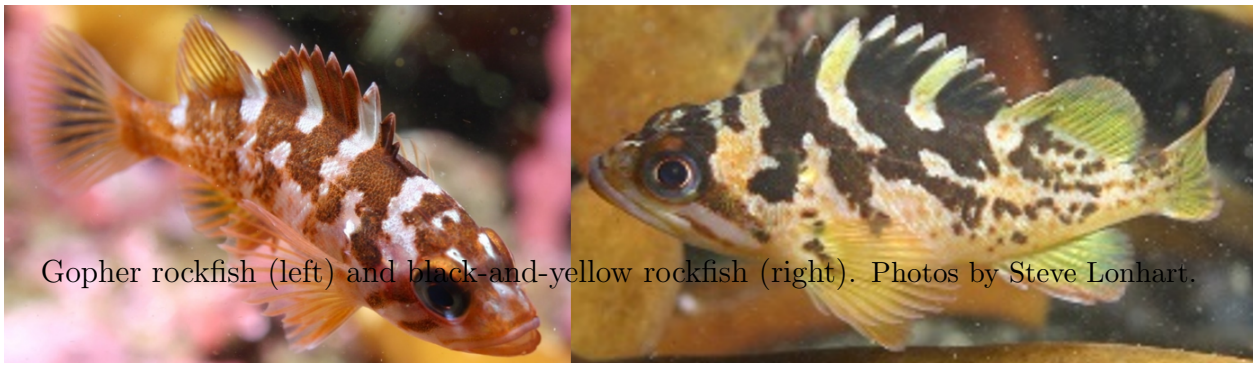
Agenda Item H.5
Attachment 11
September 2019

# The Combined Status of Gopher (*Sebastes carnatus*) and Black-and-Yellow Rockfishes (*Sebastes chrysomelas*) in U.S. Waters Off California in 2019



Gopher rockfish (left) and black-and-yellow rockfish (right). Photos by Steve Lonhart.

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# The Combined Status of Gopher (*Sebastes carnatus*) and Black-and-Yellow Rockfishes (*Sebastes chrysomelas*) in U.S. Waters Off California in 2019

## Contents

# Executive Summary

## Stock

This assessment reports the status of the gopher and black-and-yellow rockfish complex (GBYR, *Sebastes carnatus/Sebastes chrysomelas*) resource as in U.S. waters off the coast of California south of Cape Mendocino (40°10′ N. latitude) using data through 2018. Both gopher and black-and-yellow rockfishes are most abundant north of Point Conception (34°27′ N. latitude) and are rare north of Point Arena (38°57′ N. latitude). The range of gopher rockfish extends into Baja California, but the black-and-yellow rockfish are rare south of Point Conception.

## Catches

Information on historical landings of GBYR are available back to 1916 (Table a). The recreational fleet began ramping up in the 1950s and has fluctuated over the the last 50 years (Figure a). The majority of gopher and black-and-yellow rockfish recreational landings are from north of Point Conception.

Commercial landings were small during the years of World War II, ranging between 4 to 28 metric
tons (mt) per year (Figure b). Commercial landings increased after World War II and show periods of cyclical catch for gopher and black-and-yellow rockfishes. The commercial live fish fishery began in the early 1990s, with the first reported live landings in 1993. Since then the commercial catch has been dominated by the live fish fishery, with minimal landings of dead gopher or black-and-yellow rockfishes. Estimates of total mortality of commercial discards were available starting in 2004, and were estimated prior to then. The catches aggregated by fleets modeled in this assessment can be found in Figure c.

Since 2000, annual total landings of catch and discards of GBYR have ranged between 70-169 mt, with landings (catch + discards) in 2018 totaling 92 mt.

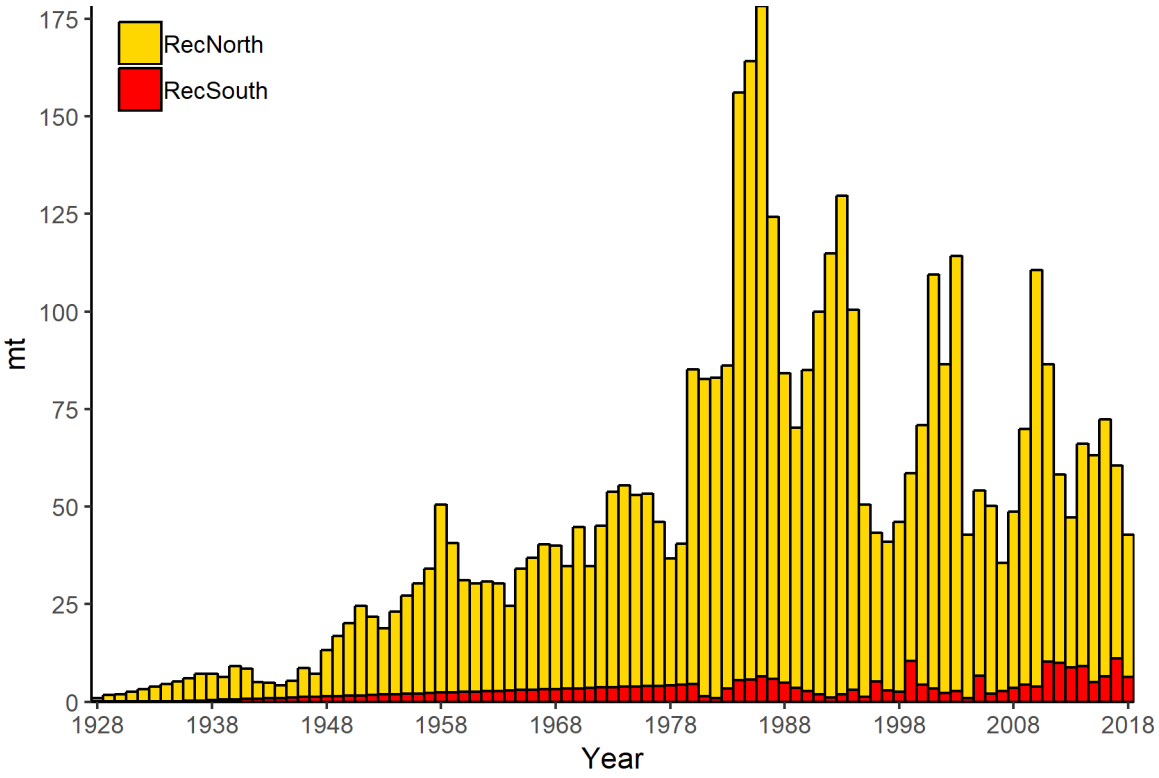


Figure a: Catch history of GBYR for the recreational fleet.

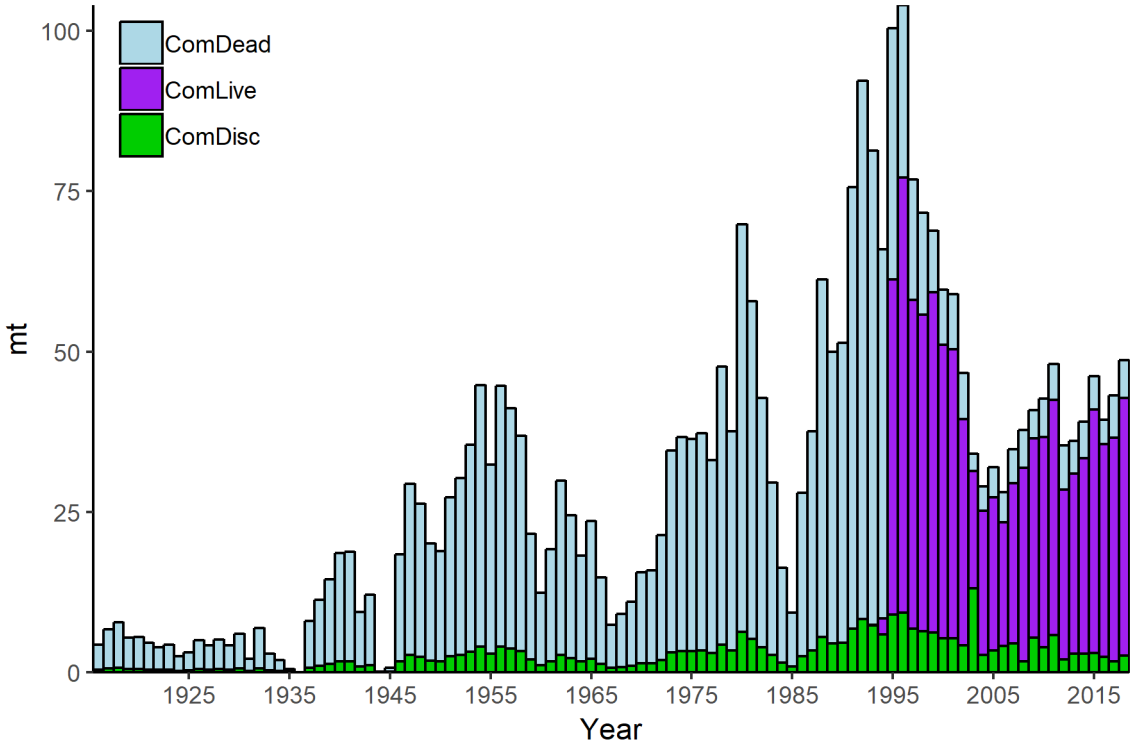


Figure b: Catch history of GBYR for the commercial fleet by dead and live landings, and discards. Catches in 1936 and 1946 were minimal.

Table a: Recent GBYR landings (mt) by fleet.

| Year | Commercial Retained | Commercial Discard | Recreational North | Recreational South | Total |
|---|---|---|---|---|---|
| 2009 | 35.62 | 5.38 | 65.64 | 4.30 | 110.93 |
| 2010 | 38.83 | 3.92 | 106.76 | 3.90 | 153.41 |
| 2011 | 42.39 | 5.72 | 76.16 | 10.24 | 134.52 |
| 2012 | 33.55 | 1.93 | 48.25 | 9.89 | 93.62 |
| 2013 | 33.45 | 2.85 | 38.43 | 8.86 | 83.59 |
| 2014 | 36.40 | 2.85 | 56.96 | 9.06 | 105.27 |
| 2015 | 43.25 | 2.93 | 58.09 | 5.00 | 109.27 |
| 2016 | 36.96 | 2.42 | 65.72 | 6.57 | 111.67 |
| 2017 | 42.04 | 1.65 | 49.36 | 11.15 | 104.19 |
| 2018 | 47.00 | 2.54 | 36.48 | 6.30 | 92.32 |

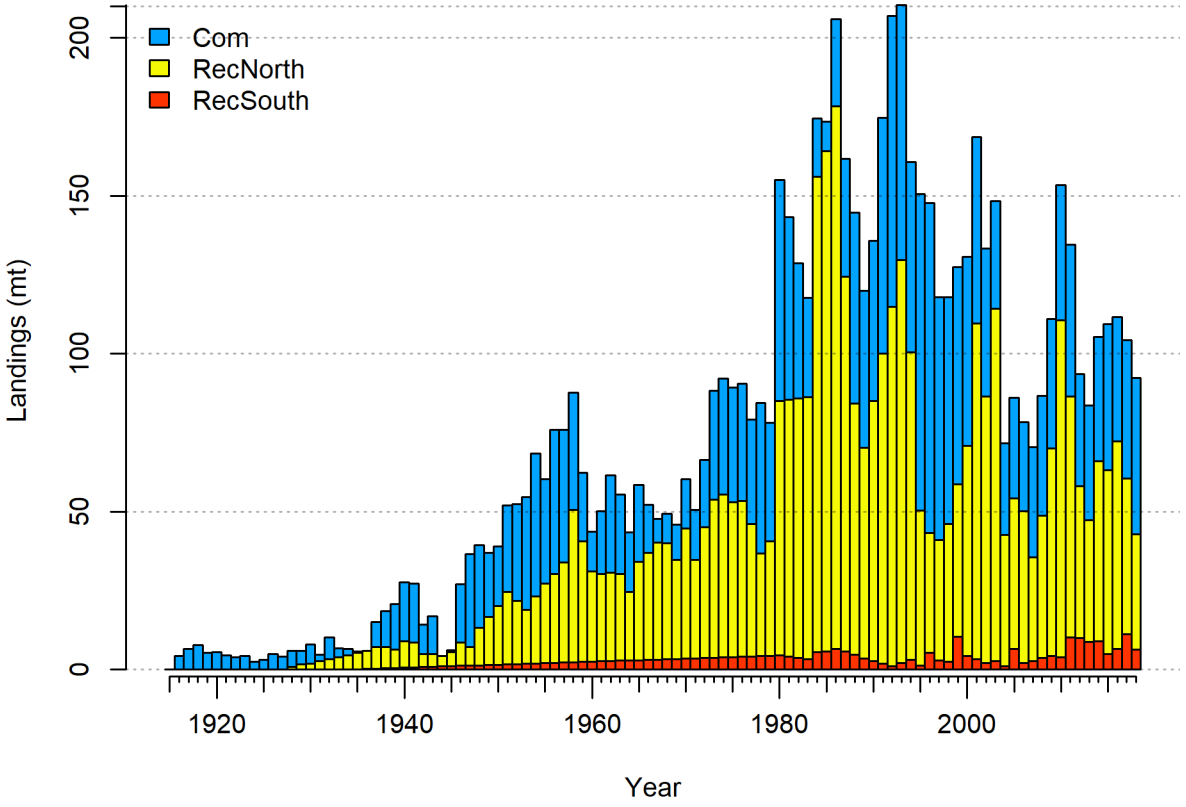


Figure c: Catch history of GBYR in the model.

## Data and Assessment

Gopher rockfish north of Point Conception (34°27′ N. latitude) was first assessed as a full stock assessment in 2005 (Key et al. 2005) using SS2 (version 1.19). The assessment was sensitive to the CPFV onboard observer index of abundance (referred to as Deb Wilson-Vandenberg's onboard observer index in this assessment). The final decision table was based around the emphasis given to a fishery-dependent index of abundance for the recreational fleet. The stock was found to be at 97% depletion.

Gopher rockfish south of Point Conception was assessed as a data poor species in 2010 (Dick and MacCall 2010). A Depletion-Corrected Average Catch (DCAC) model was used due to time constraints. The mean yield from the DCAC distribution was 25.5 mt.

This is the first full assessment to include data for black-and-yellow rockfish. Black-and-yellow rockfish was assessed coastwide as a data poor species using Depletion-Based Stock Reduction Analysis (DB-SRA) (Dick and MacCall 2010). The DB-SRA model assigned a 40% probability that the then recent (2008-2009) catch exceeded the 2010 OFL.

This assessment covers the area from Cape Mendocino to the U.S./Mexico border (Figure d). The length composition data suggested that while the lengths of gopher and black-and-yellow rockfish were similar, fish encountered south of Point Conception were smaller. The similarity of the length distributions between species and among modes within a region were similar and justified one combined recreational fleet within each of the two regions (north and south of Point Conception).

This stock assessment retains a single fleet for the commercial fishery, including discards. Data on commercial discards were not available for and not included in the 2005 assessment. The decision to retain one commercial fleet was made by examining the length distributions across species, fishing gears, and space, i.e., north and south of Point Conception. There is very little difference between the length composition of gopher and black-and-yellow rockfish landed in the commercial fleet north of Point Conception.

A number of sources of uncertainty are addressed in this assessment. This assessment includes length data, estimated growth, an updated length-weight curve, an updated maturity curve, a number of new indices, and new conditional age-at-length data.

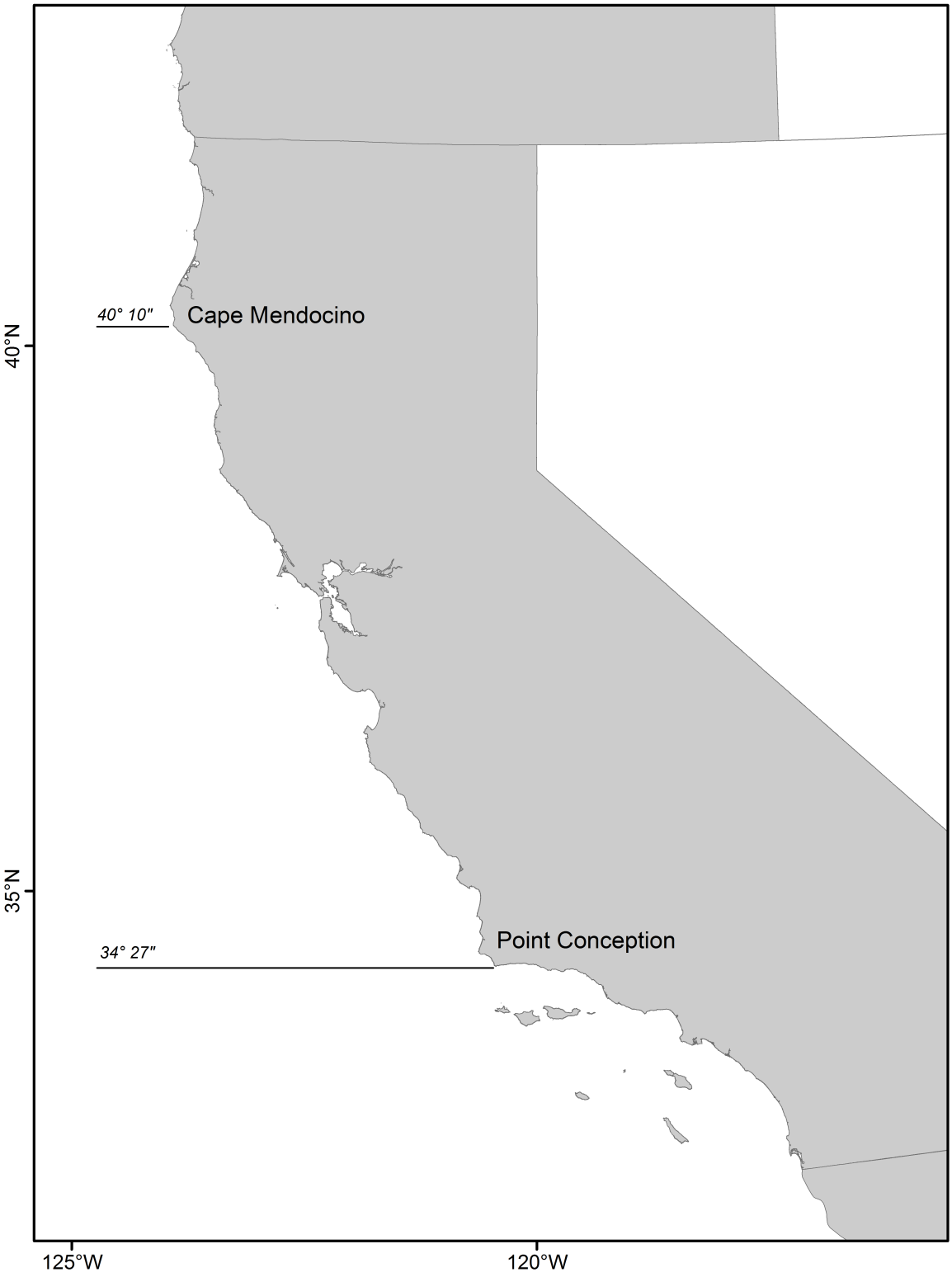


Figure d: Map depicting the core distribution of gopher and black-and-yellow rockfishes. The stock assessment is bounded at Cape Mendocino in the north to the U.S./Mexico border in the south.

## Stock Biomass

The predicted spawning output from the base model generally showed a slight decline prior to 1978, when the recruitment deviations were first estimated (Figure e and Table b). The stock declined from 1978 to 1994, followed by a period increase from 1995 to 2003. From 2004-2018 the stock has been in decline, though increased in total biomass since 2016 and stable spawning output since from 2018 to 2019. The 2019 estimated spawning output relative to unfished equilibrium spawning output is above the target of 40% of unfished spawning output at 43.82 (95% asymptotic interval: 33.57-54.06) (Figure f). Approximate confidence intervals based on the asymptotic variance estimates show that the uncertainty in the estimated spawning output is high, (95% asymptotic interval: 337-767 million eggs).

Table b: Recent trend in beginning of the year spawning output and depletion for the model for GBYR.

| Year | Spawning Output (million eggs) | ~ 95% confidence interval | Estimated depletion | ~ 95% confidence interval |
|---|---|---|---|---|
| 2010 | 882 | 597 - 1168 | 69.99 | 58.05 - 81.92 |
| 2011 | 817 | 548 - 1086 | 64.77 | 53.48 - 76.06 |
| 2012 | 761 | 507 - 1014 | 60.33 | 49.63 - 71.03 |
| 2013 | 727 | 486 - 968 | 57.66 | 47.5 - 67.81 |
| 2014 | 697 | 466 - 928 | 55.31 | 45.56 - 65.05 |
| 2015 | 655 | 434 - 877 | 51.98 | 42.4 - 61.55 |
| 2016 | 614 | 399 - 828 | 48.69 | 39.16 - 58.22 |
| 2017 | 576 | 367 - 786 | 45.70 | 36.12 - 55.28 |
| 2018 | 553 | 344 - 762 | 43.85 | 34.08 - 53.63 |
| 2019 | 552 | 337 - 767 | 43.82 | 33.57 - 54.06 |

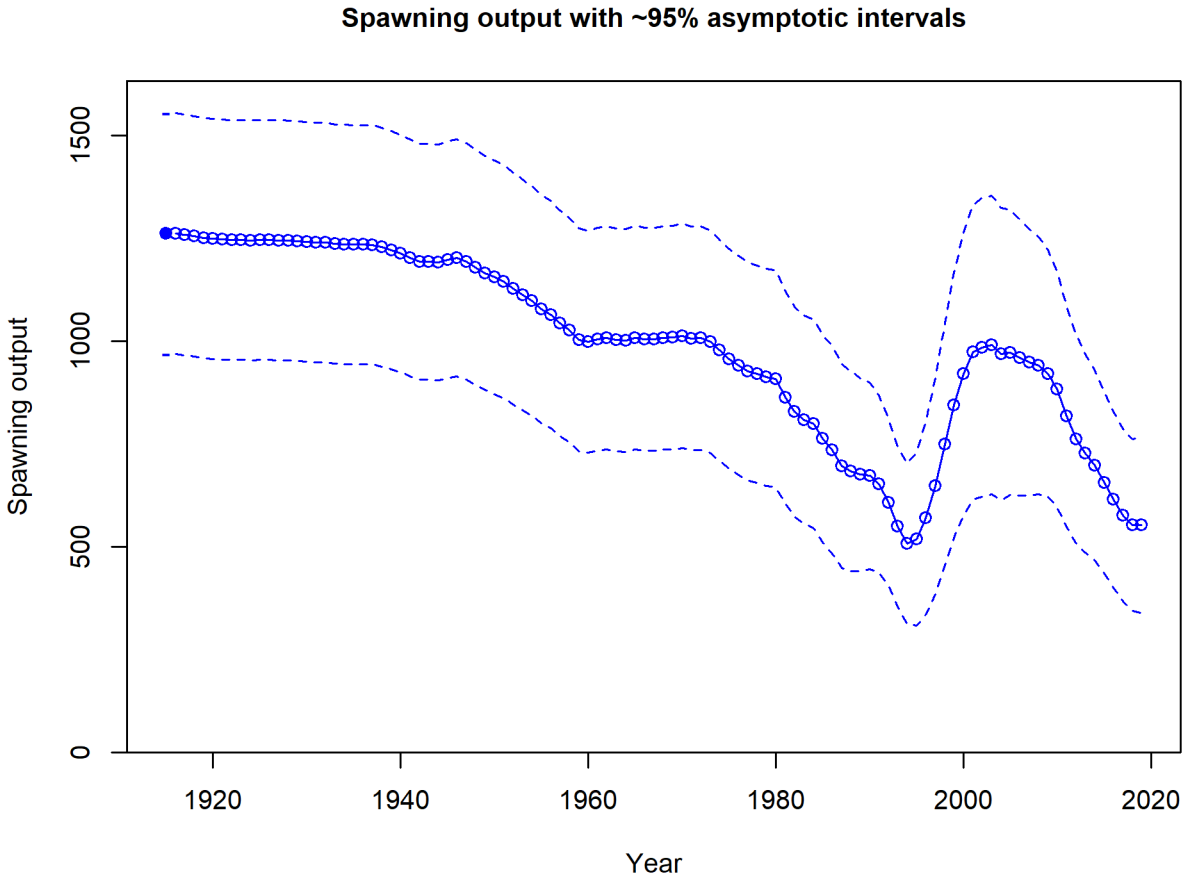


Figure e: Time series of spawning biomass trajectory (circles and line: median; light broken lines: 95% credibility intervals) for the base case assessment model.

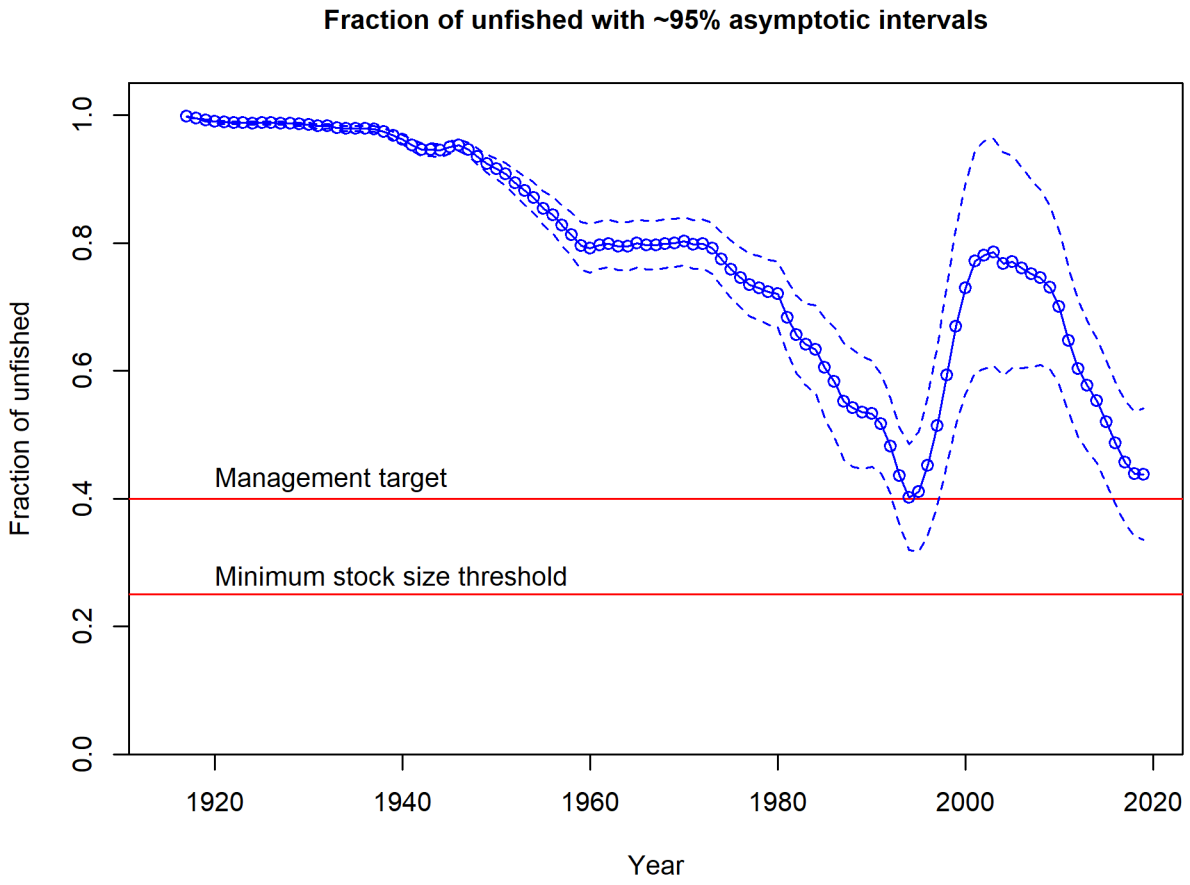


Figure f: Estimated percent depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model.

## Recruitment

Recruitment deviations were estimated from 1979-2018 (Figure g and Table c). There are estimates of very strong recruitment in 1991. Recruitment pulses were estimated for a number of other years including 1994-1995 and 2014-2015.

Table c: Recent recruitment for the GBYR assessment.

| Year | Estimated Recruitment (1,000s) | ~ 95% confidence interval |
|---|---|---|
| 2010 | 2451 | 1257 - 4779 |
| 2011 | 2014 | 983 - 4127 |
| 2012 | 1800 | 761 - 4258 |
| 2013 | 1589 | 676 - 3734 |
| 2014 | 4568 | 2519 - 8284 |
| 2015 | 5264 | 2985 - 9282 |
| 2016 | 2487 | 1274 - 4857 |
| 2017 | 3701 | 1976 - 6935 |
| 2018 | 1432 | 664 - 3089 |
| 2019 | 2778 | 1086 - 7111 |

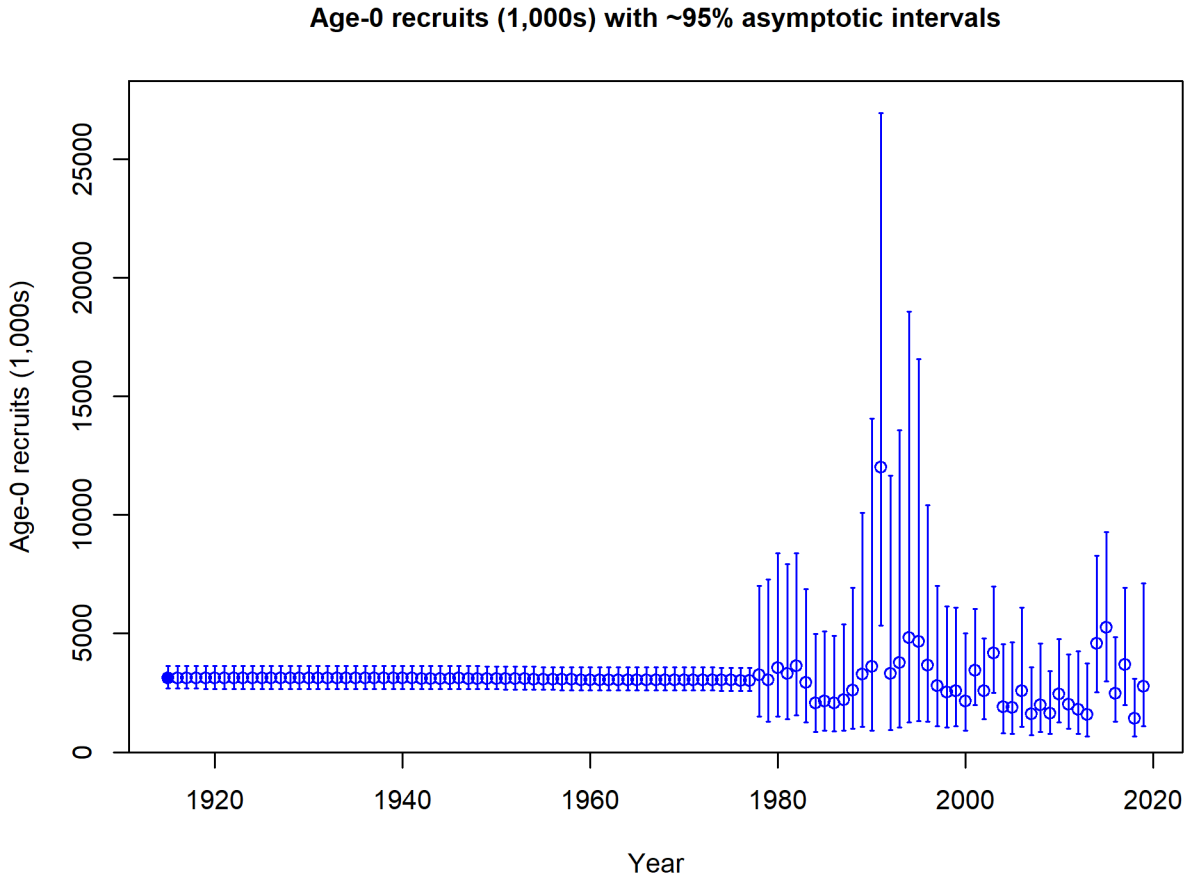


Figure g: Time series of estimated GBYR recruitments for the base-case model with 95% confidence or credibility intervals.

## Exploitation status

Harvest rates estimated by the base model indicate catch levels have been below the limits that would be associated with the Spawning Potential Ratio (SPR) = 50% limit (corresponding to a relative fishing intensity of 100%) (Table d and Figure h). 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 relative inverse SPR over the last decade increased ranged from 0.64 to 0.77 from 2009-2015, and ranged from 0.80 to 0.82 from 2016-2018 (Table d).

Table d: Recent trend in spawning potential ratio (entered as $(1 - SPR)/(1 - SPR_{50\%})$) and exploitation for GBYR in the model.

| Year | Estimated (1-SPR)/(1-SPR50%) | ~ 95% confidence interval | Exploitation rate | 95% confidence interval |
|---|---|---|---|---|
| 2009 | 0.64 | 0.5 - 0.78 | 0.07 | 0.05 - 0.09 |
| 2010 | 0.78 | 0.64 - 0.93 | 0.10 | 0.08 - 0.13 |
| 2011 | 0.77 | 0.62 - 0.92 | 0.10 | 0.07 - 0.12 |
| 2012 | 0.67 | 0.52 - 0.81 | 0.07 | 0.05 - 0.09 |
| 2013 | 0.64 | 0.49 - 0.78 | 0.07 | 0.05 - 0.09 |
| 2014 | 0.74 | 0.59 - 0.88 | 0.09 | 0.06 - 0.11 |
| 2015 | 0.77 | 0.62 - 0.92 | 0.10 | 0.07 - 0.12 |
| 2016 | 0.81 | 0.66 - 0.96 | 0.10 | 0.07 - 0.13 |
| 2017 | 0.82 | 0.66 - 0.98 | 0.09 | 0.06 - 0.11 |
| 2018 | 0.80 | 0.63 - 0.96 | 0.07 | 0.05 - 0.1 |

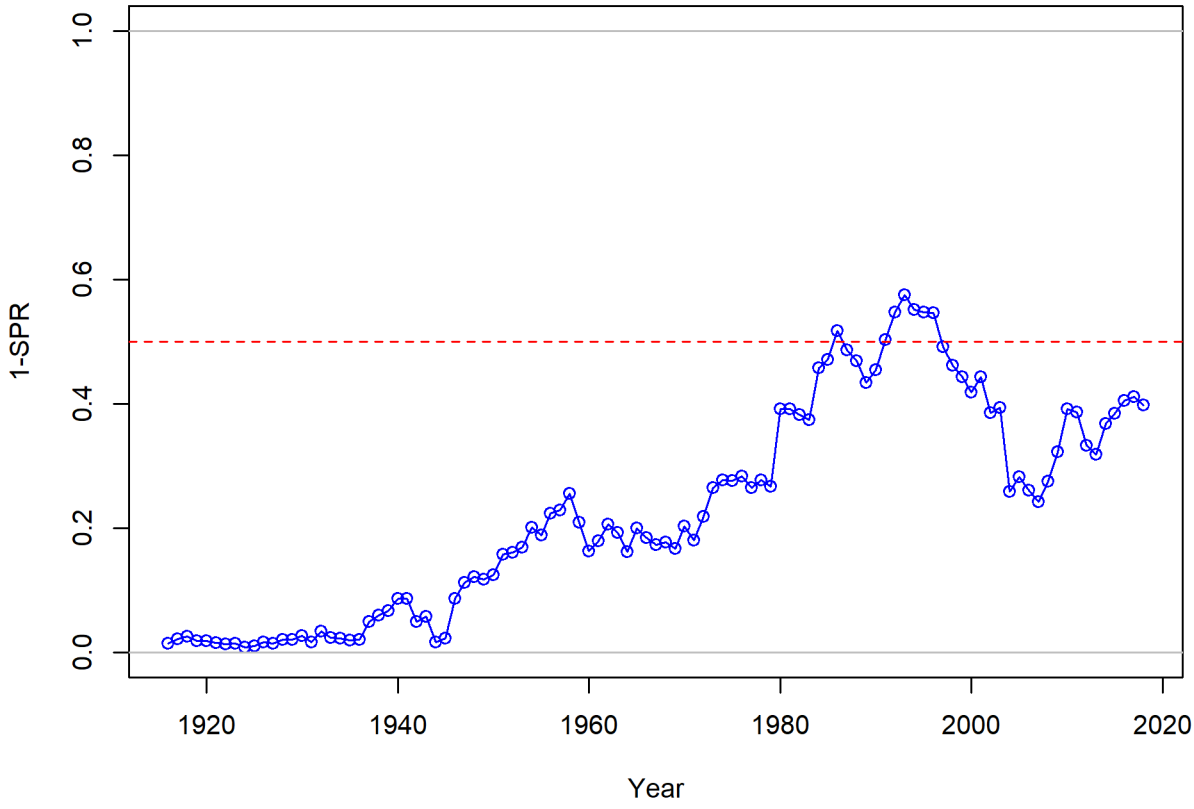


Figure h: Estimated inverse spawning potential ratio (SPR) for the post-STAR base model, plotted as one minus SPR so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the $SPR_{50\%}$ harvest rate. The last year in the time series is 2018.

# Ecosystem Considerations

In this assessment, ecosystem considerations were not explicitly included in the analysis. This is primarily due to a lack of relevant data and results of analyses (conducted elsewhere) that could contribute ecosystem-related quantitative information for the assessment.

# Reference Points

This stock assessment estimates that GBYR in the model is above the biomass target ($SB_{40\%}$), and well above the minimum stock size threshold ($SB_{25\%}$). The estimated relative depletion level for the base model in 2018 is 0.439 (95% asymptotic interval: 0.341-0.536, corresponding to an unfished spawning biomass of 552 million eggs (95% asymptotic interval: 337 - 767 million eggs) of spawning biomass in the base model (Table e). Unfished age 1+ biomass was estimated to be 2,042 mt in the base case model. The target spawning biomass ($SB_{40\%}$) is 504 million eggs, which corresponds with an equilibrium yield of 143 mt. Equilibrium yield at the proxy $F_{MSY}$ harvest rate corresponding to $SPR_{50\%}$ is 134 mt (Figure i).

Table e: Summary of reference points and management quantities for the base case model.

| **Quantity** | **Estimate** | **Low 2.5% limit** | **High 2.5% limit** |
|---|---|---|---|
| Unfished spawning output (million eggs) | 1,261 | 968 | 1,554 |
| Unfished age 1+ biomass (mt) | 2,042 | 1,637 | 2,448 |
| Unfished recruitment ($R_0$) | 3,125 | 2,643 | 3,606 |
| Spawning output (2018 million eggs) | 553 | 344 | 762 |
| Depletion (2018) | 0.439 | 0.341 | 0.536 |
| **Reference points based on SB$_{40\%}$** | | | |
| Proxy spawning output ($B_{40\%}$) | 504 | 427 | 582 |
| SPR resulting in $B_{40\%}$ ($SPR_{B40\%}$) | 0.458 | 0.458 | 0.458 |
| Exploitation rate resulting in $B_{40\%}$ | 0.126 | 0.109 | 0.144 |
| Yield with $SPR_{B40\%}$ at $B_{40\%}$ (mt) | 143 | 124 | 162 |
| ***Reference points based on SPR proxy for MSY*** | | | |
| Spawning output | 563 | 476 | 649 |
| $SPR_{proxy}$ | 0.5 | | |
| Exploitation rate corresponding to $SPR_{proxy}$ | 0.111 | 0.096 | 0.126 |
| Yield with $SPR_{proxy}$ at $SB_{SPR}$ (mt) | 134 | 116 | 152 |
| ***Reference points based on estimated MSY values*** | | | |
| Spawning output at $MSY$ ($SB_{MSY}$) | 281 | 235 | 328 |
| $SPR_{MSY}$ | 0.299 | 0.29 | 0.308 |
| Exploitation rate at $MSY$ | 0.209 | 0.174 | 0.244 |
| Dead Catch $MSY$ (mt) | 163 | 141 | 185 |
| Retained Catch $MSY$ (mt) | 163 | 141 | 185 |

# Management Performance

Gopher and black-and-yellow rockfishes are managed as part of the minor nearshore complex in the Pacific Coast Groundfish Fishery Management Plan. The total mortality of the minor nearshore rockfish has been below the ACL in all years (2011-2016). Total mortality estimates from the NWFSC are not yet available are not yet available for 2017-2018. GBYR total mortality was on average 20% of the total minor nearshore rockfish total mortality from 2011-2016. A summary of these values as well as other base case summary results can be found in Table f.

Table f: Recent trend in total mortality for gopher and black-and-yellow rockfishes (GBYR), combined, relative to the management guidelines for Nearshore Rockfish South of 40°10′ N. latitude. Total mortality estimates are based on annual reports from the NMFS NWFSC.

| | GBYR | Shallow Nearshore Rockfish South | Nearshore Rockfish South | |
|---|---|---|---|---|
| Year | Total mortality | Total mortality | ACL | OFL |
| **2011** | 122.87 | 436 | 1,001 | 1,156 |
| **2012** | 91.96 | 445 | 1,001 | 1,145 |
| **2013** | 104.53 | 495 | 990 | 1,164 |
| **2014** | 103.63 | 596 | 990 | 1,160 |
| **2015** | 107.95 | 676 | 1,114 | 1,313 |
| **2016** | 111.55 | 641 | 1,006 | 1,288 |
| **2017** | - | - | 1,163 | 1,329 |
| **2018** | - | - | 1,179 | 1,344 |

## Unresolved Problems and Major Uncertainties

The major source of uncertainty identified during the STAR panel is the structure of complex and contribution of each of the two species to the complex and biological parameters differences. Additionally, there is currently no information for either species on regional differences in biological parameters and contributions to the complex.

## Decision Table

The forecasts of stock abundance and yield were developed using the post-STAR base model, with the forecasted projections of the OFL presented in Table g. The total catches in 2019 and 2020 are set to the projected catch from CDFW of 114 mt.

Uncertainty in the forecasts is based upon the three states of nature agreed upon at the STAR panel and are based three states of nature of growth. The external estimates of growth were different than the internal estimates. Given that natural mortality is fixed in the post-STAR base model, and the growth parameter $k$ is negatively correlated with natural mortality, $k$ was chosen as the axis of uncertainty. The high state of nature fixes $k$ at the external estimate, and the low state of nature is the same distance in log space from the base as the high state of nature. The low state of nature fixed $k$ at 0.46 and the L1 and L1 parameters are estimated at 14.1 and 30.6, respectively. The high state of nature fixes all growth parameters, $k = 0.248$, L1 = 13.8, and L2 = 28.5 to the external estimate of growth. The growth parameters in the base model were estimated as $k = 0.107$, L1 = 13.4, and L2 = 28.8.

The forecasted buffer ramp was calculated assuming a category 2 stock, with sigma = 1.0 and a $p^* = 0.45$. The buffer ranges from 0.874 in 2021 ramping to 0.803 in 2030. For

reference, the model predicted sigma is 0.189 and the decision table-based sigma is 0.197. Current medium-term forecasts based on the alternative states of nature project that the stock will remain above the target threshold of 40% for all but two scenarios (Table h). The low state of nature with the high catches results in a stock at 26.4% of unfished in 2030 and the base state model with the high catches results in a stock at 33.2% of unfished in 2030. The base case model with the base catches results in an increasing stock over the period from 2021-2030. If the growth of GBYR is slower than the base model suggests, but the base case catches are removed, the stock will be at the target threshold in 2030.

Table g: Projected OFL, default harvest control rule catch (ABC = ACL) above 40% SSB), biomass, and depletion using the post-STAR base case model with 2019-2020 catches set equal to the projected catch (114 mt) rather than the ABC.

| Year | OFL (mt) | ABC Catch (mt) | Age 0+ Biomass (mt) | Spawning Output (million eggs) | Fraction unfished |
|---|---|---|---|---|---|
| 2019 | 154 | *114* | 1281 | 552.5 | 43.8 |
| 2020 | 154 | *114* | 1292 | 558.3 | 44.3 |
| 2021 | 136 | 119 | 1291 | 578.2 | 45.9 |
| 2022 | 137 | 119 | 1296 | 601.1 | 47.7 |
| 2023 | 143 | 122 | 1300 | 621.5 | 49.3 |
| 2024 | 150 | 127 | 1302 | 633.3 | 50.2 |
| 2025 | 155 | 130 | 1300 | 636.2 | 50.5 |
| 2026 | 158 | 131 | 1295 | 632.6 | 50.2 |
| 2027 | 158 | 130 | 1290 | 626.0 | 49.7 |
| 2028 | 156 | 128 | 1286 | 619.4 | 49.1 |
| 2029 | 155 | 125 | 1284 | 614.8 | 48.8 |
| 2030 | 153 | 123 | 1283 | 612.7 | 48.6 |

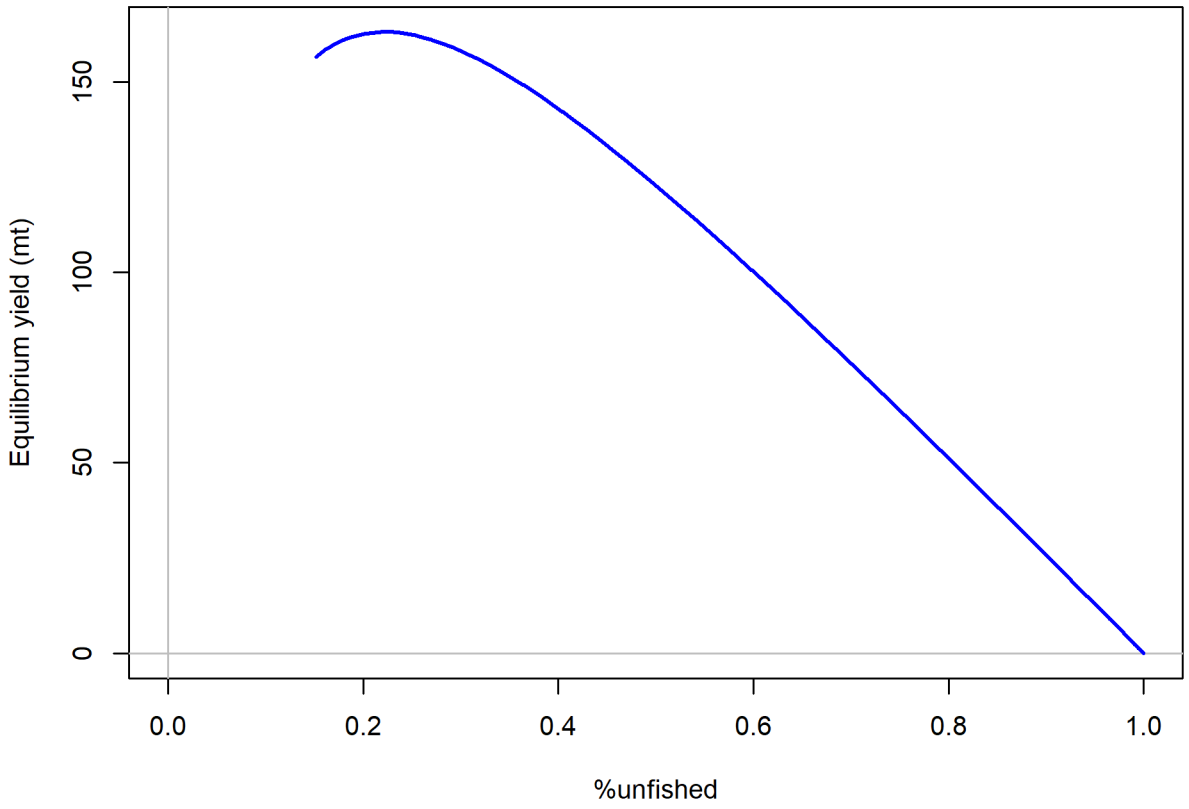


Figure i: Equilibrium yield curve for the base case model. Values are based on the 2018 fishery selectivity and with steepness fixed at 0.72.

Table h: Summary of 10-year projections beginning in 2020 for alternate states of nature based on an axis of uncertainty for the model. Columns range over low, mid, and high states of nature, and rows range over different assumptions of catch levels. The low state of nature fixed the growth parameter $k$ at 0.046 and the high state fixes all growth parameters to the external estimate ($k = 0.248$, L1 = 13.8, L2 = 28.5). For reference the base case estimated $k = 0.106$, L1 = 13.4 and L2 = 28.9. The 2019 and 2020 catches were set to the project catch of 114 mt, provided by CDFW.

| | | | **States of nature** | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Low State | | Base State | | High State | |
| | Year | Catch | Spawning Output | Depletion | Spawning Output | Depletion | Spawning Output | Depletion |
| Default harvest for Low State | 2019 | 114 | 444.4 | 37.3 | 552.5 | 43.8 | 1105.4 | 58.5 |
| | 2020 | 114 | 443.3 | 37.2 | 558.3 | 44.3 | 1168.8 | 61.9 |
| | 2021 | 75 | 449.6 | 37.7 | 578.2 | 45.9 | 1231.2 | 65.2 |
| | 2022 | 80 | 481.2 | 40.4 | 623.4 | 49.4 | 1296.5 | 68.6 |
| | 2023 | 85 | 510.4 | 42.8 | 660.8 | 52.4 | 1322.9 | 70.0 |
| | 2024 | 91 | 534.5 | 44.9 | 687.1 | 54.5 | 1329.1 | 70.4 |
| | 2025 | 96 | 552.0 | 46.3 | 702.5 | 55.7 | 1328.9 | 70.4 |
| | 2026 | 101 | 562.5 | 47.2 | 709.3 | 56.3 | 1326.8 | 70.2 |
| | 2027 | 104 | 567.1 | 47.6 | 710.4 | 56.3 | 1324.2 | 70.1 |
| | 2028 | 105 | 567.5 | 47.6 | 708.5 | 56.2 | 1321.7 | 70.0 |
| | 2029 | 105 | 565.8 | 47.5 | 706.1 | 56.0 | 1320.3 | 69.9 |
| | 2030 | 104 | 563.8 | 47.3 | 704.8 | 55.9 | 1320.2 | 69.9 |
| Default harvest for Base State | 2019 | 114 | 444.4 | 37.3 | 552.5 | 43.8 | 1105.4 | 58.5 |
| | 2020 | 114 | 443.3 | 37.2 | 558.3 | 44.3 | 1168.8 | 61.9 |
| | 2021 | 119 | 449.6 | 37.7 | 578.2 | 45.9 | 1231.2 | 65.2 |
| | 2022 | 119 | 460.9 | 38.7 | 601.1 | 47.7 | 1267.4 | 67.1 |
| | 2023 | 122 | 475.0 | 39.9 | 621.5 | 49.3 | 1270.6 | 67.3 |
| | 2024 | 127 | 486.5 | 40.8 | 633.3 | 50.2 | 1257.1 | 66.6 |
| | 2025 | 130 | 492.9 | 41.4 | 636.2 | 50.5 | 1240.8 | 65.7 |
| | 2026 | 131 | 493.9 | 41.5 | 632.6 | 50.2 | 1226.6 | 64.9 |
| | 2027 | 130 | 490.8 | 41.2 | 626.0 | 49.7 | 1216.1 | 64.4 |
| | 2028 | 128 | 485.6 | 40.8 | 619.4 | 49.1 | 1209.7 | 64.0 |
| | 2029 | 125 | 480.5 | 40.3 | 614.8 | 48.8 | 1207.0 | 63.9 |
| | 2030 | 123 | 476.8 | 40.0 | 612.7 | 48.6 | 1207.2 | 63.9 |
| Default harvest for High State | 2019 | 114 | 444.4 | 37.3 | 552.5 | 43.8 | 1105.4 | 58.5 |
| | 202 | 114 | 443.3 | 37.2 | 558.3 | 44.3 | 1168.8 | 61.9 |
| | 2021 | 235 | 449.6 | 37.7 | 578.2 | 45.9 | 1231.2 | 65.2 |
| | 2022 | 225 | 410.9 | 34.5 | 544.4 | 43.2 | 1191.3 | 63.1 |
| | 2023 | 215 | 390.6 | 32.8 | 522.5 | 41.4 | 1132.0 | 59.9 |
| | 2024 | 204 | 377.9 | 31.7 | 503.3 | 39.9 | 1071.8 | 56.7 |
| | 2025 | 192 | 366.0 | 30.7 | 484.2 | 38.4 | 1025.9 | 54.3 |
| | 2026 | 183 | 353.2 | 29.7 | 466.5 | 37.0 | 996.7 | 52.8 |
| | 2027 | 177 | 340.4 | 28.6 | 451.7 | 35.8 | 980.5 | 51.9 |
| | 2028 | 173 | 328.9 | 27.6 | 440.7 | 34.9 | 972.2 | 51.5 |
| | 2029 | 170 | 320.2 | 26.9 | 433.5 | 34.4 | 968.2 | 51.3 |
| | 2030 | 168 | 314.3 | 26.4 | 429.2 | 34.0 | 966.0 | 51.1 |

Table i: Base case results summary.

| Quantity | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total mortality (mt) | 153 | 135 | 94 | 84 | 105 | 109 | 112 | 104 | 92 | |
| Complex OFL (mt) | | 1,156 | 1,145 | 1,164 | 1,160 | 1,313 | 1,288 | 1,329 | 1,344 | |
| Complex ACL (mt) | | 1,001 | 1,001 | 990 | 990 | 1,114 | 1,006 | 1,163 | 1,179 | |
| (1-$SPR$)(1-$SPR_{50\%}$) | 0.78 | 0.77 | 0.67 | 0.64 | 0.74 | 0.77 | 0.81 | 0.82 | 0.80 | |
| Exploitation rate | 0.10 | 0.10 | 0.07 | 0.07 | 0.09 | 0.10 | 0.10 | 0.09 | 0.07 | |
| Age 1+ biomass (mt) | 1550.00 | 1469.27 | 1364.64 | 1283.44 | 1238.94 | 1196.76 | 1148.01 | 1143.82 | 1190.26 | 1237.83 |
| Spawning Output | 882 | 817 | 761 | 727 | 697 | 655 | 614 | 576 | 553 | 552 |
| 95% CI | 597 - 1168 | 548 - 1086 | 507 - 1014 | 486 - 968 | 466 - 928 | 434 - 877 | 399 - 828 | 367 - 786 | 344 - 762 | 337 - 767 |
| Depletion | 70.0 | 64.8 | 60.3 | 57.7 | 55.3 | 52.0 | 48.7 | 45.7 | 43.9 | 43.8 |
| 95% CI | 58.05 - 81.92 | 53.48 - 76.06 | 49.63 - 71.03 | 47.5 - 67.81 | 45.56 - 65.05 | 42.4 - 61.55 | 39.16 - 58.22 | 36.12 - 55.28 | 34.08 - 53.63 | 33.57 - 54.06 |
| Recruits | 2451 | 2014 | 1800 | 1589 | 4568 | 5264 | 2487 | 3701 | 1432 | 2778 |
| 95% CI | 1257 - 4779 | 983 - 4127 | 761 - 4258 | 676 - 3734 | 2519 - 8284 | 2985 - 9282 | 1274 - 4857 | 1976 - 6935 | 664 - 3089 | 1086 - 7111 |

## Research and Data Needs

We recommend the following research be conducted before the next assessment:

1. Investigate the structure of complex and contribution of each species to the GBYR complex. Investigate possible spatial differences in biological parameters within a single species and also between the two species. Little biological data for south of Point Conception or north of Point Arena was available for this assessment and is needed to better under biological parameters.
    (a) Conduct life history studies
    (b) conduct research to identify the proportion of each species in population and in catches
2. Take a closer look at the Ralston [-@Ralston2010] historical catch reconstruction for gopher and black-and-yellow rockfishes. The recreational catch reconstruction for gopher rockfish south of Point Conception was an order of magnitude higher than expected when extracted for this assessment.
3. Refine the PISCO survey data and analysis to better identify age-0 fish in each month of survey. Occasional sampling during all months of the year would better help identify the length distribution of fish classified as age-0. This is the only recruitment index available for gopher and black-and-yellow rockfish. If possible, age data should be collected from the PISCO survey to aid in determining the growth of young gopher and black-and-yellow rockfish.
4. Refine CCFRP survey index to look at different possible model structures, including a hierarchical structure and random effects. Limited time did not allow for these explorations during this assessment cycle. It is also strongly recommended to continue the coastwide sampling of the CCFRP program that began in 2017, as well as the collection of biological samples for nearshore rockfish species. The CCFRP survey is the only fishery-independent survey available for nearshore rockfish sampling the nearshore rocky reef habitats. As of this assessment, only two years of coastwide data are available, and the index was limited to the site in central California that have been monitored since 2007.
5. Collection of length and age data are recommended for both the commercial and recreational fisheries. Very little age data are available from either fishery for gopher rockfish and none for black-and-yellow rockfish.
6. Data collection across Research Recommendations 1-5 is needed to improve the efficacy of data collection and ensure that samples are representative of the data sources and the fisheries. For example, the conditional age-at-length data in the dummy fleet represent a number of sampling techniques, areas sampled, and selectivities. Better coordination of research efforts will allow the age data to be better utilized by the assessment.

Sampling of the commercial and recreational fleets by area in proportion to the length distribution of fish observed will also allow the model to better fit selectivity patterns and avoid possible patterns in the length and age composition residuals.

7. Investigate possible environmental drivers/co-variates for biological parameters, particularly for recruitment.

8. Examine the CFRS angler interview data for the recreational private/rental mode to create a "trip" based identifier or catch and effort. This will enable the creation of an index of abundance for the private/rental mode as well as investigate if selectivity for this mode differs from the party/charter mode.

9. Resolve differences between CalCOM and PacFIN expanded length composition data sets.