greater than 80 or 65 cm of either species are uncommon) and largely piscivorous ambush predators that are typically (along with longspine thornyhead and Dover sole) the most abundant and commercially important groundfish in the continental slope ecosystem (Lauth 2000). Food habits information for adult sablefish found that *Sebastolobus* and *Sebastes* species, particularly *Sebastolobus altivelis*, are key prey items, representing 15 percent to 30 percent of total prey by volume (Buckley*, et al.* 1999; Laidig*, et al.* 1997). Similarly, shortspine thornyhead preyed heavily on *S. altivelis*, unidentified *Sebastes*, and other fishes (Buckley*, et al.* 1999). Although no *S. melanostomus* were conclusively identified in either study, other slope rockfish species (*S. crameri*, *S. diploproa*, and *S. alutus*) were. The lack of specimens is likely due to both studies' focused sampling in northern California, Oregon, and Washington slope waters, rather than the south-central and southern California waters in which *S. melanostomus* are most abundant.

Stock Status and Management History

Blackgill rockfish have historically represented a minor part of California rockfish landings north of Point Conception, but a substantial fraction of landings occur south of Pt. Conception. Based on consultations with fishery participants, Butler et al. (1999a) and Kronman (1999) defined the southern California targeted fishery for blackgill rockfish as being a relatively recent phenomenon. Although longline fishing had long been the primary means of catching rockfish in southern California waters, increased participation and declines in the catches of many highly desired shelf species (such as vermilion rockfish and cowcod) contributed to a gradual shift in effort towards deeper and more offshore waters. Moreover, improvements in technology and gear (such as LORAN, affordable acoustic systems, electric line haulers) helped ease the difficulties of fishing (and relocating good fishing sites) in deeper waters. Additionally, set nets (gillnets) also began to be deployed at a larger scale in southern California in the 1970s and 1980s, often targeting deep reefs for large bocaccio, cowcod, blackgill rockfish, bank, and other rockfish species.

Such developments seem to have been associated with a geographic expansion of the regions fished, such that fishing locations were sequentially depleted and new fishing locations discovered and developed over time. The first stock assessment for blackgill rockfish (Butler*, et al.* 1999a) noted that there was significant evidence for sequential depletion of blackgill rockfish in localized areas. This included reports from fishery participants that many pinnacles or other fishing sites that routinely yielded 20,000 pounds of blackgill rockfish per trip in the early days of the fishery were now only yielding 500 or so pounds per trip and were often covered with lost gear. Similarly, in a review of historical southern California fisheries, Kronman (1999) also documented the rapid growth and development of the blackgill rockfish fishery specifically as one in which fishermen would often "completely decimate" rockfish spots with deep fishing vertical line gear, based on the accounts of the participants themselves. Consequently, there was an ongoing shift to newer fishing spots, generally further offshore and to greater depths, as well as greater experimentation with alternative gears and target species.

These observations suggest the potential for a situation in which the stock may have undergone the "sequential depletion" of biomass from available habitat patches. If so, this would suggest that a traditional (non-spatial) stock assessment assumption of evenly distributed fishing mortality across space is substantially flawed. In fact, if the fishery were sequentially depleting specific areas, the length frequency information would not be likely to suggest a shift to smaller fish over time as the length frequencies could essentially reflect "unfished" population structure for the duration over which the new habitats were discovered and exploited. The consequences of failing to recognize such patterns can lead to overexploitation and collapse, and such processes have been described for several marine invertebrate populations (Karpov et al. 2000, Orensanz et al. 2000) as well as temperate water reef fishes (Epperly and Dodrill 1995, Rudershausen et al. 2008). Ongoing efforts to analyze historical block summary data have the potential to identify such shifts and consider whether such factors are likely to be important for West Coast groundfish species such as blackgill rockfish, as well as to determine whether there is sufficient data to estimate spatial effects or develop spatially-explicit models more capable of accounting for such factors.

Management of blackgill rockfish has generally not been to the species level, but rather as part of the "*Sebastes* complex" in the PFMC era (prior to which management was under the direction of the CDFG). Blackgill rockfish have historically been managed in a complex with eleven other species of rockfishes called "remaining rockfish" and all "other" rockfish. The PFMC historically used trip limits, and later cumulative trip limits (over set time periods), to slow the pace of harvest based on allowable biological catch and to promote a year-round fishery. For all commercial gear types, the limits were initiated in 1983 when the PFMC imposed a monthly limit of 40,000 pounds per trip for the entire coastwide *Sebastes* complex, a limit that stayed in place through 1990. After recognizing the differential spatial distribution of the remaining rockfishes and the fisheries that target them, harvest limits on both open access and limited entry fisheries were divided between the northern and southern *Sebastes* complexes, and trip limits began to be implemented at variable levels over both time (month and year) and space (north and south of Mendocino), often with species-specific limits in addition to the overall limit on *Sebastes* catches. Although early limits applied to both trawl and fixed gears, beginning in 1995 fixed gear limits (hook and line and pot, primarily, as gill nets were phased out through the 1990s) were set to 10,000 lbs of *Sebastes* per trip, which persisted through the 1990s.

Consequently, prior to 1999 cumulative trip limits had been historically high relative to landings of blackgill rockfish from individual trips, and unlikely to have impacted fishing for blackgill rockfish and catches. Limits were dramatically reduced in 1999 for the southern *Sebastes* complex; 2-month cumulative limit of 3,500 pounds for limited entry and 3,600 pounds per month for open access. Since 2000, blackgill rockfish has been managed as part of the Slope Rockfish complexes, with limits ranging from 3,000-50,000 pounds per 2 months; Tables 1-3 show the trip limits implemented since 2000 for this complex for the limited entry trawl, LEFG and open access fixed gear fisheries.

In 2001 the CCAs were established prohibiting fishing in depths greater than 20 fm and the deep offshore banks within the CCAs are optimal habitat for this species. RCAs implemented to protect rebuilding shelf species, such as bocaccio, cowcod, canary rockfish and widow rockfish, do not encompass the depths at which most blackgill rockfish are encountered. Such measures may have had an indirect effect, by virtue of shifting effort to deeper waters, although for much of California the overall effect has been a sharp decline in active participation in the trawl fishery.

The first assessment for blackgill rockfish was conducted in 1998 and estimated stock depletion was between 40 and 54 percent of its unfished equilibrium at the start of 1998 (Butler*, et al.* 1999a). That assessment assumed a unit stock in southern and central California (Conception INPFC area) and was based on a stock reduction analysis assuming constant recruitment. The dynamics of the simple model were tuned to average mortality rates from catch curves and landings data. Fishery selectivity was assumed to mirror maturity at size/age; trends in fishable/mature biomass were then estimated.

A second blackgill rockfish stock assessment was completed in 2005 indicating a stock depletion of 52 percent (Helser 2006). This assessment expanded the geographic range of that in Butler et al. (1999a), including both the Monterey and Conception INPFC areas, where over 90 percent of the landings have occurred. The assessment was based on catch and length composition data from commercial fisheries and indices of relative abundance and size composition from the AFSC shelf trawl survey and the AFSC slope survey. The modeling approach included fishery and survey length compositions to explicitly estimate selectivity. The assumed natural mortality rate was identified as a key axis of uncertainty for this stock.

A third full assessment of blackgill rockfish was conducted in 2011 for the stock south of 40°10' N. lat. (Field and Pearson 2011), which estimated the stock was below target with a depletion of 30 percent of its unfished biomass at the start of 2011 (Figure 2-120). The spawning output of blackgill rockfish was at high levels in the mid-1970s and began to decline steeply in the late 1970s through the 1980s, consistent with the rapid development and growth of the targeted fishery. The biomass reached a low of approximately 18 percent of the unfished level in the mid-1990s. Since that time, catches have declined and spawning output has increased. The estimated depletion level in 2011 is 30.2 percent.

Catch data used in the assessment are generally reliable throughout the time period, although there is a lot of uncertainty in catch data prior to the early 1980s. Ageing is very difficult for this species, which appears to have highly variable size at age, as well as apparent regional differences in growth rates and potentially other life history traits. The lack of a reliable, long-term, fishery-independent survey index that reflects abundance from the entire range of the stock is problematic. In general, natural mortality and growth parameters comprised the greatest contribution to model uncertainty.

An update of the 2011 blackgill rockfish assessment was conducted in 2017, which indicated the spawning stock was at 39.4 percent depletion, just shy of the 40 percent management target, at the start of 2017 (Field and He 2018). Changes to the model since the last assessment include a new fishery selectivity time block to account for changes in trawl fishery retention since implementation of catch-shares in 2011; updated and corrected maturity; updated fecundity relationships; updated indices of abundance; updated steepness value and recent length and age data. The model results were consistent with the 2011 assessment.

The SSC endorsed the use of the blackgill rockfish stock assessment as the best scientific information available for status determination and management as a category 2 assessment since the 2011 assessment and subsequently the 2017 update were essentially production models, i.e., recruitment deviations were not estimated.

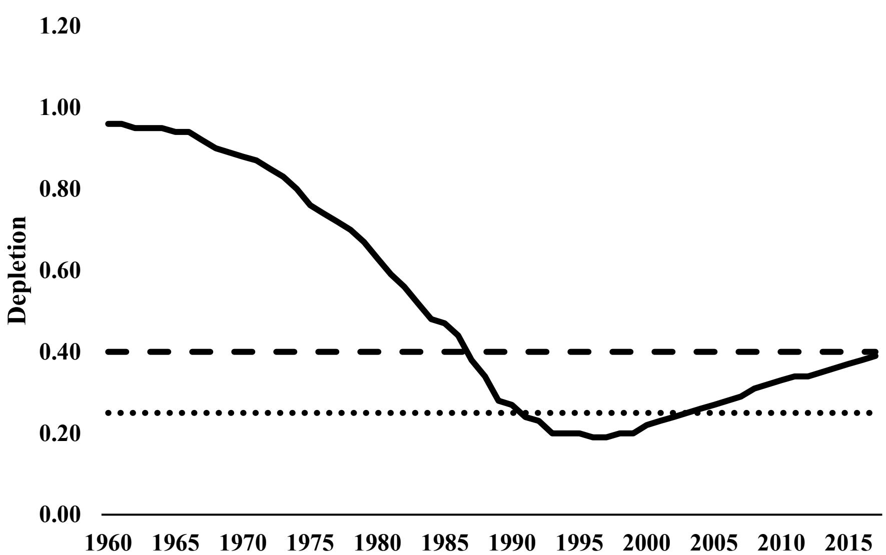

Figure 2-124. Relative depletion of blackgill rockfish from 1960 to 2017 based on the 2017 stock assessment.

The Council had decided to remove blackgill rockfish from the southern Slope Rockfish complex and manage the stock with stock-specific harvest specifications starting in 2018; however, the rulemaking has been delayed and it is uncertain when this management change will be implemented.

The Council adopted default harvest specifications (ACL = ABC with a P* of 0.45) for the blackgill rockfish contribution to the Slope Rockfish complexes north and south of 40°10' N. lat. Without a 40-10 adjustment to the 2019 and beyond ACLs for the southern portion of the stock since the stock is projected to be above the B_{MSY} target of 40 percent depletion beginning in 2018 (projected depletion in 2019 is 40 percent). A catch only-projection of blackgill rockfish south of 40°10’ N. lat. was provided to inform harvest specifications for 2021 and beyond.

Stock Productivity

In the 2011 full assessment and in the subsequent 2017 update assessment, the Beverton-Holt model was used to describe the stock-recruitment relationship. The log of the unexploited recruitment level was treated as an estimated parameter; recruits were taken deterministically from the stock-recruit curve. Recruitment deviations were not estimated, as the lack of obvious cohorts in either age or length data and the high degree of ageing uncertainty make plausible estimates unlikely. The estimated recruitment is projected to be at relatively high levels due to the fixed value of steepness (h = 0.718) based on the mean of the prior distribution of the most recent meta-analysis of rockfish steepness. This trend, however, is consistent with the trends from the survey data.

Blackgill rockfish have a relatively high potential vulnerability to overfishing (V = 2.08) driven by a combination of low productivity (P = 1.22) and relatively high susceptibility to being caught in the fishery (Table 2-2). The low productivity is due to the stock being long-lived (max. age = 87 yrs.; (Love, *et al.* 2002)), with late maturation, and relatively low natural mortality.

Fishing Mortality

Catches of blackgill rockfish primarily occur in the Southern California Bight south of Pt. Conception at 34°27’ N. lat. Where the species is caught in both directed fixed gear (hook and line) and historically, gillnet fisheries. Landings of this species are estimated to have risen slowly from very low levels (approximately 20-30 mt) in the 1950s, and then climbed rapidly in the 1970s and 1980s as improvements in technology and declines in other target species led fishermen to target blackgill rockfish in deeper and more offshore waters. Landings peaked in the mid-1980s at just over 1,000 mt and have declined to approximately 100 mt to 150 mt in recent years.

The 2017 blackgill rockfish assessment base model estimates that the SPR was below the current target (of 50 percent of the unfished level) from the mid-1970s through most of the 1990s (Figure 2-121), and irregularly in the 2000s. SPR rates have been near or above target levels for most years since the very late 1990s, corresponding to an apparent increase in stock abundance (Figure 2-120). Over the past four years, SPR rates have ranged between 0.70 and 0.82, corresponding to exploitation rates roughly half of the OFL (0.50).

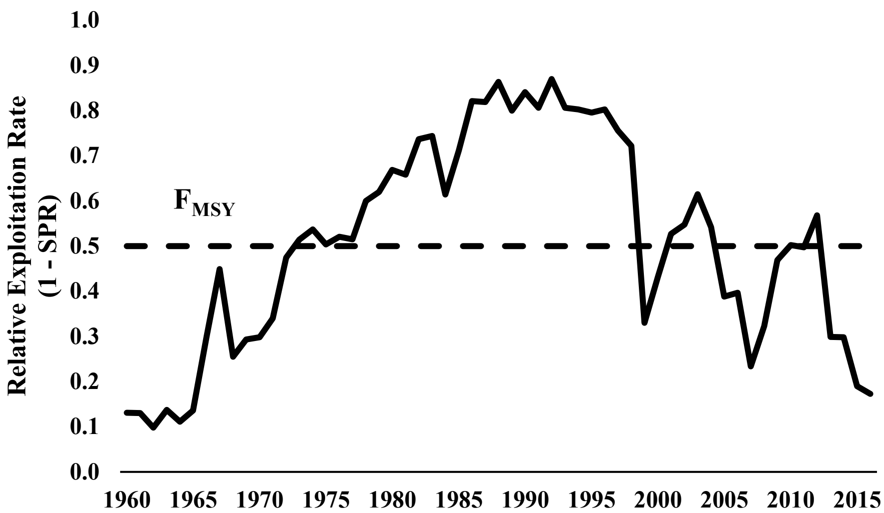

Figure 2-125. Estimated spawning potential ratio (SPR) of blackgill rockfish relative to the current F_{MSY}, 1960-2016. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis.

Rougheye/Blackspotted Rockfish

Distribution and Life History

Rougheye rockfish (*Sebastes aleutianus*) and blackspotted rockfish (*S. melanostictus*) are slope rockfish that share broad overlap in their depth and geographic distributions from the Eastern Aleutian Islands along the North American continental margin to southern Oregon, with blackspotted rockfish's range extending east beyond the Aleutian chain to the Pacific Coast of Japan (Gharrett*, et al.* 2005; Hawkins*, et al.* 2005; Orr and Hawkins 2008). It is very difficult to visually distinguish between the two species and they have been persistently confused in surveys and catches. Off the U.S. West Coast the two species have been reported as rougheye rockfish or in an even more generic rockfish category. It has only been from recent genetic studies in the early 2000s that the two separate species have been identified and described (Orr and Hawkins 2008).

Both species are encountered at depths shallower than 100 m to at least 439 m; however, blackspotted rockfish tend to be more prevalent in deeper waters (Hawkins et al. 2005, Orr and Hawkins 2008). Genetic information is not available to provide positive species identification in historical survey and landings information, but these data indicate that density of the nominal rougheye rockfish complex decreases sharply south of the Oregon-California border at 42° N. lat. Studies suggest that rougheye rockfish account for a greater proportion of the species complex along the coast of Washington and Oregon than in Alaskan waters (Gharrett*, et al.* 2005; Hawkins*, et al.* 2005; Orr and Hawkins 2008). Recent discussions with port samplers in southern Oregon suggest that both rougheye and blackspotted rockfish are encountered with some regularity in the commercial trawl and fixed gear landings in Charleston, Port Orford, and Brookings, with blackspotted rockfish composing approximately one third to one half of identified specimens (C. Good and N. Wilsman, ODFW, pers. Comm. As cited in Hicks et al. 2013).

The West Coast of the U.S. is the southern portion of the range of rougheye rockfish, and it is likely that the population north of the U.S.-Canada border is not a separate stock. The connectivity of rougheye populations throughout its range is unknown.

Compared with other rockfish species on the West Coast of the U.S., rougheye rockfish life-history is poorly described and the recent resurrection of the two species classification (rougheye and blackspotted rockfishes) has further complicated the understanding of life-history characteristics. Rougheye rockfish are often associated with boulders and steep habitats, and are typically found alone or in small aggregations (Love*, et al.* 2002). Younger fish may school and are often found in shallower waters on the shelf, and larger fish may form larger aggregations in the Pacific Northwest during the autumn and winter.

Rougheye rockfish give birth to live young with larvae released between February and June and at lengths between 4.5-5.3 mm (Love*, et al.* 2002). There are no studies on the fecundity of rougheye rockfish on the West Coast of the U.S.

A wide range of prey items make up the diet of rougheye rockfish. Crangid and pandalid shrimps make up the majority of their diets, and larger individuals, greater than 30 cm, feeding upon other fishes (Love 2011). They are also known to feed upon gammarid amphipods; mysids, crabs, polychaetes, and octopuses (Love 2011; Love*, et al.* 2002).

Stock Status and Management History

Rougheye and blackspotted rockfish (henceforth denoted as rougheye) are landed as part of the slope rockfish complexes north and south of 40°10' N. lat.; however, they are rarely caught in the south. The historical reconstruction of landings for rougheye rockfish suggests that fixed gear fisheries have caught rougheye rockfish since the turn of the 20th century and landings in the trawl fishery are estimated to have increased into the 1940s. Landings remained relatively constant throughout the 1950s and into the 1960s before the foreign trawl fleet increased catches into the 1970s. The declaration of the EEZ resulted in the buildup of a domestic fleet and landings increased rapidly into the late 1980s and early 1990s. Subsequently, landings declined in the late 1990s and have been between 100 and 200 mt in recent years. Trawl, longline, and Pacific whiting at-sea trawl fisheries make up the majority of the catch.

Rougheye rockfish are a desirable market species and discarding has been low, historically. However, management restrictions (e.g., trip limits) have resulted in increased discarding since 2000. Trawl rationalization was introduced in 2011, and since then very little discarding of rougheye rockfish has occurred.

Hicks et al. (2013) conducted the first assessment of the U.S. West Coast stock of rougheye and blackspotted rockfish as a complex of two species. The coastwide population was modeled assuming parameters for combined sexes (a single-sex model) and assuming removals beginning in 1916. The predicted spawning biomass from the base model generally showed a slight decline over the entire time series with a period of steeper decline during the 1980s and 1990s. Since 2000, the spawning biomass has stabilized and possibly increased because of reduced catches and above average recruitment in 1999. The 2013 spawning biomass relative to unfished equilibrium spawning biomass was estimated to be 47 percent of its unfished equilibrium at the start of 2013.

The stock has been estimated to be healthy throughout the time series in the new assessment (Figure 2-122).

Coastwide OFLs of rougheye rockfish are apportioned north (98 percent) and south (2 percent) of 40°10' N. lat. Based on average landings during 1985-2012. The Council adopted the default harvest control rule of ACL equal to the ABC with a P* of 0.45 for 2019 and beyond harvest specifications. A catch only-projection of rougheye and blackspotted rockfishes was provided to inform harvest specifications for 2021 and beyond.

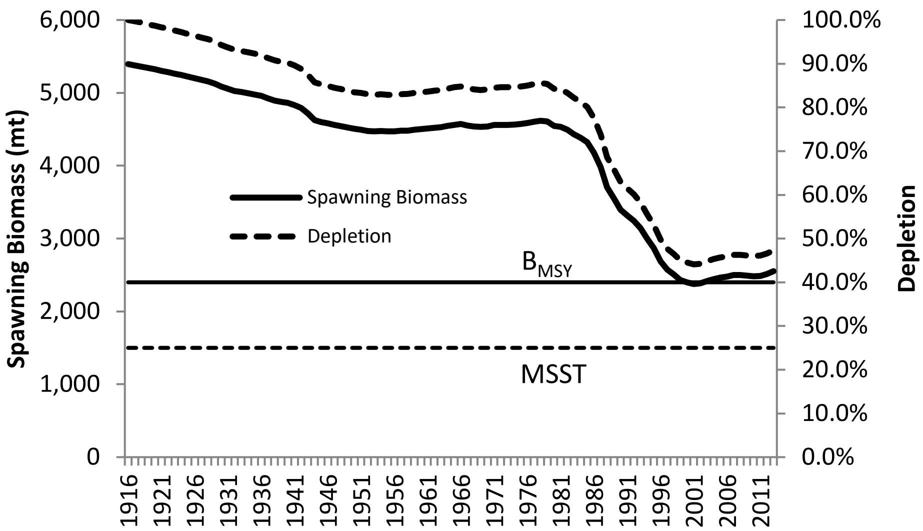

Figure 2-126. Time series of estimated spawning biomass and depletion of rougheye/blackspotted rockfish, 1916-2013 (from Hicks et al. 2013).

Stock Productivity

The parameter for steepness of the spawner-recruit relationship was fixed at 0.779 in the 2013 assessment based on a steepness meta-analysis for West Coast rockfishes (Jim Thorson, NWFSC). There is little information regarding recruitment prior to 1980, and the uncertainty in these estimates is expressed in the assessment. Estimates of recruitment appear to oscillate between periods of low and high recruitment. The four largest recruitments were estimated in 1999, 1998, 2001, and 1988, and the four smallest recruitments were estimated in 2002, 2006, 2005, and 1995 (Figure 2-123).

Rougheye rockfish have the highest potential vulnerability to overfishing (V = 2.27) driven by a combination of low productivity (P = 1.17) and relatively high susceptibility to being caught in the fishery (Table 2-2). Despite this, the 2013 assessment estimated the stock to be above the $B_{40\%}$ spawning biomass target. The low productivity is due to the stock being long-lived (max. age = 205 yrs.; (Love*, et al.* 2002)), with late maturation, and relatively low natural mortality.

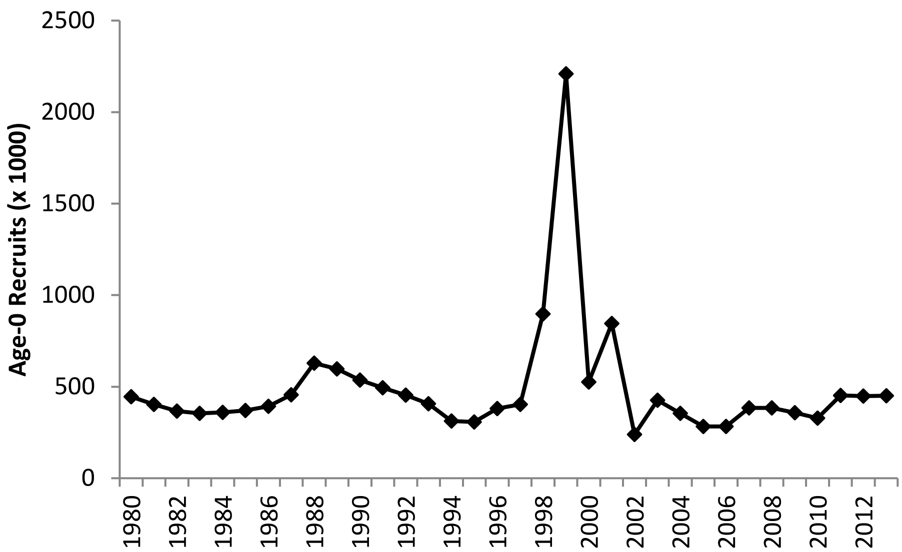

Figure 2-127. Time series of estimated age-0 recruits of rougheye/blackspotted rockfish on the U.S. West Coast, 1980-2013 (from Hicks et al. 2013).

Fishing Mortality

Rougheye rockfish are not often targeted by a specific fishery, but are desirable and marketable, thus are typically retained when captured. They are often captured in bottom trawl, midwater trawl, and longline fisheries. Small numbers have been observed in pot, shrimp, and recreational fisheries.

After many attempts to start trawl fisheries off the West Coast of the United States in the late 1800s, the availability of the otter trawl and the diesel engine in the mid-1920s helped the trawl fisheries expand (Douglas 1998). Trawl fisheries really became established during World War II when demand increased for shark livers and bottomfish. A mink food fishery also developed during World War II (Jones and Harry 1960). Foreign fleets began fishing for rockfish in the mid-1960s until the EEZ was implemented in 1977 (Rogers 2003b). Since 1977, landings of rockfish were high until management restrictions were implemented in 2000. Longline catches of rougheye rockfish are present from the turn of the century and continue in recent years, targeting sablefish and halibut.

A long-term directed fishery has not occurred for rougheye rockfish and historical discarding practices are not well known. Rougheye rockfish inhabit deeper water as adults, which were fished less often historically.

Throughout the 1980s and 1990s exploitation rates (1-SPR) were mostly above target levels (Figure 2-124). Recent exploitation rates on rougheye rockfish were predicted to be near target levels.

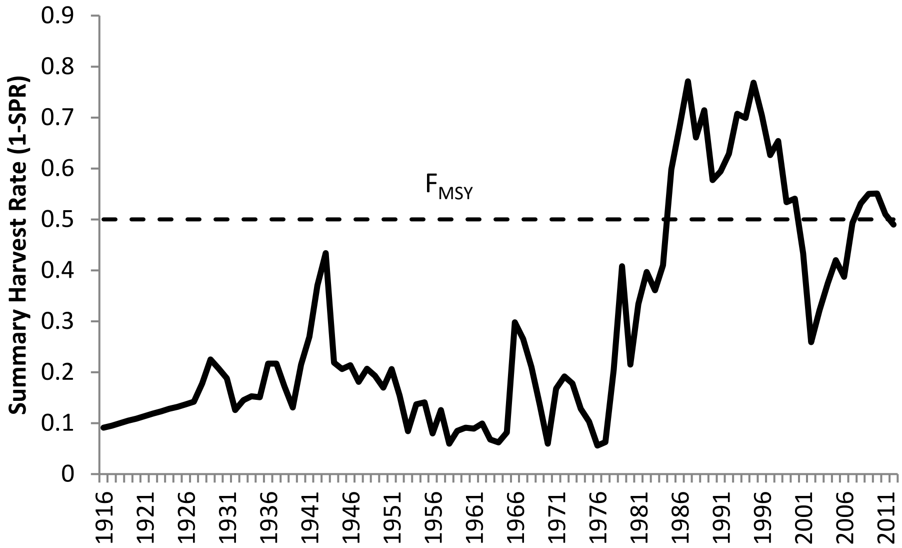

Figure 2-128. Estimated spawning potential ratio (SPR) of rougheye and blackspotted rockfish relative to the current F_{MSY}, 1916-2012. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis.

Sharpchin Rockfish

Distribution and Life History

Sharpchin rockfish (*Sebastes zacentrus*) range from the western Aleutian Islands (Attu Is.) to Southern California, though the core range is northern California to the Gulf of Alaska in waters between 100 m and 300 m (Love*, et al.* 2002). There is no indication of population structure in sharpchin rockfish. Sharpchin rockfish is a smaller-sized rockfish that inhabits waters up to 500 m, typically over muddy-rock habitats.

Mitochondrial DNA analyses indicate sharpchins are related mostly to harlequin, Puget Sound, and pygmy rockfishes (Love*, et al.* 2002).

Sharpchin rockfishes live to at least 58 years (Love*, et al.* 2002). Females attain a larger size than males with a reported maximum size of 45 cm (Love*, et al.* 2002). Off Oregon and Washington, the size at 50 percent maturity for females is 22 cm with all females being mature at 30 cm. The size at 50 percent maturity is larger for samples farther north with 25 cm and 28 cm reported off British Columbia and the Gulf of Alaska, respectively. Larval releases occur from March to June off California and Oregon and during July off British Columbia.

Sharpchin eat a variety of prey including krill, shrimps, gammarid amphipods, copepods, and small fishes.

Stock Status and Management History

Sharpchin rockfish are managed in the northern and southern Slope Rockfish complexes.

A new data-moderate assessment of sharpchin rockfish was conducted in 2013, which indicated the stock was healthy with a depletion of 68 percent at the start of 2013 (Cope*, et al.* 2014). The SSC recommended the 2013 assessment be used for setting harvest specifications and upgraded the stock from a category 3 to a category 2 stock. The coastwide OFLs were apportioned 80 percent to the north of 40°10' N. lat. and 20 percent to the south to determine the OFL contributions to the Slope Rockfish complexes based on swept area biomass estimates from the triennial survey.

Projections of harvest specifications for sharpchin rockfish for 2019 and beyond using the base model in the 2013 data-moderate assessment were provided in 2015 (Agenda Item I.4, Supplemental Attachment 8, November 2015) since long term projections were inadvertently omitted from the 2013 assessment.

The Council adopted the default harvest control rule of ACL equal to the ABC with a P* of 0.45 for 2019 and 2020 harvest specifications. The 2019 and 2020 ACL contribution of sharpchin rockfish north of 40°10' N. lat. to the Slope Rockfish complex north of 40°10' N. lat. are 322.1 mt and 317.7 mt, respectively. The 2019 and 2020 ACL contribution of sharpchin rockfish south of 40°10' N. lat. to the Slope Rockfish complex south of 40°10' N. lat. are 80.5 mt and 79.4 mt, respectively.

Stock Productivity

A high steepness of 0.77 was estimated in the 2013 sharpchin rockfish assessment, near the prior used in the assessment.

Sharpchin have a relatively low productivity (P = 1.36) and a relatively high vulnerability (V = 2.05) to overfishing based on the PSA scores derived prior to the 2013 assessment (Table 2-2).

Fishing Mortality

Sharpchin are not a major commercial target, though they are taken in large numbers and commonly seen in trawls that target Pacific ocean perch. They are taken most commonly of Oregon and Washington with POP, darkblotched rockfish, splitnose, and yellowmouth rockfish. While they are common in West Coast bottom trawl catches, their smaller size makes them less valuable than the larger rockfish species. They are rarely taken in recreational fisheries.

2.5.5 Oregon Cabezon/Kelp Greenling

The Oregon Cabezon/Kelp Greenling stock complex is comprised of cabezon (Scorpaenichthys marmoratus) and kelp greenling (Hexagrammos decagrammus) off Oregon. Both of these stocks have been assessed.

Cabezon off Oregon

Distribution and Life History

See the description of cabezon distribution and life history in section 2.9.6.

Stock Status and Management History

The 2009 assessment of the Oregon substock of cabezon (Cope and Key 2009) was the first for cabezon in Oregon waters. The assessment indicated a healthy stock status for Oregon cabezon at 52.4 percent depletion at the start of 2009. Only one index of abundance was used for modeling the Oregon cabezon substock (the ORBS CPUE index). The Oregon model was robust to almost all data and parameter manipulation trials except the removal of the ORBS survey. Removal of the only abundance index causes the population to drop sharply below the overfished level and absolute biomass to be much smaller than in the base case. Unlike the assessments for the

California substocks, the assessment of the Oregon cabezon substock does not show recent increases in spawning biomass. While the uncertainty in the estimated depletion level of the Oregon substock is generally low, uncertainty in the estimated spawning biomass is high.

A new full assessment of the cabezon substock in Oregon was conducted in 2019 (Cope*, et al.* 2019). Cabezon spawning output was estimated to be 177 mt in 2019 (~95 percent asymptotic intervals:129-226 mt), which when compared to unfished spawning output (335 mt) equates to a depletion level of 53 percent (~95 percent asymptotic intervals: 43-63 percent; Figure 2-125) in 2019. In general, spawning output had been trending downwards until the early 2000s, after which it became more stable throughout the rest of the time series with a slight increase from 2017 through 2019 due to an above average recruitment estimate for the 2014 year class. Stock size is estimated to be at the lowest level throughout the historic time series in 2014, but the stock is estimated to be above the management target of $B_{40\%}$.

The Council adopted the default harvest control rule of ACL equal to the ABC with a P* of 0.45 for 2021 and 2022 harvest specifications. The 2021 and 2022 ABC and ACL contributions of cabezon to the Oregon Cabezon/Kelp Greenling complex are 54.5 mt and 52.2 mt, respectively. These ACL contributions are also specified as the harvest guidelines for 2021 and 2022 Oregon fisheries with the intent to prevent overfishing under management in this state-specific stock complex.

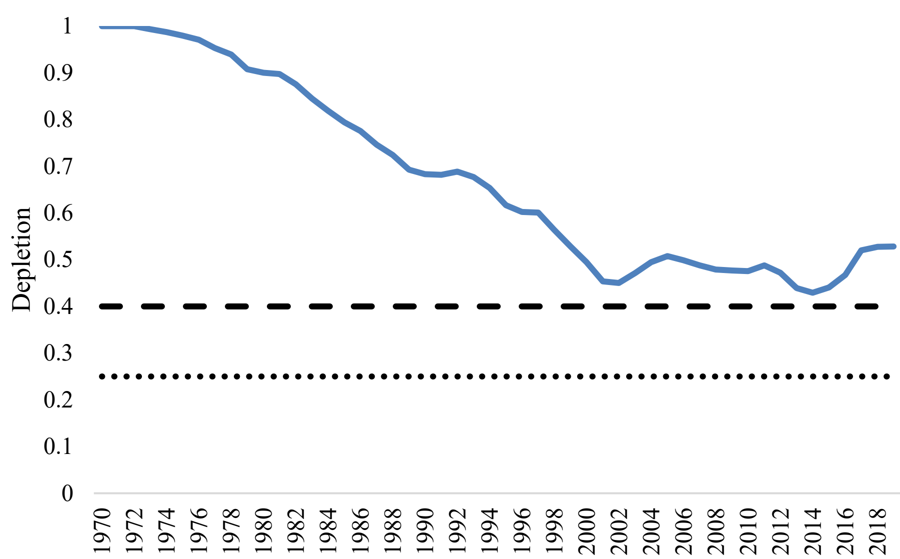

Figure 2-129. Relative depletion of cabezon in Oregon from 1970 to 2019 based on the 2019 stock assessment.

Stock Productivity

Steepness in the 2009 assessment of the Oregon substock of cabezon was assumed to be 0.7. Recruitment in the Oregon substock of cabezon was estimated to be less dynamic than that for the California substocks. The PSA productivity score of 1.72 indicates a stock of relatively high productivity.

A recent, above average, recruitment event in 2014 contributed to the recent increase in cabezon biomass in Oregon (Figure 2-126). This recruitment is informed by composition data, two relative abundance indices, and corresponds to reports from fishermen and port biologists of a recent increase in cabezon. Other years with relatively high estimates of recruitment were 1999, 2000, and 2002. The 2009 stock assessment also suggested that 1999 was an above average year class.

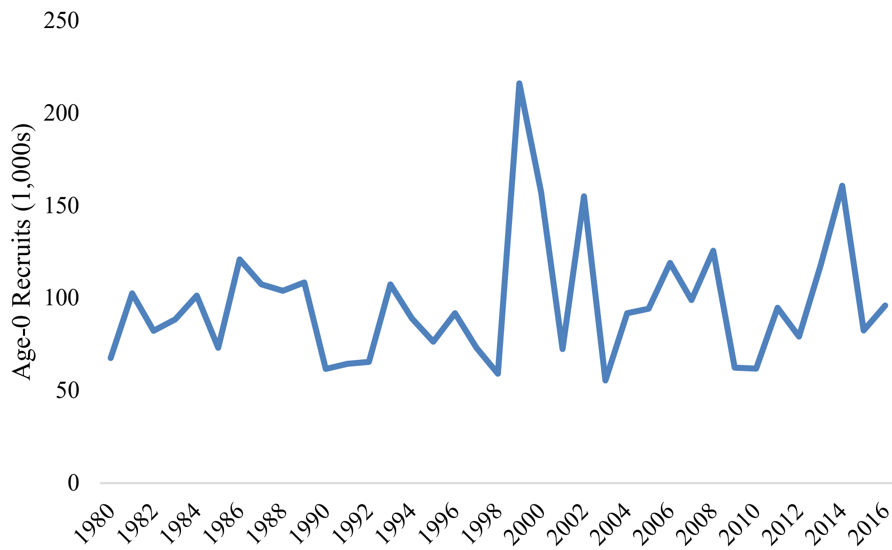

Figure 2-130. Estimated recruitments of cabezon in Oregon, 1980-2016.

Fishing Mortality

Harvest rates in Oregon have generally increased through time until reaching a more stable (but still variable from year to year) level beginning in the 2000s (Figure 2-127). The maximum relative harvest rate was 1.16 in 2001 (or 116 percent of the target level) before declining again to around 0.80 in recent years.

The PSA vulnerability score of 1.68 indicates a low risk of overfishing.

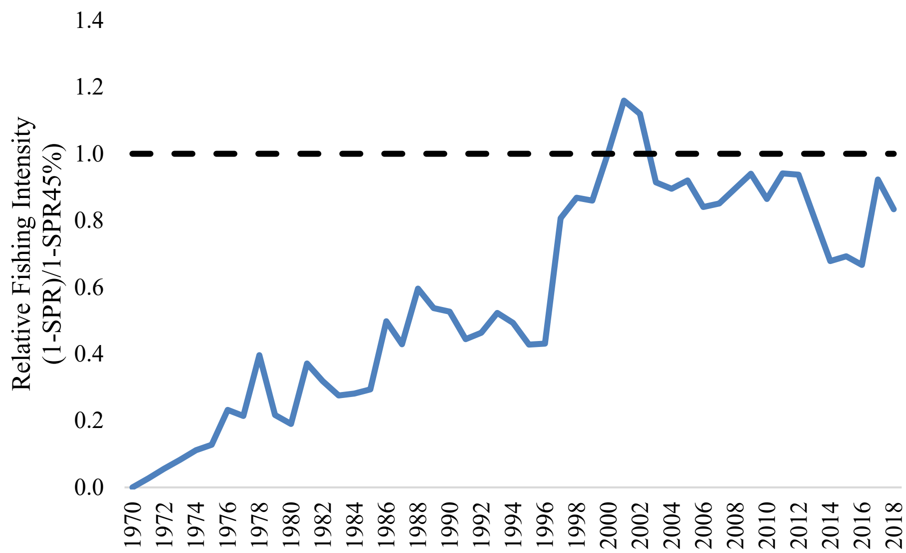

Figure 2-131. Relative fishing intensity of cabezon in Oregon, 1970-2018.

Kelp Greenling off Oregon

Distribution and Life History

Kelp greenling (*Hexagrammos decagrammus*) is a demersal, solitary finfish in the family *Hexagrammidae*, which also includes lingcod. Kelp greenling are endemic to nearshore rocky reef, kelp forest, and eelgrass habitats of the Northeast Pacific Ocean (Bodkin 1986; Eschmeyer, *et al.* 1983; Pacunski and Palsson 2001). This species ranges from southern California, north to the Aleutian Islands (Miller and Lea 1972), but are rarely found south of Point Conception, California (Feder, *et al.* 1974). The main population range and fisheries activities are from central California (including the Channel Islands) north through Oregon. Kelp greenling is primarily a nearshore species found intertidally and among rocks and kelp, usually down to depths of <50 m, though they can be found out to depths >150 m (Love 1996; Miller and Lea 1972). Kelp greenling tend to remain within three meters of benthic substrates and are often observed resting on the bottom (Rosenthal 1980). These fish tolerate salinities ranging from 5 ppt to 45 ppt (Zahr 1984), an adaptation allowing this species to occupy estuarine habitats. Evidence suggests kelp greenling may display ontogenetic movement, with smaller fish in shallower waters (DeMartini 1986; ODFW 2002).

In Oregon's nearshore, kelp greenling are found in association with finfish species including *Hexagrammids*, *Scorpaenids*, and *Cottids* among others (Easton, *et al.* 2015). Black rockfish, lingcod, China rockfish, canary rockfish, quillback rockfish, copper rockfish, yellowtail rockfish, yelloweye rockfish, rock greenling (*Hexagrammos lagocephalus*), Irish lords (*Hemilepidotus* spp.), and surfperches are species commonly co-occurring with kelp greenling. Many of these species are also exploited in Oregon's nearshore fishery.

There is little direct information on the stock structure of kelp greenling off the U.S. West Coast. Little is also known of kelp greenling movement patterns, but given their nearshore distribution and the territorial behavior of adults (Barker 1979; Bryant 1978; DeMartini 1986), they are not believed to migrate great distances. Once settled, kelp greenling in California waters are thought to establish home ranges at least 500 – 3,000 m^2 (Love 2011). Typical of nearshore reef fishes, kelp greenling subpopulations are often spatially discrete, suggesting the possibility of increasing genetic differentiation as distance along the coast increases (Palumbi 2003).

Kelp greenling are sexually dimorphic at maturity with notable chromatic differences between the sexes. Adult females are generally light gray with yellow fins and speckled orange-brown spots across the entire body. Adult males are commonly olive-brown with blue tinged fins. Males have blue spots surrounded by rings of reddish-brown spots on the anterior portion of the body. Considerable variation in coloration exists by season, geographic location and among individuals of the same sex.

Kelp greenling spawn sub-tidally in shallow rocky areas. Female kelp greenling batch spawn (Kurita*, et al.* 1995) producing at least three clutches of eggs (Crow*, et al.* 1997) during the primary reproductive season of September through December (Rodomsky*, et al.* 2015). Golf ball to tennis ball sized egg clutches are deposited sub-tidally, adhering to shallow benthic substrates of rock, kelp or biological composition in nests established by males (DeMartini 1986). It is apparent that females lay multiple batches in different nests, but whether these eggs are temporally distinct enough to qualify for separate spawning events has not been determined (Crow 1995; Crow*, et al.* 1997; Rothrock 1983). Clutches collected from Washington waters averaged 4,340 eggs each (SE = 311) with egg diameters ranging from 2.2 to 2.5 mm (mean = 2.3 mm) and egg weights from 6.8 to 8.7 mg (mean = 7.6 mg, (DeMartini 1986)). The role of female kelp greenling in reproduction ends with egg deposition.

Male kelp greenling have a significant paternal role in reproduction. Territorial during the reproductive season, males establish nests, fertilize eggs, fan eggs to increase oxygenation, and guard nests from predation. Sneak spawning by non-territorial males has been observed (Crow*, et al.* 1997). Nests are 0.001 m^2 to 7 m^2 in size and may hold one to 11 clutches (Crow 1995; Crow*, et al.* 1997; DeMartini 1986; Howard and Silverberg 2001). Clutches in a single nest are often in various stages of development and are contributed to by multiple females, indicating a polygamous mating system (Crow*, et al.* 1997). Embryos require 30 days to develop when held in 10°C water in a laboratory (DeMartini 1986). Laid eggs are sticky and adhere to the surface where deposited. After hatching, the young-of-the-year spend several months as epipelagic larvae and juveniles (Gorbunova 1970). Settlement takes place in the nearshore after a planktonic phase when the young fish have attained 5-7 cm in length (Burge and Schultz 1973; Matarese*, et al.* 1989; ODFW 2002; Robinson*, et al.* 1968a; Robinson*, et al.* 1968b). Growth is rapid in the first three years for both sexes, thereafter slowing dramatically (ODFW 2002; Rodomsky*, et al.* 2015). Adult kelp greenling reach a maximum size of 63 cm (total length) and 2.1 kg (Love 2011). In Oregon marine waters, kelp greenling rarely grow over 50 cm and live at least 17 years (Rodomsky*, et al.* 2015).

Kelp greenling is a diurnal generalist mesopredator of Northeast Pacific nearshore ecosystems (Frid*, et al.* 2012). This species uses both ram and suction feeding (Nemeth 1997) to prey on crustaceans, polychaete worms, echinoderms, mollusks, fish eggs (including kelp greenling), small fishes and algae (Bryant 1978). In turn, kelp greenling is preyed upon by a wide variety of organisms including black rockfish, Pacific halibut (*Hippoglossus stenolepis*), lingcod, cabezon, salmonids, seabirds, pinnipeds, and mink (*Mustela vison*) among others.

Stock Status and Management History

The first assessment of kelp greenling was completed in 2005 by Cope and MacCall (Cope and MacCall 2006). The assessment treated the stock as two completely independent sub-stocks divided at the California-Oregon border (excluding Washington, as there have been no substantial fisheries off its coast). There are substantial differences between the two assessments with respect to assessment period, model assumptions, results, and uncertainties. An important difference between the two sub-stocks is the first year for which historical catch data are available (1916 for California and 1981 for Oregon). The Oregon sub-stock has some age-at-length data, which were included in the assessment. The estimate of depletion for the Oregon sub-stock (49 percent of its unfished biomass at the start of 2005) is more certain than estimates of absolute abundance, which are highly imprecise. For the California sub-stock, substantial uncertainty could not be resolved regarding growth and natural mortality rates, as well as the shape of the selectivity pattern for the shore mode fishery. Due to these factors, it was not possible to formulate a model for California. The 2005 kelp greenling assessment was used only for status determination since the assessment could not adequately estimate the scale of the population's spawning biomass. The SSC lost confidence in the 2005 assessment in 2014 when it was realized the historical catch data informing the assessment were based on MRFSS estimates rather than the accepted ORBS estimates.

Berger et al. (2015) conducted an assessment of kelp greenling in Oregon waters and determined the population was healthy with a depletion of 80 percent at the start of 2015. The assessment assumed a single, two-sex population for waters off the Oregon coast and modeled the period 1915-2014. The model included four fleets which were defined as a combined commercial fleet (hook and line, and bottom longline) and three recreational fleets (ocean-boat, estuary-boat, and shore). Data included in the model were catches and associated length composition data, three fishery dependent CPUE series, and three series of conditional age-at-length data. The scale of the biomass was sensitive to the assumed value for natural mortality.

The Council adopted the default harvest control rule of ACL equal to the ABC with a P* of 0.45 for 2021 and 2022 harvest specifications.

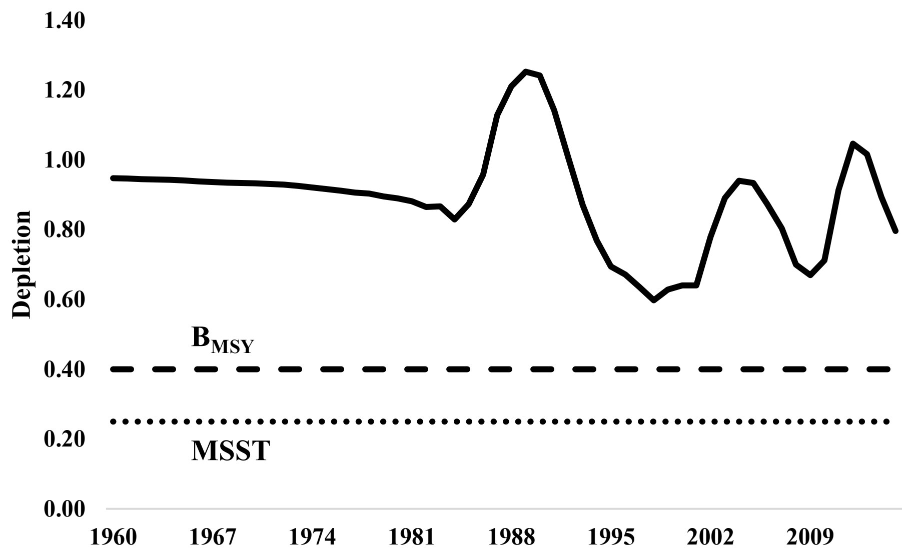

Figure 2-132. Relative depletion of kelp greenling off Oregon from 1960 to 2015 based on the 2015 stock assessment.

Stock Productivity

The 2015 kelp greenling assessment assumed a steepness of 0.7. Recruitment variability is notably dynamic for kelp greenling (Figure 2-129) and indicated above average recruitment in 2009. Other years with relatively high estimates of recruitment were 1985 and 2000. In recent years (2012-2014), the 2015 base case assessment model had difficulty estimating recruitment levels because of a lack of cohort information contained in the most recent data.

The PSA productivity score of 1.83 indicates a relative moderate productivity of kelp greenling. Kelp greenling are judged to have a low vulnerability (V = 1.56) of potential overfishing for the stock.

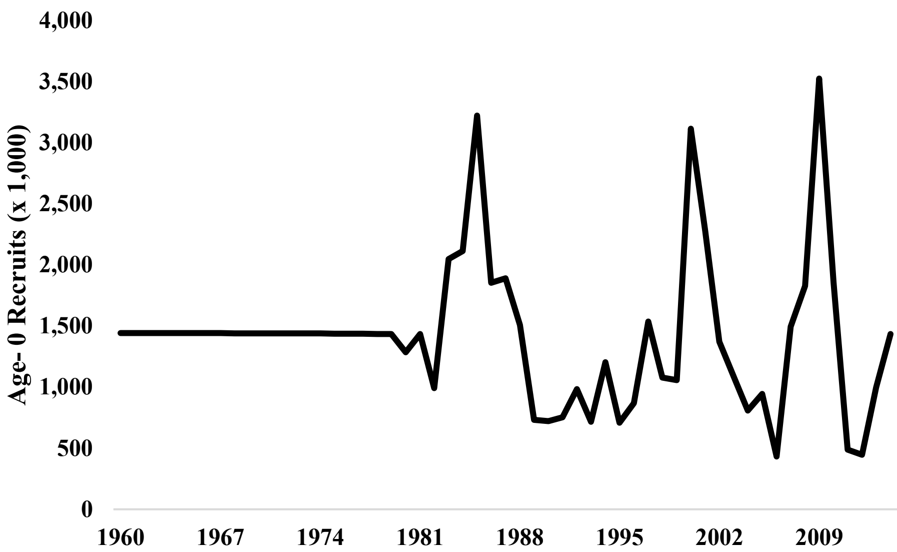

Figure 2-133. Estimated recruitments of kelp greenling off Oregon, 1960-2015 (from Berger, *et al.* 2015).

Fishing Mortality

Harvest rates of kelp greenling off Oregon have been generally increasing through time, reaching a maximum in 2002 (51 percent of the target level) before declining again to 21 percent of the limit in 2014 (Figure 2-130). Fishing intensity is estimated to have been below the target throughout the time series. In 2014, kelp greenling biomass was estimated to have been at 2.24 times higher than the target biomass level, while experiencing fishing intensity 4.76 times lower than the SPR fishing intensity target.

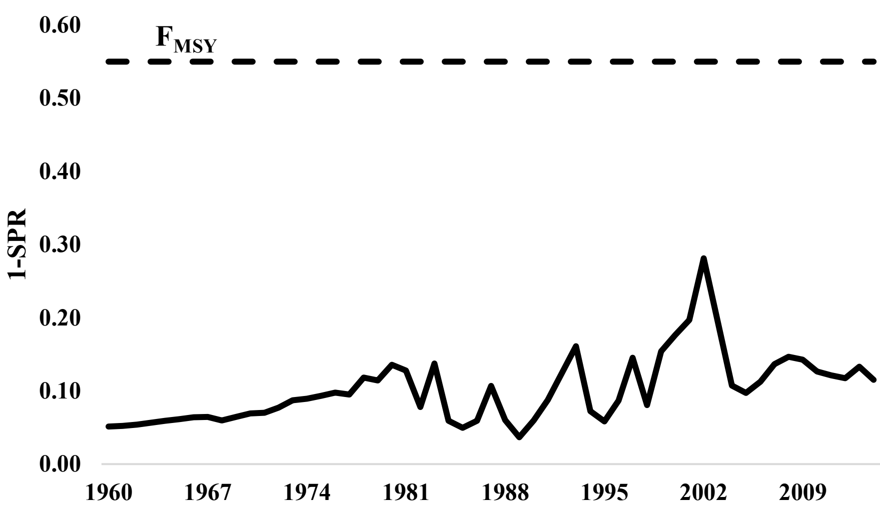

Figure 2-134. Estimated spawning potential ratio (SPR) of kelp greenling off Oregon relative to the current F_{MSY}, 1960-2014. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis.

2.5.6 Washington Cabezon/Kelp Greenling

The Washington Cabezon/Kelp Greenling stock complex is comprised of cabezon (*Scorpaenichthys marmoratus*) and kelp greenling (*Hexagrammos decagrammus*) off Washington. Both of these stocks are unassessed and managed as category 3 assessments of OFL.

2.5.7 Other Flatfish

The Other Flatfish complex contains most of the flatfish species managed in the Groundfish FMP (with the exception of arrowtooth flounder, Dover sole, English sole, petrale sole, and starry founder[14]). These species include butter sole (*Isopsetta isolepis*), curlfin sole (*Pleuronichthys decurrens*), flathead sole (*Hippoglossoides elassodon*), Pacific sanddab (*Citharichthys sordidus*), rex sole (*Glyptocephalus zachirus*), rock sole (*Lepidopsetta bilineata*), and sand sole (*Psettichthys melanostictus*).

Pacific Sanddabs

Distribution and Life History

Pacific sanddab (*Citharichthys sordidus*) is a left-eyed flounder of the family *Paralichthyidae* and is widely distributed along the Pacific West Coast from the Bering Sea to Cabo San Lucas, Baja California (Arora 1951; Hart 1988; Kramer and O'Connell 1995; Love*, et al.* 2005; Miller and Lea 1972; Rackowski and Pikitch 1989). Early studies reported that the species is the most abundant in the north-central portion of California from Eureka to San Francisco, but were also fairly common in southern California (Rackowski and Pikitch 1989). Early studies also reported that the species is usually found at depths between 18 m and 275 m and most commonly found at depths between 35 m and 95 m (Arora 1951; Demory 1971; Hart 1988; Miller and Lea 1972; Roedel 1953). On Oregon's continental shelf, Pacific sanddab is the most abundant small flatfish on sandy-bottom in the depths between 74 and 102 m (Pearcy 1978). Young Pacific sanddab (ages 0 and 1) are also found to be concentrated in the same depth range (Donohoe 2000). Pacific sanddab was also found to be relatively more abundant in shallow waters at higher latitudes (Chamberlain 1979).

Pacific sanddab are generally not considered a primary target for commercial fisheries along the U.S. West Coast, but they are nevertheless highly prized by the commercial and recreational fisheries for their excellent edibility (CDFG 2001), and have long been an important component of the nearshore flatfish fishery, commanding a high price in fresh fish markets (Arora 1951). Commercial catches of Pacific sanddab were mostly from bottom trawl fisheries, and there is a long history of catches. Recreational catches of Pacific sanddab are from the hook and line fishery and most of this catch is from southern California waters. Some recreational anglers target Pacific sanddab in southern California, mostly from small boats and CPFVs (CDFG 2001).

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[14] Starry flounder is being considered for management in the Other Flatfish complex starting in 2017 (see Section 2.9.25).

Pacific sanddabs can growth to 35cm in length. They are sexually dimorphic, with females attaining larger sizes than males. Analysis of growth rates for both sexes between the southern and northern areas (divided at the California-Oregon border at 42° N. lat.) showed no significant difference in growth rates for both sexes between the two areas.

There are no genetic or tagging studies informing stock structure of Pacific sanddab along the U.S. Pacific coast. Bottom trawl surveys in recent years (both NWFSC and triennial surveys) showed that Pacific sanddab are commonly caught along the coastal areas of all U.S. waters.

Pacific sanddabs play an important role in the coastal ecosystems in the U.S. waters, particularly because they are a relatively abundant species and are important prey items to a wide range of marine predators, including piscivorous fishes, sea mammals, and sea birds (Field, *et al.* 2006; Levin, *et al.* 2006).

Stock Status and Management History

Pacific sanddabs have been under Federal management since the implementation of the groundfish FMP in 1982 and managed within the Other Flatfish complex of unassessed flatfish species. The management performance in recent years for Pacific sanddab has been good; the average 2005-2012 total annual catch has been about 23 percent of the stock's ACL/OY contribution to the Other Flatfish complex.

A coastwide assessment of Pacific sanddab was done in 2013 indicating the stock was at 95.5 percent of its unfished biomass (He, *et al.* 2013). The SSC recommended in 2013 that this assessment not be used for deciding harvest specifications since the scale of the stock's biomass could not be adequately estimated. However, the status estimate was precise enough to conclude the stock was well above the B_{MSY} proxy of $B_{25\%}$. The SSC recommended the stock continue to be categorized as a category 3 stock given the OFL estimate from the assessment depends on the biomass estimate, which was not estimated with adequate precision. The OFL estimate is therefore based on the DB-SRA method used since 2011.

The Council adopted the default harvest control rule of ACL equal to the ABC with a P* of 0.4 for 2021 and 2022 harvest specifications.

Stock Productivity

A steepness prior of 0.8 was used in the 2013 assessment. Annual recruitment deviations were estimated between 1966 and 2011. Annual recruitment deviations were treated in a log-normal distribution with σ_R fixed at 0.45. Low recruitments occurred from the early 2000s to the mid-2000s. Recruitments in recent years have been at or above the long-term average, with a strong recruitment in 2010.

The PSA productivity score of 2.4 indicates a very high relative productivity of Pacific sanddabs. This leads to a very low vulnerability (V = 1.25) of potential overfishing for the stock.

Fishing Mortality

There is a long history of commercial catches on Pacific sanddab (Barss 1976). Sette and Fiedler (1928) reported that landings of flatfish in California waters were first reported in 1892. The first available landings of Pacific sanddab in Oregon waters were in 1942 (Karnowski, *et al.* 2014).

There were also commercial catches for mink foods in both California and Oregon waters in the 1950s and 1960s (Best 1959; Best 1961; Nitsos and Reed 1965). Reported total catches of Pacific sanddab were high in the late 1920s. And there was an increasing trend from the 1960s and reached the highest catch level in the late 1990s. Discards of Pacific sanddab in commercial trawl fisheries were high, primarily due to its small size (Sampson 2002). Catches of the species in recent years were in the range of 200 mt and 400 mt, well below the OFL contribution of the stock to the Other Flatfish complex of 4,801 mt.

Rex Sole

Distribution and Life History

Rex sole (*Glyptocephalus zachirus*) is a right-eyed flounder of the family *Pleuronectidae* ranging from central Baja California to the Aleutian Islands and the western Bering Sea. They are common from southern California to the Aleutian Islands. They are distributed over mud and sand bottom habitat in deeper depths, are commonly found in waters up to at least 500 m, and range down to more than 1,100 m.

Rex sole grow slowly and are relatively long-lived for a flatfish with a maximum age of 29 years (Cope*, et al.* 2014). Females grow faster and attain a larger size than males.

Stock Status and Management History

Rex sole are currently managed in the Other Flatfish complex.

A data-moderate assessment of rex sole using the exSSS model was conducted in 2013, which indicated the stock was healthy with a depletion of 80 percent at the start of 2013 (Cope*, et al.* 2014). The SSC recommended the 2013 assessment be used for setting harvest specifications and upgraded the stock from a category 3 to a category 2 stock.

In 2023, a data-moderate assessment of rex sole was conducted using Stock Synthesis. Relative to the prior 2013 assessment, many model specifications were updated such as the inclusion of length compositions from both fishery-dependent and fishery-independent sources, inclusion of conditional length-at-age data, modeling of discards separately from landings starting in 2002, and updating all biological parameters. Model development followed a category 2 approach, which does not include age data, however including the length-at-age data allowed for more accurate estimation of growth, model fits to data, and reasonable estimation of other model parameters and thus it was agreed to include in this assessment. Biological parameters, except growth, used in the assessment were all fixed rather than estimated and represent sources of uncertainty. The SSC recommended the stock continue to be categorized as a category 2 stock with a sigma value of 1.0. The 2023 spawning output relative to unfished equilibrium spawning output is 76 percent, above the target of 25 percent.

The Council adopted an alternative harvest control rule of ACL equal to the ABC with a P* of 0.45 for the rex sole ACL contribution to the Other Flatfish complex in 2025 and 2026 harvest specifications. Projections based on the 2023 assessment also utilized the 25:5 harvest control rule as appropriate.

Stock Productivity

Steepness of the stock-recruit relationship was fixed at 0.7 in the 2023 data-moderate stock assessment.

The PSA productivity score of 2.05 indicates a high relative productivity of rex sole. This leads to a low vulnerability (V = 1.28) of potential overfishing for the stock.

Fishing Mortality

Rex sole are a very commonly occurring species in the fishery-independent trawl surveys and are very accessible to trawl fisheries. Females are larger than males and are most commonly caught. Males are small enough to escape the minimum mesh size of U.S. West Coast bottom trawls.

Targeting for rex sole in commercial fisheries has varied over the years, with major removals occurring in the mid-1900s to provide feed for mink farms. They have not been targeted heavily in the last few decades. While their flesh is of high quality, they are small fish with very thin fillets and therefore less desired in commercial markets.

The recent 2023 data-moderate stock assessment indicated that fishing intensity (1-SPR) has been below the reference harvest rate (1-SPR 30%) in the last 25 years.

2.5.8 Other Fish

The Other Fish stock complex is comprised of kelp greenling (*Hexagrammos decagrammus*) off California and leopard shark (*Triakis semifasciata*) (primarily off California). Both of these stocks are unassessed and managed as category 3 stocks.

2.5.9 Ecosystem Component Species

The species designated as EC species in the groundfish FMP are displayed in Table 2-11. An EC species can be so designated if it is not targeted, is not subject to overfishing or being overfished in the absence of conservation measures, and not generally retained for sale or personal use. No harvest specifications or management reference points are required for EC species; however, there is a monitoring requirement to determine potential changes in their status or their vulnerability to the fishery. An unexpected increasing catch trend infers an EC species' vulnerability to overfishing may have increased, compelling a consideration to reclassify the stock as "in the fishery". Any designation of a species as an EC species or a change from an EC designation to a species considered to be "in the fishery" requires an FMP amendment.

The following species were designated EC species under FMP Amendment 24, which was implemented in 2011: big skate, California skate, all other endemic skates, soupfin shark, finescale codling, Pacific grenadier, all other endemic grenadier species, and spotted ratfish. The Council decided in 2015 under Amendment 27 to remove the EC designation for big skate and redesignate the species as actively managed with stock-specific harvest specifications (see Section 2.9.2). The rationale for this consideration was based on new evidence that big skate are targeted in trawl fisheries and retained for sale in greater amounts than previously understood. When the Council considered designating all skates except longnose skate as EC species, the GMT estimated that catches of big skate averaged 95 mt from 2007–2011 with large landings of Unspecified Skate (see Table 4-33 in the 2015-2016 Harvest Specifications and Management Measures Final Environmental Impact Statement). Subsequent analysis of Oregon port sampling data not available when the Council considered the EC designation indicated about 98 percent of the recent Unspecified Skate landings in Oregon were comprised of big skate. The GMT revised the total mortality estimates of big skate coastwide using these new data. Such large landings indicate targeting of big skate has occurred and an EC designation was not warranted.

Shortbelly rockfish was recommended to be designated an EC species under FMP Amendment 29,

Table 2-11. Ecosystem Component Species managed under the FMP in 2021 and beyond.

Common Name	Scientific Name
Shortbelly rockfish	*Sebastes jordani*
Aleutian skate	*Bathyraja aleutica*
Bering/sandpaper skate	*B. interrupta*
California skate	*Raja inornata*
Roughtail/black skate	*Bathyraja trachura*
All other skates except big and longnose skate	Endemic species in the family *Arhynchobatidae*
Pacific grenadier	*Coryphaenoides acrolepis*
Giant grenadier	*Coryphaenoides pectoralis*
All other grenadiers	Endemic species in the family *Macrouridae*
Finescale codling (aka Pacific flatnose)	*Antimora microlepis*
Ratfish	*Hydrolagus colliei*
Soupfin shark	*Galeorhinus zyopterus*

Shortbelly Rockfish

Distribution and Life History

Shortbelly rockfish (*Sebastes jordani*) range from Punta Baja in Baja California (Klingbeil 1976) as far north as La Perouse Bank off of British Columbia, and as far west as the Cobb seamount off the southern Washington coast (Pearson*, et al.* 1993). However, they are most abundant along the continental shelf break between the northern end of Monterey Bay and Point Reyes, California (particularly in the regions of Ascension Canyon and the Farallon Islands), and around the Channel Islands in the Southern California Bight (Love*, et al.* 2002; Moser*, et al.* 2000; Pearson*, et al.* 1991; Phillips 1964). Although stock structure is poorly understood, genetic analysis of fish collected between San Diego and Cape Mendocino suggests a single coastwide stock, with slight differences in allele frequencies across Point Conception (Constable 2006). The shortbelly rockfish is one of the most abundant rockfish species in the California Current and is a key forage species for many piscivorous fish, birds, and marine mammals.

Shortbelly rockfish feed primarily on juvenile and adult euphausiids, and are an important prey item to a wide range of piscivorous fishes, seabirds, and marine mammals (Chess*, et al.* 1988; Lowry and Carretta 1999; Sydeman*, et al.* 2001). Merkel (1957) reported that juvenile shortbelly rockfish were important prey of Chinook salmon along the central California coast in late spring and summer, accounting for more than 60 percent of those identified to species. For many breeding California seabirds, as much as 90 percent of their diet is comprised of pelagic stages of juvenile (age 0) rockfish during the late spring and early summer breeding seasons, and unexploited species (such as shortbelly rockfish) generally account for more than two thirds of the juvenile rockfish identified (Ainley*, et al.* 1993; Miller and Sydeman 2004; Sydeman*, et al.* 2001). However, there is considerable interannual and interdecadal variability in the frequency of rockfish in seabird diets. Throughout the 1990s, foraging rates on juvenile rockfish by central California seabirds declined for both exploited and unexploited rockfish species primarily in response to changes in ocean conditions associated with poor recruitment for rockfish (Miller and Sydeman 2004; Mills*, et al.* 2007; Sydeman*, et al.* 2001). Although rockfish have rarely been identified to the species level in the diets of many California Current marine mammals (Antonelis and Fiscus 1980; Morejohn*, et al.* 1978; Perez and Bigg 1986; Stroud*, et al.* 1981), shortbelly rockfish were among the five most significant prey items for California sea lion (*Zalophus californianus*) in the Channel Islands (Lowry and Carretta 1999) and are frequently encountered in sea lion food habits samples off of Central California (Weise and Harvey 2005). Shortbelly rockfish are also described as important prey to thresher sharks (Preti*, et al.* 2004), longnose skate (Robinson*, et al.* 2007), and jumbo squid (Field*, et al.* 2007), among others. Consequently, shortbelly rockfish are an important forage species to a wide range of predators throughout the California Current ecosystem, and generally have a trophic position and life history traits more similar to forage fishes than most other *Sebastes*.

Stock Status and Management History

The expectation of eventual development of a domestic commercial fishery (Kato 1981) led to past efforts to estimate stock abundance and productivity (Lenarz 1980, Pearson et al. 1989, Pearson et al. 1991) as well as evaluations of commercial potential. The first ABC for shortbelly rockfish was set by the Council at 10,000 mt for 1983 through 1989. A stock assessment by Pearson et al. (Pearson*, et al.* 1991) estimated that allowable catches for shortbelly rockfish might range from 13,900 to 47,000 mt per year, based on life history data and hydroacoustic survey estimates of abundance. Subsequently, the Council established an ABC of 23,500 mt, which was reduced to 13,900 mt in 2001 based on observations of poor recruitment throughout the 1990s and the continued lack of a targeted fishery. Yet despite several attempts to develop a commercial fishery for shortbelly rockfish, domestic fishery landings have never exceeded 80 mt per year along the West Coast.

A shortbelly rockfish assessment was done as an academic exercise in 2007 to understand the potential environmental determinants of fluctuations in the recruitment and abundance of an unexploited rockfish population in the California Current ecosystem (Field*, et al.* 2008). The results of the assessment indicated the shortbelly rockfish stock was healthy with an estimated spawning stock biomass of 67 percent of its unfished biomass in 2005 (Figure 2-131).

Shortbelly rockfish is an abundant species that is not targeted in any commercial or recreational fisheries or caught in substantial amounts. However, shortbelly rockfish is a valuable forage fish species in the California Current ecosystem with fluctuations in stock recruitment and biomass driven by environmental conditions. The consequence of fisheries, including high and low estimates of plausible discards, were estimated to be negligible (P<0.01) in all years with the exception of the foreign fisheries of the mid-1960s (Field*, et al.* 2008). Shortbelly rockfish were initially considered for an EC species categorization under Amendment 23. Rather than classifying shortbelly rockfish as an EC species, the Council chose to recommend a very restrictive ACL of 50 mt for the 2011-2012 and the 2013-2014 management cycles. The ACL was increased to 500 mt beginning in 2015 to prevent unavoidable bycatch from prematurely shutting down emerging midwater trawl fisheries targeting yellowtail and widow rockfish. The 500 mt ACL was still less than 10 percent of the ABC and was a level of harvest meant to accommodate unavoidable incidental bycatch of shortbelly rockfish while allowing most of the harvestable surplus of the stock to be available as forage for species in the California Current ecosystem.

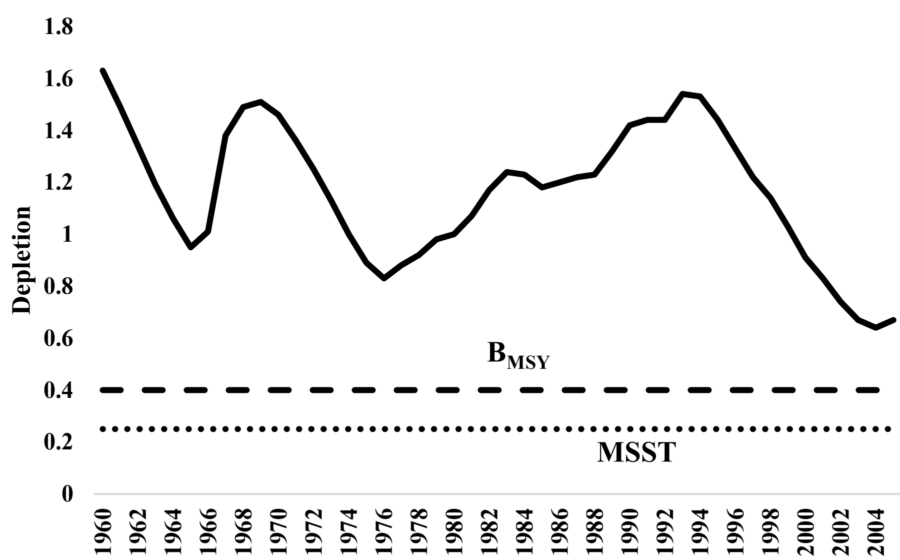

Figure 2-135. Relative depletion of shortbelly rockfish from 1960 to 2005 based on the 2007 stock assessment.

While shortbelly rockfish are most abundant along the continental shelf break between the northern end of Monterey Bay and Point Reyes, California and around the Channel Islands in the Southern

California Bight (Love, et al. 2002; Moser, et al. 2000; Pearson, et al. 1991; Phillips 1964), they have increasingly been encountered and incidentally caught in midwater trawl fisheries in waters north of 40°10’ N. lat. As far north as northern Washington. The observed magnitude of encounters of shortbelly rockfish north of 40°10’ N. lat. In recent years is unprecedented and may be the result of a climate change-driven distributional shift and/or the effect of large recruitments. It appears both explanations are contributing factors given evidence of continued high recruitment and abundance in the core habitats off southern and central California.

The ACL was raised to 500 mt in 2015 in anticipation of the re-emergence of the midwater trawl rockfish fishery after widow and canary rockfish were declared rebuilt. Incidental bycatch remained low until 2017 when it abruptly increased by an order of magnitude and has been increasing since (Figure 2-132 and Table 2-12). Most of this bycatch occurred in the Pacific whiting midwater trawl fisheries north of 40°10’ N. lat. The shortbelly rockfish ACL of 500 mt was exceeded in 2018 and 2019.

The Council and NMFS adopted an increase in the 2020 ACL to 3,000 mt to avoid premature closure of the 2020 Pacific whiting fishery. The Council recommended shortbelly rockfish be designated an EC species for 2021 and beyond.

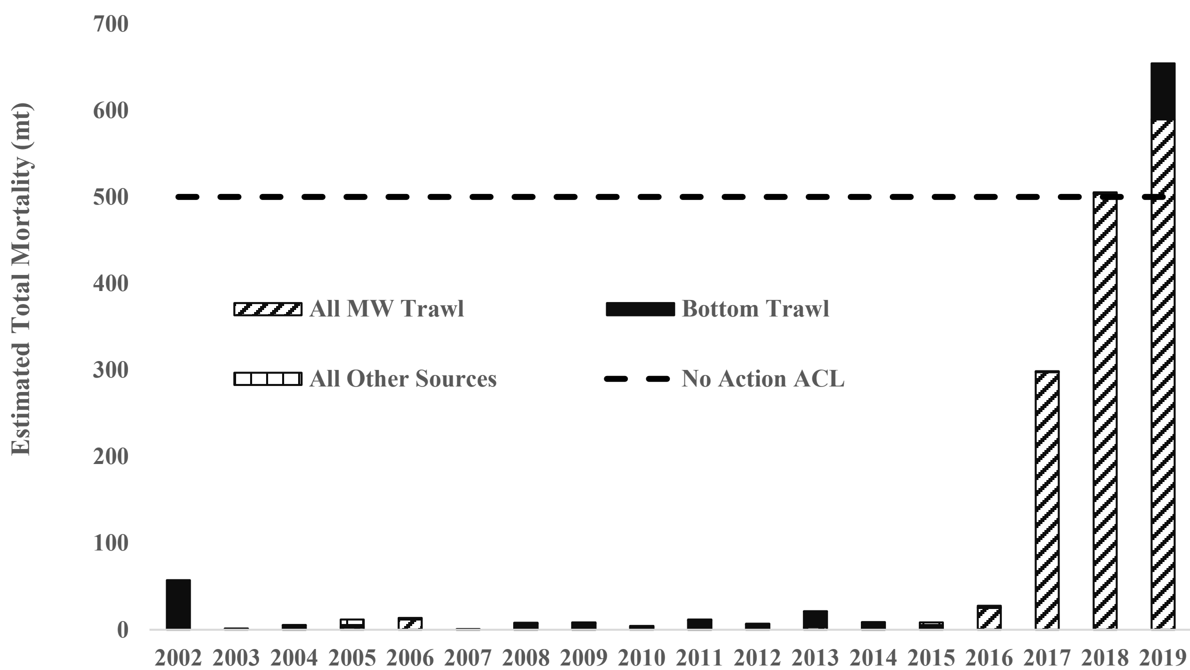

Figure 2-136. Total fishing-related mortality of shortbelly rockfish on the West Coast, 2002-2019. Mortalities in 2019 are preliminary estimates. The dotted horizontal line is the 2019 ACL.

Table 2-12. Estimated total fishing-related mortality (in mts) by sector of shortbelly rockfish on the U.S. West Coast, 2002-2023.

Year	Bottom Trawl	Fixed Gear	Midwater Rockfish	Shoreside Midwater Hake	At-sea Midwater CP	At-sea Midwater MSCV	LE Trawl	WA Tribal Shoreside	Research	Pink Shrimp	Estimated Fishing Mortality	All MW Trawl
2002	--	--	--	0.1	0.5	0.1	56.6	--	--	--	57.3	57.3
2003	--	--	--	0.0	0.5	0.0	0.5	--	--	--	1.0	1.0
2004	--	--	--	--	0.0	0.0	5.3	--	--	6.4	11.8	11.8
2005	--	--	--	--	0.0	2.7	0.8	--	8.2	1.9	13.7	5.5
2006	--	--	--	0.23	0.3	11.2	0.8	--	1.1	--	13.7	12.6
2007	--	--	--	--	0.0	0.0	0.2	0.03	0.3	0.1	0.7	0.4
2008	--	--	--	0.0			7.0	--	1.2	--	8.3	7.1
2009	--	--	--	0.0			7.4	--	1.1	--	8.6	7.5
2010	--	--	--	0.3		0.0	4.0	--	1.8	0.2	6.4	4.6
2011	10.6	--	--	0.0			--	--	1.4	0.2	12.2	10.8
2012	5.5	--	--	0.1	0.0	0.3	--	--	1.2	0.4	7.4	6.2
2013	18.2	0.00	0.02	2.1	0.0	0.7	--	0.02	0.5	3.5	25.1	24.6
2014	8.0	0.00	--	0.0	0.0	0.0	--	--	0.7	8.9	17.7	17.0
2015	4.5	--	0.01	0.7	0.0	0.0	--	--	3.1	0.9	9.3	6.2
2016	0.5	--	0.00	22.9	0.2	1.9	--	--	2.2	2.2	30.0	27.8
2017	0.5	--	3.64	125.3	140.8	27.7	--	0.01	0.6	21.5	320.2	319.6
2018	0.7	0.03	31.75	242.7	85.9	142.2	--	0.00	0.5	3.0	507.7	507.2
2019	4.4	--	7.09	221.2	31.2	345.4	--	0.02	0.7	1.2	666.7	666.0
2020	7.3		186.2	355.1	3.0	29.9	--	--	--	0.3	582.8	582.8
2021	11.1	0.01	19.1	177.5	69.1	52.3	--	0.00	4.3	0.2	333.6	329.3
2022	5.3	--	100.7	280.8	5.4	48.8	--	--	0.4	0.5	441.7	441.3
2023	24.8	0.0	36.0	122.6	4.4	10.8	--	--	0.4	2.1	201.2	200.8

Stock Productivity

Field et al. (2008) assumed a steepness of 0.65 in a Mace-Doonan stock-recruitment relationship (Mace and Doonan 1988) in the 2007 shortbelly rockfish assessment. The data in the assessment model were insufficient for estimating steepness; therefore, an assumed value was used based on the Dorn (2002b) meta-analysis of rockfish steepness available at the time the assessment was conducted.

Recruitment deviations of shortbelly rockfish from 1960-2005 were estimated in the 2007 assessment; however, there was greater confidence in relative year class strength from 1975-2005 (Figure 2-133). The model suggested a long period of poor recruitment through most of the 1990s, associated with a significant decline in biomass (Figure 2-131). The interesting conclusion of the 2007 shortbelly rockfish assessment was how apparent environmental determinants of shortbelly rockfish recruitment and not fishing mortality affected biomass and stock status.

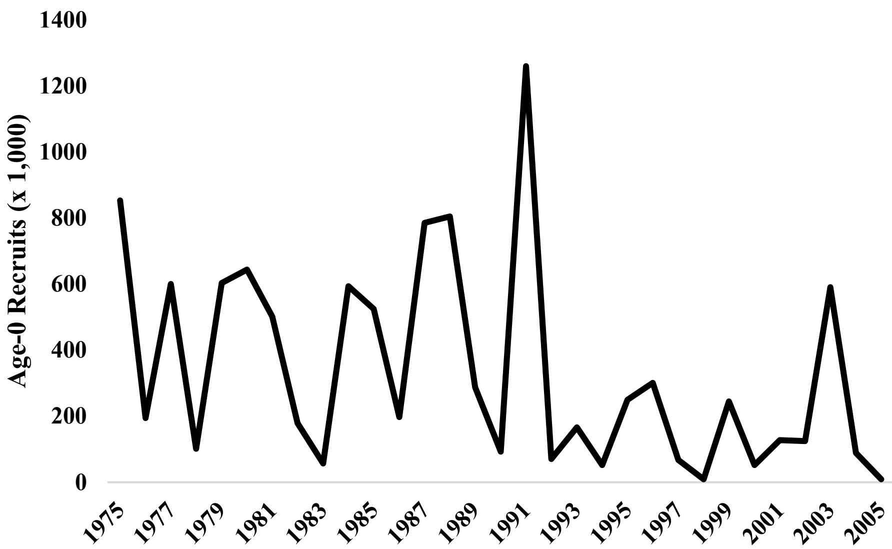

Figure 2-137. Estimated shortbelly rockfish recruitments, 1975-2005 (from Field, *et al.* 2008).

It is posited the order of magnitude increase in shortbelly rockfish bycatch since 2017 was due to a climate change-driven northerly range extension accompanied by exceptionally large recruitment. The pink shrimp trawl bycatch of shortbelly rockfish in 2017 increased by nearly an order of magnitude relative to the average bycatch in the previous 15 years before returning to an average level in 2018 (21.54 mt of the 2017 non-IFQ mortality of 21.57 mt occurred in the pink shrimp fishery (Table 2-12). Incidental rockfish caught in recent year pink shrimp fisheries tend to be very small young-of-the-year (YOY) fish given the fish excluder grates mandated in pink shrimp trawls. The 2017 spike in shortbelly rockfish bycatch in the pink shrimp fishery is indicative of a large recruitment.

Two data sets with information on shortbelly rockfish, the Rockfish Recruitment and Ecosystem Analysis Survey (RREAS) and the California Cooperative Oceanic Fisheries Investigations (CalCOFI) survey sets were examined to provide some insight into overall population size and distribution, respectively.

The RREAS uses midwater (30 m) trawls to capture young-of-the-year rockfishes and provides an index of annual rockfish recruitment (Dick*, et al.* 2018; Dick and MacCall 2013). The "Core" RREAS sample locations are between Monterey Bay and Bodega Bay, California and have been sampled annually since 1990 (Figure 2-134). The survey expanded to include North-Central, South-Central, and Southern parts of California in 2004 and far North California in 2013. The RREAS provides information on the relative number of rockfish that survive to become pelagic juveniles. Because mortality for pelagic juveniles is much lower than for larvae, the number of pelagic juveniles correlates positively with the number of one-year old rockfish the following year and the number of adults in subsequent years. Thus, if the number of pelagic juveniles is high (i.e., recruitment is high), then it is likely that there will be high numbers of adults in the future. Because 50 percent of 2-year old shortbelly rockfish are sexually mature (Love*, et al.* 2002), a high recruitment class is likely to augment the spawning stock biomass after just two years.

The California Current Ecosystem (CCE) experienced a Marine Heatwave (MHW) from 2014-2016, resulting in the warmest 3-year period on record (Jacox*, et al.* 2016). The unusual oceanographic conditions during the MHW were highly conducive for shortbelly rockfish recruitment (Figure 2-135). All RREAS regions recorded historically high shortbelly rockfish recruitment between 2013 and 2016, and recruitment in the Core region was more than an order of magnitude higher than previous values dating back to 1990. Recruitment remained high in 2017 throughout California, and recruitment was 2nd highest in 2017 since 2013 in the North. The extraordinarily high recruitment events between 2013 and 2017 suggest that overall adult shortbelly rockfish population size was very high in 2018 and 2019.

CalCOFI has systematically collected plankton samples off California since 1951 and is the longest-running ocean monitoring program on the planet. The patterns of mean shortbelly rockfish larvae abundance collected by oblique net tows (McClatchie 2014) during winter, which is the peak shortbelly rockfish spawning season (Moser*, et al.* 2001; Moser*, et al.* 2000) were examined (Figure 2-140). Larval abundance correlates with adult biomass (Hsieh*, et al.* 2005), and larval abundances is used as an index of spawning stock biomass (Dick and MacCall 2013). If larval abundance is low in southern California, then it is likely that adult population size is also low. Shortbelly rockfish larval abundance was slightly below average in 2018 in southern California. Larval abundance in 2018 was the 26th highest out of 48 sample years. It thus appears that while shortbelly rockfish are not booming in southern California, they are present at levels consistent with the long-term average.

Taken together, RREAS and CalCOFI surveys suggest that the overall shortbelly rockfish population was very high in 2018-2019, and that the population size in southern California is at close to average level. The presence of shortbelly rockfish in southern California does not necessarily preclude the possibility that the bulk of the population moved from central or northern California into Oregon and Washington, but it does show that this species has not abandoned the southern portion of its range within California.

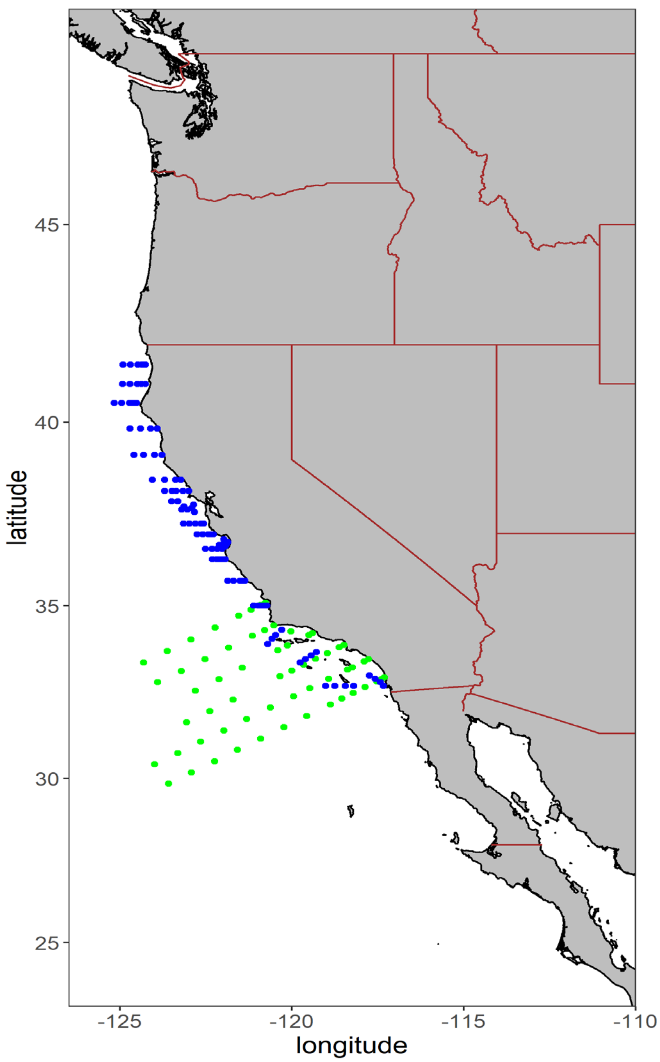

Figure 2-138. Locations of RREAS and CalCOFI sampling. RREAS locations are subdivided among North, North-Central, Core, North-Southern and Southern regions. The CalCOFI stations depict the 66 core stations that have been sampled regularly since 1951.

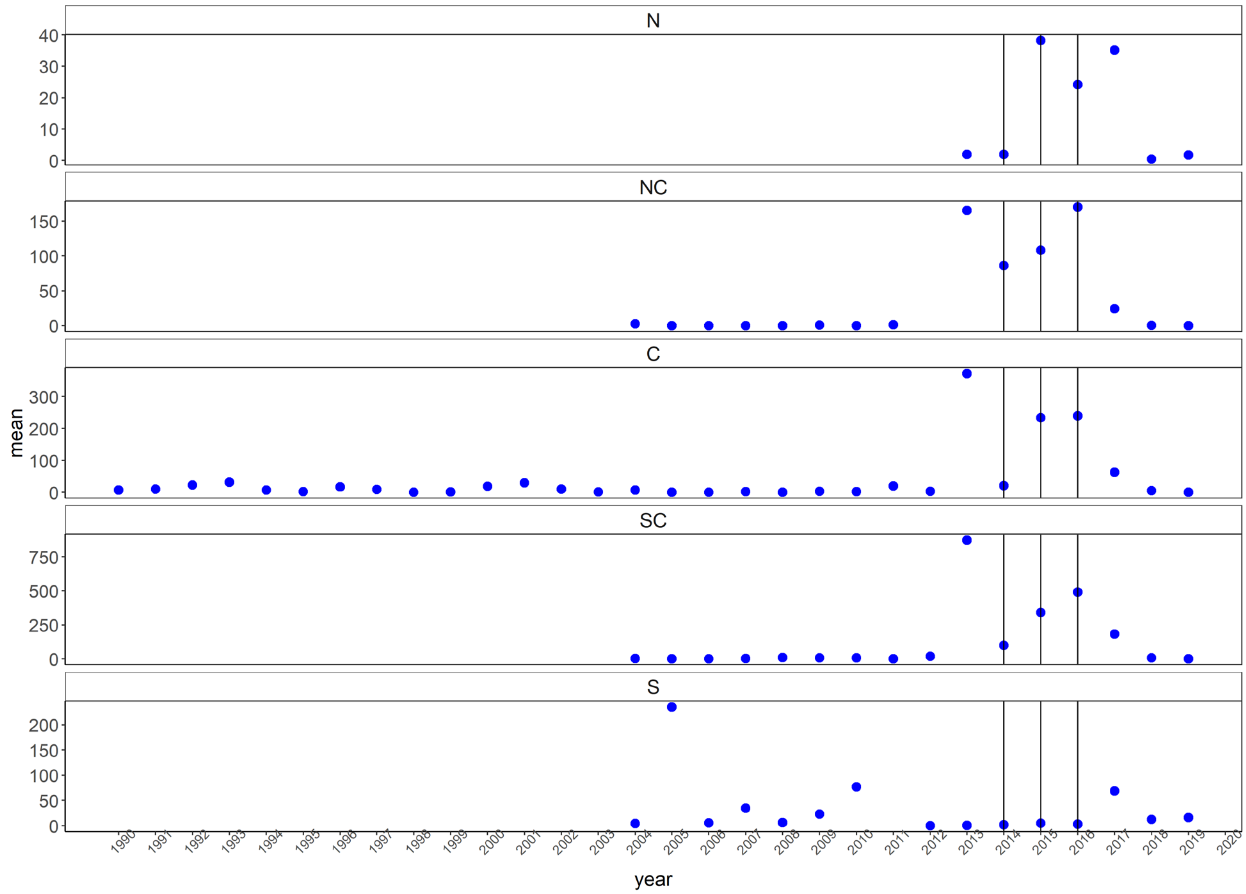

Figure 2-139. Mean abundance of young of the year shortbelly rockfishes from North (N), North-Central (NC), Core (C), South-Central (SC) and South (S) regions of the RREAS.

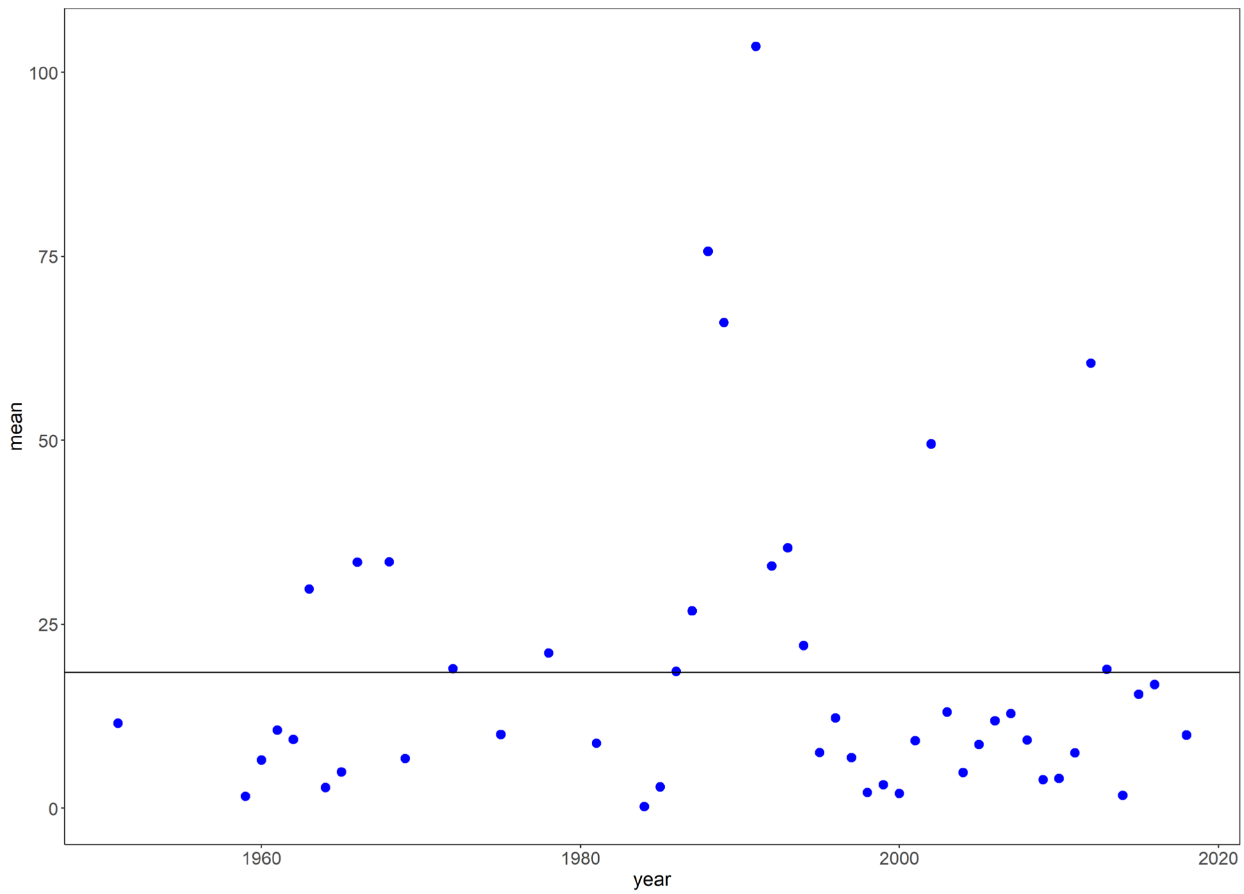

Figure 2-140. Mean winter larval shortbelly rockfish abundances from core CalCOFI stations from 1951-2018. Identification of 2017 abundances are not yet complete and 2017 data were excluded from the plot.

Schroeder et al. (2018) indicate that several strong recruitment years could continue to impact the midwater trawl fishery in 2020 and beyond. The 2018 and 2019 high bycatch levels were driven by relatively strong 2013 and 2014 year classes off central California. As the shortbelly rockfish recruits aged, they moved north into Oregon and Washington. Schroeder et al. (2018) show that 2013 was the highest recruitment anomaly of any rockfish in any year since records began in 1983 (Figure 2-141). If individuals from this record year class continue to remain in the north, off of Oregon and Washington, they will continue to be encountered as bycatch in coming years. Furthermore, Schroeder et al. (2018) show that there were also atypically high year classes in 2014, 2015, and 2016 that could start to become encountered as bycatch in 2019, and beyond.

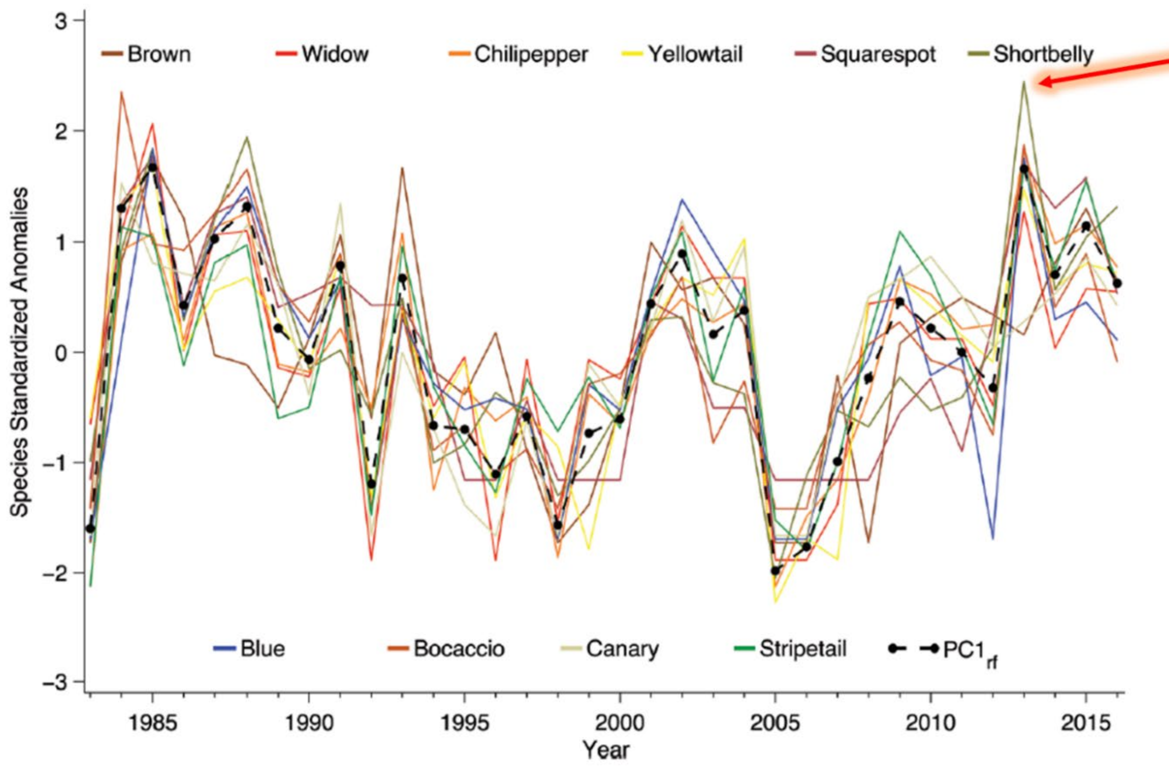

Figure 2-141. Standardized abundance anomalies of the top ten most abundant pelagic juvenile rockfish species and the common trend (Principal Component 1 rockfish; PC1rf) collected by the RREAS midwater trawls from 1983-2016 (this is figure 3 from Schroeder et al. 2018). The glowing red arrow is pointing to the 2013 standardized shortbelly rockfish anomaly.

Encounters of shortbelly rockfish in the NMFS West Coast Bottom Trawl Survey were also evaluated. While the bottom trawl survey does not deploy gear selective to a pelagic rockfish such as shortbelly rockfish, the relative encounter rate of shortbelly rockfish north and south in the survey over time shows there have been increased encounters of shortbelly rockfish in the survey off Oregon and Washington since 2013. In addition, there has been a significantly increased encounter rate in the north since 2017 without a coincident decrease in the shortbelly rockfish encounter rate off California (Figure 2-142). This supports the conclusion that the shortbelly rockfish population did not simply shift to northern waters and the relative abundance of shortbelly rockfish in waters off California has not decreased in recent years. Increased encounters of shortbelly rockfish in northern midwater trawl fisheries is more likely the result of increased recruitment and biomass coastwide coupled with an expansion of its geographic range on the West Coast. It is unclear whether this pattern of abundance and distribution will persist.

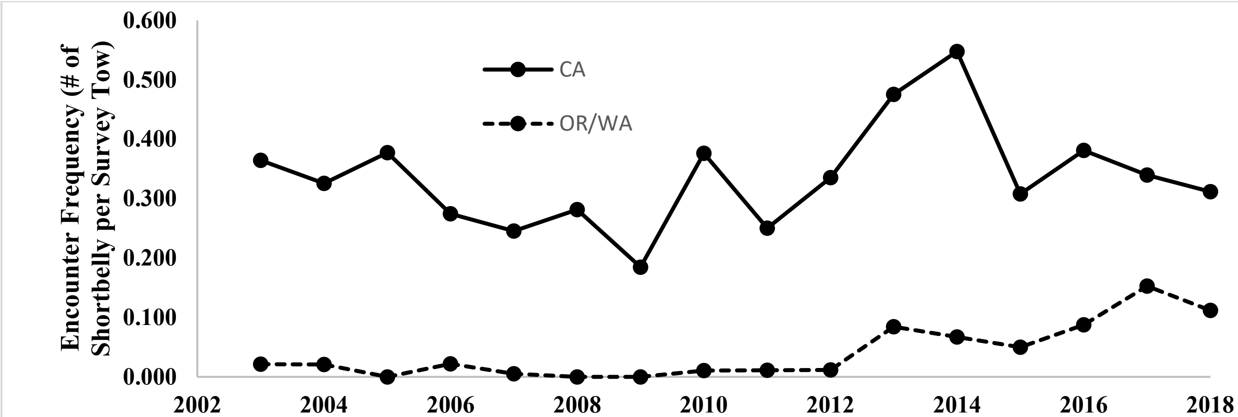

Figure 2-142. Encounter frequency (number of positive tows with shortbelly rockfish/total number of tows each year) of shortbelly rockfish in the NMFS West Coast Bottom Trawl Survey, 2003-2018.

The standardized abundance anomalies shown in Figure 2-141 from Schroeder et al. (2018) can obscure the massive strength of the 2013-2016 year classes and expected population boom. Standardized anomalies put all species on the same scale so that the data can be used in a multivariate Principal Components Analysis, but this can obscure true abundance variability. To better understand and put into context the actual abundance differences, RREAS abundance data from 1990-2016 for the 10 rockfish species analyzed by Schroeder et al. (2018) were used to calculate mean abundances for each species in each year using delta means (delta mean is a technique to calculate means for data that are zero-inflated). Evaluation of mean abundance rather than standardized anomalies illuminates the scale of shortbelly rockfish recruitment from 2013-2016 (Figure 2-143). Shortbelly rockfish mean recruit abundance in 2013 was 25 times higher than the next largest non-shortbelly rockfish yearly mean (chilipepper rockfish in 1993). Further, shortbelly rockfish recruitment in 2013 was more than three orders of magnitude (4,303) times higher than the average yearly recruitment among all rockfishes from 1990-2012. Each of the shortbelly rockfish recruitment classes from 2013-2016 were larger than any recruitment class for any species besides shortbelly rockfish from 1990-2012. Shortbelly rockfish recruitment and subsequent adult populations are currently the highest observed.

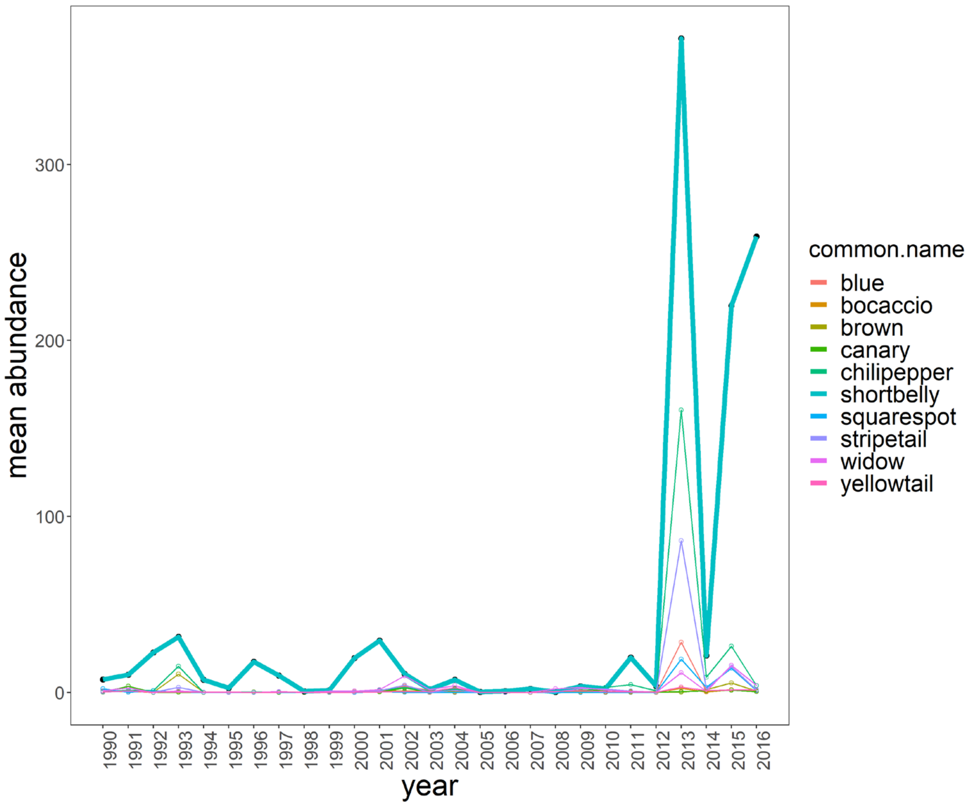

Figure 2-143. Mean yearly abundances, based on number of individuals per 15-minute tow time, from 1990-2016 for the ten rockfishes analyzed by Schroeder et al. (2018). The heavy, turquoise line depicts shortbelly rockfish.

Shortbelly rockfish recruitment in 2013 was 51 times higher than 2004 and 1,750 times higher than 2005. This suggests that shortbelly rockfish population sizes in 2019 may be on the order of 1,000 times greater than in 2005. The overall adult shortbelly rockfish population size is currently high and abundance will likely remain high over the next decade based on high recent recruitment. It is not fully understood why so many individuals moved north in recent years and whether this incursion will continue.

Fishing Mortality

Shortbelly rockfish are not targeted in any West Coast fisheries and were incidentally caught in very small amounts prior to 2017. Love et al. (2002) reported that shortbelly rockfish were commonly caught incidentally with trawl gear in the San Francisco-Monterey region during the development of the trawl fishery in the 1930s and 1940s when they were often referred to as steamer rockcod, as they tended to be common in the steamer lanes south of San Francisco. However, as a result of the small size and poor marketability, only modest domestic landings (1 to 65 mt per year) have been reported in the last 25 years. Historical landings were almost certainly less. Phillips (1939) reported that *S. jordani* accounted for 1 lb. out of 332,630 lbs examined in Monterey wholesale fish markets between 1937 and 1938. Nitsos (1965) reported trace amounts (approximately 1,000 lbs out of 1,920,000 lbs landed) of *S. jordani* landed in Monterey ports from trawlers in 1962-1963, but none were reported from ports other than Monterey. There was historically a short period in which large numbers of shortbelly rockfish were caught during the foreign fisheries of the 1960s and 1970s (Rogers 2003b). These landings (nearly 15,000 mt through 1976, over half of which was taken in 1966) were presumably incidental to the targeting of other rockfish and Pacific hake. Only in the early days of the foreign fisheries (the mid-1960s) were Pacific hake pursued in large numbers south of Cape Mendocino, which is when the bulk of documented historical landings of shortbelly rockfish occurred. Since the early 1970s the Pacific hake fishery has been prosecuted primarily off of Oregon and Washington, and to a lesser extent off of Northern California (generally north of Cape Mendocino).

The available data for historical bycatch rates of shortbelly rockfish are extremely sparse. Shortbelly rockfish had historically been caught incidentally, at times in large numbers, by trawlers targeting other pelagic rockfish (usually chilipepper and widow rockfish). As large hauls of shortbelly rockfish are not marketable but occasionally foul the mesh of typical groundfish trawls, more experienced fishermen generally recognize shortbelly rockfish sign (as well as habitat preferences) on their acoustics, and work to actively avoid schools. This is the challenge of the current midwater trawl fisheries' participants north of 40°10' N. lat. who have no previous experience with shortbelly rockfish. They must now learn to differentiate shortbelly rockfish schools on their sonars to avoid bycatch, which diminishes the value of their target catch of Pacific whiting and pelagic rockfish.

The current exploitation rate of shortbelly rockfish is unknown. However, evidence of recent strong recruitment and continued undiminished densities in its historically predominant habitats south of 40°10' N. lat., there is little apparent risk of current exploitation affecting the stock's function as an important forage in the California Current ecosystem.

2.6 *Historical Information: Rebuilding Plans*

Rebuilding plans for the overfished species are managed through the FMP. This section details the: 1) past and present rebuilding plans, including the rebuilding strategy and parameters and management measures used to limit the catch of each species; 2) a summary of past rebuilding plan parameters; and 3) a summary of the status of each stock at the time it was declared overfished as well as a detailed description of the rebuilding strategy and the communities affected by rebuilding restrictions for each species.

Council may consider changes to rebuilding plans as necessary to respond to the best scientific information available during each biennial specifications and management measures process. Any revisions to the rebuilding periods must be consistent with the MSA; rebuilding time periods must be as short as possible, taking into account the status and biology of the depleted species, the socioeconomic needs of west coast fishing communities, and the interaction of the depleted stocks within the marine ecosystem.

Rebuilding plans were first addressed in the FMP through the implementation of Amendment 12 which established a framework for rebuilding plans. Amendment 16-1 was also implemented to address frameworking issues with rebuilding plans and Amendments 16-2 through 16-5 implemented the first rebuilding plans for overfished species. Revisions to the yelloweye rockfish rebuilding plan were adopted under the 2018-19 biennial process (Appendix B). Amendment 33 was implemented to rebuild the California quillback rockfish stock under the 2025-2026 biennial process.

2.7 *Current Rebuilding Plan Parameters and ACLs*

Yelloweye and California quillback rockfishes are under rebuilding plans as of the 2025-2026 harvest specifications. Stock rebuilding parameters estimated from the most recent rebuilding analyses and current rebuilding parameters specified are provided in Table 2-13.. Table 2-14 is reference to the historical rebuilding plan parameters as adopted under Amendments 16-2 and 16.3d. Table 2-15 and Table 2-16 show rebuilding plan parameters as adopted under Amendments 16-4 and 16-5, respectfully

Table 2-13. Rebuilding parameters estimated in the most recent rebuilding analyses and specified in rebuilding plans for rebuilding groundfish stocks at the start of the 2025-2026 management cycle.

Species	B_0	B_{MSY}	T_{MIN}	$T_{F=0}$	T_{TARGET}	Harvest Control Rule Specification
Yelloweye Rockfish a/	1,139 M eggs	456 M eggs	2025	2026	2028 b/	SPR 65%
California Quillback Rockfish c/	55.08 M eggs	22.03 M eggs	2061	2045	2071	ABC Rule

a/ Yelloweye rockfish rebuilding analysis, Agenda Item F.4, Attachment 2, November 2017

b/ Yelloweye rockfish catch only rebuilding projection Agenda Item G.2, Attachment 15, September 2023

c/ California quillback rockfish rebuilding analysis Agenda Item F.2, Attachment 1, March 2024

2.8 Previous Rebuilding Plan Parameters

Table 2-14. Specified rebuilding plan parameters at the time of plan adoption under Amendments 16-2 and 16-3.

Species	Year Stock Declared Overfished	Year Rebuilding Plan Adopted	B_0	B_{MSY}	T_{MIN}	T_{MAX}	P_{MAX}	T_{TARGET}	Harvest Control Rule
Bocaccio a/	1999	2004	13,387 B eggs in 2003	5,355 B eggs	2018	2032	70%	2023	F=0.0498
Canary Rockfish	2000	2003	31,550 mt	12,620 mt	2057	2076	60%	2074	F=0.022
Cowcod Rockfish	2000	2004	3,367 mt	1,350 mt	2062	2099	60%	2090	F=0.009
Darkblotched Rockfish	2000	2003	29,044 mt	11,618 mt	2014	2047	80%	2030	F=0.027
Lingcod	1999	2003	28,882 mt N; 20,971 mt S	9,153 mt N; 8,389 mt S	2007	2009	60%	2009	F=0.0531 N; F=0.061 S
Pacific Ocean Perch	1999	2003	60,212 units of spawning output	24,084 units of spawning output	2012	2042	70%	2027	F=0.0082
Widow Rockfish b/	2001	2004	43,580 M eggs	17,432 M eggs	2026	2042	60%	2038	F=0.0093
Yelloweye Rockfish	2002	2004	3,875 mt	1,550 mt	2027	2071	80%	2058	F=0.0153

a/ Based on the STATc base model in MacCall (MacCall 2003b)
b/ Based on the Model 8 base model in He, et al. (He, et al. 2003b).

Table 2-15. Specified rebuilding plan parameters revised under Amendment 16-4.

Species	B_0	B_{MSY}	T_{MIN} a/	T_{MAX}	$T_{F=0}$ a/	P_{MAX}	T_{TARGET}	SPR Harvest Rate
Bocaccio	13,402 B eggs in 2005	5,361 B eggs	2018	2032	2021	77.7%	2026	77.7%
Canary Rockfish	34,155 mt	13,662 mt	2048	2071	2053	55.4%	2063	88.7%
Cowcod Rockfish	3,045 mt	1,218 mt	2035	2074	2035	90.6%	2039	90.0%
Darkblotched Rockfish	26,650 M eggs	10,660 M eggs	2009	2033	2010	100%	2011	60.7%
Pacific Ocean Perch	37,838 units of spawning output	15,135 units of spawning output	2015	2043	2015	92.9%	2017	86.4%
Petrale sole	49,678 M eggs	19,871 M eggs	2013	2033	2013	95.2%	2015	95.0%
Yelloweye Rockfish	3,322 mt	1,328 mt	2046	2096	2048	80%	2084	71.9% b/

a/ T_{MIN} is the shortest time to rebuild from the onset of the rebuilding plan or from the first year of a rebuilding plan, which is usually the year after the stock was declared overfished. The shortest possible time to rebuild the stocks with rebuilding plans under consideration in Amendment 16-4 is TF=0, which is the median time to rebuild the stock if all fishing-related mortality were eliminated beginning in 2007.
b/ The yelloweye rebuilding plan specified a harvest rate ramp-down strategy before resuming a constant harvest rate in 2011. F71.9% was the constant harvest rate beginning in 2011.

Table 2-16. Specified rebuilding plan parameters revised under Amendment 16-5.

Species	B_0	B_{MSY}	T_{MIN}	$T_{F=0}$	T_{MAX}	T_{TARGET}	2013 ACL	HCR Specification
Bocaccio	7,946 B eggs	3,178 B eggs	2018	2018	2031	2022	320 mt	SPR 77.7%
Canary Rockfish	25,993 mt	10,397 mt	2024	2024	2050	2030	116 mt	SPR 88.7%
Cowcod Rockfish	2,183 mt	873 mt	2059	2060	2097	2068	3 mt	SPR 82.7%
Darkblotched Rockfish	32,800 mt	13,112 mt	2012	2016	2037	2025	317 mt	SPR 64.9%
Pacific Ocean Perch	37,780 mt	15,112 mt	2017	2018	2071	2051	150 mt	SPR 86.4%
Petrale sole	25,334 mt	6,334 mt	2014	2014	2021	2016	2,592 mt	25-5 Rule
Yelloweye Rockfish	994 M eggs	389 M eggs	2044	2047	2083	2074	18 mt	SPR 76%

2.9 *Rebuilt Stocks*

The following stocks have been rebuilt:

2.9.1 Bocaccio South of 40°10’ N latitude

The bocaccio south of 40°10’ N lat. rebuilding plan was implemented under Amendment 16-3. It was declared successfully rebuilt in 2017 based on a 2017 assessment (He and Field 2018) which indicated the stock was above the $B_{40\%}$ B_{MSY} threshold with a depletion of 48.6% at the start of 2017.

2.9.2 Canary Rockfish

The Canary rockfish rebuilding plan was implemented under Amendment 16-2. It was declared successfully rebuilt in 2016 based on a 2015 assessment (Thorson and Wetzel 2015) which indicated the stock was above the $B_{40\%}$ B_{MSY} threshold with a depletion of 55.5% at the start of 2015.

2.9.3 Cowcod South of 40°10’ N latitude

The cowcod south of 40°10’ N lat. rebuilding plan was implemented under Amendment 16-3. It was declared successfully rebuilt in 2019 based on a 2019 assessment (Dick and He 2019) which indicated the stock was above the $B_{40\%}$ B_{MSY} threshold with a depletion of 57% at the start of 2019.

2.9.4 Darkblotched Rockfish

The darkblotched rockfish rebuilding plan was implemented under Amendment 16-2. It was declared successfully rebuilt in 2017 based on a 2017 assessment (Wallace and Gertseva 2018) which indicated the stock was above the $B_{40\%}$ B_{MSY} threshold with a depletion of 40.03% at the start of 2017.

2.9.5 Lingcod

The west coast lingcod stock rebuilding plan was implemented under Amendment 16-2. It was declared successfully rebuilt in 2005 after the 2005 assessment indicated the stock’s spawning biomass was above the $B_{40\%}$ B_{MSY} threshold with a depletion of 64 percent of unfished biomass ($B_{64\%}$).

2.9.6 Pacific Ocean Perch (POP)

Pacific ocean perch rebuilding plan was implemented under Amendment 16-2. It was declared successfully rebuilt in 2017 based on a 2017 assessment (Wetzel, *et al.* 2017) which indicated the stock was above the $B_{40\%}$ B_{MSY} threshold with a depletion of 76.6% at the start of 2017.

2.9.7 Petrale Sole

The petrale sole rebuilding plan was implemented under Amendment 16-5. It was declared successfully rebuilt in 2016 based on a 2015 update assessment (Stawitz, *et al.* 2015), which indicated the coastwide petrale sole stock was successfully rebuilt with a depletion of 31% at the start of 2015.

2.9.8 Widow Rockfish

The widow rockfish rebuilding plan was implemented under Amendment 16-3. It was declared successfully rebuilt in 2011 after the 2011 assessment indicated the stock's spawning biomass was above the $B_{40\%}$ B_{MSY} threshold with a depletion of 51 percent of unfished biomass ($B_{51\%}$).

3. The Groundfish Harvest Specification Framework and Harvest Specifications for Fisheries in 2025 and Beyond

At the national level, National Standard 1 Guidelines at 50 CFR §600.310 define harvest specifications and what must be considered when specifying them. FMP Chapter 4 describes the framework for biennial specifications. The OFL, ABC, and the ACL for each stock is based on the best scientific information available including endorsed stock assessments, changes in SSC-endorsed stock categories, or changes in SSC-endorsed sigma values (i.e., variances used to estimate the uncertainty in estimating OFLs). Any revised or new HCRs adopted by the Council and used to determine specifications for the subject biennial period become the new default for future biennial management cycles.

West Coast groundfish stocks are managed under a harvest specification framework that considers scientific and management uncertainties. The first specification is the OFL, which is the MSY estimated for the stock and the legal harvest limit beyond which constitutes overfishing. The OFL is determined either by applying the harvest rate estimated to result in a biomass capable of sustaining MSY (i.e., F_{MSY}) recommended by the Council's SSC to an estimate of exploitable biomass in the case of assessed stocks or through an approved data-limited method (e.g., DCAC or DB-SRA) in the case of unassessed stocks. Regardless of the method or data informing the calculation of an OFL, there is scientific uncertainty in the estimation of an OFL. The FMP mandates a precautionary buffer to account for this uncertainty by prescribing an ABC harvest level that is less than the OFL. A further reduction from the ABC can be specified when setting an ACL that accounts for management uncertainty, socioeconomic considerations, ecological considerations, conservation objectives, and/or other considerations the Council and NMFS wish to address. Since the ACL can be set equal to the ABC, the ABC is the highest harvest level that can be specified for West Coast groundfish stocks.

The Groundfish FMP further specifies the framework for harvest specifications as follows, "… the harvest controls from the previous biennium (referred to as default harvest control rules, or default HCRs) are applied to the best available scientific information to determine the numerical values of the harvest specifications for the next biennial period. The default HCR would establish the harvest specifications based on the F_{MSY} (or proxy value) used in the previous biennium applied to the best current estimate of stock biomass to determine the OFL. The ABC is determined by applying the uncertainty buffer used in the previous biennium except that if the P* approach was used, the same P* value used in the previous biennium is applied. The ACL is determined using the appropriate method for current stock status, if known.

Default HCRs were used to determine 2025-26 harvest specifications for all stocks and stock complexes, except for rex sole, dover sole, shortspine thornyhead and California quillback rockfish, for which new HCRs were decided in the 2025-26 harvest specifications process. Draft 2025-26 harvest specifications under default harvest control rules are found in Report GMT008 on PacFIN's Apex dashboard. Final specifications are available in Report GMT015. Currently, this report provides the final 2023-24 harvest specifications. The report will be updated with final

2025-26 harvest specifications when the final rule is published, which is anticipated in December 2024.

The following sections describe the harvest specification framework.

3.1.1 Overfishing Limits

The OFL is the MSY harvest level associated with the current stock abundance and is the estimated or proxy MSY harvest level, which is the harvest threshold above which overfishing occurs. The methods for determining OFL are based on the best available science and the recommendation of the SSC; therefore, alternatives are not developed for this reference point.

The OFL is calculated by applying a deterministic or proxy MSY harvest rate (denoted F_{MSY}) to the estimated exploitable biomass of a managed stock. The F_{MSY} harvest rate may be converted to a Spawning Potential Ratio (i.e. spawning per recruit at the current population level relative to that at the stock's unfished condition). For ease of comparison among stocks and to standardize the basis of rebuilding calculations, it is useful to express any specific fishing mortality rate in terms of its effect on SPR. Given fishery selectivity patterns and basic life history parameters, there is a direct inverse relationship between F and SPR (Figure 3-1). When there is no fishing, each new female recruit is expected to achieve 100 percent of its spawning potential. As fishing intensity increases, expected lifetime reproduction declines due to this added source of mortality. Conversion of F into the equivalent SPR has the benefit of standardizing for differences in growth, maturity, fecundity, natural mortality, and fishery selectivity patterns and, as a consequence, the Council's SSC recommends that it be used routinely.

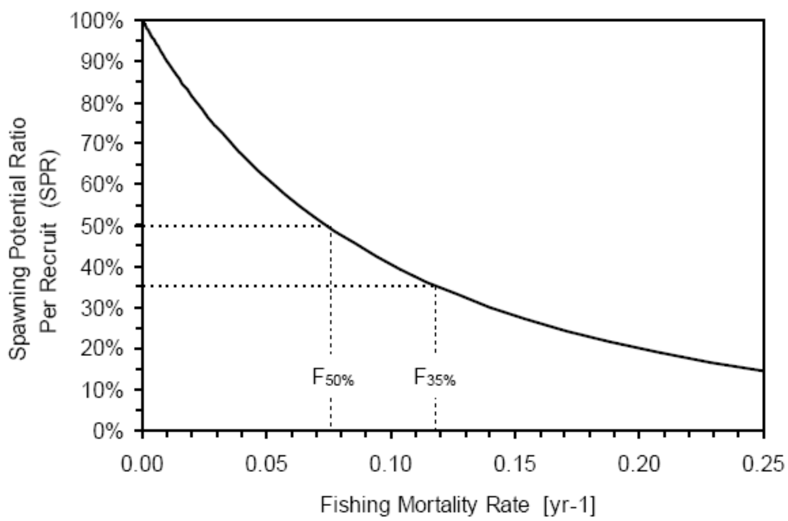

Figure 3-1. Relationship between SPR and instantaneous fishing mortality rate (F) for a hypothetical rockfish.

Amendment 23, which was adopted in December 2010 and implemented in 2011, revised the descriptions of species categories used in the development of harvest specifications. The first category (category 1) includes species with relatively data-rich quantitative stock assessments that are developed on the basis of catch-at-age, catch-at-length, or other data. Recruitments are estimated for category 1 stocks. OFLs and overfished/rebuilding thresholds can generally be calculated for these species. The second category (category 2) includes species for which some biological indicators are available yet data informing an assessment are limited (e.g., estimates of year class strength). Category 2 assessments include data-moderate assessments where catch data and one or more indices of abundance inform the status and biomass of the stock, but age and length compositional data are excluded. This type of assessment allows for a more expeditious assessment review than the category 1 full assessments, which require a rigorous review process[15], thus enabling more stocks to be assessed in an assessment cycle. The third assessment category (category 3) includes minor species which are caught and where the only available information is catch. When setting the 2025 and 2026 OFLs for category 1 or 2 species, F_{MSY} harvest rate proxies were applied to estimates of exploitable biomass for assessed stocks (Table 3-1). Proxies are used because there is insufficient information for most Pacific Coast groundfish stocks to establish a species-specific F_{MSY}. The FMP allows default harvest rate proxies to be modified as scientific knowledge improves for a particular species. Catch-based methods are generally used to determine the OFL for category 3 species.

Table 3-1. Proxy harvest rates by taxa for setting overfishing limits for West Coast groundfish stocks in 2021 and 2022.

Taxa	SPR Harvest Rate
Rockfish	50%
Elasmobranchs	50%
Roundfish	45%
Pacific Whiting	40%
Flatfish	30%

New stock assessments and revised assessment projections recommended by the SSC for use in setting biennial harvest specifications were approved by the Council for setting the 2025 and 2026 biennial harvest specifications.

3.1.2 Acceptable Biological Catches

The ABC is an annual catch specification that is the stock or stock complex's OFL reduced by an amount associated with the scientific uncertainty in estimating the OFL. Under the FMP harvest specification framework, scientific advice that is relatively more uncertain will result in ABCs that are relatively lower, all other things being equal (i.e., a precautionary reduction in catch will occur due purely to scientific uncertainty in estimating the OFL). The ABC is an SSC-recommended catch level that ACLs may not exceed. As explained in more detail below, the SSC developed a two-step approach referred to as the P* approach for determining ABCs. In the P* approach, the SSC determines the amount of scientific uncertainty associated with estimating the OFL in stock assessments, referred to as the sigma (σ) value. The Council then chooses its preferred level of risk of overfishing, a policy decision, which is designated as the overfishing probability (P*). The SSC then applies the P* value to the sigma value to determine the amount by which the OFL is reduced to establish the ABC. The SSC's recommendations for sigma and the reductions from

[15] The review process for new full assessments includes a STAR panel review and a subsequent review by the Council's SSC. Only those assessments that are endorsed by the SSC are considered for formal adoption in the Council process.

OFL associated with different P* values are science-based recommendations; therefore, alternatives to these values are not analyzed.

Sigma values and the associated ABC buffers are greater for stocks with greater uncertainty in the OFL estimate. The SSC assigned each species in the groundfish fishery to one of three categories based on the level of information available about the species (Table 3-2). Sigma values and the associated ABC buffers are highest for relatively data-limited category 3 stocks, lesser for data-moderate category 2 stocks, with data-rich category 1 stocks having the lowest sigma values and smallest ABC buffers.

The SSC evaluated two analytical approaches to inform new sigmas used to determine ABCs in 2021 and beyond (Table 3-3). The first approach used to calculate the baseline sigmas is an update of the meta-analysis of biomass variance of category 1 groundfish and coastal pelagic species (CPS) stocks used to calculate the status quo sigmas (Ralston*, et al.* 2011). The revised meta-analysis evaluated the uncertainty on projected OFLs and more thoroughly evaluated recruitment stochasticity. The second approach (time-varying sigmas) characterized the increased uncertainty associated with using projected OFLs from older assessments. Since true population dynamics will likely differ from expected or assumed dynamics in an assessment projection, there is increased uncertainty in future spawning output and projected OFLs as the projection period increases.

The approach used to determine the baseline sigma for category 1 stocks conducted 25-year projections for each assessment starting in 1998, 2003, and 2008, and set fishing mortality to the F_{MSY} proxy for those years, with stochastic recruitment. One-year projections derived across 15 years for each of the two or three assessments were used for each species. The standard errors for the recruitment deviations for the years before the start of the projection period were set to those for the estimated recruitment deviations from the most recent ten years of the assessment. The resulting sigma using this is 0.439. The new analyses were restricted to benchmark assessments conducted using recent versions of the stock synthesis software (from 2009 to present) and technical constraints prevented the use of seasonal models (e.g., for Pacific sardine). To account for the limitations associated with having only a subset of groundfish species in the analysis, the SSC recommended that the value chosen for sigma from the full set of species (including CPS) be scaled by the ratio of the sigma from the updated historical biomass approach (0.389) and from the subset of species used for this analysis (0.342). The SSC recommended a baseline sigma value of 0.50 (= 0.439*(0.389/0.342)) for category 1 stocks. The SSC recommended baseline sigma values of twice the category 1 value for category 2 stocks (1.0) and four times that value for category 3 stocks (2.0), which were the status ratios between these stock categories.

Time-varying sigmas apply to ABCs for category 1 and 2 stocks beginning in 2021. The OFLs from category 3 analyses are constant; therefore, time-varying sigmas do not apply to category 3 stocks. The approach used to calculate the time-varying sigmas was based on deterministic projections of spawning biomass starting from a low state of nature relative to base-model projections of spawning biomass in category 1 stock assessments. The low state of nature was constructed so that starting spawning biomass is consistent with the previous value for sigma (0.36) with a probability of 25 percent. Projections for both the base model and the low state of nature were based on an assumption of full attainment of the ABCs derived from the base model, which causes the two projections to diverge with the rate of divergence reflecting the population dynamic characteristics of the stock. The SSC recommended applying the relative rate of increase in sigma

(7.5 percent of the baseline value with each additional year) to the baseline category 1 and 2 sigmas of 0.5 and 1.0, –i.e., Sigma (years since assessment) = (baseline sigma) * (1.0 + (years since assessment – 1) * 0.075). The projection year resets to 1 when a full or update assessment is conducted; the projection year will not reset following a catch-only projection.

Table 3-2. Criteria used by the SSC to categorize stocks based on the quantity and quality of data informing the estimate of OFL. Stock categories are used in deciding ABCs that accommodate the uncertainty in estimating OFLs.

Category	Sub-category	Criteria
Category 1 - Data rich stocks. OFL based on F_{MSY} or F_{MSY} proxy from model output. ABC based on P* buffer.		
1	a	Reliable compositional (age and/or size) data sufficient to resolve year-class strength and growth characteristics. Only fishery-dependent trend information available. Age/size structured assessment model.
1	b	As in 1a, but trend information also available from surveys. Age/size structured assessment model.
1	c	Age/size structured assessment model with reliable estimation of the stock-recruit relationship.
Category 2 - Data moderate. OFL derived from model output (or natural mortality).		
2	a	M*survey biomass assessment (as in Rogers 1996).
2	b	Historical catches, fishery-dependent trend information only. An aggregate population model is fit to the available information.
2	c	Historical catches, survey trend information, or at least one absolute abundance estimate. An aggregate population model is fit to the available information.
2	d	Full age-structured assessment, but results are substantially more uncertain than assessments used in the calculation of the P* buffer. The SSC will provide a rationale for each stock placed in this category. Reasons could include that assessment results are very sensitive to model and data assumptions, or that the assessment has not been updated for many years.
Category 3 - Data poor. OFL derived from data-limited methods using historical catch.		
3	a	No reliable catch history. No basis for establishing OFL.
3	b	Reliable catch estimates only for recent years. OFL is average catch during a period when stock is considered to be stable and close to B_{MSY} equilibrium on the basis of expert judgment.
3	c	Reliable aggregate catches during period of fishery development and approximate values for natural mortality. Default analytical approach DCAC.
3	d	Reliable annual historical catches and approximate values for natural mortality and age at 50% maturity. Default analytical approach DB-SRA.

Table 3-3. Relationship between P* and the percent reduction of the OFL for deciding the ABCs in 2021 and beyond for category 1, category 2, and category 3 stocks. Sigmas and ABC buffers increase with the number of years since the last assessment for category 1 and 2 stocks.

Year since assessment	Category 1 (baseline σ = 0.5)				
	P*				
	0.45	0.4	0.35	0.3	0.25
1	6.1%	11.9%	17.5%	23.1%	28.6%
2	6.5%	12.7%	18.7%	24.6%	30.4%

3	7.0%	13.6%	19.9%	26.0%	32.1%
4	7.4%	14.4%	21.0%	27.5%	33.8%
5	7.8%	15.2%	22.2%	28.9%	35.5%
6	8.3%	16.0%	23.3%	30.3%	37.1%
7	8.7%	16.8%	24.4%	31.6%	38.7%
8	9.1%	17.6%	25.5%	33.0%	40.2%
9	9.6%	18.3%	26.5%	34.3%	41.7%
10	10.0%	19.1%	27.6%	35.5%	43.2%
11	10.4%	19.9%	28.6%	36.8%	44.6%
12	10.8%	20.6%	29.6%	38.0%	46.0%
13	11.3%	21.4%	30.7%	39.2%	47.3%
14	11.7%	22.1%	31.6%	40.4%	48.6%
15	12.1%	22.9%	32.6%	41.6%	49.9%
Year since assessment	**Category 2 (baseline σ = 1.0)**				
	P*				
	0.45	**0.4**	**0.35**	**0.3**	**0.25**
1	11.8%	22.4%	32.0%	40.8%	49.1%
2	12.6%	23.8%	33.9%	43.1%	51.6%
3	13.5%	25.3%	35.8%	45.3%	54.0%
4	14.3%	26.7%	37.6%	47.4%	56.2%
5	15.1%	28.1%	39.4%	49.4%	58.4%
6	15.9%	29.4%	41.1%	51.4%	60.4%
7	16.7%	30.7%	42.8%	53.3%	62.4%
8	17.4%	32.0%	44.4%	55.1%	64.2%
9	18.2%	33.3%	46.0%	56.8%	66.0%
10	19.0%	34.6%	47.6%	58.5%	67.7%
11	19.7%	35.8%	49.0%	60.1%	69.3%
12	20.5%	37.0%	50.5%	61.6%	70.8%
13	21.2%	38.2%	51.9%	63.1%	72.2%
14	22.0%	39.4%	53.3%	64.5%	73.6%
15	22.7%	40.5%	54.6%	65.9%	74.9%
	Category 3 (constant σ = 2.0)				
	P*				
	0.45	0.4	0.35	0.3	0.25
	22.2%	39.8%	53.7%	65.0%	74.0%

Considerations for Deciding the Overfishing Probability (P*) When Specifying an Acceptable Biological Catch

The overfishing probability metric (P*) is technically defined as the probability of overfishing a stock based on the scientific uncertainty in estimating the OFL. Interpretation of this definition has generated much discussion in the Council's harvest specification decision-making process. Either P* is interpreted narrowly as the actual probability of overfishing, or P* is considered more broadly as the Council's level of tolerance towards the risk that the OFL will be exceeded. Both viewpoints have merit, but the latter view has more utility in the Council process and is a more accurate representation of how the P* value is decided.

The one problem with the literal definition of P* is that the SSC has recommended a baseline value of sigma (0.50) for category 1 stocks, which are stocks that have assessments with estimated recruitment deviations (i.e., the strength of individual year classes is estimated). Nevertheless, category 1 assessments vary greatly both in the degree of uncertainty and how that uncertainty is characterized in the assessment model. It is common that one or more parameters are either estimated outside the model or assumed based on the assessment scientist's best judgment. In such cases, the uncertainty associated with that parameter is also not estimated nor characterized in any way within the assessment. For example, the 2019 sablefish assessment (Haltuch*, et al.* 2019) appeared to estimate current biomass with significant uncertainty. However, within that assessment many of the key parameters that affect the estimated biomass such as growth and natural mortality are explicitly estimated within the model. The confidence interval associated with the ending year biomass estimate appears quite large relative to other assessments since the uncertainties associated with estimated growth and natural mortality are included within the overall assessment uncertainty. This compares to many other assessments, such as splitnose rockfish in 2009 (Gertseva*, et al.* 2009) or longspine thornyhead in 2013 (Stephens and Taylor 2013) where many parameters are assumed and fixed (e.g., natural mortality and steepness) because there is insufficient information to estimate these parameters in the assessment. In these cases, the biomass variances tend to underestimate the actual uncertainty.

The spectrum of assessment approaches vary between fully Bayesian models with most key parameters estimated (e.g., sablefish in 2019) to deterministic models with most parameters fixed (e.g., longspine thornyhead in 2013). Within the spectrum are parameter estimations using informed or diffuse priors. Given this variety of approaches and the degree to which uncertainty is characterized, it is hard to pursue a formulaic approach where the P* decision hinges on the scientific uncertainty associated with estimating the OFL. For the most part, the relative uncertainty in estimating the OFL is addressed with the SSC's sigma specification, which is only intended to broadly distinguish between assessments along the data-limited to data-rich continuum. The Council's P* decision is therefore most appropriately considered as a risk assessment given many sources of uncertainty regarding the true state of nature for a stock.

3.1.3 Annual Catch Limits

ACLs are specified for each stock and stock complex that is "in the fishery" as specified under the FMP framework. An ACL is a harvest specification set equal to or below the ABC in consideration of conservation objectives, management uncertainty, socioeconomic considerations, ecological considerations, and other factors (e.g., rebuilding considerations) needed to meet management objectives. Sector-specific ACLs may be specified in cases where a sector has a formal, long-term allocation of the harvestable surplus of a stock or stock complex. The ACL counts all sources of fishing-related mortality including landed catch; discard mortalities; research catches; and set-asides for tribal catches, incidental catches in non-groundfish fisheries, and EFPs.

Under the FMP, the biomass level that produces MSY (B_{MSY}) is defined as both the target biomass and the precautionary threshold. When the biomass for an assessed category 1 or 2 stock falls below the precautionary threshold, the harvest rate will be reduced to help the stock return to the B_{MSY} level. If a stock biomass is larger than B_{MSY}, the ACL may be set equal to or less than the ABC. Because B_{MSY} is a long-term average, the true biomass could be below B_{MSY} in some years and above B_{MSY} in other years. Even in the absence of overfishing, biomass may decline to levels below B_{MSY} due to natural fluctuations in recruitment. The MSST is the biomass threshold for declaring a stock overfished. When spawning stock biomass falls below the MSST, a rebuilding plan must be developed that determines the strategy for rebuilding the stock in the shortest time possible while considering impacts to fishing-dependent communities and other factors. As an overfished stock rebuilds above the MSST yet is still below B_{MSY}, the stock is categorized as rebuilding. When spawning stock biomass is below B_{MSY} yet above the MSST and the stock is not managed under a rebuilding plan, the stock is considered to be in the precautionary zone. The current proxy B_{MSY} and MSST reference points for West Coast groundfish stocks are as follows:

- Assessed flatfish stocks: B_{MSY} = 25 percent of initial biomass or $B_{25\%}$; MSST = 12.5 percent of initial biomass or $B_{12.5\%}$ (PFMC and NMFS 2011); and
- All other assessed groundfish stocks: B_{MSY} = 40 percent of initial biomass or $B_{40\%}$; MSST = 25 percent of initial biomass or $B_{25\%}$.

These reference points are only used to manage assessed stocks since they require estimates of spawning stock biomass and relative depletion.

West Coast groundfish stocks are managed with harvest control rules that calculate ACLs below the ABCs when spawning biomass is estimated to be in the precautionary zone. These harvest control rules are designed to prevent a stock from becoming overfished. The FMP defines the 40-10 harvest control rule for stocks with a B_{MSY} proxy of $B_{40\%}$ that are in the precautionary zone. The analogous harvest control rule for assessed flatfish stocks is the 25-5 harvest control rule. Both ACL harvest control rules are applied after the ABC deduction is made. The further the stock biomass is below the precautionary threshold, the greater the reduction in ACL relative to the ABC, until at $B_{10\%}$ for a stock with a B_{MSY} proxy of $B_{40\%}$ or $B_{5\%}$ for a stock with a B_{MSY} proxy of $B_{25\%}$, the ACL would be set at zero[16] (Figure 3-2). These harvest policies foster a quicker return to the B_{MSY} level and serve as an interim rebuilding policy for stocks that are below the MSST. The Council may recommend setting the ACL higher than what the default ACL harvest control rule specifies as long as the ACL does not exceed the ABC, complies with the requirements of the MSA, and is consistent with the FMP and National Standard Guidelines. Additional precautionary adjustments may be made to an ACL if necessary to address management uncertainty,

[16] The lower $B_{10\%}$ and $B_{5\%}$ thresholds in the precautionary ACL harvest control rules are used to establish the slope of the ACL curve in Figure 3-2. These precautionary ACL control rules only apply for stocks in the precautionary zone ($B_{MSY} > B_{CURRENT} >$ MSST). A rebuilding plan governs the ACL harvest control rule for any stock that falls below the MSST and is designated as overfished.

conservation concerns, socioeconomic concerns, ecological considerations, and the other factors that are considered when setting ACLs.

The ACL serves as the basis for invoking AMs, which are management measures or mechanisms used to address any management uncertainty that may result in exceeding an ACL. If ACLs are exceeded more often than 1 in 4 years, then AMs, such as catch monitoring and inseason adjustments to fisheries, need to improve or additional AMs may need to be implemented. Additional AMs may include setting an annual catch target (ACT), which is a specified level of harvest below the ACL. The use of ACTs may be especially important for a stock subject to highly uncertain inseason catch monitoring. A sector-specific ACT may serve as a HG for a sector or may be used strategically in a rebuilding plan to attempt to reduce mortality of an overfished/rebuilding stock more than the rebuilding plan limits prescribe.

The Council has the discretion to adjust the ACLs for uncertainty on a case-by-case basis. In cases where there is a high degree of uncertainty about the condition of the stock or stocks, the ACL may be reduced accordingly. Most category 3 species are managed in a stock complex (such as the rockfish complexes and the Other Flatfish complex) where harvest specifications are set for the complex in its entirety. For stock complexes, the ACL will be less than or equal to the sum of the individual component ABCs. The ACL may be adjusted below the sum of component ABCs as appropriate.

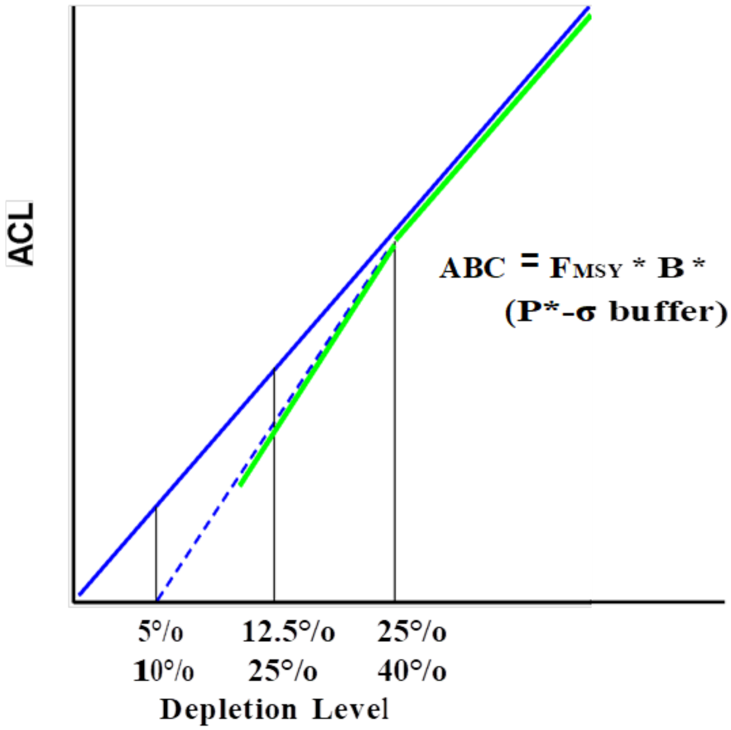

Figure 3-2. Conceptual diagram of the 25-5 and 40-10 ACL harvest control rules used to manage assessed West Coast flatfish and other groundfish species, respectively, that are in the precautionary zone.

4. Discard Mortality

4.1.1 Commercial Fisheries

As noted above, the West Coast commercial fishery utilizes multiple gear types to target the fishery resource. Each gear type, and resulting fishery practice, affects mortality rates of the discarded fish. The following discussion details the rationale for species and gear related discard mortality rates (DMRs). Table 4-1 shows the DMRs by commercial gear type (fixed and trawl) used in the most recent assessments for lingcod, big skate, longnose skate, sablefish, and spiny dogfish.

Lingcod

The GMT recommended using the 50 percent mortality rate for lingcod discarded in West Coast bottom trawl fisheries based on a study that evaluated tow duration and time on deck of trawl-caught lingcod that were ultimately discarded (Parker*, et al.* 2003). Additionally, Davis and Olla (2002) examined tow duration, air temperature, and increased air exposure on lingcod. This study showed increased air and water temperatures likely increase mortality in lingcod. Both the 2009 and 2017 lingcod stock assessment modeled the 50 percent DMR for discarded lingcod in trawl fisheries (Hamel*, et al.* 2009). The GMT recommended a seven percent lingcod DMR be used for the IFQ fixed gear and non-trawl fixed gear commercial fisheries (Table 4-1), qualified by being north or south of 40°10' N. lat. (Table 4-3 and Table 4-4), as well as discards in recreational fisheries (Table 4-6). These DMRs are based on a study off California evaluating immediate and delayed mortality of lingcod caught using these gears (Albin and Karpov 1996).

Quota pounds (QP) for lingcod caught and discarded in the trawl catch shares fishery are debited from IFQ accounts based on the gear-specific DMRs used in stock assessments and year-end catch accounting (Table 4-1). This change was implemented in 2019; previously 100 percent of the discarded lingcod QP were debited from accounts.

Big and Longnose Skate

No studies have been conducted to estimate DMRs for either big or longnose skate (or any other skate). In tagging studies conducted in Canada (Gordon McFarlane, Pacific Biological Station, Fisheries and Oceans Canada, pers. com. as cited in (Gertseva and Schirripa 2008)), tagged skates were recovered several times in trawl surveys, indicating that skates can survive trawl capture and on-deck sorting time. Anecdotal evidence from commercial fisheries also indicates that skates are generally durable and can handle capture and release well. However, many factors, such as trawl time, handling techniques, and time spent on the deck certainly affect skate survival. Gertseva and Schirripa (2008) assumed that 50 percent of commercially-discarded skates die in the 2007 longnose skate assessment. This DMR of 50 percent is assumed for these actively managed skate species, big and longnose skates, for bottom trawl fisheries (Table 4-1). These rates are not applied to bycatch in the pink shrimp trawl fishery.

Sablefish

Sablefish DMRs have been the subject of numerous research studies and analyses supporting historical sablefish stock assessments. Sablefish, lacking a swim-bladder (and therefore the propensity for severe barotrauma), have a very good chance of survival after capture depending on the specific conditions they experience during the process. Generally warmer water results in higher mortality, as the physiological stress of transitioning from very cold bottom temperatures to warmer surface water and air temperatures can be great (Davis*, et al.* 2001). Further, some gears, such as pot and hook and line gear, are less physically damaging to sablefish than, for example, spending an extended period of time in a trawl cod-end with a large catch volume. Treatment and handling of captured fish, including time-on-deck is also important for subsequent survival. The GMT reviewed the research studies informing sablefish discard mortality and recommended the mortality rates of 50 percent for trawl discards and 20 percent for fixed gear discards (Table 4-1); however, for age-0, regardless of fishery, the DMR is assumed to be 100 percent (Johnson et al. 2015). These rates are not applied in nearshore or pink shrimp fisheries. The 2015 update assessment (Johnson et al., 2015) followed the Stewart et al. (2011) assumed DMRs, by gear type of 50 percent for trawl discards and 20 percent for fixed gear discards.

QP for sablefish caught and discarded in the trawl catch shares fishery are debited from IFQ accounts based on the gear-specific DMRs used in stock assessments and year-end catch accounting (Table 4-1). This change was implemented in 2019; previously 100 percent of the discarded sablefish QP were debited from accounts.

Spiny Dogfish Shark

There have been no studies performed on discard mortality of spiny dogfish in the Northeast Pacific Ocean for the bottom trawl or the hook and line fleet. In spiny dogfish assessments conducted elsewhere, different values of discard mortality were assumed, from five percent to 50 percent for bottom trawl and from six percent to 75 percent for hook and line gears, but all sources noted considerable uncertainty in these estimates. Gertseva and Taylor (2011) assumed trawl discard mortality to be 100 percent and hook and line discard mortality to be 50 percent (Table 4-1). The WCGOP/FOS programs use the 50 percent rate for all longline gear in the IFQ, Pacific halibut derby and non-nearshore fixed gear sectors. These two programs assume a 100 percent mortality for all other sectors.

Table 4-1. Mortality rates applied in bottom trawl and fixed gear fisheries. Species without a rate listed for a given fishery and gear were assumed to have a 100 percent mortality rate. Source: Supplemental GMT Report June 2017

Species	Fishery	Gear	Discard Mortality Rate
Big Skate	California Halibut	Trawl	50%
	IFQ Bottom Trawl	Trawl	50%
	LE Bottom Trawl	Trawl	50%
Lingcod	California Halibut	Trawl	50%
	IFQ Bottom Trawl	Trawl	50%
	IFQ Fixed Gear	Line	7%
	LE Bottom Trawl	Trawl	50%
	Non-Nearshore Fixed Gear	Line	7%
	Pacific Halibut Derby	Line	7%
Longnose Skate	California Halibut	Trawl	50%
	IFQ Bottom Trawl	Trawl	50%
	IFQ Fixed Gear	Line and Pot	50%
	LE Bottom Trawl	Trawl	50%
	Non-Nearshore Fixed Gear	Line and Pot	50%
	Pacific Halibut Derby	Line	50%
Sablefish	California Halibut	Trawl	50%
	IFQ Bottom Trawl	Trawl	50%
	IFQ Fixed Gear	Line and Pot	20%
	LE Bottom Trawl	Trawl	50%
	Non-Nearshore Fixed Gear	Line and Pot	20%
	Pacific Halibut Derby	Line	50%
Spiny Dogfish Shark	IFQ Fixed Gear	Line	50%
	Non-Nearshore Fixed Gear	Line	50%
	Pacific Halibut Derby	Line	50%

4.1.2 Nearshore Discard Mortality Rates

Rockfish (*Sebastes* spp.), as well as other nearshore species, DMRs are dependent on the species, depth of capture, and gear type. The GMT updated the surface-release DMRs by depth for rockfish, and other co-occurring species, caught in nearshore commercial fisheries in (see Agenda Item I.2.a, GMT Report 1 and GMT Report 2, March 2017. The changes to the model were:

- Updating the gear proportions by depth with recent data.
- Calculation of regional DMRs to match the WCGOP estimation strata (i.e., north and south of 40°10' N. lat.).
- Utilized the Council approved changes to the "sport-like" surface DMRs.
- Incorporating a bias modifier to calibrate the gear proportions from WCGOP (a sub-sample of landings) to reflect the gear proportions from fish tickets in PacFIN.

The GMT assumed the same DMRs by depth and species for nearshore commercial fisheries using recreational hook and line gear (i.e., rod and reel gear) as recommended by the SSC for recreational fisheries (Table 4-2). For rockfish caught using non-recreational gear types (e.g., longline, dinglebar, etc.), a 100 percent DMR was applied by the GMT in their work on harvest specifications and management measures. Discard rates were weighted by depth bin for recreational and non-recreational gear types by the proportion of these gears types deployed in the Oregon nearshore commercial fishery using 2004-2006 Oregon logbook data (Table 4-2). The mortality rates in the deepest depth bin, >30 fm, as shown in Table 4-3, did not use the above prescribed method due to small sample sizes informing bycatch and discard at those deeper depths and are considered risk-averse. The combined weighted discard rates for all nearshore commercial gears by rockfish species and depth bin were updated in 2017 and qualified above or below the nearshore DMRs for rockfish, by depth, for commercial fisheries north and south of 40°10’ N. lat. (Table 4-3 and Table 4-4).

Table 4-2. Proportion of recreational and non-recreational gears used in 2004-06 Oregon nearshore commercial fisheries based on logbook data.

Gear Type	Depth Bin		
	0-10 fm	11-20 fm	>20 fm
Recreational	86.6%	72.3%	60.7%
Non-recreational	13.4%	27.7%	39.3%

Table 4-3 and Table 4-4 show the updated nearshore DMRs for rockfish species, by depth bins, for areas north and south of 40°10’ N. lat. Table 4-5 shows the commercial nearshore DMRs for non-rockfish, co-occurring species, by depth.

Table 4-3. Nearshore discard mortality rates for rockfish, by depth, commercial fisheries north of 40°10’ N. lat. Source: Supplemental GMT Report June 2017

Species	Depth Bins			
	0-10 fm	10-20 fm	20-30 fm	>30 fm
Black & Yellow Rockfish	20%	31%	52%	100%
Black Rockfish	18%	28%	46%	63%
Blue/Deacon Rockfish	25%	37%	57%	100%
Boccaccio Rockfish	26%	39%	59%	100%
Brown Rockfish	19%	30%	49%	100%
Calico Rockfish	19%	30%	49%	100%
Canary rockfish	27%	43%	65%	100%
China Rockfish	20%	31%	52%	100%
Copper Rockfish	26%	40%	61%	100%
Gopher Rockfish	26%	40%	62%	100%
Grass Rockfish	29%	50%	72%	100%
Kelp Rockfish	18%	27%	46%	100%
Olive Rockfish	39%	50%	68%	100%
Quillback Rockfish	27%	41%	64%	100%

Species	Depth Bins			
	0-10 fm	**10-20 fm**	**20-30 fm**	**>30 fm**
Tiger Rockfish	26%	41%	63%	100%
Treefish	21%	32%	54%	100%
Vermilion Rockfish	26%	40%	62%	100%
Widow Rockfish	27%	42%	64%	100%
Yelloweye rockfish	28%	45%	67%	100%
Yellowtail Rockfish	17%	25%	43%	50%

Table 4-4. Nearshore discard mortality rates for rockfish, by depth, for commercial fisheries south of 40°10’ N. lat.

Species	Depth Bins			
	0-10 fm	**10-20 fm**	**20-30 fm**	**>30 fm**
Black & Yellow Rockfish	54%	65%	72%	100%
Black Rockfish	53%	63%	69%	96%
Blue/Deacon Rockfish	57%	67%	75%	100%
Boccaccio Rockfish	57%	68%	76%	100%
Brown Rockfish	54%	64%	71%	100%
Calico Rockfish	54%	65%	72%	100%
Canary rockfish	60%	73%	82%	100%
China Rockfish	58%	71%	79%	100%
Copper Rockfish	57%	69%	77%	100%
Gopher Rockfish	57%	69%	78%	100%
Grass Rockfish	59%	74%	84%	100%
Kelp Rockfish	53%	62%	69%	100%
Olive Rockfish	65%	74%	81%	100%
Quillback Rockfish	58%	70%	79%	100%
Tiger Rockfish	58%	70%	78%	100%
Treefish	55%	65%	73%	100%
Vermilion Rockfish	58%	69%	78%	100%
Widow Rockfish	58%	70%	79%	100%
Yelloweye rockfish	59%	72%	81%	100%
Yellowtail Rockfish	53%	61%	67%	94%

Table 4-5. Nearshore discard mortality rates for all depths in West Coast commercial fisheries (Somers, *et al.* 2020).

Species Group	Species	DMR
Ecosystem Component	Spotted Ratfish	7%
	Soupfin Shark	7%
	Sandpaper Skate	7%
	All other skates other than Longnose and Big Skate	7%
Other Fish Species	Big Skate	7%
	Cabezon (CA)	7%
	Cabezon (OR)	7%
	Kelp Greenling (CA)	7%
	Kelp Greenling (OR)	7%
	Lingcod	7%
	Longnose Skate	7%
	Spiny Dogfish Shark	7%
Flatfish	Butter Sole	7%
	Pacific Halibut	7%
	Pacific Sanddab	7%
	Petrale Sole	7%
	Rock Sole	7%
	Sand Sole	7%

4.1.3 Recreational

The GMT analyzed the disposition of observed discards of groundfish species released at the surface of recreational charter fishing efforts off California and Oregon to determine depth-based DMRs using recreational hook and line gear. The GMT considered “surface” mortality (i.e., mortality that is observable when a fish is brought to the surface, handled on deck, and thrown back) from charter observations, as well as short-term, below-surface mortality that has been documented in research trials to a limited extent using underwater cameras or divers. Using a guild-based GLM analysis comparing mortality rates of species with similar depth-distributions and vertical orientation in the water column, the GMT determined mortality rates for species with limited discard observations. The GMT calculated the upper 95 percent confidence intervals of surface mortality rates to illustrate the uncertainty associated with GLM predictions. Since upper 95 percent confidence limits for surface mortality approach 100 percent at depths greater than 30 fm, mortality beyond this depth was assumed to be 100 percent. The two exceptions to this approach were yellowtail and black rockfish, given their relatively low mortality rates. The depth-based discard mortality matrix developed by the GMT shows a wide variation in rockfish mortality rates by depth reflecting the diversity of rockfish adaptations to barotrauma (Table 4-6). Yellowtail and black rockfish, which are more pelagic than most of the other rockfish, tend to suffer less barotrauma and therefore exhibit lower surface-release mortality rates.

Estimates of surface release discard mortalities for groundfish species that lack a swim bladder (e.g., lingcod and flatfishes) were based on research efforts off California (Albin and Karpov 1996). The seven percent DMR is assumed for such species; however, the analysis only considered FMP species lacking a swim bladder and therefore the seven percent DMR does not apply to non-FMP species. The resulting depth-based surface release mortality rates for various groundfish species released using recreational hook and line gears were implemented in 2009 to determine discard mortalities (Table 4-6).

Table 4-6. Discard mortality rates by depth of groundfish species released at the surface in West Coast recreational fisheries using hook-and-line gear.

Species Group	Species	Depth Bins			
		0-10 fm	11-20 fm	21-30 fm	>30 fm
Rockfish	Black Rockfish	11%	20%	29%	63%
	Black-and-yellow Rockfish	13%	24%	37%	100%
	Blue Rockfish	18%	30%	43%	100%
	Bocaccio	19%	32%	46%	100%
	Brown Rockfish	12%	22%	33%	100%
	Calico Rockfish	24%	43%	60%	100%
	Canary rockfish	21%	37%	53%	100%
	China Rockfish	13%	24%	37%	100%
	Copper Rockfish	19%	33%	48%	100%
	Gopher Rockfish	19%	34%	49%	100%
	Grass Rockfish	23%	45%	63%	100%
	Kelp Rockfish	11%	19%	29%	100%
	Olive Rockfish	34%	45%	57%	100%
	Quillback Rockfish	21%	35%	52%	100%
	Tiger Rockfish	20%	35%	51%	100%
	Treefish	14%	25%	39%	100%
	Vermilion Rockfish	20%	34%	50%	100%
	Widow Rockfish	21%	36%	52%	100%
	Yelloweye Rockfish	22%	39%	56%	100%
	Yellowtail Rockfish	10%	17%	25%	50%
Other Fish	Cabezon	7%	7%	7%	7%
	California Scorpionfish	7%	7%	7%	7%
	Kelp Greenling	7%	7%	7%	7%
	Lingcod	7%	7%	7%	7%
	Pacific Cod	5%	32%	53%	97%
General Cat.	Flatfish	7%	7%	7%	7%
	Sharks and Skates	7%	7%	7%	7%
	Dogfish	7%	7%	7%	7%

4.1.4 Pacific Halibut Discard Mortality Rates

Pacific halibut are managed by the IPHC and they establish DMRs for use in the fishery at-large. There are considerable data on post-release survivorship of Pacific halibut and the IPHC has established release viability condition codes, which can be translated into DMRs. These condition codes are assigned to discarded halibut by observers when they asses the condition of Pacific halibut upon release (West Coast Groundfish Observer Program Manual). Condition codes are specific to fishery gear, but, in general, contain three condition codes: excellent, poor, or dead.

In 2017, the Council tasked the SSC to review the GMT's proposed methodology for determining Pacific halibut DMRs for camera-based - (EM) as historically halibut caught on EM trips were assigned 90 percent mortality (corresponding with the dead viability category) because video reviewers could not determine the condition of the halibut using the IPHC key, as it requires hands-on assessment. Given that the 90 percent DMR is conservative compared to the observer viability approach, and because halibut bycatch can be constraining, the Council requested development of alternative EM DMRs that better reflect the estimated mortality of the halibut discarded on EM trips and more closely align with the rates used on observed trips. The GMT presented a time-on-deck methodology, which was endorsed by the SSC, for halibut discarded on bottom trawl trips (Agenda Item F.11.a, GMT Report 1, November 2017).

In terms of management and catch accounting, for IFQ bottom trawl trips north of 40°10' N. lat. with onboard observers, discarded Pacific halibut are debited from the vessel's individual bycatch quota account based on the viability of the discarded fish. Whereas on EM EFP trips, the rates vary by gear type. For bottom trawl trips, the DMR is based on time on deck. For discarded halibut on non-whiting midwater trawl trips, they are assigned the default IPHC mortality rate of 90 percent mortality for optimized retention trips and a 100 percent mortality for maximized retention trips.

4.1.5 Descending Devices

Research has shown the effects of barotrauma can be mitigated in physoclistous (i.e., the swim bladder is not connected to the alimentary canal via a pneumatic duct) fish such as rockfish by releasing them at depth by using descending devices (Hannah*, et al.* 2012; Jarvis and Lowe 2008; Parker*, et al.* 2006; Pribyl*, et al.* 2012).

Research on rockfish barotrauma mitigation for black rockfish, canary rockfish, cowcod, and yelloweye rockfish was evaluated to determine depth-based mortality rates associated with release using descending devices by the GMT in 2022 (Agenda Item H.4.a, Supplemental GMT Report 2, November 2022). The use of descending devices for returning discarded rockfish species back to depth has the ability to reduce barotrauma mortality. If descending devices are used, the application of existing surface mortality rates may result in overestimates of discard mortality for depths greater than 10 to 20 fathoms. While discard mortality may vary by species based on their anatomical and physiological adaptations to changes in pressure affecting barotrauma, there are likely to be general trends across species that allow for a generalized estimate of discard mortality for grouping of species (e.g., demersal, pelagic, and dwarf species guild groups) that can be applied to those species without sufficient data to inform a species-specific estimate. The existing surface release mortality rates that are used to estimate mortality of discarded rockfish apply a similar grouping approach where there are pelagic or demersal specific mortality rates (i.e., they are additionally broken out into shallow and deep by guild).

The GMT determined depth-based DMRs associated with the use of descending devices for these stocks in a Bayesian Hierarchical model that considered the uncertainty of using other species as a proxy for these three, as well as the uncertainty associated with missing observations in one or more depth bins (Agenda Item H.4.a, Supplemental GMT Report 1, November 2022). The 2014 Bayesian hierarchical model was updated hyper-prior to develop posterior predicted estimates of discard mortality when descending devices (referred to as simply "discard mortality") are used for each species and grouped across species. Additionally, the GMT proposed (and Council adopted) a simplified approach to determine the final mortality rates used by management, termed "cumulative mortality" (i.e., an approach that can combine both model estimated discard mortality and an additional unaccounted mortality component) at the 80th percentile. Finally, the GMT proposed that the cumulative mortality rates by species groups can provide general

The methodology used to develop the following descending device DMRs is described in Agenda Item H.4.a, Supplemental GMT Report 1, November 2022 and is incorporated by reference. A key aspect of this work was defining guilds of species where DMRs were expected to be similar (Table 4-8)

Table 4-7. GMT recommended species-specific depth-dependent cumulative mortality rates (in percent) with the use of descending devices based on the 80th percentile.

Depth Bin (in fms)	Canary rockfish	Yelloweye rockfish	Cowcod	Black rockfish
0-10	3% [a/]	9% [a/]	9% [a/]	11% [b/]
10-30	3%	9%[a]	9%[c/]	16%
30-50	18%	11%	25%	24% [c/]
50-100	92% [c/]	38% [c/]	38% [c/]	63% [b/]
100+	100% [b/]			

[a/] Depth-dependent discard mortality based on guild-based estimate from the next deeper-depth bin with the use of a descending device.

[b/] Depth-dependent discard mortality based on the surface mortality rate.

[c/] Depth-dependent discard mortality rate with the use of a descending device based on the guild-based estimate.

Table 4-8. List of the rockfish species or species complex within each rockfish guild that do not have species-specific cumulative mortality rates where the guild-based estimate would be used to estimate recreational discard mortality with the use of descending devices.

Guild	Rockfish Species or Species Complex
Demersal	Aurora, Bank, Black and Yellow, Blackgill, Blackspotted, Bronzespotted, Brown, Calico, Chameleon, China, Copper, Darkblotched, Dusky, Flag, Gopher, Grass, Greenblotched, Greenspotted, Greenstriped, Kelp, Mexican, Pacific ocean perch, Pink, Pinkrose, Puget Sound, Quillback, Redbanded, Redstripe, Rosethorn, Rosy, Rougheye, Sharpchin, Shortbelly, Shortraker, Silvergray, Speckled, Splitnose, Starry, Stripetail, Sunset/Vermilion, Swordspine, Tiger, Treefish, Yellowmouth
Pelagic	Blue/Deacon, Bocaccio, Chilipepper, Olive, Widow, Yellowtail
Dwarf	Dwarf-red, Freckled, Halfbanded, Harlequin, Honeycomb, Pygmy, Semaphore, Squarespot

Table 4-9. GMT recommended guild-specific depth-dependent cumulative mortality rates (in percent) with the use of descending devices based on the 80th percentile.

Depth Bin (in fm)	Pelagic Guild	Demersal Guild	Dwarf Guild
0-10	34% [c/]	9% [a/]	21% [b/]
10-30	34%	9%	67% [a/]
30-50	53%	30%	67%
50-100	92%	38%	100% [b/]
100+	100% [b/]		

[a/] Depth-dependent discard mortality based on guild-based estimate from the next deeper-depth bin with the use of a descending device.

[b/] Depth-dependent discard mortality based on the surface mortality rate.

[c/] Depth-dependent discard mortality based on the surface mortality rate for olive rockfish that had the highest pelagic surface mortality rate at this depth.

5. Impact Projection Models

5.1 Non-nearshore/Nearshore Fixed Gear Models

5.1.1 Non-Nearshore

The non-nearshore model projects bycatch impacts for limited entry and open access fixed gear vessels that are fishing seaward of the non-trawl Rockfish Conservation Area (NT_RCA). The main focus is on bycatch of yelloweye rockfish. This model was reviewed by the Pacific Fishery Management Council's (PMFC) Scientific and Statistical Committee (SSC) in 2013 and endorsed as "best available science and appropriate for use in the 2015-16 specifications process." (Agenda Item F.7.b, Supplemental SSC Report, June 2013) West Coast Groundfish Observer Program (WCGOP) observations on discards and landed catch 2002-21 provide the primary data input for estimating bycatch with Pacific Fishery Information Network (PacFIN) fish ticket data also providing information on the distribution of catch among gear types. Data from 2021 were the most recent data available at the time of the analysis. The core structure of the projection model has not been changed from 2019-20 biennial process.

Sablefish is the primary target for vessels fishing in these sectors. The sablefish (*Anoplopoma fimbria*) annual catch limit (ACL) north of 36° N lat. is apportioned according to the formal intersector allocations shown in Figure 1-1. The formal intersector allocations of sablefish north of 36° N lat. Management measures are intended to keep the total mortality—i.e., discard mortality and landings—within the allocation for each sector (Figure 5-1). Because of the economic importance of sablefish, the bycatch impact analysis assumes that the annual sablefish allocation will be fully attained by the fixed gear fleets seaward of the NT_RCA. WCGOP bycatch observations are therefore expressed as a ratio to the expected landings of sablefish.

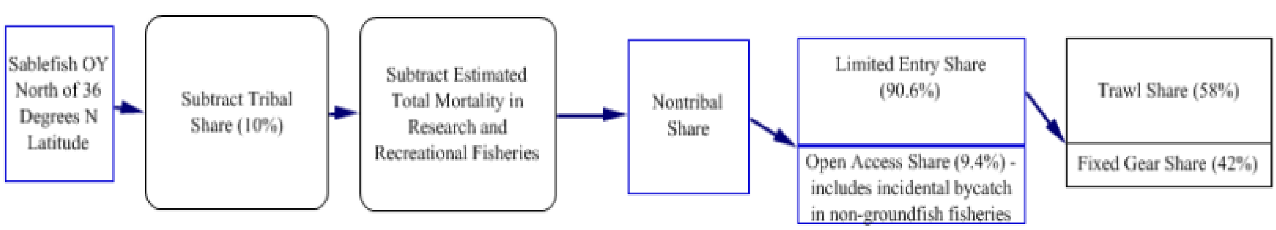

Figure 5-1. **The formal intersector allocations of sablefish north of 36° N lat**

The model continues to combine data from the fixed gear sablefish fishery north of 40° 10' N lat. and 40°10' to 36° N. lat. from the years 2002-21. Data from each year is weighted equally. There are tradeoffs with data accuracy and precision involved with stratifying observations to finer levels across attributes (i.e., time, area, depth, and gear type). Aggregating data across years allows reporting of retained and discarded catch of groundfish species by gear type at a finer latitudinal and depth scale than would otherwise be possible. Differences in the encounter rate of yelloweye rockfish (and previously canary rockfish) between depths and areas are the major focus of the model and so these stratifications have taken priority. The data is stratified by gear because of the differences in the rate of encounter between pot and longline gear types.

Data summarizing observed retained and discarded catch from fishing efforts north of 40° 10' N lat. are stratified across three alternative depth ranges that are used to evaluate the potential impact of extending the seaward boundary of the NT_RCA on bycatch levels. As described in the Agenda Item F.6, Attachment 2, June 2022, the seaward NT_RCA boundary is the key bycatch management measures in these non-nearshore sectors. Although the range of depths recorded for an individual fixed gear set by observers is commonly much smaller than for observed trawl tows, there is some uncertainty in the assignment of catch and discard from many sets to a specific 25 fm interval. For this exercise, the average of the beginning and ending depths of each set was used to represent the depth at which all fish on the set were caught.

The area stratification used in this model was developed first for use in the 2009-10 biennial management cycle. This stratification was arrived at through consideration of canary rockfish and yelloweye rockfish bycatch north of 40° 10' N lat. by depth and area and provides the Council with the option of employing differential seaward RCA boundaries within these areas. Four subareas were identified bounded by:

1. Cape Mendocino 40°10' N lat. to the boundary of the northern Eureka International North Pacific Fishery Commission (INPFC) statistical area at 43°30' N lat.;
2. Northern Eureka INPFC boundary to Cascade Head at 45°03' N lat.);
3. Cascade Head to Point Chehalis (46°54’ N lat.), and
4. Point Chehalis to the U.S.-Canada border (49° N. lat.).

Several alternative boundaries were evaluated. Analysts determined that the four listed above provided the greatest contrast and reliability between areas of high and low yelloweye rockfish bycatch. Since rockfish bycatch in the pot gear fleet is small and there are limited numbers of pot gear observations in some areas, results for this group are summarized with respect to depth only (without subareas). Note at the beginning of the 2017-18 biennium, the seaward boundary of the NT_RCA was moved from 150 fm to 125 fm in the area between 34°27′ N lat. and 40°10′ N lat.

To produce estimates of catch by area, the model must assume a distribution of sablefish catch north of 40°10’ N. lat. and in the area between 40°10' N lat. and 36° N. lat.by gear types (longline vs pot) for both the open access and limited entry sectors. The assumed distribution is based on fish ticket landings for the years 2002-21. The 2002-21 average of WCGOP observed landings are then used to project the distribution of the longline catch north of 40°10' N lat. among the four management subareas. The model then applies WCGOP observed discard rates to these projected catch distributions using the appropriate area, depth, and gear stratification to produce annual estimates of discard for the rebuilding rockfish (e.g., yellowtail rockfish) encountered by the non-nearshore fixed gear sectors. Discard rates were calculated by dividing the total observed discard weight for each species by the weight of retained sablefish. Data is available for all species encountered in the non-nearshore sectors; yet focuses on yelloweye rockfish and the potential need to adjust the seaward boundary of the NT_RCA to lower their catch. The total mortality of other groundfish species discarded and landed by these sectors is reviewed and accounted for annually and will be addressed if catch reaches levels where a sector allocation or other catch limit is at risk of being exceeded. If necessary, the structure and data in this model could be used to project bycatch of species for which discard becomes a concern in the non-nearshore sectors.

5.1.2 Sablefish Daily Trip Limit Model Description

The models used to project sablefish landings by the Limited Entry Fixed Gear (LEFG) and Open Access (OA) Daily Trip Limit (DTL) sectors north and south of 36° N. lat. are multiple linear regression models that use trip limits and or expected inflation-adjusted sablefish price per pound to predict bimonthly landings, separately for each sector. They are also used for inseason management. Detailed descriptions of the models can be found in Appendix A of the 2011-2012 harvest specifications EIS. The models were originally produced by members of the GMT, Oregon Department of Fish and Wildlife (ODFW), National Oceanic and Atmospheric Administration (NOAA) Southwest Fisheries Science Center (SWFSC), and Northwest Fisheries Science Center (NWFSC) in 2006 (LEFG) and 2009 (OA).

Changes in model specification are made as needed over time to increase accuracy of projections where possible. The LEFG and OA models north of 36° N. lat. were reviewed and updated in 2023 as part of an SSC methodology review.[17] Changes since the 2017-18 harvest specifications include: new landings data through 2023 were added to all four models, period-specific fixed effects were used in place of the former method which created separate linear regressions for each period, data weighting was removed, the period 4 adjuster variable was removed, and fixed effects from the COVID-19 pandemic (2020-2021) were added. The time range of data included in each model varies from 2007-2023, to 2012-2023, depending on its information content for making projections. Sablefish DTL Model Methodology Review Materials for May 9 SSC Subcommittee Workshop (May 2023).

Accuracy of prediction varies among the four models. Of the four, the best fit of predicted to actual bimonthly landings is produced by the model for the LEFG sector north of 36° N. lat. (LEN), with an in sample R^2 value of 0.8059. Using the most recent data, the worst fit between predicted and actual landings comes from the model for the OA sector north of 36° N. lat. (OAN), with an R^2 value of 0.3038. However, in spite of the relatively low model fit, landings in the OAN sector have been less than 23 percent of the landings target since 2017, and, therefore, there is little concern of exceeding the landing share. Prediction outputs and input variables for each of the DTL sectors are shown in Table . To predict total fleetwide landings for each sector, predicted landings per vessel is multiplied Table 5-1 by the predicted number of vessels for each period, with the exception of LES for which fleetwide landings are predicted in a single model.

Table 5-1. Prediction outputs and input variables for each of the sablefish DTL models.

Sector	Prediction Output	Regression Inputs
LEN	Landings per vessel	Bimonthly trip limit + period-specific fixed effects + COVID-19 fixed effects
	# of vessels	Price (inflation adjusted) + period-specific fixed effects + COVID-19 fixed effects
OAN	Landings per vessel	Bimonthly trip limit + period-specific fixed effects + COVID-19 fixed effects

17 Sablefish DTL Model Methodology Review Materials for May 9 SSC Subcommittee Workshop (May 2023)
Groundfish Management Team Report on Updates to the Sablefish Trip Limit Model (October 2023)
SSC's Economics and Groundfish Subcommittees Report on Sablefish Daily Trip Limit Model (October 2023)

Sector	Prediction Output	Regression Inputs
	# of vessels	Price (inflation adjusted) + period-specific fixed effects + COVID-19 fixed effects
LES	Total fleet-wide landings	Weekly trip limit + price (inflation adjusted)
OAS	Landings per vessel	Bimonthly trip limit + weekly trip limit
	# of vessels	Bimonthly trip limit + weekly trip limit

5.1.3 Model Input Data

Landings and catch data were acquired from PacFIN Comprehensive FT database using the "GMT Sablefish Flags." This flag initially assigns vessel-daily landings data to each sector based on the fields described in Table 5-2.

All sablefish landings are required to be reported on electronic fish tickets. For the LEN sector, the software tracks landings accumulation by vessel against their sablefish endorsed tier permits. If the vessel has active sablefish endorsed primary tier permits attached, the season is open, and there is room on the attached permits, landings are counted as primary. When either the tier permits on the vessel are exhausted or the season ends, landings are then counted as DTL. The algorithm in the software adheres to the specific federal regulations concerning primary and DTL landings in 50 CFR 660.232. If a vessel is not landing against a tier permit but has a fixed gear endorsement (with or without a trawl endorsement), then it is landed in LE. If only a trawl endorsement is present, it is OA. To separate by area, all landings south of the INPFC Conception area (Mexico/US border to Point Conception) are counted against the limits south of 36° N. lat., while all other landings are considered north of 36° N. lat.

Table 5-2. PacFIN codes are used to assign vessel-daily landings and catch data to each sector.

Field	Value	Description
Council_Code	P	PFMC only
Is IFQ landing	F	No IFQ landings included
PacFIN Species Code	SABL	Sablefish Only
Round_weight_lbs	>0	Must have landed at least 1 pound of sablefish
Participation group code	C	Commercial tickets only
Removal type code	Not in "R" or "E"	Not research or EFP
PacFIN group gear code	Not in "TWL" or "TWS"	No trawl gear used

5.1.4 Accounting for Discards and Discard Mortality

The sablefish catch share for the LEFG sectors north of 36° N. lat. is divided amongst the primary sector and the DTL sector, the latter of which is reduced to account for discard mortality by multiplying the DTL catch share by 19 percent (observed discard rate estimate) and by 20 percent (discard mortality rate estimate), resulting in the LEN landings target. The same rates are applied to the OA DTL sector north of 36° N. lat. catch share. For the sectors south of 36° N. lat., the observed discard rate is 9 percent, and the same discard mortality rate is applied (20 percent).

Landings should fall within the sector-specific landings targets in order to ensure that the total harvest guideline is not exceeded. The GMT compares model-projected landings to each sector's landings target to set appropriate trip limits. The estimated discard rate used by the GMT was calculated using the report "Estimated Discard and Catch of Groundfish Species in the 2020 US West Coast Fisheries" by Somers et al. (2021). The discard mortality rate estimate was taken from information in Davis (2001) and Shirripa and Colbert (2006). Shirripa (2008) used experimental data and sea surface temperature to predict varying release mortality by gear. The GMT considered that Davis (2001) demonstrated high sensitivity to temperature and deck time, and that Shirripa and Colbert (2006) demonstrated high variability of predicted discard mortality informed by sea surface temperature data, and adopted an estimate of 20 percent. This value was also used in the 2021 update assessment (Kapur et al. 2021).

5.1.5 Nearshore Fisheries

The Nearshore fishery comprises small vessels operating off the coasts of Oregon and California operate under state limited entry programs but are also considered federal OA vessels as they harvest federally managed species. While the fishery predominately caters to the live fish markets as they receive much greater prices for live "plate-sized" fish, there is also a smaller secondary component that caters to the fillet markets. Federally managed species that comprise the fishery are nearshore rockfishes, lingcod, cabezon, California scorpionfish, and kelp greenling.

In terms of catch accounting, all landings for the nearshore fishery are recorded on fish tickets. However, discard mortality has to be estimated since less than 20 percent of total trips are observed each year. To estimate total discard mortality for both observed and unobserved trips, discards from the portion of observed trips are applied to the unobserved trips by the WCGOP. This same general approach is also used to project future discard mortality for the nearshore (described in greater detail below).

5.1.6 Methods for Projecting Nearshore Landings and Discard Mortality

Separate approaches are used to project future landings and discard mortality for the nearshore fisheries. Landings are projected using three different approaches: (1) full attainment of landings targets is assumed for high attainment stocks (e.g., Oregon black rockfish); (2) via trip limits models for stocks where changes are proposed (e.g., lingcod and canary rockfish); and (3) via trend analysis (including averages where trend is flat) for low attainment stocks of which regulations are similar to the past.

To project total economic value associated with nearshore landings, the total ex-vessel price (i.e., paid to the fishermen) associated with these landings is expanded to include the "multiplier" effects that these landings also generate to processors, fishery-related businesses (e.g., boat yards), and coastal communities in general. In short, the value generated by fishing extends far beyond just the price paid to fishermen. These secondary effects of additional value as fish sale proceeds trickle throughout coastal communities are generated using the IO-PAC model (not just for the nearshore fishery, but for all fisheries).

Future discard mortality projections are produced by the nearshore model, which was designed to directly mimic the procedures used by WCGOP to estimate post-season "actual" catch. This mimicry is important since the WCGOP estimates are the official mortality source used in the management of the nearshore fishery. Mismatches would compromise the ability of the model to reliably produce projections to meet management objectives.

The GMT concluded that the main source of inaccuracy with the nearshore model has been very high volatility in annual bycatch rates that are used by WCGOP for estimates of catch. Since the annual bycatch rates fluctuate by a large degree from year to year and cannot be accurately predicted at this time, this means that the bycatch rate inputs from the nearshore model that are based on averages will oftentimes differ from the annual bycatch rates (and sometimes by large degrees).

The main issue with the nearshore model has therefore been an overreliance in the accuracy of the point estimate projections. Until the annual bycatch rates can be better predicted, the nearshore model projections should be only viewed as “ball-park” estimates. The GMT has developed a preliminary bootstrap model to project the uncertainty associated with future nearshore projections, but more work needs to be done until it can be used for management purposes.

In regards to methodology, the nearshore model uses a multi-species bycatch rate approach that is depth- and area-specific (described in detail in 2009-10 FEIS).

Table 5-3.. Estimation process and data sources used in the nearshore model to project discard mortality of overfished rockfish.

	STEP 1:				STEP 2:	STEP 3:				STEP 4:				STEP 5:				STEP 6:				STEP 7:			
	Bycatch rates by depth from WCGOP observed trips				Users enters projected Landings of targets	Depth of Landings provided by WCGOP				Landings of each species split by depth = Step 2 x Step 3. Then summed (black shading)				Discarded mt computed = Bycatch rates (Step 1) by depth applied to sum of landings by depth				Discard mortality rates applied to discarded mt (from step 5)				Discarded mortality by depth = Step 5 x Step 6. Sum is the total mortality			
	Depth bin (fathoms)					Depth bin (fathoms)				Depth bin (fathoms)				Depth bin (fathoms)				Depth bin (fathoms)				Depth bin (fathoms)			
	0-10	11-20	21-30	30+		0-10	11-20	21-30	30+	0-10	11-20	21-30	30+	0-10	11-20	21-30	30+	0-10	11-20	21-30	30+	0-10	11-20	21-30	30+
Bycatch stock																									
Yelloweye Rockfish	0.003	0.012	0.043	0.003	0.000	53.6%	46.4%	0.0%	0.0%					0.318	1.533	0.196	0.005	28%	45%	67%	100%	0.089	0.690	0.131	0.005
Target stocks																									
Black Rockfish					120.000	47.1%	51.0%	1.4%	0.5%	56.53	61.16	1.69	0.62												
Cabezon					23.385	40.6%	55.9%	3.2%	0.2%	9.51	13.08	0.75	0.05												
Lingcod					65.000	37.5%	59.5%	2.1%	0.9%	24.40	38.65	1.34	0.61									**TOTAL MORTALITY = 0.915 MT**			
Black and Yellow Rockfish					0.017	0.0%	42.9%	57.1%	0.0%	0.00	0.01	0.01	0.00												
Blue/Deacon Rockfish					7.458	26.3%	70.6%	2.6%	0.6%	1.96	5.26	0.19	0.04												
Brown Rockfish					0.017	0.0%	0.0%	0.0%	0.0%	0.00	0.00	0.00	0.00												
China Rockfish					6.498	30.5%	65.1%	3.7%	0.7%	1.98	4.23	0.24	0.04												
Copper Rockfish					1.007	38.1%	58.7%	3.2%	0.0%	0.38	0.59	0.03	0.00												
Gopher Rockfish					0.045	78.2%	21.8%	0.0%	0.0%	0.04	0.01	0.00	0.00												
Grass Rockfish					0.222	100.0%	0.0%	0.0%	0.0%	0.22	0.00	0.00	0.00												
Nearshore Rockfish Unid					0.000	0.0%	0.0%	0.0%	0.0%	0.00	0.00	0.00	0.00												
Olive Rockfish					0.000	57.1%	42.9%	0.0%	0.0%	0.00	0.00	0.00	0.00												
Quillback Rockfish					1.307	17.1%	70.2%	11.8%	1.0%	0.22	0.92	0.15	0.01												
Greenling Unid					0.000	29.6%	70.4%	0.0%	0.0%	0.00	0.00	0.00	0.00												
Kelp Greenling (Oregon)					18.144	49.7%	49.2%	1.0%	0.2%	9.01	8.92	0.18	0.03												
Painted Greenling					0.000	0.0%	0.0%	0.0%	0.0%	0.00	0.00	0.00	0.00												
						Total landings by depth =				104.3	132.8	4.6	1.4												

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5.2 Individual Fishing Quota Projection Model

5.2.1 Introduction: Summary of the 2025-26 model

The role of this model is to produce two outputs for use in the biennial groundfish harvest specifications Analytical Document: 1) projections of total annual IFQ sector fishing mortality (hereafter referred to as "catch" or "total catch") of each species, under a suite of allocations, and 2) projections of annual vessel-level landings for input to the Commercial Fisheries Landings Distribution Model, followed by the Input-Output Model for Pacific Coast Fisheries (IO-PAC) for subsequent economic analysis, also within the harvest specifications Analytical Document. The model is not intended as an inseason management tool. The model projects catch of IFQ species categories only; species managed with trip limits are not included.

Catch projections are produced using a combination of three methods among the thirty different IFQ species categories (hereafter as "species") included in the fishery, based on a combination of a) attainment of vessel quota, and b) average annual vessel catch; or c) a bycatch option for non-target species. The fishery is stratified into two fleets with separate sets of predictions, based on the proportion of Pacific whiting caught on each trip. Corresponding uncertainty estimates are produced as bootstrapped 95 percent prediction intervals. The model is written in R. See Matson et al. 2017 for a full description of all but the bycatch module. The bycatch module was adapted to the Matson et al. 2017 model for the 2019-2020 harvest specifications cycle. An early version of the model (Matson and Taylor, 2012) was used in the 2013-14 harvest specifications (https://www.pcouncil.org/wp-content/uploads/September_2012_AppendixA_13-14_FEIS_SPEX.pdf).

Projections of the range of alternative allocations recommended by the Council and provided by the GMT were originally analyzed in early January 2024. A second set of allocations, with substantially expanded ranges for canary rockfish, was analyzed at Council request, in February 2024. And a final, third set of allocations was analyzed after recommendation by the Council, following the April 2024 meeting. The last set of allocations differed from the February allocations by small amounts across several species categories, including widow, yellowtail, and yelloweye rockfish; as well as shortspine thornyheads, starry flounder, and petrale sole.

5.2.2 Methods

The model projects catch of each target species by individual vessel in the fleet using a combination of two methods; the first is based on weighted mean vessel attainment of annual quota pounds, and the other, on weighted mean of annual vessel catch. The model's choice between the two target catch projection methods at the vessel-species level is mediated by a vector of parameter values, one for each species, which are determined through an optimization process using residuals from hindcasts of a year with known final catch estimates, in this case 2023. Predictions of catch for each species within a fleet are produced by aggregating the vessel level predictions to the fleet level, then summing the two fleet projections (whiting and non-whiting).

Inputs to the model include catch data at the fishing trip level for each vessel (with separate landings and discard estimates for each species), IFQ quota pounds (QP) data for each vessel, annual fishery allocation data, and proposed fishery allocations (“alternatives”) under which catch is to be predicted. Each alternative consists of a set of proposed values for future allocations of quota pounds to the fishery, with a single fishery level value for each species. Fishery-level quota pounds from the alternative are then distributed among vessels, according to the fleet allocation distribution in the most recent year.

The bycatch method employed here predicts catch of each designated bycatch species, using weighted average, annual, vessel-specific bycatch rates, according to ratios of each bycatch species to aggregate target catch, in shelf or slope species groups. Each of the 30 species categories is designated as “target” or “bycatch” and “shelf” or “slope” in the model input files. Those estimated bycatch rates are then used to project mortality of bycatch species, according to the predicted catch amounts for appropriate target species. Uncertainty is estimated in the same way for bycatch as target species, using bootstrap-simulated distributions.

Weighted average annual vessel and species-specific retention rates were used to convert predicted total catch to predicted landings.

Projections for the whiting sector were constrained to 2023 levels, since the Pacific whiting allocation was fixed at the 2023 level among all alternatives (as a placeholder), and the overall purpose of the analysis was not to predict whiting catch, which is an internationally managed species, with a separate process. All other species in the whiting sector were modeled as bycatch fixed at 2023 bycatch rates. Although fixed, making the whiting sector projections using the model allowed distribution of the catch among vessels combined with the non-whiting sector projections, for use in downstream economic analysis.

These projections reflect data that includes surplus carryover trends for 2018-2023. Under the current No Action alternative for sablefish, and most other IFQ species categories, the sum of the northern and southern ACLs is set equal to the ABC. If this is the case for the Final Preferred Alterative, then no surplus carryover is allowed under the law. The court ruling Conservation Law Foundation v. Pritzker, No. 13-00821 (D.D.C. Apr. 4, 2014), stated that under the plain language of 302(h)(6) of the MSA, 16 U.S.C. § 1852(h)(6), neither the Council nor NMFS may establish a total potential catch level that exceeds the ABCs recommended by the SSC. This total potential catch level includes surplus carryover.

5.2.3 Recent IFQ model retrospective analysis

Projected catch in metric tons for each IFQ species, among the different suites of alternative allocations, is shown at the fleet level in Table 5-5. Predicted attainment levels are shown in Table 5-6. Example plots of point projections with accompanying 95% prediction intervals (depicted as proportion of each respective allocation) by species and sector, at the fleet level are shown in Table 5-4.

For Arrowtooth flounder, the alternatives ranged between 43 to 55 percent of the 2023 levels, for this low-attainment species (5 percent in 2023, and an average of 8 percent since 2018, over the reference years for the model), which has shown a decreasing catch trend since 2011. A decrease in allocation of this scale is not projected to have a substantial impact on catch. Catch has not generally been responsive to allocation levels for Arrowtooth flounder since 2011. Projected catch over the range of the alternatives fell within 96 to 100 percent of No Action levels.

Canary rockfish
The range of Canary rockfish alternative allocation levels analyzed here (in February 2024) for 2025-2026 was between 32 and 41 percent of 2023 levels. Model-based projections suggest that allocations at the "Low" level of each alternative in each year, between 268 and 269 mt, could prove challenging for the fishery. Projected attainment for the "Low" allocation level for each alternative and year presented in Table 5-4 is between 95 and 96 percent (Table 5-6) corresponding to predicted catch of between 256 to 256.5 mt (Table 5-5).

However, these results are more encouraging than those from preliminary (January 2024) low-end alternative allocations, analyzed while developing the range, whose corresponding projections indicated likely over-attainment by the fishery. The current low-end allocation levels (Table 5-3) are approximately 38 mt higher; previous values were between 230 and 230.5 mt, and corresponded to just 27 percent of 2023 levels. Model-based projections indicated that allocation levels that low were likely to be problematic; projected attainment was between 103.6 and 103.7 percent, corresponding to predicted catch of between 238.4 to 238.7 mt. Over-attainment of Canary rockfish at that level is not unprecedented, and has occurred before in the IFQ fishery, during 2015.

At the same time, under the "High" allocation levels, predicted attainment is less than 84 percent, with projected catch of between approximately 291.1 and 291.5 mt. Additionally, the way the shorebased whiting fleet is treated in the model, as part of the total IFQ fishery model projections also becomes important at these very low potential allocation levels. Because we have no way to know what the whiting TAC level will be going forward, the shorebased whiting fleet portion of the projections for all species is held constant across all alternatives, at 2023 levels, and in this case makes up nearly half of the total IFQ prediction for the current "Low" level within each alternative (120 mt, which is slightly lower than the actual whiting fleet catch in 2023, of 127 mt). Although Canary rockfish is bycatch for the whiting fleet, it is possible, or even likely that if faced with very low allocation levels, rather than the much higher 2023 levels; that bycatch of Canary could also be much lower by the IFQ whiting fleet, although this situation is difficult to model under the current configuration. Because of this, the Canary rockfish projection could be high biased in a way that becomes important at the scale of the "Low" alternative allocation levels. This factor is worth considering for decision making.

Canary rockfish in 2023 showed an attainment of approximately 60 percent, and an average of 48 percent since 2018, since the stock has been rebuilt. However, during times of constraint, when the allocation was very low during rebuilding in 2015, attainment did reach 103.6%; (Figure 5-2 2), suggesting that fishers went into deficit. In conclusion, the allocation levels being contemplated at the low end of the range for Canary rockfish deserve careful consideration, as these projections suggest that they could produce marked fishery constraint.

The range of Chilipepper rockfish allocations being considered ranges between 125 and 134 percent of 2023 levels. Projections are for similar attainment levels as 2023, of the somewhat higher allocations, at approximately 61 percent of the allocation, and projected catch between 1,191 and 1,268 mt. There has been a trend of increasing catch over the model reference period since 2018, despite decreasing allocations.

Proposed allocations for Other flatfish range between 140 and 169 percent of 2023 levels, from approximately 5,807 to 6,987 mt. Catch and allocations have been trending downward in recent years for this low-attainment species, but attainment has varied little since 2018, with a mean of 8.9 percent. Projected catch varies little among alternatives, and is between approximately 337 and 340 mt, with projected attainment between 5 and 6 percent of the much higher potential allocations.

Petrale sole has consistently been a very highly attained species, with mean attainment since 2018 at 91.2 percent, despite a sizable drop experienced during the pandemic. Attainment in 2023 was 92.6 percent. The range of potential allocations analyzed was between just 59 and 63 percent of 2023 levels, or between approximately 1,810 and 1,941 mt, rather than 3,064 in 2023. Model predictions are mainly attainment-based for this species, with catch demonstrating a consistent dependence upon allocation, with an R-square value of 0.92 since 2011, 0.64 since 2018, and high attainment levels. The predicted attainment level across the alternatives is 92.6 percent, and projected catch ranges between 1,675 and 1,796 mt.

Sablefish

Sablefish shows by far the greatest degree of change in proposed allocation levels versus No Action for this biennium, with increases to the IFQ allocation for northern and southern areas, of nearly 3 ½ times the 2023 levels (between 339 and 345 percent). Catch and attainment in the North and South have historically shown vastly different patterns in IFQ, with consistently high attainment in the North, and the opposite case in the South. Sablefish North of 36° N. attainment stayed between 90 and 100 percent (and sometimes above) from 2011-2019. Catch and attainment then fell dramatically during the pandemic, to 69 percent in 2020, rose a bit to 73 percent in 2021, and by 2022 made a recovery to 98 percent, along with the highest catch ever, over the history of the IFQ fishery (Figure 5-3). However, in 2023, when the northern sablefish allocation rose dramatically, to its highest level ever during IFQ management, instead of following the allocation, catch instead fell off somewhat, and attainment dropped again to 69 percent. The approximately 30 percent increase in allocation from 2022 to 2023 was apparently more than the fishery could effectively make use of at that time. This departure from the previously strong attainment trend could be due to a combination of factors. Sablefish prices were low in 2023, perhaps due to a combination of a small size distribution (sablefish pricing is size-dependent) as well as market conditions, and the outlook for prices in 2024 has thus far not been encouraging. Between 2022 and 2023, sablefish prices dropped 16 percent for bottom trawl, where the bulk of IFQ sablefish is caught. Non-trawl IFQ sablefish saw a much more dramatic drop in price during 2023, to just 56 percent of 2022 levels. According to media reports, Alaskan fisheries have also been struggling to make use of their higher sablefish quotas, and there have apparently been calls for restraint among some commercial fishers, due to concern of flooding the market and further driving down prices.

Potential allocations of Sablefish North of 36° N. range between 13,091 and 13,420 mt, versus 3,894 mt in 2023. Projected resulting catch is between 8,076 and 8,268 mt, which is 300 and 303 percent of 2023 levels, respectively. Projected attainment varies little, between 61.6 and 61.7 percent (with prediction intervals between approximately 40 and 80 percent attainment), lower than 2023 attainment levels of approximately 69 percent. Although 61-62 percent would be the lowest sablefish attainment rate in IFQ fishery history, the projected increase of catch, in and of itself still appears rather enormous.

Recent context, including apparent price/market conditions, together with the recent lack of response to the 30 percent allocation increase from 2022 to 2023, create intuitive skepticism about whether, or when this projected vast increase in catch may be realized. However, the projections are for years 2025 and 2026; sablefish prices and other market factors can vary considerably both among and even within year, so while there is uncertainty, conditions could conceivably change in coming years.

The model projection is informed by weighted annual catch and attainment patterns over the recent history of the fishery (2018-2023). Although the informativeness is heavily weighted to the most recent year, when a shift in attainment patterns occurred, and is also informed by the relatively poor attainment year of 2020, as well as 2021, the out-of-reference problem seen here, in which the conditions for which we are trying to forecast within, do not occur within the data used to inform the model. The allocations for which we are trying to project catch are more than 3 times the size of the largest allocation in the history of the IFQ fishery. This is a common, and exceedingly difficult problem to reconcile for forecasting in general; and this general type of problem has occurred in the West Coast Groundfish Fishery before, when a stock has begun management under a rebuilding plan and harvest levels dropped outside the range of available data, or when a stock has rebuilt, and harvest levels increased out of that range.

Additionally, the model is not informed about future prices for instance, and we don't have forecasted sablefish price information, or forecast exchange rate for the Japanese Yen, which is a strong predictor of sablefish landings in general, particularly in fixed gear fishery sectors.

There is additional uncertainty about potential changes in catch for species that co-occur with sablefish, particularly within the Dover-Thornyhead-Sablefish (DTS) complex. This was investigated through examining between-species correlations among DTS species, at the IFQ fishery, fleet (a.k.a. sub-sector), and vessel levels. At the fishery level, sablefish catch did not show significant correlation with other IFQ species categories within the same management area, and the DTS complex, over the years used to inform the projection model (2018-2023); nor the entire time series of the IFQ fishery (2011-2023; Table 5-7, Figure 5-4), although Dover sole catch showed strong correlation with both Longspine and Shortspine thornyheads. Results are presented at the fishery level, for years 2018-2023, which were used to inform the projection model (Table 5-7, Figure 5-4).

The lack of significant correlation between sablefish and other DTS species at the fishery level was not resolved by extending the time series through 2011, nor by stratifying the fishery further into smaller fleets (bottom trawl, whiting, mid-water rockfish, non-trawl). However, when more granular, vessel-level, annual catch data were examined, it revealed mixed results among vessels, along a continuum between no correlations, and significant correlations between catch of sablefish and one or more DTS species.

Taken together, the results suggest that at the high level, fishers appear to have some control over their catch composition among DTS species, given the lack of aggregate, fleet-level relationship, and broad range of variation among vessels along a continuum, in correlation strength and significance among species in the DTS complex. Results clearly vary among vessels, even within the same IFQ fleet or subsector, as well as among years. Spatial and temporal variation in vessel-specific fishing effort patterns, as well as specific target strategy likely affect DTS catch composition, but this would take more than the time available for this harvest specifications analysis to determine.

Conclusions for northern sablefish

The projected catch levels for northern sablefish are highly uncertain, given that the enormous scale of the modeled allocation levels have not been observed before in the IFQ fishery, recent market conditions and prices have been poor for sablefish, and future market conditions and currency exchange rates for export markets are unknown.

Given the lack of fishery or fleet-level (subsector) correlations between sablefish catch and that of other DTS species; if projected increases in sablefish catch occur, although some accompanying increases in other DTS species might occur (beyond projected levels) as a result, it appears unlikely that they would be of similar scale as sablefish itself, or that it would lead to substantial constraint or exceedance of allocations for co-occurring DTS species.

The mixed nature of DTS species catch correlations in different vessels show both a mechanism for the lack of significance at fleet and fishery levels, and contribute to the considerable uncertainty of this issue for future outcomes. Results suggest that many fishers have some control over their DTS catch composition, which is encouraging, in terms of navigating the uncharted territory of the large sablefish allocations proposed for 2025 and 2026.

Southern sablefish

Potential allocations of Sablefish South of 36° N. range between 3,288 and 3,288.6 mt, versus 970 mt in 2023. Projected resulting catch is between 293.7-293.8 mt, which is 312 percent of 2023 levels. Even with the more than threefold increase in projected catch, projected attainment would be just 8.9 percent, somewhat lower than the 2023 rate of 9.7 percent. Attainment rates of southern IFQ sablefish have been in this very low range since 2017-2018. The last time catch of southern IFQ sablefish was in the projected range was 2011-2012, which showed accompanying attainment rates of between 86 and 44 percent, respectively. Much like for northern sablefish, there is considerable uncertainty whether 2025 and 2026 catch will reach the projected levels, even with the very high allocation.

Catch, allocation, and attainment of Shortspine thornyheads North of 34°27' N. have all been on a declining trend in IFQ from 2011 forward. Alternative allocations of Shortspine thornyheads North of 34°27' N. for the next biennium are for between 27 and 38 percent of No Action 2023 levels of 310.1 and 436.2 mt, respectively. Although attainment of this species category in IFQ has been quite low, at a mean of 31 percent since 2018 (projection model reference years) and 24 percent in 2023, concern is that it could become a constraint, with higher or current catch levels of other DTS species. Although catch of IFQ sablefish hasn't shown a significant correlation with shortspine thornyheads at the fishery or fleet level, it has shown a positive correlation in some vessels, and catch of sablefish could increase dramatically in the coming biennium, if market conditions and prices are amenable. Also, catch of longspine thornyheads and Dover sole have shown high, positive, significant catch correlations with this species (Figure 5-4, Table 5-7), and their catch is projected to stay at 2023 levels or drop modestly, which is at odds with the decreases in allocation for northern shortspine thornyheads. As a result of the decreased allocation, shortspine thornyhead attainment North of 34°27' N. is projected to rise to between 45 and 53 percent of the alternative allocations, with projected catch between 165.2 and 198.1 mt, although this projected catch range would represent between 58 and 70 percent of 2023 catch levels.

Shortspine thornyheads South of 34°27' N. has had a static IFQ allocation of 50 mt since the beginning of the fishery in 2011, when IFQ catch of this species category was at its highest, of approximately 8.5 mt. Annual catch dropped from 2011 until it reached zero in 2017, where it has remained since. Since annual catch has been absent during the entire reference data period for the model (2018-2023), catch is not formally projected, but assumed to remain at zero.

Widow rockfish has transitioned into a mode of high attainment since 2017 when the allocation dramatically increased to more than 10,000 mt, and has shown a mean IFQ allocation level of 11,292 mt since 2018. Attainment has shown a mean rate of 91.4 percent since 2018, over the model reference data period, and was nearly 95 percent in 2023. The alternative allocations are set to drop to between 81 and 90 percent of 2023 levels, to between 9,297.7 and 10,342.7 mt in the next biennium. Projected attainment ranges between 95 and 96 percent of the allocation, with projected catch at between 82 and 90 percent of 2023 levels, at between 8,900.3 and 9,844.7 mt.

Catch of yelloweye rockfish in IFQ since 2018 has been low and variable between 0.13 to 0.81 mt, with a mean of 0.45 mt (CV = 48%) since 2018. Annual catch has been trending raggedly upwards over the model reference data period, since 2018, but dropped abruptly in 2023, from its highest IFQ level in 2022 at 0.81 mt, down to 0.45 mt. Alternative yelloweye rockfish allocations are proposed to slightly decrease to between 79 and 81 percent of 2023 levels, to between 3.5 and 3.6 mt. Corresponding catch of yelloweye is projected at between 76 and 80 percent of 2023 levels, approximately 0.3 to 0.4 mt, and an attainment rate of 10 percent of the allocation. Annual projections are well within the recent historical range, and slightly lower than the average.

Yellowtail rockfish has shown relatively steady high attainment since 2018, with a mean of 75 percent, and mean catch of 4,030 mt per year, and 2,861 mt in 2023. Alternative yellowtail rockfish allocations are proposed to slightly increase to between 107 and 114 percent of 2023 levels, to between 4,037.8 and 4,270.2 mt. Catch under the range of alternative allocations is projected to increase to between 105 and 109 percent of 2023 levels, to between 2,998.2 and 3,112 mt, and between 73 and 74 percent attainment.

5.2.4 Final allocations, projections and results

At the April 2024 PFMC meeting, the Council recommended an updated, final range of allocations, which would encompass, and facilitate analysis of options across the full range of potential fishery allocations considered for the 2024-2025 biennium, including those chosen for the PPA and FPA. The final, comprehensive range of allocations analyzed is shown in Table 5-8, the corresponding model-based catch projections are shown in Table 5-9, and projected attainment values in Table 5-10.

Differences between the final, post-April allocations and the previous set, modeled in February, were between zero and trace amounts for most species categories and alternatives (Table 5-8). For the remaining species categories, the differences were small, between less than one and six percent; although for Shortspine thornyheads North of 34°27' N., allocation levels at the high end of both alternatives in 2026 increased by between 11 and 12 percent. Allocations for yelloweye rockfish dropped by between 0.2 mt across the alternatives (Table 5-8). The low end of the petrale sole range increased by between four and six percent. Changes to widow, yellowtail, and cowcod rockfish were all less than two percent.

Differences in projected catch (Table 5-9) from the final alternatives, versus the previous set analyzed were also minimal, and echoed the changes to alternatives. The predicted catch of Shortspine thornyheads North of 34°27' N. increased by five to 6 percent, in response to the 11 to 12 percent increased allocations. Projected catch of petrale sole was also between 3 and 6 percent higher under the April allocations, compared with the previous set, nearly mirroring the changes to allocations themselves, for this high-attainment, target species. Predicted bycatch of yelloweye rockfish remained very low, and changed between zero and 0.1 metric ton (between 0.029 and 0.055 mt), within rounding error for the resolution shown in the tables (Table 5-9), across the alternatives. Projected catch of yellowtail rockfish was between zero and 1.5 percent lower than under the previous set of alternatives.

Differences in projected attainment, between the final, post-April allocations and previous set of allocations analyzed in February (Table 5-10 were between zero and 0.5 percent different for the vast majority of species categories. The exception was Shortspine thornyheads North of 34°27' N., in which attainment was between 2.5 and 2.7 percent higher under the high-end of both alternatives in 2026.

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Table 5-4. Suites of analytical allocations (mt) used to "bookend" the range of projected (catch) impacts, in modeling predicted catch in the IFQ fishery, for 2025-2026, as well as 2023 (No Action) for comparison. See text for key to column headings.

	2023	2025 - ALT 1		2026 - ALT 1		2025 - ALT 2		2026 - ALT 2	
Species	**NO**	**LOW**	**HIGH**	**LOW**	**HIGH**	**LOW**	**HIGH**	**LOW**	**HIGH**
Arrowtooth flounder	15640.2	8543.1	8573.1	6675.4	6705.4	8543.1	8573.1	6675.4	6705.4
Bocaccio rockfish South	700.3	652.548	652.548	647.5	647.5	652.5	652.5	647.5	647.5
Canary rockfish	842.5	268	347.6	269	348.4	268	347.6	269	348.4
Chilipepper rockfish South	1563.8	2091	2091	1961.4	1961.4	2091	2091	1961.4	1961.4
Cowcod South	24.8	24.1	24.1	23.4	23.4	24.1	24.1	23.4	23.4
Darkblotched rockfish	646.8	543.3	616.9	522.4	596	543.3	616.9	522.4	596
Dover sole	45972.7	45985.1	45985.1	45985.1	45985.1	43537.9	43537.9	38819.3	38819.3
English sole	8320.6	8235.9	8235.9	8174.2	8174.2	8235.9	8235.9	8174.2	8174.2
Lingcod North of 40°10' N.	1829.3	1502.5	1502.5	1448.8	1448.8	1502.5	1502.5	1448.8	1448.8
Lingcod South of 40°10' N.	284.2	294.6	294.6	304.68	304.68	294.6	294.6	304.68	304.68
Longspine thornyhead	2129.2	1900.7	1900.7	1811.9	1811.9	1900.7	1900.7	1811.9	1811.9
Minor shelf rockfish North	694.7	763.1	763.1	755	755	763.1	763.1	755	755
Minor shelf rockfish South	163.0	175.4	175.4	175.2	175.2	175.4	175.4	175.2	175.2
Minor slope rockfish North	894.4	858.3	858.3	835.6	835.6	858.3	858.3	835.6	835.6
Minor slope rockfish South	417.1	424.6	424.6	422.7	422.7	424.6	424.6	422.7	422.7
Other flatfish	4142.1	6398.63	6463.63	5807.3	5872.3	6922.4	6987.4	6175.4	6240.4
Pacific cod	1039.3	1043.7	1043.7	1043.7	1043.7	1043.7	1043.7	1043.7	1043.7
Pacific halibut (IBQ) North	97.2	97.2	97.2	97.2	97.2	97.2	97.2	97.2	97.2
Pacific ocean perch North	2956.1	2723.4	2723.4	2620.8	2620.8	2723.4	2723.4	2620.8	2620.8
Pacific whiting	178581.0	178581	178581	178581	178581	178581	178581	178581	178581
Petrale sole	3063.8	1925.5	1940.5	1809.5	1824.5	1925.5	1940.5	1809.5	1824.5
Sablefish North of 36° N.	3893.5	13091	13420	13091	13420	13091	13420	13091	13420
Sablefish South of 36° N.	970.0	3288.6	3288.6	3288	3288	3288.6	3288.6	3288	3288
Shortspine thornyheads	1146.7	310.1	360.1	311.8	361.8	380.5	430.5	386.2	436.2
Shortspine thornyheads	50.0	50	50	50	50	50	50	50	50
Splitnose rockfish South	1494.7	1419.2	1419.2	1382.2	1382.2	1419.2	1419.2	1382.2	1382.2
Starry flounder	171.9	188.65	188.65	188.65	188.65	188.65	188.65	188.65	188.65
Widow rockfish	11509.7	10142.7	10342.7	9297.7	9497.7	10142.7	10342.7	9297.7	9497.7
Yelloweye rockfish	4.4	3.5	3.5	3.6	3.6	3.5	3.5	3.6	3.6
Yellowtail rockfish North	3761.8	4230.2	4270.2	4037.8	4077.8	4230.2	4270.2	4037.8	4077.8

Table 5-5. Projected catch for the IFQ fishery, in years 2023 (No Action), actual 2023 catch, and based on alternative allocations for 2025 and 2026.

Predicted catch (mt)	2023 Predicted	2023 Actual	2025 - ALT 1		2026 - ALT 1		2025 - ALT 2		2026 - ALT 2	
Species	NO ACTION	NO ACTION	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
Arrowtooth flounder	798.1	800.2	776.3	776.5	762.4	762.7	776.3	776.5	762.4	762.7
Bocaccio rockfish South	255.4	255.6	253.5	253.5	253.3	253.3	253.5	253.5	253.3	253.3
Canary rockfish	500.1	516.0	256	291.1	256.5	291.5	256	291.1	256.5	291.5
Chilipepper rockfish South	954.0	950.3	1,268.0	1,268.0	1,190.9	1,190.9	1,268.0	1,268.0	1,190.9	1,190.9
Cowcod South of 40°10' N.	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Darkblotched rockfish	183.0	184.0	157.5	175.6	152.3	170.5	157.5	175.6	152.3	170.5
Dover sole	3,835.5	3,832.4	3,835.6	3,835.6	3,835.6	3,835.6	3,829.5	3,829.5	3,817.6	3,817.6
English sole	232.8	234.8	232.4	232.4	232.1	232.1	232.4	232.4	232.1	232.1
Lingcod North of 40°10' N.	397.1	400.5	381.8	381.8	378.2	378.2	381.8	381.8	378.2	378.2
Lingcod South of 40°10' N.	50.3	50.1	52.0	52.0	53.7	53.7	52.0	52.0	53.7	53.7
Longspine thornyhead North	22.0	21.4	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9
Minor shelf rockfish North	270.6	271.8	295.1	295.1	292.2	292.2	295.1	295.1	292.2	292.2
Minor shelf rockfish South	35.8	44.3	38.3	38.3	38.2	38.2	38.3	38.3	38.2	38.2
Minor slope rockfish North	194.3	192.1	192.8	192.8	191.8	191.8	192.8	192.8	191.8	191.8
Minor slope rockfish South	27.7	27.7	28.1	28.1	28.0	28.0	28.1	28.1	28.0	28.0
Other flatfish	329.6	319.1	338.7	338.9	337.2	337.3	340.1	340.3	338.1	338.3
Pacific cod	36.5	39.2	36.6	36.6	36.6	36.6	36.6	36.6	36.6	36.6
Pacific halibut (IBQ) North	28.2	27.7	44.5	45.2	44.5	45.2	44.6	45.3	44.5	45.1
Pacific ocean perch North	222.5	224.7	221.4	221.4	221.0	221.0	221.4	221.4	221.0	221.0
Pacific whiting	101,966.3	100,955.0	101,966.3	101,966.3	101,966.3	101,966.3	101,966.3	101,966.3	101,966.3	101,966.3
Petrale sole	2,836.2	2,836.3	1,782.5	1,796.4	1,675.1	1,689.0	1,782.5	1,796.4	1,675.1	1,689.0
Sablefish North of 36° N.	2,689.0	2,677.4	8,076.1	8,268.3	8,076.1	8,268.3	8,076.1	8,268.3	8,076.1	8,268.3
Sablefish South of 36° N.	94.2	93.9	293.8	293.8	293.7	293.7	293.8	293.8	293.7	293.7
Shortspine thornyheads North	282.8	276.9	165.2	180.2	165.8	180.6	185.5	196.9	186.9	198.1
Shortspine thornyheads South	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Splitnose rockfish South	19.8	19.9	19.7	19.7	19.6	19.6	19.7	19.7	19.6	19.6
Starry flounder	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Widow rockfish	10,899.3	10,896.9	9,664.0	9,844.7	8,900.3	9,081.1	9,664.0	9,844.7	8,900.3	9,081.1
Yelloweye rockfish	0.5	0.5	0.4	0.4	0.3	0.3	0.4	0.4	0.3	0.3
Yellowtail rockfish North	2,863.1	2,860.8	3,092.4	3,112.0	2,998.2	3,017.8	3,092.4	3,112.0	2,998.2	3,017.8

Table 5-6. Projected attainment (percent of allocation) of IFQ species categories by year and alternative.

Predicted attainment	2023 Predicted	2023 Actual	2025 - ALT 1		2026 - ALT 1		2025 - ALT 2		2026 - ALT 2	
Species	**NO ACTION**		**LOW**	**HIGH**	**LOW**	**HIGH**	**LOW**	**HIGH**	**LOW**	**HIGH**
Arrowtooth flounder	5.1%	5.1%	9.1%	9.1%	11.4%	11.4%	9.1%	9.1%	11.4%	11.4%
Bocaccio rockfish South	36.5%	36.5%	38.8%	38.8%	39.1%	39.1%	38.8%	38.8%	39.1%	39.1%
Canary rockfish	59.4%	61.2%	95.5%	83.8%	95.3%	83.7%	95.5%	83.8%	95.3%	83.7%
Chilipepper rockfish South	61.0%	60.8%	60.6%	60.6%	60.7%	60.7%	60.6%	60.6%	60.7%	60.7%
Cowcod South of 40°10' N.	6.9%	6.9%	7.0%	7.0%	7.1%	7.1%	7.0%	7.0%	7.1%	7.1%
Darkblotched rockfish	28.3%	28.4%	29.0%	28.5%	29.2%	28.6%	29.0%	28.5%	29.2%	28.6%
Dover sole	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.8%	8.8%	9.8%	9.8%
English sole	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%
Lingcod North of 40°10' N.	21.7%	21.9%	25.4%	25.4%	26.1%	26.1%	25.4%	25.4%	26.1%	26.1%
Lingcod South of 40°10' N.	17.7%	17.6%	17.7%	17.7%	17.6%	17.6%	17.7%	17.7%	17.6%	17.6%
Longspine thornyhead North	1.0%	1.0%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%
Minor shelf rockfish North	39.0%	39.1%	38.7%	38.7%	38.7%	38.7%	38.7%	38.7%	38.7%	38.7%
Minor shelf rockfish South	22.0%	27.2%	21.8%	21.8%	21.8%	21.8%	21.8%	21.8%	21.8%	21.8%
Minor slope rockfish North	21.7%	21.5%	22.5%	22.5%	23.0%	23.0%	22.5%	22.5%	23.0%	23.0%
Minor slope rockfish South	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%
Other flatfish	8.0%	7.7%	5.3%	5.2%	5.8%	5.7%	4.9%	4.9%	5.5%	5.4%
Pacific cod	3.5%	3.8%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%
Pacific halibut (IBQ) North	29.0%	28.4%	45.8%	46.6%	45.8%	46.5%	45.9%	46.6%	45.7%	46.4%
Pacific ocean perch North	7.5%	7.6%	8.1%	8.1%	8.4%	8.4%	8.1%	8.1%	8.4%	8.4%
Pacific whiting	57.1%	56.5%	57.1%	57.1%	57.1%	57.1%	57.1%	57.1%	57.1%	57.1%
Petrale sole	92.6%	92.6%	92.6%	92.6%	92.6%	92.6%	92.6%	92.6%	92.6%	92.6%
Sablefish North of 36° N.	69.1%	68.8%	61.7%	61.6%	61.7%	61.6%	61.7%	61.6%	61.7%	61.6%
Sablefish South of 36° N.	9.7%	9.7%	8.9%	8.9%	8.9%	8.9%	8.9%	8.9%	8.9%	8.9%
Shortspine thornyheads North	24.7%	24.1%	53.3%	50.0%	53.2%	49.9%	48.8%	45.7%	48.4%	45.4%
Shortspine thornyheads South	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Splitnose rockfish South	1.3%	1.3%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%
Starry flounder	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Widow rockfish	94.7%	94.7%	95.3%	95.2%	95.7%	95.6%	95.3%	95.2%	95.7%	95.6%
Yelloweye rockfish	10.3%	10.4%	10.3%	10.4%	9.6%	9.7%	10.3%	10.4%	9.6%	9.7%
Yellowtail rockfish North	76.1%	76.0%	73.1%	72.9%	74.3%	74.0%	73.1%	72.9%	74.3%	74.0%

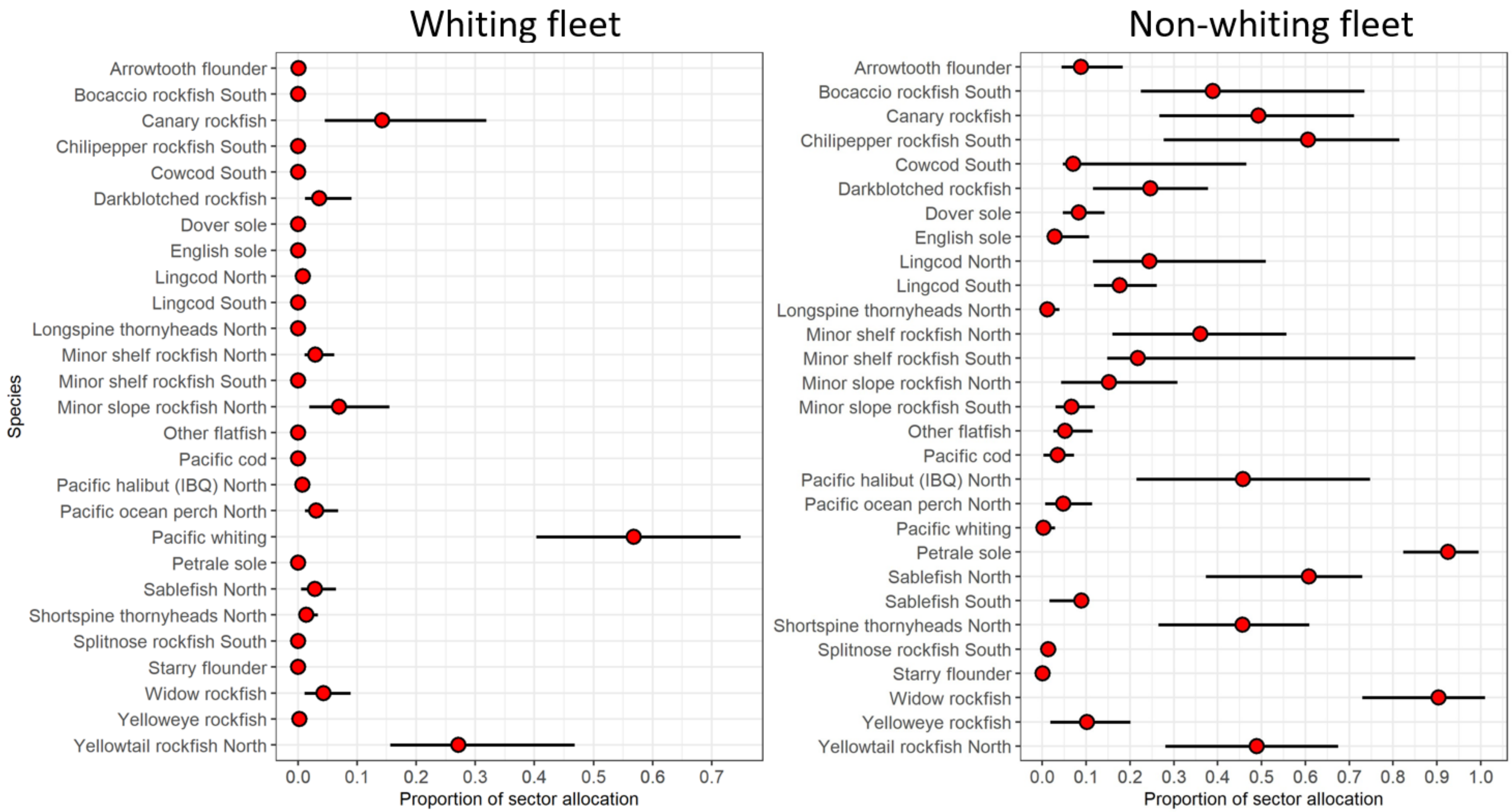

Figure 5-2. Example plots of point projections with accompanying 95% prediction intervals (depicted as proportion of each respective allocation) by species and sector, at the fleet level. Species with consistent catch histories and similar predictions across methods (attainment, mean annual catch, and bycatch-based methods), show smaller intervals.

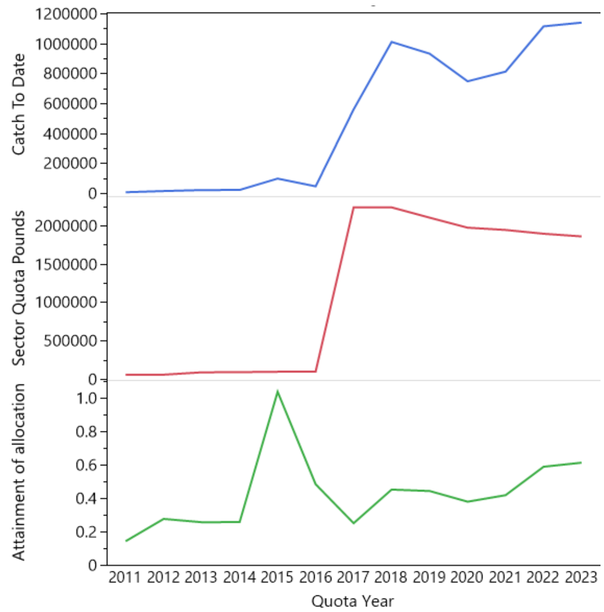

Figure 5-3. Annual catch (lb), allocations (lb), and attainment (proportion of allocation) for Canary rockfish in the IFQ fishery, from 2011 through 2023.

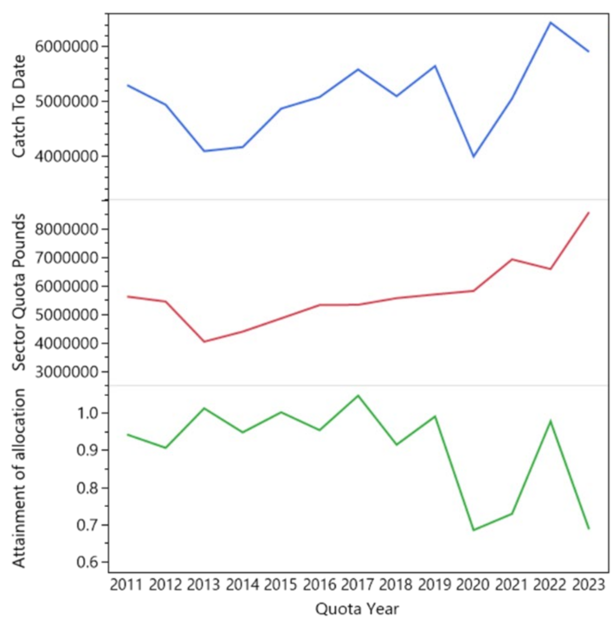

Figure 5-4. Annual catch (lb), allocations (lb), and attainment (proportion of allocation) for Sablefish north of 36° N. latitude in the IFQ fishery, from 2011 through 2023.

Table 5-7. Values of Pearson's correlation coefficient (a), probability (significance) values for correlations (b), and their confidence limits (c), for assessing the degree of covarying catch within the DTS complex, between pairs of species in the IFQ fishery, at the fleet level, between years 2018 and 2023, the years used to inform model projections for the 2025-26 groundfish harvest specifications analysis. Significant values appear in bold font. Catch of Shortspine thornyheads South has been zero in the IFQ fishery from 2018 forward.

Pearson's correlation coefficient values

	Dover	Lngsp_N	Sable_N	Sable_S	Shrtsp_N	Shrtsp_S
Dover	-	**0.976**	-0.013	-0.738	**0.984**	-
Lngsp_N	**0.976**	-	-0.059	-0.791	**0.993**	-
Sable_N	-0.013	-0.059	-	0.440	0.027	-
Sable_S	-0.738	-0.791	0.440	-	-0.769	-
Shrtsp_N	**0.984**	**0.993**	0.027	-0.769	-	-
Shrtsp_S	-	-	-	-	-	-

Significance probabilities for correlation coefficients

	Dover	Lngsp_N	Sable_N	Sable_S	Shrtsp_N	Shrtsp_S
Dover	-	**0.001**	0.980	0.094	**0.000**	-
Lngsp_N	**0.001**	-	0.912	0.061	**<.0001**	-
Sable_N	0.980	0.912	-	0.383	0.960	-
Sable_S	0.094	0.061	0.383	-	0.074	-
Shrtsp_N	**0.000**	**<.0001**	0.960	0.074	-	-
Shrtsp_S	-	-	-	-	-	-

Confidence limits for correlation coefficients

Variable	by Variable	Correlation	Lower 95%	Upper 95%
Lngsp_N	Dover	**0.9764**	**0.7941**	**0.9975**
Sable_N	Dover	-0.0135	-0.8161	0.8069
Sable_N	Lngsp_N	-0.0585	-0.8306	0.7906
Sable_S	Dover	-0.7379	-0.9691	0.1837
Sable_S	Lngsp_N	-0.7907	-0.976	0.0583
Sable_S	Sable_N	0.44	-0.5779	0.9222
Shrtsp_N	Dover	**0.9843**	**0.8583**	**0.9984**
Shrtsp_N	Lngsp_N	**0.9932**	**0.9363**	**0.9993**
Shrtsp_N	Sable_N	0.0266	-0.8023	0.8204
Shrtsp_N	Sable_S	-0.7692	-0.9732	0.1127
Shrtsp_S	Shrtsp_N	0	-	-

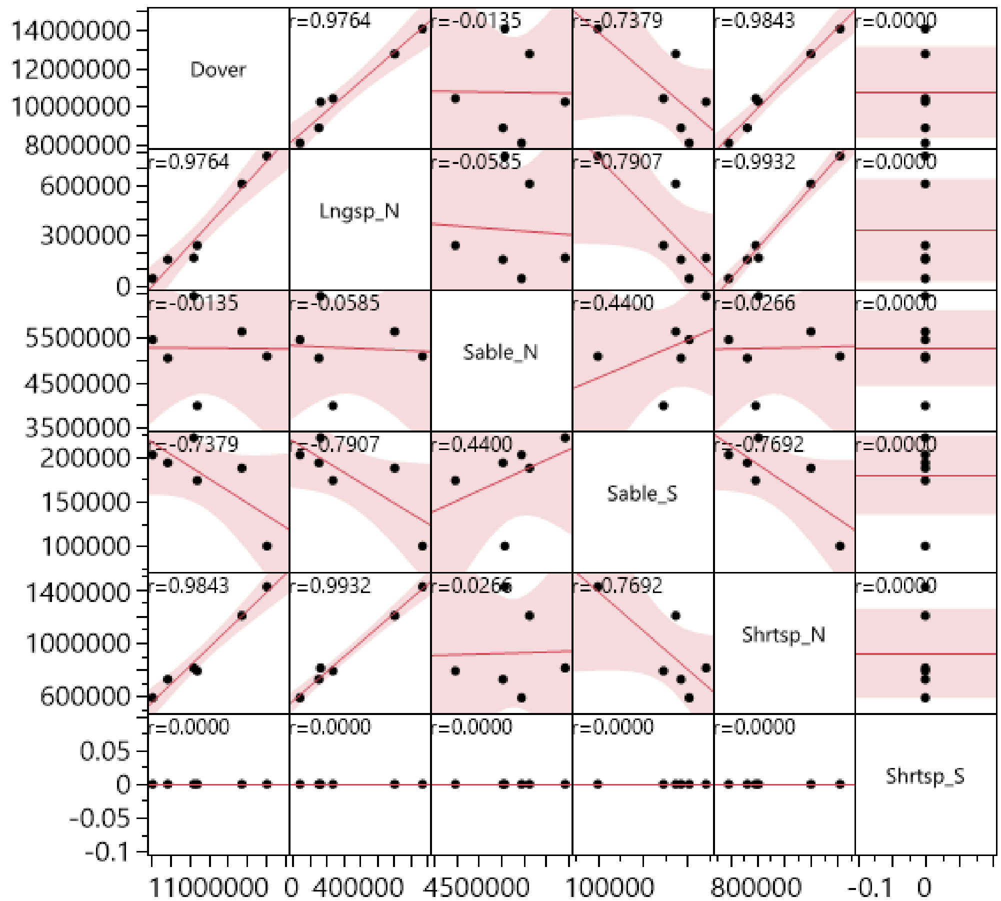

Figure 5-5. Relationships among IFQ species categories for annual IFQ fishery catch of Dover-Thornyhead-Sablefish (DTS) complex species, over the most recent six years of data (2018-2023) used to inform the projection model. Data show significant relationships between Dover sole and thornyheads (both shortspine and longspine) catch within management area, but no significant relationships between sablefish and other DTS complex members (see Table 4), at the annual level.

Table 5-8. Final (post-April 2024 PFMC meeting), suites of analytical allocations (mt) used to "bookend" the range of projected (catch) impacts, in modeling predicted catch in the IFQ fishery, for 2025-2026, as well as 2023 (No Action) for comparison. See text for key to column headings.

	2023	2025 - ALT 1		2026 - ALT 1		2025 - ALT 2		2026 - ALT 2	
Species	**NO ACTION**	**LOW**	**HIGH**	**LOW**	**HIGH**	**LOW**	**HIGH**	**LOW**	**HIGH**
Arrowtooth flounder	15640.2	8,543	8,573	6,675	6,705	8,543	8,573	6,675	6,705
Bocaccio rockfish South	700.3	653	653	648	648	653	653	648	648
Canary rockfish	842.5	268	348	269	348	268	348	269	348
Chilipepper rockfish South	1563.8	2,091	2,091	1,961	1,961	2,091	2,091	1,961	1,961
Cowcod South	24.8	24	24	23	23	24	24	23	23
Darkblotched rockfish	646.8	543	617	522	596	543	617	522	596
Dover sole	45972.7	45,985	45,985	45,985	45,985	43,538	43,538	38,819	38,819
English sole	8320.6	8,236	8,236	8,174	8,174	8,236	8,236	8,174	8,174
Lingcod North of 40°10' N.	1829.3	1,503	1,503	1,449	1,449	1,503	1,503	1,449	1,449
Lingcod South of 40°10' N.	284.2	295	295	305	305	295	295	305	305
Longspine thornyhead	2129.2	1,901	1,901	1,812	1,812	1,901	1,901	1,812	1,812
Minor shelf rockfish North	694.7	763	763	755	755	763	763	755	755
Minor shelf rockfish South	163.0	175	175	175	175	175	175	175	175
Minor slope rockfish North	894.4	858	858	836	836	858	858	836	836
Minor slope rockfish South	417.1	425	425	423	423	425	425	423	423
Other flatfish	4142.1	6,399	6,464	5,807	5,872	6,922	6,987	6,175	6,240
Pacific cod	1039.3	1,044	1,044	1,044	1,044	1,044	1,044	1,044	1,044
Pacific halibut (IBQ) North	97.2	97	97	97	97	97	97	97	97
Pacific ocean perch North	2956.1	2,723	2,723	2,621	2,621	2,723	2,723	2,621	2,621
Pacific whiting	178581.0	178,581	178,581	178,581	178,581	178,581	178,581	178,581	178,581
Petrale sole	3063.8	2,001	2,001	1,920	1,885	2,001	2,001	1,920	1,885
Sablefish North of 36° N.	3893.5	13,091	13,420	13,091	13,420	13,091	13,420	13,091	13,420
Sablefish South of 36° N.	970.0	3,289	3,289	3,288	3,288	3,289	3,289	3,288	3,288
Shortspine thornyheads	1146.7	309	360	310	405	376	431	381	484
Shortspine thornyheads	50.0	50	50	50	50	50	50	50	50
Splitnose rockfish South	1494.7	1,419	1,419	1,382	1,382	1,419	1,419	1,382	1,382
Starry flounder	171.9	188	188	188	188	188	188	188	188
Widow rockfish	11509.7	10,143	10,519	9,298	9,674	10,143	10,519	9,298	9,674
Yelloweye rockfish	4.4	3.3	3.3	3.4	3.4	3.3	3.3	3.4	3.4
Yellowtail rockfish North	3761.8	4,140	4,270	3,948	4,078	4,140	4,270	3,948	4,078

Table 5-9. Final (post-April 2024 PFMC meeting), projected catch for the IFQ fishery, in years 2023 (No Action), actual 2023 catch, and based on alternative allocations for 2025 and 2026.

Predicted catch (mt)	2023 Predicted	2023 Actual	2025 - ALT 1		2026 - ALT 1		2025 - ALT 2		2026 - ALT 2	
Species	NO ACTION	NO ACTION	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
Arrowtooth flounder	798.1	800.2	776.3	776.5	762.4	762.7	776.3	776.5	762.4	762.7
Bocaccio rockfish South	255.4	255.6	253.5	253.5	253.3	253.3	253.5	253.5	253.3	253.3
Canary rockfish	500.1	516.0	256.0	291.3	256.5	291.3	256.0	291.3	256.5	291.3
Chilipepper rockfish South	954.0	950.3	1,268.0	1,268.0	1,190.7	1,190.7	1,268.0	1,268.0	1,190.7	1,190.7
Cowcod South of 40°10' N.	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Darkblotched rockfish	183.0	184.0	157.4	175.6	152.2	170.5	157.4	175.6	152.2	170.5
Dover sole	3,835.5	3,832.4	3,835.6	3,835.6	3,835.6	3,835.6	3,829.5	3,829.5	3,817.6	3,817.6
English sole	232.8	234.8	232.4	232.4	232.1	232.1	232.4	232.4	232.1	232.1
Lingcod North of 40°10' N.	397.1	400.5	381.8	381.8	378.2	378.2	381.8	381.8	378.2	378.2
Lingcod South of 40°10' N.	50.3	50.1	52.1	52.1	53.7	53.7	52.1	52.1	53.7	53.7
Longspine thornyhead North	22.0	21.4	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9
Minor shelf rockfish North	270.6	271.8	295.0	295.0	292.2	292.2	295.0	295.0	292.2	292.2
Minor shelf rockfish South	35.8	44.3	38.2	38.2	38.2	38.2	38.2	38.2	38.2	38.2
Minor slope rockfish North	194.3	192.1	192.8	192.8	191.8	191.8	192.8	192.8	191.8	191.8
Minor slope rockfish South	27.7	27.7	28.1	28.1	28.0	28.0	28.1	28.1	28.0	28.0
Other flatfish	329.6	319.1	338.7	338.9	337.2	337.3	340.1	340.3	338.1	338.3
Pacific cod	36.5	39.2	36.6	36.6	36.6	36.6	36.6	36.6	36.6	36.6
Pacific halibut (IBQ) North	28.2	27.7	44.5	45.2	44.5	45.3	44.6	45.3	44.5	45.2
Pacific ocean perch North	222.5	224.7	221.4	221.4	221.0	221.0	221.4	221.4	221.0	221.0
Pacific whiting	101,966.3	100,955.0	101,966.3	101,966.3	101,966.3	101,966.3	101,966.3	101,966.3	101,966.3	101,966.3
Petrale sole	2,836.2	2,836.3	1,852.4	1,852.4	1,777.4	1,745.0	1,852.4	1,852.4	1,777.4	1,745.0
Sablefish North of 36° N.	2,689.0	2,677.4	8,076.1	8,268.3	8,076.1	8,268.3	8,076.1	8,268.3	8,076.1	8,268.3
Sablefish South of 36° N.	94.2	93.9	293.8	293.8	293.7	293.7	293.8	293.8	293.7	293.7
Shortspine thornyheads North	282.8	276.9	164.8	180.1	165.2	191.3	184.4	197.0	185.6	207.4
Shortspine thornyheads South	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Splitnose rockfish South	19.8	19.9	19.7	19.7	19.6	19.6	19.7	19.7	19.6	19.6
Starry flounder	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Widow rockfish	10,899.3	10,896.9	9,664.2	10,004.0	8,900.6	9,240.4	9,664.2	10,004.0	8,900.6	9,240.4
Yelloweye rockfish	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Yellowtail rockfish North	2,863.1	2,860.8	3,048.3	3,111.9	2,954.3	3,017.9	3,048.3	3,111.9	2,954.3	3,017.9

Table 5-10. Final (post-April 2024 PFMC meeting) projected attainment (% of allocation), of IFQ species categories by year and alternative.

Predicted attainment	2023 Predicted	2023 Actual	2025 - ALT 1		2026 - ALT 1		2025 - ALT 2		2026 - ALT 2	
Species	NO ACTION		LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
Arrowtooth flounder	5.1%	5.1%	9.1%	9.1%	11.4%	11.4%	9.1%	9.1%	11.4%	11.4%
Bocaccio rockfish South	36.5%	36.5%	38.8%	38.8%	39.1%	39.1%	38.8%	38.8%	39.1%	39.1%
Canary rockfish	59.4%	61.2%	95.5%	83.7%	95.3%	83.7%	95.5%	83.7%	95.3%	83.7%
Chilipepper rockfish South	61.0%	60.8%	60.6%	60.6%	60.7%	60.7%	60.6%	60.6%	60.7%	60.7%
Cowcod South of 40°10' N.	6.9%	6.9%	7.0%	7.0%	7.2%	7.2%	7.0%	7.0%	7.2%	7.2%
Darkblotched rockfish	28.3%	28.4%	29.0%	28.5%	29.2%	28.6%	29.0%	28.5%	29.2%	28.6%
Dover sole	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.8%	8.8%	9.8%	9.8%
English sole	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%
Lingcod North of 40°10' N.	21.7%	21.9%	25.4%	25.4%	26.1%	26.1%	25.4%	25.4%	26.1%	26.1%
Lingcod South of 40°10' N.	17.7%	17.6%	17.7%	17.7%	17.6%	17.6%	17.7%	17.7%	17.6%	17.6%
Longspine thornyhead North	1.0%	1.0%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%
Minor shelf rockfish North	39.0%	39.1%	38.7%	38.7%	38.7%	38.7%	38.7%	38.7%	38.7%	38.7%
Minor shelf rockfish South	22.0%	27.2%	21.8%	21.8%	21.8%	21.8%	21.8%	21.8%	21.8%	21.8%
Minor slope rockfish North	21.7%	21.5%	22.5%	22.5%	22.9%	22.9%	22.5%	22.5%	22.9%	22.9%
Minor slope rockfish South	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%	6.6%
Other flatfish	8.0%	7.7%	5.3%	5.2%	5.8%	5.7%	4.9%	4.9%	5.5%	5.4%
Pacific cod	3.5%	3.8%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%
Pacific halibut (IBQ) North	29.0%	28.4%	45.9%	46.6%	45.9%	46.7%	45.9%	46.7%	45.8%	46.6%
Pacific ocean perch North	7.5%	7.6%	8.1%	8.1%	8.4%	8.4%	8.1%	8.1%	8.4%	8.4%
Pacific whiting	57.1%	56.5%	57.1%	57.1%	57.1%	57.1%	57.1%	57.1%	57.1%	57.1%
Petrale sole	92.6%	92.6%	92.6%	92.6%	92.6%	92.6%	92.6%	92.6%	92.6%	92.6%
Sablefish North of 36° N.	69.1%	68.8%	61.7%	61.6%	61.7%	61.6%	61.7%	61.6%	61.7%	61.6%
Sablefish South of 36° N.	9.7%	9.7%	8.9%	8.9%	8.9%	8.9%	8.9%	8.9%	8.9%	8.9%
Shortspine thornyheads North	24.7%	24.1%	53.3%	50.0%	53.3%	47.2%	49.1%	45.7%	48.7%	42.9%
Shortspine thornyheads South	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Splitnose rockfish South	1.3%	1.3%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%
Starry flounder	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Widow rockfish	94.7%	94.7%	95.3%	95.1%	95.7%	95.5%	95.3%	95.1%	95.7%	95.5%
Yelloweye rockfish	10.3%	10.4%	11.1%	11.2%	10.4%	10.4%	11.1%	11.2%	10.4%	10.4%
Yellowtail rockfish North	76.1%	76.0%	73.6%	72.9%	74.8%	74.0%	73.6%	72.9%	74.8%	74.0%

5.3 Washington Recreational

The Washington Ocean Sampling Program (OSP) generates catch and effort estimates for the recreational boat-based groundfish fishery, which are provided to Pacific States Marine Fisheries Commission (PSMFC) and incorporated directly into the Recreational Fisheries Information Network (RecFIN) database. The OSP provides catch in total numbers of fish, and also collects biological information on average fish size, which is provided to RecFIN to enable conversion of numbers of fish to total weight of catch. Boat egress from the Washington coast is essentially limited to four major ports, which enables a sampling approach to strategically address fishing effort from these ports. Effort estimates are generated from either exit or entrance counts of boats leaving coastal ports while catch per effort is generated from boat intercepts at the conclusion of their fishing trip. The goal of the program is to provide information to RecFIN on a monthly basis with a one-month delay to allow for inseason estimates. For example, estimates for the month of May would be provided at the end of June. Some specifics of the program are:

- **Exit/entrance count** – boats are counted either leaving the port (as early as 3:00 AM - end of the day) or entering the port (approximately 8:00 AM through end of the day) to give a total count of sport boats for the day.
- **Unit of sample –** The unit of sample used by the OSP is a single boat trip.
- **Interview** – boats are encountered systematically as they return to port; anglers are interviewed for target species, number of anglers, area fished, released catch data and depth of fishing (non-fishing trips are recorded as such and included in the effort expansion). The OSP collects information on released catch but does not collect information on the condition of the released fish. However, the angler provides a depth at which the majority of rockfish were encountered allowing for; released catches to be post-stratified as live or dead based upon an assumed species specific discard mortality rate. Onboard observers are deployed on charter vessels throughout the salmon season primarily to observe hatchery salmon mark rates but also to collect rockfish discard information on these trips.
- **Examination of catch** – catch is counted and speciated by the sampler. Salmon are electronically checked for coded wire tags and biodata are collected from other species.
- **Sampling Rates** – vary by port and boat type. Generally, at boat counts less than 30, the goal is 100 percent coverage. The sampling rate goal decreases as boat counts increase (e.g., at an exit count of 1500, sample rate goal is 30 percent; over 300, sample rate goal is 20 percent). Overall sampling rates average approximately 50 percent coastwide through March-October season.
- **Sampling Schedules** – due to differences in effort patterns, weekdays/weekend days are stratified separately. Usually, both weekend days and a random 3 of 5 weekdays are sampled.
- **Personnel** – OSP sampling staff include three permanent biologists coordinating data collection, one permanent biologist generating in-season estimates of groundfish catch, one Natural Resource Scientist overseeing the program, approximately twenty-four port samplers, and two on-board observers.
- **Volume of Data** – Between 20,000 and 30,000 boat interviews completed per season coastwide.

5.3.1 Data Expansion Algorithms

Algorithm for expanding sampled days:

$$P_t = \frac{Exit\ Count}{Total\ Boats\ Sampled} * P_s\ sampled$$

Where:

P_s = any parameter (anglers, fish retained, fish released) within a stratum,
P_t = total of any parameter with stratum for the sample day

Algorithm for expanding for non-sampled days:

$$Total\ Weekday\ Catch = \frac{\Sigma(P_t) on\ sampled\ weekdays}{\#\ of\ weekdays\ sampled} * \#\ of\ weekdays\ in\ stratum$$

$$Total\ Weekend\ Catch = \frac{\Sigma(P_t) on\ sampled\ weekend\ days}{\#\ of\ weekend\ days\ sampled} * \#\ of\ weekend\ days\ in\ stratum$$

$$Total\ catch\ in\ stratum = Total\ Weekend\ catch + Total\ weekday\ catch$$

Notes on Data Expansion:

Salmon and halibut catch estimates are stratified by week; catch estimates for all other species are stratified by month. All expansions are stratified by boat type (charter or private), port, area, and target species trip type (e.g., salmon, halibut, groundfish, and albacore).

5.3.2 Washington Recreational Fishery Impact Modeling

Projected impacts for Washington's recreational fishery are essentially based upon recent years harvest as estimated by the OSP and incorporated in RecFIN. This is especially true if recreational regulations remain consistent.

WDFW doesn't use a formal model to produce estimates of projected impacts under various management measure scenarios but has relied instead on an ad hoc approach that uses historical catch on a case by case basis to evaluate impacts to overfished species.

5.3.3 Angler Effort

WDFW's approach to estimating projected impacts was reviewed and approved by the SSC Economics and Groundfish Subcommittees (SSC E-G/F) in the fall of 2012. With the review, the SSC E-G/F recommended a retrospective analysis of effort projections compared to post-season effort estimates for past biennial harvest specifications and management measures cycles to better understand the historical performance of Washington's ad hoc approach. Angler effort has increased since 2011. Projected fishing effort follows the same trend as actual fishing effort

5.3.4 Inseason Catch Projections for 2023-2024

Inseason catch projections are based upon the most recent OSP estimates and incorporated in RecFIN (with a one-month time lag) with subsequent months extrapolated from the pre-season catch projections. Beginning in 2009, depth dependent mortalities have been applied uniformly to all discarded fish coast wide through RecFIN It should be noted that the precision of recreational groundfish catch estimates based upon previous seasons will continue to be influenced by factors such as the length and success of salmon, albacore, and Pacific halibut seasons, as well as weather and other unforeseen factors.

5.4 Oregon Recreational Fishery Model for 2024-25

Groundfish mortality associated with regulatory scenarios for each alternative were projected using the Model of Oregon Recreational Groundfish (MORG), which was reviewed by the SCC and found to "use appropriate data and methods and provides a sound basis for management decisions" prior to the 2015-2016 Groundfish Biennial Specifications Process (PFMC 2015).

The model, described below, has been updated since the review to incorporate all process recommendations made by the SSC (e.g., inclusion of variances to provide measures of uncertainty). recommended changes. Additional updates were made to accommodate new data sources (e.g., mortality rates for rockfish released with descending devices and the proportion of fish release with the devices) and to increase ease of use for users to manipulate model inputs (e.g., a user interface "switchboard" was developed for all model inputs."

5.4.1 Landings and Discard Mortality Estimation

The MORG produces projections of landings and discard mortality for thousands of combinations of regulation options (i.e., bag limit, size limit, depth closures, and season closures). To produce these projections, MORG manipulates the exact same data inputs that the sport fishery monitoring survey, the Oregon Recreational Boat Survey (ORBS) uses to estimate total landings, discard mortality, and effort. In short, the MORG manipulates the data sets ORBS uses to estimate total catch and effort and then reruns the estimates in the same manner as done by ORBS.

Since MORG functions by manipulating the data sets used by ORBS to estimate catch and effort, it is important to first understand the process and data inputs used by ORBS to estimate total sport catch and effort. To estimate these factors, ORBS assumes un-sampled boats catch the same as sampled boats. In finer detail, ORBS obtains catches from a portion of boats intercepted by the dockside survey for a given trip type (e.g., Newport charter boats) and assumes the un-sampled boats of that similar trip type caught same (strata and domains used to lump similar trips include boat type, port, week, area fished). And by statistical definition, ORBS estimates total catch and effort by multiplying catch rates (catch per boat) for each trip type to the portion of total boats (sample and un-sampled) from that same trip type.

5.4.2 Landings and Discard Mortality Projections

As stated above, the two main survey components used to estimate total catch and effort are the dockside survey and the total boat survey. And the MORG projects catch and effort for regulatory options by manipulating the dockside survey interviews by adjusting what the anglers caught and where they fished, and then reruns the total catch and effort estimates using the same ORBS procedures (along with variance computations). By manipulating the individual trips, this provides the greatest ability to adjust multiple regulations at once – and is manipulating what truly occurs in the fishery.

And to account for total effort, which is used to expand the dockside interviews to total catch and effort, a variety of approaches have been taken. Until recently, the average angler trips were used because the number of trips was relatively consistent across years; however, to account for a major spike in total effort since 2015 (i.e., from ~60,000-70,000 per year prior to 2015 to a record ~110,000 in 2015 and over 100,000 through August in 2017), the model uses a "stair-step" effort ramp with the assumption that 2023-2024 will also have similar amounts of high effort.

5.4.3 MORG Model Components

Bag limit model component: The bag limit model adjusts the landings of individual anglers to not exceed the proposed (new) daily bag limit, and any previous landings above the bag limit are converted to discards (with discard mortality rates applied). For example, if three anglers landed nine black rockfish and discarded six with a bag limit of seven, the catches for a bag limit of one would be three black rockfish landed (one per angler) and 12 discarded (six originally discarded plus the six of nine that were landed, but now had to be thrown back). And in a reverse situation where the bag limit is increased, anglers would be able to retain more of their discards (and the mortality rate of these fish would be changed to the discard mortality rate to 100 percent).

- **Size limit model component:** The size limit component functions very similarly to the bag limit component, but is more uncertain since lengths of discarded fish are unknown (and are assumed to match the distribution obtained by the sport observer survey, which records the sizes of discarded fish). For example, if the size limit is decreased to 10" from a current no size restriction, the model forces anglers to discard any catch below 10" (which are then converted to discards with discard mortality rates applied) and they can retain any of their catch above 10".
- **Area closure model component:** The area closure component primarily models projections of catch and effort pertaining to depth closures, as depth is the most common area closure used in the sport fisheries (to limit yelloweye rockfish interactions). And the depth closure component differs from the bag and size limit components; instead of converting landings to discards or vice versa, the depth model moves anglers from areas that become closed to open areas. To do this, the model excludes trips that occur in closed areas from the dataset, and then gives a greater weighting to the existing trips in open areas. And the main assumption is that no effort is lost due to area closures; rather that all effort shifts to open areas (this assumption based on historical data that shows the number of trips years with depth restrictions did not appear to decrease compared to years without).
- **Seasonal closure model component:** The season model component functions rather simply by forcing effort to be zero during closed times. This may result in an underestimate of catch and effort since some anglers may continue to fish during closed periods by practicing catch-and-release (which would result in discard mortality). While the effects of complete season closures may be uncertain, it was deemed reasonable to expect that most anglers would stop fishing if unable to harvest their catch. Further, season closures are the least desired regulation option, and are only used when all other regulatory options have failed to limit mortality to acceptable levels.
- **Regional catch and effort component:** Following review of MORG, the SSC recommended that the model produce regional catch and effort estimates. With one reason being that the economic multipliers used to expand the base value of recreational trips (trip expenditures; money spent on fuel, tackle, etc.) to total economic impacts to communities differ throughout regions in Oregon (i.e., "multiplier" effect of the based spending creating additional value as it cycles through the economy from business to business until all is leaked to outside the community). While regional catch and effort has not yet been coded for in the model, it is a future goal. To complete regional modeling, both data sets (dockside intercept and total effort) could be filtered for the desired region prior to rerunning the estimation procedures.

- **Multivariate predictors of effort:** At the SSC review, ODFW demonstrated that weather (wind, waves, and wind*wave interaction) and strength of other fisheries (e.g., salmon) are related to sport groundfish effort (but not factors such as economic indicators and other environmental factors) and thus explored whether inclusion of these factors could help model performance (via use of a hybrid GLM / manipulation model). However, following further investigation ODFW concluded that while these factors may affect sport groundfish effort (and thus catch), weather and strength of other fisheries cannot be accurately predicted, and thus cannot be used as explanatory variables in MORG at this time.
- **Other features and specifications:** While MORG is simple in concept; hundreds of pages of code are required account for the approximately 60,000 (and counting) regulatory options for which MORG provides projections for. As such, MORG includes a user interface that allows users, even without any familiarity of the fisheries or modeling details, to simply adjust regulations in order to create projections for different regulation scenarios.

In addition to being able to adjust regulations, users may also adjust alpha to create projection intervals to their desired level of risk tolerance (e.g., 75 percent if more risk tolerant, 95 percent if more risk adverse). This inclusion of measures of uncertainty is new, and addresses the main SSC recommendation during the model review.

Finally, MORG is a duel function inseason tracking tool (of actual landings) and projection model combined. When actual catch and effort are added, projections from that timeframe are replaced with the true values and the remainder of the year remains projections. This allows managers to closely monitor and manage the fishery throughout the year.

5.5 California Recreational Groundfish Model for 2024-25

5.5.1 Groundfish Fishery Projection Model

The anticipated mortality for select groundfish in the California recreational fishery under various season structure options are modeled using the RecFISH model. The model was developed in 2004 under contract with MRAG Americas, with subsequent augmentation of catch by depth and time parameters by California Department of Fish and Wildlife (CDFW). RecFISH allows projection of catch by depth and season length in each of the five groundfish management areas.

5.5.2 Model Description

The model incorporates proportion of catch by depth and time from historical unregulated periods and recent estimates of mortality in each management area to project mortality under given various season structures. The RecFISH model is a catch based model as opposed to an effort based model and has been previously reviewed by the SSC.

5.5.3 Methods

The model utilizes catch data from a recent regulated year ("base year") and expands that catch for the entire "unregulated" year. The assumption is that the historical proportion of catch by time and depth is representative of what will occur in the future. While this presents some uncertainties (discussed below) measures are available to mitigate this risk. For the 2025-2026 biennial cycle, catch data from the 2017 through 2019 and January through October 2021 recreational fishery was used as the base years, with post-model adjustments to incorporate catch data from the 2022 and 2023 fisheries. Utilizing the most recent years' data captures recent trends and is likely more reflective of future fishing behavior. The COVID-19 pandemic, beginning in 2020 and continuing into 2021, impacted catch data collection. The California Recreational Fisheries Survey (CRFS) program did not conduct sampling activities from mid-March through June 2020. When sampling activities resumed in July 2020, only the minimal necessary data were collected. Catch data for 2020 are not used in the RecFISH model as they are incomplete and do not capture total fishery removals for the year.

The expected magnitude of unregulated catch by depth and time for the base years is back-calculated to reflect mortality during an unregulated year. This is performed for each management area and species within the model by expanding mortality during the regulated period by what would be expected from an unregulated fishery using the historical proportion of catch by depth and time from unregulated years. In expanding baseline catch data from regulated seasons to all depths and months, data from other areas were used to supplement the existing historical data.

Further, historical data for California can only be stratified north and south of Point Conception (34°27' N). However, estimates of catch by time north of Point Conception during this period were dominated by the San Francisco and Central Management Areas where more effort was exerted over more months than north of Point Arena. As a result, for select species the proportion of catch by time from Oregon was used in the Northern and Mendocino Management Areas due to greater similarity in the timing of the fishery than that of the fishery south of Point Arena (38°57.5'). Contemporary depth strata information from the 2019-2020 all depth fishery in the Northern and Mendocino Management Areas, and the boat-based fishery from 2021 in the Southern

Management Area where the depth limit was the 100 fm RCA contour line were used to augment the historic depth strata data.

To account for depth dependent mortality rates, base catch in each month and depth bin is multiplied by the average proportion of catch from discarded fish (reported discarded live + reported discarded dead) in the base years described above for each species and management area. This results in the expected tonnage of discarded fish. The species-specific depth dependent mortality rates (by 10 fm depth bin) derived by the GMT (or suitable proxy) are applied to the discarded catch to provide an estimate of the expected discards for each depth bin. The resulting discard mortality estimate is added to the expected tonnage of retained catch to provide a projection of total mortality for each depth bin and month. This is used as the "base season" reflecting the mortality expected in an unregulated fishery.

The model also takes into account effort shifts that are likely to occur with varying depth restrictions. If depths are restricted to 20 fm or 30 fm, the model accounts for effort which would have occurred in deeper depth bins shifting to the shallower depth bins, by applying an increase of 39.3 percent and 27.6 percent, respectively.

Projected mortality from the desired depth and season is obtained by summing the projected mortality values for each month and depth bin by species or species group in each management area. Projected mortality is then summed by the relevant management areas to obtain the total projected mortality in relation to the relevant management area (i.e., statewide or north and south of Cape Mendocino 40°10' N lat.).

Once mortality projections are complete adjustments can be made to account for increases or decreases in mortality resulting from other management measures (e.g., bag limits). The anticipated percent reduction or increase in mortality expected from such management measures are estimated using recent CRFS data and the RecFIN bag limit analysis tool.

Each management cycle post model adjustments are made to immediate model outputs when review of the output does not align with recent catch trends or expected changes in catch under various management measures. The post model adjustments may be based on recent or historic catch trends when regulations were similar or dis-similar. Post model adjustments for several species were made in this analysis, are primarily based on 2023 projected end of year total mortality, and also take into account the following information:

- All depth fisheries in each of the five Management Areas during part of the year, and "offshore only" fisheries in each of the five Management Areas beginning in 2023
- Sub-bag limits for black rockfish, canary rockfish, and cabezon were removed beginning with the 2021 season, and reduced bag limits for copper rockfish, quillback rockfish, and vermilion rockfish were introduced beginning with the 2022 season and RecFISH outputs are adjusted using the RecFIN bag limit tool and actual 2023 total mortality.
- Inseason action in 2023 to prohibit retention on quillback rockfish, and to shift all Management Area depth constraints in the areas north of Point Conception to "offshore only" (seaward of the 50 fathom RCA line) resulted in reduced impacts for 2023 than initially projected for nearshore rockfish species, cabezon, kelp greenling, and lingcod;

while mortality for several minor shelf rockfish species increased. RecFISH outputs for 2025-2026 for these species are adjusted using the bag limit tool and 2023 total mortality.

A step by step explanation of the methodology used in the RecFISH model can be found in greater detail in Appendix B of the 2015-2016 FEIS; no changes were implemented during this cycle. .

5.5.4 Model Uncertainty

While the RecFISH model is the best available science, there are some known uncertainties which are explained here. For some species, few data are available to inform the model, which is particularly the case for species with deeper depth distributions, such as the shelf and slope rockfish species, or species for which retention is prohibited or encounters are infrequent. For these species and depth bins projected impacts may vary from actual impacts.

The model also assumes that fishing behavior during the historic period will be representative of the current fishery. However, many changes have occurred in the fishery which has likely affected behavior and distribution of fishing effort. For example, Marine Protected Areas have been established, closing some areas to recreational fishing which were previously accessible during the "unregulated years."

It is also assumed the fishing behavior during the historic period and current fishery will be representative of fishing behavior under proposed management measures. If significant changes to management measures are made to the fishery, substantial changes to angler behavior may occur, which the model cannot predict. Significant changes to management measures were made in 2022, the start of 2023, inseason in 2023, and additional inseason changes are proposed for the 2024 fisheries; all of these changes to management measures increase the uncertainty of the model outputs when projecting impacts for the 2025 and 2026 cycle.

Opportunities in other fisheries may also cause model projections to deviate from actual impacts. For example, opportunity in the salmon fishery affects effort and participation in the groundfish fishery. In good salmon years, there is less effort in the groundfish fishery and in poor salmon years groundfish effort is much higher.

Along with the availability of other fisheries, changes in oceanographic conditions can cause actual impacts to deviate from projections. For example, in 2015, abnormally warm waters caused a shift in the distribution of many species. In central California, anglers shifted some effort from groundfish to bonito, which are not normally encountered in the region.

5.6 *Estimating Effort for use in the Input Output Pacific Coast Fishery Model*

The Northwest Fishery Science Center (NWFSC) Input Output Pacific Coast Fishery (IO-PAC) is designed to estimate the changes in economic contributions and economic impacts resulting from policy, environmental, or other changes that affect fishery harvest. IO-PAC was built by customizing the Impact Analysis for Planning (IMPLAN) regional input-output software. The original methodology employed in developing this model was similar to that used in the Northeast Region Commercial Fishing Input-Output Model (Steinback and Thunberg, 2006). The development and design of IO-PAC is documented in detail in Leonard and Watson (2011). The model was subsequently updated as part of an ongoing effort to continually improve the IO-PAC model with the latest available data and improvements in regional impact modeling capabilities. Substantial changes were made to model construction, new commercial fishing sectors were added, and a recreational fishing component was added, and these changes are documented in the final environmental impact statement for the 2015-2016 groundfish harvest specifications and management measures (PFMC, 2015). The current version of IO-PAC is detailed therein, except that there have been several data updates. This section summarizes the data updates that have been made since the documentation in PFMC 2015.

The data updates made include the following. One, the underlying IMPLAN data is changed from the 2012 base year to 2014. Two, the fish-ticket (landings) data from PacFIN changed from 2014 to 2016. Three, the commercial vessel production functions incorporate the latest data from the voluntary Limited Entry and Open Access Surveys conducted by the Northwest Fisheries Science Center. Four, it incorporates the latest data collected as part of the EDC program. Five, it incorporates 2012 data from the charter vessel surveys completed by the Northwest and Southwest Fisheries Science Centers. Table 5-11 provides a summary of the data that is currently used in IO-PAC and its application.

Table 5-11. IO-PAC data sources, applications, and year of data incorporation into the model

Data Year	OA Survey	LEFG Survey	Marine Rec. Exp. Survey	WA and OR Charter Vessel Survey	CA Charter Vessel Survey	EDC DATA	EDC Data	IMPLAN	PacFIN Fish Ticket
	2012	**2012**	**2011**	**2012**	**2012**	**2016**	**2015**	**2014**	**2014**
Application									
Commercial Vessels									
Production Functions	X	X				X			X
Vessel Industry Output				X	X	X		X	X
Vessel Employment	X	X				X			X
Processors									
Production Functions						X	X	X	
Processor Industry Output						X	X	X	X
Processor Employment						X	X	X	X
Recreational Fishing									
Expenditures			X						
Charter Prod. Functions				X	X				
Charter Industry Output			X	X	X				
Charter Employment			X	X	X				
Non-Fishing Data								X	

5.6.1 Commercial Landings Distribution Model

The purpose of the commercial fishery landings distribution model (LDM) is to inform the PFMC's management processes by projecting where PacFIN Port Code Identifier (PCID) landings are likely to occur under a set of alternative scenarios (e.g., alternative ACLs or management measures). The projected landing ports can then be mapped onto Port Area aggregations to allow comparison of the geographic distribution of ex-vessel revenues under the alternatives. Since all the alternatives are modeled consistently, projections from the LDM facilitate comparison of the alternatives in an apples-to-apples fashion.

A list of Port Areas, and underlying PCIDs, is shown in Table 6-2 and Table 6-3. Although used primarily to inform the groundfish management processes, the LDM methodology can be applied to analyze any west coast fishery. In the case of groundfish, ex-vessel revenue results from the LDM, aggregated by Port Area, are fed directly into the IO-PAC input-output and vessel net revenue projection models, where they are used to calculate and compare economic impacts under the different alternatives[18].

5.6.2 Data Elements

The core of the LDM is a recent-year commercial fishing landings data report from the PacFIN data system. The standardized PacFIN daily (vdrfd) or monthly (vfcmrfd) vessel landing summary or other summary queried tables can be used for this purpose.

For analyzing the alternative 2023-2024 groundfish management specifications, a table of monthly landings for 2021 was used.

Key data elements of the LDM provided by the PacFIN landings data report include:

- Inventories of all species (SPIDs including nominal and market categories after application of species composition factors), round weights and ex-vessel values landed by port (i.e., PCID).
- Assignment of landing vessel IDs to current groundfish federal limited entry permits, if applicable.
- Assignment of each landing to a fisheries management sector (dahl_sector).
- Distribution of species landings and ex-vessel revenues by landing vessel ID.
- Distribution of species landings and ex-vessel revenues among first receivers (Processor ID).
- This historical information forms one of baselines against which changes under the management alternatives can be measured.

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[18] IO-PAC is a set of regional economic impact models constructed using landings data, vessel expenditure estimates, and secondary economic data to estimate income and employment impacts resulting from a change in the distribution of commercial fishery landings. It is maintained by Northwest Fisheries Science Center (NWFSC) and used by the Pacific Fishery Management Council (PFMC) to estimate economic impacts of West Coast fishery management actions.

5.6.3 Model Description

Groundfish landings records in the vessel landings table are categorized by fisheries sector (PacFIN "dahl_sector"). This categorization is based on limited entry permit status, PFMC catch area, landing port, species and gear used. The fisheries sector categories align with the GMT fishery sector projection models listed below. The GMT models project landings in each of five fishery sectors under the management alternative as part of their overall analysis of harvest specifications and management measure alternatives.

The next step is to compute the base year percentage of landings for each fishery sector by each combination of Area, Vessel (or Permit) ID, Species Identifier (SPID) and PCID. The "area" used for this calculation varies according to the resolution of the corresponding fishery sector projection model, as noted below. The percentages are then applied to the results from the GMT fishery sector projection models to estimate the geographic distribution of landings across ports in each fishery.

To project the geographic distribution of landings under the alternatives, results from the commercial fisheries sector landings projection models are applied to the landings percentages calculated from the landings data as noted above. Unless indicated otherwise (by the GMT model results or the proposed management measures) landings under the alternatives are assumed to occur in the same ports in proportion to landings observed in the base year. Only landings of the main economic groundfish species that are modeled for each fishery sector are of concern in the LDM. Landings of non-groundfish species, incidentally, caught groundfish species, and overfished species such as yelloweye are generally not modeled, as these are not managed under the Groundfish FMP or do not generate significant revenues in federally managed groundfish fisheries.

The level of detail carried over from the GMT models to the LDM varies considerably by fisheries sector. The most detailed results are produced by the TRAT IFQ catch projection model which generates a table of projected landings by species category for each participating vessel/groundfish permit ID.

More aggregated results are used to link the LDM with the non-IFQ fishery sector models. For example, aggregate sablefish catch projected by the Non-nearshore fisheries model is used to model sablefish landings by the non-nearshore LE, OA, and tribal fixed gear sectors north of 36° N. lat. Unless otherwise indicated, each PCID north of 36° N lat. is expected to receive the same proportions of coastwide LEFG, OA, and tribal sablefish landings under each alternative during the biennial cycle as it received in the base year landings data.

Linkage between the LDM and the Nearshore fisheries model is similar, except that additional area detail in the nearshore model is incorporated to distribute projected landings of nearshore groundfish species to ports (PCIDs) in Oregon and in California north and south of 40°10' N. lat. in proportion to where those landings occurred in the base year vdrfd data table.

The main features, model inputs and additional procedures used for integrating landings information in the LDM are described below:

- **TRAT IFQ catch projection model:** Projected groundfish target species landings by each vessel/permit participating in the IFQ fishery. The list of IFQ target species projected includes sablefish, longspine thornyhead, shortspine thornyhead, Dover sole, arrowtooth flounder, petrale sole, English sole, other flatfish, and Pacific whiting, among others. Incidental landings of non-target IFQ and overfished species are also projected by the model, however these landings are not generally relevant for economic analysis.

- **Non-nearshore fisheries model**: Projected maximum aggregate landings of sablefish by vessels participating in the LEFG, OA DTL, and tribal fisheries north of 36° N lat. Only projected sablefish landings are used in the economic analysis. To date sablefish landings south of 36° N lat. have not been explicitly modeled by the GMT. Instead, the ratios of sablefish ACLs specified under each alternative are compared with landings and ACLs observed in the base year, and the resulting ratios are applied to project sablefish landings in ports south of 36° N lat. under the alternatives.
- **Nearshore fisheries model:** Projected aggregate landings by area (Oregon, California north of 40°10′N lat., and California south of 40°10′ N lat.) of nearshore target species (black rockfish, blue/deacon rockfish, cabezon, kelp greenling, lingcod, and other minor nearshore rockfish) by vessels participating in the fixed gear OA fishery. Catch of canary and yelloweye rockfish are also projected, although landings of those species have not been relevant for economic analysis of the nearshore sector.
- **At sea Pacific whiting fisheries model:** Projected allocations of Pacific whiting to the at-sea catcher processor and mothership fisheries sectors, constrained by allocations of anticipated relevant constraining species and observed bycatch rates, if applicable.
- **Tribal fisheries model:** Projected total Pacific whiting (shoreside and at sea) and non-Pacific whiting groundfish target species landings by the tribal groundfish fisheries off the Washington Coast.

5.6.4 Sectors in the Landings Distribution Model

IFQ Sector

Information in the final end-of-year run for the most recent year from the IFQ catch projection model is used to adjust base year landings for IFQ fishery participants. This step produces a calibrated landings report that can be linked with IFQ catch projections generated for each groundfish management option or alternative. Projected landings by vessels (i.e., permits) are assumed to be distributed to ports based on where those vessels landed as reported in the base year landings data. Note: Although Pacific whiting harvest is regulated separately from the non-whiting groundfish specifications process, whiting landings by vessels/permits participating in the IFQ fishery are also modeled using this method. For purposes of comparison, sometimes a range of Pacific whiting harvests is associated with the groundfish harvest alternatives being analyzed; or alternatively, a single, fixed Pacific whiting catch scenario is assumed to apply under all the alternatives analyzed.

Non-Nearshore Sectors

Total sablefish landings projected under each option or alternative by the Non-nearshore fisheries model for fixed gear LE, OA-DTL and tribal fisheries north of 36° N. lat. are distributed to participating vessels and PCIDs, as shown in Table 5-12 and Table 5-13 in proportion to where sablefish landings were recorded in the base year landings data. For areas south of 36° N. lat. a different procedure is used. The ratio of sablefish landings in the base year to the alternative sablefish ACL is calculated. This ratio is then applied to the corresponding ACL projected under each option or alternative to estimate total sablefish landings south of 36° N. lat. under the management scenarios. Estimated total landings are then distributed to vessels and associated landing ports south of 36° N. lat. in proportion to where sablefish landings were recorded in the base year landings data.

Nearshore Sector

For the fixed gear OA fishery, total projected nearshore target species landings projected by the nearshore sector model under each option or alternative are distributed to participating vessels and landing ports in the same proportions observed in the base year landings data. Nearshore target species distributed in this manner include black rockfish, blue/deacon rockfish, cabezon, kelp greenling, lingcod, and other Minor Nearshore Rockfish. Nearshore fishery landings projected by the Nearshore OA model are split into three catch area stratifications: California south of 40°10′ N lat., California north of 40°10′ N lat., and Oregon. Note that sablefish landings by the tribal sector are projected using the Non-nearshore sector models

At-sea Pacific Whiting Sectors

Total projected Pacific whiting catch under the alternatives in the two nontribal at-sea Pacific whiting fisheries (catcher processers and motherships) is distributed in proportion to catch during the base year. Pacific whiting harvest is regulated separately from the non-whiting groundfish specifications process, but for purposes of comparison a range of Pacific whiting harvests is sometimes analyzed along with the alternative groundfish harvest specifications.

Tribal Groundfish Sector

Total projected landings and deliveries under each option or alternative by the tribal groundfish fisheries, including shoreside and at-sea Pacific whiting, are distributed among ports that participated in those fisheries in proportion to those ports' participation during the base year.

5.6.5 Assumptions and Caveats

Major simplifying assumptions used in the analysis include:

- Average ex-vessel prices observed in the base year will carry over to the projection period(s).
- Average annual ex-vessel prices are assumed to apply in each port no matter when during the year the landings occur.
- There is no cross-hauling of raw product. That is, landings in a given port are not shipped elsewhere for processing.

One concern with this approach is that the more ex-vessel prices deviate from the range of prices observed in the base year, the more inaccurate projected revenue impacts may be. However, if better information is available on future ex-vessel price trends, it is certainly possible to incorporate this type of information into the revenue projections.

Landings and revenue impacts projected by the LDM are used with the IO-PAC model to estimate community income impacts under the management alternatives. To the degree that processing activities, vessels' home ports, or the residences of owners and workers are located in the ports of landing, then a larger portion of the economic impacts generated by these landings will accrue to the port. However, to the extent that processing activities, vessels' home ports, or the residences of workers and owners are located elsewhere historical landings patterns may or may not be representative of the impact of these activities in the local economy. For example, if landings are made in one port but vessels' home ports or crew's residences are elsewhere, or if first receivers transport landings to another place for processing, then at least a portion of the projected income and employment impacts may be attributed to the wrong port or region.

5.6.6 Results

Results from the LDM are used as inputs to estimate community income and employment impacts and vessel sector net revenues under the alternatives. Projected landings and ex-vessel revenues by species, fishery sector and port are applied to impact coefficients estimated using the IO-PAC model to generate community personal income and employment impacts under each management alternative. Projected landings and ex-vessel revenues by groundfish fishery sectors coupled with vessel cost estimates derived from IO-PAC are also used to estimate aggregate net revenues accruing to vessel owners participating in west coast groundfish fisheries. The resulting estimates are then used to compare economic impacts across the range of groundfish management alternatives under consideration.

Table 5-12.. List of California Port Groups and PacFIN PCIDs in the Landings Distribution ModelList of Washington and Oregon Port Groups and associated PacFIN Port Codes (PCIDs) in the Landings Distribution.

Port Group Area	County	PCID	Port Name
WASHINGTON			
Puget Sound	Whatcom	BLN	Blaine
	Whatcom	BLL	Bellingham Bay
	San Juan	FRI	Friday Harbor
	Skagit	ANA	Anacortes
	Skagit	LAC	La Conner
	Snohomish	ONP	Other North Puget Sound Ports
	Snohomish	EVR	Everett
	King	SEA	Seattle
	Pierce	TAC	Tacoma
	Thurston	OLY	Olympia
	Mason	SHL	Shelton
North Washington Coast	Jefferson	TNS	Port Townsend
	Clallam	SEQ	Sequim
	Clallam	PAG	Port Angeles
	Clallam	NEA	Neah Bay
	Clallam	LAP	La Push
South & Central WA Coast	Grays Harbor	CPL	Copalis Beach
	Grays Harbor	GRH	Grays Harbor
	Grays Harbor	WPT	Westport
	Pacific	WLB	Willapa Bay
	Pacific	LWC	Ilwaco/Chinook
	Klickitat	OCR	Other Columbia River Ports
OREGON			
Columbia River	Multnomah	CRV	Pseudo Port Code for Columbia River
Astoria-Tillamook	Clatsop	AST	Astoria
	Clatsop	GSS	Gearhart - Seaside
	Clatsop	CNB	Cannon Beach
	Tillamook	NHL	Nehalem Bay
	Tillamook	TLL	Tillamook / Garibaldi
	Tillamook	NTR	Netarts Bay
	Tillamook	PCC	Pacific City
Newport	Lincoln	SRV	Salmon River
	Lincoln	SLZ	Siletz Bay
	Lincoln	DPO	Depoe Bay
	Lincoln	NEW	Newport
	Lincoln	WLD	Waldport
	Lincoln	YAC	Yachats
Coos Bay	Lane	FLR	Florence
	Douglas	WIN	Winchester Bay
	Coos	COS	Coos Bay
	Coos	BDN	Bandon
Brookings	Curry	ORF	Port Orford
	Curry	GLD	Gold Beach
	Curry	BRK	Brookings

Table 5-13. List of California Port Groups and associated PacFIN Port Codes (PCIDs) in the Landings Distribution Model

Port Group Area	County	PCID	Port Name
CALIFORNIA			
Crescent City	Del Norte	CRS	Crescent City
	Del Norte	ODN	Other Del Norte County Ports
Eureka	Humboldt	ERK	Eureka (Includes Fields Landing)
	Humboldt	FLN	Fields Landing
	Humboldt	TRN	Trinidad
	Humboldt	OHB	Other Humboldt County Ports
Fort Bragg	Mendocino	BRG	Fort Bragg
	Mendocino	ALB	Albion
	Mendocino	ARE	Arena
	Mendocino	OMD	Other Mendocino County Ports
San Francisco (incl. Bodega Bay)	Sonoma	BDG	Bodega Bay
	Marin	BOL	Bolinas
	Marin	TML	Tomales Bay
	Marin	RYS	Point Reyes
	Marin	OSM	Other Son. and Mar. Co. Outer Coast Ports
	Marin	SLT	Sausalito
	Alameda	OAK	Oakland
	Alameda	ALM	Alameda
	Alameda	BKL	Berkely
	Contra Costa	RCH	Richmond
	San Francisco	SF	San Francisco
	San Mateo	PRN	Princeton
	San Francisco	SFA	San Francisco Area
	San Francisco	OSF	Other S.F. Bay and S.M. Co. Ports
Monterey	Santa Cruz	CRZ	Santa Cruz
	Monterey	MOS	Moss Landing
	Monterey	MNT	Monterey
	Monterey	OCM	Other S.C. and Mon. Co. Ports
Morro Bay	San Luis Obispo	MRO	Morro Bay
	San Luis Obispo	AVL	Avila
	San Luis Obispo	OSL	Other S.L.O. Co. Ports
Santa Barbara	Santa Barbara	SB	Santa Barbara
	Santa Barbara	SBA	Santa Barbara Area
	Ventura	HNM	Port Hueneme
	Ventura	OXN	Oxnard
	Ventura	VEN	Ventura
	Ventura	OBV	Other S.B. and Ven. Co. Ports
Los Angeles	Los Angeles	TRM	Terminal Island
	Los Angeles	SPA	San Pedro Area
	Los Angeles	SP	San Pedro
	Los Angeles	WLM	Willmington
	Los Angeles	LGB	Longbeach
	Orange	NWB	Newport Beach
	Orange	DNA	Dana Point

Port Group Area	County	PCID	Port Name
	Orange	OLA	Other LA and Orange Co. Ports
San Diego	San Diego	SD	San Diego
	San Diego	OCN	Oceanside
	San Diego	SDA	San Diego Area
	San Diego	OSD	Other S.D. Co. Ports

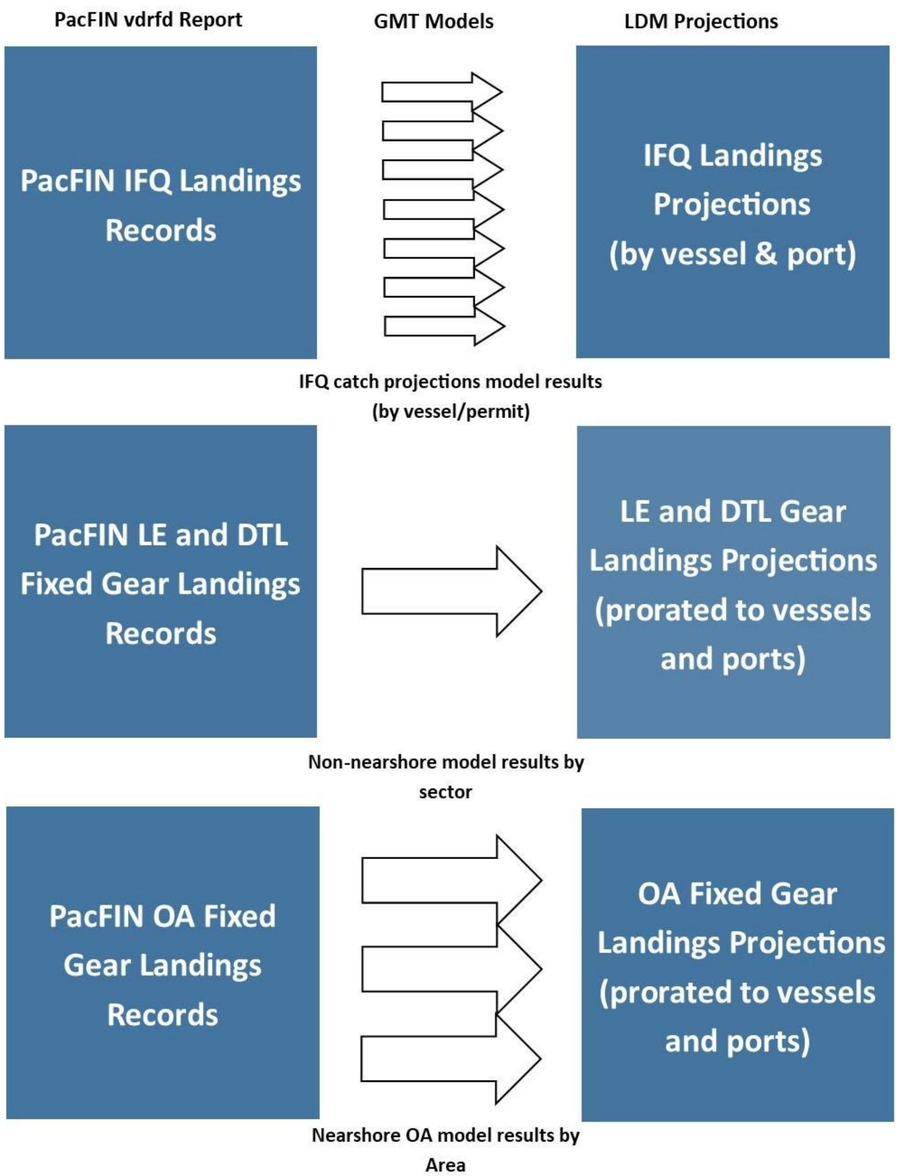

Figure 5-6. **Illustration of linkages between base year data and GMT landings projections used in the LDM.**

Note: Results from the at-sea Pacific whiting fisheries and tribal fisheries models are incorporated in similar fashion.

5.6.7 Estimated Commercial Vessel Net Revenue Impacts of the Alternatives

In order to project how changes in future landings may affect costs, we form a model where the landings (*L)* for each groundfish species (s), as well as their respective interactions, are associated with the natural log of non-labor variable costs (*VC*), for each vessel (i) and year (t) (equation 1). Key variable costs vary by sector and include fuel, bait, ice, food, observer coverage, and electronic monitoring. Intuitively, we would expect costs to increase when a vessel catches a greater quantity of fish, and interactions allow for cost complementarities between species. The economic rationale behind using a logarithmic function to model non-labor variable costs is that marginal costs increase with landings.

$$ln\, ln\, (VC_{it}) = \sum_{s} L_{its} + \sum_{s} \sum_{r,r\neq s} L_{its}L_{itr} + \epsilon_{it} \quad (1)$$

First, we project non-labor variable costs for each alternative by inputting forecasted landings by species into the regression estimates from equation (1). Then, to obtain projected wages, we calculate the historical proportion of wages (*wp*) to variable costs net revenues based on actual recorded wages, and apply them to projected variable cost net revenues. The intuition here is that wages are typically paid out as shares of variable costs net revenues. Wage projections are based on actual recorded wages.

Finally, fixed costs, including vessel and on-board equipment, fishing gear, moorage, and insurance are aggregated from survey data by sector for all vessels that fished in 2020. We impute these fixed costs using sector-specific means for any vessels not in the survey sample

Total costs net revenues (*TCNR*) are calculated as revenues (*R*), less projections of non-labor variable costs (*VC*), wages (labor), cost recovery fees (*CR*), buyback fees (*BB*), and fixed costs (*FC*) in equation (2). Cost recovery fees and buyback fees were calculated using rates of 3.0percent and 3.5percent of revenue, respectively.

$$TCNR = R - VC - (R - VC) * wp - FC - CR - BB \quad (2)$$

6. Landings and Revenue in Commercial, Tribal, and Recreational Pacific Coast Groundfish Fisheries

This section summarizes commercial, tribal, and recreational fishery 2023 landings and revenue data as made available from the Pacific Fishery Information Network (PacFIN) data system, specifically the Apex reporting system, and the Recreational Fishery Information Network (RecFIN). A detailed examination of the 2023 fishery can be found in Agenda Item F.6, Attachment 2, June 2024 in the No Action sections of Chapters 1 – 8. Socioeconomic data presented here is reflected at a similar scale as found in Agenda Item F.6, Supplemental Attachment 9, June 2024. Table 6-1 provides the 2023 attainments for all managed Council managed groundfish stocks/stock complexes. Table 6-2 shows ex-vessel revenue for all stocks/stock complexes managed by the Council.

Table 6-1. Harvest specifications for Council managed stocks/stock complexes, annual catch limits (ACL) estimated total mortality, and resulting percentage (%) of ACL (PacFIN, 1/12/2024)

Species	Area	ACL (mt)	Est. Mortality (mt)	% ACL
YELLOWEYE ROCKFISH	Coastwide	66	24.9	47.7%
Arrowtooth flounder	Coastwide	18,632	710.5	3.8%
Big skate	Coastwide	1,320	128.5	9.7%
Black rockfish	Washington	290	148.9	44.6%
Black rockfish	California	334	158.6	54.7%
Bocaccio	S of 40º10′ N. lat.	1,842	596.9	32.4%
Cabezon	S of 42º N. lat.	182	33.2	18.3%
California scorpionfish	S of 34°27’ N. lat.	262	121.6	46.4%
Canary rockfish	Coastwide	1,284	717.5	53.6%
Chilipepper	S of 40º10′ N. lat.	2,183	1,179.1	54.0%
Cowcod	S of 40º10′ N. lat.	80	8.7	10.9%
Darkblotched rockfish	Coastwide	785	304.7	37.2%
Dover sole	Coastwide	50,000	3,861.7	7.7%
English sole	Coastwide	9,018	209.9	2.3%
Lingcod	N of 40º10′ N. lat.	4,378	1,011.8	23.1%
Lingcod	S of 40º10′ N. lat.	726	248.4	34.2%
Longnose skate	Coastwide	1,708	578.2	33.9%
Longspine thornyhead	N of 34º27’ N. lat.	2,295	36.7	1.6%
Longspine thornyhead	S of 34º27’ N. lat.	725	5.2	0.7%
Pacific cod	Coastwide	1,600	68.8	4.3%
Pacific Ocean perch	N of 40º10′ N. lat.	3,573	316.9	8.9%
Pacific spiny dogfish	Coastwide	1,456	473.0	32.5%
Pacific whiting	Coastwide	394,400	241,034.7	65.3%
Petrale sole	Coastwide	3,485	2,968.0	85.2%

Species	Area	ACL (mt)	Est. Mortality (mt)	% ACL
Sablefish	N of 36º N. lat.	8,433	5,819.4	69.0%
Sablefish	S of 36º N. lat.	2,338	283.4	11.8%
Shortspine thornyhead	N of 34º27' N. lat.	1,359	422.6	4.1%
Shortspine thornyhead	S of 34º27' N. lat.	719	29.1	1.5%
Splitnose rockfish	S of 40º10′ N. lat.	1,592	23.8	2.7%
Starry flounder	Coastwide	392	10.4	87.7%
Widow rockfish	Coastwide	12,624	11,067.9	47.7%
Yellowtail rockfish	N of 40º10′ N. lat.	5,666	3,293.7	58.1%
Stock Complexes				
Nearshore rockfish north	N of 40º10′ N. lat.	93	49.6	53.3%
Nearshore rockfish south	S of 40º10′ N. lat.	887	280.6	31.6%
Shelf rockfish north	N of 40º10′ N. lat.	1,283	358.3	27.9%
Shelf rockfish south	S of 40º10′ N. lat.	1,469	902.9	61.7%
Slope rockfish north	N of 40º10′ N. lat.	1,540	345.1	22.4%
Slope rockfish south	S of 40º10′ N. lat.	701	80.7	11.5%
Other flatfish	Coastwide	4,862	477.4	9.8%
Other fish	Coastwide	223	59.0	26.5%
Oregon black/blue/deacon rockfish	Oregon	597	448.1	75.1%
Oregon cabezon/kelp greenling	Oregon	185	50.7	27.4%
Washington cabezon/kelp greenling	Washington	20	9.9	49.9%

Table 6-2. Coastwide ex-vessel revenue for all stocks and stock complexes in 2023 sorted from highest to lowest ex-vessel revenue for all gear types combined.

Species	Ex-Vessel Revenue ($1,000)
Pacific whiting	$18,793
Sablefish a/	$17,343
Petrale sole	$7,636
Widow rockfish	$6,419
Dover sole	$3,566
Lingcod	$2,131
Shortspine thornyhead	$1,758
Yellowtail rockfish	$1,758
Nearshore rockfish Complex	$1,498
Chilipepper	$1,311
Shelf rockfish complex	$1,017
Pacific spiny dogfish	$952
Black rockfish	$729
Bocaccio	$659

Species	Ex-Vessel Revenue ($1,000)
Canary rockfish a/	$575
Cabezon	$519
Slope rockfish complex	$461
Longnose skate	$423
Other flatfish complex	$341
Other fish complex	$188
Pacific Ocean perch	$124
Darkblotched rockfish	$122
Big skate	$71
Longspine thornyhead	$61
Pacific cod	$60
Arrowtooth flounder	$27
English sole	$27
Splitnose rockfish	$7
YELLOWEYE ROCKFISH	$6
Cowcod	$1.9
California scorpionfish	$0.4

6.1 Commercial Fishery

The commercial fishery data presented in this section reflects non-confidential data which is available to the public via the APEX reporting system. If a data value is attributed to fewer than three vessels or processors the data are considered confidential. In limited instances this requirement may affect the totals reported in the tables, meaning totals may be higher than shown in the tables.

6.1.1 Trends in Landings and Revenue

Figure 6-1 shows shoreside groundfish landings (panel a) and inflation adjusted ex-vessel revenue (panel b) trends since 2017. The solid horizontal lines show one standard deviation above and below the mean, represented by the dotted line. Shoreside groundfish landings and ex-vessel revenue reached their highest point in 2019 and their lowest in 2023. At-sea showed a similar patter, with highest landings in 2017, but lowest ex-vessel revenue in 2020. Similarly, ex-vessel revenue follows the same trend as landings.

Figure 6-1. (a) shoreside groundfish landings (mt), (b) shoreside inflation-adjusted revenue ($1,000), (c) at-sea landings (mt), and (d) at-sea inflation-adjusted revenue ($1,000), 2017-2023. (PacFIN comprehensive_ft, 4/22/2024)

6.1.2 Landings by Species

Table 6-3 shows annual average annual shoreside landings and revenue for groundfish species and species groups for the last five years, 2019- 23. Pacific whiting dominates landings by weight, while sablefish accounts for the largest share of ex-vessel revenue. Dover sole, rockfish, petrale sole, and thornyheads account for most of the rest of landings and revenue.

Table 6-3. Average non-tribal Shoreside commercial and tribal groundfish landings (mt) and ex-vessel revenue in inflation-adjusted, $1,000s, by species or species group; annual average last 5 years (2019-23).

Species	Metric Tons	Revenue ($1,000s)
Pacific Whiting	124,713	$25,530
Sablefish	5,201	$18,981
Rockfish	16,796	$14,519
Petrale sole	2,713	$7,466
Dover sole	4,484	$4,501
Lingcod	611	$2,176
Thornyheads	562	$2,000
Other Roundfish	312	$801
Other Groundfish	11,568	$576
Other Flatfish	728	$509

6.1.3 Shoreside Non-whiting IFQ Fishery

Table 6-4 shows annual average landings and revenue between 2019-23 in the shoreside non-whiting IFQ trawl fishery This sector catches a variety species with trawl and fixed gear and is managed under an IFQ program. Sablefish, rockfish, petrale and Dover soles are the main revenue earners for vessels not targeting Pacific whiting.

Table 6-4. Shoreside non-whiting trawl IFQ fishery landings (mt) and ex-vessel revenue in inflation-adjusted, $1,000s, by species or species group; annual average last 5 years (2019-23).

Species	Metric Tons	Revenue ($1,000s)
Sablefish	1,431	$15,651
Rockfish	13,675	$9,138
Petrale sole	2,600	$7,157
Dover sole	4,556	$4,473
Lingcod	377	$829
Other Groundfish	622	$471
Thornyheads	446	$454
Other Flatfish	819	$415
Pacific Whiting	259	$26
Other Roundfish	33	$4

Table 6-5 shows annual average landings and revenue in the non-tribal non-trawl sector in the last 5 years, 2019-23. Landings and revenue are almost entirely sablefish in contrast to the trawl component of the IFQ fishery.

Table 6-5. Shore side IFQ non-trawl landings (mt) and ex-vessel revenue in inflation-adjusted ($1,000s) for the landed groundfish species or species group where ex-vessel revenue is greater than $1,000; annual average last 5 years (2019-23).

Species	Metric Tons	Revenue ($1,000s)
Sablefish	3,773	$19,163
Thornyheads	145	$2,418
Other Groundfish	88	$72
Other Roundfish	54	$230
Other Slope Rockfish	50	$116
Blackgill Rockfish	28	$123
Shelf Rockfish	28	$128
Other Rockfish	13	$43
Flatfish	10	$14
Pacific Spiny Dogfish	1	$1

6.1.4 Non-nearshore Fixed Gear Sector

Fixed gear (longline and pot) fisheries are divided between limited entry (LEFG) and open access (OA) from a regulatory standpoint. LEFG and OA data is reported as non-nearshore and nearshore. Non-nearshore represents the portion of the fishery that, in general, targets shelf and slope groundfish species. The non-nearshore fishery primarily targets sablefish.

Table 6-6 shows annual average landings and revenue for the non-nearshore fixed gear fishery for the last 5 years, 2019-23. The species composition in this sector is similar to the IFQ non-trawl sector, which also uses longline gear to target sablefish, the predominant species in terms of both landings and revenue. In this fishery sablefish accounts for the majority of ex-vessel revenue followed by thornyheads.

Table 6-6. Non-nearshore fixed gear sector groundfish landings (mt) and ex-vessel revenue in inflation-adjusted ($1,000s) by groundfish species or species group; annual average last 5 years(2019-23). Species and species groups are ranked from largest to smallest by ex-vessel revenue.

Species	Metric Tons	Revenue ($1,000s)
Sablefish	2,264	$11,498
Thornyheads	87	$1,451
Other Roundfish	33	$138
Other Slope Rockfish	30	$70
Shelf Rockfish	17	$77
Blackgill Rockfish	17	$74
Other Groundfish	53	$43
Rougheye Rockfish	13	$28
Other Rockfish	8	$26

Unlike most groundfish, which have a trawl and non-trawl allocation, sablefish north of 36° N. lat. is managed with allocations that were established under Amendment 6 (see Figure 6-1 of the Groundfish FMP). The non-nearshore fishery targeting sablefish is comprised of the primary tier fishery (LEFG), the LE Daily Trip Limit (DTL) fishery, and the OA fishery. Table 6-7 below provides a historical estimate of total mortality of sablefish north in each of these sectors from 2019-23.

Table 6-7. Non-trawl total landings (mt) for sablefish north of 36° N. lat. by sector, 2019-23. Source: PacFIN for landings a/ and WCGOP GEMM for discard b/.

Year	LEFG Primary (mt)	LEFG DTL (mt)	OA (mt)
2019	1,362.6	159.2	301.7
2020	1,203.4	138.4	147.9
2021	1,383.8	150.6	207.6
2022	1,518.8	290.4	499.3
2023	2,442.7	232.5	502.9

Note: The WCGOP GEMM estimates landings and discards for sablefish in the directed halibut fishery. Unlike all other groundfish species though where mortality in this fishery is counted in the "off-the-top" deductions, sablefish mortality is accounted for in the sector in which the vessel is participating.
a/ Landings apportioned using the GMT_SABLEFISH_CODE
b/ Discard mortality is calculated by proportioning the sablefish discard mortality in the directed Pacific halibut fishery by the landings in each sector and adding it to the estimated discard mortality for each of the three non-trawl sablefish sectors (LEFG primary, LEFG DTL, OA).

6.1.5 Nearshore Fixed Gear Sector

Table 6-8 shows annual average landings and revenue for the nearshore fixed gear fishery, 2019-23. This fishery primarily catches black rockfish, lingcod, and other nearshore rockfish species.

Table 6-8. Nearshore fixed gear sector landings (mt) and ex-vessel revenue in inflation-adjusted ($1,000s) by groundfish species or species group; annual average last 10 years. Species and species groups are ranked from largest to smallest by ex-vessel revenue.

Species	Metric Tons	Revenue ($1,000s)
Black Rockfish	151	$818
Lingcod	100	$720
Other Nearshore Rockfish	61	$935
Cabezon	49	$588
Other Rockfish	67	$494
Gopher Rockfish	26	$482
Brown Rockfish	18	$281
Kelp Greenling	15	$190
Blue Rockfish	19	$126
Non-Groundfish	7	$70

6.1.6 Comparison of Shoreside Fishery Sectors

Table 6-9 summarizes annual average groundfish landings and revenue by shoreside fishery sectors for the last 5 years including the shoreside whiting sector. IFQ Trawl fisheries account for the majority of ex-revenue from these sectors. The shoreside whiting fishery has the highest landings but has a lower annual ex-vessel revenue average than IFQ non-whiting fishery, which is reflective of the fact that this is a high volume, low unit value fishery.

Table 6-9. Annual average groundfish landings (mt) and ex-vessel revenue in inflation-adjusted, $1,000s, last 5 years, by shoreside fishery sector.

Sector	Metric Tons		Ex-vessel Revenue ($1,000)	
	Average (mt)	% of Total	Average (mt)	% of Total
Shoreside Whiting	128,281	81%	$25,806	35%
Shoreside Non-whiting	24,685	16%	$26,016	34%
Shoreside IFQ Non-trawl	4,145	1%	$2,909	4%
Non-nearshore Non-trawl	3,555	2%	$14,737	20%
Nearshore Non-trawl	512	<1%	$4,668	6%
Incidental Open Access	39	<1%	$172	<1%
EFP/Research	467	<1%	$490	1%

6.1.7 Pacific Whiting At-sea Sectors

The three Pacific whiting sectors – at-sea catcher-processor, at-sea mothership, and shoreside – are managed to fixed allocations of 34 percent, 24 percent, and 42 percent respectively, although actual landings have varied somewhat from these allocations. Table 6-10 shows average annual landings and revenue for the at-sea Pacific whiting sectors, which catch almost exclusively Pacific whiting.

Table 6-10. Five year, 2019-23. average of annual Pacific whiting landings (mt) and ex-vessel revenue in inflation-adjusted, $1,000s by the at-sea sector.

Whiting Sector	Averaged Landings (mt)	Average Annual Ex-vessel Revenue ($1,000)
Catcher-Processor	114,546	$26,110
Mothership	44,386	$9,647

6.1.8 Seasonality of Landings

Table 6-11 shows average monthly landings by fishery sector, 2019-23. Overall, the at-sea and trawl sectors land, on average, the majority of groundfish; however, Pacific whiting is the principle fish caught. Landings generally peak for whiting in late summer. Other fleets tend to land groundfish consistently throughout the year, though tonnage generally increase toward late summer to early fall.

Table 6-11. Average monthly landings (mt) by fishery sector in the last 5 years. A '-' indicates no landings for a given month. Months are abbreviated to their first letter for space.

	J	F	M	A	M	J	J	A	S	O	N	D
At-sea												
Catcher Processor	-	-	-	-	31,714	18,886	-	2,623	24,777	27,787	8,018	-
Mothership	-	-	-	-	17,967	12,261	-	-	3,933	6,915	1,430	-
Trawl: Non-Whiting												

Whiting	-	-	-	-	10,458	19,323	28,128	29,544	23,467	13,295	1,066	-
Non-whiting	1,250	1,670	2,932	2,383	2,064	1,828	1,507	1,459	1,652	2,729	3,343	1,868
Gear-switcher	-	22	48	38	33	22	58	94	99	156	151	85
Non-Trawl												
Non Nearshore	70	76	92	153	185	236	300	357	398	484	244	132
Nearshore	25	29	35	36	48	54	57	58	57	50	41	25
Other												
IOA	1	1	1	2	3	9	14	4	1	1	1	1
EFP/Research	1	3	2	3	11	38	14	255	102	30	4	4

6.1.9 Landings and Participation by Port Group

The Groundfish SAFE tables present regional landings by IOPAC port groups. IOPAC is a regional input/output model developed by the NWFSC to estimate income and employment impacts from fishing. These impact estimates are part of the environmental impact evaluation of groundfish biennial harvest specifications and management measures. For a list of the ports included in IOPAC port groups see Table 9 in NOAA Technical Memorandum NMFS-NWFSC-111, Description of the Input-Output Model for Pacific Coast Fisheries by Jerry Leonard and Phillip Watson (June 2011).

Table 6-12, Table 6-13, and Table 6-14 provide detail regarding recent average annual landings and inflation adjusted ex-vessel revenue for select IOPAC port group, 2019-23. Oregon accounts for nearly 69 percent of all groundfish landings, followed by Washington at 27 percent and California at 4 percent. Similarly, Oregon accounts for nearly 61 percent of groundfish revenue, Washington at 16 percent, and California at 23 percent.

Table 6-12. Groundfish landings (mt) and ex-vessel revenue in inflation adjusted dollars, $1,000s by IOPAC port group, annual average in the last 5 years.

IOPAC Port Grout	Average Landings (mt)	Average Ex-vessel Revenue ($1,000)
Puget Sound	731	$2,288
North WA Coast	613	$1,841
South and Central WA Coast	41,219	$8,541
Astoria	68,745	$25,069
Tillamook	33	$197
Newport	37,472	$16,521
Coos Bay	1,123	$2,442
Brookings	849	$2,623
Crescent City	131	$576
Eureka	2,757	$4,187
Fort Bragg	1,872	$3,721
Bodega Bay	42	$269

IOPAC Port Grout	Average Landings (mt)	Average Ex-vessel Revenue ($1,000)
San Francisco	484	$1,268
Monterey	457	$2,013
Morro Bay	248	$2,047
Santa Barbara	261	$2,427
Los Angeles	58	$455
San Diego	65	$548

Table 6-13. Average annual (2019-23) landings (mt) by port group and fishery sector. (*Excluded for confidentiality.)

Port Group	Shoreside IFQ Trawl (Whiting) (mt)	Shoreside IFQ Trawl (Non-whiting) (mt)	Shoreside IFQ Non-trawl (mt)	Non-Nearshore Fixed Gear (mt)	Nearshore Fixed Gear (mt)
Puget Sound	0	*	0	94	0
North WA Coast	0	0	0	28	0
South/Central WA Coast	*	*	*	65	0
Astoria	28,922	5,170	33	61	*
Tillamook	0	0	0	11	-
Newport	12,332	1,628	39	239	10
Coos Bay	0	*	0	103	8
Brookings	0	*	0	76	93
Crescent City	0	*	0	30	24
Eureka	0	489	*	80	12
Fort Bragg	0	385	0	133	21
Bodega Bay	0	0	*	17	-
San Francisco	0	139	*	38	8
Monterey	0	*	*	127	9
Morro Bay	0	*	0	39	-
Santa Barbara	0	0	0	108	15
Los Angeles	0	0	0	22	1
San Diego	0	0	0	29	1

Table 6-14. Average annual (2019-23) inflation-adjusted ex-vessel revenue ($1,000s) for all groundfish sectors excluding the at-sea Pacific whiting fishery by port group and fishery sector. (*Excluded for confidentiality.)

Port Group	Shoreside IFQ Trawl (Whiting) (mt)	Shoreside IFQ Trawl (Non-whiting) (mt)	Shoreside IFQ Non-trawl (mt)	Non-Nearshore Fixed Gear (mt)	Nearshore Fixed Gear (mt)
Puget Sound	0	*	0	$386	0
North WA Coast	0	0	0	$28	0
South/Central WA Coast	*	*	*	-	0
Astoria	$6,453	$5,396	$77	$277	*
Tillamook	0	0	0	$34	$63
Newport	$2,776	$1,659	$194	$1,113	$69
Coos Bay	0	*	0	$567	$73
Brookings	0	*	0	$328	$654
Crescent City	0	*	0	$127	$144
Eureka	0	$377	*	$75	-
Fort Bragg	0	$575	0	$499	$235
Bodega Bay	0	0	*	$113	$7
San Francisco	0	$181	*	$277	$86
Monterey	0	*	*	$739	$139
Morro Bay	0	*	0	$269	$579
Santa Barbara	0	0	0	$1,031	156
Los Angeles	0	0	0	$186	$7
San Diego	0	0	0	$256	$11

"-" indicates less than $1,000

Table 6-15 shows measures of port engagement and dependence on groundfish fisheries based on inflation adjusted ex-vessel revenue from 2019-23. Engagement measures the proportion of coastwide revenue flowing to a port, while dependence measures how much of total ex-vessel revenue in each port comes from the groundfish fishery. As reflected in the landings data reported above, the three most engaged port groups are Astoria (32 percent), Newport (20 percent), and South and Central WA Coast (11 percent). The ports most dependent on groundfish are Astoria (50 percent), Fort Bragg (47 percent), and Morro Bay (49 percent). Coastwide dependence on groundfish is 17 percent.

Table 6-15. Engagement (groundfish ex-vessel revenue by port group as percent of ex-vessel coastwide revenue) and dependence (groundfish ex-vessel revenue in port as percent of total ex-vessel revenue in port), using inflation adjusted dollars in the last five years. Note, a '-' indicates a less than 1 percent value.

Port Group	Engagement	Dependance
Washington	16%	12%
Puget Sound	3%	32%
North WA Coast	3%	28%

Port Group	Engagement	Dependance
South/Central WA Coast	11%	9%
Oregon	61%	27%
Astoria	32%	50%
Tillamook	-%	2%
Newport	20%	22%
Coos Bay	3%	6%
Brookings	4%	18%
California	23%	10%
Crescent City	1%	3%
Eureka	5%	27%
Fort Bragg	5%	47%
Bodega Bay	-%	3%
San Francisco	2%	5%
Monterey	3%	11%
Morro Bay	2%	49%
Santa Barbara	3%	5%
Los Angeles	1%	2%
San Diego	1%	5%

6.2 *Tribal Fishery*

Because the Coastal Treaty Tribes have sovereign rights to manage their fisheries, the tribal sectors do not have an equivalent regulatory dimension like the commercial sectors discussed above. These tribes participate in whiting and non-whiting fisheries. Due to confidentiality concerns, the data presented here is aggregated to a high level, showing average annual groundfish landings and average annual ex-vessel revenue. The average landings, in metric tons, for the 2019-23 period is 663.4 mt per year and the average annual ex-vessel revenue is $1,764,800.

6.3 *Recreational Fishery*

Recreational fisheries are an important part of fishery-related economic activity. Because recreational catch is not sold, it is more difficult to impute the economic value of these fisheries. Effort can provide a key indicator of socio-economic impact to a state/community. Agenda Item F.6, Attachment 9, June 2024 provides projected economic impacts from recreational fishing in the next biennium as well as a retrospective analysis of effort to 2007; Recreational fisheries are broadly subdivided between private anglers and commercial passenger fishing vessels, commonly referred to as charter vessels. Private anglers fish from shore or from their own boats, while charter vessels take paying passengers. There are two other non-boat-based fishing modes, from the shoreline (beach/bank) and from man-made structures such as piers. These two modes account for relatively little angler effort directed towards groundfish, except in noted instances (i.e., North Jetty Columbia River). Trip types are not specified with respect to the species managed under the Groundfish FMP but bottomfish and halibut directed trips represent the best approximation of groundfish directed trips.

Table 6-16 shows recreational fishing effort from 2019 through 2023. In the federally managed fishery, groundfish trips occur from vessels, either private or commercial passenger fishing vessels (CPFV) aka "party boats" or charter boats. As federally managed stocks are caught from shore as well, effort estimates are included for those modes as well. Recreational anglers target a variety of groundfish. Given the varying levels of fishery knowledge, some anglers may report they are targeting 'anything' when indeed they are targeting groundfish. To limit uncertainty, the effort estimates presented here represent only 'bottomfish" which is the catchall term for groundfish in West Coast recreational fishery surveys. Table 6-17 demonstrates the most angler trips occur in the South Coast: San Diego, Orange, and Los Angeles region at 49.4 percent of the coastwide total.

Table 6-16. Estimated average annual angler groundfish trips by mode for Washington, Oregon, and California 2019-23. (Source RecFIN)

	Washington	Oregon	California
Man-Made	2,974	-	50,518
CPFV	14,116	47,773	395,172
Private Boat	16,622	57,546	186,313

Table 6-17. Average annual (2019-23) groundfish angler trips by type and percent by region. (Source RecFIN)

Port	Man Made	CPFV	Private
Neah Bay	0	408	7,235
La Push	0	187	2,248
Westport	0	12,133	4,540
Columbia River: North Jetty	2,974	-	-
Astoria	-	94	721
Depoe Bay	-	16,678	3,195
Garibaldi	-	6,480	4,672
Newport	-	14,300	10,322
Pacific City	-	1,356	4,210
Charleston	-	2,266	10,007
Brookings	-	4.714	14,365
Redwood	8,080	3,962	20,155
Mendocino	534	9,253	11,982
Bay Area	9,676	35,613	32,964
Central	8,415	41,016	40,388
Channel	1,846	54,147	15,123
South	25,346	282,243	68,028

7. Essential Fish Habitat

Essential fish habitat (EFH) for groundfish was first established in 1998 under FMP Amendment 11, and in response to the MSA reauthorization of 1996. EFH was revised significantly and finalized in 2006 as part of Amendment 19 to the groundfish FMP.

The EFH regulations call for a review of EFH elements at least every five years. The most recent review was initiated in December 2010 and concluded in April 2018, after being combined with final action to consider removing the trawl RCA.

The Council took final action on FMP Amendment 28 to reopen the groundfish trawl RCA off Oregon and California to bottom trawling, and to modify the current configuration of EFH Conservation Areas (EFHCAs) where groundfish bottom trawl gear is prohibited coastwide. This includes a new EFHCA prohibiting groundfish bottom trawl gear in most of the Southern California Bight. The Council also took final action to prohibit use of all groundfish bottom contact gear in waters deeper than 3,500 meters. (EEZ waters deeper than 3500 m are not designated as groundfish EFH, hence the regulatory avenue for this action was the MSA discretionary authorities at 303b(2), 303b(3), and 303b(12)). The action did not affect non-trawl RCAs, the trawl RCA off Washington, the use of midwater trawl gear within any of the trawl RCAs, nor any of the EFHCAs in the tribal usual and accustomed fishing areas off the Washington coast.

8. Safety At Sea

National Standard 10 (NS10) guidelines interpreting the MSA state, “Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea”. During preparation of any FMP, FMP amendment, or regulation that might affect safety of human life at sea, the Council should consult with the United States Coast Guard (USCG) and the fishing industry as to the nature and extent of any adverse impacts. This consultation may be done through a Council advisory panel, committee, or other review of the FMP, FMP amendment, or regulations.

There are many ways in which an FMP may avoid or provide alternative measures to reduce potential impacts on safety of human life at sea. The following is a list of some factors that could be considered when management measures are developed:

1) Setting seasons to avoid hazardous weather.
2) Providing for seasonal or trip flexibility to account for bad weather (weather days).
3) Allowing for pre- and post-season ‘‘soak time’’ to deploy and pick up fixed gear, so as to avoid overloading vessels with fixed gear.
4) Tailoring gear requirements to provide for smaller or lighter gear for smaller vessels.
5) Avoiding management measures that require hazardous at-sea inspections or enforcement if other comparable enforcement could be accomplished as effectively.
6) Limiting the number of participants in the fishery.
7) Spreading effort over time and area to avoid potential gear and/or vessel conflicts.
8) Implementing management measures that reduce the race for fish and the resulting incentives for fishermen to take additional risks with respect to vessel safety.

The Council consults with the USCG on safety-at-sea considerations through a non-voting USCG seat on the Council and through the Council’s enforcement advisory body, the Enforcement Consultants. The Council also has considered safety-at-sea factors when deciding groundfish management measures. For example, the sablefish fishery for LEFG permit holders with a sablefish endorsement fish their tier limits any time during the April to October primary season, which allows fishermen to fish when weather conditions are amenable to fishing safely. Likewise, the rationalized trawl fishery, managed using a system of IFQs and harvest cooperatives, has reduced the propensity to race for fish in that fishery and enhanced safety-at-sea. In general, most of the groundfish fishery has also limited participation through a limited entry system.

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