# 6. Assessment of the rex sole stock in the Gulf of Alaska

By

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## Executive Summary

GOA rex sole is assessed on a biennial cycle, following the availability of new survey data. Due to the federal government shutdown in October 2013, an update was conducted for rex sole in 2013 instead of a full assessment. The most recent full age-structured assessment for GOA rex sole occurred in 2011. This year, a full, age-structured assessment is presented for GOA rex sole and the biomass estimates of the assessment are used to calculate OFLs and ABCs using a Tier 5 management approach (as for previous assessments).

**In September 2015, an alternative modeling framework for rex sole using Stock Synthesis, version 3.24u, was presented to and accepted by the GOA Plan Team and was subsequently accepted by the SSC. The GOA Plan Team and SSC agreed that the base case model for GOA rex sole should use the Stock Synthesis framework. The assessment presented here uses the SS3 framework. The development of a rex sole model using the SS3 framework and a comparison to the accepted 2011 model are presented in Appendix 6C.**

### Summary of Changes in Assessment Inputs

(1) 2012-2015 catch biomass was added to the model
(2) 2011 catch biomass was updated to reflect October-December 2011 catches
(3) 2012-2015 fishery length composition data were added to the model and 2011 fishery length composition data were updated to reflect October – December 2011 catches.
(4) 2013 and 2015 GOA trawl survey biomass estimates were added to the model
(5) 2013 and 2015 GOA trawl survey length composition data were added to the model
(6) 2011 and 2013 GOA trawl survey age composition data were added to the model
(7) Effective sample sizes for fishery and survey length and age composition data were changed to the number of hauls where lengths or ages were observed, respectively.
(8) Data weights among data sources were adjusted such that input sample size matched the harmonic mean of effective sample sizes, as calculated following the methods described in McAllister and Ianelli (1997), Appendix 2.

### Summary of Changes in Assessment Methodology

The following substantive structural changes were made to the assessment methodology. **All changes were accepted by the GOA Plan Team and SSC following the September 2015 Plan Team meeting** (see the section "Responses to SSC and Plan Team Comments Specific to this Assessment" below):

(1) The assessment was conducted in Stock Synthesis version 3.24u (SS3); Appendix 6C includes a full description of the transition from the 2011 rex sole assessment model to an equivalent model in SS3.

(2) The age-length transition matrix is constructed within the SS assessment model and is based on the same von-Bertalanffy growth functions and CVs as for the previously used age-length transition matrix, but is not an exact match.
(3) Recruitment deviations were estimated using simple deviations with a sigmaR of 0.6. Previously, no sigmaR was specified. Using simple deviations minimizes the impact of sigmaR. In addition, estimates of recruitment deviations were not subject to a "sum-to-zero" constraint.
(4) The fishery and survey selectivity curves were estimated using an age-based double-normal function without a descending limb instead of an age-based logistic function.

## Summary of Results

The key results of the assessment, based on the author's preferred (base case) model, are compared to the key results of the accepted 2014 update assessment in the table below. An alternative table is shown in Appendix 6A, based on the SS3 version of the 2011 model with new data added.

| Quantity | As estimated or *recommended last* year for: | | As estimated or *recommended this* year for: | |
|---|---|---|---|---|
| | 2015 | 2016 | 2016* | 2017* |
| *M* (natural mortality rate) | 0.17 | 0.17 | 0.17 | 0.17 |
| Tier | 5 | 5 | 5 | 5 |
| Projected total (3+) biomass (t) | 82,972 | 81,414 | 67,941* | 68,074* |
| Female spawning biomass (t) | 49,804 | 48,554 | 43,808 | 46,292 |
| $B_{100\%}$ | 55,393 | 55,393 | 56,845 | 56,845 |
| $B_{40\%}$ | 22,159 | 22,159 | 22,738 | 22,738 |
| $B_{35\%}$ | 19,434 | 19,434 | 19,896 | 19,896 |
| $F_{OFL}=M$ | 0.170 | 0.170 | 0.17 | 0.17 |
| $maxF_{ABC}=0.75*M$ | 0.128 | 0.128 | 0.128 | 0.128 |
| $F_{ABC}$ | 0.128 | 0.128 | 0.128 | 0.128 |
| OFL (t) | 11,957 | 11,733 | 9,791 | 9,810 |
| maxABC (t) | 9,150 | 8,979 | 7,493 | 7,507 |
| ABC (t) | 9,150 | 8,979 | 7,493 | 7,507 |
| **Status** | As determined in 2014 for: | | As determined in 2015 for: | |
| | 2013 | 2014 | 2014 | 2015 |
| Overfishing | no | n/a | no | n/a |
| Overfished | n/a | no | n/a | no |

* Projections are based on estimated catches of 1,817.6 t, 3,188 t, and 8,979 t that were used in place of maximum permissible ABC for 2015, 2016, and 2017 respectively. The 2015 projected catch was calculated as the current catch of GOA rex sole as of October 10, 2015 added to the average October 10 – December 31 GOA rex sole catches over the 5 previous years. The 2016 projected catch was calculated as the average catch from 2010-2014. The 2017 projected catch was set equal to the maxABC as recommended in 2014 for the year 2016, based on Tier 5 calculations. Projected total (3+) biomass for GOA rex sole is currently defined as numbers-at-age multiplied by maturity-at-age and weight-at-age, summed over males and females, as for previous assessments.

The table below shows apportionment of the 2016 and 2017 ABCs and among areas, based on random effects model predictions of survey biomass in each area for 2016-2017.

| Quantity | Western | Central | West Yakutat | Southeast | Total |
|---|---|---|---|---|---|
| Area Apportionment | 17.55% | 59.32% | 10.22% | 12.90% | 100.00% |
| 2016 ABC (t) | 1,315 | 4,445 | 766 | 967 | 7,493 |
| 2017 ABC (t) | 1,318 | 4,453 | 767 | 969 | 7,507 |

## Responses to SSC and Plan Team Comments on Assessments in General

GPT comment: *The Teams recommend that the random effects survey smoothing model be used as a default for determining current survey biomass and apportionment among areas.*

The random effects model was used in the current assessment to estimate 2016 and 2017 survey biomass, proportion of survey biomass expected in each management area in 2016 and 2017, and apportionment of ABCs according to these estimates of survey biomass in each area.

SSC comment: *Of the options presented in the Joint Plan Teams minutes <for model numbering>, the SSC agrees that that Option 4 has several advantages and recommends that this Option be advanced next year. Under Option 4, analysts would number their models as follows: "Alpha-numeric model identifiers incorporating two-digit year labels of the form "yy.jx," where the digit after the decimal ("j") represents a major accepted model change and the alphabetic character ("x") represents a proposed model change (e.g., "12.1c" and "13.4a" might describe two models introduced in 2012 and 2013, respectively)". Differences between major and minor changes would be calculated based on "average difference in spawning biomass" (ADSB: see equation in Team Procedures) or as noted in sub-option c below, some other improvement to the model.*

The above system for numbering models will be adopted for the next assessment, as recommended by the SSC.

## Responses to SSC and Plan Team Comments Specific to this Assessment

GPT comment: *The Team recommends moving forward with the SS model, including a run mimicking the structure of the older model and updated with the most recent data available (e.g. trawl index, age and length comps, fishery lengths, etc). This should be brought forward in November.*

*In addition, the team recommends one or more alternative models should also be brought forward, reflecting the author's suggestions for minor changes: inclusion of fishery age composition data (the Team recommends that these data be prioritized and included in this assessment) to help inform fisheries selectivity, re-estimation of survey biomass using the random effects approach to estimate the contributions from the Eastern GOA for years where this area was not surveyed, exploration of age/length compositions to better understand whether they should be treated differently for years when the trawl survey omitted the deep strata, reevaluating effective sample sizes, adding externally estimated ageing error, explore other selectivity curves. Internal estimation of growth parameters could be included* *for November, unless it produces substantially different results. Major changes (such as exploration of growth morphs) can be explored, but may need to wait until next year for inclusion.*

*The Team recognized that it is possible that not all of these changes will be completed for the November meeting.*

The 2015 assessment model was completed using the SS3 assessment platform. Two models are presented in this assessment: (1) a model conducted in Stock Synthesis that that best mimics the previously accepted 2011 GOA rex sole assessment model, and (2) an alternative model where effective sample sizes for all length composition data were changed to reflect the number of hauls for which lengths of rex sole were collected (Volstad and Pennington 2004) and the weighting among data sources was adjusted by tuning to the harmonic mean of effective sample sizes, with effective sample sizes calculated according to methods described in McAllister and Ianelli (1997), Appendix 2. Both changes replaced arbitrary specifications in the model with scientifically defensible specifications. Further progress on alternative models incorporating the suggestions above is being made and will be presented to the GPT in the future.

SSC comment: *The SSC supports the Plan Team's recommendations, including the recommendation to moving forward with the SS3 assessment platform.*

The 2015 assessment model was completed using the SS3 assessment platform.

# Introduction

Rex sole (*Glyptocephalus zachirus*) is a right-eyed flatfish occurring from southern California to the Bering Sea and ranging from shallow water (<100m) to about 800 meters depth (Mecklenburg et al., 2002). They are most abundant at depths between 100 and 200m and are found fairly uniformly throughout the Gulf of Alaska (GOA).

Rex sole appear to exhibit latitudinal changes in growth rates and size at sexual maturity. Abookire (2006) found marked differences in growth rates and female size at maturity between stocks in the GOA and off the coast of Oregon. Size at sexual maturity was greater for fish in the GOA than in Oregon, as was size-at-age. However, these trends offset each other such that age-at-maturity was similar between the two regions.

Rex sole are batch spawners with a protracted spawning season in the GOA (Abookire, 2006). The spawning season for rex sole spans at least 8 months, from October to May. Eggs are fertilized near the sea bed, become pelagic, and probably require a few weeks to hatch (Hosie et al. 1977). Hatched eggs produce pelagic larvae that are about 6 mm in length and are thought to spend about a year in a pelagic stage before settling out to the bottom as 5 cm juveniles.

Rex sole are benthic feeders, preying primarily on amphipods, polychaetes, and some shrimp.

*Management units and stock structure*

In 1993 rex sole was split out of the deep-water management category because of concerns regarding the Pacific ocean perch bycatch in the rex sole target fishery. The stock within the GOA is managed as a unit stock but with area-specific ABC and TAC apportionments to avoid the potential for localized depletion. Little is known on the stock structure of this species. However, otoliths exhibit two distinct growth patterns (pers. Comm. D. Anderl 2015), which could reflect different growth patterns among areas or different sub-stocks. Further research is needed to explore these patterns.

# Fishery

Rex sole in the Gulf of Alaska are caught in a directed fishery using bottom trawl gear. Fishing seasons are driven by seasonal halibut PSC apportionments, with approximately 7 months of fishing occurring between January and November. Catches of rex sole occur primarily in the Western and Central management areas in the gulf (statistical areas 610 and 620 + 630, respectively). Recruitment to the fishery begins at about age 5.

Catch is currently reported for rex sole by management area (Table 1). Catches for rex sole were estimated from 1982 to 1994 by multiplying the deepwater flatfish catch by the fraction of rex sole in the observed catch. Historically, catches of rex sole have exhibited decadal-scale trends. Catches increased from a low of 93 t in 1986 to a high of 5,874 t in 1996, then declined to 1,464 t in 2004. The 2009 catch (4,753 t) was the largest since 1996. Catches declined after 1996, but increased to 3,707 t in 2013. The current catch in 2015 (as of October 26, 2015) was 1,678 t.

The catch of rex sole is widely distributed along the outer margin of the continental shelf in the central and western portions of the Gulf (Table 1) and few, if any, catches occur in the Eastern Gulf.

Historical specifications from 1995-2015 are shown in Table 2. The ABC for rex sole has been specified as the TAC in each year since 1997. The fishery catches from 2010-2014 ranged from 25-39% of the TAC and ABC. As of October 10, catch in 2015 was 18% of the 2015 ABC and TAC.

Estimates of retained and discarded catch (t) in the rex sole fishery since 1995 were calculated from discard rates observed from at-sea sampling and industry reported retained catch (Table 2). Retention of rex sole is high and has generally been over 95%.

# Data

The following data were included in the assessment model:

| Source | Data | Years |
|---|---|---|
| NMFS Groundfish Survey | Survey Biomass | 1984-1999 (triennial); 2001-2015 (biennial) |
| | Age Composition | 1984, 1987, 1993, 1999; 2001-2013 (biennial) |
| | Length Composition | 1984-1999 (triennial); 2001-2015 (biennial) |
| U.S. Trawl Fisheries | Catch | 1982-2015 |
| | Length Composition | 1982-1984, 1990-2015 |

## Fishery Data

This assessment used fishery catches from 1982 through October 10, 2015 (Table 1, Figure 1), as well as estimates of the proportion of individuals caught by length group and sex for the years 1982-2015 (as of October 10, 2015; http://www.afsc.noaa.gov/REFM/Docs/2015/FTP_GOA_Rex_Composition_Data_And_SampleSize_2015.xlsx). Sample sizes for the length composition data were set to the number of fishery hauls for which length data were collected (Table 4).

## Survey Data

This assessment used estimates of total biomass for rex sole in the Gulf of Alaska from triennial (1984-1999) and biennial (2001-2015) groundfish surveys conducted by the AFSC's Resource Assessment and

Conservation Engineering (RACE) division to provide an index of population abundance (Table 5, Figure 3). Although survey depth coverage has been inconsistent for depth strata > 500 m (Table 5), the fraction of the rex sole stock occurring in these depth strata is typically small (Table 5), so we have not attempted to correct the survey estimates of total biomass for missing depth strata. We have, however, corrected the 2001 survey estimate of total biomass, because the eastern section of the Gulf was not sampled that year. We estimated the average stock biomass occurring in the unsampled area from the 1993, 1996 and 1999 surveys and expanded the 2001 estimate to correct for the missing area. As is evident from Figure 3, survey biomass has fluctuated on decadal time scales. From an initial low of ~60,000 t in 1984, estimated biomass increased to a high of almost 100,000 t in 1990, then declined during the 1990s to slightly above 70,000 t. Subsequently, survey biomass increased once again and was above 100,000 t in the 2005-2009 period. In the most recent period from 2011 – 2015, the survey biomass was slightly lower, between 95,000 t and 101,000 t. The survey biomass for 2015 was 87,286 t. Consistently over time, survey biomass has been greatest in the central GOA and smallest in the western GOA, but occurs in all three regions (central, eastern, and western GOA; Table 5, Figure 2).

Estimates of the total number of individuals by length group (length compositions) from each RACE GOA groundfish survey (http://www.afsc.noaa.gov/REFM/Docs/2015/FTP_GOA_Rex_Composition_Data_And_SampleSize_2015.xlsx) were included in the assessment, as were estimates of the distribution of ages in each year (http://www.afsc.noaa.gov/REFM/Docs/2015/FTP_GOA_Rex_Composition_Data_And_SampleSize_2015.xlsx). Survey age compositions were available for all survey years except for 2015 (1984, 1987, 1990, 1993, 1996, 1999, 2001, 2003, 2005, 2007, 2009, 2011, and 2013), although the age composition for 1990 was excluded from the model because the underlying ages may be biased due to the age reading technique (surface age reading) used to process the otoliths. Because age compositions were calculated from age-length data using the corresponding size compositions, size compositions were de-weighted in the model likelihood for years where age composition data was available to avoid double counting. Survey size composition data was fully weighted in the model likelihood only for years when age compositions were unavailable (1990 and 2011). Effective sample sizes used in the model are listed with length and age composition data at http://www.afsc.noaa.gov/REFM/Docs/2015/FTP_GOA_Rex_Composition_Data_And_SampleSize_2015.xlsx. Number of hauls and individuals that for which lengths were measured and otoliths collected and measured are shown in Table 7.

# Analytic Approach

## Model Structure

*Age-structured model used to inform biomass for Tier 5 management*

The assessment was a split sex, age-structured statistical catch-at-age model implemented in Stock Synthesis version 3.24u (SS3) using a maximum likelihood approach. SS3 equations can be found in Methot and Wetzel (2013) and further technical documentation is outlined in Methot (2009). Previous assessments were conducted using an ADMB-based, split-sex, age-structured population dynamics model (Stockhausen 2011). Briefly, the current assessment model covers 1982-2015. Age classes included in the model run from age 0 to 20. Age at recruitment was set at 0 years in the model. The oldest age class in the model, age 20, serves as a plus group. Survey catchability was fixed at 1.0. **A detailed description of the transition of the previous model to SS3 and potential benefits of transitioning the assessment to SS3 were presented at the 2013 September Plan Team Meeting and the September SAFE chapter is included in this document as Appendix 6C.** The current model in SS3 mimics the behavior of the previously accepted rex sole assessment model. The modeling of fishery and survey selectivity, the recruitment deviations, and the age-length transition matrix differ slightly from the previously accepted model and the techniques used in the current model are outlined below.

*Fishery and Survey Selectivity*

The fishery and survey selectivity curves were estimated using sex-specific, age-based double-normal functions without a descending limb (instead of a logistic function). The SS3 modeling framework does not currently include the option of estimating sex-specific, age-based logistic selectivity where both male and female selectivity maintain a logistic shape (as was used in the previous assessment model). Therefore, the double-normal curve without a descending limb was the closest match to the selectivity formulation used in the 2011 model (Appendix 6C).

*Recruitment Deviations*

Recruitment deviations were estimated for the period 1965-2012 and were forecast from 2013-2015 using simple deviations with a $\sigma_R = 0.6$. A bias adjustment factor was specified using the Methot and Taylor (2011) bias adjustment method. Recruitment deviations prior to the start of composition data and in the most recent years in the time-series are less informed than in the middle of the time-series. This creates a bias in the estimation of recruitment deviations and mean recruitment that is corrected using methods described in Methot and Taylor (2011).

*Data Weighting*

Effective sample sizes for all length and age composition data were set to the number of hauls for which lengths were measured for length compositions and number of hauls for which ages were measured for age compositions (Pennington and Volstad 1994). Data sources were weighted relative to one another using the McAllister-Ianelli method (McAllister and Ianelli 2007). Previous rex sole assessment models specified data weights arbitrarily.

## Parameters Estimated Outside the Assessment Model

*Natural mortality*

Male and female natural mortality were fixed and equal to 0.17.

*Growth*

Length-at-age was estimated externally using data from the GOA groundfish survey from 1984-1996 (Turnock et al. 2005) and assumed to follow the von-Bertalanffy growth curve:

$L_t = L_{\inf}(1-e^{-k(t-t_0)})$. The estimated values are as follows:

| Sex | $L_\infty$ | k | $t_0$ |
|---|---|---|---|
| Males | 39.5 | 0.38 | 0.79 |
| Females | 44.9 | 0.31 | 0.69 |

Fixed sex-specific age-length conversion matrices are calculated within SS3 (Methot and Wetzel 2013) based on the parameters of the von-Bertalanffy growth curve and specified coefficients of variation (CVs) for length-at-age for the youngest and oldest age classes of 0.13 and 0.08, respectively, for both males and females.

*Weight-at-Age Relationship*

The weight-at-age relationship was that used in the previous assessment (Stockhausen 2011) and is based on the weight-length relationship $w_L = \alpha L^\beta$ and the parameters of the von-Bertalanffy growth curve. The vectors of weight-at-age values were input directly to the assessment and are listed in Table 8.

*Maturity*

Abookire (2006) modeled female rex sole size-at-maturity using a logistic model, obtaining a value for size at 50% maturity of 351.7 mm with a slope of 0.0392 $mm^{-1}$. About half of the maturity samples were obtained from fishery catches and half from research trawls during 2000-2001. Using the mean length-at-age relationship estimated from the 1984-1996 survey data, the age at 50%-maturity was estimated at 5.6 years, (Table 6.9, Fig. 6.6). Estimates of mean size-at-age for the maturity samples were similar to those for mean size-at-age estimated from the survey data (Turnock et al., 2005).

*Survey catchability*

For the assessment, survey catchability was fixed at 1.

## Parameters Estimated Inside the Assessment Model

Parameters estimated within the assessment model were the log of unfished recruitment ($R_0$), log-scale recruitment deviations, yearly fishing mortality, and selectivity parameters for the fishery and survey. The selectivity parameters are described in greater detail in Table 9.

# Results

## Model Evaluation

*Comparison among models*

Figure 3-Figure 6 compare the base case assessment model to the most recent previously accepted rex sole assessment model run in SS3 (the 2011 model) and to the 2011 model run in SS3 with new data added. Fits to survey biomass, recruitment deviations, and spawning stock biomass are very similar among the three models. The likelihood component for survey biomass was –lnL = -12.69 for the base case model and –lnL = -2.05 for the previous model run in SS3 with new data (Table 11), which is an improvement in the model fit to the survey biomass index. Likelihood components for length and age compositions are not directly comparable because the effective sample sizes and data weighting changed. The base case model was chosen because fits to the survey biomass index were improved over the SS3 version of the 2011 model with new data added and because the effective sample sizes and data weighting approach have a scientific basis.

*The base case model*

The survey biomass index and fits to survey biomass show fluctuations over time with peak in 2009 and a small decline thereafter. Recruitment deviations have also fluctuated over time with above average recruitment in the early 1980s, mid-late 1990s to mid-2000s, and in 2011-2012, and below average recruitment prior to 1982, in the early 1990s, and from 2006-2009 (Figure 4, Figure 5, Table 12). Yearly fishing mortality rates are listed in Table 13.

Estimated survey selectivity showed that peak selectivity occurs by around age 5-6 for both males and females, while peak fishery selectivity is estimated to occur around age 12-13 for both males and females (Figure 7, Table 10). Plots of fits to survey and fishery length and age compositions aggregated over years are shown in Figure 8. The model predicted slightly more males and females between 35-40cm in length in the fishery than were observed and slightly fewer larger (45cm+) females in the fishery than were observed (Figure 8). Figure 9 shows the fits to survey age compositions, aggregated over years. Overall, the model predicted slightly more age 4-7 females than were observed, and fewer females in the plus group than were observed. The model predicted fewer age 4, 6, and 20+ males than were observed and more age 7-14 males than were observed. As for females, the model predicted fewer age 20+ males than were observed.

Figure 10 and Figure 11 show model fits to fishery length compositions by year. Fits for fishery length compositions are reasonable, with the exception of fits in 1982-1984 and 1988; it appears that fishery selectivity and/or availability were quite different in those years. Fits to survey length compositions appear skewed slightly towards older lengths than were observed (Figure 12), while fits to survey age compositions are reasonable and show no consistent skew (Figure 13). The effective sample sizes for survey length composition data are very low (1 in most years) and so the model is fitting primarily to age compositions. A pattern in fits to the length compositions, but not the age compositions is an indication that future assessments should explore the growth relationships in the model.

## Time Series Results

Time series results are shown in Table 14 - Table 17 and Figure 14. Age 3 recruitment, age 0 recruitment, and standard deviations of age 0 recruitment are presented in Table 14. Total biomass for ages 3+, spawning stock biomass, and standard deviations of spawning stock biomass estimates for the previous and current assessments are presented in Table 15. Female and male estimates of numbers-at-age for the current assessment are shown in Table 16 and Table 17. Figure 14 shows spawning stock biomass estimates and corresponding asymptotic 95% confidence intervals. A plot of biomass relative to $B_{35\%}$ and F relative to $F_{35\%}$ for each year in the time series, along with the OFL and ABC control rules is not shown for rex sole because it is thought that estimates of $F_{35\%}$ and $F_{40\%}$ are not reliable and these quantities are not used for management of the rex sole stock.

*Retrospective analysis*

Spawning stock biomass, recruitment, and recruitment deviations, and corresponding 95% asymptotic confidence intervals from a retrospective analysis extending back 10 years are shown in Figure 15-Figure 16. Models excluding 7-10 years of data estimated lower values for recent spawning stock biomass, while models excluding 1-6 years of data estimated higher values for spawning stock biomass in recent years (Figure 15), but a consistent retrospective pattern over the 10 model runs is not evident. Historical recruitment deviations and age-0 recruitment estimates were similar among models (Figure 16).

## Harvest Recommendations

*Reference fishing mortality rates*

Because $F_{35\%}$ and $F_{40\%}$ are highly uncertain, Tier 3 considerations cannot be used to set reference fishing mortality rates and make harvest specifications for the GOA rex sole stock. In 2009, the GOA Plan Team decided that reference rates and harvest specifications for rex sole should be set using Tier 5 considerations. For Tier 5 stocks, reference fishing mortality rates are given by $F_{OFL} = M$ (the rate of natural mortality) and max $F_{ABC} = 0.75 \cdot M$. Consequently, values for the reference fishing mortality rates for GOA rex sole are $F_{OFL} = 0.17$ yr$^{-1}$ and $F_{ABC} = 0.128$ yr$^{-1}$.

*Acceptable Biological Catch and Overfishing Level*

For Tier 5 stocks, harvest specifications are given by $OFL = F_{OFL} \cdot \bar{B}$ and $ABC = F_{ABC} \cdot \bar{B}$, where $\bar{B}$ is an estimate of stock biomass. For most Tier 5 stocks, the estimate of survey biomass for the stock from the most recent groundfish survey is used as $\bar{B}$. For rex sole, however, the GOA Plan Team determined that estimates of “adult” biomass (i.e., total biomass-at-age weighted by the fraction mature-at-age) from the assessment model provided more appropriate estimates of stock biomass than the groundfish survey and should be used for setting harvest specifications. Estimating adult biomass in the assessment model for 2016 and 2017 requires predictions of the total catch taken in 2015 and 2016. Because the 2015 fishery is not yet complete, we estimated the total catch taken in 2015 as the current catch of GOA rex sole as of October 10, 2015 added to the average October 10 – December 31 GOA rex sole catches over the 5 previous years. Total catch in 2016 as the average catch over the last five years (2010-2014). Using these values and the estimated numbers-at-age at the start of 2015 from the assessment model, we projected the stock ahead and calculated adult biomass ($B_A$) at the start of 2016 and 2017 using the Baranov catch equation

$$\bar{B} = \frac{(1 - e^{-Z})}{Z} \cdot B_A$$

where Z=M+F and F was $F_{ABC}$ or $F_{OFL}$.

The estimated ABCs for 2016 and 2017 are 7,493 and 7,507, respectively, while the estimated OFLs are 9,791 and 9,810.

*Area allocation of harvests*

The table below shows apportionment of the 2016 and 2017 ABCs among areas, based on random effects model predictions of survey biomass in each area for 2016-2017.

| **Quantity** | **Western** | **Central** | **West Yakutat** | **Southeast** | **Total** |
|---|---|---|---|---|---|
| Area Apportionment | 17.55% | 59.32% | 10.22% | 12.90% | 100.00% |
| 2016 ABC (t) | 1,315 | 4,445 | 766 | 967 | 7,493 |
| 2017 ABC (t) | 1,318 | 4,453 | 767 | 969 | 7,507 |

# Ecosystem Considerations

## Ecosystem effects on the stock

*Prey availability/abundance trends*

Based on results from an ecosystem model for the Gulf of Alaska (Aydin et al., 2007), rex sole in the Gulf of Alaska occupy an intermediate trophic level (Figure 17). Polychaetes, euphausiids, and miscellaneous worms were the most important prey for rex sole in the Gulf of Alaska (Figure 18). Other major prey items included benthic amphipods, polychaetes, and shrimp (Livingston and Goiney, 1983; Yang, 1993; Yang and Nelson, 2000). Little to no information is available to assess trends in abundance for the major benthic prey species of rex sole.

*Predator population trends*

Important predators on rex sole include longnosed skate and arrowtooth flounder (Figure 19). The flatfish-directed fishery constitutes the second-largest known source of mortality on rex sole. However, unexplained mortality is the second largest component of mortality.

## Fishery Effects on the Ecosystem

Table 18 and Table 19 show the contribution of the GOA rex sole fishery to bycatch of non-target and prohibited species. No birds were recorded as bycatch in the GOA rex sole fishery. The GOA rex sole fishery caught 1% of the halibut PSC caught in 2015 and 2% of the halibut PSC caught in 2014.

Likewise, the GOA rex sole fishery was responsible for an estimated 1.7% and 3.4% of halibut mortality in 2015 and 2014, respectively (Table 19). The GOA rex sole fishery caught between 0 and 8% of the catch of any non-target species in 2014 and 2015 (Table 18).

## Data gaps and research priorities

The rex sole fishery is primarily a bycatch fishery that takes mainly older, larger fish. Current estimates of optimum harvest levels based on Tier 3 calculations (e.g., at $F_{40\%}$ harvest rates) are very large but highly uncertain. The rex sole fishery should continue to be monitored to assess whether a directed rex sole fishery has developed; quantities such as $F_{40\%}$ (=$F_{ABC}$ in Tier 3a) will be sensitive to the characteristics of the resulting fishery selectivity curves. More information should be collected on fishery size and age compositions to inform selectivity parameters and potentially improve estimates of harvest rates.

The assessment is now conducted using Stock Synthesis (SS3), which will allow for further exploration of alternative selectivity formulations, stock-recruit curves, time-varying effects, and spatial effects. Inclusion of additional data sources could be explored, such as fishery age composition data, which may better inform estimation of reference points. The ADF&G small mesh survey could be included as well, and an ageing error matrix could be developed.

GOA rex sole otoliths appear to show two different patterns for the same age and year of fish, indicating that some rex sole grow at different rates than others. Further research on genetics and growth should be conducted to explore these two growth patterns seen on the otoliths.

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# Tables

Table 1. Fishery catches for GOA rex sole by management area. Catch for 2015 is through October 26, 2015.

| Year | Total Catch | Western Gulf | Central Gulf | West Yakutat | Southeast |
|---|---|---|---|---|---|
| 1982 | 959 | | | | -- |
| 1983 | 595 | | | | -- |
| 1984 | 365 | | | | -- |
| 1985 | 154 | | | | -- |
| 1986 | 93 | | | | -- |
| 1987 | 1151 | | | | -- |
| 1988 | 1192 | | | | -- |
| 1989 | 599 | | | | -- |
| 1990 | 1,269 | | | | -- |
| 1991 | 4,636 | | | | -- |
| 1992 | 3,000 | | | | -- |
| 1993 | 3,000 | | | | -- |
| 1994 | 3,673 | | | | -- |
| 1995 | 4,021 | | | | -- |
| 1996 | 5,874 | | | | -- |
| 1997 | 3,294 | | | | -- |
| 1998 | 2,669 | | | | -- |
| 1999 | 3060 | | | | -- |
| 2000 | 3,591 | | | | -- |
| 2001 | 2,940 | | | | -- |
| 2002 | 2,941 | | | | -- |
| 2003 | 3,485 | 767 | 2,716 | 1 | 1 |
| 2004 | 1,464 | 526 | 936 | 0 | 0 |
| 2005 | 2,176 | 576 | 1,600 | 0 | 0 |
| 2006 | 3,294 | 350 | 2,944 | 0 | 0 |
| 2007 | 2,852 | 413 | 2,438 | 1 | 0 |
| 2008 | 2,703 | 185 | 2,518 | 0 | 0 |
| 2009 | 4,753 | 342 | 4,410 | 1 | 0 |
| 2010 | 3,636 | 134 | 3,500 | 2 | 0 |
| 2011 | 2,594 | 105 | 2,488 | 1 | 0 |
| 2012 | 2,425 | 215 | 2,210 | 0 | 0 |
| 2013 | 3,707 | 104 | 3,603 | 0 | 0 |
| 2014 | 3,577 | 126 | 3,450 | 1 | 0 |
| 2015 | 1,678 | 75 | 1,603 | 0 | 0 |

Table 2. Historical catch specifications, percent of the catch retained, and percent of the TAC and ABC caught from 1995-2015.

| Year | OFL (t) | ABC (t) | TAC (t) | Total Catch | % Retained | % of TAC caught | % of ABC Caught |
|---|---|---|---|---|---|---|---|
| 1995 | 13,091 | 11,210 | 9,690 | 4,021 | 90% | 41% | 36% |
| 1996 | 13,091 | 11,210 | 9,690 | 5,874 | 95% | 61% | 52% |
| 1997 | 11,920 | 9,150 | 9,150 | 3,294 | 92% | 36% | 36% |
| 1998 | 11,920 | 9,150 | 9,150 | 2,669 | 97% | 29% | 29% |
| 1999 | 11,920 | 9,150 | 9,150 | 3,060 | 96% | 33% | 33% |
| 2000 | 12,300 | 9,440 | 9,440 | 3,591 | 97% | 38% | 38% |
| 2001 | 12,300 | 9,440 | 9,440 | 2,940 | 95% | 31% | 31% |
| 2002 | 12,320 | 9,470 | 9,470 | 2,941 | 95% | 31% | 31% |
| 2003 | 12,320 | 9,470 | 9,470 | 3,485 | 95% | 37% | 37% |
| 2004 | 16,480 | 12,650 | 12,650 | 1,464 | 92% | 12% | 12% |
| 2005 | 16,480 | 12,650 | 12,650 | 2,176 | 91% | 17% | 17% |
| 2006 | 12,000 | 9,200 | 9,200 | 3,294 | 95% | 36% | 36% |
| 2007 | 11,900 | 9,100 | 9,100 | 2,852 | 98% | 31% | 31% |
| 2008 | 11,933 | 9,132 | 9,132 | 2,703 | 97% | 30% | 30% |
| 2009 | 11,756 | 8,996 | 8,996 | 4,753 | 99% | 53% | 53% |
| 2010 | 12,714 | 9,729 | 9,729 | 3,636 | 98% | 37% | 37% |
| 2011 | 12,499 | 9,565 | 9,565 | 2,594 | 97% | 27% | 27% |
| 2012 | 12,561 | 9,612 | 9,612 | 2,425 | 96% | 25% | 25% |
| 2013 | 12,492 | 9,560 | 9,560 | 3,707 | 98% | 39% | 39% |
| 2014 | 12,207 | 9,341 | 9,341 | 3,577 | 99% | 38% | 38% |
| 2015 | 11,957 | 9,150 | 9,150 | 1,678 | 98% | 18% | 18% |

Table 3. GOA rex sole fishery closures by sub-area in 2015

| Sub-Area | Program | Status | Reason | Effective Date |
|---|---|---|---|---|
| GOA - Central 620/630 | All | Bycatch | Regulations | 01-Jan |
| GOA - Western 610 | All | Bycatch | Regulations | 01-Jan |
| GOA - Central 620/630 | All | Open | Regulations | 20-Jan |
| GOA - Western 610 | All | Open | Regulations | 20-Jan |
| West Yakutat - 640 | All | Open | Regulations | 20-Jan |
| West Yakutat - 640 | All | Bycatch | Regulations | 01-Jan |
| GOA - Central 620/630 | Catcher Vessel | Bycatch | Chinook Salmon | 03-May |
| GOA - Western 610 | Catcher Vessel | Bycatch | Chinook Salmon | 03-May |
| GOA - Central 620/630 | Catcher Vessel | Open | Regulations | 10-Aug |
| GOA - Western 610 | Catcher Vessel | Open | Regulations | 10-Aug |

Table 4. Number of hauls and number of individuals represented in the fishery length composition data used in the assessment (excludes unsexed fish).

| Year | Total Number of Hauls | Total Number of Individuals | Number of hauls with females | Number of females | Number of hauls with males | Number of males |
|---|---|---|---|---|---|---|
| 1982 | 75 | 9,516 | 74 | 3,547 | 73 | 5,856 |
| 1983 | 5 | 647 | 5 | 241 | 5 | 406 |
| 1984 | 2 | 297 | 2 | 60 | 2 | 237 |
| 1990 | 74 | 7,438 | 56 | 2,482 | 56 | 3,693 |
| 1991 | 257 | 18,652 | 120 | 4,724 | 118 | 4,339 |
| 1992 | 220 | 19,586 | 161 | 8,045 | 159 | 6,420 |
| 1993 | 372 | 25,972 | 245 | 9,067 | 242 | 7,293 |
| 1994 | 328 | 19,756 | 225 | 6,935 | 222 | 6,038 |
| 1995 | 257 | 11,868 | 133 | 3,282 | 111 | 1,897 |
| 1996 | 277 | 18,548 | 224 | 8,212 | 221 | 6,474 |
| 1997 | 194 | 10,391 | 182 | 4,982 | 183 | 5,136 |
| 1998 | 213 | 10,509 | 154 | 4,609 | 156 | 3,313 |
| 1999 | 393 | 8,294 | 392 | 4,466 | 388 | 3,816 |
| 2000 | 347 | 6,526 | 341 | 3,896 | 330 | 2,560 |
| 2001 | 194 | 3,484 | 194 | 1,931 | 187 | 1,550 |
| 2002 | 320 | 5,595 | 314 | 3,033 | 311 | 2,550 |
| 2003 | 352 | 6,357 | 346 | 2,644 | 342 | 3,667 |
| 2004 | 62 | 1,039 | 62 | 484 | 60 | 555 |
| 2005 | 71 | 1,190 | 70 | 606 | 67 | 584 |
| 2006 | 37 | 501 | 35 | 256 | 32 | 229 |
| 2007 | 140 | 2,138 | 139 | 1,115 | 126 | 1,008 |
| 2008 | 159 | 2,677 | 154 | 1,205 | 156 | 1,459 |
| 2009 | 230 | 4,189 | 223 | 1,992 | 226 | 2,114 |
| 2010 | 152 | 2,892 | 151 | 1,241 | 149 | 1,651 |
| 2011 | 164 | 3,153 | 162 | 1,417 | 161 | 1,733 |
| 2012 | 159 | 2,724 | 155 | 1,376 | 146 | 1,346 |
| 2013 | 278 | 5,600 | 275 | 2,454 | 269 | 3,137 |
| 2014 | 230 | 4,069 | 225 | 2,466 | 222 | 1,602 |
| 2015 | 135 | 2,116 | 129 | 1,204 | 124 | 910 |

Table 5. Survey biomass by area, depth, and year in metric tons

| | | Regulatory Area | | | |
|---|---|---|---|---|---|
| | | **Central** | **Eastern** | **Western** | **Total** |
| 1984 | | **40,688** | **13,311** | **6,672** | **60,670** |
| | 1 | 1,423 | 2,235 | 329 | 3,987 |
| | 101 | 26,777 | 7,519 | 2,744 | 37,040 |
| | 201 | 8,557 | 2,041 | 2,485 | 13,083 |
| | 301 | 2,900 | 1,223 | 1,038 | 5,161 |
| | 501 | 689 | 292 | 76 | 1,057 |
| | 701 | 342 | 0 | 0 | 342 |
| 1987 | | **39,722** | **15,304** | **8,801** | **63,826** |
| | 1 | 2,504 | 2,246 | 941 | 5,691 |
| | 101 | 24,515 | 9,351 | 6,379 | 40,244 |
| | 201 | 11,537 | 2,031 | 940 | 14,508 |
| | 301 | 711 | 767 | 335 | 1,812 |
| | 501 | 426 | 909 | 207 | 1,542 |
| | 701 | 30 | | 0 | 30 |
| 1990 | | **75,147** | **16,313** | **6,765** | **98,225** |
| | 1 | 8,717 | 5,472 | 1,272 | 15,460 |
| | 101 | 48,066 | 8,049 | 3,718 | 59,833 |
| | 201 | 17,970 | 2,097 | 1,724 | 21,791 |
| | 301 | 394 | 696 | 51 | 1,140 |
| 1993 | | **55,310** | **20,901** | **10,700** | **86,911** |
| | 1 | 4,980 | 3,143 | 3,110 | 11,233 |
| | 101 | 36,890 | 11,115 | 6,059 | 54,064 |
| | 201 | 11,665 | 4,754 | 577 | 16,995 |
| | 301 | 1,775 | 1,889 | 954 | 4,619 |
| 1996 | | **43,778** | **19,560** | **9,419** | **72,757** |
| | 1 | 4,421 | 2,460 | 3,522 | 10,403 |
| | 101 | 29,214 | 10,784 | 3,421 | 43,419 |
| | 201 | 9,049 | 4,036 | 1,844 | 14,929 |
| | 301 | 1,094 | 2,280 | 632 | 4,006 |
| 1999 | | **42,750** | **19,464** | **12,755** | **74,969** |
| | 1 | 2,677 | 4,365 | 7,640 | 14,682 |
| | 101 | 30,570 | 7,271 | 2,399 | 40,239 |
| | 201 | 8,231 | 6,142 | 1,393 | 15,766 |
| | 301 | 1,001 | 1,523 | 1,317 | 3,841 |
| | 501 | 271 | 163 | 6 | 440 |
| | 701 | 0 | 0 | 0 | 0 |
| 2001 | | **41,687** | | **9,571** | **51,258** |
| | 1 | 6,458 | | 1,284 | 7,742 |
| | 101 | 24,792 | | 4,414 | 29,206 |
| | 201 | 8,964 | | 2,081 | 11,045 |
| | 301 | 1,473 | | 1,793 | 3,265 |
| 2003 | | **57,973** | **28,659** | **13,265** | **99,897** |
| | 1 | 6,220 | 7,411 | 3,898 | 17,529 |
| | 101 | 37,610 | 14,832 | 6,345 | 58,787 |
| | 201 | 13,078 | 3,668 | 2,348 | 19,094 |
| | 301 | 985 | 2,368 | 664 | 4,017 |
| | 501 | 81 | 380 | 9 | 470 |
| 2005 | | **60,600** | **27,795** | **12,766** | **101,161** |
| | 1 | 8,142 | 4,061 | 2,580 | 14,783 |

| | | | | | |
|---|---|---|---|---|---|
| | 101 | 40,766 | 15,392 | 8,902 | 65,060 |
| | 201 | 10,457 | 5,241 | 939 | 16,637 |
| | 301 | 1,136 | 3,063 | 335 | 4,535 |
| | 501 | 98 | 29 | 9 | 136 |
| | 701 | 0 | 10 | 0 | 10 |
| 2007 | | **76,514** | **15,672** | **11,614** | **103,800** |
| | 1 | 4,505 | 2,022 | 2,577 | 9,105 |
| | 101 | 55,711 | 9,466 | 6,338 | 71,514 |
| | 201 | 13,371 | 3,050 | 1,947 | 18,368 |
| | 301 | 2,803 | 948 | 752 | 4,504 |
| | 501 | 124 | 186 | 0 | 309 |
| | 701 | 0 | 0 | 0 | 0 |
| 2009 | | **82,091** | **22,873** | **19,780** | **124,744** |
| | 1 | 8,533 | 3,419 | 4,065 | 16,017 |
| | 101 | 52,749 | 13,539 | 13,375 | 79,662 |
| | 201 | 19,267 | 3,801 | 1,964 | 25,032 |
| | 301 | 1,332 | 1,272 | 376 | 2,980 |
| | 501 | 211 | 843 | 0 | 1,054 |
| | 701 | 0 | 0 | 0 | 0 |
| 2011 | | **63,490** | **18,681** | **12,964** | **95,134** |
| | 1 | 4,614 | 3,421 | 3,934 | 11,969 |
| | 101 | 39,259 | 7,942 | 5,998 | 53,199 |
| | 201 | 18,749 | 3,980 | 2,442 | 25,171 |
| | 301 | 726 | 3,027 | 590 | 4,342 |
| | 501 | 143 | 311 | 0 | 454 |
| 2013 | | **64,188** | **22,913** | **13,877** | **100,978** |
| | 1 | 4,784 | 7,110 | 837 | 12,731 |
| | 101 | 47,669 | 10,460 | 10,307 | 68,435 |
| | 201 | 10,686 | 2,998 | 1,899 | 15,583 |
| | 301 | 782 | 1,659 | 835 | 3,276 |
| | 501 | 267 | 686 | 0 | 952 |
| 2015 | | **48,877** | **22,474** | **15,936** | **87,286** |
| | 1 | 5,090 | 7,437 | 2,839 | 15,365 |
| | 101 | 33,365 | 9,593 | 9,733 | 52,691 |
| | 201 | 9,431 | 2,890 | 3,096 | 15,416 |
| | 301 | 906 | 1,919 | 269 | 3,093 |
| | 501 | 85 | 636 | 0 | 721 |
| | 701 | 0 | 0 | 0 | 0 |

Table 6. Number of hauls and number of individuals represented in the survey length composition data used in the assessment (excludes unsexed fish).

| Year | Total Number of Hauls | Total Number of Individuals | Number of hauls with females | Number of females | Number of hauls with males | Number of males |
|---|---|---|---|---|---|---|
| 1984 | 227 | 13,930 | 225 | 6,739 | 221 | 7,191 |
| 1987 | 103 | 11,362 | 103 | 5,364 | 102 | 5,998 |
| 1990 | 237 | 14,386 | 237 | 7,593 | 227 | 6,793 |
| 1993 | 367 | 18,109 | 359 | 9,943 | 319 | 8,166 |
| 1996 | 517 | 14,486 | 487 | 6,768 | 401 | 7,718 |
| 1999 | 462 | 11,612 | 430 | 5,408 | 374 | 6,204 |
| 2001 | 278 | 7,675 | 255 | 3,861 | 229 | 3,814 |
| 2003 | 519 | 17,806 | 490 | 8,778 | 440 | 9,028 |
| 2005 | 546 | 18,981 | 511 | 9,373 | 459 | 9,608 |
| 2007 | 512 | 17,160 | 489 | 8,606 | 434 | 8,554 |
| 2009 | 555 | 19,910 | 536 | 9,969 | 470 | 9,941 |
| 2011 | 413 | 12,800 | 392 | 6,634 | 328 | 6,166 |
| 2013 | 337 | 10,249 | 321 | 4,829 | 272 | 5,420 |
| 2015 | 487 | 15,153 | 466 | 7,708 | 376 | 7,445 |

Table 7. Number of hauls and number of individuals represented in the survey age composition data used in the assessment (excludes unsexed fish).

| Year | Total Number of Hauls | Total Number of Individuals | Number of hauls with females | Number of females | Number of hauls with males | Number of males |
|---|---|---|---|---|---|---|
| 1984 | 5 | 233 | 5 | 155 | 5 | 78 |
| 1987 | 5 | 159 | 5 | 91 | 5 | 87 |
| 1990 | 27 | 270 | 26 | 156 | 20 | 114 |
| 1993 | 29 | 332 | 26 | 193 | 20 | 139 |
| 1996 | 79 | 378 | 61 | 218 | 44 | 160 |
| 1999 | 59 | 410 | 52 | 218 | 45 | 192 |
| 2001 | 132 | 382 | 106 | 296 | 96 | 253 |
| 2003 | 94 | 594 | 82 | 328 | 69 | 266 |
| 2005 | 104 | 520 | 86 | 289 | 78 | 268 |
| 2007 | 55 | 416 | 48 | 220 | 38 | 196 |
| 2009 | 100 | 484 | 85 | 267 | 71 | 217 |
| 2011 | 89 | 509 | 75 | 283 | 60 | 226 |
| 2013 | 94 | 483 | 84 | 267 | 62 | 216 |

Table 8. Weight-at-age and maturity-at-age relationships used in the assessment model. The length- and weight-at-age relationships were estimated using data from 1984-1996.

| Age | Female Weight-at-Age | Male Weight-at-Age | Maturity |
|---|---|---|---|
| 0 | 0.000 | 0.000 | 0.000 |
| 1 | 0.000 | 0.000 | 0.000 |
| 2 | 0.000 | 0.000 | 0.000 |
| 3 | 0.069 | 0.064 | 0.009 |
| 4 | 0.150 | 0.130 | 0.082 |
| 5 | 0.241 | 0.196 | 0.323 |
| 6 | 0.328 | 0.253 | 0.620 |
| 7 | 0.405 | 0.298 | 0.799 |
| 8 | 0.469 | 0.331 | 0.885 |
| 9 | 0.519 | 0.356 | 0.925 |
| 10 | 0.558 | 0.373 | 0.946 |
| 11 | 0.588 | 0.386 | 0.958 |
| 12 | 0.611 | 0.394 | 0.965 |
| 13 | 0.628 | 0.400 | 0.969 |
| 14 | 0.641 | 0.404 | 0.972 |
| 15 | 0.650 | 0.407 | 0.974 |
| 16 | 0.657 | 0.409 | 0.975 |
| 17 | 0.662 | 0.410 | 0.976 |
| 18 | 0.665 | 0.411 | 0.977 |
| 19 | 0.668 | 0.412 | 0.977 |
| 20 | 0.670 | 0.412 | 0.977 |

Table 9. Configuration of fishery and survey age-based, sex-specific double-normal selectivity curves used in the assessment. A numeric value indicates the fixed value of a parameter. An asterisk indicates that the parameter was fixed at 0 for ages 0-2.

| **Double-normal selectivity parameters** | **Fishery** | **Survey** |
|---|---|---|
| Peak: beginning size for the plateau | Estimated | Estimated |
| Width: width of plateau | 30 | 30 |
| Ascending width (log space) | Estimated | Estimated |
| Descending width (log space) | 8 | 8 |
| Initial: selectivity at smallest length or age bin | 0* | 0* |
| Final: selectivity at largest length or age bin | 999 | 999 |
| Male Peak Offset | Estimated | Estimated |
| Male ascending width offset (log space) | Estimated | Estimated |
| Male descending width offset (log space) | 0 | 0 |
| Male "Final" offset (transformation required) | 0 | 0 |
| Male apical selectivity | 1 | 1 |

Table 10. Final parameter estimates for unfished recruitment and selectivity parameters for the current base case model. Estimates of yearly recruitment deviations and fishing mortality rates are listed in separate tables. “StDev” refers to the standard deviation about the parameter estimate.

| | **Parameter** | **Estimate** | **StDev** |
|---|---|---|---|
| | Log of unfished recruitment | 11.569 | 0.038 |
| **Fishery selectivity parameters** | Peak: beginning size for the plateau (females) | 13.546 | 1.166 |
| | Ascending width (females; log space) | 2.925 | 0.297 |
| | Male peak offset | 0.651 | 1.047 |
| | Male ascending width offset (log space) | 0.278 | 0.313 |
| **Survey selectivity parameters** | Peak: beginning size for the plateau (females) | 6.590 | 0.694 |
| | Ascending width (females; log space) | 2.378 | 0.454 |
| | Male peak offset | -0.697 | 0.572 |
| | Male ascending width offset (log space) | -0.421 | 0.432 |

Table 11. Negative log likelihood components for three GOA rex sole models: the 2013 model run using SS3, the 2013 model updated with 2015 data, and the 2015 model. Likelihood component values cannot be compared between the 2013 model and the two models that include 2015 data. Only the survey likelihood component can be directly compared between the two models that include 2015 data.

| Likelihood Component | 2013 Model | 2013 Model w New Data | 2015 Model |
|---|---|---|---|
| TOTAL | 607 | 657 | 256 |
| Survey | -1.22 | -2.05 | -12.69 |
| Length_comp | 471 | 493 | 196 |
| Age_comp | 151 | 176 | 75 |
| Recruitment | -14.188 | -11.059 | -3.096 |

Table 12. Estimated yearly recruitment deviations for the current base case model.

| Year | Recruitment Deviations | Std. Dev. | Year | Recruitment Deviations | Std. Dev. |
|---|---|---|---|---|---|
| 1965 | -0.291 | 0.525 | 1995 | -0.144 | 0.188 |
| 1966 | -0.309 | 0.516 | 1996 | 0.124 | 0.167 |
| 1967 | -0.348 | 0.509 | 1997 | 0.559 | 0.146 |
| 1968 | -0.351 | 0.498 | 1998 | 0.438 | 0.161 |
| 1969 | -0.404 | 0.492 | 1999 | 0.407 | 0.176 |
| 1970 | -0.440 | 0.487 | 2000 | 0.378 | 0.173 |
| 1971 | -0.451 | 0.480 | 2001 | 0.197 | 0.196 |
| 1972 | -0.463 | 0.475 | 2002 | -0.006 | 0.211 |
| 1973 | -0.485 | 0.471 | 2003 | 0.393 | 0.180 |
| 1974 | -0.487 | 0.464 | 2004 | 0.322 | 0.176 |
| 1975 | -0.468 | 0.454 | 2005 | 0.378 | 0.168 |
| 1976 | -0.475 | 0.445 | 2006 | -0.428 | 0.235 |
| 1977 | -0.469 | 0.430 | 2007 | -0.363 | 0.238 |
| 1978 | -0.539 | 0.430 | 2008 | -1.213 | 0.346 |
| 1979 | -0.320 | 0.413 | 2009 | -1.018 | 0.410 |
| 1980 | -0.283 | 0.423 | 2010 | 0.948 | 0.172 |
| 1981 | -0.060 | 0.413 | 2011 | 0.299 | 0.292 |
| 1982 | 0.160 | 0.351 | 2012 | 0.588 | 0.194 |
| 1983 | 0.366 | 0.318 | 2013 | 0.000 | 0.000 |
| 1984 | 0.218 | 0.291 | 2014 | 0.000 | 0.000 |
| 1985 | 0.266 | 0.227 | 2015 | 0.000 | 0.000 |
| 1986 | -0.114 | 0.222 | | | |
| 1987 | 0.153 | 0.166 | | | |
| 1988 | -0.263 | 0.253 | | | |
| 1989 | -0.315 | 0.242 | | | |
| 1990 | -0.293 | 0.224 | | | |
| 1991 | -0.535 | 0.245 | | | |
| 1992 | -0.470 | 0.230 | | | |
| 1993 | -0.636 | 0.244 | | | |
| 1994 | -0.396 | 0.218 | | | |

Table 13. Estimated fishing mortality for the current base case model.

| Year | Estimate | StdDev | Year | Estimate | StdDev |
|---|---|---|---|---|---|
| **1982** | 0.023 | 0.003 | **2001** | 0.114 | 0.013 |
| **1983** | 0.015 | 0.002 | **2002** | 0.123 | 0.014 |
| **1984** | 0.009 | 0.001 | **2003** | 0.148 | 0.018 |
| **1985** | 0.004 | 0.000 | **2004** | 0.060 | 0.008 |
| **1986** | 0.003 | 0.000 | **2005** | 0.082 | 0.012 |
| **1987** | 0.032 | 0.003 | **2006** | 0.113 | 0.018 |
| **1988** | 0.034 | 0.004 | **2007** | 0.090 | 0.015 |
| **1989** | 0.017 | 0.002 | **2008** | 0.078 | 0.013 |
| **1990** | 0.035 | 0.004 | **2009** | 0.128 | 0.020 |
| **1991** | 0.130 | 0.016 | **2010** | 0.095 | 0.014 |
| **1992** | 0.084 | 0.011 | **2011** | 0.073 | 0.010 |
| **1993** | 0.082 | 0.011 | **2012** | 0.061 | 0.008 |
| **1994** | 0.099 | 0.014 | **2013** | 0.092 | 0.012 |
| **1995** | 0.110 | 0.015 | **2014** | 0.090 | 0.012 |
| **1996** | 0.171 | 0.022 | **2015** | 0.040 | 0.005 |
| **1997** | 0.101 | 0.012 | | | |
| **1998** | 0.085 | 0.010 | | | |
| **1999** | 0.103 | 0.011 | | | |
| **2000** | 0.130 | 0.014 | | | |

Table 14. Time series of recruitment at ages 3 and 0 and standard deviation of age 0 recruits for the previous and current assessments.

| | *2011 Assessment* | | | *2015 Assessment* | | |
|---|---|---|---|---|---|---|
| **Year** | **Recruits (Age 3)** | **Recruits (Age 0)** | **Std. dev** | **Recruits (Age 3)** | **Recruits (Age 0)** | **Std. dev** |
| 1981 | | 48,127 | 7,098 | | | |
| 1982 | | 95,588 | 10,969 | 41,482 | 109,895 | 39,073 |
| 1983 | | 101,583 | 11,356 | 42,848 | 134,359 | 42,463 |
| 1984 | 28,900 | 109,576 | 12,130 | 53,239 | 115,260 | 33,387 |
| 1985 | 57,400 | 119,401 | 11,485 | 65,992 | 120,360 | 27,370 |
| 1986 | 61,000 | 104,081 | 9,033 | 80,682 | 81,861 | 18,470 |
| 1987 | 65,800 | 104,747 | 8,517 | 69,213 | 106,408 | 17,368 |
| 1988 | 71,700 | 85,596 | 7,614 | 72,275 | 69,799 | 17,618 |
| 1989 | 62,500 | 61,116 | 6,194 | 49,157 | 66,105 | 15,992 |
| 1990 | 62,900 | 70,608 | 6,710 | 63,897 | 67,566 | 15,105 |
| 1991 | 51,400 | 51,457 | 5,678 | 41,914 | 53,026 | 13,098 |
| 1992 | 36,700 | 58,285 | 5,936 | 39,696 | 56,642 | 13,125 |
| 1993 | 42,400 | 46,628 | 5,420 | 40,573 | 47,958 | 11,772 |
| 1994 | 30,900 | 72,107 | 6,839 | 31,842 | 60,975 | 13,314 |
| 1995 | 35,000 | 91,591 | 7,614 | 34,013 | 78,470 | 14,742 |
| 1996 | 28,000 | 111,908 | 8,646 | 28,799 | 102,590 | 17,303 |
| 1997 | 43,300 | 156,371 | 10,840 | 36,615 | 158,494 | 22,816 |
| 1998 | 55,000 | 138,719 | 10,324 | 47,121 | 140,311 | 22,102 |
| 1999 | 67,200 | 137,387 | 10,840 | 61,605 | 136,120 | 23,678 |
| 2000 | 93,900 | 130,725 | 10,840 | 95,175 | 132,195 | 22,752 |
| 2001 | 83,300 | 106,912 | 10,453 | 84,256 | 110,284 | 21,640 |
| 2002 | 82,500 | 73,439 | 9,162 | 81,739 | 90,007 | 19,115 |
| 2003 | 78,500 | 142,549 | 14,582 | 79,383 | 134,241 | 23,925 |
| 2004 | 64,200 | 122,565 | 15,227 | 66,225 | 124,948 | 21,982 |
| 2005 | 44,100 | 191,009 | 25,035 | 54,049 | 132,228 | 22,336 |
| 2006 | 85,600 | 83,098 | 7,872 | 80,611 | 59,067 | 14,231 |
| 2007 | 73,600 | 86,262 | 8,259 | 75,031 | 63,013 | 15,471 |
| 2008 | 114,700 | 82,265 | 7,872 | 79,402 | 26,933 | 9,624 |
| 2009 | 49,900 | | | 35,470 | 32,716 | 13,889 |
| 2010 | 51,800 | | | 37,839 | 233,793 | 41,012 |
| 2011 | 49,400 | | | 16,173 | 122,091 | 37,674 |
| 2012 | | | | 19,646 | 163,140 | 32,474 |
| 2013 | | | | 140,392 | 105,746 | 3,973 |
| 2014 | | | | 73,315 | 105,746 | 3,973 |
| 2015 | | | | 97,965 | 105,746 | |
| Average | 59,700 | 101,536 | | 59,342 | 101,415 | |

Table 15. Time series of total and spawning biomass and standard deviation of spawning biomass (Std_Dev) for the previous and current assessments.

| | *2011 Assessment* | | | *2015 Assessment* | | |
|---|---|---|---|---|---|---|
| **Year** | **Total Biomass (age 3+)** | **Spawning Biomass** | **Stdev_SPB** | **Total Biomass (age 3+)** | **Spawning Biomass** | **Stdev_SPB** |
| 1982 | 76,500 | 34,800 | 1,900 | 128,146 | 40,287 | 3,342 |
| 1983 | 77,100 | 34,900 | 1,900 | 83,452 | 38,780 | 3,037 |
| 1984 | 77,100 | 35,100 | 1,800 | 81,587 | 37,781 | 2,724 |
| 1985 | 78,400 | 35,600 | 1,700 | 81,428 | 37,361 | 2,435 |
| 1986 | 80,900 | 36,000 | 1,700 | 83,327 | 37,672 | 2,196 |
| 1987 | 84,600 | 36,600 | 1,600 | 87,719 | 38,892 | 2,029 |
| 1988 | 88,400 | 37,300 | 1,600 | 92,967 | 40,523 | 1,932 |
| 1989 | 92,200 | 38,600 | 1,600 | 97,696 | 42,811 | 1,916 |
| 1990 | 96,600 | 40,800 | 1,500 | 100,960 | 45,444 | 1,971 |
| 1991 | 99,100 | 42,800 | 1,500 | 104,380 | 47,126 | 2,036 |
| 1992 | 96,400 | 42,600 | 1,500 | 105,170 | 46,247 | 2,049 |
| 1993 | 94,500 | 43,100 | 1,500 | 101,180 | 45,789 | 1,974 |
| 1994 | 91,400 | 42,800 | 1,500 | 98,051 | 44,586 | 1,850 |
| 1995 | 87,200 | 41,400 | 1,500 | 93,862 | 42,488 | 1,729 |
| 1996 | 82,000 | 39,400 | 1,400 | 88,646 | 39,874 | 1,637 |
| 1997 | 76,400 | 36,200 | 1,300 | 82,727 | 36,036 | 1,574 |
| 1998 | 74,500 | 34,300 | 1,300 | 75,557 | 33,813 | 1,522 |
| 1999 | 75,300 | 32,900 | 1,200 | 72,500 | 32,147 | 1,476 |
| 2000 | 79,200 | 32,200 | 1,200 | 72,131 | 30,893 | 1,449 |
| 2001 | 84,500 | 32,400 | 1,200 | 75,230 | 30,514 | 1,463 |
| 2002 | 91,300 | 34,600 | 1,300 | 80,016 | 32,193 | 1,527 |
| 2003 | 98,100 | 37,900 | 1,400 | 86,671 | 35,247 | 1,642 |
| 2004 | 103,000 | 41,100 | 1,500 | 93,426 | 38,519 | 1,761 |
| 2005 | 106,700 | 45,100 | 1,600 | 98,501 | 42,724 | 1,869 |
| 2006 | 110,100 | 47,800 | 1,700 | 103,483 | 45,726 | 1,966 |
| 2007 | 112,000 | 48,700 | 1,800 | 107,540 | 47,084 | 2,027 |
| 2008 | 116,900 | 49,400 | 1,900 | 110,056 | 48,232 | 2,022 |
| 2009 | 119,700 | 50,600 | 2,000 | 113,154 | 49,560 | 1,994 |
| 2010 | 118,600 | 51,300 | 2,300 | 113,501 | 49,667 | 1,997 |
| 2011 | 116,900 | 52,600 | 2,600 | 109,702 | 49,603 | 2,038 |
| 2012 | | | | 104,087 | 48,466 | 2,080 |
| 2013 | | | | 97,408 | 46,191 | 2,099 |
| 2014 | | | | 98,124 | 42,728 | 2,119 |
| 2015 | | | | 99,119 | 41,418 | 2,304 |
| 2016 | | | | 108,340 | 43,808 | 0 |

Table 16. Time series of female numbers-at-age for the current base case assessment.

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1982** | 54,948 | 37,399 | 25,394 | 20,741 | 14,138 | 12,858 | 10,839 | 9,254 | 7,702 | 6,542 | 5,673 | 4,871 | 4,177 | 3,671 | 3,281 | 2,793 | 2,462 | 2,125 | 2,479 | 2,092 | 11,287 |
| **1983** | 67,180 | 46,357 | 31,552 | 21,424 | 17,498 | 11,926 | 10,843 | 9,135 | 7,789 | 6,470 | 5,478 | 4,730 | 4,044 | 3,454 | 3,028 | 2,706 | 2,303 | 2,030 | 1,752 | 2,044 | 11,031 |
| **1984** | 57,630 | 56,677 | 39,110 | 26,620 | 18,074 | 14,760 | 10,058 | 9,141 | 7,695 | 6,553 | 5,431 | 4,586 | 3,949 | 3,367 | 2,871 | 2,517 | 2,249 | 1,914 | 1,688 | 1,456 | 10,868 |
| **1985** | 60,180 | 48,620 | 47,816 | 32,996 | 22,457 | 15,248 | 12,450 | 8,482 | 7,705 | 6,480 | 5,511 | 4,560 | 3,844 | 3,304 | 2,814 | 2,400 | 2,103 | 1,879 | 1,600 | 1,410 | 10,300 |
| **1986** | 40,930 | 50,772 | 41,019 | 40,341 | 27,837 | 18,946 | 12,863 | 10,502 | 7,153 | 6,495 | 5,460 | 4,640 | 3,836 | 3,231 | 2,776 | 2,365 | 2,016 | 1,767 | 1,579 | 1,344 | 9,839 |
| **1987** | 53,204 | 34,532 | 42,834 | 34,606 | 34,034 | 23,485 | 15,983 | 10,850 | 8,858 | 6,032 | 5,475 | 4,600 | 3,907 | 3,229 | 2,719 | 2,336 | 1,990 | 1,697 | 1,487 | 1,329 | 9,411 |
| **1988** | 34,899 | 44,886 | 29,133 | 36,138 | 29,194 | 28,706 | 19,801 | 13,464 | 9,125 | 7,427 | 5,035 | 4,544 | 3,794 | 3,205 | 2,640 | 2,222 | 1,909 | 1,626 | 1,386 | 1,215 | 8,775 |
| **1989** | 33,052 | 29,443 | 37,869 | 24,578 | 30,486 | 24,624 | 24,202 | 16,678 | 11,321 | 7,648 | 6,197 | 4,175 | 3,743 | 3,107 | 2,615 | 2,153 | 1,812 | 1,557 | 1,326 | 1,131 | 8,148 |
| **1990** | 33,783 | 27,885 | 24,840 | 31,949 | 20,735 | 25,716 | 20,767 | 20,402 | 14,047 | 9,520 | 6,417 | 5,183 | 3,481 | 3,111 | 2,578 | 2,169 | 1,786 | 1,503 | 1,291 | 1,100 | 7,696 |
| **1991** | 26,513 | 28,502 | 23,526 | 20,957 | 26,952 | 17,489 | 21,681 | 17,491 | 17,152 | 11,771 | 7,938 | 5,317 | 4,265 | 2,847 | 2,535 | 2,099 | 1,767 | 1,454 | 1,224 | 1,052 | 7,163 |
| **1992** | 28,321 | 22,368 | 24,046 | 19,848 | 17,675 | 22,716 | 14,717 | 18,180 | 14,566 | 14,115 | 9,515 | 6,270 | 4,094 | 3,211 | 2,114 | 1,879 | 1,556 | 1,309 | 1,078 | 907 | 6,088 |
| **1993** | 23,979 | 23,893 | 18,871 | 20,287 | 16,741 | 14,902 | 19,133 | 12,367 | 15,209 | 12,092 | 11,583 | 7,691 | 4,985 | 3,207 | 2,494 | 1,640 | 1,457 | 1,207 | 1,016 | 836 | 5,426 |
| **1994** | 30,488 | 20,230 | 20,158 | 15,921 | 17,112 | 14,115 | 12,552 | 16,079 | 10,348 | 12,630 | 9,929 | 9,371 | 6,123 | 3,912 | 2,496 | 1,938 | 1,274 | 1,133 | 938 | 789 | 4,866 |
| **1995** | 39,235 | 25,721 | 17,068 | 17,007 | 13,429 | 14,426 | 11,885 | 10,541 | 13,432 | 8,567 | 10,315 | 7,967 | 7,375 | 4,737 | 2,995 | 1,908 | 1,481 | 974 | 866 | 717 | 4,323 |
| **1996** | 51,295 | 33,101 | 21,700 | 14,399 | 14,344 | 11,320 | 12,144 | 9,976 | 8,795 | 11,096 | 6,970 | 8,229 | 6,219 | 5,649 | 3,587 | 2,264 | 1,442 | 1,120 | 736 | 654 | 3,810 |
| **1997** | 79,247 | 43,276 | 27,926 | 18,308 | 12,143 | 12,086 | 9,518 | 10,163 | 8,273 | 7,180 | 8,847 | 5,389 | 6,151 | 4,513 | 4,026 | 2,550 | 1,609 | 1,025 | 796 | 523 | 3,173 |
| **1998** | 70,155 | 66,858 | 36,510 | 23,561 | 15,442 | 10,237 | 10,176 | 7,992 | 8,488 | 6,845 | 5,859 | 7,089 | 4,233 | 4,748 | 3,447 | 3,070 | 1,944 | 1,227 | 782 | 607 | 2,819 |
| **1999** | 68,060 | 59,188 | 56,406 | 30,802 | 19,873 | 13,019 | 8,622 | 8,551 | 6,685 | 7,044 | 5,615 | 4,733 | 5,631 | 3,313 | 3,683 | 2,670 | 2,378 | 1,506 | 951 | 605 | 2,654 |
| **2000** | 66,098 | 57,420 | 49,934 | 47,587 | 25,980 | 16,753 | 10,961 | 7,239 | 7,140 | 5,529 | 5,744 | 4,495 | 3,713 | 4,339 | 2,526 | 2,803 | 2,032 | 1,810 | 1,146 | 723 | 2,480 |
| **2001** | 55,142 | 55,764 | 48,443 | 42,128 | 40,134 | 21,897 | 14,098 | 9,191 | 6,028 | 5,875 | 4,469 | 4,536 | 3,459 | 2,794 | 3,221 | 1,871 | 2,076 | 1,505 | 1,341 | 849 | 2,374 |
| **2002** | 45,003 | 46,521 | 47,046 | 40,870 | 35,532 | 33,831 | 18,432 | 11,830 | 7,666 | 4,975 | 4,773 | 3,557 | 3,530 | 2,639 | 2,106 | 2,424 | 1,408 | 1,562 | 1,133 | 1,009 | 2,425 |
| **2003** | 67,121 | 37,968 | 39,248 | 39,691 | 34,470 | 29,949 | 28,472 | 15,460 | 9,858 | 6,316 | 4,030 | 3,782 | 2,751 | 2,672 | 1,972 | 1,571 | 1,807 | 1,050 | 1,165 | 845 | 2,561 |
| **2004** | 62,474 | 56,627 | 32,032 | 33,112 | 33,474 | 29,048 | 25,193 | 23,854 | 12,851 | 8,084 | 5,075 | 3,154 | 2,874 | 2,038 | 1,949 | 1,435 | 1,143 | 1,315 | 764 | 848 | 2,479 |
| **2005** | 66,114 | 52,707 | 47,774 | 27,024 | 27,932 | 28,228 | 24,478 | 21,194 | 20,004 | 10,718 | 6,686 | 4,153 | 2,550 | 2,300 | 1,620 | 1,548 | 1,140 | 908 | 1,045 | 607 | 2,643 |
| **2006** | 29,534 | 55,778 | 44,467 | 40,306 | 22,795 | 23,550 | 23,776 | 20,572 | 17,734 | 16,613 | 8,801 | 5,410 | 3,306 | 2,002 | 1,790 | 1,259 | 1,203 | 886 | 706 | 812 | 2,526 |
| **2007** | 31,507 | 24,916 | 47,058 | 37,515 | 33,995 | 19,215 | 19,824 | 19,952 | 17,159 | 14,640 | 13,501 | 7,008 | 4,213 | 2,524 | 1,510 | 1,348 | 949 | 906 | 667 | 532 | 2,514 |
| **2008** | 13,466 | 26,581 | 21,021 | 39,701 | 31,643 | 28,661 | 16,182 | 16,654 | 16,682 | 14,230 | 11,991 | 10,882 | 5,550 | 3,285 | 1,950 | 1,165 | 1,040 | 732 | 699 | 515 | 2,349 |
| **2009** | 16,358 | 11,361 | 22,425 | 17,735 | 33,488 | 26,681 | 24,143 | 13,602 | 13,942 | 13,866 | 11,702 | 9,725 | 8,692 | 4,374 | 2,568 | 1,523 | 910 | 812 | 571 | 546 | 2,236 |
| **2010** | 116,897 | 13,801 | 9,585 | 18,920 | 14,957 | 28,225 | 22,452 | 20,246 | 11,329 | 11,476 | 11,213 | 9,247 | 7,493 | 6,550 | 3,252 | 1,905 | 1,130 | 675 | 602 | 424 | 2,064 |
| **2011** | 61,046 | 98,622 | 11,643 | 8,086 | 15,958 | 12,610 | 23,768 | 18,857 | 16,918 | 9,385 | 9,382 | 9,012 | 7,294 | 5,813 | 5,031 | 2,494 | 1,461 | 866 | 518 | 462 | 1,908 |
| **2012** | 81,570 | 51,502 | 83,204 | 9,823 | 6,821 | 13,456 | 10,623 | 19,983 | 15,793 | 14,074 | 7,728 | 7,625 | 7,219 | 5,769 | 4,563 | 3,944 | 1,955 | 1,146 | 679 | 406 | 1,858 |
| **2013** | 52,873 | 68,818 | 43,450 | 70,196 | 8,286 | 5,752 | 11,338 | 8,937 | 16,756 | 13,169 | 11,638 | 6,322 | 6,163 | 5,774 | 4,585 | 3,623 | 3,132 | 1,552 | 910 | 539 | 1,798 |
| **2014** | 52,873 | 44,607 | 58,059 | 36,658 | 59,208 | 6,986 | 4,844 | 9,525 | 7,471 | 13,890 | 10,780 | 9,371 | 4,999 | 4,797 | 4,451 | 3,530 | 2,789 | 2,411 | 1,195 | 700 | 1,799 |
| **2015** | 52,873 | 44,607 | 37,633 | 48,982 | 30,920 | 49,918 | 5,883 | 4,069 | 7,963 | 6,195 | 11,376 | 8,687 | 7,419 | 3,897 | 3,704 | 3,432 | 2,722 | 2,150 | 1,859 | 922 | 1,927 |

Table 17. Time series of male numbers-at-age for the current base case assessment.

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1982** | 54,948 | 37,399 | 25,394 | 20,741 | 14,138 | 12,858 | 10,839 | 9,254 | 7,702 | 6,542 | 5,673 | 4,871 | 4,177 | 3,671 | 3,281 | 2,793 | 2,462 | 2,125 | 2,479 | 2,092 | 11,287 |
| **1983** | 67,180 | 46,357 | 31,552 | 21,424 | 17,496 | 11,924 | 10,840 | 9,131 | 7,786 | 6,467 | 5,477 | 4,733 | 4,048 | 3,458 | 3,031 | 2,706 | 2,303 | 2,030 | 1,752 | 2,044 | 11,031 |
| **1984** | 57,630 | 56,677 | 39,110 | 26,620 | 18,073 | 14,758 | 10,055 | 9,136 | 7,689 | 6,548 | 5,429 | 4,587 | 3,954 | 3,374 | 2,877 | 2,519 | 2,249 | 1,914 | 1,688 | 1,456 | 10,868 |
| **1985** | 60,180 | 48,620 | 47,816 | 32,996 | 22,457 | 15,246 | 12,447 | 8,478 | 7,699 | 6,474 | 5,507 | 4,559 | 3,846 | 3,310 | 2,821 | 2,404 | 2,105 | 1,880 | 1,600 | 1,410 | 10,300 |
| **1986** | 40,930 | 50,772 | 41,019 | 40,341 | 27,837 | 18,945 | 12,860 | 10,498 | 7,149 | 6,490 | 5,455 | 4,637 | 3,836 | 3,234 | 2,781 | 2,370 | 2,020 | 1,769 | 1,579 | 1,344 | 9,839 |
| **1987** | 53,204 | 34,532 | 42,834 | 34,606 | 34,034 | 23,484 | 15,982 | 10,848 | 8,854 | 6,028 | 5,471 | 4,596 | 3,905 | 3,229 | 2,722 | 2,341 | 1,995 | 1,700 | 1,489 | 1,329 | 9,411 |
| **1988** | 34,899 | 44,886 | 29,133 | 36,138 | 29,190 | 28,700 | 19,792 | 13,455 | 9,117 | 7,420 | 5,031 | 4,544 | 3,797 | 3,209 | 2,643 | 2,224 | 1,912 | 1,630 | 1,389 | 1,216 | 8,775 |
| **1989** | 33,052 | 29,443 | 37,869 | 24,578 | 30,482 | 24,615 | 24,186 | 16,661 | 11,305 | 7,637 | 6,189 | 4,175 | 3,748 | 3,115 | 2,622 | 2,156 | 1,814 | 1,560 | 1,329 | 1,133 | 8,149 |
| **1990** | 33,783 | 27,885 | 24,840 | 31,949 | 20,734 | 25,710 | 20,755 | 20,383 | 14,027 | 9,503 | 6,406 | 5,179 | 3,483 | 3,119 | 2,586 | 2,175 | 1,788 | 1,504 | 1,294 | 1,102 | 7,698 |
| **1991** | 26,513 | 28,502 | 23,526 | 20,957 | 26,948 | 17,483 | 21,666 | 17,470 | 17,122 | 11,747 | 7,924 | 5,312 | 4,268 | 2,854 | 2,545 | 2,106 | 1,771 | 1,456 | 1,225 | 1,054 | 7,167 |
| **1992** | 28,321 | 22,368 | 24,046 | 19,848 | 17,667 | 22,692 | 14,689 | 18,125 | 14,508 | 14,058 | 9,491 | 6,275 | 4,114 | 3,237 | 2,131 | 1,886 | 1,561 | 1,313 | 1,079 | 908 | 6,093 |
| **1993** | 23,979 | 23,893 | 18,871 | 20,287 | 16,736 | 14,886 | 19,093 | 12,325 | 15,136 | 12,026 | 11,532 | 7,685 | 5,008 | 3,239 | 2,523 | 1,653 | 1,463 | 1,211 | 1,018 | 837 | 5,430 |
| **1994** | 30,488 | 20,230 | 20,158 | 15,921 | 17,106 | 14,103 | 12,526 | 16,022 | 10,294 | 12,551 | 9,871 | 9,346 | 6,141 | 3,949 | 2,529 | 1,961 | 1,285 | 1,137 | 941 | 791 | 4,870 |
| **1995** | 39,235 | 25,721 | 17,068 | 17,007 | 13,424 | 14,411 | 11,860 | 10,500 | 13,356 | 8,507 | 10,246 | 7,936 | 7,388 | 4,778 | 3,036 | 1,934 | 1,499 | 982 | 869 | 719 | 4,328 |
| **1996** | 51,295 | 33,101 | 21,700 | 14,399 | 14,338 | 11,307 | 12,115 | 9,935 | 8,741 | 11,011 | 6,919 | 8,192 | 6,227 | 5,695 | 3,634 | 2,295 | 1,462 | 1,133 | 742 | 657 | 3,815 |
| **1997** | 79,247 | 43,276 | 27,926 | 18,308 | 12,136 | 12,066 | 9,487 | 10,108 | 8,208 | 7,114 | 8,773 | 5,368 | 6,172 | 4,564 | 4,088 | 2,584 | 1,631 | 1,039 | 805 | 528 | 3,179 |
| **1998** | 70,155 | 66,858 | 36,510 | 23,561 | 15,436 | 10,223 | 10,147 | 7,951 | 8,423 | 6,780 | 5,802 | 7,044 | 4,236 | 4,792 | 3,500 | 3,117 | 1,970 | 1,244 | 792 | 614 | 2,827 |
| **1999** | 68,060 | 59,188 | 56,406 | 30,802 | 19,867 | 13,006 | 8,601 | 8,513 | 6,639 | 6,980 | 5,559 | 4,695 | 5,617 | 3,332 | 3,730 | 2,711 | 2,415 | 1,526 | 964 | 614 | 2,665 |
| **2000** | 66,098 | 57,420 | 49,934 | 47,587 | 25,970 | 16,736 | 10,937 | 7,208 | 7,093 | 5,481 | 5,690 | 4,460 | 3,700 | 4,354 | 2,550 | 2,839 | 2,063 | 1,838 | 1,161 | 733 | 2,495 |
| **2001** | 55,142 | 55,764 | 48,443 | 42,128 | 40,116 | 21,869 | 14,060 | 9,149 | 5,986 | 5,822 | 4,428 | 4,505 | 3,453 | 2,806 | 3,249 | 1,890 | 2,103 | 1,529 | 1,361 | 860 | 2,392 |
| **2002** | 45,003 | 46,521 | 47,046 | 40,870 | 35,517 | 33,788 | 18,382 | 11,774 | 7,612 | 4,930 | 4,728 | 3,532 | 3,524 | 2,652 | 2,125 | 2,446 | 1,422 | 1,583 | 1,150 | 1,024 | 2,447 |
| **2003** | 67,121 | 37,968 | 39,248 | 39,691 | 34,454 | 29,910 | 28,393 | 15,384 | 9,785 | 6,258 | 3,991 | 3,756 | 2,747 | 2,686 | 1,991 | 1,585 | 1,824 | 1,060 | 1,180 | 858 | 2,589 |
| **2004** | 62,474 | 56,627 | 32,032 | 33,112 | 33,456 | 29,005 | 25,115 | 23,724 | 12,747 | 8,003 | 5,025 | 3,133 | 2,874 | 2,053 | 1,971 | 1,450 | 1,153 | 1,327 | 772 | 859 | 2,509 |
| **2005** | 66,114 | 52,707 | 47,774 | 27,024 | 27,926 | 28,201 | 24,423 | 21,106 | 19,869 | 10,620 | 6,618 | 4,117 | 2,540 | 2,308 | 1,636 | 1,566 | 1,152 | 916 | 1,055 | 613 | 2,675 |
| **2006** | 29,534 | 55,778 | 44,467 | 40,306 | 22,788 | 23,532 | 23,729 | 20,495 | 17,629 | 16,476 | 8,717 | 5,364 | 3,290 | 2,003 | 1,802 | 1,272 | 1,217 | 895 | 712 | 820 | 2,556 |
| **2007** | 31,507 | 24,916 | 47,058 | 37,515 | 33,981 | 19,194 | 19,780 | 19,872 | 17,054 | 14,522 | 13,384 | 6,958 | 4,199 | 2,529 | 1,519 | 1,357 | 958 | 917 | 674 | 536 | 2,542 |
| **2008** | 13,466 | 26,581 | 21,021 | 39,701 | 31,633 | 28,631 | 16,146 | 16,591 | 16,583 | 14,119 | 11,891 | 10,808 | 5,533 | 3,291 | 1,960 | 1,172 | 1,047 | 739 | 707 | 520 | 2,375 |
| **2009** | 16,358 | 11,361 | 22,425 | 17,735 | 33,478 | 26,658 | 24,095 | 13,553 | 13,866 | 13,765 | 11,608 | 9,659 | 8,663 | 4,380 | 2,581 | 1,531 | 915 | 818 | 577 | 552 | 2,260 |
| **2010** | 116,897 | 13,801 | 9,585 | 18,920 | 14,950 | 28,192 | 22,397 | 20,158 | 11,257 | 11,386 | 11,125 | 9,197 | 7,486 | 6,577 | 3,273 | 1,915 | 1,136 | 679 | 607 | 428 | 2,087 |
| **2011** | 61,046 | 98,622 | 11,643 | 8,086 | 15,952 | 12,596 | 23,711 | 18,779 | 16,810 | 9,309 | 9,305 | 8,959 | 7,286 | 5,840 | 5,071 | 2,511 | 1,469 | 871 | 520 | 465 | 1,929 |
| **2012** | 81,570 | 51,502 | 83,204 | 9,823 | 6,819 | 13,444 | 10,601 | 19,909 | 15,702 | 13,965 | 7,663 | 7,574 | 7,201 | 5,787 | 4,598 | 3,976 | 1,968 | 1,151 | 683 | 408 | 1,877 |
| **2013** | 52,873 | 68,818 | 43,450 | 70,196 | 8,284 | 5,748 | 11,320 | 8,909 | 16,673 | 13,079 | 11,546 | 6,276 | 6,139 | 5,779 | 4,611 | 3,651 | 3,157 | 1,563 | 914 | 542 | 1,814 |
| **2014** | 52,873 | 44,607 | 58,059 | 36,658 | 59,188 | 6,980 | 4,835 | 9,494 | 7,433 | 13,798 | 10,702 | 9,314 | 4,984 | 4,804 | 4,472 | 3,550 | 2,810 | 2,430 | 1,203 | 704 | 1,814 |
| **2015** | 52,873 | 44,607 | 37,633 | 48,982 | 30,910 | 49,870 | 5,872 | 4,055 | 7,922 | 6,153 | 11,297 | 8,641 | 7,405 | 3,905 | 3,723 | 3,449 | 2,737 | 2,167 | 1,874 | 928 | 1,941 |

Table 18. Non-target catch in the directed GOA rex sole fishery as a proportion of total weight of bycatch of each species. Conditional highlighting from white (lowest numbers) to green (highest numbers) is applied. Birds (recorded in numbers) have not been recorded as bycatch in the GOA rex sole fishery.

| Non-Target Species | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Benthic urochordata | 0.12 | 0.02 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| Bivalves | 0.09 | 0.07 | 0.05 | 0.00 | 0.00 | 0.17 | 0.07 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Brittle star unidentified | 0.00 | 0.00 | 0.03 | 0.00 | 0.03 | 0.20 | 0.04 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.01 |
| Capelin | 0.00 | 0.00 | 0.00 | 0.00 | | 0.06 | 0.68 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.01 |
| Corals Bryozoans - Unidentified | 0.04 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.02 | 0.02 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 |
| Corals Bryozoans -Red Tree Coral | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.56 | 0.00 | 0.00 |
| Dark Rockfish | | | | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 |
| Eelpouts | 0.00 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Eulachon | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Giant Grenadier | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.03 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| Greenlings | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| Ratail Grenadier Unidentified | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 |
| Gunnels | 0.00 | | | 0.00 | | 0.70 | | | | 0.00 | 0.00 | | 0.00 |
| Hermit crab unidentified | 0.10 | 0.00 | 0.01 | 0.17 | 0.01 | 0.00 | 0.02 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 |
| Invertebrate unidentified | 0.00 | 0.01 | 0.00 | 0.00 | 0.03 | 0.06 | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| Large Sculpins | 0.02 | 0.03 | 0.02 | 0.01 | 0.01 | | | | | | | | |
| Large Sculpins - Bigmouth Sculpin | | | | | | 0.05 | 0.30 | 0.14 | 0.08 | 0.16 | 0.10 | 0.01 | 0.08 |
| Large Sculpins - Great Sculpin | | | | | | 0.00 | 0.05 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Large Sculpins - Hemilepidotus Unidentified | | | | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Large Sculpins - Yellow Irish Lord | | | | | | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| Misc crabs | 0.20 | 0.05 | 0.18 | 0.37 | 0.04 | 0.22 | 0.29 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Misc crustaceans | 0.85 | 0.00 | 0.22 | | | | 0.00 | 0.00 | 0.08 | 0.34 | 0.00 | 0.00 | 0.00 |
| Misc fish | | | | | | 0.01 | | | | | 0.00 | | 0.00 |
| Misc inverts (worms etc) | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.53 | | | 0.00 | 0.00 |
| Other osmerids | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Other Sculpins | 0.05 | 0.00 | 0.01 | 0.01 | 0.02 | 0.04 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Pandalid shrimp | 0.15 | 0.00 | 0.00 | 0.00 | 0.03 | 0.05 | 0.13 | 0.04 | 0.01 | 0.00 | 0.08 | 0.01 | 0.01 |
| Polychaete unidentified | 0.00 | | 0.89 | | 0.00 | 0.00 | 1.00 | 1.00 | 0.00 | | 0.39 | | 0.00 |
| Scypho jellies | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.02 | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| Sea anemone unidentified | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sea pens whips | 0.04 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sea star | 0.02 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Snails | 0.08 | 0.06 | 0.01 | 0.13 | 0.02 | 0.21 | 0.02 | 0.02 | 0.02 | 0.00 | 0.03 | 0.00 | 0.00 |
| Sponge unidentified | 0.05 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.05 | 0.00 | 0.03 | 0.00 | 0.21 | 0.03 | 0.01 |
| Stichaeidae | 0.17 | 0.00 | 0.01 | 0.00 | 0.09 | 0.12 | 0.01 | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 | 0.05 |
| urchins dollars cucumbers | 0.32 | 0.01 | 0.15 | 0.00 | 0.02 | 0.01 | 0.22 | 0.29 | 0.03 | 0.06 | 0.10 | 0.02 | 0.02 |

Table 19. Prohibited species catch in the GOA rex sole directed fishery as a proportion of all prohibited species catch in the GOA in 2014 and 2015.

| | 2015 | | 2014 | |
|---|---|---|---|---|
| **Species Group Name** | **PSCNQ Estimate** | **Halibut Mortality** | **PSCNQ Estimate** | **Halibut Mortality** |
| Bairdi Tanner Crab | 0.000 | -- | 0.001 | -- |
| Blue King Crab | | | | |
| Chinook Salmon | 0.007 | -- | 0.025 | -- |
| Golden (Brown) King Crab | 0.000 | -- | 0.000 | -- |
| Halibut | 0.010 | 0.017 | 0.020 | 0.034 |
| Herring | 0.000 | -- | 0.000 | -- |
| Non-Chinook Salmon | 0.000 | -- | 0.038 | -- |
| Opilio Tanner (Snow) Crab | 0.000 | -- | 0.000 | -- |
| Other King Crab | | | | |
| Red King Crab | 0.000 | -- | 0.000 | -- |

# Figures

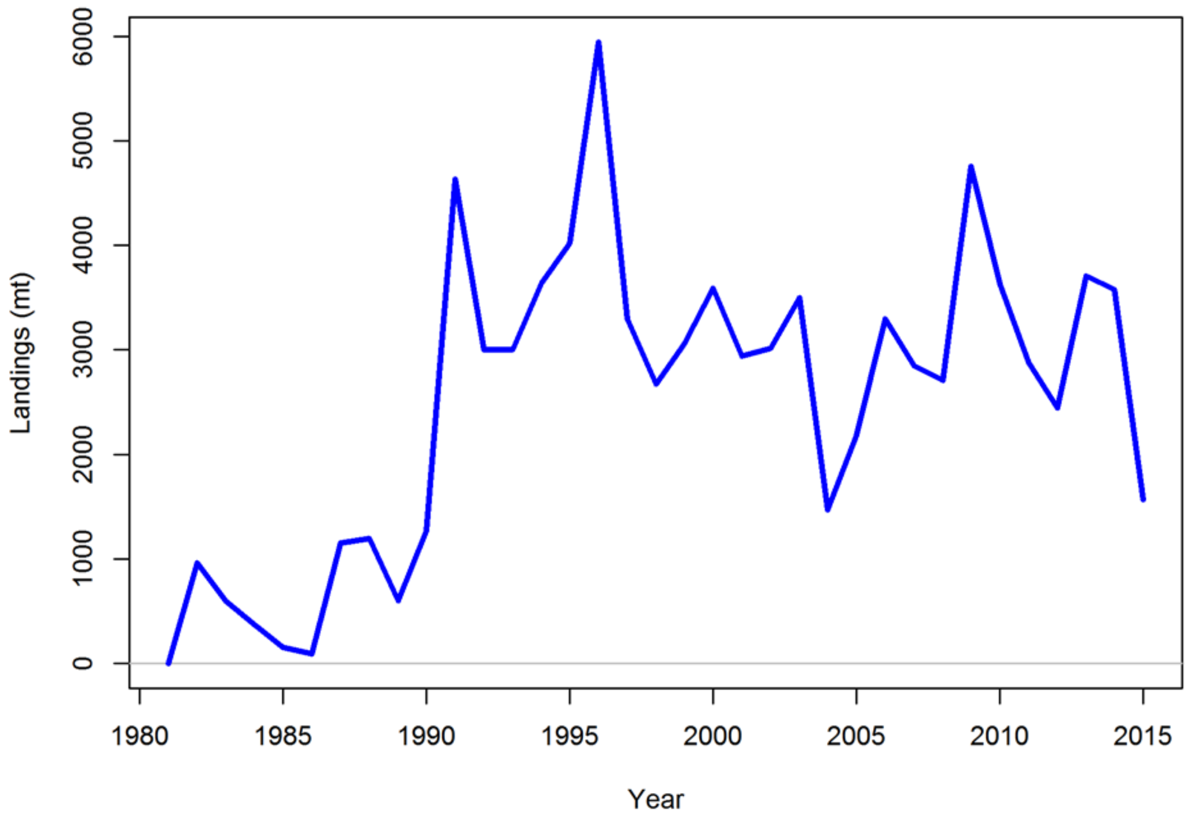



Figure 1. Fishery catches for GOA rex sole, 1982-2015. Catch for 2015 is through October 10, 2015.

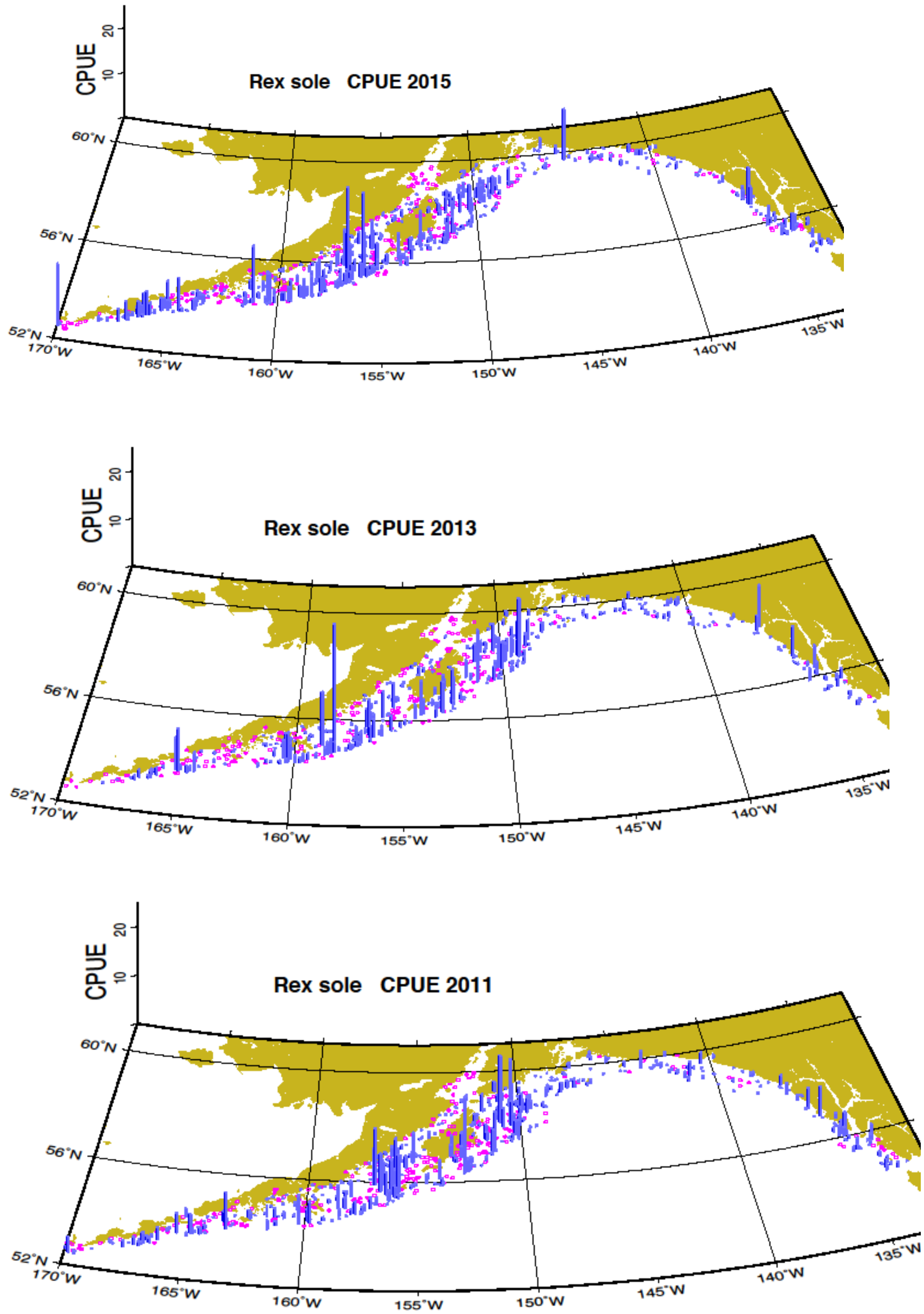



Figure 2. Maps of GOA rex sole survey catch per unit effort (CPUE) for 2015, 2013, and 2011 (the three most recent survey years). Purple lines denote CPUE and pink dots denote trawls where no rex sole were captured.

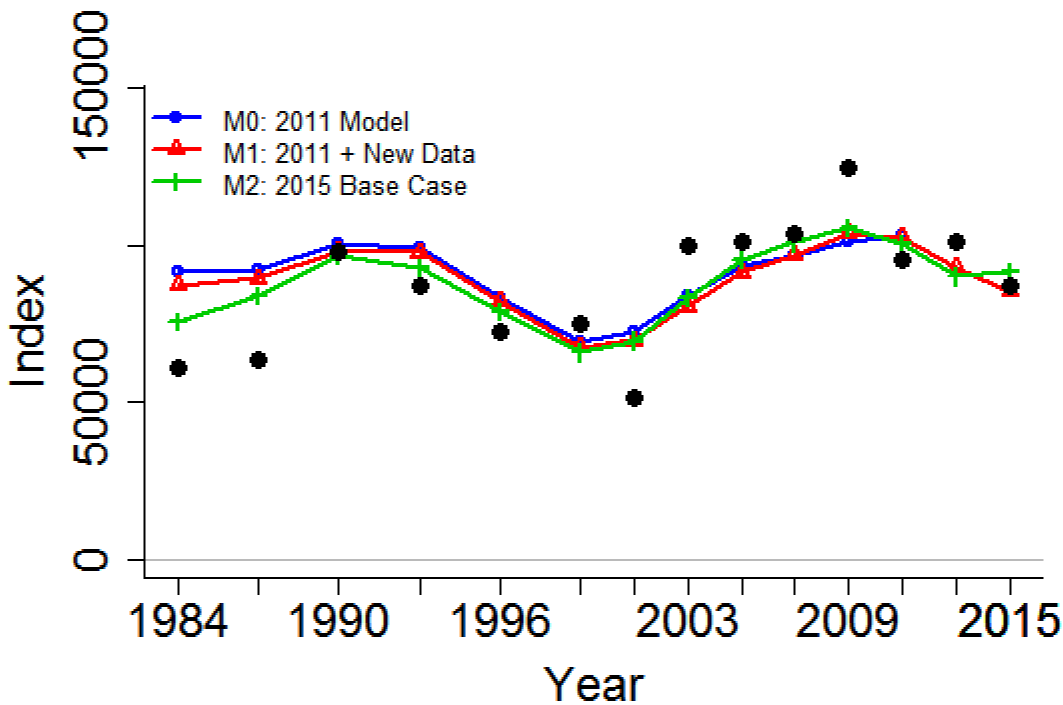



Figure 3. GOA survey biomass estimates for rex sole (dots) and model fits to survey biomass (lines).

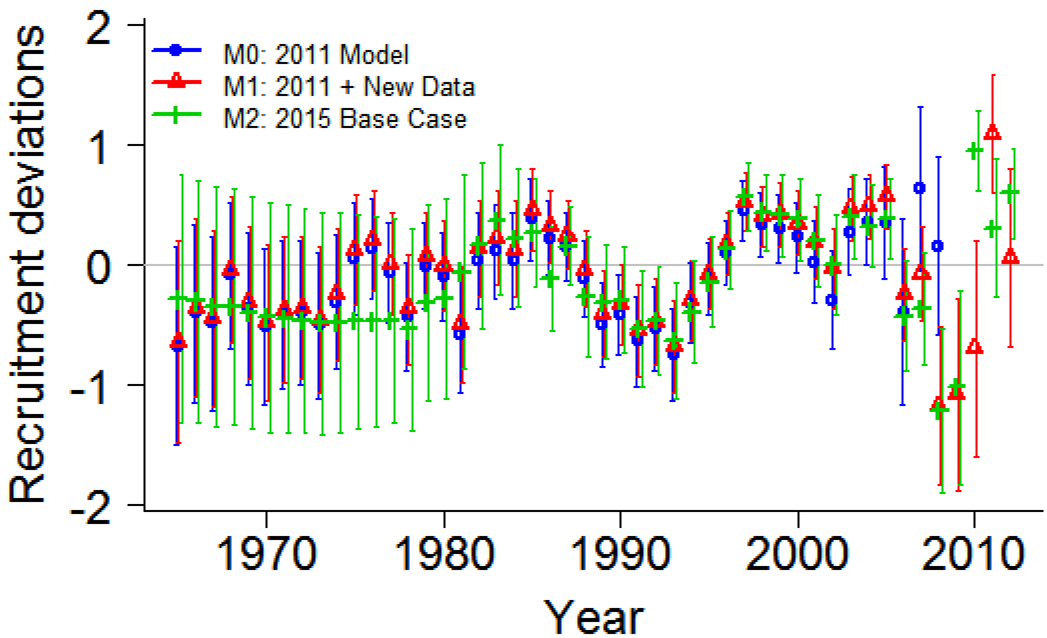



Figure 4. Estimates of recruitment deviations and corresponding 95% asymptotic confidence intervals for the 2011 model, the 2011 model structure with new data (in SS3), and the current base case model.

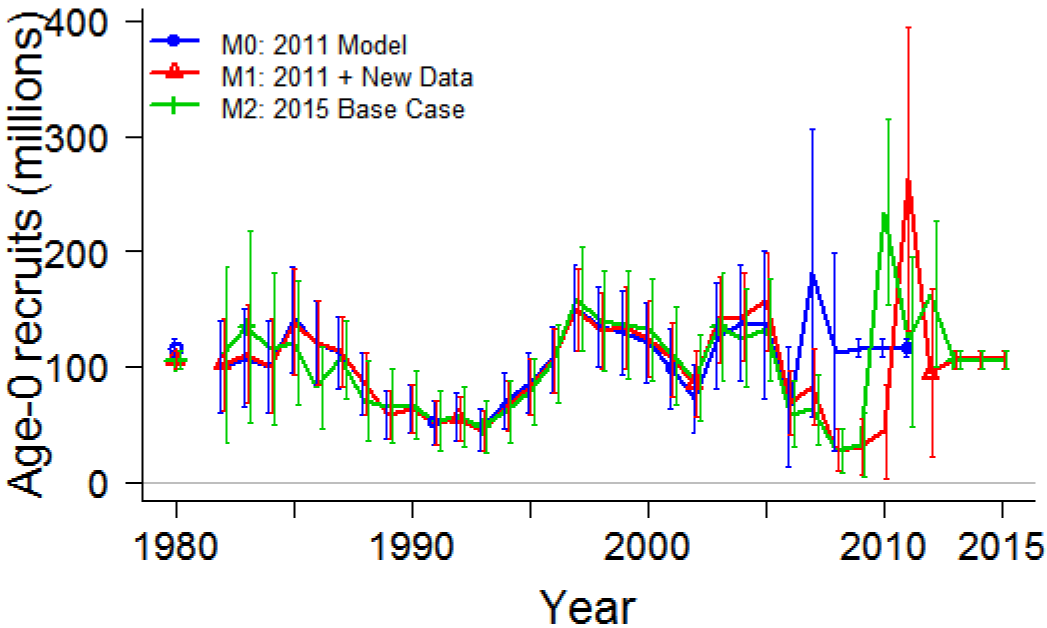



Figure 5. Estimates of age 0 recruitments with associated 95% asymptotic confidence intervals for the SS3 version of the 2011 model, the SS3 version of the 2011 model with new data added, and the current base case model.

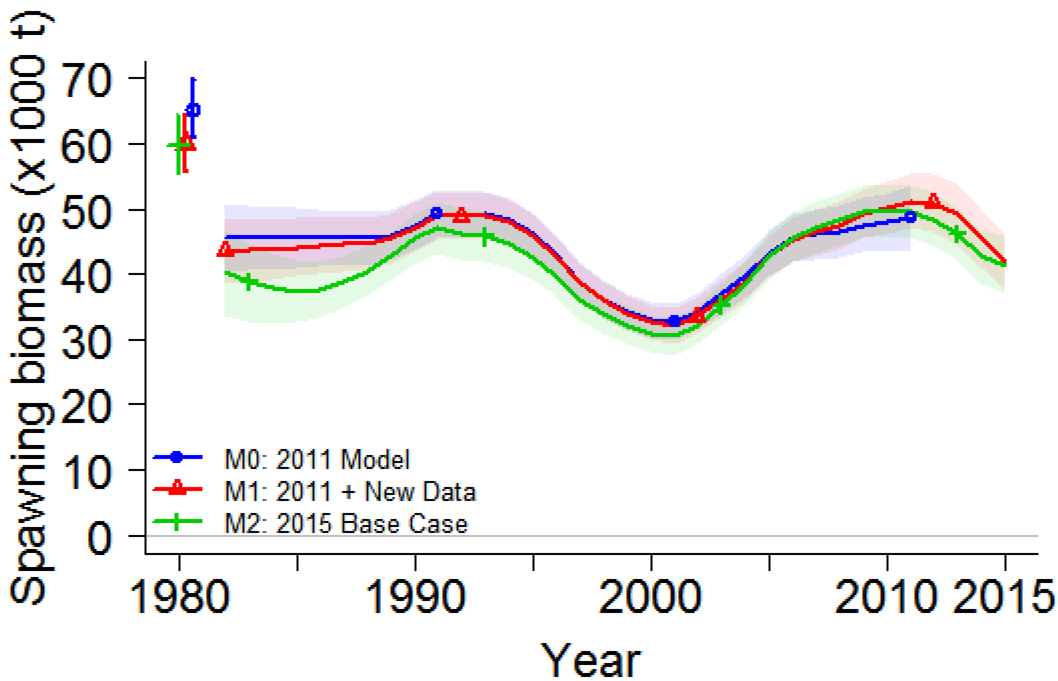



Figure 6. Spawning biomass for the SS3 version of the 2011 model, the SS3 version of the 2011 model with new data added, and the current base case model.

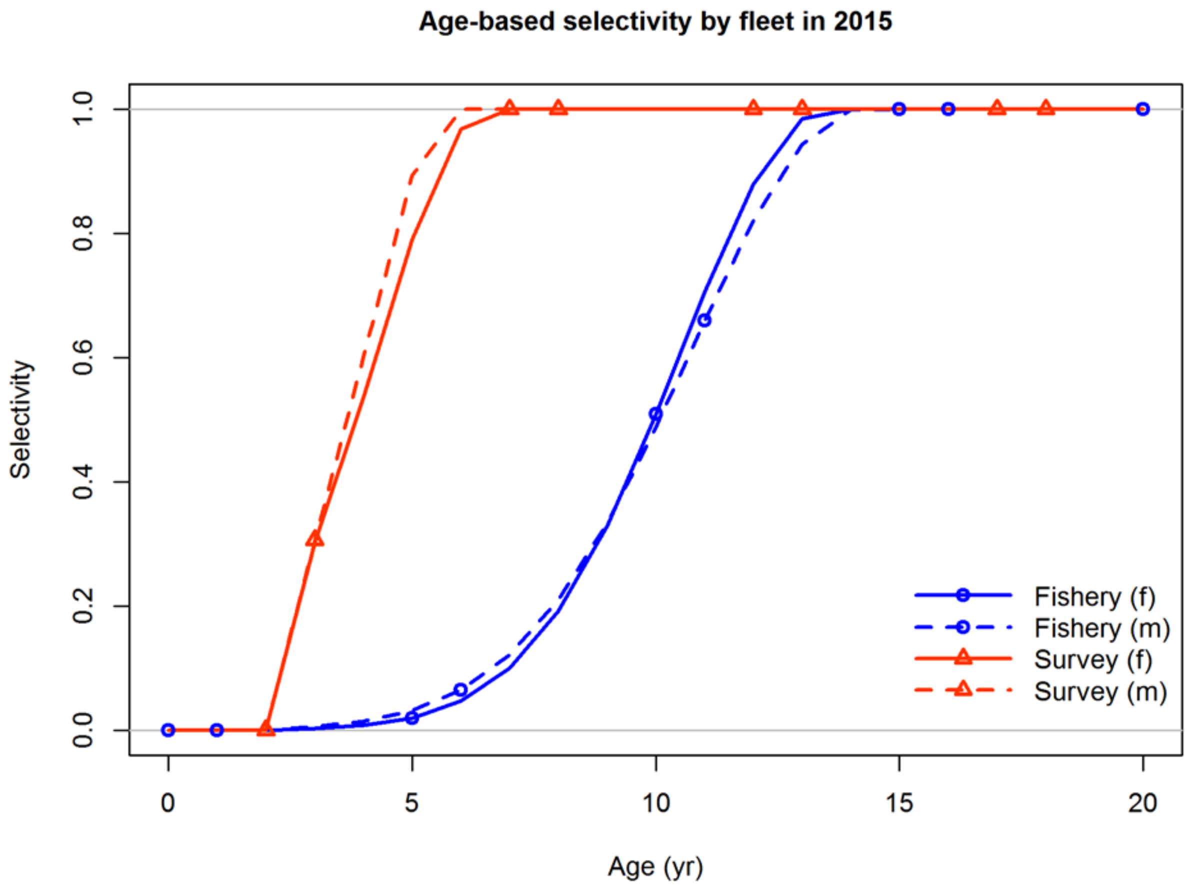



Figure 7. Fishery and survey selectivity at age for the current base case model.

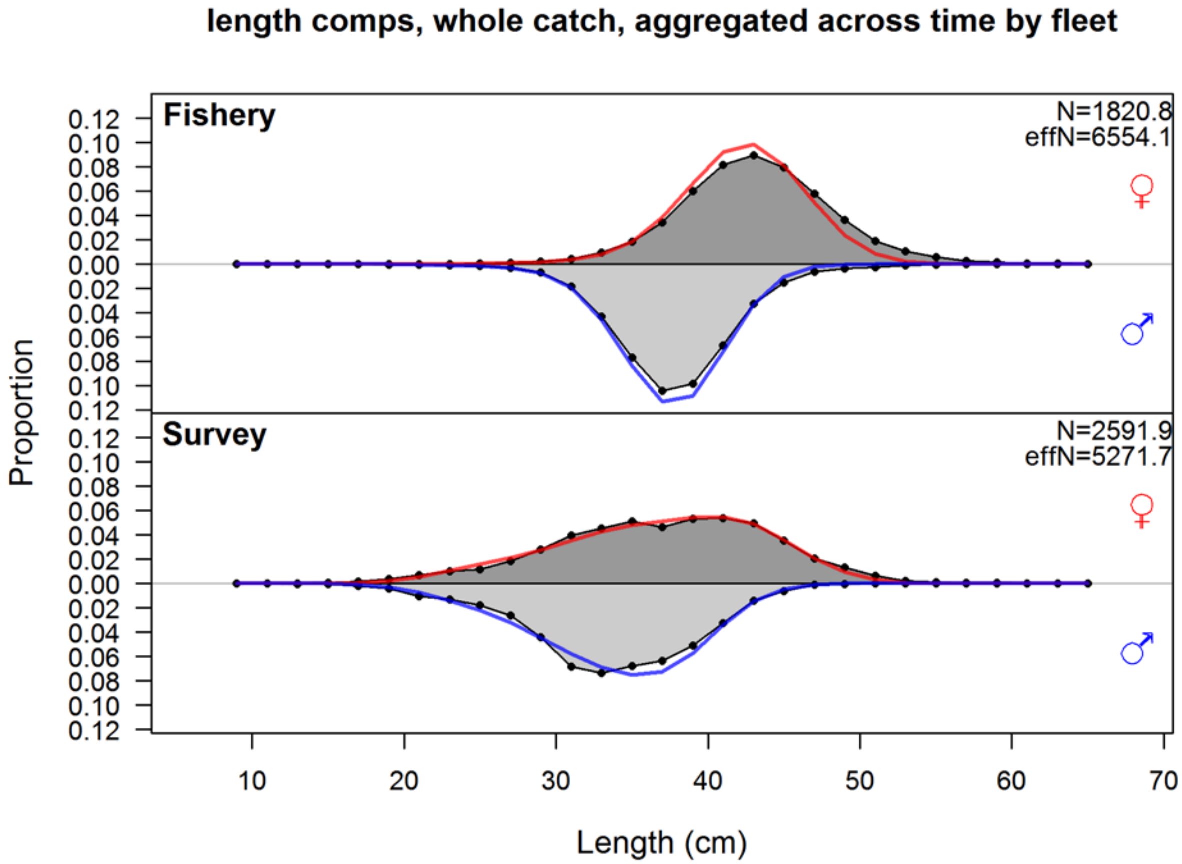



Figure 8. Observed (grey shaded area, black lines) and expected (red lines) proportions-at-length, aggregated over years for the fishery and survey and for females (above x-axes) and males (below x-axes).

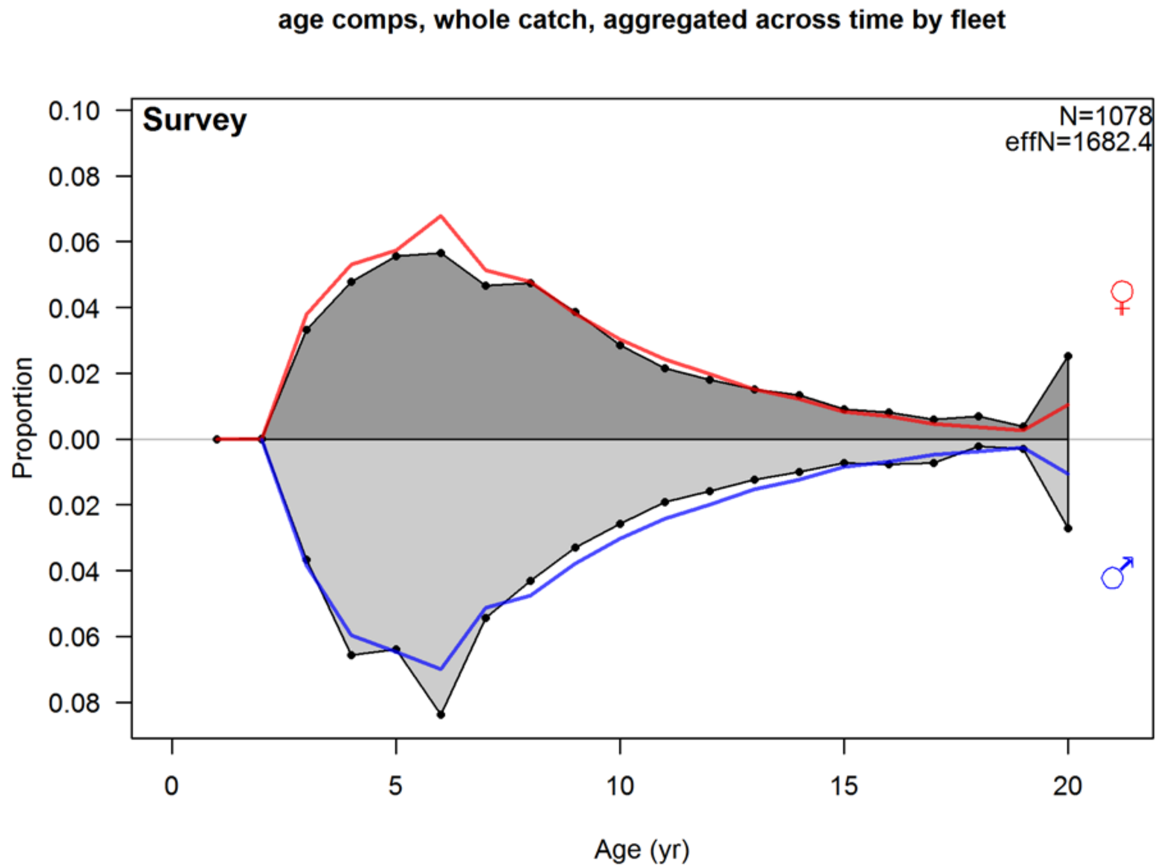



Figure 9. Observed (grey shaded area, black lines) and expected (red lines) proportions-at-age, aggregated over years for the fishery and survey and for females (above x-axes) and males (below x-axes).

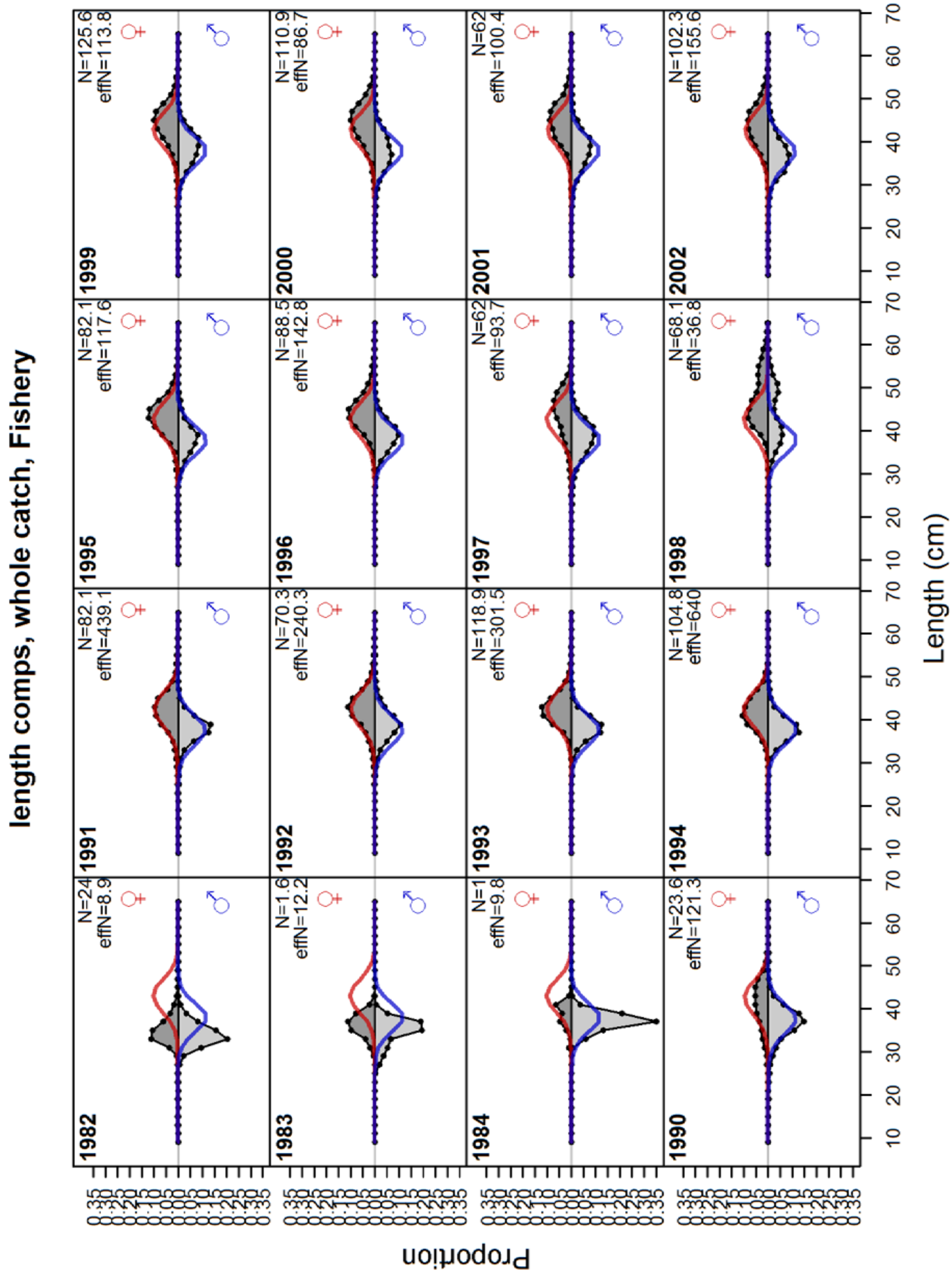



Figure 10. Observed (grey filled area and black line) and expected (red and blue lines) fishery length compositions for years 1982-2002 for males (blue lines) and females (red lines).

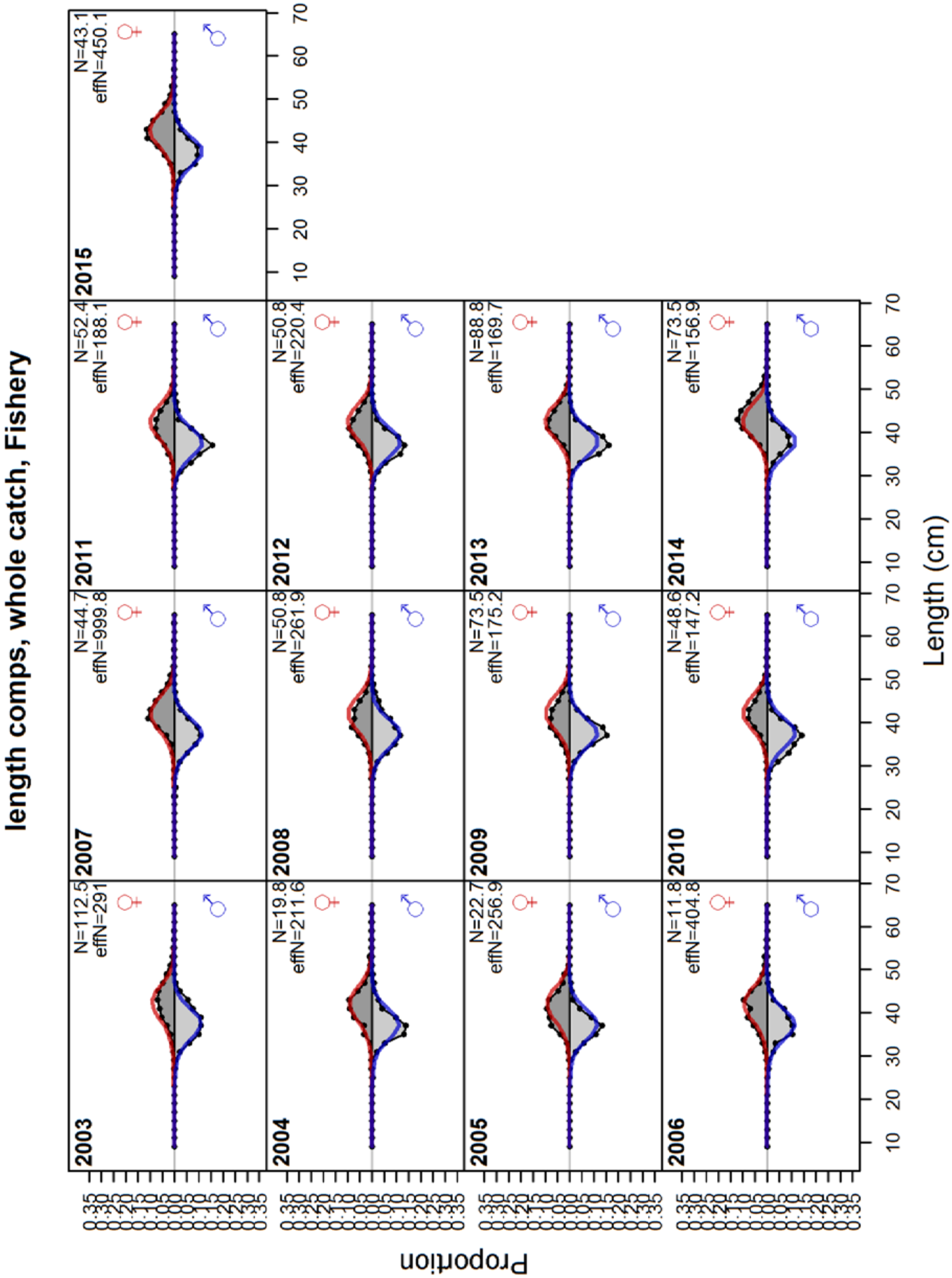



Figure 11. As for Figure 10, but for years 2003-2015.

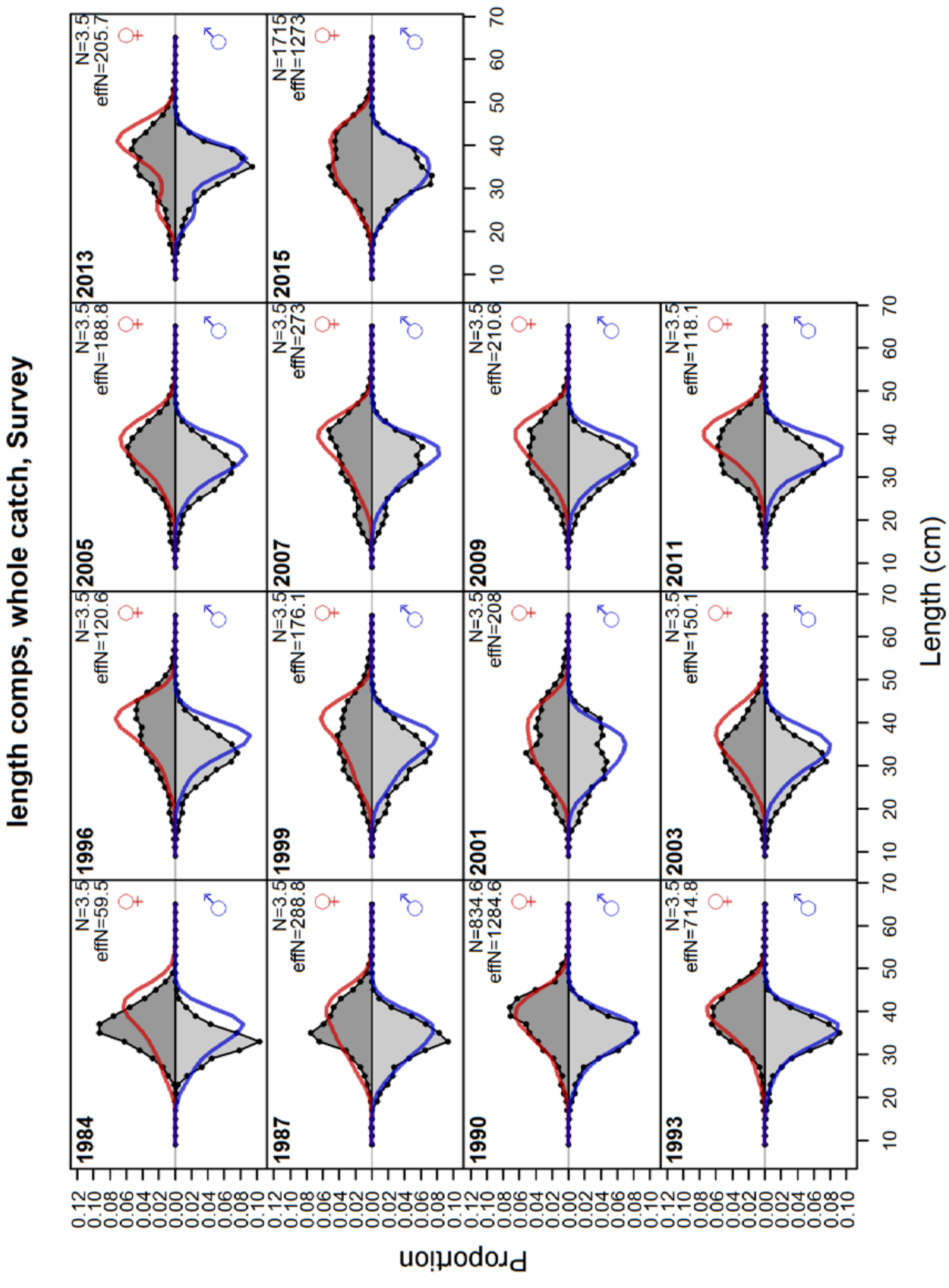



Figure 12. Observed (grey filled area and black line) and expected (red and blue lines) survey length compositions for all years of survey data for males (blue lines) and females (red lines).

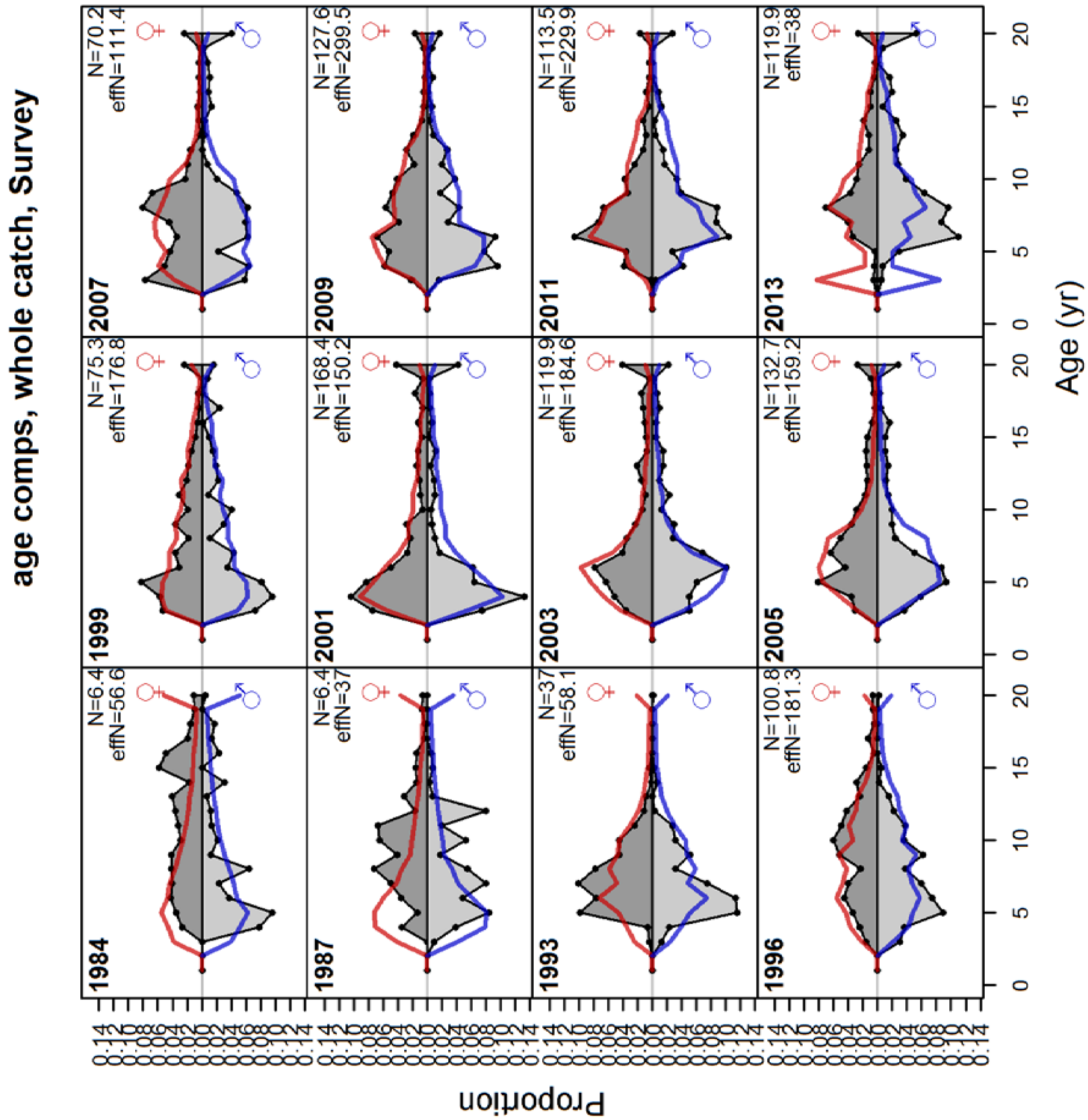



Figure 13. Observed (grey filled area and black line) and expected (red and blue lines) survey age compositions for all years of survey data for males (blue lines) and females (red lines).

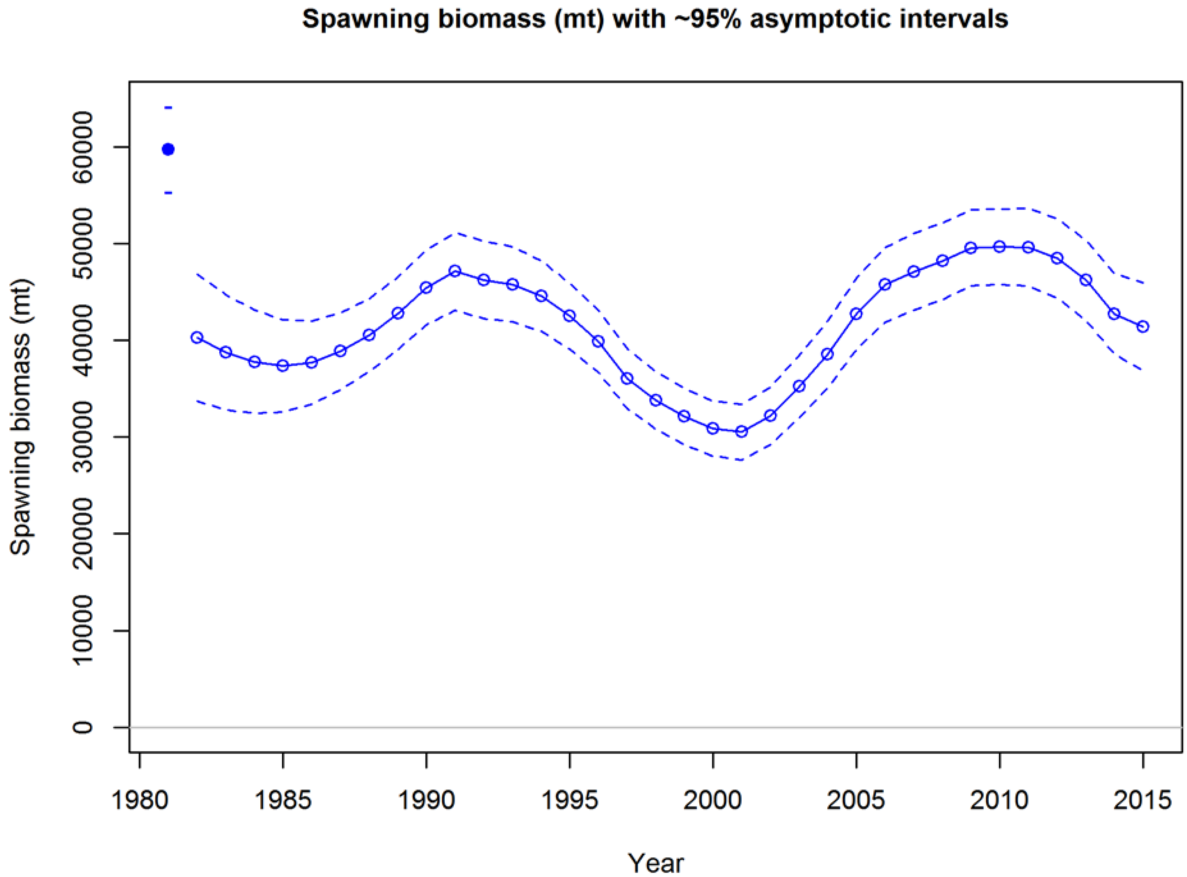



Figure 14. Spawning stock biomass (solid blue line with dots) and 95% asymptotic confidence intervals (dotted blue lines) for the current base case assessment model.

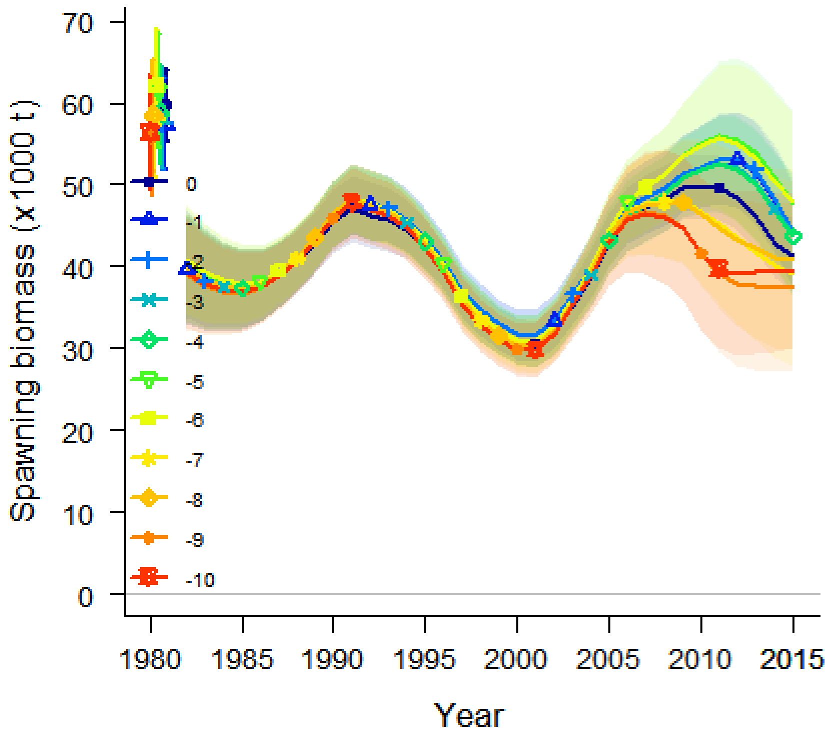
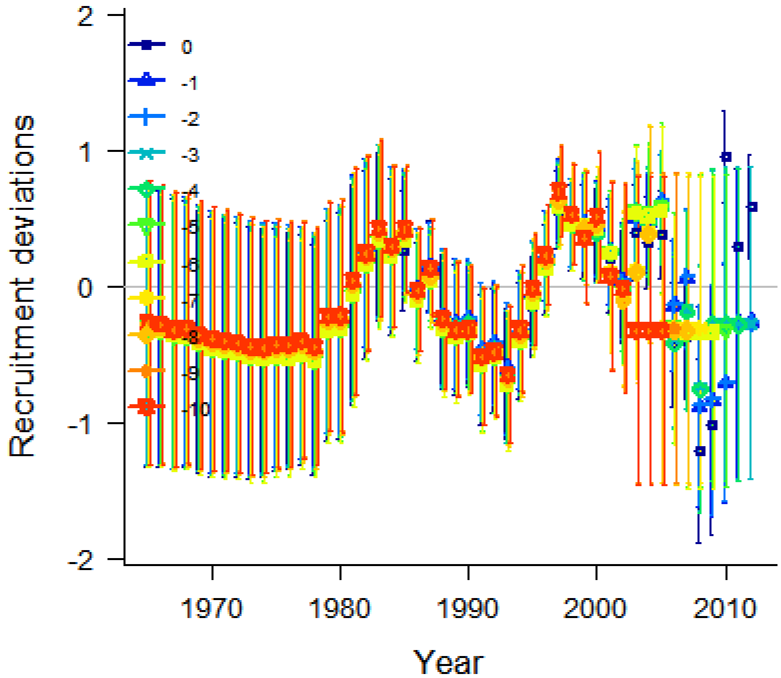



Figure 15. Spawning stock biomass and corresponding 95% asymptotic confidence intervals for model runs, leaving out 0 to 10 years of the most recent data. All models were run until 2015, assuming mean recruitment for all years of data excluded in the run.



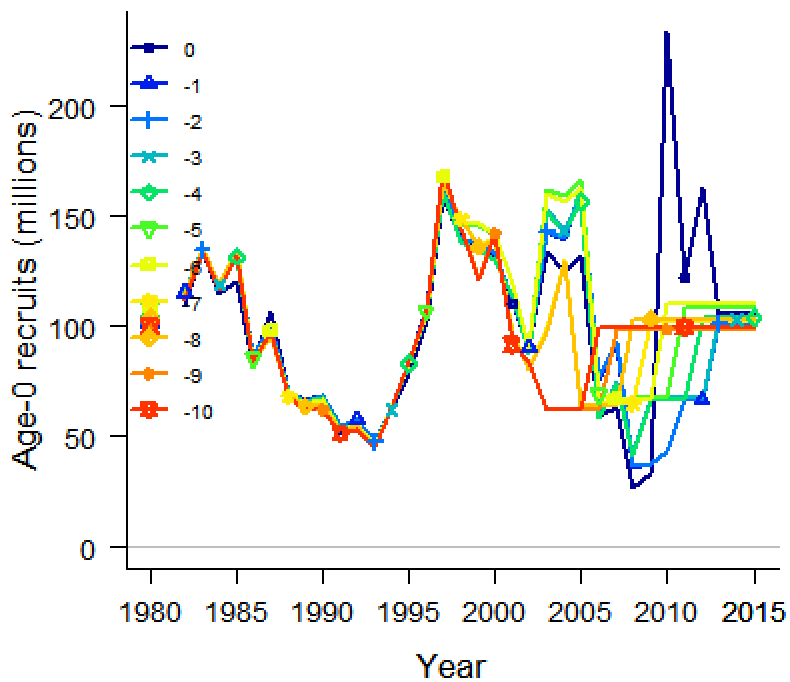




Figure 16. Recruitment deviations and corresponding 95% asymptotic confidence intervals (top panel) and age 0 recruits (bottom panel) for all runs of a retrospective analysis excluding 0 to 10 years of the most recent data. All models were run until 2015, assuming mean recruitment for all years of data excluded in the run.

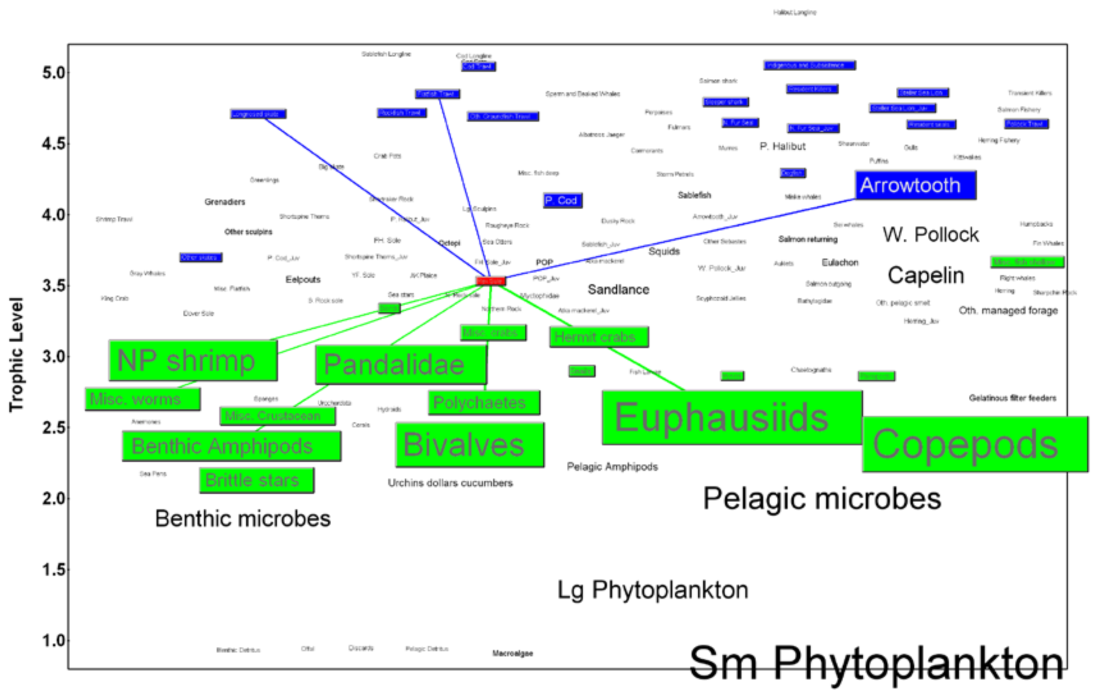



Figure 17. Gulf of Alaska food web from the GOA ecosystem model (Aydin et al., 2007) highlighting rex sole links to predators (blue boxes and lines) and prey (green boxes and lines). Box size reflects relative standing stock biomass.

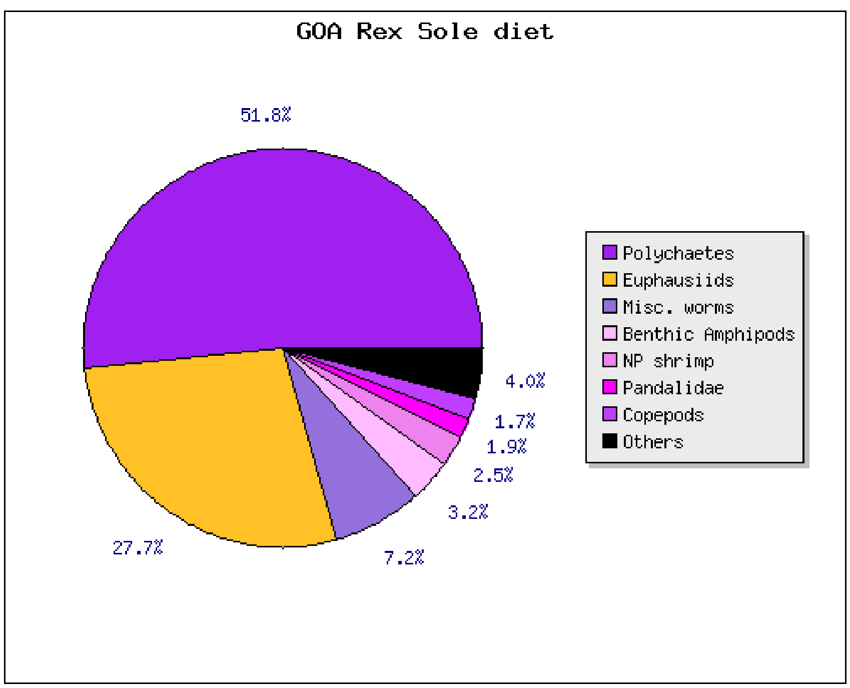



Figure 18. Diet composition for Gulf of Alaska rex sole from the GOA ecosystem model (Aydin et al., 2007).

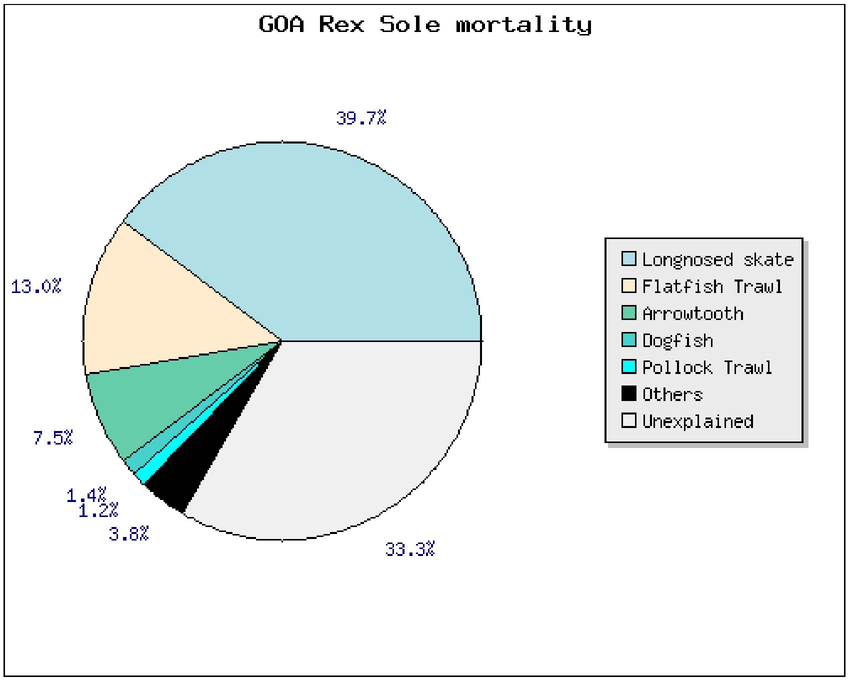



Figure 19. Decomposition of natural mortality for Gulf of Alaska rex sole from the GOA ecosystem model (Aydin et al., 2007).

# Appendix 6A: Specifications for the 2011 model run in SS3 with new data

| Quantity | As estimated or *recommended this* year for: 2015 | 2016 | As estimated or *recommended this* year for: 2016 | 2017 |
|---|---|---|---|---|
| *M* (natural mortality rate) | 0.17 | 0.17 | 0.17 | 0.17 |
| Tier | 5 | 5 | 5 | 5 |
| Projected total (3+) biomass (t) | 82,972 | 81,414 | 74,860 | 75,006 |
| Female spawning biomass (t) | 49,804 | 48,554 | 44,616 | 44,733 |
| $B_{100\%}$ | 55,393 | 55,393 | 54,856 | 54,676 |
| $B_{40\%}$ | 22,159 | 22,159 | 21,942 | 21,942 |
| $B_{35\%}$ | 19,434 | 19,434 | 19,200 | 19,200 |
| $F_{OFL}=M$ | 0.170 | 0.170 | 0.17 | 0.17 |
| $maxF_{ABC}=0.75*M$ | 0.128 | 0.128 | 0.128 | 0.128 |
| $F_{ABC}$ | 0.128 | 0.128 | 0.128 | 0.128 |
| OFL (t) | 11,957 | 11,733 | 10,788 | 10,809 |
| maxABC (t) | 9,150 | 8,979 | 8,256 | 8,272 |
| ABC (t) | 9,150 | 8,979 | 8,256 | 8,272 |
| **Status** | As determined in 2014 for: 2013 | 2014 | As determined in 2015 for: 2014 | 2015 |
| Overfishing | no | n/a | no | n/a |
| Overfished | n/a | no | n/a | no |

* Projections are based on estimated catches of 1,817.6 t, 3,188 t, and 8,979 t that were used in place of maximum permissible ABC for 2015, 2016, and 2017 respectively. The 2015 projected catch was calculated as the current catch of GOA rex sole as of October 10, 2015 added to the average October 10 – December 31 GOA rex sole catches over the 5 previous years. The 2016 projected catch was calculated as the average catch from 2010-2014. The 2017 projected catch was set equal to the maxABC as recommended in 2014 for the year 2016, based on Tier 5 calculations.

# Appendix 6B: Non-Commercial Catches of GOA Rex Sole

| | ADF&G Data Source | | | |
|---|---|---|---|---|
| Year | Large-Mesh Trawl Survey | Scallop Dredge Survey | Small-Mesh Trawl Survey | Subsistence Fishery |
| 1991 | | | | 392.65 |
| 1998 | 282.75 | 2.21 | | |
| 1999 | 842.63 | | | |
| 2000 | 380.37 | 0.30 | 105.63 | |
| 2001 | 1,294.13 | | | |
| 2002 | 505.56 | 1.58 | | |
| 2003 | 1,964.35 | | 284.59 | |
| 2004 | 625.35 | 0.21 | 128.37 | |
| 2005 | 1,468.14 | 2.85 | 266.52 | |
| 2006 | 307.47 | 11.55 | 264.94 | |
| 2007 | 770.91 | 0.50 | 99.58 | |
| 2008 | 229.35 | | | |
| 2009 | 1,075.48 | 0.55 | | |
| 2010 | 5,452.67 | 0.48 | 342.18 | |
| 2011 | 4,367.69 | | 146.95 | |
| 2012 | 3,828.64 | 0.44 | 62.58 | |
| 2013 | 3,923.75 | | 78.05 | |
| 2014 | 1,810.35 | | 137.19 | |

| | NMFS Data Source | | | |
|---|---|---|---|---|
| Year | Annual Longline Survey | Salmon EFP 13-01 | Shelikof Acoustic Survey | Shumigans Acoustic Survey |
| 1992 | 0.915 | | | |
| 1994 | 5.489 | | | |
| 1995 | 0.915 | | | |
| 2010 | | | 8.928 | 36.258 |
| 2011 | | | | |
| 2012 | 0.91 | | | |
| 2013 | 1.83 | 130 | | |
| 2014 | | 184 | | |

# Appendix 6C: An Exploration of Alternative Gulf of Alaska Rex Sole Assessment Models

http://www.afsc.noaa.gov/REFM/Docs/2015/McGilliard_SUPPLEMENTAL_September_2015_GOA_Rex.pdf