SUMMARY OF WEST COAST GROUNDFISH ASSESSMENTS CONDUCTED IN 2023

The Northwest Fisheries Science Center provides the following information to communicate the results from this year's groundfish stock assessments conducted by Northwest and Southwest Fisheries Science Center staff, any major changes in the data, modeling assumptions, and how these results compare to previous assessments.

Copper rockfish in California

The 2023 assessment of copper rockfish in California waters was modeled as two separate areas north and south of Point Conception (Wetzel et al., 2023; Monk et al., 2023), similar to the 2021 assessment (Wetzel et al., 2021; Wetzel et al. 2021). The 2023 assessments for copper rockfish were benchmark assessments that included additional data sources and types compared to the 2021 length-based data-moderate assessments. The new data sources and types of data included lengths and ages from the California Cooperative Fisheries Research Program (CCFRP), catch-per-unit-effort time series for the recreational CPFV and private/shoreside fleets, historical recreational lengths, and ages associated with fishery and survey fleets. The additional data, primarily the age data, allowed the 2023 assessment for the area south of Point Conception to estimate annual recruitment variation by year whereas the 2021 assessment necessarily relied on the assumption of deterministic recruitment from the stock-recruitment curve (i.e., the total recruitment that would be expected based on the spawning output by year). Additionally, the inclusion of data from the CCFRP survey provided composition and index of abundance data representative of both open and closed areas.

This year's assessments for copper rockfish in California produced generally similar estimates to the 2021 assessments in terms of the fraction unfished for each model area and in regards to the

overall status across California with the stock estimated to be in the precautionary zone at 36.6 percent of unfished spawning output (Figure 1). Differences in the population trajectory at the end of the time series south of Point Conception between the 2023 and 2021 assessments were driven by the estimation of annual recruitment variation in the new assessment that estimated above average recruitment in recent years supporting the high removals in recent years.

The estimated unfished scale of the population for each area varied slightly in this year's assessments compared to the 2021 assessment with the scale south of Point Conception slightly lower and the north of Point Conception slightly higher than the comparable estimates in 2021 (Figure 2). For comparisons of scale across assessments, the estimated long-term equilibrium maximum sustainable yield ($MSY_{SPR = 0.50}$) under a SPR of 0.50 can be a useful reference that accounts for changes in estimated population size but is independent of the estimated fraction unfished at the time of the assessment (i.e., dissimilar from overfishing limits [OFLs] that vary depending upon the estimated population size and status). The 2023 assessments estimated a California-wide $MSY_{SPR = 0.50}$ of 165 metric tons (mt), marginally higher than the 2021 estimate of 158 mt.

In 2013, an index-only data-moderate assessment was conducted for copper rockfish with the population off the U.S. west coast modeled as two areas: U.S./Mexico border to south of Point Conception and north of Point of Conception to the U.S./Canada border. Across the three assessments for copper rockfish south of Point Conception, the 2013 index-only data-moderate assessment incorporated the least amount of data, including only catch and a recreational CPUE data along with assumptions (i.e., referred to as priors) about realistic ranges for productivity, natural mortality, the relative stock size that would produce maximum sustainable yield, and the fraction unfished in the year 2000, with these being updated based on fits to the CPUE data. Prior information, based on species-grouped productivity-susceptibility-vulnerability data, pointed to a mean predicted fraction unfished of 30 percent in 2000 with the final model estimating the fraction unfished in 2013 at 76 percent. Both the 2021 and 2023 assessments estimated a much more depleted population south of Point Conception in the year 2000 and in recent years (Figure 3) with the estimated fraction unfished being informed by fishery and survey length data.

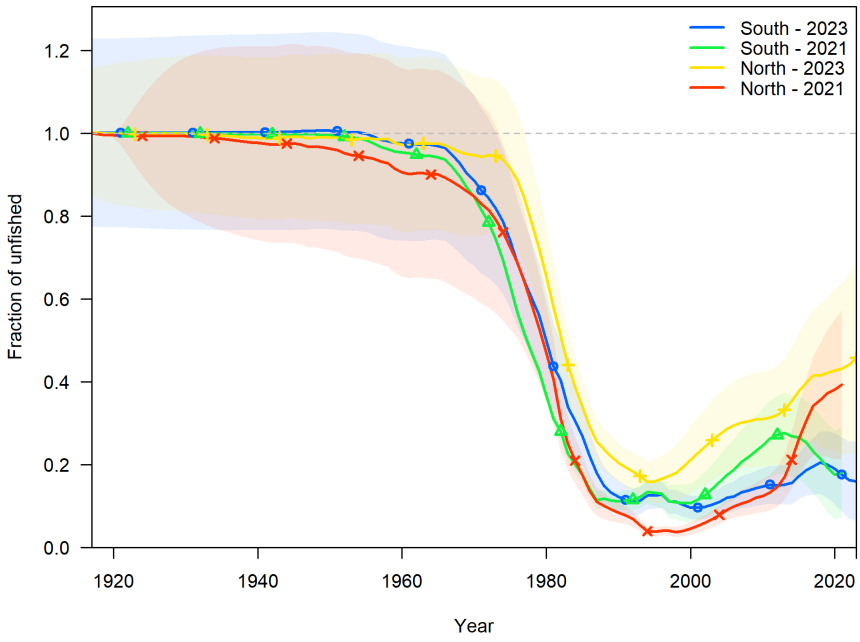

Figure 1. The estimated fraction of unfished between the 2023 and 2021 assessments for copper rockfish in California areas north and south of Point Conception.

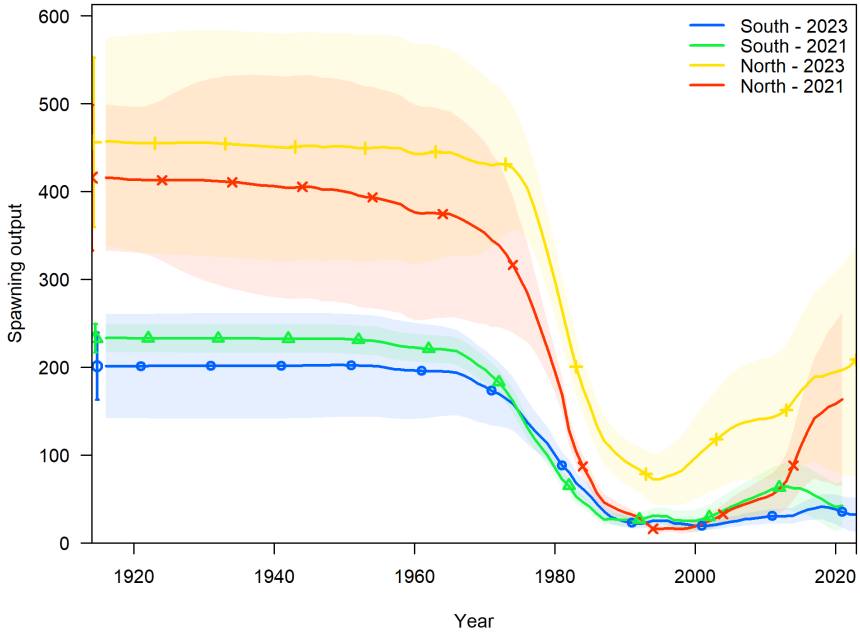

Figure 2. The spawning output between the 2023 and 2021 assessments for copper rockfish in California areas north and south of Point Conception.

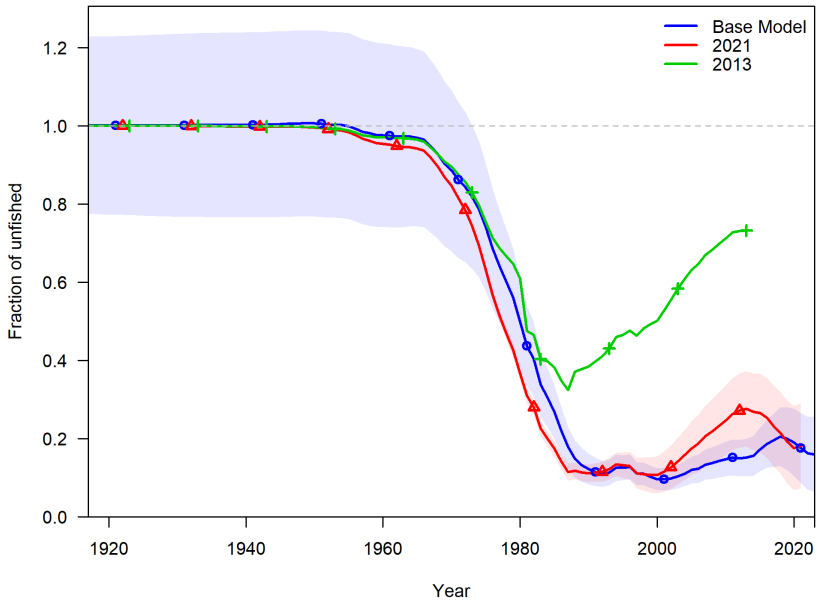

Figure 3. Estimated fraction unfished across assessments where "Base Model" is the 2023 model for copper rockfish in California south of Point Conception.

Black rockfish in California

The 2023 stock assessment of black rockfish in California waters was modeled as two areas split north and south of Point Arena (38° 57.5′ N. lat.) in order to account for size composition, exploitation history, recruitment, and other factors affecting stock dynamics (Dick et al., 2023). The previous assessment conducted in 2015 modeled black rockfish in California as a single model area (Cope et al., 2016). Both the 2015 and 2023 assessments were benchmark assessments that incorporated catch, index of abundance, length, and age data. Estimates of stock status and fraction unfished were very similar between the 2023 and 2015 assessments with the new assessment estimating the stock to be at the higher end of the precautionary zone at 37.7 percent of unfished (Figure 4). Additionally, the estimated California-wide equilibrium $MSY_{SPR = 0.50}$ from the 2023 assessment was 330 mt, similar to the 2015 estimate of 319 mt.

The 2015 assessment of black rockfish in California provided a 10-year projection that reflected increases in spawning output with the stock ending up at a fraction unfished of 52 percent in 2023 (Table 1). These projected increases in population size were largely driven by multiple strong year classes estimated to have occurred from 2008-2010. The 2023 assessment also estimated strong recruitment in those years but only in the central California model area that makes up a relatively small fraction of the entire population in California waters (Figure 5). The data did not support as large recruitments in those years within the northern model area. Therefore the observed increase

in the black rockfish stock in California was reduced relative to the projections from the 2015 assessment.

Table 1. Population projections for spawning output, age 3+ biomass, and estimated fraction of unfished (depletion) based on assumed removals in metric tons from the 2015 assessment for black rockfish in California.

Year	Predicted OFL	Projected removals	Age 3+ biomass	Spawning output	Depletion (%)
2015	354	420	5,773	353	33%
2016	354	420	5,800	396	37%
2017	349	334	5,754	450	42%
2018	347	332	5,747	503	47%
2019	344	329	5,716	538	51%
2020	341	326	5,677	555	52%
2021	338	323	5,640	558	53%
2022	336	321	5,608	554	52%
2023	334	319	5,583	547	52%
2024	333	318	5,565	539	51%
2025	332	318	5,550	532	50%
2026	332	317	5,540	526	50%

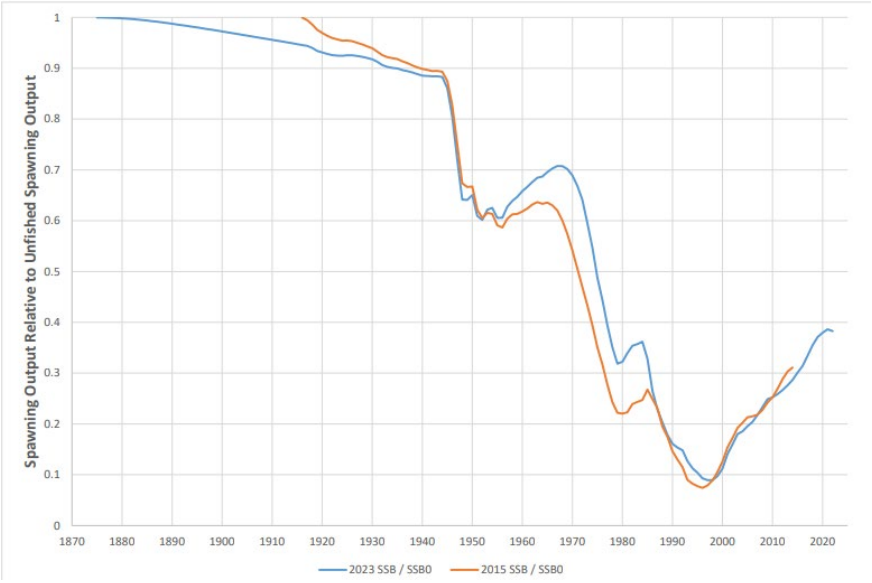

Figure 4. The estimated spawning output relative to unfished ("fraction unfished") for black rockfish in California between the 2015 (orange line) and the 2023 (blue line) assessments.

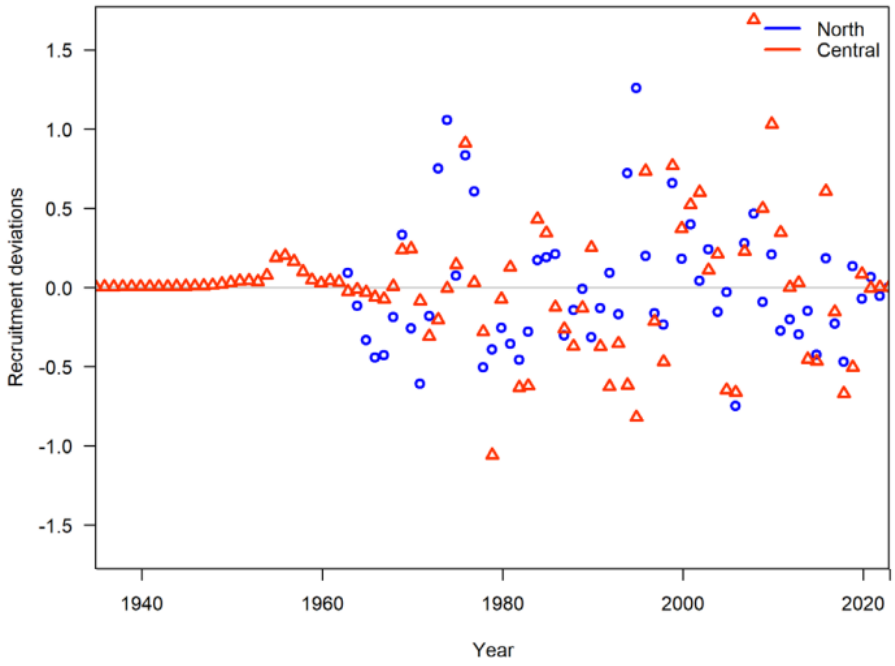

Figure 5. Comparison of estimated annual recruitment deviations in the northern and central area models for black rockfish in California.

Black rockfish in Oregon

The 2023 stock assessment of black rockfish in Oregon waters was modeled as a single area (Cope et al., 2023), similar to the previous assessment conducted in 2015 (Cope et al., 2016). Both the 2015 and 2023 assessments were benchmark assessments that incorporated catch, index of abundance, length, and age data. While the estimated of stock size was roughly comparable between the two assessments (Figure 6), the estimated fraction unfished varied among the assessments with the new assessment estimating a fraction of unfished of 45 percent in 2023 and an estimate of 43 percent in 2015 compared to the 2015 estimate of 60.4 percent in 2015 (Figure 7). The estimated equilibrium $MSY_{SPR=0.50}$ from the 2023 assessment was 422 mt, less than the 2015 estimate of 518 mt, primarily driven by assumptions of constant natural mortality in the 2023 assessment.

The 2015 assessment pre-specified the scale of the stock to an absolute abundance estimate from a tag survey index. The new assessment incorporated a new absolute abundance tied to the acoustic-visual survey with the catchability fixed such that the estimated stock size and status balanced varying signals from the length composition data and the acoustic-visual survey. The model was highly sensitive to model specifications for acoustic-visual survey catchability and recruitment. The reference model fixed acoustic-visual survey catchability at a value of 1.0 that assumes observed and estimated vulnerable biomass to be equal, given the survey design and black rockfish biology. Reconciling the signal in the biological data (which suggests a lower population

size and status) versus the acoustic-visual and tag surveys (which suggest high stock sizes and status) is a major uncertainty.

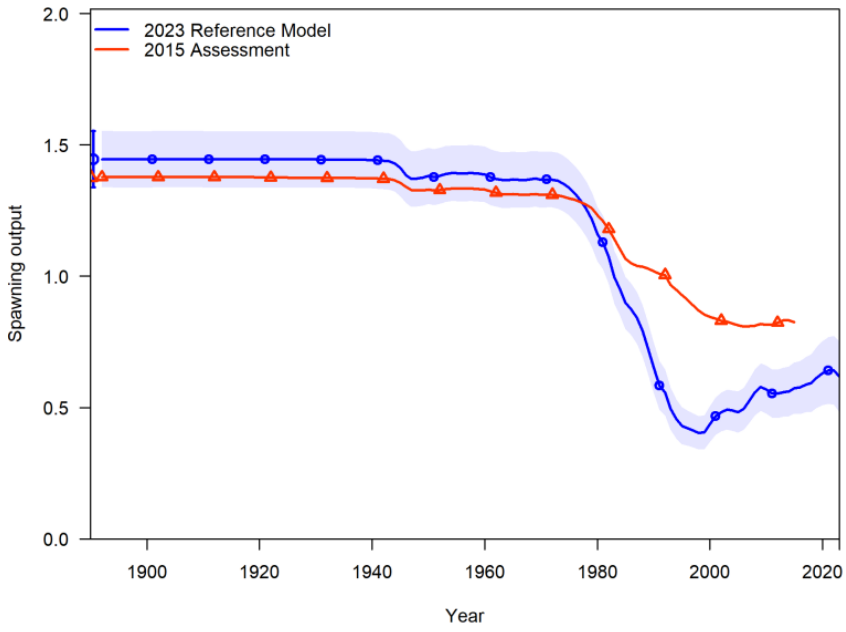

Figure 6. The estimated spawning output between the 2023 and 2015 assessments for black rockfish in Oregon waters.

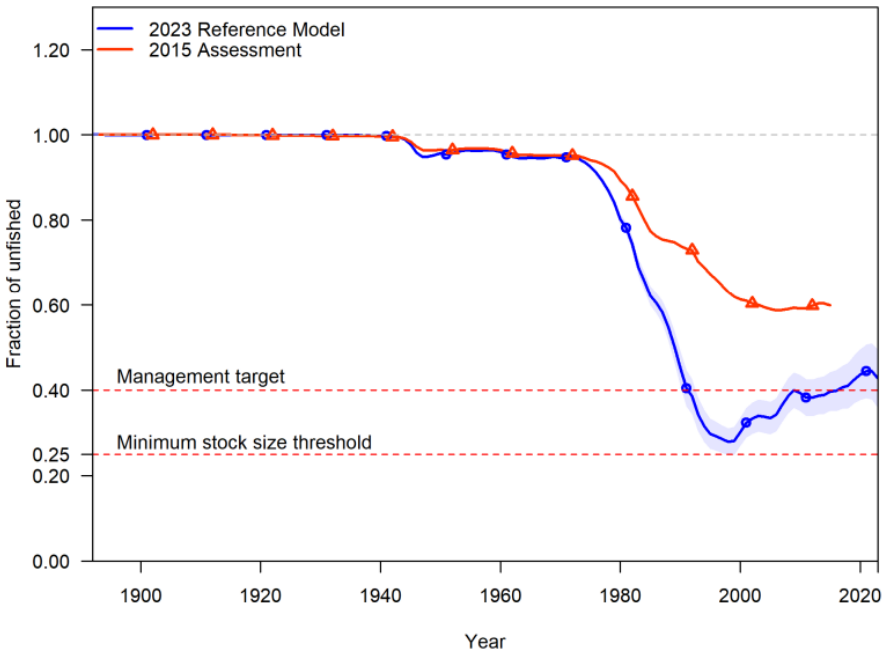

Figure 7. The estimated fraction unfished between the 2023 and 2015 assessments for black rockfish in Oregon waters.

Black rockfish in Washington

The 2023 stock assessment of black rockfish in Washington waters was modeled as a single area (Cope et al., 2023), similar to the previous assessment conducted in 2015 (Cope et al., 2016). Both the 2015 and 2023 assessments were benchmark assessments that incorporated catch, index of abundance, length, and age data. The estimates of final fraction unfished were roughly comparable between the two assessments (2023: 45 percent, 2015: 43 percent, Figure 8), the 2023 assessment estimated that the fraction unfished dropped below the management target in the late-1980s and has only recently surpassed 40 percent. The estimated unfished spawning output varied among the assessments with the new assessment estimating a lower unfished stock size relative to the estimate in 2015 (Figure 9). The estimated equilibrium $MSY_{SPR = 0.50}$ from the 2023 assessment was 276 mt, less than the 2015 estimate of 311 mt, primarily driven by both the decrease in the unfished stock size and the assumption of a constant natural mortality.

The change in the estimated unfished stock size was primarily due to changes in the catch time series, specifically the trawl fishery catches in area 3A off Astoria. It has been, and continues to be, a common practice for Oregon fleets to fish off the Washington coast and land their catches in Oregon ports. Although the separate geographic assessments by state region would ideally have strict geographic separation of landed catch to the location of capture, this is not possible to accomplish perfectly because information on the precise location of catch is generally unavailable. The 2023 assessment evaluated the frequency of catch from Oregon waters being landed in Washington and vice versa. Applying a more robust apportionment approach to the current and historical catch time series resulted in a time series that should more closely align with the true removals from Oregon and Washington waters, respectively. This resulted in a reduction in the historical trawl landings for Washington compared to historical catch time series used in previous assessments (Figure 10).

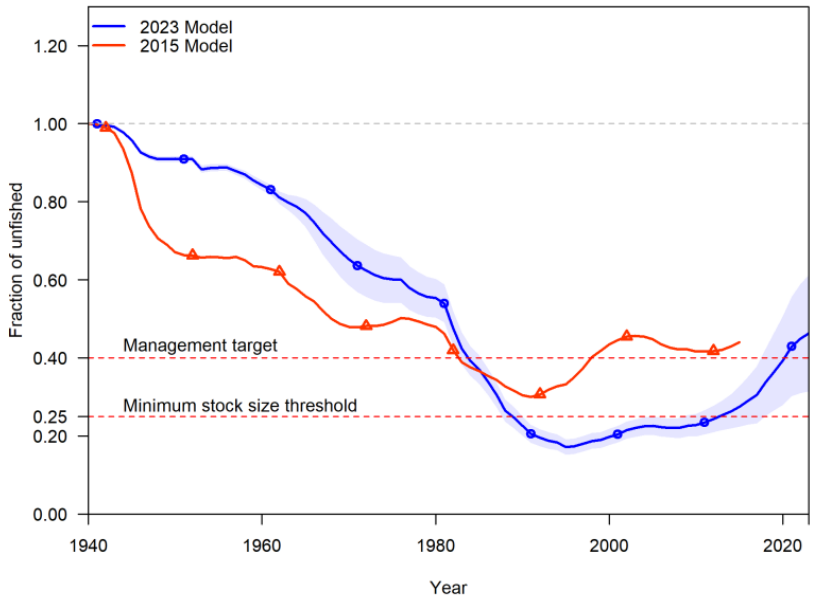

Figure 8. The estimated fraction unfished between the 2023 and 2015 assessments for black rockfish in Washington waters.

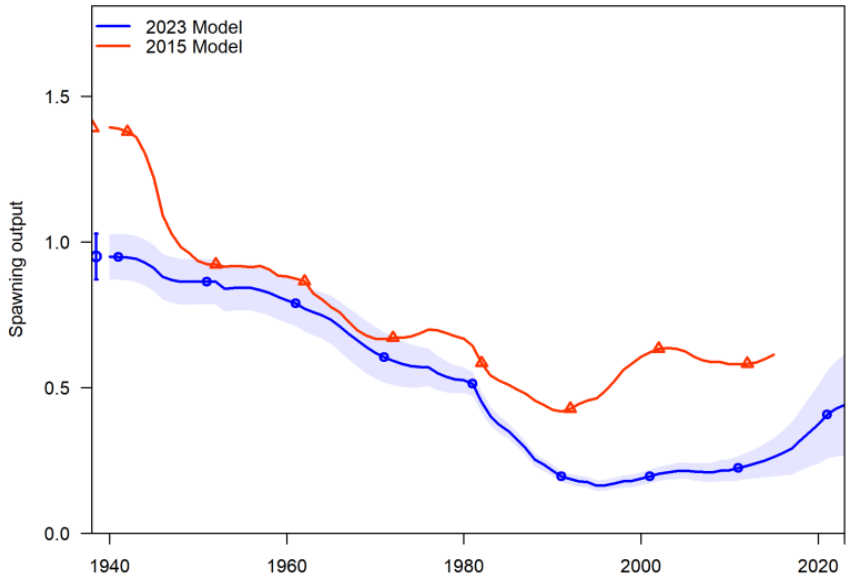

Figure 9. The estimated spawning output between the 2023 and 2015 assessments for black rockfish in Washington waters.

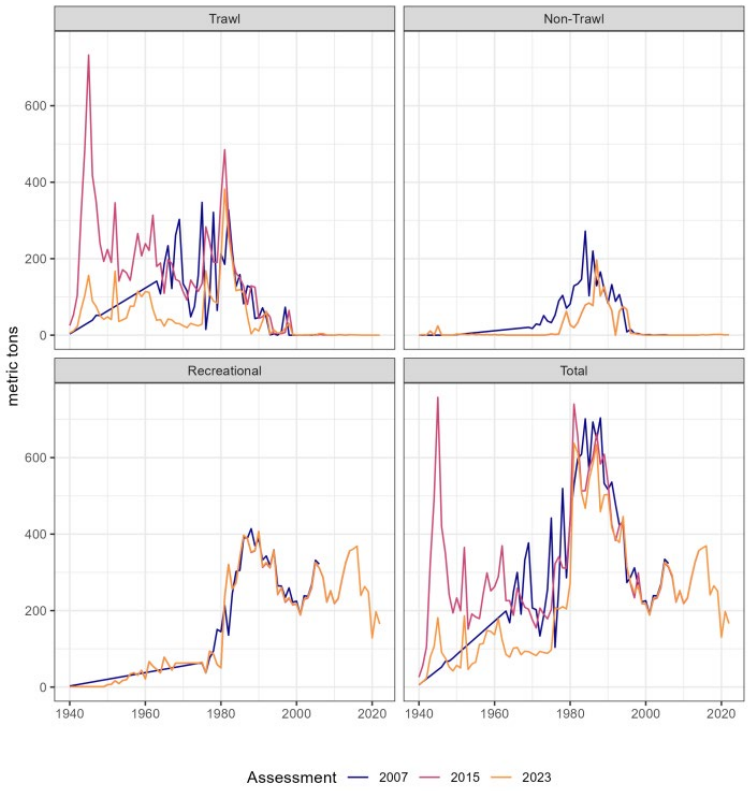

Figure 10. Comparison of total removals and removals by fleet between the 2023 and the previous assessments (2015 and 2007). The lines show the non-trawl and recreation removal time series for the 2015 assessment cannot be seen as they are masked by lines from the 2023 time series.

Petrale sole

The 2023 stock assessment of petrale sole was modeled as a single area (Taylor et al., 2023), similar to the previous assessment conducted in 2019 (Wetzel 2019), an update of the 2013 benchmark assessment (Haltuch et al., 2013). The 2023 assessment is benchmark assessment that incorporated catch, index of abundance, length, and age data that applied a simplified fleet structure (i.e., removed seasonal fleet structure). The 2023 assessment estimates a fraction unfished of 33.6 percent, above the flatfish target reference point of 25 percent. The new assessment estimates a declining biomass in recent years due to below average recruitment, continuing a trend observed in the 2019 update assessment. Unfished age 3+ biomass from the 2023 assessment was 15,803 mt, lower compared to the 2013 estimate of 23,351 and the subsequent update assessments of that model (2015 and 2019) but greater than earlier petrale sole assessments (2005, 2009, and 2010; Figure 11). The estimated equilibrium $MSY_{SPR=0.30}$ from the 2023 assessment was 2,482 mt, smaller than the 2019 estimate of 3,157 mt, due to the decrease in the estimated unfished stock size.

The change in the estimated stock scale for petrale sole is primarily driven by change in catch history. The Washington Department of Fish and Wildlife completed a historical catch reconstruction for petrale sole, and newly estimated landings are lower than those used in previous assessments (Figure 12). Historical landings in the last assessment were based on preliminary estimates, which most likely included catches from Canadian waters. New Washington historical landings are more consistent with history of commercial removals on the U.S. West Coast and represent improvement to the assessment. Additionally, the historical discard estimates in the new assessment were lower than those from previous assessments and are considered more realistic for such an economically valuable species. Finally, minor changes in the estimated stock productivity (i.e., steepness), sex-specific natural mortality rate, and data reweighting also contributed to the change in estimated stock scale, but to a much smaller degree.

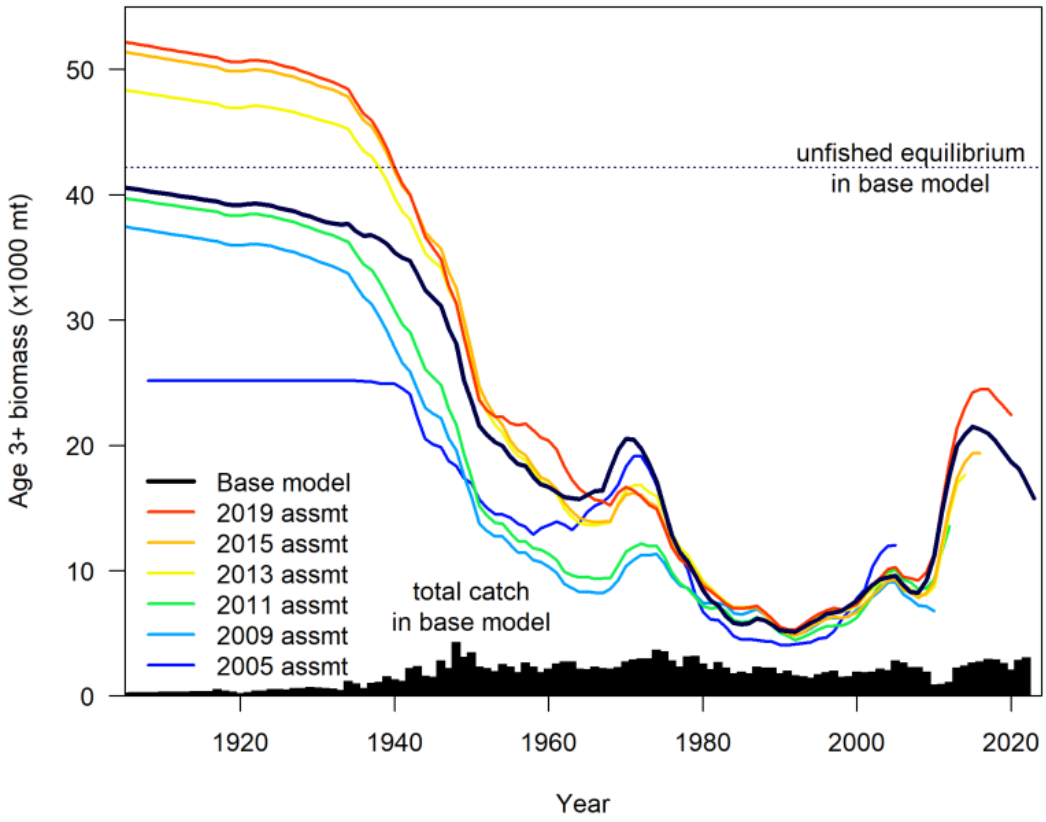

Figure 11. The estimated age 3+ biomass across assessments for petrale sole.

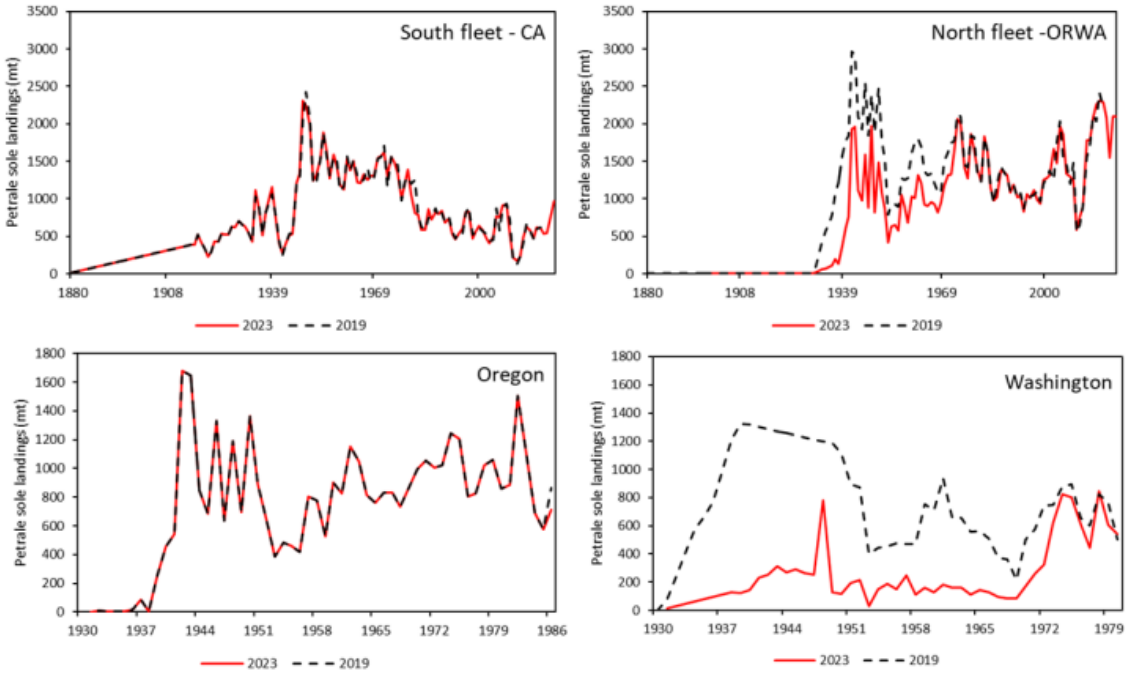

Figure 12. Comparison of landings used in the 2023 petrale sole assessment (solid red line) with landings used in 2019 assessment (dashed black line) by state and fleet.

Canary rockfish

The 2023 stock assessment of canary rockfish modeled the stock as a single area with fleet structure based on state areas (Langseth et al., 2023). This was a simplification from the previous 2015 assessment model structure that modeled the stock using a single model with multiple areas corresponding to state-areas (e.g., Washington, Oregon, and California) with no movement between the areas (Thorson and Wetzel, 2015). The estimates of unfished summary biomass age 5+ from the 2023 and 2015 assessments were highly similar with the estimates from the two assessments differing in recent years in the time series with the new assessment estimating a slower increase in biomass (Figure 13). The 2023 assessment estimated a fraction unfished of 35.1 percent, below the target reference point for rockfish of 40 percent (Figure 14). In contrast, the 2015 assessment estimated the fraction unfished at 55.5 percent which resulted in the previously overfished stock being declared rebuilt. The estimated equilibrium $MSY_{SPR = 0.50}$ from the 2023 assessment is 1,094 mt, marginally lower than the 2015 estimate of 1,156 mt.

While the estimated status did change relative to the 2015 assessment, the 2023 assessment was generally consistent with earlier assessments of canary rockfish with the 2015 assessment being more of the outlier in terms of the stock trajectory since the mid-1990s (Figure 14). The bridging analysis within the 2023 assessment highlights the factors contributing to the change in population trajectory from the 2015 assessment. The primary factor was the change in assumptions related to

natural mortality (Figure 15). The 2023 model assumed female natural mortality was constant over all ages, and did not increase as fish grew older, which the stock assessment team (STAT) and Stock Assessment Review (STAR) panel agreed was more in line with what we know about rockfish life history.

A secondary factor was reapplying data weighting. While building the assessment model, it became clear that the data weighting procedure used in the 2015 model was unusual and not in line with standard practices. When reweighting was applied cumulative to changes made to data and biology (and in particular the change in natural mortality structure), the result was a much less optimistic view of the population (Figure 16). These changes, as well as additional changes with lesser effects were discussed during the STAR panel and were considered to be appropriate by the panel.

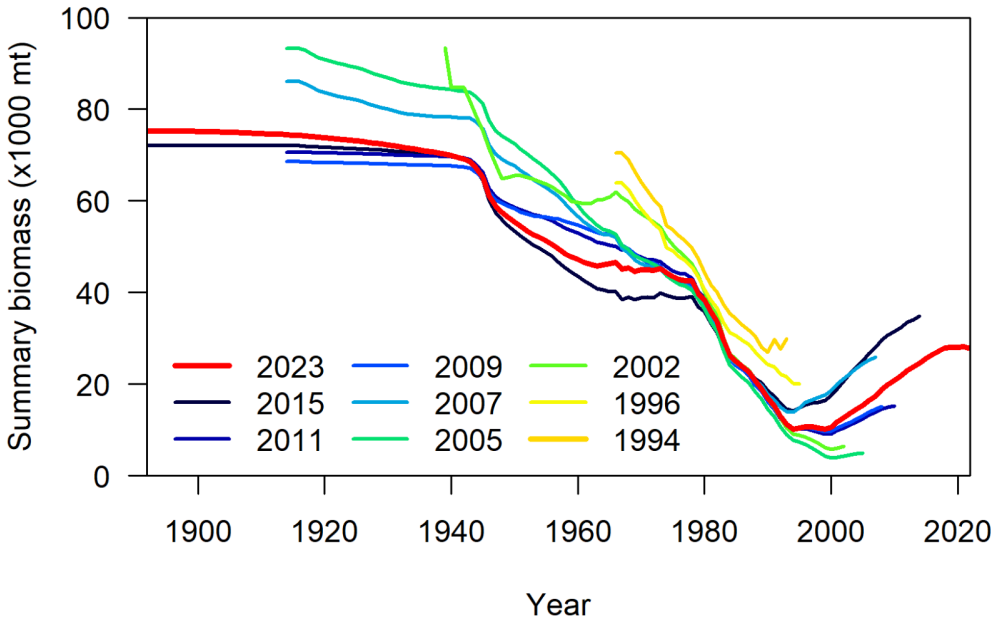

Figure 13. Canary rockfish summary biomass of current and past full and update assessments in 1,000s of mt. Summary biomass shows age 5+ canary rockfish with the exception of the 2002 update, which provided summary biomass for age 3+ canary rockfish.

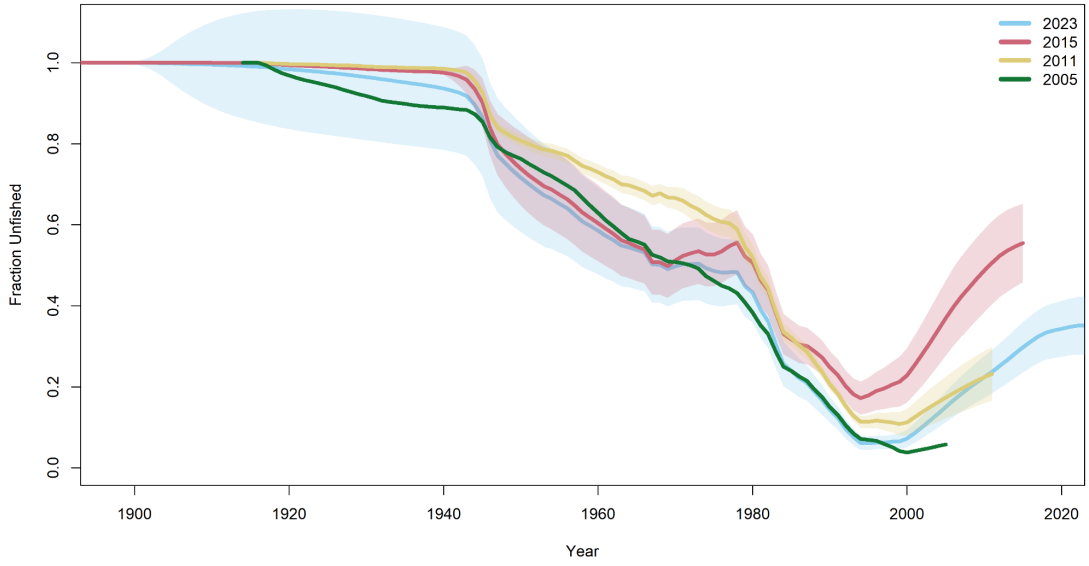

Figure 14. The estimated fraction unfished for canary rockfish from the current assessment and select previous benchmark assessments (2015 and 2005) and update assessments (2011).

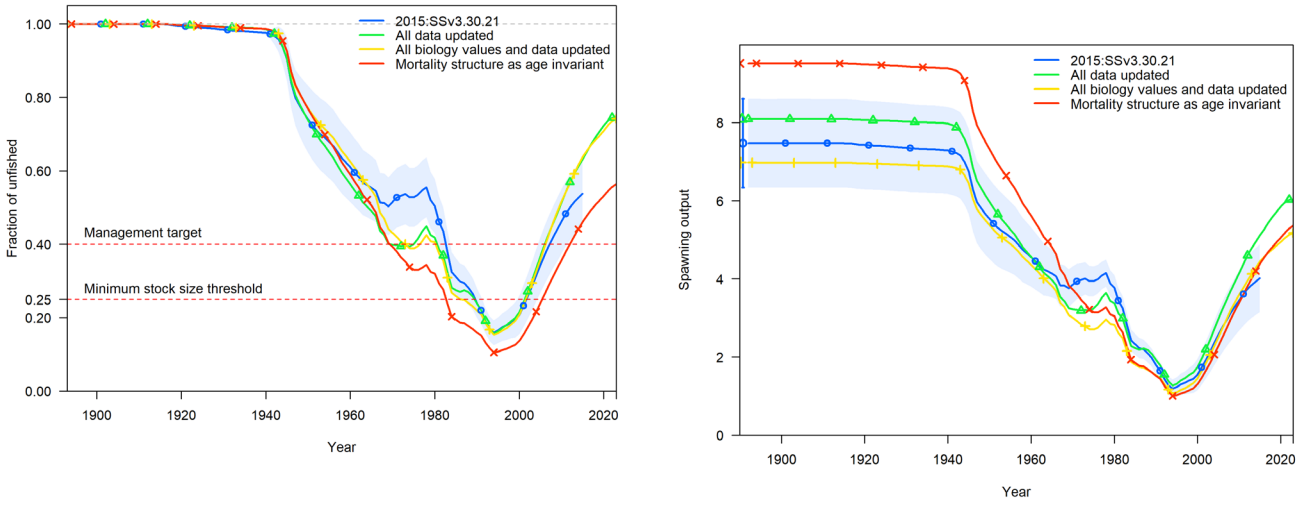

Figure 15. Figures 43-44 in the 2023 canary rockfish assessment for fraction unfished (left panel) and spawning output (right panel) reflecting changes in the estimates between the 2015 assessment (blue line) and the 2023 model whe updating the structure of natural mortality (red line).

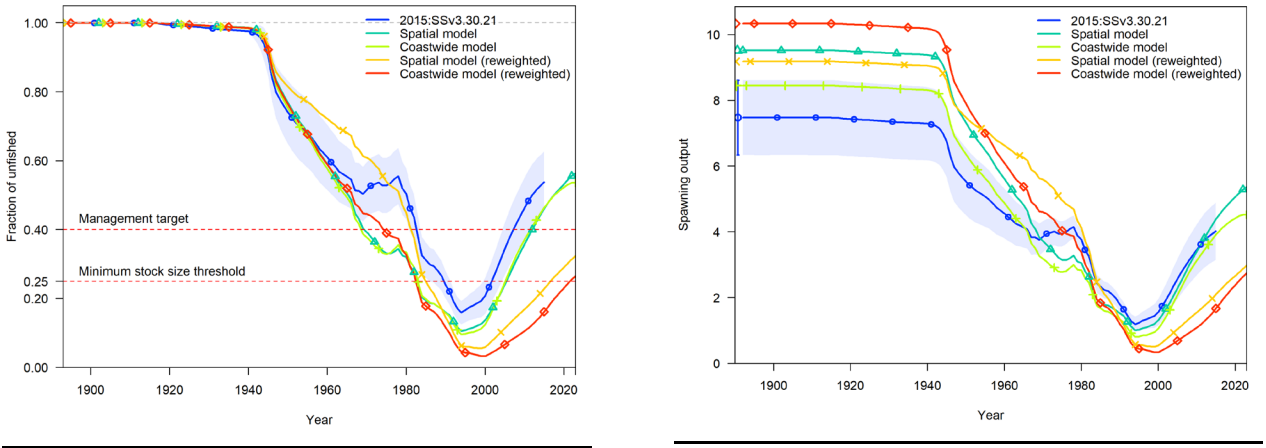

Figure 16: Figures 45-46 in the 2023 canary rockfish assessment for fraction unfished (left panel) and spawning output (right panel) reflecting changes in the estimates between the 2015 assessment (blue lines) and the 2023 model when updating the spatial structure (teal line) to coastwide structure (lime green line) and data reweighting (red line).

Rex sole

The 2023 length-based data-moderate assessment of rex sole incorporated catch, indices of abundance, length composition, and conditional-age-at-length data to inform estimates annual recruitment variation, stock scale, status, and growth (Min et al., 2023). The previous assessment in 2013 was an index-only data-moderate assessment including only catch data and survey indices of abundance along with strong assumptions (i.e., referred to as priors) about productivity, natural mortality, the relative stock size that would produce maximum sustainable yield, and the fraction unfished in the year 2000 that were then updated based on fits to the index of abundance data (Cope et al., 2013). The new assessment estimated an increase in the unfished total biomass (Figure 17) and similar estimates of fraction unfished at the end of the time series relative to the 2013 assessment (Figure 18). The estimated fraction unfished in 2023 was estimated at 76 percent compared to the previous estimate of 80 percent of unfished in 2013. The estimated equilibrium $MSY_{SPR=0.30}$ from the 2023 assessment was 1,683 mt, consistent with the 2013 estimate of 1,679 mt.

The new assessment provided more informed population estimates for rex sole off the West Coast by incorporating composition data to inform estimates of growth and stock status and by updating both fecundity and maturity assumptions based on recent research. Additionally, incorporating both length and conditional-age-at-length data supported the estimation of annual recruitment variation whereas the previous assessment in 2013 assumed recruitment equal to the stock recruitment curve based on changes in spawning output. Flatfish are generally highly productive and can have swings in population size driven by good or bad recruitments. The new assessment estimated a period of strong recruitment in the late-1980s through mid-1990s, followed by period

of below average recruitment in the mid-1990s through the early 2000s, and with multiple strong recruitments in 2010, 2011, and 2013 (Figure 19).

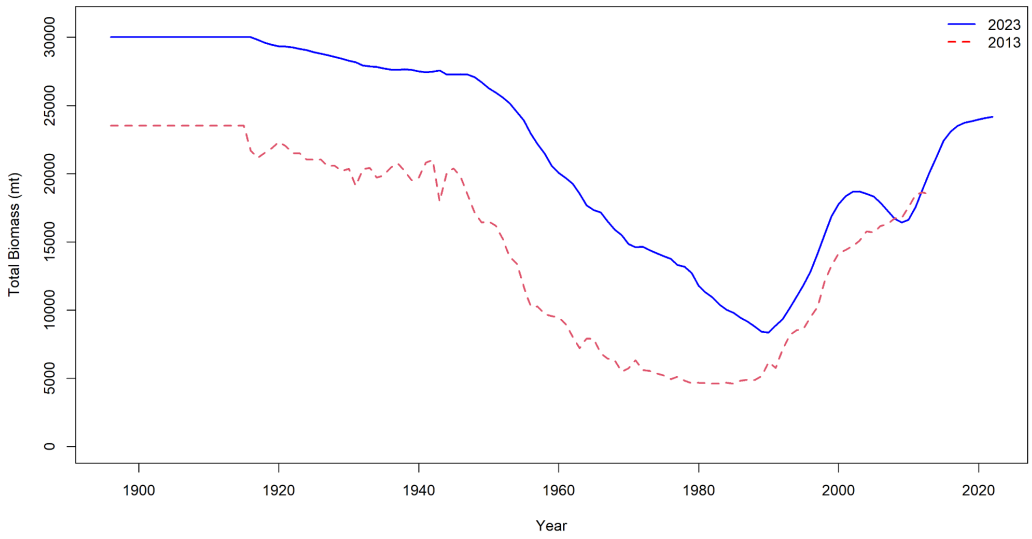

Figure 17. The estimated total biomass across assessments for rex sole.

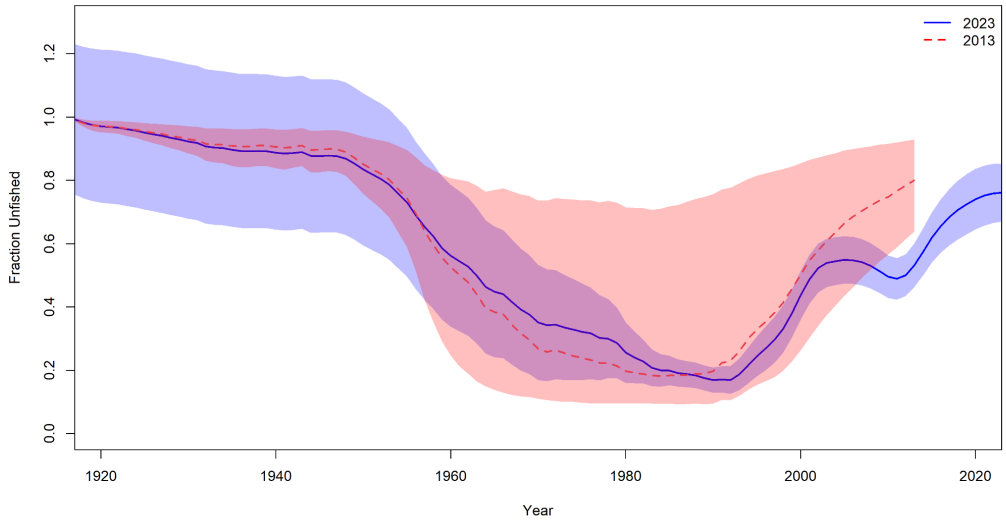

Figure 18. The estimated fraction unfished across assessments for rex sole.

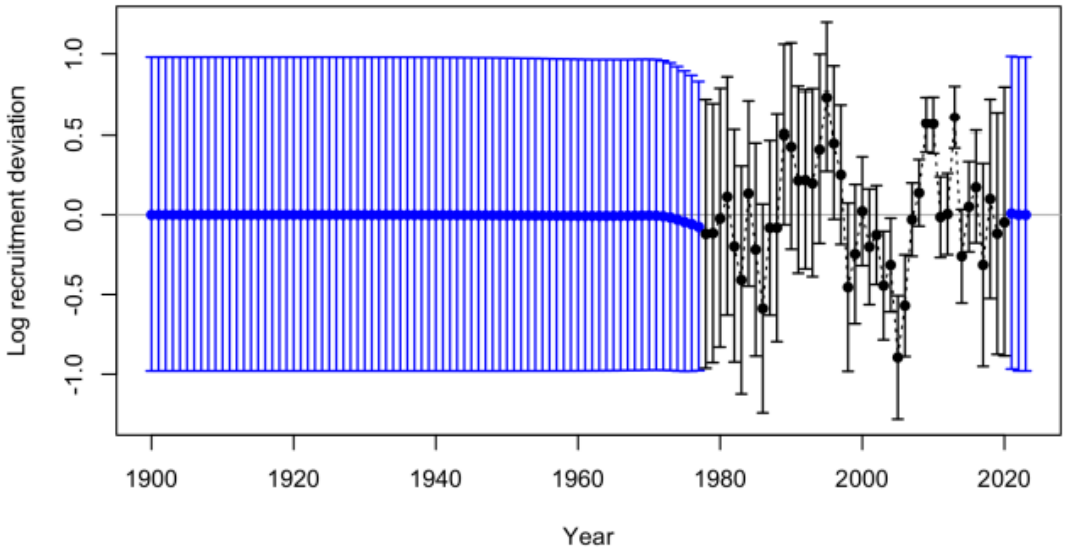

Figure 19. The estimated annual recruitment deviations from the 2023 assessment of rex sole.

Shortspine thornyhead

The 2023 assessment of shortspine thornyhead modeled a coastwide population off the U.S. West Coast (Zaher et al., 2023) similar to the previous assessment conducted in 2013 (Taylor and Stephens, 2013). The 2023 assessment incorporated catch, multiple indices of abundance, length composition, and discard data to inform the rates and sizes of discarded fish, similar to the previous assessment. The new assessment estimated a lower unfished total biomass relative to the 2013 assessment but similar to the 2005 assessment (Figure 20). The estimated fraction unfished in 2023 was 39 percent, lower than the previous estimate of 74 percent of unfished in 2013, but roughly comparable to earlier assessments (Figure 21). The estimated equilibrium $MSY_{SPR = 0.50}$ from the 2023 assessment was 1,108 mt, lower than the 2013 assessment estimate of 2,034 mt, primarily driven by changes in natural mortality and maturity.

The change in the estimated stock size and fraction unfished was driven by multiple factors: assumptions around natural mortality, maturity, and improved data weighting. Shortspine thornyhead is long-lived rockfish that have been estimated to live more than 100 years but there is high uncertainty around the maximum age. The 2023 assessment assumed a natural mortality of 0.04 yr^{-1}, decreasing from the 2013 fixed value of 0.0505 yr^{-1}, which resulted in a reduced fraction unfished (Figure 22) The revised assumption about natural mortality was based on the data, literature, and assessment of shortspine thornyhead off Canada and Alaska (0.03 yr^{-1}).

The new maturity estimate in the 2023 assessment was based on samples collected by the Northwest Fisheries Science Center (NWFSC) West Coast Groundfish Bottom Trawl (WCGBT) survey that had broad spatial coverage and is considered to be an improvement in the understanding in the fundamental biology of shortspine thornyhead. The new maturity estimated

the length at 50 percent maturity of 31.4 cm, increasing from the assumed value of 18 cm used in the last assessment, which resulted in a reduction in the estimated scale of the stock (Figure 22).

Data weighting had limited impact on the model estimates in the 2023 assessment with both the Francis and McAllister-Ianelli approaches providing similar estimates of stock size and status (Figure 24). The 2013 assessment applied the McAllister-Ianelli data weighting method. When changing that model to Francis weighting, the scale and fraction unfished both decline substantially. When McAllister-Ianelli data weighting is applied to the current assessment, the scale and depletion do increase, but less so, suggesting that the addition of new data stabilized the model, but at a lower status and scale.

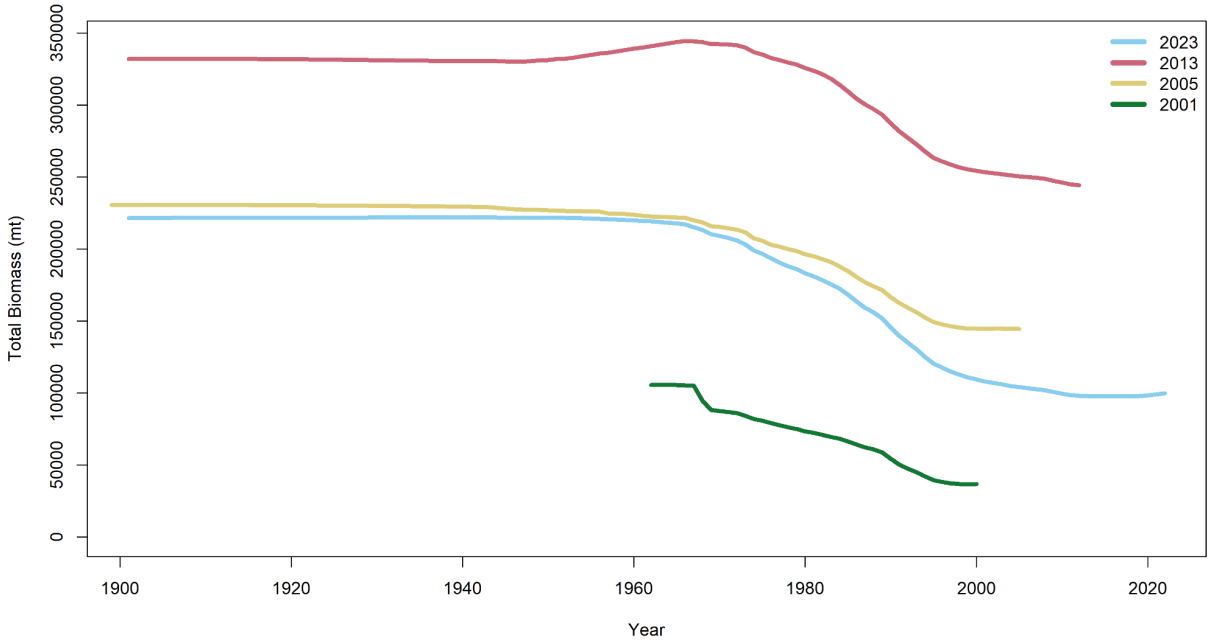

Figure 20. The estimated total biomass across assessments for shortspine thornyhead.

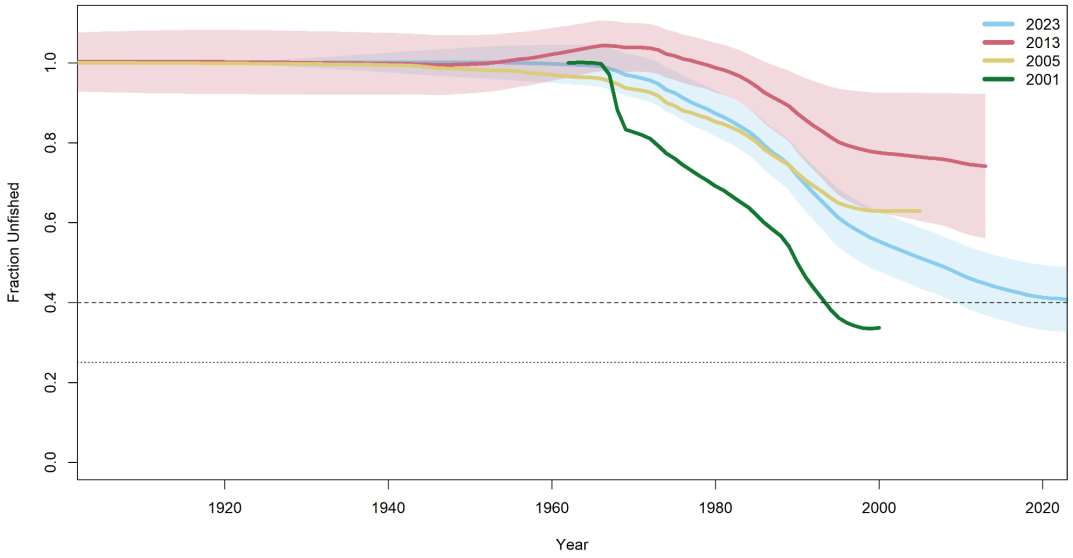

Figure 21. The estimated total biomass across assessments for shortspine thornyhead.

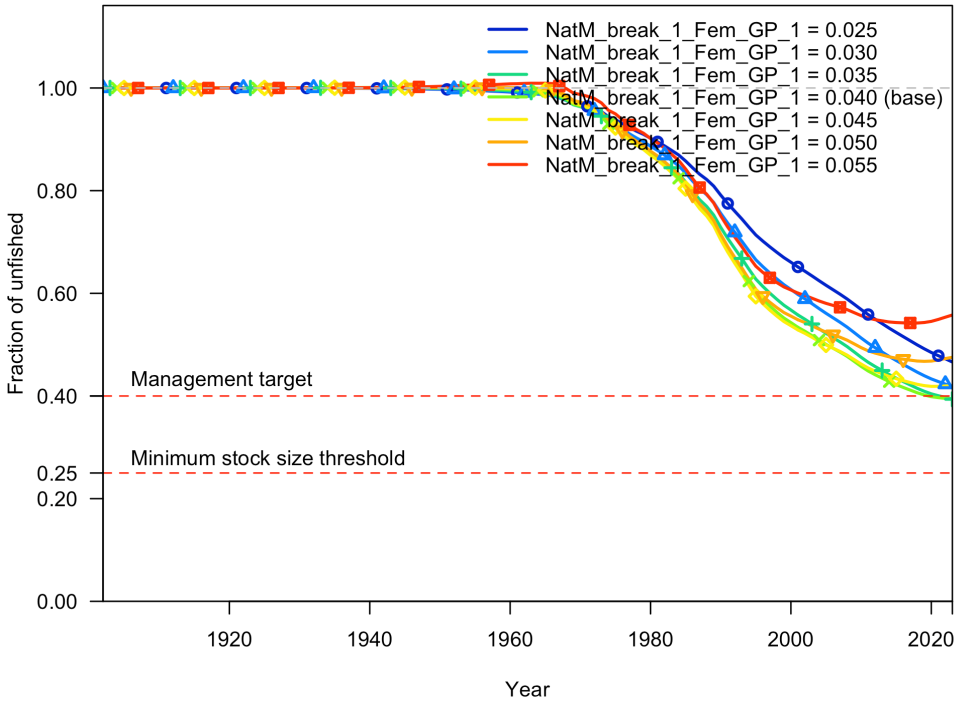

Figure 22. The shortspine thornyhead estimated fraction unfished based on alternative natural mortality values.

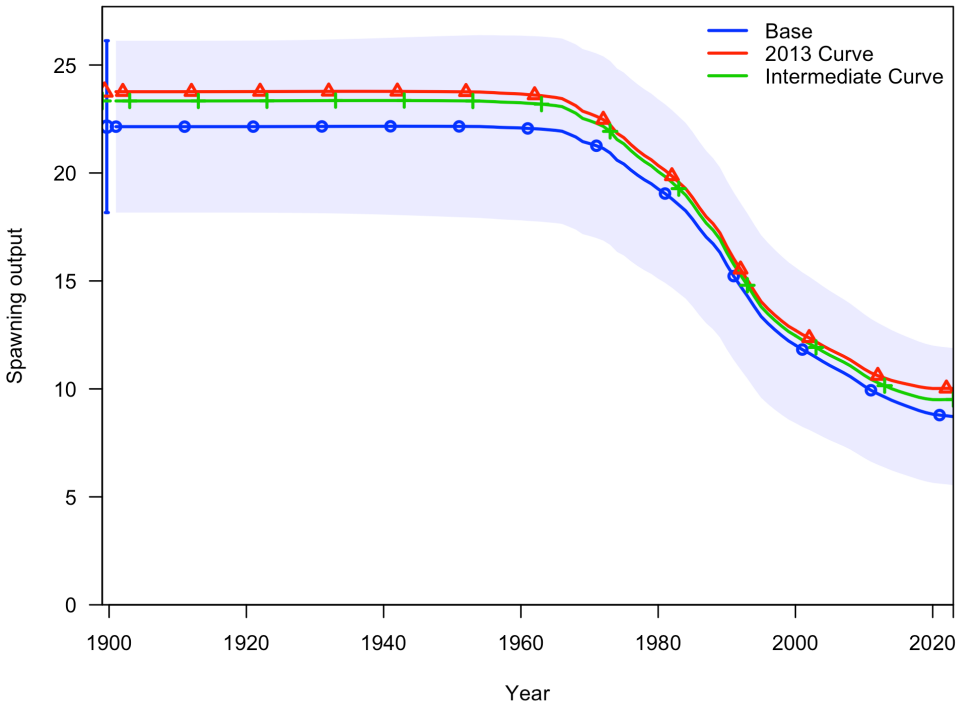

Figure 23. The shortspine thornyhead estimated spawning output based on alternative assumptions around natural mortality where the Base model reflects the 2023 assessment.

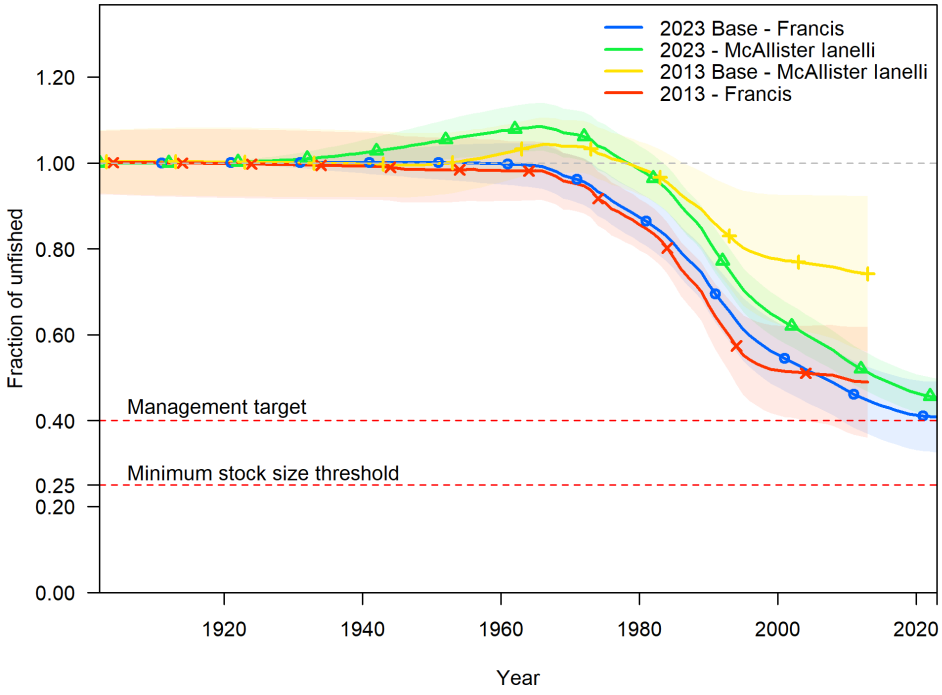

Figure 24. The shortspine thornyhead estimated fraction unfished based on alternative data weighting approaches for the 2023 and 2013 assessments.

Sablefish

The 2023 limited update assessment of sablefish (Johnson et al., 2023) updated catch and discard data, along with NWFSC WCGBT index of abundance, length, and conditional-age-at-length data based on the 2021 update assessment (Kapur et al., 2021). The estimated unfished spawning biomass, recent spawning biomass, and fraction unfished (63 percent) all increased relative to the previous assessment (Figures 25 and 26). The estimated equilibrium $MSY_{SPR = 0.45}$ from the 2023 assessment was 9,641 mt, comparable to the 2021 assessment estimate of 8,350 mt.

Sharp increases in spawning biomass and fraction unfished at the end of the time series and stock projections are driven by multiple strong recruitment events in 2016, 2020, and 2021 (Figure 27). Estimates of 2020-2021 recruitment from the 2023 assessment update are the largest estimates of recruitment deviations in the entire time series and the largest estimates of age-0 fish except for the 1966 estimate of 171,566 fish. Thus, the estimate unfished recruitment also increased such that the time series of recruitment deviations could sum to zero with these large estimates of recent recruitment.

The growth rate of fish from the 2020 and 2021 cohorts is different from the constant/average growth for young fish assumed in the assessment. The size of the recruitments in those years, the relative growth rate, and the relative survivorship of those cohorts through 2025 and 2026 is more uncertain than the trajectory of the portion of the stock that represents cohorts from earlier than 2020. This is both because of the few observations of these cohorts, the inherent variability in mortality rate of young and small fish, and the impact of the unusually large cohorts themselves.

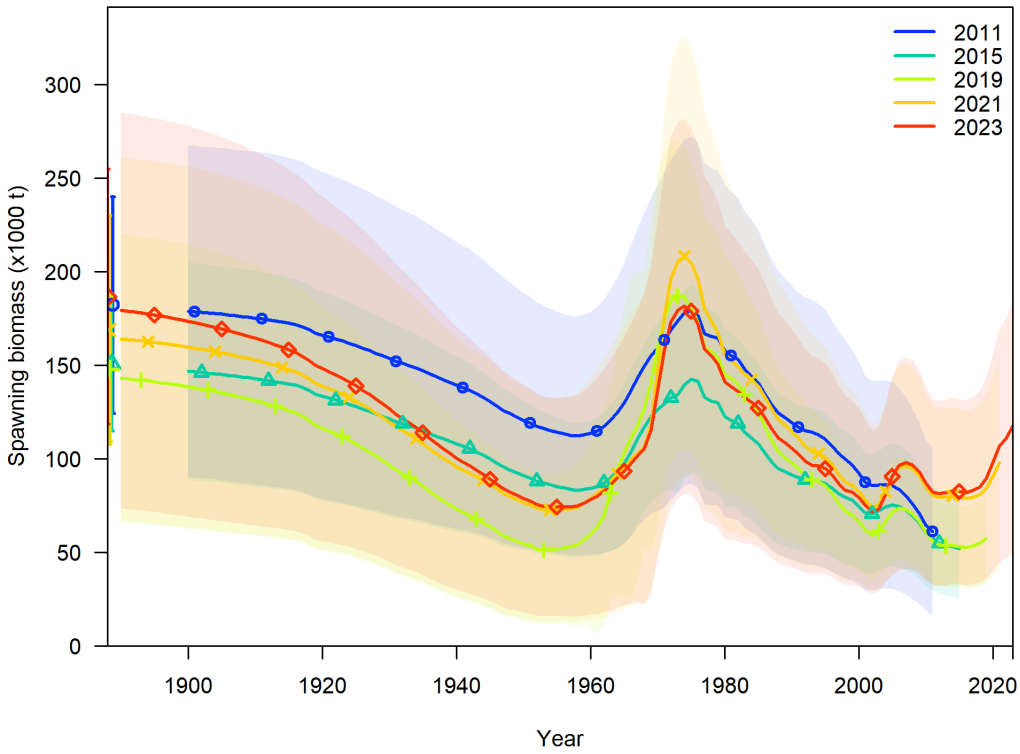

Figure 25. The estimated spawning output for sablefish across assessments.

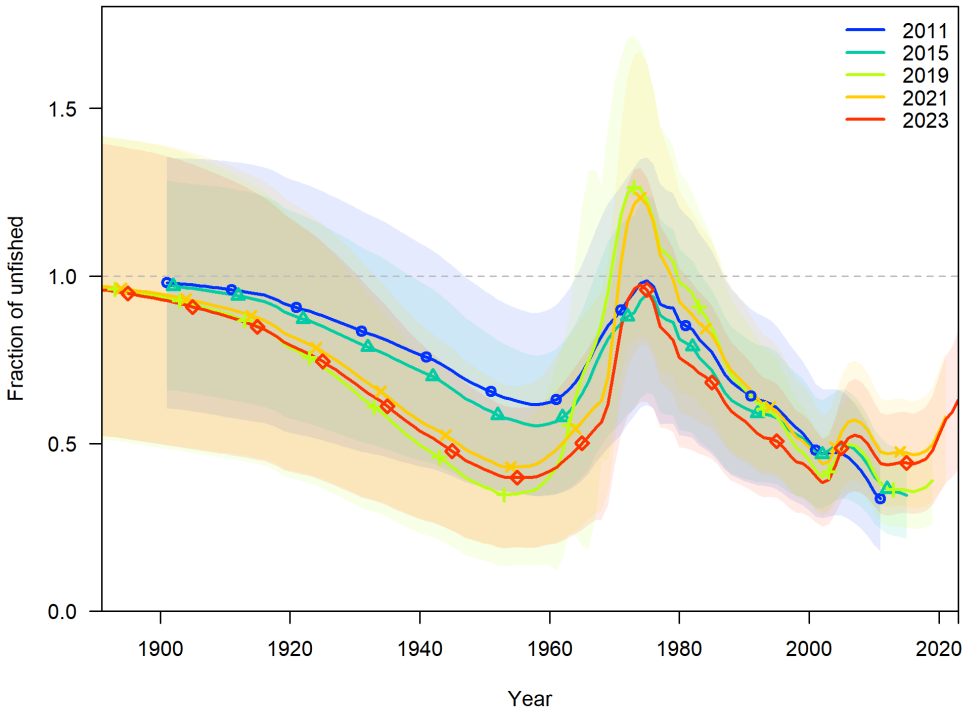

Figure 26. The estimated fraction unfished for sablefish across assessments.

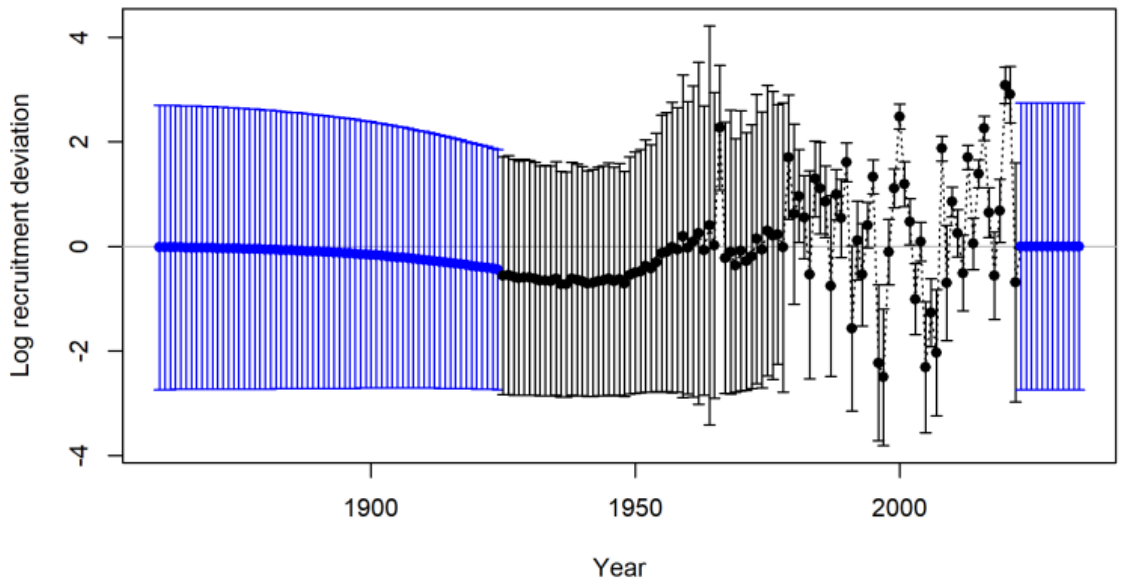

Figure 27. Annual estimates of recruitment deviation from the 2023 update assessment for sablefish.

Consistency in Stock Synthesis Model Estimates Across Versions

Since the original development of Stock Synthesis in 2000, the integrated modeling platform has grown in the ability to incorporate a wide range of data types and to model fishery and biological processes using a range of functional forms (e.g., selectivity, retention, stock-recruitment, growth, maturity). Stock Synthesis is highly flexible supporting the ability to model populations under the simplest of assumptions around biology and age-structure (i.e., surplus production with pooled mature age-structure) or with highly complex time-varying processes. The general flexibility of Stock Synthesis has led to its application for modeling fish populations around the world.

Stock Synthesis is continuously maintained with ongoing development based upon the needs of stock assessors globally. A part of that ongoing development is rigorous model testing that occurs prior to any new version release to ensure that model performance is tested and to ensure general backward compatibility is maintained. In 2017, Stock Synthesis version 3.30.00 was released that dramatically improved how data were input into the model, expanded the consistency of parameter lines that supporting the expansion of time-varying processes, and added new model features (e.g., dome-shape retention, revised parameter-space for time-varying selectivity parameters, three parameter stock-recruitment curve, etc.). Given the large changes and improvements to Stock

Synthesis, the Groundfish Sub-Committee of the Scientific and Statistical Committee (GFSC-SSC) conducted a review in the spring of 2017 of the modeling platform and any potential impacts to the estimated population dynamics for West Coast groundfish assessments. Across species, the model estimates were practically identical (i.e., varied between 0-2 percent generally) with only minor variations of the estimated final spawning biomass or output of fraction unfished (Figure 28).

Stock Synthesis provides an executable that can generally convert older version 3.24 model files into the revised structure needed for version 3.30 models. However, there are some items that may need to be converted by hand depending upon a specific model parameterization. Additionally, depending on the model configuration, models with time-varying parameters may need to also convert the input parameters into log space (i.e., a parameterization that improved parameter estimation). The infrequent nature of assessors needing to convert old model files can lead to model conversions that are not fully comparable to earlier model versions (e.g., time-varying selectivity parameters not being fully converted) that inadvertently lead to differences in the estimated quantities between models. For example, both shortspine thornyhead and black rockfish in Oregon in assessment documents presented bridging comparisons that did not fully match estimates from earlier versions of Stock Synthesis. Both models were included in the 2017 analysis presented to the GFSC-SSC (Figure 28) that reflected little to no change in model estimates. Additional work has also been done converting the 2017 models to the current version of Stock Synthesis and have been verified that model results are consistent with earlier Stock Synthesis versions. Given that parameterization and fleet structure are re-examined and revised in a new assessment, any lack of full comparability to earlier versions of Stock Synthesis, should not impact any of the final model estimates.

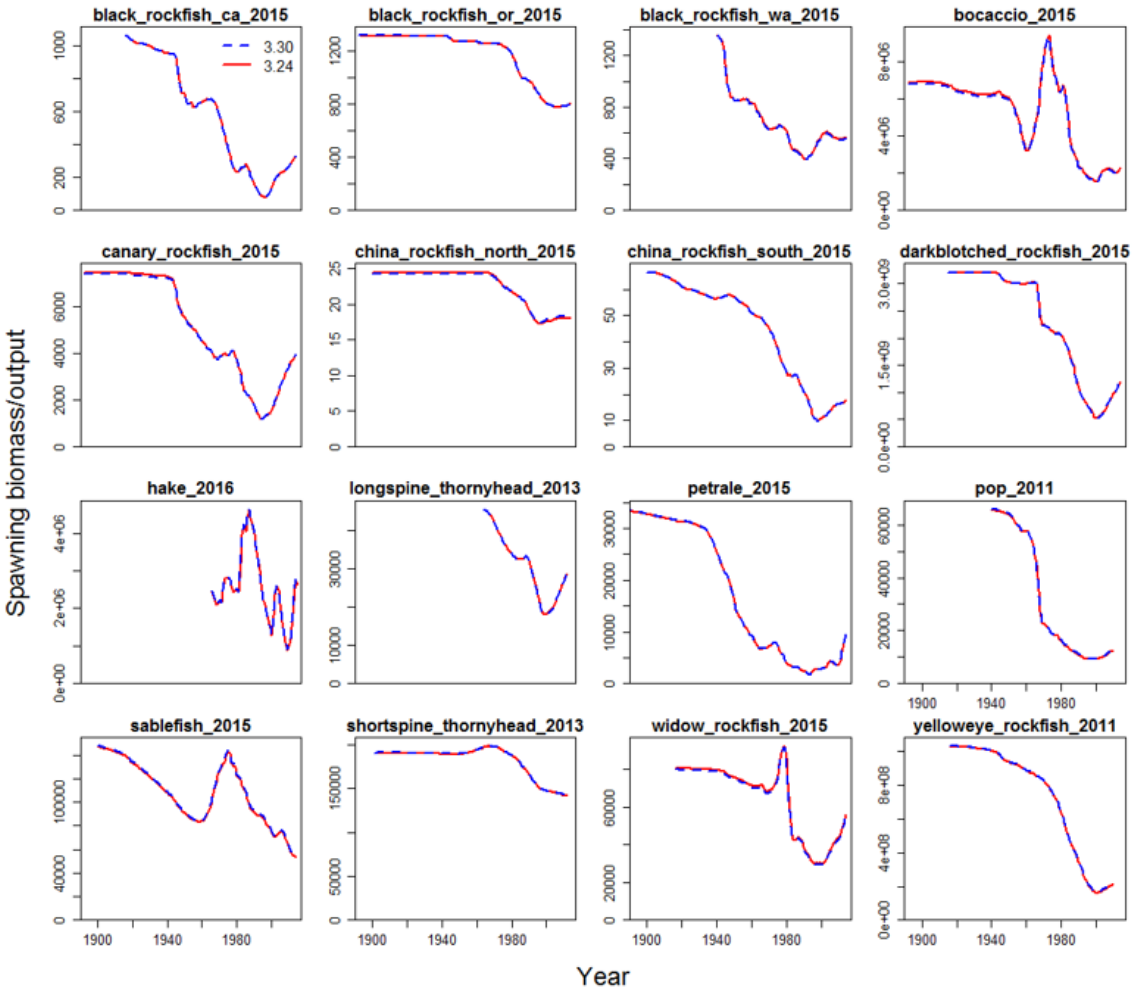

Figure 28. Comparisons of the estimated spawning biomass/output between Stock Synthesis version 3.30.00 to previous 3.24 versions for 16 groundfish assessments. The estimates from Stock Synthesis version 3.30.00 are shown by a blue dashed line with the previous model estimates shown by a solid red line.