6. Assessment of the Rex Sole Stock in the Gulf of Alaska

By
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Executive Summary

Changes in the Input Data

1) The fishery catch and length compositions for 2010 and 2011 (through Sept. 24, 2011) were incorporated in the model.
2) The 2009 fishery catch and length compositions were updated.
3) The 2011 GOA groundfish survey biomass estimate and length composition data were added to the model. Survey biomass declined from 124,744 t in 2009 to 95,134 t in 2011. Survey biomass estimates and length compositions were recalculated by the RACE GOA Groundfish Survey for all survey years.
4) Survey age compositions for two years (1999 and 2009) were added to the model.

Changes in the Assessment Model

No changes were made in the assessment model. Because estimates of $F_{40\%}$ and $F_{35\%}$ (required for Tier 3 calculations) from the assessment model are considered unreliable while estimates of current and projected biomass are considered reliable, harvest specifications are based on Tier 5 calculations using estimated "adult biomass" from an age-structured assessment model (rather than survey biomass)

Changes in the Assessment Results

1. Based on Tier 5 calculations, F_{ABC} was found to correspond to a harvest level of 0.128 yr^{-1}, while F_{OFL} corresponded to a harvest level of 0.170 yr^{-1}.
2. Using the age-structured assessment model and best estimates of actual catches in 2011 and 2012, "adult biomass" was estimated to be 87,162 t in 2012 and 85,528 in 2013. Estimates of adult biomass were calculated by applying the rex sole maturity curve to estimates of biomass-at-age.
3. Using estimates of adult biomass from the age-structured assessment model, based on our best estimates for harvest levels in 2011-12, the recommended ABC for 2012 is 9,612 t and the recommended ABC for 2013 is 9,432 t.
4. The OFL for 2012 is 12,561 t and the OFL for 2013 is 12,326 t.

The area apportionments, based on the 2011 GOA Groundfish Survey, corresponding to the recommended ABCs are:

	Western	Central	West Yakutat	Southeast Outside	Total
Area Apportionment	13.6%	66.7%	8.7%	11.0%	100.0%
2012 ABC (t)	1,307	6,412	836	1,057	9,612
2013 ABC (t)	1,283	6,291	821	1,037	9,432

A summary of the recommended ABCs from the 2011 assessment, relative to the 2010 SAFE projections, is as follows:

Quantity	As estimated or specified last year (2010)		As estimated or specified this year (2011)	
	2011	2012	**2012**	**2013**
M (natural mortality)	0.17	0.17	**0.17**	**0.17**
Specified/recommended tier	5	5	**5**	**5**
Biomass (adult; t)	86,729	85,203	**87,162**	85,528
F_{OFL} =M	0.170	0.170	**0.170**	0.170
max F_{ABC} =0.75*M	0.128	0.128	**0.128**	0.128
recommended F_{ABC}	0.128	0.128	**0.128**	0.128
OFL (t)	12,499	12,279	**12,561**	12,326
max ABC (t)	9,565	9,396	**9,612**	9,432
ABC (t)	9,565	9,396	**9,612**	9,432
Status	**As determined last year (2010) for:**		**As determined this year (2011) for:**	
	2009	2010	**2010**	**2011**
Overfishing	no	n/a	**no**	n/a

Plan Team Summary Tables

Species	Year	Biomass[1]	OFL[2,3]	ABC[2,3]	TAC[2,3]	Catch[4]
Rex sole	2010	88,221	12,714	9,729	9,729	3,636
	2011	86,974	12,499	9,565	9,565	2,594
	2012	87,162	12,561	9,612		
	2013	85,528	12,326	9,432		

[1] Adult biomass from the assessment model.
[2] http://www.fakr.noaa.gov/sustainablefisheries/specs10_11/goa_table1.pdf
[3] http://www.fakr.noaa.gov/sustainablefisheries/specs11_12/goa_table1.pdf
[4] As of Sept. 24, 2011.

Stock/ Assemblage	Area	2011 OFL[1]	2011 ABC[1]	2011 TAC[1]	2011 Catch[2]	2012 OFL[3]	2012 ABC[3]	2013 OFL[3]	2013 ABC[3]
Rex sole	W	--	1,517	1,517	105	--	1,307	--	1,283
	C	--	6,294	6,294	2,488	--	6,412	--	6,291
	WYAK	--	868	868	1	--	1,057	--	1,038
	SEO	--	886	886	0	--	836	--	820
	Total	12,499	9,565	9,565	2,594	12,561	9,612	12,326	9,432

[1]http://www.fakr.noaa.gov/sustainablefisheries/specs11_12/goa_table1.pdf
[2]As of Sept. 24, 2011.
[3]Based on Tier 5 calculations using adult biomass estimates from the assessment model.

SSC Comments Specific to the Rex Sole Assessments

SSC comment: *The SSC requests that the next assessment re-evaluate the assumed age-length transition matrix to determine how it influences the estimated fishery selection curve. Also, the next assessment should provide analyses of mechanisms…that might account for the large differences between the survey and the fishery selection curves.*

Author response: B. Matta of AFSC's Age and Growth Program has found potential differences in growth patterns for rex sole between the eastern portion of the Gulf of Alaska and the western and central portions, with individuals growing more slowly and attaining smaller maximum sizes in the eastern Gulf. While this result may have important implications for stock structure, the analysis is not yet complete. In addition, this year the Age and Growth Program completed processing several years worth of survey age data and, for the first time, fishery age data. Age composition data based on the new survey ages have been incorporated into this assessment, but the current assessment model does not incorporate fishery age compositions. The principal assessment author will make it a top priority to use the new age data to re-evaluate the age-length conversion matrices used in the assessment. Unfortunately, he was not able to complete this analysis in time for inclusion in this assessment.

SSC comment: *The SSC requests that the next assessment provide likelihood profiles or similar analyses that illustrate the consistency of the model fits to the various input data sources.*

Author response: Posterior density plots for model parameters and other estimated quantities have been developed based on MCMC integration, replacing the limited number of likelihood profiles provided in the previous assessment. A number of these, both for individual parameters/quantities as well as for time series, have been incorporated into the current assessment. While these appear to address the overall issue of consistency of the model fits with respect to the input data, they do not address the issue of consistency of model fits with respect to individual data sources. Further guidance from the SSC on this issue would be greatly appreciated.

SSC Comments on Assessments in General

SSC request: *The SSC requested that the next round of assessments consider the possible use of ADF&G bottom trawl survey data to expand the spatial and depth coverage.*

Author response: The current assessment model does not accommodate surveys from multiple sources. We are (still) developing a new assessment model that will incorporate surveys from multiple sources as one of its new features. When completed, this new model will allow us to explore the utility of using the ADF&G bottom trawl survey data in future assessments.

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, although this is an area .

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 6.1, Fig. 6.1). 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 about 3,000 t thereafter. The 2009 catch (4,753 t) was the largest since 1996. Catches have subsequently declined the past two years and is now more similar to the longterm average. In 2010 the catch was 3,636 t and in 2011 it was 2,594 t (as of Sept. 24; 2011).

Based on observer data, 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 (Figures 6.2-3). The spatial pattern of catches has been reasonably consistent over the past three years, with persistent areas of catches occurring off the Shumagin Islands, and the southwest tip and Cape Barnabas regions of Kodiak Island. Most of the catch is taken in the first and second quarters of the year.

The rex sole resource has been moderately harvested in recent years (Table 6.2). The fishery catches in 2009 and 2010 each represented between 40-50% of the rex sole ABC in that year. As of Sept. 24, catch in 2011 was less than 30% of the 2011 ABC.

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 6.2a). Retention of rex sole is high and has generally been over 95%.

Data

Fishery Data

This assessment used fishery catches from 1982 through 24 September, 2011 (Table 6.1, Fig. 6.1), as well as estimates of the proportion of individuals caught by length group and sex for the years 1982-2011 (as of Sept. 24; Table 6.3). Thanks to recent work by the Alaska Fisheries Science Center's (AFSC) Age & Growth Program, two years of fishery age composition data is also available now, but the current assessment model does not incorporate fishery age data. Direct incorporation of fishery age data in the assessment awaits completion of a new assessment model. Sample sizes for the size (and age) compositions are shown in Table 6.4a.

Survey Data

Because rex sole are often taken incidentally in target fisheries for other species, CPUE from commercial fisheries seldom reflects trends in abundance for this species. It is therefore necessary to use fishery-independent survey data to assess the condition of this stock.

This assessment used estimates of total biomass for rex sole in the Gulf of Alaska from triennial (1984-1999) and biennial (2001-2011) groundfish surveys conducted by the AFSC's Resource Assessment and Conservation Engineering (RACE) division to provide an index of population abundance (Table 6.5, Fig. 6.4). Although survey depth coverage has been inconsistent for depth strata > 500 m (Table 6.5a), the fraction of the rex sole stock occurring in these depth strata is typically small (Table 6.5b), 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 Fig. 6.4, 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. Survey biomass from the 2011 groundfish survey was 95,134 t, representing a 24% decline from the 2009 value (124,744 t), which was the largest in the time series. However, the 2011 survey biomass estimate is above the longterm average (~86,000 t).

Estimates of the total number of individuals by length group from each RACE GOA groundfish survey (Table 6.6) were also incorporated into the assessment, as were estimates of total population numbers-at-age (Table 6.7). Survey age compositions were available for all survey years except for 2011 (1984, 1987, 1990, 1993, 1996, 1999, 2001, 2003, 2005, 2007 and 2009), although the age composition for 1990 was excluded from the model because the underlying ages are probably biased low due to the age reading technique (surface age reading) originally 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). Sample sizes for the survey-related data sources are given in Table 6.4b.

Data on individual growth was incorporated in the assessment using sex-specific age-length conversion matrices (Table 6.8a, b). These matrices have been used in previous assessments (Turnock et al., 2005; Stockhausen et al., 2007; Stockhausen et al. 2009). Sex-specific weight-at-age relationships and female maturity schedules used in previous assessments (Turnock et al., 2005; Stockhausen et al., 2007; Stockhausen et al. 2009) were also used in this assessment (Table 6.9)

To summarize, the following data was incorporated in the assessment:

Source	type	years
Fishery	catch	1982--2011
	size compositions	1982-1984, 1990-2011
Survey	biomass	1984-1999 (triennial); 2001-2011 (biennial)
	size compositions	1984-1999 (triennial); 2001-2011 (biennial)
	age compositions	1984, 1987, 1993, 1999; 2001-2009 (biennial)

Analytic Approach

Several alternative model configurations have been considered in previous assessments (Turnock et al., 2005; Stockhausen et al., 2007; Stockhausen et al., 2009). For this assessment, due to time constraints, we adopted the approach endorsed by the GOA Plan Team for this stock at the November 2009 Plan Team Meetings in Seattle. Consequently, we have developed harvest recommendations for the GOA rex sole stock using a Tier 5 approach (F_{OFL}=M, F_{ABC}=0.75·M) applied to estimates of adult biomass from a Tier 3-type age-structured assessment model.

Model structure

Current stock levels were estimated for 2011 and projected for 2012-2013 using the "base" model formulation as in 2009: a split-sex, age-structured model with parameters evaluated in a maximum likelihood context. The model structure (Appendix A) was developed following Fournier and Archibald's (1982) methods, with many similarities to Methot (1990). We implemented the model using automatic differentiation software developed as a set of libraries under C++ (ADModel Builder). ADModel Builder can estimate a large number of parameters in a non-linear model using automatic differentiation software extended from Greiwank and Corliss (1991) and developed into C++ class libraries. This software provides the derivative calculations needed for finding the minimum of an objective function via a quasi-Newton function minimization routine (e.g., Press et al. 1992). It also gives simple and rapid access to these routines and provides the ability to estimate the variance-covariance matrix for all parameters of interest.

Age classes included in the model run from age 3 to 20. Age at recruitment was set at 3 years in the model due to the small number of fish caught at younger ages. The oldest age class in the model, age 20, serves as a plus group in the model; the maximum age of rex sole based on otolith age determinations has been estimated at 27 years (Turnock et al., 2005). Details of the population dynamics and estimation equations, description of variables and likelihood components are presented in Appendix A (Tables A.1, A.2, and A.3). Model parameters that are typically fixed are presented in Table A.4. A total of 89 parameters were estimated in the model (Table A.5).

Parameters estimated independently

Model parameters related to natural mortality, growth, weight, maturity and survey catchability were fixed in the final model (Table A.4).

Natural mortality

As in the previous full assessment (Turnock et al., 2005), natural mortality (M) was fixed at 0.17 yr^{-1} for both sexes in all age classes. This value was based on maximum observed age of 27 years for rex sole (Turnock et al., 2005).

Growth

The model estimates size compositions using fixed sex-specific age-length conversion matrices (Table 6.8). The distribution of size-at-age was assumed to be normally-distributed, with mean size-at-age modeled using the standard von Bertalanffy growth equation (Table 6.9, Fig. 6.6a):

$$L_t = L_{\text{inf}}(1 - e^{-k(t-t_0)})$$

and age-varying variance. Sex-specific parameter values for the von Bertalanffy equation were estimated from mean length-at-age data collected during the 1984, 1987, 1990, 1993 and 1996 groundfish surveys (Turnock et al., 2005). The estimated values are

Sex	L_∞	k	t_0
Males	39.5	0.38	0.79
Females	44.9	0.31	0.69

Coefficients of variation (CVs) for length-at-age were also estimated from the survey data, and varied linearly from 0.13 for age 3 to 0.08 for age 20+ (Turnock et al., 2005) for both sexes.

Weight at length

Weight-at-length was modeled using the equation $W = aL^b$, with L in centimeters and W in grams. The parameter values for this equation, estimated from survey data, are

Sex	a	b
Males	1.0770E-06	3.30571
Females	4.7933E-07	3.44963
Combined	5.9797E-07	3.41049

and are the same as used in the previous assessment. Weight-at-age (Table 6.9, Fig. 6.6b) was estimated using the weight-length relationship and the age-length conversion matrices.

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 (Q in Table A.1) was fixed at 1.

Parameters estimated conditionally

A total of 89 parameters were estimated in the final model (Table A.5), including parameters on the recruitment of rex sole to the population (48 parameters total, including ones determining the initial age composition) and values related to annual fishing mortality (31 parameters total). The separable age component of fishing mortality was modeled using ascending logistic functions estimated separately for males and females (4 parameters total). The same approach was also used to estimate relative age-specific survey selectivity (4 parameters total). We also estimated the Tier 3 values for F_{ABC} and F_{OFL}: F40% and F35% (2 parameters).

Annual recruitment to the age 3 year class was parameterized in the model using one parameter for the log-scale mean recruitment and 47 parameters for the annual log-scale deviation from the mean. Recruitments were estimated back to 1965 to provide an initial age distribution for the model in its starting year (1982). In an analogous fashion, fully-recruited fishing mortality was parameterized in the model using one parameter for the log-scale mean and 30 parameters for the annual log-scale deviation from the mean.

Parameters in the model were selected based on minimizing an objective function equivalent to a negative log-likelihood function; hence, the parameter estimates are maximum likelihood estimates. Components that contribute to the overall (negative log) likelihood include those related to observed fishery catches, fishery size compositions, survey biomass estimates, survey size compositions, survey age composition, and recruitment deviations (Table A.3). The observed fishery catch was assumed to have a lognormal error structure, as was estimated survey biomass. The recruitment deviation parameters were incorporated directly into the overall likelihood via three components: “early” recruitment, “ordinary” recruitment and “late” recruitment (Table A.3). The “early” recruitment component incorporated deviations from 1965 to 1981 (i.e., prior to the modeled age structure), “ordinary” recruitment incorporated deviations from 1982-2008 and “late” recruitment incorporated deviations from 2009-2011. All three components were formulated assuming a lognormal error structure. The size and age compositions were assumed to be drawn from different sex-specific multinomial distributions. If this assumption were strictly correct, then the number of individuals contributing to each composition would be the appropriate corresponding sample size. However, because fish of the same size and age tend to be found together, size and age compositions tend to be overdispersed with respect to actual multinomial distributions. Also, the use of high sample sizes can lead to numerical problems in estimating the model parameters. Previous experience indicates that using a uniform sample size of 200 for compositions with more than 200 individuals provides an adequately simple solution to the problem of assigning sample sizes. Thus, a sample size of 200 was used for fully-weighted compositions (all age compositions and size compositions from years with no corresponding age compositions) and 1 for de-weighted compositions (size compositions with corresponding age compositions).

Different weights can be assigned to each likelihood component to increase or decrease the relative degree of model fit to the data underlying the respective component; a larger weight induces a closer fit to a given likelihood component. Typically, a relatively large weight (e.g., 20) is applied to the catch component while smaller weights (e.g., 1) are applied to the survey biomass, recruitment, and size and age composition components. This reflects a belief that total catch data are reasonably well known (smaller variance) compared with the other types of data. For the recruitment components, larger weights applied to a component force the deviations contributing to that component closer to zero (and thus force recruitment closer to the geometric mean over the years that contribute to the component). The weights used in this assessment are given in Table 6.10.

Initial values for the estimable parameters were set as listed in Table 6.11. To test whether resulting model solutions were indeed global, rather than local, maximum on the likelihood surface, we started the two model cases using several different parameter sets. Most runs converged to the same (maximum) likelihood value and parameter estimates, providing evidence that the original solution was indeed the global maximum. The scores associated with different components of the maximum likelihood (e..g, fishery catch, survey biomass) are given in Table 6.12.

Final parameter estimates

The estimated maximum likelihood parameter values are given in Table 6.13 for all model parameters.

Model evaluation

Model estimates of fishery catch closely matched the observed values (Table 6.14 and Figure 6.7). This, however, is expected because a large weighting factor (20) was placed on the catch biomass component in the likelihood function. The model did not fit observed survey biomass values as closely as it did the catch (Table 6.14 and Figure 6.8), but the fit does appear reasonable.

Model fits to fishery size compositions and survey size and age compositions were quite similar to those obtained in the last full assessment (Stockhausen et al., 2009). For the most part, the model fit the fishery size compositions reasonably well, although not in 1982-1984 and 1988 (Figures 6.9a, b). Excluding these notable years, the model tended to slightly underestimate the peak and overestimate the width of the size compositions, particularly when the observed size composition was dominated by a single size class and thus sharply peaked—females in 1993, for example (Figure 6.9a). The smoothing inherent in using an age-length conversion matrix to convert age classes to size classes in the model precludes close fits to peaked size compositions: the peak will be underestimated and the tails will be overestimated. The slight bias in these fits might be improved by reducing the currently-assumed age-to-length conversion variance, but it may also be indicative of an interaction between fishery selectivity and age/size segregation in the stock.

The model's substantial misfits to the observed fishery size compositions in 1982-1984 (Figures 6.9a, b) suggest that fishery size selection patterns changed between 1982-1984 (years when the foreign fleets operated) and subsequent to 1990 (implementation of the domestic-only fishery). The average observed size caught was 35.6 cm in 1982-1984 and 40.4 cm since 1990. However, the model assumes that fishery selection is constant over the entire model time period (1982-2011) and is much more influenced by the data from the post-1990 era than by the 1982-1984 data. Finally, the model's substantial misfit in to the observed fishery size compositions in 1998 is caused by a secondary peak and exceedingly heavy right tail in the observed size composition in both sexes. This feature is unique in the 25-year time series of observed fishery size compositions; it is unclear what might have been different in the fishery in 1998 to have caused this unique occurrence.

On the whole, the model fits to survey size compositions were better than those to fishery size compositions (Figures 6.10a, b). As with the fishery size compositions, the model fits to the survey size compositions were poorest when the observed size compositions were sharply peaked (e.g., 1984-1990, Figure 6.10a). Also, the model tends to overestimate abundance at large sizes (> 40 cm) for both sexes, although the effect is more consistent for males. Although this may indicate a bias in the current age/size conversion matrix used in the model, it may also indicate somewhat higher natural mortality than is assumed in the model (0.17 yr^{-1}) or a decrease in survey selectivity at larger ages/sizes—the latter cannot be accommodated in the current model configuration because selectivity is modeled using ascending logistic functions.

As in the previous full assessment (Stockhausen et al., 2009), the model fit survey age compositions "marginally well". The model fits to age compositions that were included in the previous assessment are very similar to the fits obtained in that assessment. One reason for this marginal performance may be that recruitment in the model to the youngest age class (age 3) is assumed to have an equal sex ratio, while several of the survey age compositions exhibit substantial differences in sex ratio in the early age classes. For example, the 1987 survey age composition indicates six times more male age-5's (1982 year class) than females. However, there are no dynamics in the model that allow it to fit this type of discrepancy well, so the model ends up underestimating the proportion of males and overestimating the proportion of females in this case. It is also possible that these types of differences by sex in the observed age compositions indicate more overdispersion in the age sampling than is currently assumed. In this latter case, a different weighting scheme for the individual age composition—based on number of hauls, for example, rather than number of individuals—may improve the fits somewhat.

Results

The estimated selectivity curves for the fishery and survey indicate that the fishery generally catches older flathead sole than the survey (Figures 6.12, 6.13). For the fishery, age at 95% selection was 12.4 years for females and 13.5 years for males. For the survey, the ages at 95% selection were younger: 6.3 years for females and 5.1 years for males. The rates of increase in the selectivity curves at 50% selection (β) were reasonably steep (> 1 yr^{-1}) and similar between males and females, the fishery and the survey. Examination of the marginal posterior distributions from MCMC integration for these parameters indicates that they were well-estimated in the model, except for the value of the β parameter for female selectivity in the fishery (Figure 6.13). Although the uncertainty associated with this latter parameter is fairly large, it has little impact on the resulting selectivity function—the actual curve approximates a knife-edge selectivity curve over the range of values indicated.

The model also estimates other population variables of interest, such as time series of total biomass, spawning biomass, recruitment and fully-selected fishing mortality. In this assessment, total biomass is represented by age 3+ biomass whereas spawning biomass is female spawning biomass. Model quantities such as median recruitment, median fishing mortality, total biomass, spawning biomass and recruitment all seem to be reasonably well-estimated, based on examination of MCMC posterior distributions (Figures 6.14-15). The maximum likelihood estimates of these quantities tends to be very close to the posterior modes, with median F (Fig. 6.17, upper right plot) and estimates of recent recruitment (2005-2009; Figure 6.15, lower plot) being exceptions to this. Median recruitment was estimated at 47.6 million individuals. Median fishing mortality was estimated at 0.015 yr^{-1}. Total biomass in 2011 was estimated at 117,000 t, spawning stock biomass at 52,600 t and recruitment at 49.4 million.

Model estimates suggest that age 3+ biomass generally underwent a decadal-scale oscillation, with total biomass increasing from 76,500 t in 1982 to 99,100 t in 1991 followed by a decline to 74,500 t in 1998 and a subsequent increase to 119,700 t in 2009 (Table 6.15, Figures 6.15-16). The estimate for 2011 is 116,900 t, slightly smaller than the maximum in 2009. In years where they overlap, the estimated age 3+ biomass in this assessment is almost identical to that estimated in previous assessments (Table 6.15, Figure 6.16). The time series for estimated female spawning biomass underwent a progression similar to that of total biomass, but lagging the timing of the peaks and valleys in total biomass by 2 years (Table 6.16, Figures 6.15-16). The estimated 2011 spawning biomass is the largest in the time series (52,600 t). As with total biomass, spawning biomass estimated in this assessment is almost identical to that from previous assessments in years where they overlap (Table 6.16, Figure 6.16).

Model estimates of annual recruitment (age 3 numbers) ranged from a low of 28.9 million individuals in 1984 to a high of 114.7 million in 2008 (Table 6.17 and Figure 6.17). Prior to 1999 recruitment was generally below the long-term average (51.2 million) while it has generally been higher since 1999. In 2011, recruitment was estimated below the long-term average, but this is expected because of the structure of the recruitment likelihood component. Results from the current assessment are generally similar to those estimated in the previous assessment, particularly prior to 2006 (Table 6.17, Figure 6.17).

However, the last 3-5 recruitment estimates are highly uncertain, as is reflected in the variation between assessments.

Marginal posterior distributions based on MCMC integration are shown in Figure 6.18 for the Tier 3 quantities $F_{35\%}$ and $F_{40\%}$, $B_{35\%}$ and $B_{40\%}$, and max ABC and OFL for 2012 as calculated using Tier 3a rules. The distributions for $F_{35\%}$ and $F_{40\%}$ indicate that, as expected from previous assessments, these quantities are highly uncertain and consequently rex sole does not qualify as a Tier 3 stock. This uncertainty results from a combination of relatively young age-at-maturity for rex sole (5.6 years) and selection by the fishery at relatively old ages (Figure 6.12), making spawner-per-recruit calculations insensitive to the overall level of fishing mortality (i.e., no matter how high F is, all fish caught by the fishery have already spawned several times).

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

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, 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 2012 and 2013 requires predictions of the total catch taken in 2011 and 2012. Because the 2011 fishery is not yet complete, we estimated the total catch taken in 2011 (3,448 t) using the average catch over the last 5 years. We assumed the same catch would be taken in 2012, as well. Using these values and the estimated numbers-at-age at the start of 2011 from the assessment model, we projected the stock ahead and calculated adult biomass (B_A) at the start of 2012 and 2013 (87,162 t and 85,528 t, respectively). We then calculated appropriate $\bar{B}$'s for 2012 and 2013 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 2012 and 2013 are 9,612 t and 9,432 t, respectively, while the estimated OFLs are 12,561 t and 12,326 t.

Area allocation of harvests

TACs for rex sole in the Gulf of Alaska are divided among four smaller management areas (Western, Central, West Yakutat and Southeast Outside). As in the previous assessment, the area-specific ABCs for rex sole in the GOA are divided up over the four management areas by applying the fraction of the most recent survey biomass estimated for each area (relative to the total over all areas) to the 2012 and 2013 ABCs. The area-specific allocations for 2012 and 2013 are:

	Western	Central	West Yakutat	Southeast Outside	Total
Area Apportionment	13.6%	66.7%	8.7%	11.0%	100.0%
2012 ABC (t)	1,307	6,412	836	1,057	9,612
2013 ABC (t)	1,283	6,291	821	1,037	9,432

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 (Fig. 6.19). Polychaetes, euphasiids, and miscellaneous worms were the most important prey for rex sole in the Gulf of Alaska (Fig. 6.20).. 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 (Fig. 6.21). 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.

The longnose skate population appears to be stable. Arrowtooth flounder are currently the most abundant groundfish in the Gulf of Alaska, and have steadily increased in abundance since the early 1970's (Turnock et al., 2003b). Although the continued increase in abundance of arrowtooth flounder is cause for some concern, the abundance of rex sole has actually increased in recent years, as well. Increased predation by arrowtooth may be limiting the potential rate of increase of rex sole under current conditions, but it does not appear to represent a threat to the stock.

Fishery effects on ecosystem

Catches of rex sole are widely distributed in the Gulf of Alaska over the past few years (Figure 6.2). The ecosystem effects of this spatial distribution of fishing activity are unknown.

Prohibited species such as halibut, salmon, and crab are also taken to some extent in the rex sole-directed fishery (Table 6.18). In 2011 (through September), the overall prohibited species catch (PSC) rate for Bairdi crab was 6,102 individuals, which accounted for 6.8% of the total Bairdi PSC. No king crab or opilio crab were caught in the rex sole fishery. The halibut PSC in the rex sole fishery was 172 t—less than half that in 2010 (388 t). This accounted for 3.9% of the total PSC for halibut in 2011. The salmon PSC in the rex sole fishery was 2,300 Chinook and 93 non-Chinook in 2010. This accounted for 4.2% of the total Chinook PSC and 4.6% of the total non-Chinook PSC in 2010. o information was available at the time this document was compiled for 2011.

Bycatch of non-target species in the rex sole fishery tends be highly variable between years, at least when expressed as a percentage of the total observed bycatch in the FMP by non-target species group (Table 6.19). In 2010, the rex sole fishery accounted for more than 10% of the bycatch of four species groups: corals and bryozoans (10.3%), unidentified invertebrates (14.3%), miscellaneous invertebrates (e.g., worms) (100%) and unidentified polychaetes (100%). In 2009, by contrast, the fishery reportedly accounted for over 10% of total bycatch in 19 species groups, including three of the four species groups caught in 2010 (miscellaneous worms were not caught in 2009). The fishery has had no bycatch of birds and has accounted for less than 10% of bycatch in all shark and skate species groups over the time frame analyzed (2003-2011), except for other skates (2003, 2006, 2009). The rex sole fishery has played a substantial role in bycatch of forage fish (capelin, eulachon, sandlance) in certain years, accounting for over 50% of capelin bycatch in 2008 and 2009 and almost 20% of eulachon bycatch in 2009.

Over the past five years, the rex sole-directed fishery caught more arrowtooth flounder than any other non-prohibited FMP species, including rex sole (Table 6.20). Rex sole was the second most-caught species in the directed fishery. Only small amounts of arrowtooth were retained (typically 10-20%), while generally more than 98% of rex sole was retained. Catches of other non-prohibited species in the rex sole fishery were typically less than 20% of the rex sole catch.

Effects of discards and offal production on the ecosystem are unknown for the rex sole fishery.

Data gaps and research priorities

The AFSC's Age and Growth Program has made substantial progress in processing survey age data for rex sole in the Gulf of Alaska. While this information has been incorporated in the current stock assessment in the form of survey age compositions, age information also enters the assessment in the form of age-length conversion matrices estimated outside the assessment model. The matrices currently used in the assessment are now several years old. One of our top priorities for the next assessment is to use the newly-available age data to revise growth schedules for GOA rex sole and reassess these age-length conversion matrices. In addition, we are working to incorporate such estimation directly into the assessment model, rather than performing it outside the model. This approach will also allow us to incorporate ageing error into the model structure.

Although the AFSC's Age and Growth Program has made substantial progress in processing survey age data for rex sole in the Gulf of Alaska, only two years of fishery age data has been processed. Additional age data (both survey and fishery) should improve future stock assessments by allowing improved estimates of individual growth and age-length transition matrices, and by filling in missing years with age composition data.

We will also investigate potential growth rate differences for rex sole between the eastern Gulf and the central/western Gulf. Although little catch is taken from the eastern Gulf, divergent growth patterns may have management implications for the stock as they may influence the perceived productivity of the stock.

Finally, further modeling research should address the use of length-based approaches to fishery and survey selectivity in the assessment model, as well as alternative forms for the selectivity function. The utility of potential environmental predictors of recruitment (e.g., temperature) should also be investigated. We also plan to revisit the estimates used for natural mortality in the model.

Summary

Tier	5	
Reference mortality rates		
M	0.17	
Fishing rates		
F_{OFL}	0.170	
F_{ABC} (maximum permissible)	0.128	
F_{ABC} (recommended)	0.128	
Projected biomass	**2012**	**2013**
Adult biomass (t)	87,162	85,528
Harvest limits	**2012**	**2013**
OFL (t)	12,561	12,326
ABC (maximum permissible; t)	9,612	9,432
ABC (recommended; t)	9,612	9,432

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Tables

Table 6.1. Annual catch of rex sole in the Gulf of Alaska, from 1982 to 2011. 2011 catch is through Sept. 24.

year	total catch (t)	Western Gulf	Central Gulf	West Yakutat	Southeast
1982	959				--
1983	595				--
1984	365				--
1985	154				--
1986	93				--
1987	1,151				--
1988	1,192				--
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	3,060				--
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

Table 6.2a. Time series of recent reference points (ABC, OFL), TACs, total catch and retention rates for rex sole.

Year	ABC (t)	TAC (t)	OFL (t)	Total Catch (t)	% Retained
1995	11,210	9,690	13,091	4,021	90%
1996	11,210	9,690	13,091	5,874	95%
1997	9,150	9,150	11,920	3,294	92%
1998	9,150	9,150	11,920	2,669	97%
1999	9,150	9,150	11,920	3,060	96%
2000	9,440	9,440	12,300	3,591	97%
2001	9,440	9,440	12,300	2,940	95%
2002	9,470	9,470	12,320	2,941	95%
2003	9,470	9,470	12,320	3,485	95%
2004	12,650	12,650	16,480	1,464	93%
2005	12,650	12,650	16,480	2,176	91%
2006	9,200	9,200	12,000	3,294	95%
2007	9,100	9,100	11,900	2,852	98%
2008	9,132	9,132	11,933	2,703	97%
2009	8,996	8,996	11,756	4,753	99%
2010	9,729	9,729	12,714	3,636	98%
2011	9,565	9,565	12,499	2,594	97%

Table 6.2b. Status of the rex sole fishery in recent years.

Year	Dates	Status
2005	Jan 20	open
	Mar 23	halibut bycatch status
	Apr 1	open
	Apr 8	halibut bycatch status
	Apr 24	open
	May 3	halibut bycatch status
	Jul 5	open
	Jul 24	halibut bycatch status
	Sep 1	open
	Sep 4	halibut bycatch status
	Sep8	open
	Sep 10	halibut bycatch status
	Oct 1	open
	Oct 1	halibut bycatch status
2006	Jan 20	open
	Apr 27	halibut bycatch status
	Jul 1	open
	Sep 5	halibut bycatch status
	Oct 1	open
	Oct 8	halibut bycatch status
2007	Jan 20	open
	May 17	halibut bycatch status
	Jul 1	open
	Aug 10	halibut bycatch status
	Sep 1	open
	Sep 8	halibut bycatch status
	Oct 1	open
	Oct 15	halibut bycatch status
	Oct 22	open
2008	Jan 20	open
	Apr 21	halibut bycatch status
	Jul 1	open
	Sep 9	A80 vessels subject to sideboard limits
	Sep 11	halibut bycatch status
	Oct 1	open
	Nov 6	halibut bycatch status
	Nov 16	open
2009	Jan 20	open
	Mar 3	halibut bycatch status
	Apr 1	open
	Apr 23	halibut bycatch status
	Jul 1	open

Year	Dates	Status
2010	Jan 20	open
	Apr 28	halibut bycatch status
	Jul 1	open
2011	Jan 20	open
	Apr 22	halibut bycatch status
	Jul 1	open
	Jul 1	Rockfish Program CV Coop.s and Limited Access on halibut

Table 6.3a. Annual fishery size compositions for female rex sole. The 2011 composition is based on observer reports through Sept. 24.

	Length cutpoints (cm)																							
year	**9**	**11**	**13**	**15**	**17**	**19**	**21**	**23**	**25**	**27**	**29**	**31**	**33**	**35**	**37**	**39**	**41**	**43**	**45**	**47**	**49**	**51**	**53**	**55**
1982	0.0001	0.0000	0.0010	0.0018	0.0000	0.0004	0.0003	0.0004	0.0005	0.0015	0.0057	0.0362	0.1111	0.1040	0.0590	0.0332	0.0153	0.0039	0.0010	0.0009	0.0005	0.0002	0.0001	0.0000
1983	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0046	0.0185	0.0386	0.0974	0.1097	0.0788	0.0216	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1984	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0101	0.0067	0.0236	0.0471	0.0404	0.0640	0.0101	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1985	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1986	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1987	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1988	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1989	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1990	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0011	0.0003	0.0055	0.0050	0.0151	0.0225	0.0291	0.0366	0.0491	0.0530	0.0525	0.0531	0.0426	0.0188	0.0097	0.0053	0.0013
1991	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.0017	0.0009	0.0032	0.0070	0.0117	0.0226	0.0414	0.0717	0.0920	0.0957	0.0813	0.0444	0.0243	0.0106	0.0066	0.0033
1992	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0005	0.0003	0.0010	0.0021	0.0055	0.0075	0.0131	0.0256	0.0382	0.0588	0.0946	0.1105	0.0904	0.0520	0.0277	0.0131	0.0070	0.0043
1993	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002	0.0006	0.0010	0.0028	0.0050	0.0121	0.0345	0.0778	0.1167	0.1229	0.0871	0.0488	0.0240	0.0103	0.0053	0.0026
1994	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0005	0.0006	0.0015	0.0029	0.0092	0.0244	0.0476	0.0865	0.1066	0.0954	0.0765	0.0439	0.0212	0.0106	0.0045	0.0017
1995	0.0000	0.0000	0.0002	0.0002	0.0000	0.0006	0.0006	0.0004	0.0008	0.0015	0.0025	0.0075	0.0098	0.0137	0.0315	0.0653	0.0960	0.1218	0.1187	0.0799	0.0402	0.0237	0.0102	0.0050
1996	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0003	0.0003	0.0007	0.0012	0.0038	0.0082	0.0213	0.0449	0.0791	0.1058	0.1068	0.0781	0.0462	0.0276	0.0136	0.0103
1997	0.0000	0.0000	0.0000	0.0001	0.0000	0.0002	0.0003	0.0007	0.0030	0.0025	0.0047	0.0074	0.0126	0.0172	0.0279	0.0381	0.0451	0.0623	0.0761	0.0720	0.0621	0.0349	0.0158	0.0061
1998	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0004	0.0009	0.0018	0.0038	0.0115	0.0309	0.0635	0.0847	0.0773	0.0684	0.0492	0.0398	0.0437	0.0396
1999	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001	0.0001	0.0007	0.0007	0.0012	0.0037	0.0056	0.0133	0.0239	0.0418	0.0634	0.0844	0.0983	0.0915	0.0589	0.0305	0.0128	0.0062
2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0005	0.0006	0.0009	0.0031	0.0056	0.0101	0.0138	0.0342	0.0479	0.0702	0.0875	0.0984	0.0945	0.0657	0.0389	0.0183	0.0068
2001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0009	0.0020	0.0026	0.0040	0.0072	0.0187	0.0448	0.0701	0.0790	0.0893	0.0856	0.0689	0.0348	0.0236	0.0121
2002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0004	0.0005	0.0007	0.0018	0.0070	0.0174	0.0303	0.0548	0.0711	0.0810	0.0849	0.0795	0.0494	0.0304	0.0167	0.0099
2003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0008	0.0016	0.0038	0.0081	0.0146	0.0309	0.0526	0.0597	0.0689	0.0656	0.0475	0.0315	0.0168	0.0081	0.0051
2004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0019	0.0010	0.0029	0.0038	0.0318	0.0318	0.0760	0.0914	0.0943	0.0568	0.0298	0.0173	0.0087	0.0096	0.0029
2005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0042	0.0050	0.0126	0.0378	0.0739	0.0849	0.0941	0.0857	0.0487	0.0277	0.0210	0.0067	0.0017	0.0042
2006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0021	0.0103	0.0206	0.0351	0.0557	0.0804	0.0701	0.0990	0.0680	0.0351	0.0206	0.0124	0.0124	0.0041
2007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000	0.0011	0.0022	0.0011	0.0067	0.0134	0.0324	0.0687	0.1067	0.0983	0.0771	0.0508	0.0268	0.0145	0.0056	0.0011
2008	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0012	0.0024	0.0048	0.0143	0.0308	0.0565	0.0826	0.0721	0.0719	0.0496	0.0255	0.0155	0.0037	0.0037	0.0007
2009	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.0008	0.0015	0.0029	0.0048	0.0139	0.0310	0.0533	0.0766	0.0785	0.0723	0.0461	0.0295	0.0131	0.0034	0.0026	0.0002
2010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0012	0.0023	0.0040	0.0062	0.0184	0.0277	0.0549	0.0789	0.0759	0.0505	0.0344	0.0219	0.0079	0.0047	0.0027
2011	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0008	0.0041	0.0078	0.0228	0.0347	0.0639	0.0753	0.0734	0.0574	0.0318	0.0103	0.0063	0.0022	0.0025

Table 6.3b. Annual fishery size compositions for male rex sole. The 2011 composition is based on observer reports through Sept. 24.

	Length cutpoints (cm)																							
year	**9**	**11**	**13**	**15**	**17**	**19**	**21**	**23**	**25**	**27**	**29**	**31**	**33**	**35**	**37**	**39**	**41**	**43**	**45**	**47**	**49**	**51**	**53**	**55**
1982	0.0000	0.0003	0.0022	0.0022	0.0009	0.0006	0.0017	0.0006	0.0022	0.0056	0.0227	0.0968	0.2051	0.1560	0.0822	0.0342	0.0082	0.0011	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1983	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0015	0.0015	0.0031	0.0185	0.0371	0.0526	0.0680	0.1963	0.1901	0.0541	0.0046	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1984	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0067	0.0572	0.1313	0.3502	0.2088	0.0370	0.0034	0.0034	0.0000	0.0000	0.0000	0.0000	0.0000
1985	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1986	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1987	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1988	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1989	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1990	0.0000	0.0000	0.0000	0.0000	0.0000	0.0019	0.0006	0.0023	0.0055	0.0086	0.0177	0.0322	0.0536	0.1082	0.1467	0.1283	0.0622	0.0202	0.0057	0.0013	0.0006	0.0010	0.0008	0.0000
1991	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0002	0.0009	0.0025	0.0045	0.0078	0.0089	0.0259	0.0649	0.1251	0.1349	0.0664	0.0253	0.0066	0.0025	0.0010	0.0004	0.0002	0.0002
1992	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0008	0.0015	0.0020	0.0054	0.0127	0.0239	0.0498	0.0812	0.1053	0.0774	0.0423	0.0216	0.0086	0.0046	0.0019	0.0010	0.0019
1993	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0002	0.0004	0.0013	0.0028	0.0087	0.0219	0.0590	0.1195	0.1214	0.0766	0.0246	0.0059	0.0016	0.0012	0.0006	0.0000	0.0000
1994	0.0000	0.0000	0.0000	0.0000	0.0002	0.0001	0.0003	0.0005	0.0006	0.0013	0.0028	0.0084	0.0314	0.0751	0.1260	0.1150	0.0634	0.0244	0.0093	0.0035	0.0015	0.0008	0.0002	0.0001
1995	0.0000	0.0000	0.0000	0.0002	0.0002	0.0010	0.0000	0.0015	0.0010	0.0019	0.0077	0.0160	0.0292	0.0502	0.0701	0.0805	0.0541	0.0249	0.0151	0.0081	0.0025	0.0017	0.0000	0.0000
1996	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0007	0.0010	0.0032	0.0051	0.0080	0.0249	0.0522	0.0786	0.0990	0.0850	0.0475	0.0192	0.0079	0.0035	0.0029	0.0012	0.0003
1997	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0007	0.0022	0.0038	0.0057	0.0101	0.0185	0.0421	0.0636	0.0846	0.0959	0.0898	0.0561	0.0230	0.0069	0.0034	0.0006	0.0003	0.0001
1998	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0003	0.0011	0.0014	0.0047	0.0168	0.0290	0.0486	0.0573	0.0559	0.0352	0.0255	0.0284	0.0413	0.0394	0.0189	0.0092
1999	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0004	0.0011	0.0023	0.0045	0.0076	0.0186	0.0356	0.0589	0.0763	0.0832	0.0838	0.0508	0.0225	0.0068	0.0043	0.0022	0.0008	0.0006
2000	0.0000	0.0000	0.0000	0.0002	0.0005	0.0008	0.0014	0.0026	0.0051	0.0050	0.0118	0.0189	0.0386	0.0626	0.0694	0.0603	0.0534	0.0367	0.0178	0.0064	0.0020	0.0023	0.0008	0.0002
2001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0009	0.0020	0.0052	0.0083	0.0210	0.0419	0.0554	0.0718	0.0781	0.0758	0.0428	0.0250	0.0066	0.0049	0.0020	0.0014	0.0011
2002	0.0000	0.0000	0.0000	0.0004	0.0000	0.0002	0.0004	0.0005	0.0027	0.0048	0.0115	0.0319	0.0665	0.0801	0.0867	0.0711	0.0430	0.0297	0.0170	0.0066	0.0011	0.0009	0.0014	0.0004
2003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0000	0.0005	0.0030	0.0071	0.0236	0.0621	0.1016	0.1085	0.1084	0.0748	0.0553	0.0244	0.0079	0.0022	0.0008	0.0002	0.0002
2004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0010	0.0000	0.0019	0.0000	0.0000	0.0212	0.0539	0.1309	0.1405	0.0972	0.0423	0.0250	0.0077	0.0096	0.0019	0.0000	0.0010	0.0000
2005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0059	0.0261	0.0571	0.1084	0.1328	0.0891	0.0429	0.0151	0.0084	0.0042	0.0008	0.0000	0.0000	0.0000
2006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0041	0.0041	0.0247	0.0330	0.1031	0.1010	0.0866	0.0701	0.0247	0.0165	0.0021	0.0021	0.0000	0.0000	0.0000
2007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0011	0.0006	0.0028	0.0056	0.0022	0.0095	0.0235	0.0542	0.0877	0.1061	0.0961	0.0570	0.0257	0.0101	0.0039	0.0011	0.0011	0.0000	0.0000
2008	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0012	0.0009	0.0027	0.0090	0.0218	0.0611	0.0956	0.1181	0.0949	0.0745	0.0391	0.0279	0.0102	0.0047	0.0011	0.0008	0.0002
2009	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0007	0.0028	0.0047	0.0203	0.0448	0.0946	0.1528	0.1374	0.0729	0.0294	0.0058	0.0011	0.0009	0.0001	0.0001	0.0000
2010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0012	0.0048	0.0117	0.0446	0.0893	0.1112	0.1415	0.1122	0.0561	0.0196	0.0090	0.0009	0.0009	0.0007	0.0004	0.0004
2011	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0009	0.0014	0.0076	0.0263	0.0684	0.1054	0.1621	0.1142	0.0724	0.0171	0.0150	0.0083	0.0042	0.0005	0.0003	0.0000

Table 6.4a. Sample sizes from the domestic fishery.

year	Size compositions				Age compositions				
	hauls	total indiv.s	females	males	hauls	total indiv.s	females	males	otoliths collected
1990	74	7438	2482	3693					165
1991	257	18652	4724	4339					262
1992	220	19586	8045	6420					300
1993	372	25972	9067	7293					79
1994	328	19756	6935	6038					158
1995	257	11868	3282	1897					209
1996	277	18548	8212	6474					53
1997	193	10305	4962	5070					
1998	213	10509	4609	3313					35
1999	393	8294	4466	3816					669
2000	347	7435	4484	2881					368
2001	194	3546	1949	1594					243
2002	320	5790	3110	2667					345
2003	352	6414	2662	3706					643
2004	62	1039	484	555					101
2005	71	1205	615	590					163
2006	37	501	256	229					150
2007	140	2261	1189	1057	44	192	109	82	277
2008	159	2677	1205	1459					297
2009	230	4189	1992	2114	73	344	166	177	486
2010	152	2892	1241	1651					350
2011	143	2859	1235	1621					413

Table 6.4b. Sample sizes from the GOA groundfish survey.

year	biomass	Size compositions				Age compositions				
	total hauls	hauls	total indiv.s	females	males	hauls	total indiv.s	females	males	otoliths collected
1984	929	310	16927	6739	7191	5	233	155	78	233
1987	783	105	11577	5364	5998	5	189	102	87	823
1990	708	237	14387	7593	6793	27	270	156	114	550
1993	775	374	19100	9943	8166	29	332	193	139	341
1996	807	517	14496	6768	7718	77	370	212	158	383
1999	764	469	11652	5408	6204	51	381	196	174	487
2001	489	278	7675	3861	3814	130	668	383	284	682
2003	809	520	17833	8778	9028	95	596	328	266	602
2005	839	551	19233	9393	9806	102	588	310	278	600
2007	820	514	17305	8606	8555	55	416	220	196	424
2009	823	555	19933	9969	9941	100	484	267	217	496
2011	670	414	12871	6634	6166					523

Table 6.5. Biomass estimates (t) for GOA rex sole from the NMFS groundfish trawl surveys. Note that the Eastern Gulf (West Yakutat + Southeast) was not surveyed in 2001.

a) Biomass by NPFMC regulatory area. "Max Depth" is the maximum depth stratum surveyed.

Year	Western Gulf	Central Gulf	West Yakutat	Southeast	Total	Std. Dev	Max Depth (m)
1984	6,672	40,688	9,209	4,102	60,670	6,023	1000
1987	8,801	39,722	11,160	4,144	63,826	5,906	1000
1990	6,765	75,147	12,745	3,569	98,225	10,731	500
1993	10,700	55,310	15,761	5,140	86,911	6,211	500
1996	9,419	43,778	9,855	9,705	72,757	5,301	500
1999	12,755	42,750	10,138	9,326	74,969	8,655	1000
2001	9,571	41,687	0	0	51,258	4,404	500
2003	13,265	57,973	10,566	18,093	99,897	7,559	700
2005	12,768	60,600	11,539	16,351	101,257	8,195	1000
2007	11,614	76,490	5,914	9,758	103,776	9,646	1000
2009	19,780	82,091	11,318	11,555	124,744	9,608	1000
2011	12,964	63,490	8,296	10,385	95,134	7,211	700

b) Biomass by depth stratum.

year	Depth range (m)				
	1-100	101-200	201-300	301-500	>500
1984	3,987	37,040	13,083	5,161	1,399
1987	5,691	40,244	14,508	1,812	1,572
1990	15,460	59,833	21,791	1,140	--
1993	11,233	54,064	16,995	4,619	--
1996	10,403	43,419	14,929	4,006	--
1999	14,682	40,239	15,766	3,841	440
2001	7,742	29,206	11,045	3,265	--
2003	17,529	58,787	19,094	4,017	470
2005	14,786	65,060	16,731	4,535	146
2007	9,081	71,514	18,368	4,504	309
2009	16,017	79,662	25,032	2,980	1,054
2011	11,969	53,199	25,171	4,342	454

Table 6.6. Survey size compositions (in 1000's) for rex sole.

a) Females.

year	Length bin cutpoints (cm) 9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47
1984	0	0	0	0	3	23	64	215	1,363	2,473	4,418	6,919	9,932	14,852	14,810	12,028	8,941	5,979	3,820	1,963
1987	0	0	63	0	16	267	394	977	1,484	2,432	4,290	5,623	11,104	12,967	10,274	8,841	8,183	6,566	4,052	2,441
1990	0	0	0	40	342	655	1,428	2,222	1,940	3,214	4,695	7,845	9,513	12,188	13,151	18,024	18,356	15,896	10,378	4,263
1993	0	14	17	87	292	495	634	536	876	1,512	3,361	5,114	8,930	11,925	13,904	13,509	13,518	11,324	9,504	6,524
1996	9	33	219	326	757	1,359	1,241	1,609	2,571	3,452	4,295	5,588	6,901	8,140	8,485	8,170	9,412	9,445	9,244	6,813
1999	22	38	163	538	1,034	2,131	2,431	3,180	3,935	6,402	7,864	7,557	9,026	8,958	9,481	7,987	8,173	7,666	6,709	4,597
2001	31	84	187	384	1,158	2,340	2,718	2,681	4,197	4,781	5,099	6,946	8,045	6,026	5,387	6,187	5,686	5,143	4,965	3,802
2003	92	381	1,024	1,272	2,137	4,563	5,881	6,974	10,071	13,522	15,947	18,050	19,262	20,527	17,516	13,654	10,210	8,028	5,780	3,432
2005	0	142	414	1,774	1,978	2,153	2,312	3,379	5,195	8,560	12,017	15,689	17,296	18,967	19,285	17,500	14,443	10,950	6,497	3,478
2007	71	0	339	1,597	3,732	4,960	6,524	5,212	6,500	6,988	9,776	11,966	11,982	12,662	14,063	16,091	16,975	12,802	9,308	5,594
2009	53	23	221	652	1,456	3,036	2,975	5,417	8,567	10,358	12,935	17,624	19,703	18,683	18,998	17,240	18,564	13,445	11,119	6,506
2011	0	0	13	171	415	1,410	1,645	2,050	3,236	5,646	9,630	13,974	14,622	14,859	16,027	15,471	14,489	12,286	8,675	5,167

b) Males.

year	Length bin cutpoints (cm) 9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47
1984	0	0	7	7	14	186	193	581	2,282	5,131	7,178	12,590	16,570	12,058	6,898	4,049	2,174	713	339	34
1987	0	0	0	51	72	1,110	1,787	3,320	4,530	4,742	7,920	11,331	16,219	14,296	11,421	8,456	4,223	1,620	374	49
1990	0	0	34	98	393	970	2,091	2,119	3,476	4,874	9,361	15,469	18,820	21,143	20,689	12,464	7,418	3,668	1,185	101
1993	11	0	21	206	334	1,103	1,042	1,430	2,121	4,303	7,026	11,695	17,235	19,454	16,650	12,095	6,609	2,937	750	239
1996	48	42	164	741	952	1,691	1,694	2,722	4,901	7,640	10,058	13,671	15,125	13,728	10,597	7,770	4,953	2,305	1,257	672
1999	47	130	215	598	1,761	3,858	4,594	4,306	6,834	9,562	10,477	14,753	16,055	14,203	12,254	8,654	6,217	4,018	1,966	518
2001	0	63	111	687	1,889	2,123	3,178	3,794	4,403	6,706	6,814	7,223	6,420	5,471	6,494	6,258	5,961	3,394	1,114	223
2003	56	449	998	1,809	2,698	5,226	8,479	11,194	13,354	18,595	22,049	28,362	26,513	21,152	13,636	8,689	6,163	3,406	883	374
2005	146	36	599	947	1,828	2,490	3,152	5,558	9,966	16,061	19,653	23,121	23,995	20,691	15,771	11,622	6,786	2,896	990	390
2007	42	34	85	946	2,633	4,161	5,677	5,412	6,108	10,053	15,187	17,473	19,137	17,813	20,016	16,052	9,341	5,389	1,981	592
2009	88	40	129	588	1,301	3,287	4,279	7,063	10,505	14,658	20,590	26,509	31,402	28,897	23,860	15,937	7,437	2,940	1,360	373
2011	0	0	183	144	416	1,607	2,640	3,784	5,922	9,424	12,848	16,447	20,091	19,265	15,441	10,836	6,937	3,722	1,380	300

Table 6.7. Survey age compositions (in 1000's) for rex sole. The 1990 age composition was not used in the assessment model because the ages were probably underestimated due to the ageing technique (surface age reading) used.

a) Females.

year	Age bins 3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1984	0	4,034	5,375	6,379	6,153	6,211	6,291	4,308	4,791	5,447	6,145	2,685	8,774	7,386	3,001	2,307	1,449	1,717
1987	0	5,468	2,088	5,579	7,797	11,349	6,408	10,242	10,505	2,668	4,923	2,270	2,518	2,310	600	395	1,061	1,021
1990	9,751	10,080	41,666	29,769	23,529	12,381	1,245	205	217	0	0	0	0	0	0	0	0	0
1993	903	1,415	21,052	16,290	21,540	16,457	9,562	9,713	5,134	2,389	1,834	243	994	90	0	0	0	73
1996	1,983	4,792	6,637	8,970	7,879	4,544	10,243	11,775	9,820	8,374	4,782	5,606	3,214	814	2,459	780	1,353	1,356
1999	10,986	12,858	18,539	7,056	8,159	4,218	8,160	4,438	6,992	4,699	4,135	3,304	2,120	1,433	776	1,092	0	5,347
2001	8,390	15,964	12,771	7,621	4,234	3,615	4,340	980	1,466	1,594	2,217	1,925	1,048	1,975	889	2,528	924	5,497
2003	8,022	19,580	23,987	29,895	15,374	13,203	8,809	5,058	3,482	5,708	7,820	2,817	3,308	3,968	4,726	5,719	1,445	12,539
2005	5,506	11,846	26,923	14,655	21,590	17,008	12,093	9,703	5,542	4,492	4,891	5,493	4,762	2,518	1,226	1,829	2,710	9,250
2007	9,128	16,469	14,031	10,915	14,489	25,930	21,932	7,248	6,418	4,838	752	1,329	1,774	882	1,316	1,129	840	6,924
2009	4,944	22,579	20,560	26,746	15,363	22,453	18,790	16,021	7,047	11,016	7,286	3,001	1,948	2,041	1,169	846	1,803	6,697

b) Males.

year	Age bins 3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1984	0	11,696	14,404	5,642	3,556	9,754	1,817	3,148	1,956	1,734	996	4,661	0	3,497	1,976	2,588	0	665
1987	1,580	6,167	13,342	7,596	12,547	8,620	2,872	8,290	3,110	12,694	1,142	516	1,260	780	0	0	0	0
1990	11,896	24,450	52,356	26,245	8,333	688	0	0	0	0	0	0	0	0	0	0	0	0
1993	2,389	4,926	24,642	24,216	15,868	6,658	11,018	6,722	5,870	708	59	1,302	436	0	0	0	0	191
1996	4,905	7,138	17,588	14,689	11,723	7,396	12,189	7,105	7,346	4,370	3,153	340	991	0	0	0	0	314
1999	10,511	21,674	18,335	7,933	9,685	2,523	6,637	8,995	2,050	5,053	4,287	3,364	2,167	237	5,444	0	1,731	2,907
2001	7,688	20,414	9,910	9,597	2,622	1,619	1,008	853	1,644	1,534	614	1,801	377	1,031	522	489	450	5,128
2003	15,432	18,937	22,860	38,205	25,693	10,704	11,233	4,742	8,781	3,591	5,540	5,426	2,027	2,122	3,482	2,351	916	6,685
2005	7,794	19,670	30,953	29,080	16,589	7,876	6,651	6,396	4,657	3,923	4,912	3,258	3,449	5,568	1,312	1,011	80	6,808
2007	6,681	20,353	7,348	20,081	19,098	19,882	15,149	6,522	2,449	0	962	962	3,996	2,876	3,616	2,326	744	13,033
2009	3,900	37,596	30,549	36,463	11,415	17,214	7,216	14,795	8,122	10,780	3,234	1,500	2,746	480	2,830	0	2,676	6,773

Table 6.8. Age-length conversion matrices for rex sole. Values at a row/column combination correspond to the fraction of individuals at the age indicated by the row that fall into the length group indicated by the column.

a) Females.

	length cutpoints (cm)																												
age	**9**	**11**	**13**	**15**	**17**	**19**	**21**	**23**	**25**	**27**	**29**	**31**	**33**	**35**	**37**	**39**	**41**	**43**	**45**	**47**	**49**	**51**	**53**	**55**	**57**	**59**	**61**	**63**	**65**
3	0	0.0002	0.0022	0.0143	0.0589	0.1528	0.2504	0.2594	0.1698	0.0702	0.0183	0.003	0.0003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0.0001	0.0004	0.0024	0.0107	0.0351	0.0855	0.1551	0.2091	0.2096	0.1561	0.0865	0.0356	0.0109	0.0025	0.0004	0.0001	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0.0003	0.0013	0.0051	0.0164	0.0421	0.0858	0.1396	0.1811	0.1872	0.1544	0.1015	0.0532	0.0222	0.0074	0.002	0.0004	0.0001	0	0	0	0	0	0	0	0
6	0	0	0	0	0.0001	0.0003	0.0012	0.0045	0.0132	0.0323	0.0653	0.1093	0.1513	0.1731	0.1639	0.1283	0.0831	0.0445	0.0197	0.0072	0.0022	0.0005	0.0001	0	0	0	0	0	0
7	0	0	0	0	0	0.0001	0.0005	0.0017	0.0055	0.0147	0.0332	0.0635	0.1027	0.1404	0.162	0.1581	0.1303	0.0907	0.0534	0.0266	0.0112	0.004	0.0012	0.0003	0.0001	0	0	0	0
8	0	0	0	0	0	0.0001	0.0002	0.0009	0.0029	0.0081	0.0195	0.0404	0.0715	0.1084	0.1408	0.1566	0.1492	0.1217	0.0851	0.0509	0.0261	0.0114	0.0043	0.0014	0.0004	0.0001	0	0	0
9	0	0	0	0	0	0	0.0001	0.0005	0.0018	0.0052	0.0131	0.0284	0.0532	0.0862	0.1205	0.1456	0.1521	0.1372	0.1069	0.072	0.0419	0.0211	0.0092	0.0034	0.0011	0.0003	0.0001	0	0
10	0	0	0	0	0	0	0.0001	0.0004	0.0013	0.0038	0.0097	0.0218	0.0424	0.0715	0.1051	0.1341	0.1488	0.1435	0.1202	0.0876	0.0555	0.0305	0.0146	0.0061	0.0022	0.0007	0.0002	0	0
11	0	0	0	0	0	0	0.0001	0.0003	0.001	0.003	0.0078	0.0179	0.0356	0.062	0.094	0.1246	0.144	0.1453	0.1279	0.0983	0.066	0.0386	0.0197	0.0088	0.0034	0.0012	0.0003	0.0001	0
12	0	0	0	0	0	0	0.0001	0.0002	0.0008	0.0025	0.0067	0.0155	0.0313	0.0556	0.0863	0.1173	0.1395	0.1452	0.1323	0.1056	0.0737	0.0451	0.0241	0.0113	0.0046	0.0017	0.0005	0.0001	0
13	0	0	0	0	0	0	0.0001	0.0002	0.0007	0.0022	0.006	0.0139	0.0285	0.0513	0.0808	0.1118	0.1357	0.1444	0.1348	0.1104	0.0793	0.05	0.0276	0.0134	0.0057	0.0021	0.0007	0.0002	0.0001
14	0	0	0	0	0	0	0	0.0002	0.0007	0.002	0.0055	0.0129	0.0266	0.0483	0.077	0.1078	0.1327	0.1435	0.1363	0.1137	0.0834	0.0537	0.0304	0.0151	0.0066	0.0025	0.0008	0.0003	0.0001
15	0	0	0	0	0	0	0	0.0002	0.0006	0.0019	0.0051	0.0121	0.0252	0.0462	0.0742	0.1049	0.1305	0.1427	0.1372	0.116	0.0863	0.0564	0.0324	0.0164	0.0073	0.0029	0.001	0.0003	0.0001
16	0	0	0	0	0	0	0	0.0002	0.0006	0.0018	0.0049	0.0116	0.0243	0.0447	0.0722	0.1028	0.1288	0.142	0.1377	0.1176	0.0883	0.0584	0.034	0.0174	0.0078	0.0031	0.0011	0.0003	0.0001
17	0	0	0	0	0	0	0	0.0002	0.0006	0.0018	0.0047	0.0113	0.0237	0.0436	0.0708	0.1013	0.1275	0.1414	0.1381	0.1187	0.0899	0.0599	0.0352	0.0182	0.0083	0.0033	0.0012	0.0004	0.0001
18	0	0	0	0	0	0	0	0.0002	0.0006	0.0017	0.0046	0.011	0.0232	0.0429	0.0698	0.1002	0.1266	0.141	0.1383	0.1195	0.0909	0.061	0.036	0.0187	0.0086	0.0035	0.0012	0.0004	0.0001
19	0	0	0	0	0	0	0	0.0002	0.0005	0.0017	0.0046	0.0109	0.0228	0.0423	0.0691	0.0993	0.1259	0.1406	0.1384	0.12	0.0917	0.0618	0.0367	0.0192	0.0088	0.0036	0.0013	0.0004	0.0001
20	0	0	0	0	0	0	0	0.0002	0.0005	0.0017	0.0045	0.0107	0.0226	0.0419	0.0685	0.0987	0.1254	0.1404	0.1385	0.1204	0.0923	0.0624	0.0371	0.0195	0.009	0.0037	0.0013	0.0004	0.0002

b) Males.

	length cutpoints (cm)																												
age	**9**	**11**	**13**	**15**	**17**	**19**	**21**	**23**	**25**	**27**	**29**	**31**	**33**	**35**	**37**	**39**	**41**	**43**	**45**	**47**	**49**	**51**	**53**	**55**	**57**	**59**	**61**	**63**	**65**
3	0	0.0006	0.0047	0.0254	0.0873	0.1906	0.2649	0.2344	0.1321	0.0474	0.0108	0.0016	0.0001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0.0001	0.001	0.0052	0.0204	0.059	0.1251	0.1947	0.2221	0.1857	0.1139	0.0512	0.0169	0.0041	0.0007	0.0001	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0.0001	0.0006	0.0029	0.0112	0.0331	0.076	0.1353	0.1867	0.1998	0.1658	0.1067	0.0533	0.0206	0.0062	0.0014	0.0003	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0.0001	0.0007	0.003	0.0106	0.0299	0.0669	0.1192	0.169	0.1907	0.1712	0.1223	0.0695	0.0314	0.0113	0.0032	0.0007	0.0001	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0.0002	0.0011	0.0043	0.0139	0.036	0.0751	0.1261	0.1706	0.1856	0.1626	0.1146	0.0651	0.0297	0.0109	0.0032	0.0008	0.0001	0	0	0	0	0	0	0
8	0	0	0	0	0	0.0001	0.0005	0.0021	0.0075	0.0217	0.0506	0.0956	0.1459	0.1798	0.179	0.144	0.0936	0.0491	0.0208	0.0071	0.002	0.0004	0.0001	0	0	0	0	0	0
9	0	0	0	0	0	0	0.0002	0.0011	0.0045	0.0143	0.0367	0.0758	0.1263	0.1699	0.1845	0.1616	0.1143	0.0652	0.03	0.0112	0.0033	0.0008	0.0002	0	0	0	0	0	0
10	0	0	0	0	0	0	0.0001	0.0007	0.0029	0.0101	0.0281	0.0626	0.1121	0.1611	0.1861	0.1727	0.1288	0.0772	0.0372	0.0144	0.0045	0.0011	0.0002	0	0	0	0	0	0
11	0	0	0	0	0	0	0.0001	0.0004	0.002	0.0075	0.0225	0.0535	0.1017	0.1544	0.1869	0.1806	0.1393	0.0857	0.0421	0.0165	0.0052	0.0013	0.0003	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0.0003	0.0014	0.0057	0.0184	0.0468	0.0941	0.1496	0.1881	0.1871	0.1472	0.0916	0.0451	0.0176	0.0054	0.0013	0.0003	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0.0002	0.001	0.0044	0.0154	0.0416	0.0882	0.1462	0.1898	0.1929	0.1534	0.0956	0.0466	0.0178	0.0053	0.0012	0.0002	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0.0001	0.0007	0.0035	0.0129	0.0374	0.0834	0.144	0.1923	0.1986	0.1587	0.098	0.0469	0.0173	0.0049	0.0011	0.0002	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0.0001	0.0005	0.0027	0.0109	0.0337	0.0793	0.1425	0.1953	0.2044	0.1632	0.0994	0.0462	0.0164	0.0044	0.0009	0.0001	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0.0004	0.0021	0.0092	0.0304	0.0756	0.1414	0.1989	0.2103	0.1672	0.0999	0.0449	0.0151	0.0038	0.0007	0.0001	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0.0002	0.0016	0.0076	0.0273	0.072	0.1406	0.203	0.2166	0.1709	0.0996	0.043	0.0137	0.0032	0.0006	0.0001	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0.0002	0.0012	0.0063	0.0244	0.0685	0.14	0.2074	0.2232	0.1743	0.0988	0.0406	0.0121	0.0026	0.0004	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0.0001	0.0009	0.0051	0.0216	0.065	0.1393	0.2123	0.2301	0.1775	0.0973	0.038	0.0105	0.0021	0.0003	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0.0004	0.0032	0.0164	0.0577	0.1378	0.2232	0.2453	0.1829	0.0926	0.0318	0.0074	0.0012	0.0001	0	0	0	0	0	0	0

Table 6.9. Age-specific schedules for rex sole in the Gulf of Alaska. The maturity ogive is based on Abookire (2006).

	Length (cm)		Weight (g)		Maturity
Age	Males	Females	Males	Females	ogive
3	22.44	22.96	31.52	23.74	0.0083
4	27.84	28.81	64.22	51.93	0.0763
5	31.52	33.10	96.88	83.82	0.3073
6	34.05	36.24	124.95	114.66	0.6037
7	35.77	38.55	147.12	141.86	0.7901
8	36.95	40.24	163.77	164.52	0.8796
9	37.76	41.48	175.89	182.70	0.9224
10	38.31	42.39	184.53	196.91	0.9444
11	38.68	43.06	190.60	207.82	0.9566
12	38.94	43.55	194.84	216.08	0.9639
13	39.12	43.91	197.77	222.29	0.9685
14	39.24	44.18	199.79	226.93	0.9715
15	39.32	44.37	201.18	230.37	0.9736
16	39.38	44.51	202.14	232.92	0.9749
17	39.42	44.61	202.79	234.80	0.9759
18	39.44	44.69	203.24	236.19	0.9766
19	39.46	44.75	203.55	237.21	0.9771
20	39.47	44.79	203.76	237.96	0.9775

Table 6.10. Likelihood multiplier settings for all model cases.

Fishery		Survey			Recruitment		
catch	size compositions	biomass	size compositions	age compositions	early	ordinary	late
20	1	1	2	1	1	1	1

Table 6.11. Initial parameter values. Subscripts for recruitment deviations (τ) run from 1965 to 2011, with the subscript increasing moving across, then down. Subscripts for fishing mortality deviations (ε) run from 1982 to 2011 in the same manner.

Recruitment										
$\overline{\ln R_0}$	17									
τ_t			1965-2011:			0	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000									
Fishing mortality										
$\overline{\ln F}$	0									
ε_t	1982-2011:		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000									
Fishery Selectivity										
	females	**males**								
slope	0.4	0.4								
A_{50}	5	5								
scale par.	--	0								
Survey Selectivity										
	females	**males**								
slope	0.8	0.4								
A_{50}	4	4								
scale par.	--	0								

Table 6.12. Likelihood components for the model.

likelihood component	Value
ordinary recruitment	-6.52
"late" recruitment	-0.01
"early" recruitment	-2.24
fishery catch	-0.16
fishery size composition	-707.06
survey biomass	-9.81
survey size composition	-21.48
survey age composition	-273.51

Table 6.13. Final parameter estimates. Subscripts for recruitment deviations (τ) run from 1965 to 2011, with the subscript increasing moving across, then down. Subscripts for fishing mortality deviations (ε) run from 1982 to 2011 in the same manner.

Recruitment										
$\overline{\ln R_0}$	16.98683									
τ_t				1965-2011:	-1.0525	-0.4049	-0.4453	-0.3883	-0.1999	-0.2549
	0.0714	-0.1345	-0.2511	-0.1805	-0.1926	-0.3289	-0.2538	-0.0304	0.0149	-0.1315
	-0.4037	0.0070	-0.0226	-0.4995	0.1863	0.2457	0.3221	0.4078	0.2712	0.2774
	0.0745	-0.2610	-0.1183	-0.4342	-0.3105	-0.5325	-0.0956	0.1433	0.3429	0.6783
	0.5575	0.5479	0.4983	0.2975	-0.0787	0.5855	0.4343	0.8780	0.0454	0.0830
	0.0355									
Fishing mortality										
$\overline{\ln F}$	-2.694578									
ε_t	1982-2011:	-0.6254	-1.0893	-1.5621	-2.4128	-2.9254	-0.5241	-0.4777	-1.1408	-0.4166
	0.9129	0.5208	0.4421	0.5939	0.6484	0.9769	0.4784	0.2955	0.4394	0.6398
	0.5007	0.5522	0.8092	0.0068	0.3390	0.6638	0.4225	0.2673	0.7918	0.4995
	0.3734									
Fishery Selectivity										
	females	**males**								
slope	1.3496	0.9241								
A_{50}	10.25	10.32								
scale par.	--	0.0000								
Survey Selectivity										
	females	**males**								
slope	1.3461	1.9828								
A_{50}	4.12	3.65								
scale par.	--	0.0000								

Table 6.14. Model-estimated fishery catch and survey biomass.

year	catch (t)			survey biomass (t)		
	estimate	std dev	observed	estimate	std dev	observed
1982	1,015	159	959	70,758	3,776	
1983	636	99	595	70,830	3,639	
1984	400	62	365	71,526	3,525	60,670
1985	175	27	154	72,153	3,403	
1986	108	17	93	73,404	3,276	
1987	1,205	188	1,151	76,098	3,181	63,826
1988	1,247	194	1,192	79,026	3,127	
1989	641	99	599	82,888	3,107	
1990	1,326	207	1,269	87,474	3,109	98,225
1991	4,762	750	4,636	90,727	3,107	
1992	3,053	478	3,000	89,477	3,067	
1993	2,855	433	3,000	88,399	2,983	86,911
1994	3,422	514	3,673	86,082	2,884	
1995	3,704	553	4,021	82,223	2,770	
1996	5,112	742	5,874	77,501	2,647	72,757
1997	3,060	458	3,294	71,392	2,545	
1998	2,539	383	2,669	68,246	2,456	
1999	2,847	426	3,060	67,443	2,416	74,969
2000	3,268	484	3,591	68,872	2,448	
2001	2,650	391	2,940	72,891	2,558	71,326
2002	2,622	385	2,941	79,576	2,746	
2003	3,197	477	3,485	86,652	2,961	99,897
2004	1,437	219	1,464	92,469	3,193	
2005	2,159	333	2,176	98,157	3,397	101,255
2006	3,271	507	3,294	100,740	3,555	
2007	2,865	446	2,852	101,700	3,684	103,776
2008	2,747	429	2,703	104,290	3,885	
2009	4,945	791	4,753	108,390	4,249	124,744
2010	3,783	601	3,636	109,550	4,839	
2011	3,389	523	2,594	109,150	5,207	95,134

Table 6.15. Total (age 3+) population biomass estimated in this year's model, compared with estimates from previous assessments.

year	Age 3+ Biomass (1000's t)					
	2011 Assessment		2009 Assessment		2007 Assessment	
	estimate	std dev	estimate	std dev	estimate	std dev
1982	76.5	3.9	79.0	4.0	74.6	3.8
1983	77.1	3.7	79.4	3.9	74.2	3.7
1984	77.1	3.6	79.2	3.7	73.2	3.6
1985	78.4	3.5	80.1	3.6	73.0	3.4
1986	80.9	3.4	82.7	3.5	73.8	3.3
1987	84.6	3.3	86.5	3.4	76.4	3.3
1988	88.4	3.2	90.3	3.3	81.6	3.3
1989	92.2	3.2	94.0	3.4	87.7	3.3
1990	96.6	3.2	98.1	3.4	94.5	3.4
1991	99.1	3.2	100.4	3.3	99.1	3.5
1992	96.4	3.2	97.4	3.3	97.4	3.5
1993	94.5	3.1	95.3	3.2	95.2	3.4
1994	91.4	3.0	92.2	3.1	91.7	3.3
1995	87.2	2.9	87.8	2.9	86.0	3.1
1996	82.0	2.8	82.5	2.8	79.4	3.0
1997	76.4	2.7	77.0	2.7	74.4	2.8
1998	74.5	2.6	76.1	2.7	72.2	2.7
1999	75.3	2.6	78.3	2.8	72.9	2.8
2000	79.2	2.7	82.5	2.9	73.7	2.9
2001	84.5	2.8	87.6	3.1	79.1	3.1
2002	91.3	3.1	94.0	3.3	85.6	3.4
2003	98.1	3.3	100.6	3.6	95.3	3.8
2004	103.0	3.6	104.9	4.0	101.5	4.4
2005	106.7	3.8	108.6	4.3	106.9	4.9
2006	110.1	4.0	113.8	4.8	108.7	5.2
2007	112.0	4.2	116.1	5.3	108.2	5.4
2008	116.9	4.6	117.6	5.7		
2009	119.7	5.1	117.9	6.0		
2010	118.6	5.6				
2011	116.9	5.7				

Table 6.16. Female spawning biomass estimated in this year's model, compared with estimates from previous assessments.

year	Female Spawning Stock Biomass (1000's t)					
	2011 Assessment		2009 Assessment		2007 Assessment	
	estimate	std dev	estimate	std dev	estimate	std dev
1982	34.8	1.9	36.0	2.0	34.2	1.9
1983	34.9	1.9	36.1	1.9	34.1	1.9
1984	35.1	1.8	36.2	1.9	34.1	1.8
1985	35.6	1.7	36.6	1.8	34.1	1.7
1986	36.0	1.7	37.0	1.8	34.1	1.7
1987	36.6	1.6	37.5	1.7	34.0	1.6
1988	37.3	1.6	38.0	1.6	33.8	1.5
1989	38.6	1.6	39.4	1.6	34.7	1.5
1990	40.8	1.5	41.7	1.6	37.4	1.5
1991	42.8	1.5	43.6	1.6	40.7	1.6
1992	42.6	1.5	43.3	1.6	42.1	1.6
1993	43.1	1.5	43.6	1.6	43.5	1.7
1994	42.8	1.5	43.2	1.5	43.6	1.7
1995	41.4	1.5	41.6	1.5	41.9	1.6
1996	39.4	1.4	39.5	1.4	39.2	1.5
1997	36.2	1.3	36.4	1.4	35.3	1.5
1998	34.3	1.3	34.3	1.3	32.6	1.4
1999	32.9	1.2	33.1	1.3	31.2	1.3
2000	32.2	1.2	32.8	1.3	30.7	1.3
2001	32.4	1.2	33.7	1.3	30.7	1.3
2002	34.6	1.3	36.2	1.4	31.9	1.4
2003	37.9	1.4	39.3	1.5	34.4	1.5
2004	41.1	1.5	42.2	1.6	38.0	1.6
2005	45.1	1.6	46.0	1.8	43.3	1.9
2006	47.8	1.7	48.6	1.9	47.3	2.2
2007	48.7	1.8	49.5	2.1	48.8	2.4
2008	49.4	1.9	50.7	2.3		
2009	50.6	2.0	52.3	2.6		
2010	51.3	2.3				
2011	52.6	2.6				

Table 6.17. Age 3 recruitment (in millions) estimated in this year's model, compared with estimates from previous assessments.

Year	2011 Assessment		2009 Assessment		2007 Assessment	
	estimate	std dev	estimate	std dev	estimate	std dev
1982	48.0	6.5	49.1	6.6	43.3	5.9
1983	46.6	6.5	46.5	6.6	37.0	5.3
1984	28.9	5.5	28.9	5.5	23.2	4.5
1985	57.4	8.5	54.8	8.5	44.4	7.0
1986	61.0	8.8	66.9	9.4	49.6	7.0
1987	65.8	9.4	67.1	9.8	64.7	8.5
1988	71.7	8.9	71.3	9.4	100.3	11.1
1989	62.5	7.0	61.5	7.3	72.2	8.8
1990	62.9	6.6	60.9	6.8	69.5	8.2
1991	51.4	5.9	53.4	6.5	53.5	7.0
1992	36.7	4.8	34.2	5.1	25.5	4.7
1993	42.4	5.2	42.4	5.8	31.1	5.7
1994	30.9	4.4	34.4	5.3	34.1	6.5
1995	35.0	4.6	31.1	5.0	19.5	4.9
1996	28.0	4.2	29.8	5.3	22.8	7.2
1997	43.3	5.3	46.2	6.9	68.3	19.8
1998	55.0	5.9	67.5	7.6	39.7	16.2
1999	67.2	6.7	78.5	7.6	67.1	13.1
2000	93.9	8.4	81.9	8.2	47.4	16.2
2001	83.3	8.0	79.4	8.4	120.7	20.4
2002	82.5	8.4	82.3	9.2	74.9	23.9
2003	78.5	8.4	83.1	9.8	120.0	21.8
2004	64.2	8.1	61.1	9.4	48.9	17.2
2005	44.1	7.1	47.5	9.3	48.1	5.8
2006	85.6	11.3	115.8	21.1	46.7	5.8
2007	73.6	11.8	59.3	7.4	58.7	7.1
2008	114.7	19.4	58.6	7.5		
2009	49.9	6.1	57.6	7.2		
2010	51.8	6.4				
2011	49.4	6.1				

Table 6.18. Prohibited species catch (PSC) in the rex sole target fishery.

a). Crab.

year	PSC in target fishery (#)					fraction of total PSC				
	King Crab			Tanner Crab		King Crab			Tanner Crab	
	Blue	Golden	Red	Bairdi	Opilio	Blue	Golden	Red	Bairdi	Opilio
2003	0	0	0	28,780	0	0.0%	0.0%	0.0%	19.5%	0.0%
2004	0	0	0	9,014	0	0.0%	0.0%	0.0%	12.5%	0.0%
2005	0	0	0	7,949	0	0.0%	0.0%	0.0%	3.4%	0.0%
2006	0	0	0	73,530	0	0.0%	0.0%	0.0%	17.9%	0.0%
2007	0	0	0	45,272	0	0.0%	0.0%	0.0%	9.2%	0.0%
2008	0	0	0	48,204	0	0.0%	0.0%	0.0%	12.9%	0.0%
2009	0	54	0	140,364	0	0.0%	1.6%	0.0%	54.0%	0.0%
2010	0	0	0	14,266	0	0.0%	0.0%	0.0%	5.4%	0.0%
2011	0	0	0	6,102	0	0.0%	0.0%	0.0%	6.8%	0.0%

b). Halibut.

Year	directed fishery halibut PSC (kg)	% total halibut PSC
2003	393,373	7.2%
2004	304,274	5.0%
2005	86,281	1.8%
2006	208,398	3.7%
2007	60,735	1.3%
2008	173,430	2.9%
2009	435,047	9.2%
2010	387,523	8.6%
2011	171,575	3.9%

c). Salmon. (PSC for2011 unavailable at time of document preparation).

Year	Chinook		Non-Chinook	
	PSC (#)	fraction of total	PSC (#)	fraction of total
2003	2,900	18.3%	520	4.9%
2004	494	2.8%	1,049	18.1%
2005	525	2.4%	98	1.5%
2006	1,445	7.5%	557	12.4%
2007	715	1.8%	663	19.0%
2008	0	0.0%	140	5.9%
2009	1,909	24.2%	413	16.2%
2010	2,300	4.2%	93	4.6%

Table 6.19. Catch of nontarget species in the rex sole target fishery, expressed as the fraction of species catch by all fisheries in the FMP.

Nontarget Species Group	Year								
	2011	2010	2009	2008	2007	2006	2005	2004	2003
Benthic urochordata	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	28.8%	0.3%	48.9%
Birds	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bivalves	0.5%	0.0%	9.6%	9.9%	0.0%	0.0%	5.4%	8.4%	8.6%
Brittle star unidentified	4.0%	0.1%	15.1%	3.8%	7.1%	0.0%	0.2%	0.0%	0.0%
Capelin	0.0%	0.0%	51.0%	95.5%	--	0.0%	0.0%	0.0%	17.3%
Corals Bryozoans	3.1%	10.3%	13.5%	0.0%	6.7%	0.0%	0.0%	0.0%	17.8%
Dark Rockfish	0.0%	0.0%	0.0%	0.0%	--	--	--	--	--
Eelpouts	2.6%	9.8%	19.3%	0.0%	0.0%	0.0%	0.3%	0.5%	11.0%
Eulachon	0.0%	5.5%	11.5%	2.9%	4.4%	0.0%	1.9%	0.0%	9.9%
Giant Grenadier	3.6%	8.9%	21.5%	3.2%	5.2%	8.6%	3.6%	0.0%	0.0%
Greenlings	0.0%	8.4%	10.5%	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%
Grenadier	11.2%	0.0%	0.0%	4.0%	0.0%	0.0%	0.0%	0.4%	7.8%
Gunnels	--	--	--	12.9%	--	0.0%	--	--	0.0%
Hermit crab unidentified	4.9%	4.3%	11.7%	4.6%	5.8%	15.6%	4.8%	0.0%	10.2%
Invertebrate unidentified	0.0%	14.3%	17.0%	5.9%	0.5%	0.0%	0.0%	0.3%	9.0%
Lanternfishes (myctophidae)	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Large Sculpins	1.8%	3.4%	7.9%	1.5%	3.2%	5.8%	3.1%	3.3%	7.8%
Misc crabs	0.2%	5.7%	14.2%	4.5%	5.6%	12.6%	3.9%	0.2%	8.3%
Misc crustaceans	10.0%	0.0%	0.0%	--	--	--	64.7%	0.0%	65.1%
Misc deep fish	--	--	--	0.0%	--	--	--	--	--
Misc fish	2.1%	3.5%	8.5%	2.5%	3.4%	4.1%	1.9%	2.5%	5.7%
Misc inverts (worms etc)	50.5%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	--	--
Octopus	0.2%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.2%
Other osmerids	4.4%	7.7%	16.1%	4.2%	6.5%	0.0%	0.0%	0.0%	5.2%
Other Sculpins	4.1%	6.3%	11.2%	3.4%	4.1%	8.8%	4.3%	0.3%	7.6%
Pacific Sand lance	0.0%	--	0.0%	0.0%	--	0.0%	0.0%	0.0%	0.0%
Pandalid shrimp	4.0%	6.4%	18.8%	4.3%	5.8%	8.7%	2.9%	0.0%	10.4%
Polychaete unidentified	0.0%	100.0%	100.0%	0.0%	0.0%	--	40.4%	--	0.0%
Scypho jellies	2.4%	3.6%	12.6%	0.0%	5.3%	0.0%	2.2%	0.0%	5.2%
Sea anemone unidentified	3.2%	3.7%	9.3%	0.5%	4.2%	0.0%	3.0%	4.5%	7.2%
Sea pens whips	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	16.3%
Sea star	2.6%	4.8%	9.5%	3.3%	4.7%	4.9%	3.0%	3.4%	7.7%
Shark, Other	2.0%	0.0%	0.5%	0.0%	0.1%	0.9%	0.6%	8.8%	4.1%
Shark, Pacific sleeper	0.4%	0.5%	1.8%	0.1%	0.1%	2.6%	1.1%	1.4%	3.7%
Shark, salmon	0.0%	0.2%	0.0%	0.0%	0.7%	0.0%	0.0%	0.0%	0.7%
Shark, spiny dogfish	0.2%	2.0%	0.3%	0.0%	0.0%	0.6%	1.3%	0.8%	3.0%
Skate, Alaska	0.1%	0.1%	--	--	--	--	--	--	--
Skate, Aleutian	0.6%	--	--	--	--	--	--	--	--
Skate, Big	3.3%	4.3%	7.0%	2.2%	5.8%	8.9%	4.7%	2.9%	--
Skate, Longnose	4.0%	4.9%	7.4%	4.1%	6.1%	5.9%	2.2%	2.5%	0.0%
Skate, Other	3.2%	6.3%	11.4%	5.2%	8.9%	10.0%	6.4%	5.9%	10.0%
Skate, Whiteblotched	0.0%	--	--	--	--	--	--	--	--
Snails	3.2%	5.9%	9.5%	4.3%	4.6%	9.2%	3.8%	4.7%	8.0%
Sponge unidentified	3.0%	5.6%	12.4%	0.0%	10.0%	0.0%	6.1%	0.0%	9.7%
Squid	0.2%	0.6%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%
Stichaeidae	0.0%	14.1%	21.8%	22.8%	13.7%	0.0%	17.5%	0.0%	34.7%
Surf smelt	--	--	--	0.0%	--	--	0.0%	0.0%	--
urchins dollars cucumbers	4.0%	7.7%	15.1%	3.7%	4.8%	0.0%	4.8%	0.4%	7.7%

Table 6.20. Catch of non-prohibited species in the rex sole target fishery. The species accounting for the two largest totals are highlighted.

	2011		2010		2009		2008		2007	
Species	total (t)	% retained	total (t)	% retained	total (t)	% retained	total (t)	% retained	total (t)	% retained
Atka mackerel	4	99%	225	83%	225	83%	0	0%	1	89%
arrowtooth flounder	1,790	19%	5,628	10%	6,207	9%	2,501	12%	3,108	8%
big skate	106	84%	214	83%	264	85%	70	96%	74	99%
deep water flatfish	47	7%	269	7%	321	6%	227	3%	68	0%
flathead sole	178	94%	497	93%	629	94%	283	81%	264	92%
longnose skate	44	94%	76	93%	82	94%	36	97%	24	97%
northern rockfish	12	39%	37	38%	37	39%	12	0%	12	0%
all sharks, squid, sculpin, octopus	--	--	31	1%	36	2%	9	0%	15	0%
Pacific cod	155	87%	557	86%	592	85%	238	96%	409	88%
pelagic rockfish complex	11	78%	35	89%	42	91%	5	94%	31	94%
pollock	118	83%	550	70%	615	72%	70	95%	110	99%
POP	291	25%	399	34%	420	32%	76	2%	68	10%
rex sole	1,073	98%	3,142	99%	3,401	99%	1,091	98%	1,556	100%
rougheye	3	92%	10	27%	10	29%	14	41%	4	94%
other rockfish	1	37%	3	9%	3	9%	1	0%	0	0%
sablefish	29	91%	122	93%	125	93%	35	76%	42	83%
shallow water flatfish	11	93%	32	88%	46	92%	12	82%	10	100%
shortraker	9	78%	20	62%	21	62%	4	71%	4	92%
thornyheads	27	95%	52	99%	54	97%	29	100%	24	95%
unidentified skates	21	28%	50	66%	60	63%	22	56%	103	50%
octopus	0	8%	--	--	--	--	--	--	--	--
sculpin	3	6%	--	--	--	--	--	--	--	--
USRK (???)	6	0%	--	--	--	--	--	--	--	--

Figures

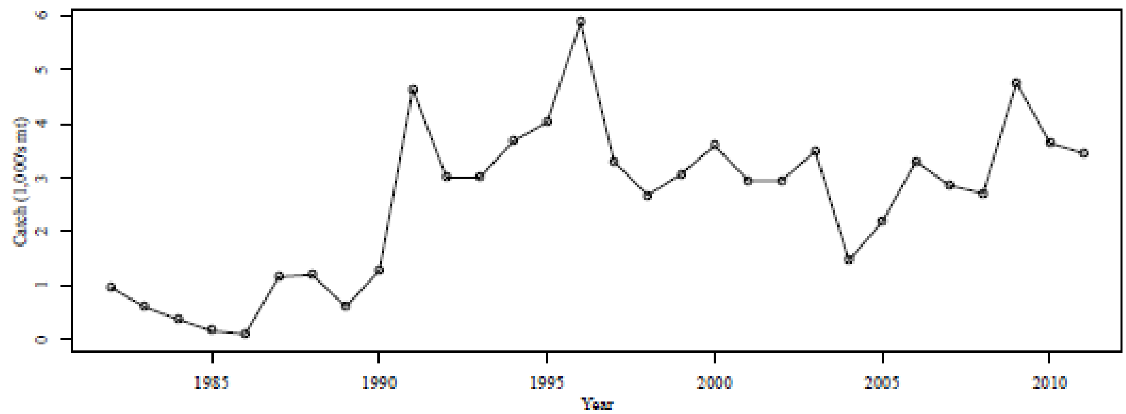


Figure 6.1. Fishery catches for GOA rex sole, 1982-2011. Catch for 2011 is through Sept. 24.

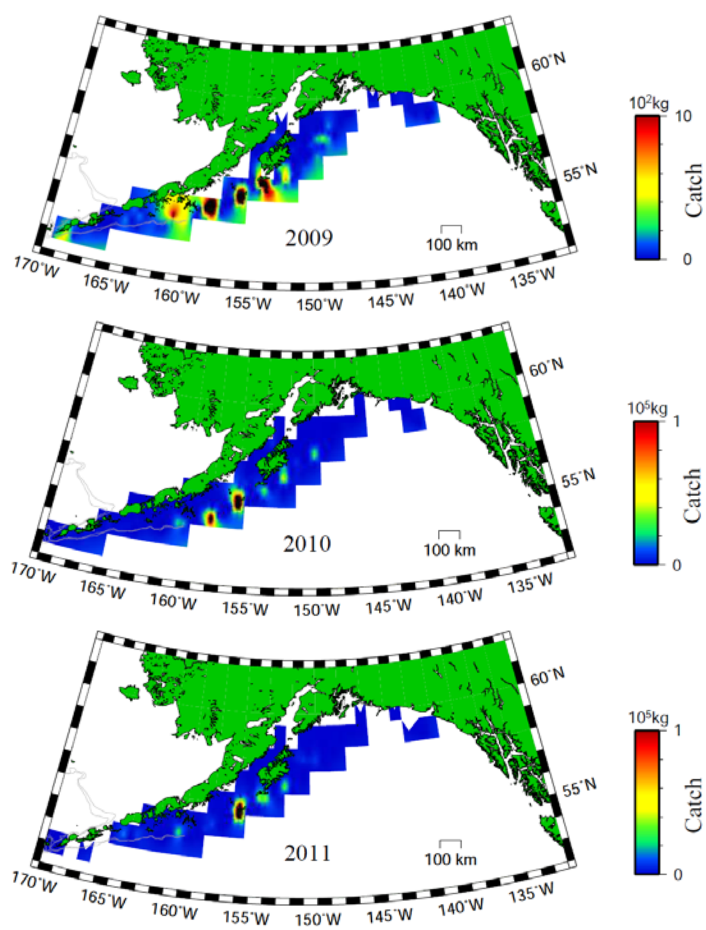


Figure 6.2. Spatial patterns of fishery catches for GOA rex sole, 2009-2011.

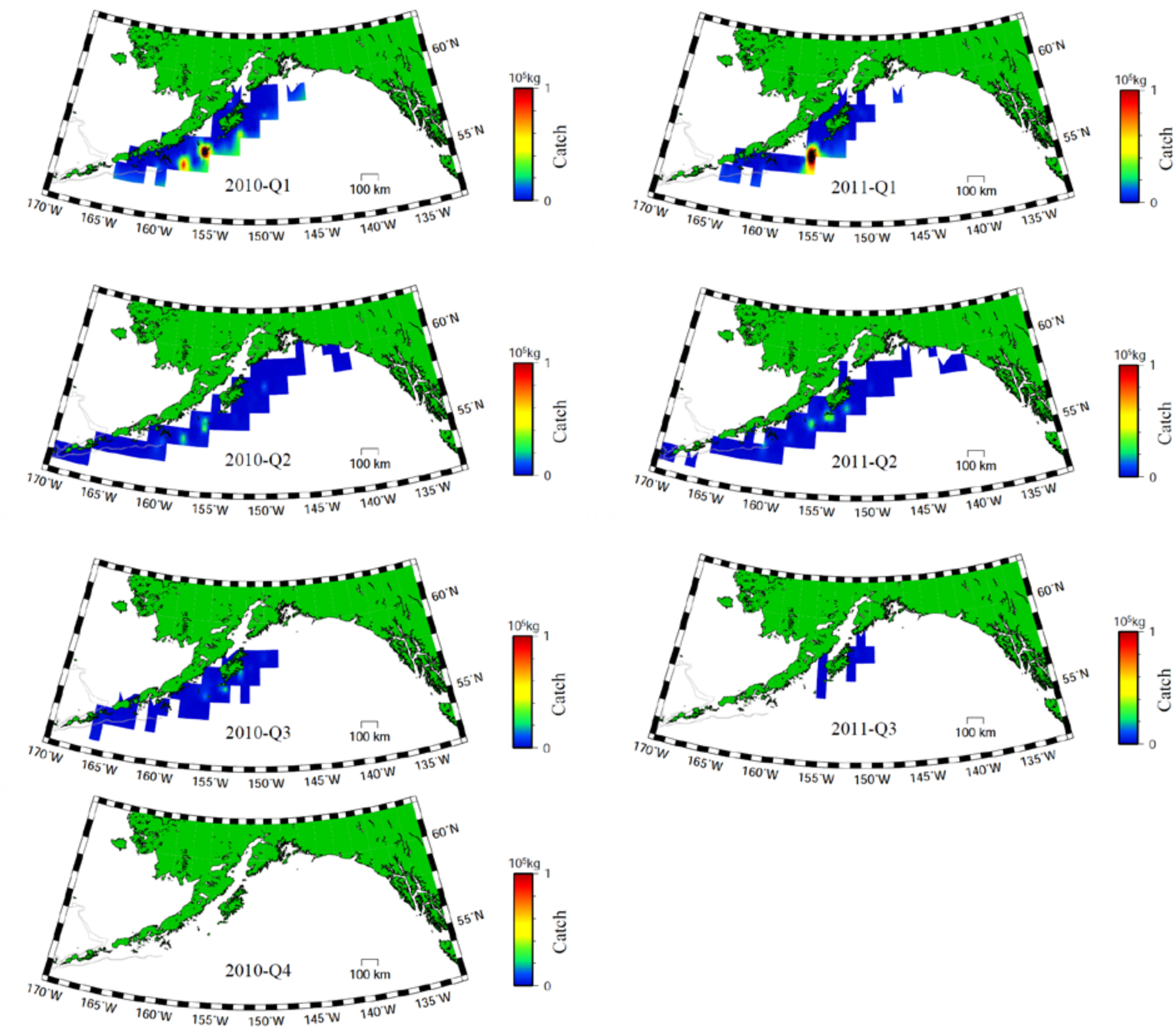


Figure 6.3. Spatial patterns of observed fishery catches by for GOA rex sole from 2010 and the first three quarters of 2011.

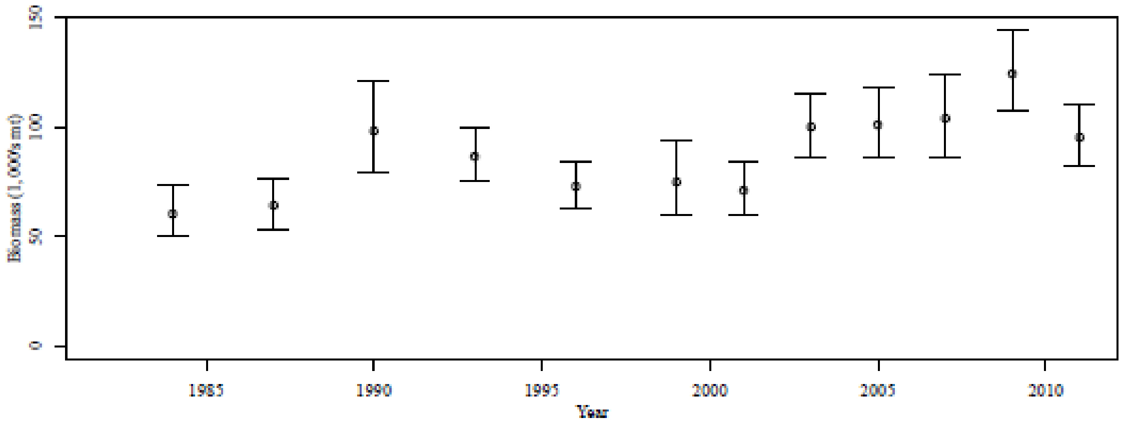


Figure 6.4. GOA survey biomass for rex sole. Error bars represent 95% lognormal confidence intervals. The 2001 GOA survey did not survey the Eastern Gulf. The value shown here for 2001 has been corrected to account for this (see text).

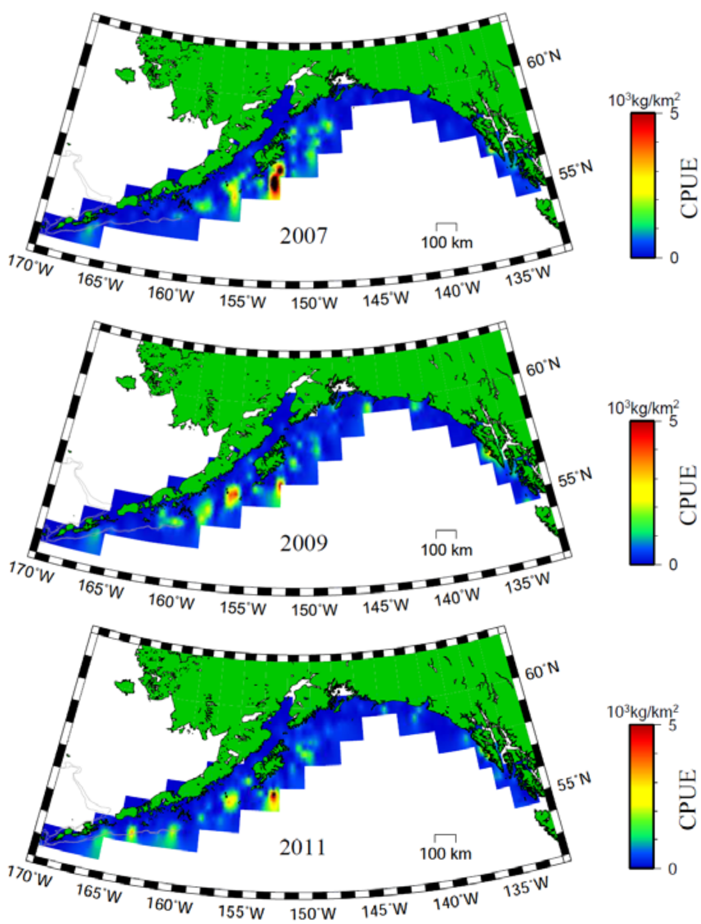
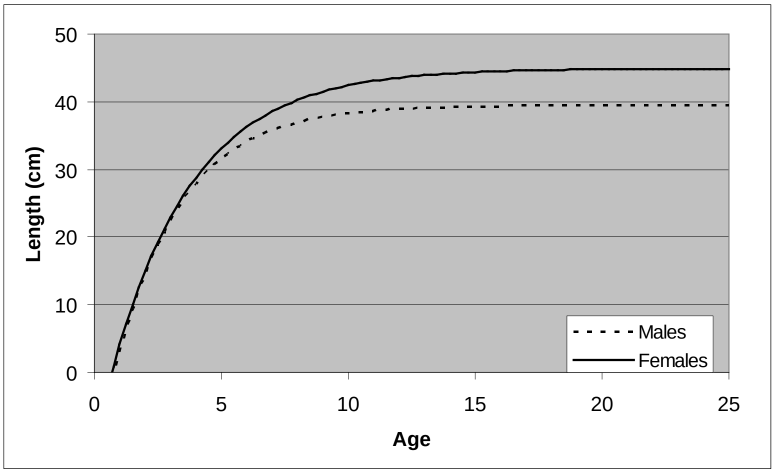
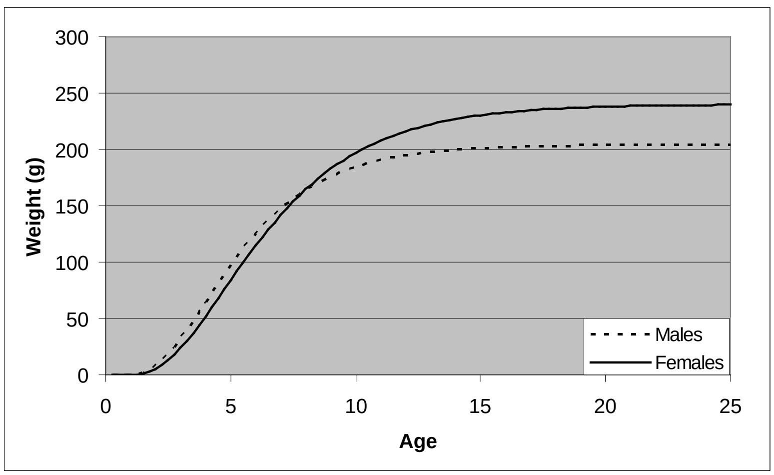


Figure 6.5. Spatial patterns of CPUE for rex sole in the GOA groundfish surveys for 2007, 2009 and 2011.

a) Length-at-age.



b) Weight-at-age.



c) Maturity-at-age (females).

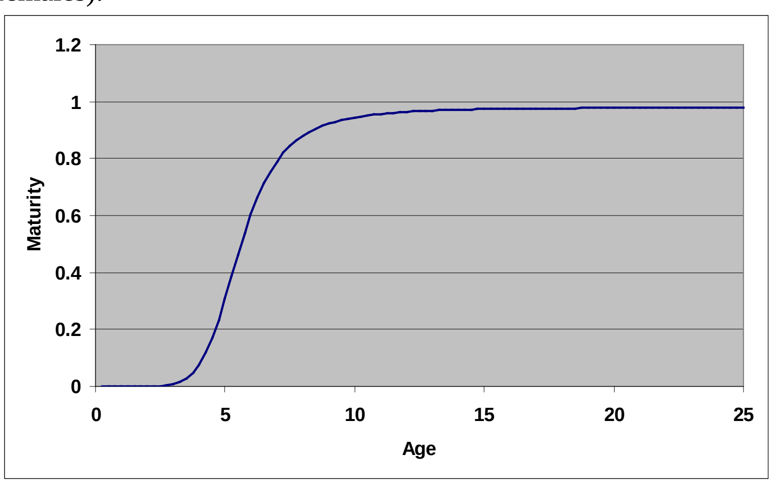


Figure 6.6. Age-specific schedules for GOA rex sole: females solid line, males dotted line.

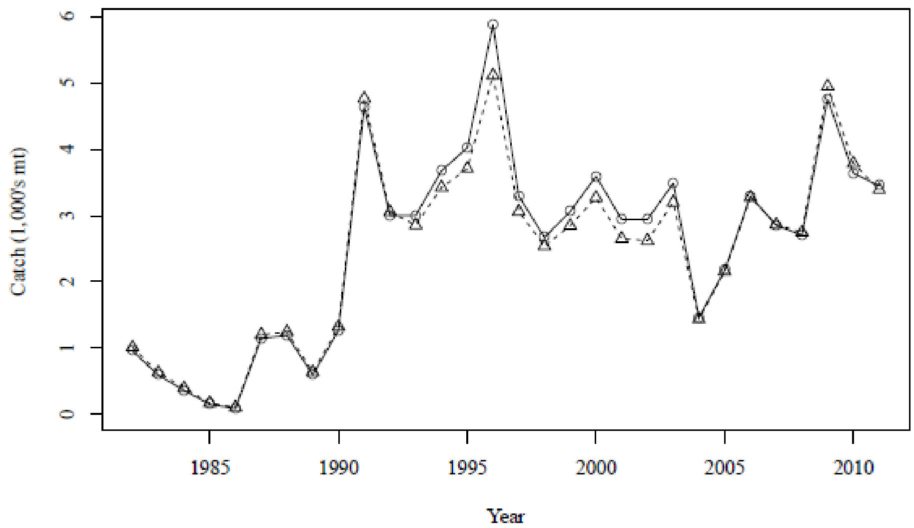


Figure 6.7. Estimated and observed annual catches for GOA rex sole for the assessment model. Estimated catch = dotted line with circles, observed catch = solid line.

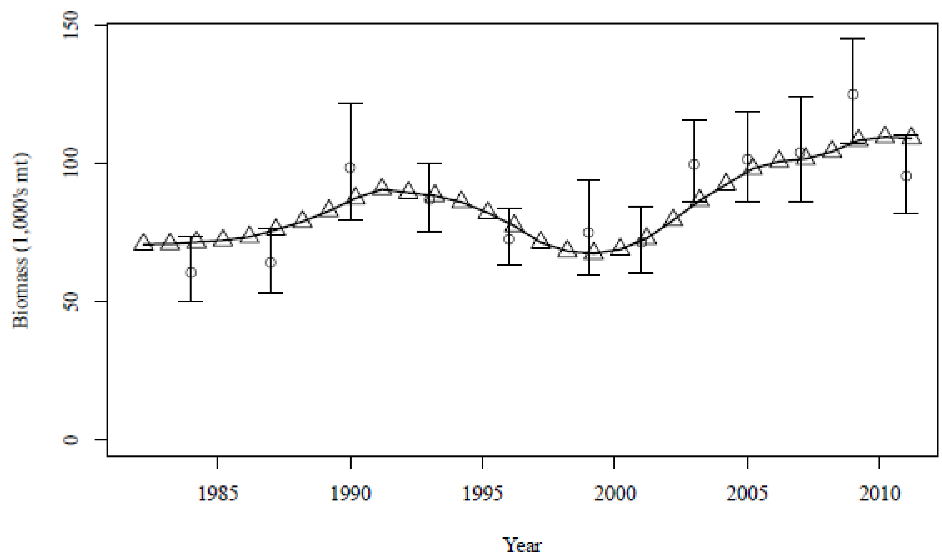


Fig. 6.8. Estimated and observed survey biomass for GOA rex sole for the assessment model. Estimated survey biomass = triangles, observed survey biomass = circles (error bars are approximate lognormal 95% confidence intervals).

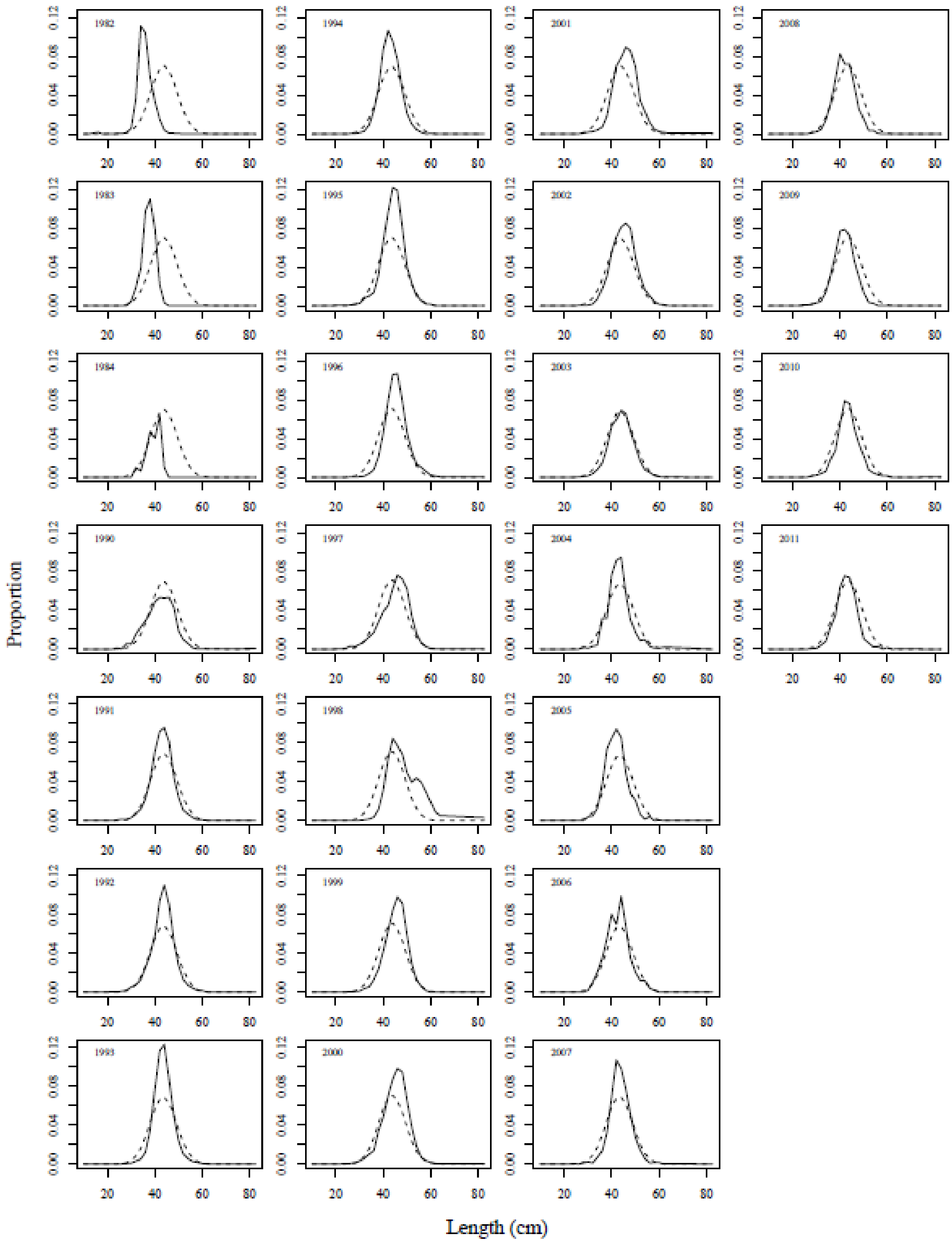


Figure 6.9a. Fits to female GOA rex sole fishery size composition data for the assessment model. Dashed lines represent the model estimates, solid lines represent the data.

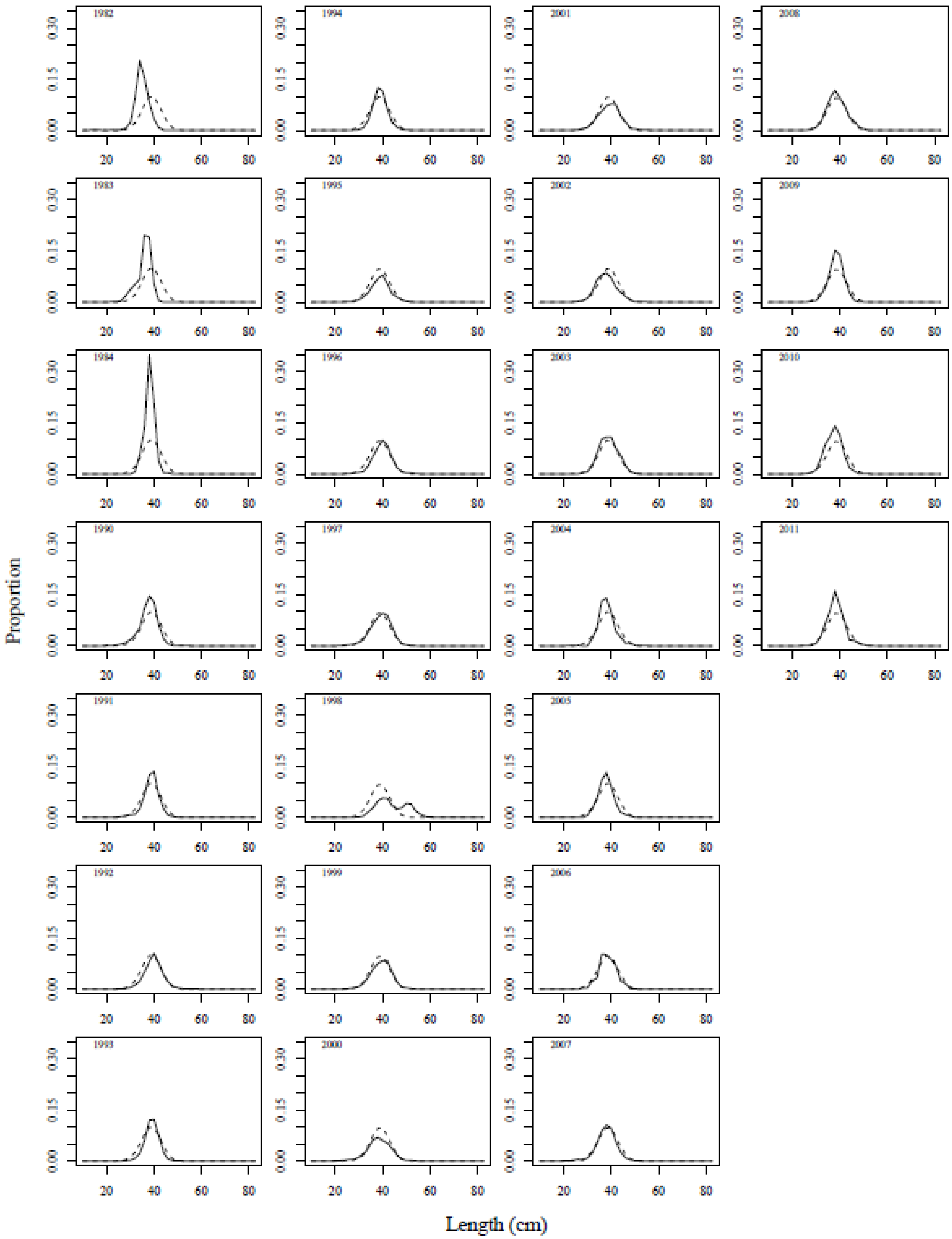


Figure 6.9b. Fits to male GOA rex sole fishery size composition data for the assessment model. Dashed lines represent the model estimates, solid lines represent the data.

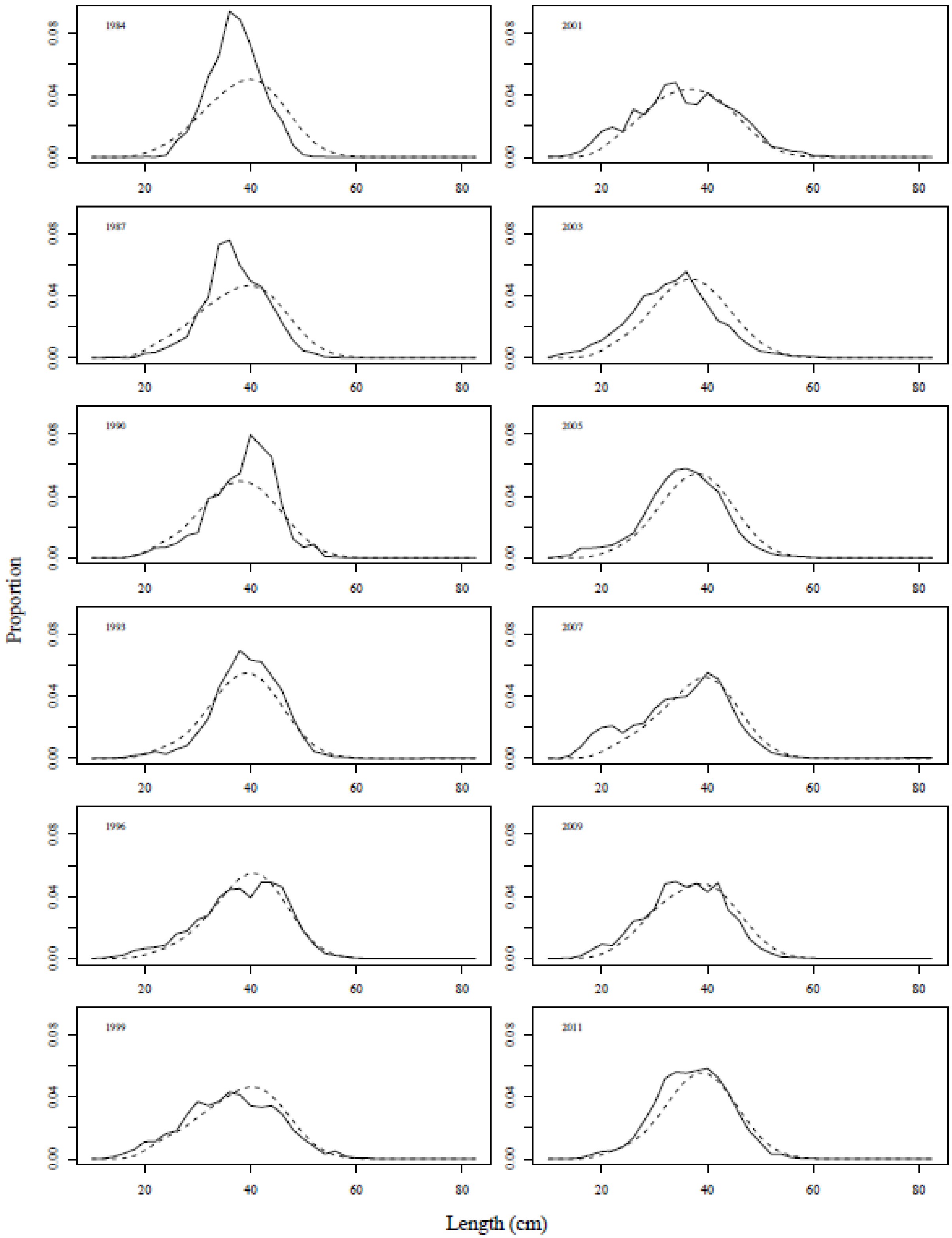


Figure 6.10a. Fit to the female GOA rex sole survey size composition data for the assessment model. Dashed lines represent the model estimates, solid lines represent the data.

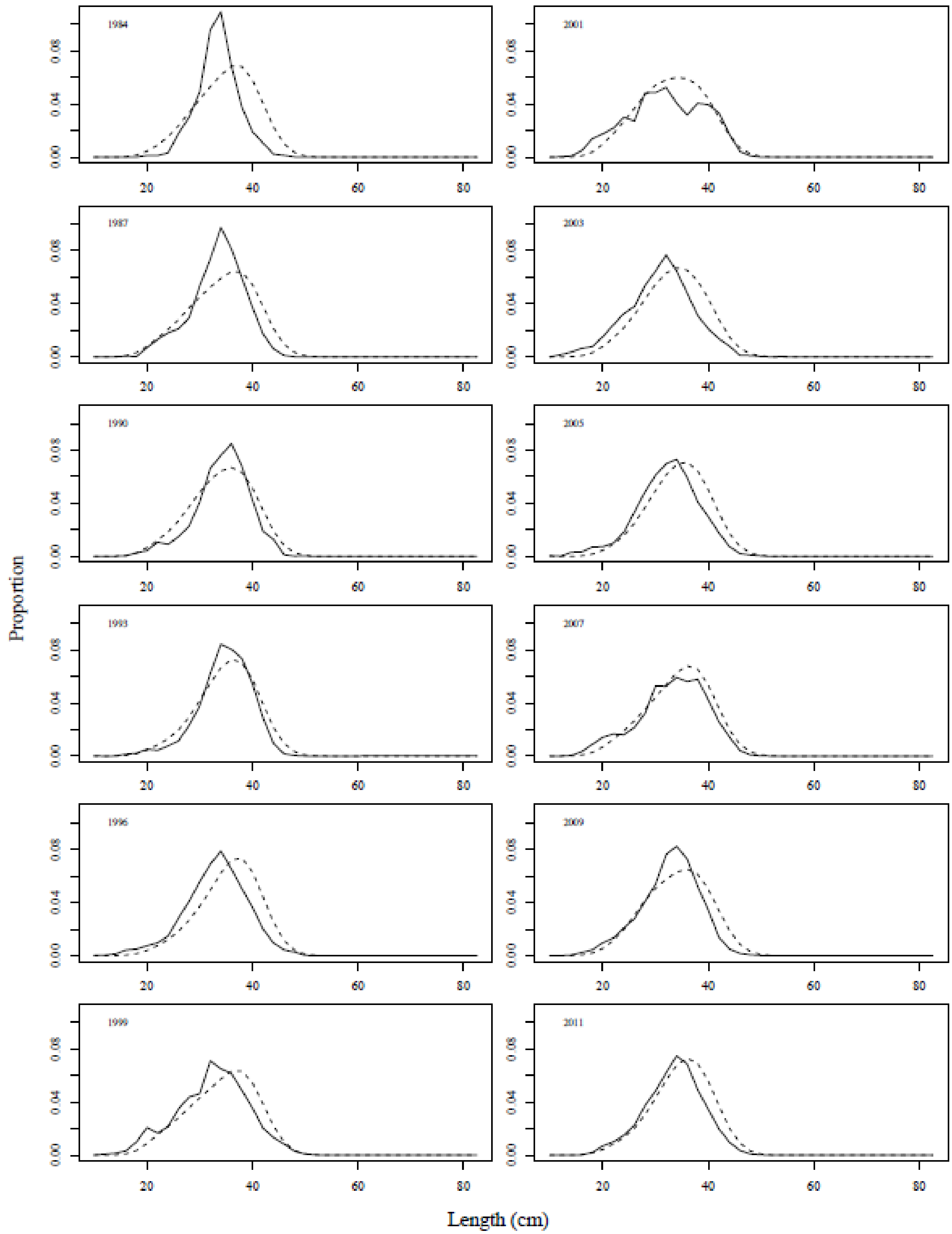


Figure 6.10b. Fits to the male GOA rex sole survey size composition data for the assessment model. Dashed lines represent the model estimates, solid lines represent the data.

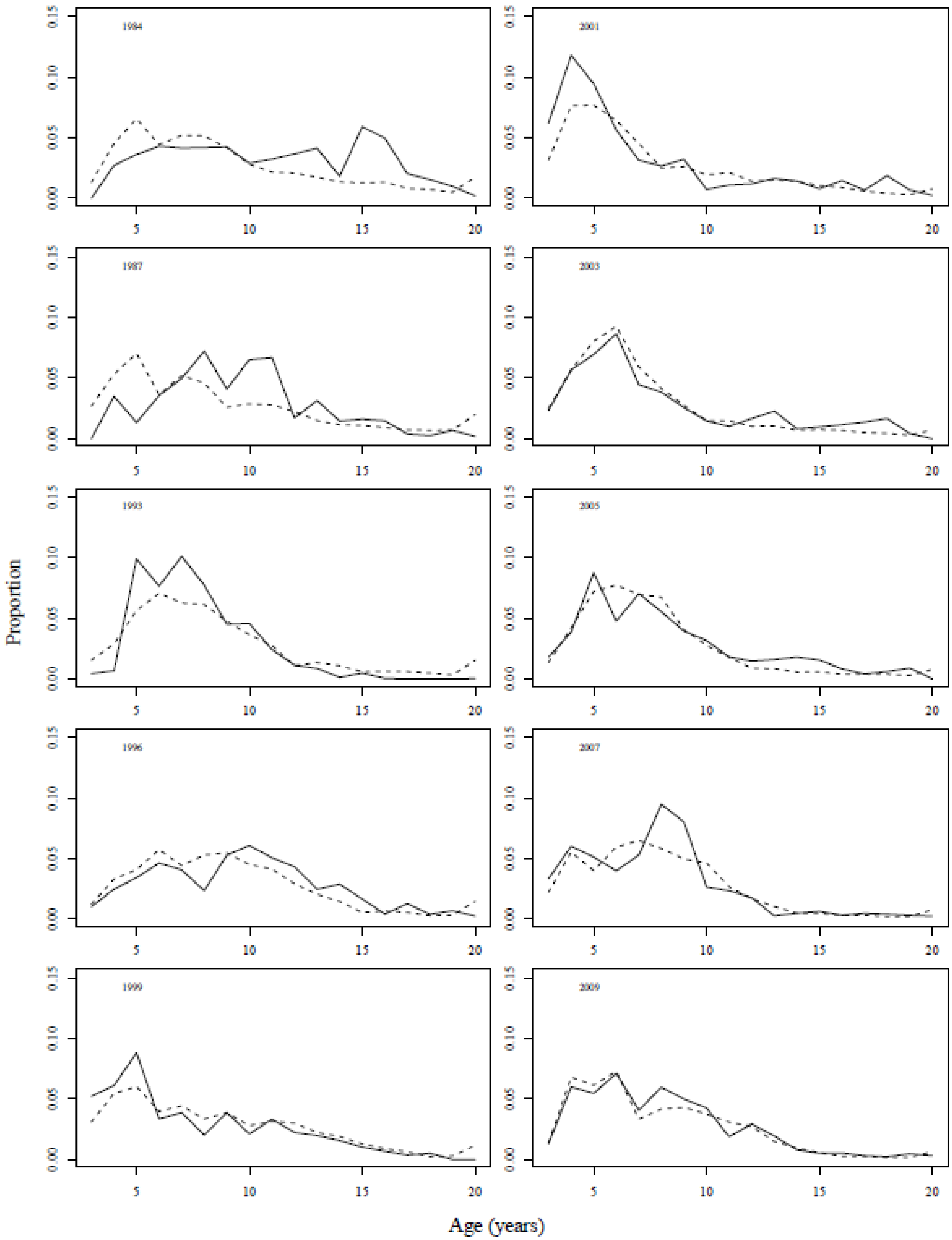


Figure 6.11a. Fits to the female survey GOA rex sole age composition data for the assessment model. Dashed lines represent the model estimates, solid lines represent the data.

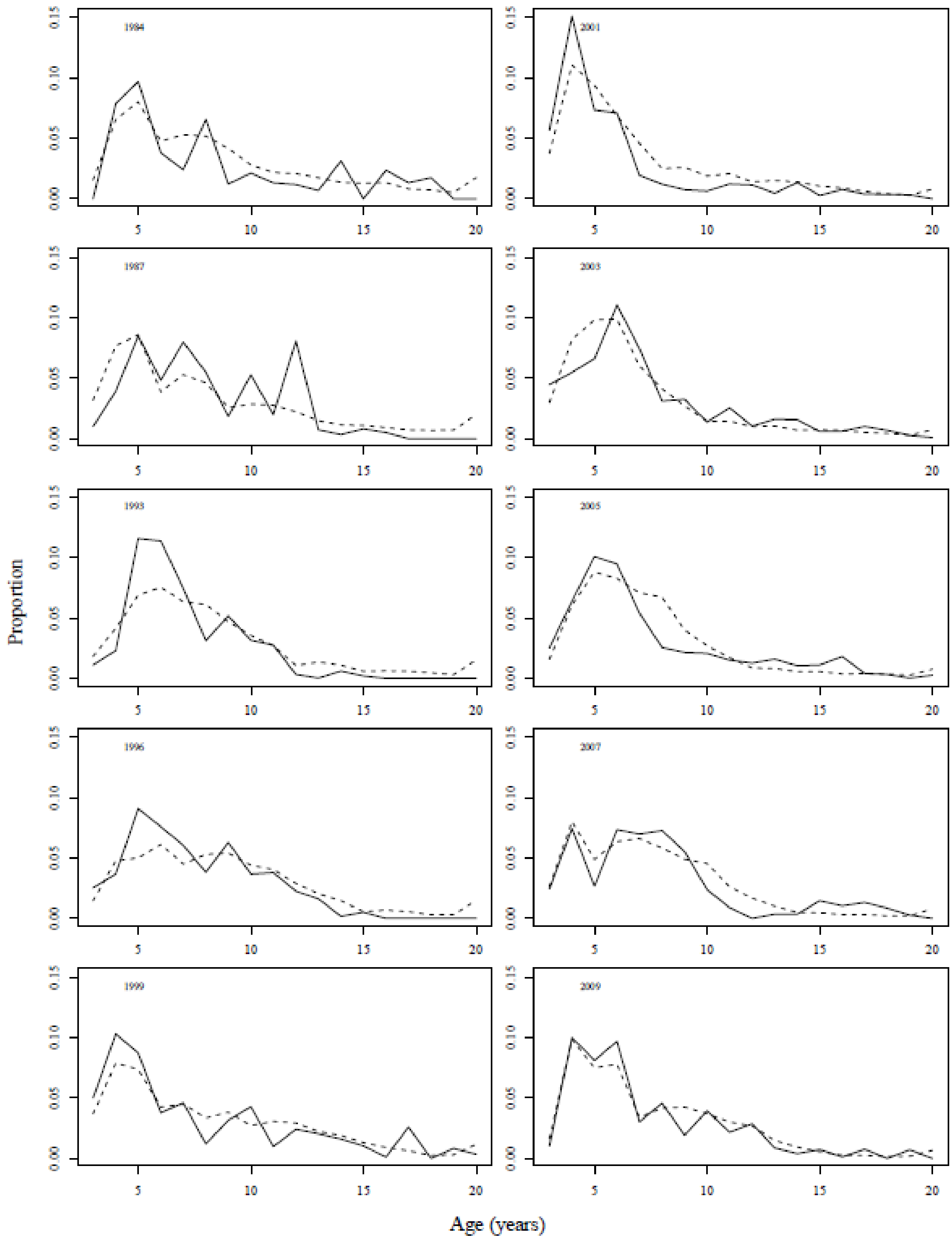


Figure6.11b. Fit to the male survey GOA rex sole age composition data for the assessment model. Dashed lines represent the model estimates, solid lines represent the data.

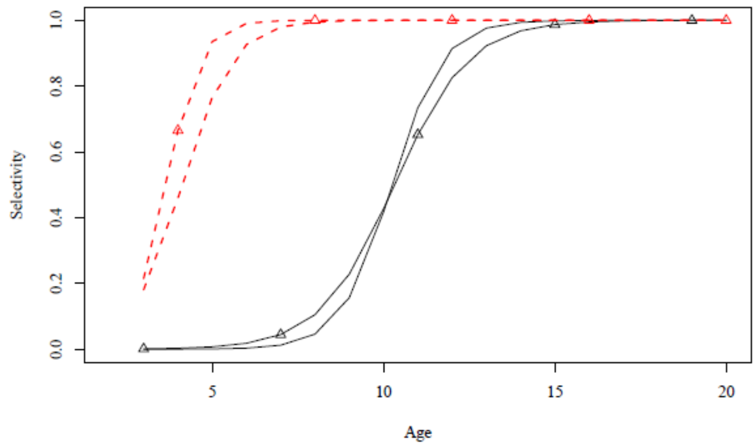


Figure 6.12. Estimated selectivity functions. Survey selectivities are plotted in red with a dotted line, fishery selectivities are plotted in black with a solid line. Male selectivity functions are plotted with a triangle symbol, female selectivity functions are plotted without a symbol.

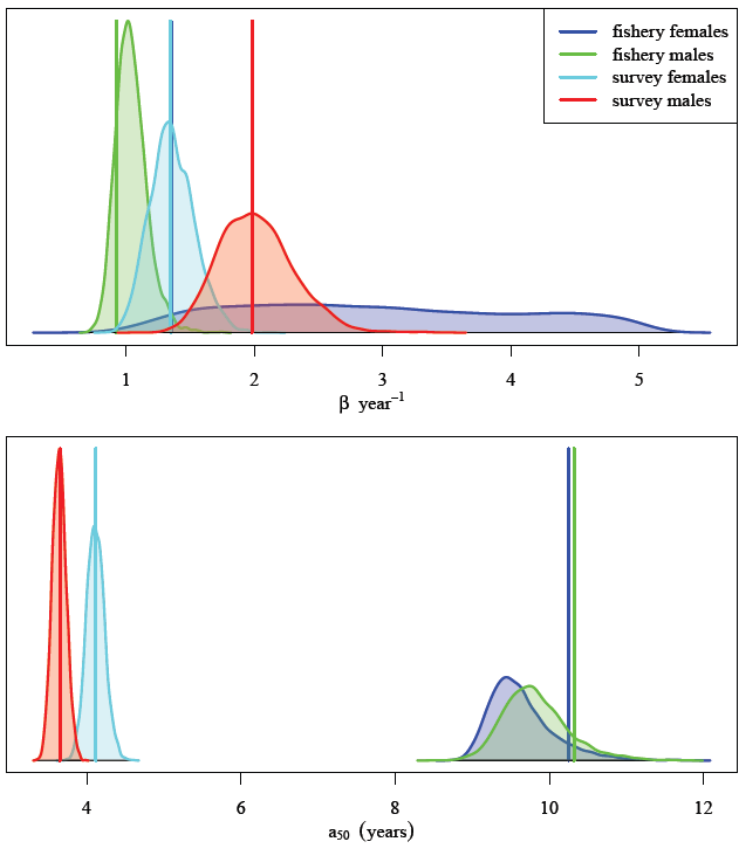


Figure 6.13. Marginal posterior distributions based on MCMC integration for parameters related to fishery and survey age selectivity functions. "a_{50}" denotes the parameter for the age at which the logistic selectivity function is 50%. "β" is related to the slope of the selectivity function at age = a_{50}. The maximum likelihood estimate for each parameter is indicated by the appropriately-colored vertical line.

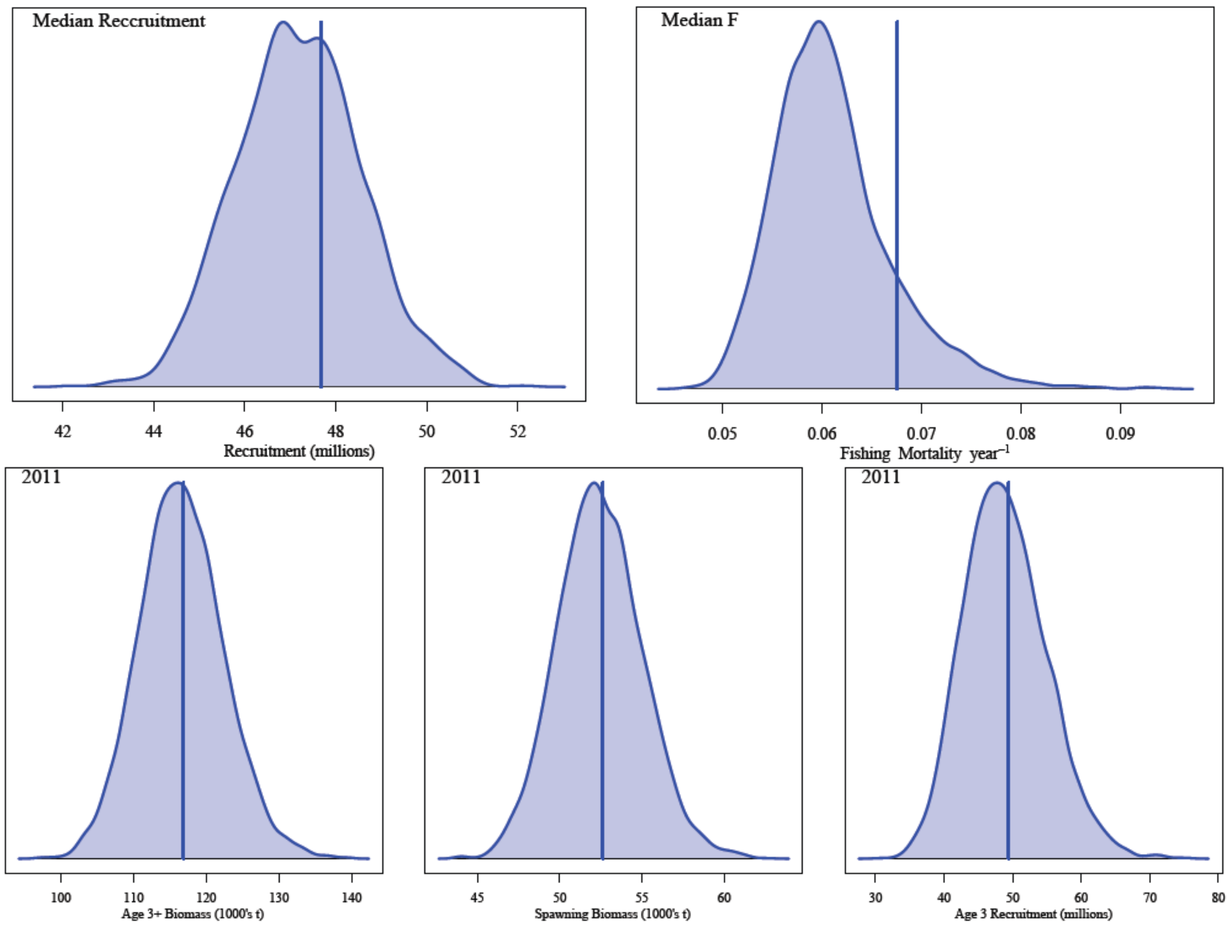


Figure 6.14. Marginal posterior distributions based on MCMC integration for: median recruitment (upper left), median fishing mortality (upper right), total (age 3+) biomass in 2011 (lower left), spawning biomass in 2011 (lower middle), and recruitment in 2011 (lower right). The maximum likelihood estimate for each quantity is indicated by the vertical line.

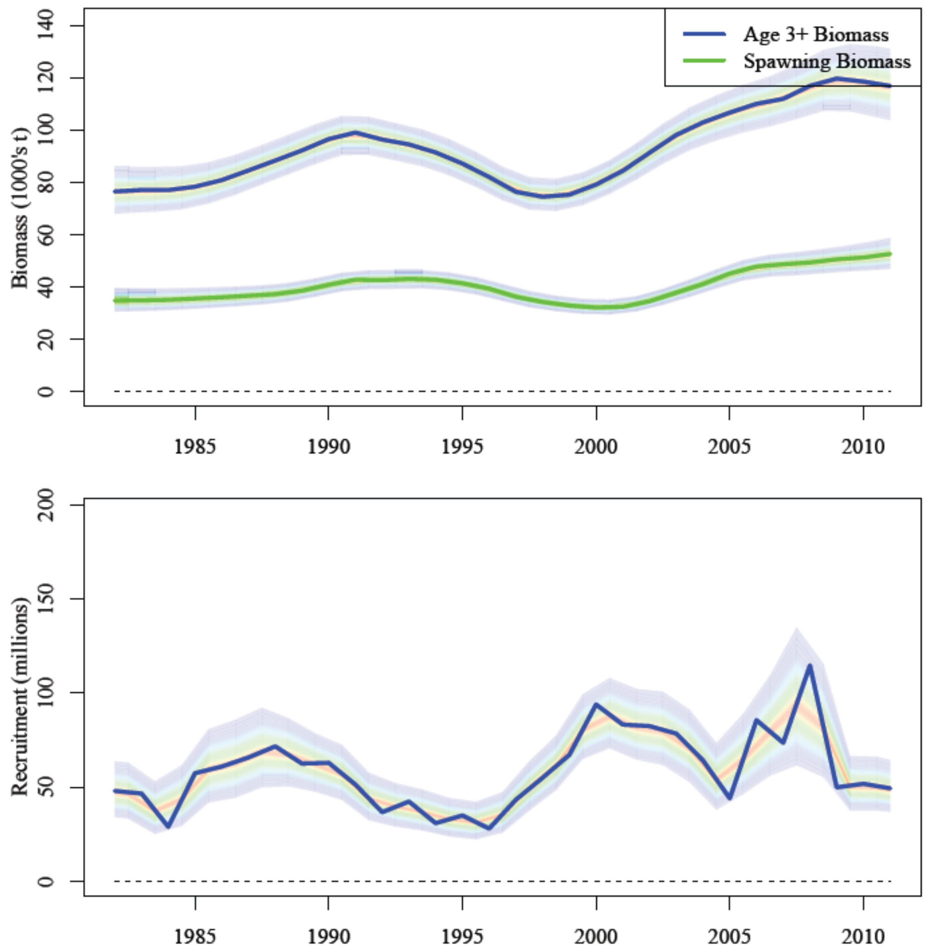


Figure 6.15. Time series plots of estimated total (age 3+) biomass and spawning biomass (upper graph) and recruitment (lower graph). 99% credibility intervals based on marginal posterior distributions from MCMC integration for parameters related to fishery (top row) and survey (bottom row) age selectivity functions. The solid lines indicate time series of maximum likelihood estimates.

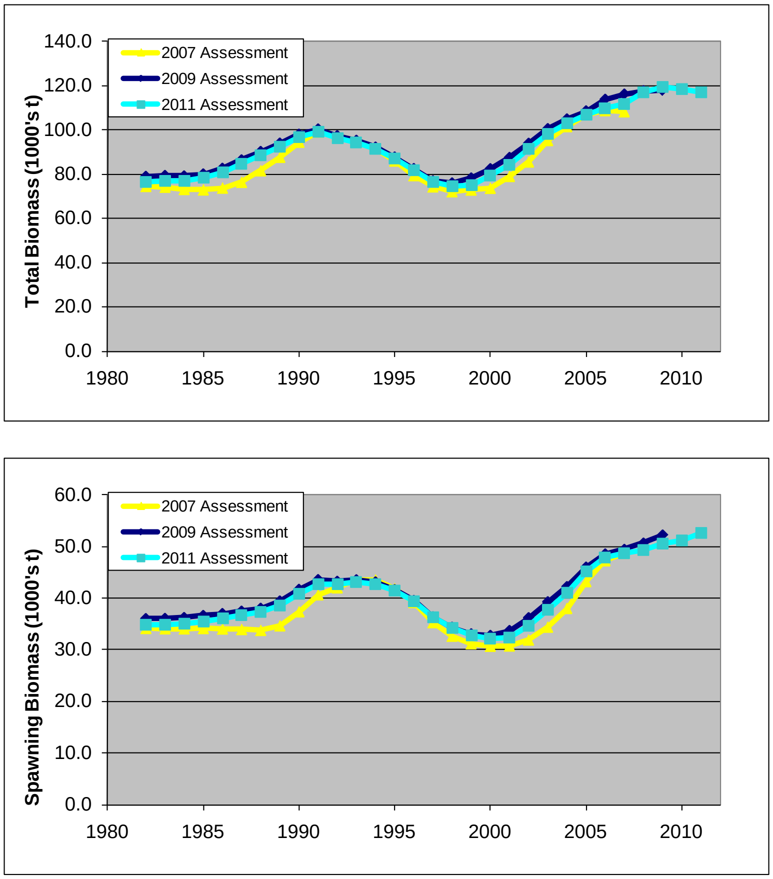
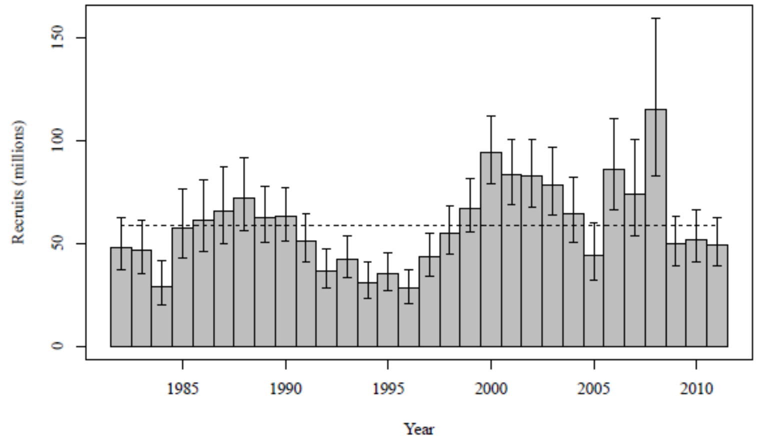


Figure 6.16. Upper: : Comparison of total (age 3+) biomass estimates from the current assessment with results from the 2009 and 2007 assessments. Lower: Comparison of spawning biomass estimates from the current assessment with results from the 2009 and 2007 assessments.



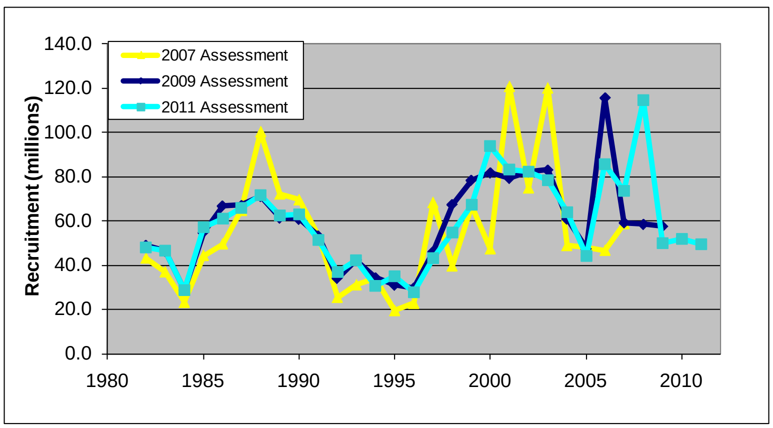


Figure 6.17. Upper: Estimated age 3 recruitments of GOA rex sole with approximate 95% lognormal confidence intervals estimated from the model hessian. Horizontal line is mean recruitment. Lower: Comparison of recruitment estimates from the current assessment with results from the 2009 and 2007 assessments.

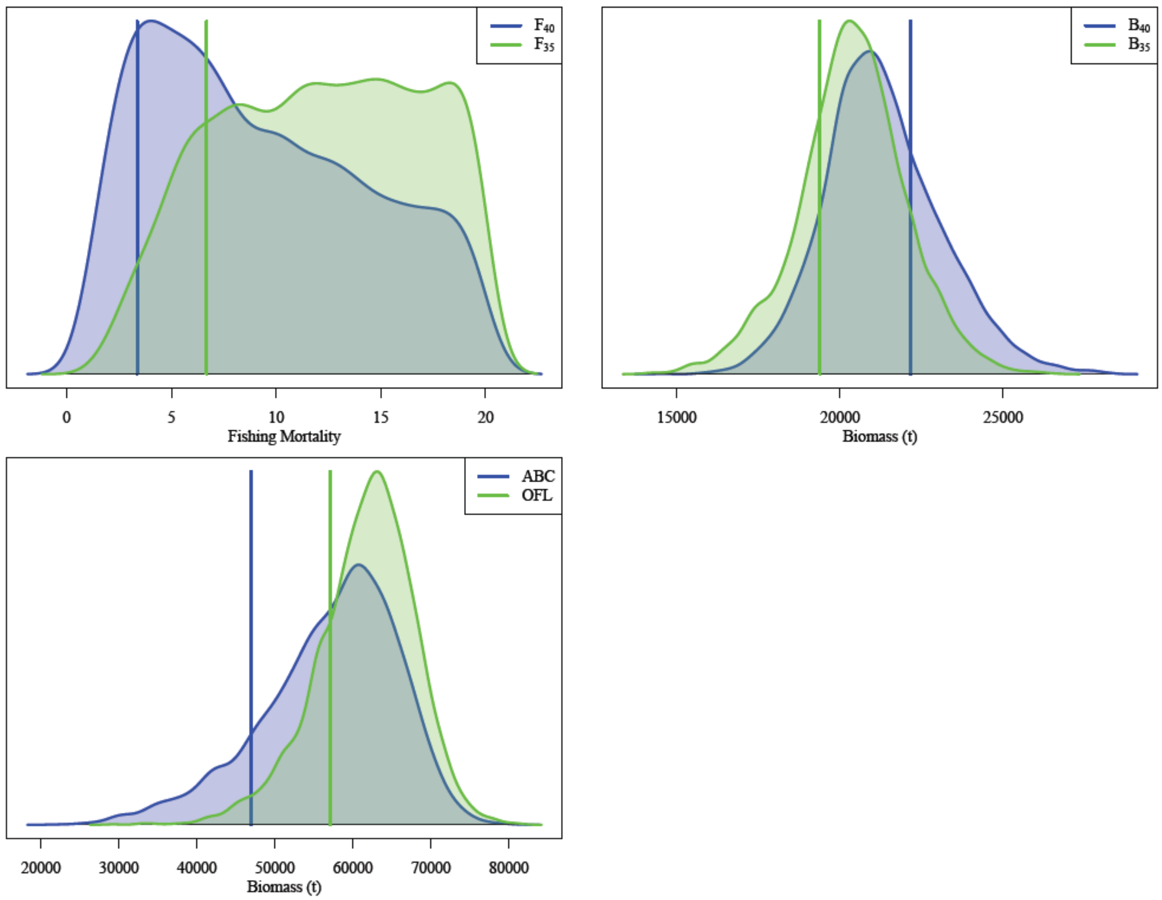


Figure 6.18. Marginal posterior distributions based on MCMC integration for several management-related quantities estimated in the model: $F_{40\%}$ and $F_{35\%}$,(upper left), $B_{40\%}$, and $B_{35\%}$ (upper right), and example Tier 3-based estimates of 2012 ABC, OFL (lower left). The value for each quantity associated with the maximum likelihood solution is indicated by the appropriately-colored vertical line. Note: $F_{40\%}$ and $F_{35\%}$ are not considered to be estimated reliably and so ABCs and OFLs for GOA rex sole are based on Tier 5 calculations, not those shown here.

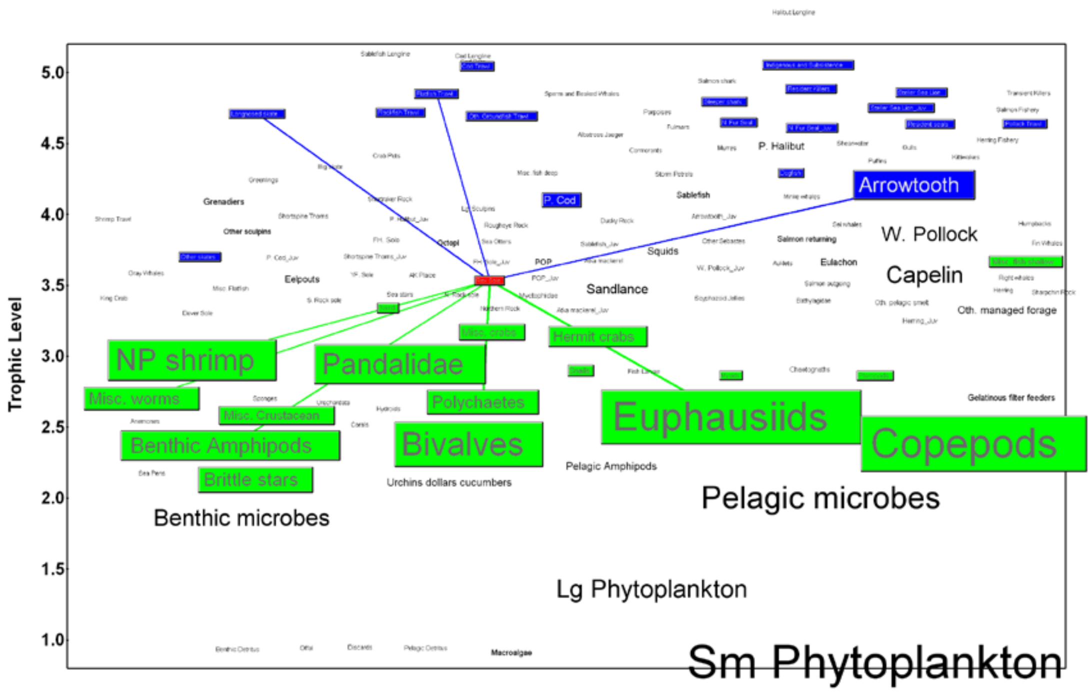


Figure 6.19. Gulf of Alaska food web from the GOA ecosystem model (Aydin et al., 2007) highlighting rex sole links to predators (blue boxes and lines) and prey (green boxes and lines). Box size reflects relative standing stock biomass.

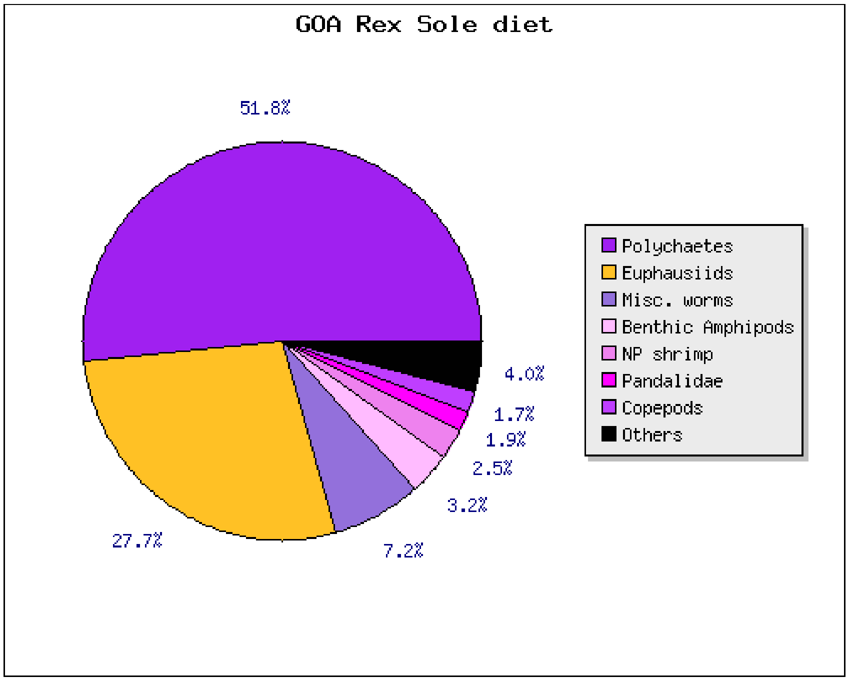


Figure 6.20. Diet composition for Gulf of Alaska rex sole from the GOA ecosystem model (Aydin et al., 2007).

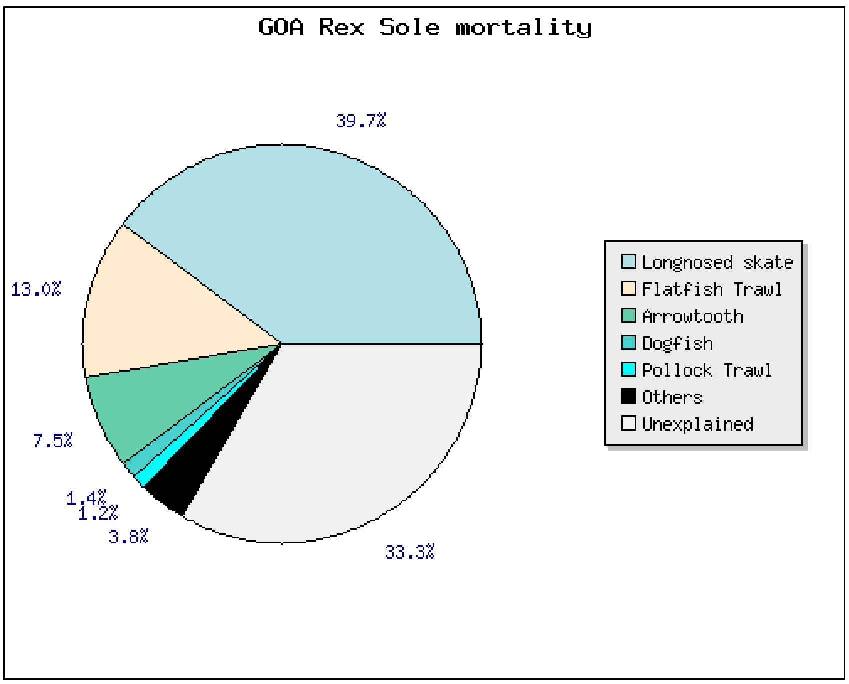


Figure 6.21. Decomposition of natural mortality for Gulf of Alaska rex sole from the GOA ecosystem model (Aydin et al., 2007).

Chapter 6 Appendix A: Model Equations

Table A.1. List of quantities and their definitions as used in the model.

Quantity	Definition
T	number of years in the model.
A	number of age classes (18).
L	number of length classes (29).
T_{min}	model start year (1982).
T_{max}	assessment year (2011).
t	time index.
a	age index ($1 \le a \le A$; a=1 corresponds to age at recruitment).
x	sex index ($1 \le x \le 2$; 1=female, 2=male).
l	length index ($1 \le l \le L$; l=1 corresponds to minimum length class).
$\{t^S\}$	set of years for which survey biomass data is available.
$\{t^{F,A}\}$	set of years for which fishery age composition data is available.
$\{t^{F,L}\}$	set of years for which fishery length composition data is available.
$\{t^{S,A}\}$	set of years for which survey age composition data is available.
$\{t^{S,L}\}$	set of years for which survey length composition data is available.
$L^x_{l,a}$	elements of length-age conversion matrix (proportion of sex x fish in age class a that are in length class l). (fixed)
$w_{x,a}$	mean body weight (kg) of sex x fish in age group a. (fixed)
ϕ_a	proportion of females mature at age a. (fixed)
$\overline{\ln R_0}$	mean value of log-transformed recruitment. (estimable)
τ_t	recruitment deviation in year t. (estimable)
M_x	instantaneous natural mortality rate. (fixed)
$\overline{\ln F}$	mean value of log-transformed fishing mortality. (estimable)
ε_t	deviations in fishing mortality rate in year t. (estimable)
R_t	recruitment in year t.
$N_{t,x,a}$	number of fish of sex x and age class a in year t.
$C_{t,x,a}$	catch (number) of fish of sex x and age class a in year t.
$p^{F,A}_{t,x,a}$	proportion of the total catch in year t that is sex x and in age class a.
$p^{F,L}_{t,x,l}$	proportion of the total catch in year t that is sex x and in length class l.
$p^{S,A}_{t,x,a}$	proportion of the survey biomass in year t that is sex x and in age group a.
$p^{S,L}_{t,x,l}$	proportion of the survey biomass in year t that is sex x and in age group a.
C_t	total catch (yield) in tons in year t.
$F_{t,x,a}$	instantaneous fishing mortality rate for sex x and age group a in year t.
$Z_{t,x,a}$	instantaneous total mortality for sex x and age group a in year t.
$s^{FU}_{x,a}$	unnormalized fishery selectivity for sex x and age group a.
$s^{SU}_{x,a}$	unnormalized survey selectivity for sex x and age group a.
$s^{FN}_{x,a}$	normalized fishery selectivity for sex x and age group a.
$s^{SN}_{x,a}$	normalized survey selectivity for sex x and age group a.

Table A.2. Model equations describing the model populations dynamics.

Equation	Description
$\tau_t \sim N(0,\sigma_R^2)$	Random deviate associated with recruitment.
$N_{t,x,1} = R_t = \exp\left(\overline{\ln R_0} + \tau_t\right)$	Recruitment (assumed equal for males and females).
$N_{t+1,x,a+1} = N_{t,x,a} e^{-Z_{t,x,a}}$	Numbers at age.
$N_{t+1,x,A} = N_{t,x,A-1} e^{-Z_{t,x,A-1}} + N_{t,x,A} e^{-Z_{t,x,A}}$	Numbers in “plus” group.
$C_{t,x,a} = \frac{F_{t,x,a}}{Z_{t,x,a}}(1-e^{-Z_{t,x,a}})N_{t,x,a}$	Catch at age (in numbers caught).
$C_t = \sum_{x=1}^{2}\sum_{a=1}^{A} w_{x,a} C_{t,x,a}$	Total catch in tons (i.e., yield).
$FSB_t = \sum_{a=1}^{A} w_{1,a}\phi_a N_{t,1,a}$	Female spawning biomass.
$Z_{t,x,a} = F_{t,x,a} + M$	Total mortality.
$F_{t,x,a} = s_{x,a}^{F} \cdot \exp\left(\overline{\ln F} + \varepsilon_t\right)$	Fishing mortality.
$\varepsilon_t \sim N(0,\sigma_F^2)$	Random deviate associated with fishing mortality.
$s_{x,a}^{FU} = \frac{1}{1+e^{(-b_x^F(age-{}_{50}A_x^F))}}$	Unnormalized fishery selectivity- 2 parameter ascending logistic - separate for males and females.
$s_{x,a}^{SU} = \frac{1}{1+e^{(-b_x^S(age-{}_{50}A_x^S))}}$	Unnormalized survey selectivity- 2 parameter ascending logistic - separate for males and females.
$s_{x,a}^{FN} = \exp(r_x^F)\frac{s_{x,a}^{FU}}{\max\{s_{1,a}^{FU}\}}$	Normalized fishery selectivity. $r^F_1 \equiv 0$.
$s_{x,a}^{SN} = \exp(r_x^S)\frac{s_{x,a}^{SU}}{\max\{s_{1,a}^{SU}\}}$	Normalized survey selectivity. $r^S_1 \equiv 0$.
$N^S{}_{t,x,a} = Q\, s^S{}_{x,a} N_{t,x,a}$	Survey numbers for sex *x*, age *a* at time *t*.
$SB_t = \sum_{x=1}^{2}\sum_{a=1}^{A} w_{x,a}\, N^S{}_{t,x,a}$	Total survey biomass.
$p_{t,x,a}^{F,A} = C_{t,x,a} / \sum_{x=1}^{2}\sum_{a=1}^{A} C_{t,x,a}$	Proportion at age in the catch.
$p_{t,x,l}^{F,L} = \sum_{a=1}^{A} L_{l,a}^{x} \cdot p_{t,x,a}^{F,A}$	Proportion at length in the catch.
$p_{t,x,a}^{S,A} = N^S{}_{t,x,a} / \sum_{x=1}^{2}\sum_{a=1}^{A} N^S{}_{t,x,a}$	Proportion at age in the survey.
$p_{t,x,l}^{S,L} = \sum_{a=1}^{A} L_{l,a}^{x} \cdot p_{t,x,a}^{S,A}$	Proportion at length in the survey.

Table A.3. Likelihood components.

Component	**Description**
$\sum_{t=1}^{T}\left[\log(C_t^{obs})-\log(C_t)\right]^2$	Catch; assumes a lognormal distribution.
$\sum_{t\in\{t^{F,A}\}}\sum_{x=1}^{2}\sum_{a=1}^{A} n_t^{samp}\cdot p_{t,x,a}^{F,A,obs}\cdot\log(p_{t,x,a}^{F,A})$ - offset	Fishery age composition; assumes a multinomial distribution. Observed sample size is n_t^{samp}.
$\sum_{t\in\{t^{F,L}\}}\sum_{x=1}^{2}\sum_{l=1}^{L} n_t^{samp}\cdot p_{t,x,l}^{F,L,obs}\cdot\log(p_{t,x,l}^{F,L})$ - offset	Fishery length composition; assumes a multinomial distribution. Observed sample size is n_t^{samp}.
$\sum_{t\in\{t^{F,A}\}}\sum_{x=1}^{2}\sum_{a=1}^{A} n_t^{samp}\cdot p_{t,x,a}^{S,A,obs}\cdot\log(p_{t,x,a}^{S,A})$ - offset	Survey age composition; assumes a multinomial distribution. Observed sample size is n_t^{samp}.
$\sum_{t\in\{t^{F,L}\}}\sum_{x=1}^{2}\sum_{l=1}^{L} n_t^{samp}\cdot p_{t,x,l}^{S,L,obs}\cdot\log(p_{t,x,l}^{S,L})$ - offset	Survey length composition; uses a multinomial distribution. Observed sample size is n_t^{samp}.
offset = $\sum_{t}\sum_{x=1}^{2}\sum_{a=1}^{A} n_t^{samp}\cdot p_{t,x,a}^{obs}\cdot\log(p_{t,x,a}^{obs}))$	The offset constants for age composition components are calculated from the observed proportions and the sample sizes. A similar formula is used for length composition component offsets.
$\sum_{t\in\{t^S\}}\left[\dfrac{\log\left[\dfrac{SB_t^{obs}}{SB_t}\right]}{\sqrt{2}\cdot s.d.(\log(SB_t^{obs}))}\right]^2$	Survey biomass; assumes a lognormal distribution.
$\sum_{t=T_{\min}}^{T_{\max}-3}(\tau_t)^2$	Recruitment; assumes a lognormal distribution, since τ_t is on a log scale.
$\sum_{t=T_{\max}-2}^{T_{\max}}(\tau_t)^2$	"Late" recruitment; assumes a lognormal distribution, since τ_t is on a log scale.
$\sum_{t=T_{\min}-A+1}^{T_{\min}-1}(\tau_t)^2$	"Early" recruitment; assumes a lognormal distribution, since τ_t is on a log scale. Determines age composition at starting year of model.

Table A.4. Parameters fixed in the model.

Parameter	Description
M_x = 0.17	sex-specific natural mortality rate.
Q = 1.0	survey catchability.
$L^x_{l,a}$	sex-specific length-at-age conversion matrix.
$w_{x,a}$	sex-specific weight-at-age.
ϕ_a	proportion of females mature at age *a*.

Table A.5. Parameters estimated in the accepted model. A total of 87 population parameters were estimated.

Parameter	Subscript range	Total no. of Parameters	Description
$\ln(R_0)$	NA	1	natural log of the geometric mean value of age 3 recruitment.
τ_t	$T_{\min} - A + 1 \le t \le T_{\max}$	47	log-scale recruitment deviation in year *t*.
$\ln(f_0)$	NA	1	natural log of the geometric mean value of fishing mortality.
ε_t	$T_{\min} \le t \le T_{\max}$	30	log-scale deviations in fishing mortality rate in year *t*.
r^F_2	NA	not estimated	scaling from female to male fishery selectivity (log-scale).
b^F_x , $_{50}A^F_x$	$1 \le x \le 2$	4	sex-specific selectivity parameters (slope and age at 50% selected) for the fishery.
r^S_2	S=1	not estimated	scaling from female to male survey selectivity (log-scale).
b^S_x , $_{50}A^S_x$	$1 \le x \le 2$ S=1	4	sex-specific selectivity parameters (slope and age at 50% selected) for the survey.

Chapter 6 Appendix B: Supplemental Catch Data

In order to comply with the Annual Catch Limit (ACL) requirements, two new datasets have been generated to help estimate total catch and removals from NMFS stocks in Alaska.

The first dataset, non-commercial removals, estimates total removals that do not occur during directed groundfish fishing activities (Table 6B.1). This includes removals incurred during research, subsistence, personal use, recreational, and exempted fishing permit activities, but does not include removals taken in fisheries other than those managed under the groundfish FMP. These estimates represent additional sources of removals to the existing Catch Accounting System estimates. For the GOA rex sole stock, these estimates (currently available only for 2010) can be compared to research removals that have occurred in conjunction with the Gulf of Alaska Groundfish Surveys (Table 6B.2). Compared with the 2010 ABC (9,729 t), these non-commercial catches are miniscule (< 0.2% ABC) and do not present a risk to the GOA rex sole stock.

The second dataset, the Halibut Fishery Incidental Catch Estimation (HFICE), is an estimate of the incidental catch of groundfish in the halibut IFQ fishery in Alaska, which is currently unobserved. To estimate removals in the halibut fishery, methods were developed by the HFICE working group and approved by the Gulf of Alaska and Bering Sea/Aleutian Islands Plan Teams and the Scientific and Statistical Committee of the North Pacific Fishery Management Council. A detailed description of the methods is available in Tribuzio et al. (2011).

These estimates are for total catch of groundfish species in the halibut IFQ fishery and do not distinguish between “retained” or “discarded” catch. These estimates should be considered a separate time series from the current CAS estimates of total catch. Because of potential overlaps HFICE removals should not be added to the CAS produced catch estimates. The overlap will apply when groundfish are retained or discarded during an IFQ halibut trip. IFQ halibut landings that also include landed groundfish are recorded as retained in eLandings and a discard amount for all groundfish is estimated for such landings in CAS. Discard amounts for groundfish are not currently estimated for IFQ halibut landings that do not also include landed groundfish. For example, catch information for a trip that includes both landed IFQ halibut and sablefish would contain the total amount of sablefish landed (reported in eLandings) and an estimate of discard based on at-sea observer information. Further, because a groundfish species was landed during the trip, catch accounting would also estimate discard for all groundfish species based on available observer information and following methods described in Cahalan et al. (2010). The HFICE method estimates all groundfish caught during a halibut IFQ trip and thus is an estimate of groundfish caught whether landed or discarded. This prevents simply adding the CAS total with the HFICE estimate because it would be analogous to counting both retained and discarded groundfish species twice. Further, there are situations where the HFICE estimate includes groundfish caught in State waters and this would need to be considered with respect to ACLs (e.g. Chatham Strait sablefish fisheries), although the extent to which this occurs for rex sole is unknown. Therefore, the HFICE estimates should be considered preliminary estimates for what is caught in the IFQ halibut fishery. Improved estimates of groundfish catch in the halibut fishery may become available following restructuring of the Observer Program in 2013.

The HFICE estimates of rex sole catch by the halibut fishery in the Gulf of Alaska are miniscule compared with recent ABC’s for the GOA stock (Table 6B.3). Based on these values, the risk to the stock from the halibut IFQ fishery is nil.

References:

Cahalan J., J. Mondragon., and J. Gasper. 2010. Catch Sampling and Estimation in the Federal Groundfish Fisheries off Alaska. NOAA Technical Memorandum NMFS-AFSC-205. 42 p.

Tribuzio, CA, S Gaichas, J Gasper, H Gilroy, T Kong, O Ormseth, J Cahalan, J DiCosimo, M Furuness, H Shen, K Green. 2011. Methods for the estimation of non-target species catch in the unobserved halibut IFQ fleet. August Plan Team document. Presented to the Joint Plan Teams of the North Pacific Fishery Management Council.

Tables

Table 6B.1. Non-commercial use catches of rex sole in the Gulf of Alaska for 2010. Non-commercial use includes catches for research, recreation, subsistence, personal use and exempted fishing permits. The ABC for 2010 was 9,729 t.

Source	Rex Sole (t)
2010 Shelikof Acoustic Survey	0.0
2010 Shumigans Acoustic Survey	0.0
large-mesh trawl	5.5
Scallop dredge	0.0
small-mesh trawl	0.3
Grand Total	**5.8**

Table 6B.2. Research catches from the Gulf of Alaska Groundfish Surveys. The ABC for 2011 was 9,565 t.

year	Research Catch (t)
1984	13.58
1987	17.02
1990	11.99
1993	12.53
1996	6.02
1999	4.73
2001	3.07
2003	6.39
2005	7.78
2007	8.52
2009	9.31
2011	5.77

Table 6B.3. HFICE estimated catches of rex sole in the Gulf of Alaska by the halibut fishery. The ABC for the GOA rex sole fishery is also listed for each year. The ABC for 2011 was 9,565 t.

	Rex sole (t)					
Year	Western Gulf	Central Gulf	West Yakutat	Southeast	Total	ABC
2001	0.0	0.0	0.0	0.0	0.0	9,440
2002	0.0	0.0	0.0	0.0	0.0	9,470
2003	0.0	1.6	0.0	0.0	1.6	9,470
2004	0.0	0.0	0.0	0.0	0.0	12,650
2005	0.0	0.0	0.0	0.0	0.0	12,650
2006	0.1	0.0	0.0	0.0	0.1	9,200
2007	0.0	0.0	0.0	0.0	0.0	9,100
2008	0.0	0.0	0.0	0.0	0.0	9,132
2009	0.0	0.0	0.0	0.0	0.0	8,996
2010	0.0	0.0	0.0	0.0	0.0	9,729