14. Assessment of Blackspotted and Rougheye Rockfish stock complex in the Bering Sea/Aleutian Islands

by

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Executive Summary

Fish previous referred to as rougheye rockfish are now recognized as consisting of two species, the rougheye rockfish (*Sebastes aleutianus*) and blackspotted rockfish (*Sebastes melanostictus*) (Orr and Hawkins 2007). The current information on these two species is not sufficient to support species-specific assessments, so they are combined in this assessment. Since 2008, an age-structured model has been applied to the Aleutian Islands portion of the population whereas the EBS portion of the population are assessed with Tier 5 methods applied to survey biomass estimates.

Relatively recent year classes (the 1998 year classes in the 2010 assessment, and the 1998 and 1999 year classes in the 2012 assessment) are estimated as very large in recent asssessments. In the 2010 assessment, the 1998 year class and other recent year classes were excluded from the computation of the harvest control rule on the grounds that they were imprecisely estimated. However, in both the 2010 and 2012 assess the recent large year classes have relatively low coefficients of variation. Additionally, the estimates of recent biomass levels for the AI population biomass from the 2012 assessment are estimated as larger than those estimated from the 2010 assessment, which results primarily from the growth of individual fish of the large 1998 and 1999 year classes.

Fishery age and length composition data indicates that a substantial portion of fish harvested are immature, resulting in the age of 50% fishery selectivity such that it is now less than the age at 50% maturity.

Sub-area ABCs within the BSAI were adopted in 2010 after an evaluation of stock structure, and are intended to spatially distribute the harvest. Comparison of spatial patterns of fishery catch and survey biomass indicate a large portion of the harvest in the AI management area (43%) occurs in the western Aleutian Islands, an area where the current proportion of AI biomass is estimated as 8%. This disproportionate pattern of harvest is exacerbated from 2012 survey biomass estimate in the western Aleutian Islands being reduced to 335 t (the lowest on record) from an average of 1,075 t in the 2000-2010 surveys. Estimated exploitation rates in the western Aleutian Islands exceeded $U_{F40\%}$ (the exploitation rate that would occur from fishing at $F_{40\%}$) each year 2004-2012, with the exception of 2011. The catch and survey data, area-specific exploitation rates, and hypotheses for the discrepancy for the catch and survey data are examined in more detail in Appendix A.

The ABC and OFL produced in the summaries below were obtained by applying the same methodology in the 2010 assessment, and show an increase in estimated biomass and harvest specification levels. However, the BSAI Plan Team may wish to consider not increasing the harvest specifications from the 2012 levels due the factors mentioned above: 1) the rationale that recent large year classes should be excluded from the computation of the harvest control rule because they are imprecisely estimated is not consistent with the relative precision of the recruitment estimates; 2) recent fishery catches are composed

of smaller individuals than in previous years, which has lowered the age at 50% selectivity to below the age of 50% maturity; 3) the available catch and survey data indicate a strong pattern of disproportionate harvesting in the western AI, where the biomass estimate from the 2012 survey is now the lowest on record.

Summary of Changes in Assessment Inputs

Changes in the input data

1) Catch updated through October 6, 2012.
2) The biomass estimate from the 2012 AI survey was added to the model input data.
3) The 2009 and 2011 fishery age composition and 2010 fishery length composition were added to the model input data.
4) The 2010 survey age composition and 2012 survey length composition were added to the model input data.

Changes in the assessment methodology

1) The age error matrix was recomputed to better account for aging error within the plus group.

Summary of Results

As mentioned above, an age-structure population model was used to estimate the population size and harvest levels for the AI portion of the population. A summary of the 2012 assessment recommended ABC's for the AI portion of the population relative to the 2011 recommendations is shown below.

Quantity	As estimated or *specified* last year for: 2012	2013	As estimated or *recommended* this year for: 2013	2014
M (natural mortality rate)	0.033	0.033	0.033	0.033
Tier	3a	3a	3a	3a
Projected total (age 3+) biomass (t)	23,443	24,157	28,036	29,025
Female spawning biomass (t)				
Projected	6070	6398	6,836	7,344
$B_{100\%}$	11,847	11,847	12,989	12,989
$B_{40\%}$	4,739	4,739	5,196	5,196
$B_{35\%}$	4,146	4,146	4,546	4,546
F_{OFL}	0.041	0.041	0.043	0.043
$maxF_{ABC}$	0.034	0.034	0.035	0.035
F_{ABC}	0.034	0.034	0.035	0.035
OFL (t)	527	556	632	674
maxABC (t)	438	462	525	560
ABC (t)	438	462	525	560
Status	As determined last year for: 2012	2013	As determined this year for: 2013	2014
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

The population size and harvest levels for the EBS portion of the population were obtained by applying Tier 5 methods to recent survey biomass estimates. A summary of the 2010 assessment recommended ABC's for the EBS portion of the population relative to the 2009 recommendations is shown below.

Quantity	As estimated or *specified* last year for: 2012	2013	As estimated or *recommended* this year for: 2013	2014
M (natural mortality rate)	0.033	0.033	0.033	0.033
Tier	5	5	5	5
Biomass (t)	1500	1500	1774	1774
F_{OFL}	0.033	0.033	0.033	0.033
$maxF_{ABC}$	0.0248	0.0248	0.0248	0.0248
F_{ABC}	0.0248	0.0248	0.0248	0.0248
OFL (t)	49	49	59	59
maxABC (t)	37	37	44	44
ABC (t)	37	37	44	44
Status	As determined last year for: 2012	2013	As determined this year for: 2013	2014
Overfishing	No	n/a	No	n/a

The overall BSAI ABC and OFL are shown below.

Quantity/Status	As estimated or *specified* last year for: 2012	2013	As estimated or *recommended* this year for: 2013	2014
OFL (t)	576	605	691	733
ABC (t)	475	499	569	604

Summaries for the Plan Team

Year	Biomass[1]	OFL	ABC	TAC	Catch
2011	24,170	549	454	454	170
2012	24,943	576	475	475	185[2]
2013	29,810	691	569		
2014	30,799	733	604		

[1] Total biomass from AI age-structured projection model, and survey biomass estimates from EBS.
[2] BSAI catch as of October 6, 2012.

The ABC for BSAI blackspotted/rougheye is currently apportioned among two areas: the western and central Aleutian Islands, and eastern Aleutian Islands and eastern Bering Sea. A weighted average of the three most recent trawl survey biomass estimates in western and central Aleutians, and the eastern Aleutians, is used to apportion the AI ABC. Weights of 4, 6, and 9 are used, with higher weights the EBS ABC, which is obtained from the Tier 5 methods described above. The current Aleutian Islands apportionment used in this assessment are:

Western and Central Aleutians	62.4%
Eastern Aleutians	37.6%

The following table gives the current apportionments used in this assessment, the projected OFLs and apportioned ABCs for 2013 and 2014, and the recent OFLs, ABCs, TACs, and catches.

	BSAI	WAI+CAI	EAI+EBS	Total
OFL (2011)	549			549
ABC (2011)		220	234	454
TAC (2011)		220	234	454
Catch (2011)		77	93	170
OFL (2012)	576			576
ABC (2012)		244	231	475
TAC (2012)		244	231	475
Catch (2012)[1]		118	67	185
OFL (2013)	691			691
ABC (2013)		328	241	569
OFL (2014)	733			733
ABC (2014)		350	254	604

[1] BSAI catch as of October 6, 2012.

Responses to SSC and Plan Team Comments on Assessments in General

The minutes of the December, 2011, meeting of the SSC includes the following general request for age-structured assessment.

We recommend that all assessment authors (Tier 3 and higher) bring retrospective analyses forward in next year's assessments.

Retrospective model runs are included in this assessment.

Responses to SSC and Plan Team Comments Specific to this Assessment

There were no comments or requests from the December 2010 or December 2011 SSC meetings pertaining specifically to BSAI blackspotted/rougheye rockfish.

Introduction

Rougheye rockfish (*Sebastes aleutianus*) have historically been managed within various stock complexes within the Bering Sea/Aleutian Islands (BSAI) region. For example, from 1991 to 2000 rougheye rockfish in the eastern Bering Sea (EBS) area were managed under the "other red rockfish" species complex, which consisted of shortraker (*Sebastes borealis*), rougheye (*S. aleutianus*), sharpchin (*S. zacentrus*), and northern rockfish (*S. polyspinis*), whereas in the Aleutian Islands (AI) area during this time rougheye rockfish were managed within the rougheye/shortraker complex. In 2001, the other red rockfish complex in the eastern Bering Sea was split into two groups, rougheye/shortraker and sharpchin/northern, matching the complexes used in the Aleutian Islands. Additionally, separate TACs were established for the EBS and AI management areas, but the overfishing level (OFL) pertained to the entire BSAI area. By 2004, rougheye, shortraker, and northern rockfish were managed with species-specific OFLs applied to the BSAI management area.

Fish historically referred to as "rougheye" rockfish are now recognized as consisting of two separate species (Orr and Hawkins 2008), with rougheye rockfish retaining the name *Sebastes aleutianus* and resurrection of a new species, blackspotted rockfish (*S. melanostictus*). Both species are distributed widely throughout the north Pacific. *S. aleutianus* is distributed from the eastern Aleutian Islands near Unalaska Islands along the continental slope to southern Oregon, where *S. melanostictus* is distributed along the continental slope from Japan to California (Orr and Hawkins 2008). Several studies (Hawkins et al. 2005; Gharrett et al. 2005; Orr and Hawkins 2008) have used genetic and morphometric analyses to document the scarcity of rougheye rockfish west of the eastern Aleutian Islands (AI) and the occurrence of blackspotted rockfish throughout the BSAI area, thus establishing differences in species composition between areas in the BSAI. This distribution pattern has also been observed in recent AI trawl surveys, where rougheye rockfish are rarely found in the central and western AI. Some differences in species composition based upon field identification may be due to errors in species identification, particularly in areas where both species are common, as blackspotted and rougheye rockfish are similar in appearance. This issue appears to be particularly problematic in the Gulf of Alaska (GOA), where a field test in the 2009 GOA trawl survey reported high misidentification rates. However, the distribution pattern in the AI survey biomass estimates is consistent with information obtained from the previously cited genetic and morphometric analyses, which did not rely on field identification. The title of this assessment was changed to "blackspotted and rougheye rockfish" in 2008 upon recognition of blackspotted rockfish and its high abundance in the BSAI relative to rougheye rockfish. Data for the two species are combined in the assessment, as species-specific catch records do not exist and identification by species has occurred in the AI trawl survey only since 2006.

Information on stock structure

A stock structure evaluation report was included in the 2010 assessment, and evaluated species distributions within the blackspotted/rougheye complex, genetic data, and size at age data. The patterns of spatial variation in species composition noted above for this two-species complex was considered in this evaluation because differences in species composition could imply different levels of productivity across spatial areas. Tests for genetic homogeneity indicated that genetic differences occurred between samples of blackspotted rockfish grouped into four areas within the BSAI, and a significant isolation by distance (IBD) pattern also occurred within the BSAI area. Dispersal distance between parents and offspring was estimated from the IBD relationship and a sensitivity analysis was conducted to examine the influence of the slope of the IBD relationship and assumptions of effective population size upon this estimate. The maximum estimate of dispersal distance from the sensitivity analysis was ~ 500 km.

Differences in size at age (for ages between about 10 and 30) and in age composition were also detected between the eastern Bering Sea (EBS) slope and the Aleutian Islands (AI) from analyses that were conducted upon the two-species blackspotted/rougheye complex. Although interpretation of these observations is confounded at the species level, it does not appear to be consistent with the concept of a well-mixed stock complex across the BSAI.

The BSAI Plan Team concluded in 2010 that spatial structure exists within the BSAI for blackspotted and rougheye rockfish, and recommended the BSAI ABC be partitioned into an ABC for the western and central Aleutian Islands, with a separate ABC for the remainder of the BSAI area. Additional information was presented to the BSAI Plan Team in 2010 and 2012 indicating disproportionate harvesting within the three subareas within the Aleutian Islands. This analysis has been extended and updated with the 2012 survey data, and is presented in Appendix 1 of this assessment.

Fishery

Historical Background

Catches of rougheye rockfish have been reported in a variety of species groups in the foreign and domestic Alaskan fisheries. Foreign catch records did not identify rougheye rockfish by species, but reported catches in categories such as "other species" (1977, 1978), "POP complex" (1979-1985, 1989), and "rockfish without POP" (1986-1988). Rougheye rockfish have been managed in the domestic fishery as part of the "other red rockfish" or "shortraker/rougheye" complexes. Reported ABCs, TACs, and catches by management complex from 1988-2012 are shown in Table 1. Since 2003, the catch accounting system (CAS) has reported catch of rougheye by species and area. From 1991-2002, species catches were reconstructed by computing the harvest proportions within management groups from the North Pacific Foreign Observer Program database, and applying these proportions to the estimated total catch obtained from the NOAA Fisheries Alaska Regional Office "blend" database. This reconstruction was conducted by estimating the rougheye catch for each area (i.e., the EBS and each of the three AI areas) and gear type from 1994-2002. For 1991-1993, the Regional Office blend catch data for the Aleutian Islands was not reported by AI subarea, and the AI catch was obtained using the observer harvest proportions by gear type for the entire AI area. Similar procedures were used to reconstruct the estimates of catch by species from the 1977-1989 foreign and joint venture fisheries. Estimated domestic catches in 1990 were obtained from Guttormsen et al. 1992. Catches from the domestic fishery prior to the domestic observer program were obtained from PACFIN records. Catches of rougheye since 1977 by area are shown in Table 2. Catches were relatively high during the late 1970s, declined during the late 1980s as the foreign fishery was reduced, increased in the early 1990s and mid-1990s, and declined in the late-1990s.

The catches by area from 1994-2012 have been relatively evenly distributed throughout the three AI subareas, with 33%, 27%, and 25% in the WAI, CAI, and EAI, respectively, and the remaining 5% in the EBS management area (Table 3). In recent years, the proportion of the BSAI catch is the WAI has increased to 39% from 2004 -2012. However, biomass estimates from the AI survey indicate that a relative small portion of the stock (approximately 8%) occurs in WAI. Since 1994, the two largest annual values of subarea catch occurred in the WAI in 1996 (446 t) and 1997 (513 t). Information on spatial exploitation rates is presented in more detail in Appendix 1.

Discards

Estimates of discarding by species complex are shown in Table 4. Estimates of discarding of the other red rockfish complex in the EBS were generally above 56% from 1993 to 2000, with the exception of 1993 and 1995 when discard rates were less than 26%. The variation in discard rates may reflect different species composition of the other red rockfish catch. Discard rates of EBS RE/SR complex from 2001 to 2003 were at or below 52%, and discard rates of AI SR/RE complex from 1993-2003 were below 41%.

In general, the discard rates of EBS RE/SR (2001-2003) are less than the discard rates of EBS other red rockfish (1993-2000), likely reflecting the relatively higher value of rougheye and shortraker rockfishes over other members of the complex. From 2004 to 2012, discard rates of rougheye in the Aleutian Islands and EBS averaged 20% and 38%, respectively.

Recent Distribution of Catch across Areas and Target Fisheries

Rougheye rockfish in the Aleutian Islands have been caught primarily in the rockfish trawl, Pacific cod longline, and Atka mackerel trawl fisheries in recent years. From 2004-2012, these three fisheries accounted for 86% of the AI rougheye catch. Catches of AI rougheye rockfish from 2004-2012 were primarily taken in the western and central Aleutians, with 43% and 30% in areas 543 and 542, respectively (Table 5). Approximately 91% of the catches of rougheye rockfish from 2004-2012 in the EBS management area were in the arrowtooth flounder trawl fishery, Pacific cod longline , halibut longline fishery, rockfish trawl fishery, turbot longline fishery, pollock midwater trawl fishery, and “other flatfish” trawl fisheries. Catches of rougheye in the EBS management area were concentrated in areas 517, 518, 519 and 521, which comprise much of the EBS slope and the area north of Unmak and Unalaska Islands (Table 5).

Data

Fishery data

The catch data used in the assessment model are the estimates of single species catch described above and shown in Table 2.

Prior to 1999, the fishery data is characterized by inconsistent sampling of length (Table 6) and age (Table 7), as many fish were measured in some years whereas other years had no data. In 1979, 1990, 1992, and 1993 over 1000 fish were measured in the Aleutians Islands and the size compositions were used in the assessment model. In the domestic fishery, changes in observer sampling protocol since 1999 increased the number of fish and hauls from which rougheye rockfish age and length data were collected, increasing the utility for stock assessment modeling. The size compositions in 2003 and 2010, and the age compositions in 2004-2005, 2007-2008, 2009, and 2011 were used in the assessment model.

The fishery age composition data indicates relatively moderate cohorts from the early 1970s to early 1980s, but some of the more recent cohorts from the mid-1990s appear inconsistently in the data (Figure 1). For example, the 1997 cohort is appears as 12 year olds in the 2009 age composition, but were not observed in previous samples. Similarly, the 1996 cohort appears strong in the 2008 fishery age composition, is not observed in the 2009 age composition, and appears weak in the 2011 age composition. One exception to this pattern is the 1998 cohort, which appears relatively strong in both the 2009 and 2011 fishery age compositions.

Survey data

Biomass estimates for rougheye rockfish were produced from cooperative U.S.-Japan trawl survey from 1979-1985 on the eastern Bering Sea slope, and from 1980-1986 in the Aleutian Islands. U.S trawl surveys, conducted by the National Marine Fisheries Service (NMFS) were conducted in 1988, 1991, 2000, 2002, 2004, 2008, 2010, and 2012 on the eastern Bering Sea slope, and in 1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, and 2012 in the Aleutian Islands (Table 8). The Aleutian Islands survey scheduled for 2008 was canceled due to lack of funding. Differences exist between the 1980-1986 cooperative surveys and the 1991-2012 U.S. domestic surveys with regard to the vessels and gear design used. For example, the Japanese nets used in the 1980, 1983, and 1986 cooperative surveys of the Aleutian Islands varied between years and included large roller gear, in contrast to the poly-nor’eastern nets used since 1991 (Ronholt et al 1994, Stauffer 2004), and similar variations in gear between surveys occurred in the cooperative EBS surveys.

The Aleutian Island surveys from 1991 to 2012 indicated higher abundances in the central (542) and eastern Aleutians than in the western Aleutian Islands (543) or southern Bering Sea area (Figure 2). In the western Aleutians, surveys prior to 2012 typically had positive CPUE tows near Attu Island and Tahoma Bank-Buldir Island area. However, the 2012 survey was characterized generally lower CPUE levels in the WAI, which reduced the biomass estimate for this area to 335 t from an average of 1,075 t in the 2000-2010 surveys. In the central and eastern AI, high CPUE tows were located to the northwest of Amchitka Island, inside the western border of the central Aleutian Islands, and from the Delarof Islands to Islands of the Four Mountains. The 2012 survey biomass estimate for rougheye and blackspotted rockfish from the portion of the AI survey in the AI management area was 12,401 t, which represents an increase of 45% from the 2010 estimate of 8,541 t. Much of this increase occurred in the central AI, where the estimates biomass increased from 2,238 t in 2010 to 8,268 t in 2012 (Table 9), with one very large CPUE value occurring near Kiska Island (Figure 2).

The biennial EBS slope survey was initiated in 2002. The most recent slope survey prior to 2002 (excluding some experimental tows in 2000 to evaluate survey gear) was in 1991. The 2008 EBS slope survey was completed, but the 2006 survey was canceled due to lack of funding. The survey biomass estimates of blackspotted and rougheye rockfish from the 2002-2012 EBS slope surveys have ranged between 553 t (2002) and 1,613 t (2012), with CVs between 0.16 and 0.50. Given these low levels of biomass, the slope survey results are not used in this assessment, and the feasibility of incorporating this time series in the age-structured model will be evaluated as new data becomes available.

Identification to species within the blackspotted/rougheye complex was initiated in the 2006 AI survey and the 2008 EBS slope survey. These data show the complex is composed nearly entirely of blackspotted rockfish in the AI management area (ranging between 95% and 99% by weight in the 2006 – 2012 surveys, with a higher proportion of rougheye rockfish in the southern Bering Sea (SBS) and EBS slope. Field identification of these species can be difficult in areas where both species are abundant, such as the Gulf of Alaska, but blackspotted rockfish in the Aleutian Islands have been observed to have more clearly identifiable characteristics than blackspotted rockfish in other areas (Jay Orr, AFSC, pers. comm.).

The AI survey provides data on age and length composition of the population, growth rates, and length-weight relationships. The number of lengths measured and otoliths sampled are shown in Tables 10 and 11, along with the number of hauls producing these data. The survey data produce reasonable sample sizes of lengths and otoliths throughout the survey area. The maximum age observed in the survey samples was 121 years.

The survey age composition data indicates that in most surveys, blackspotted/rougheye rockfish are distributed relatively evenly across a broad range of ages (i.e., ages 20 to 40) (Figure 3). Prior to 2006, fish less than 10 years old have been uncommon in the surveys; however, the 2006 and 2010 survey does indicate potentially strong 1998 and 1999 year classes.

The survey otoliths were read with the break and burn method, and are considered unbiased (Chilton and Beamish 1982); however, the potential for aging error exists. Information on aging error was obtained from multiple independent readings on GOA otoliths collected in 1990, 1999, and 2003 (Shotwell et al. 2007). These data were used to estimate the error in age reading based on the percent agreement between the readers. A fitted relationship describing the standard deviation in age read by age was used to produce the aging error matrix.

The AI survey otolith data was used to estimate size at age and von Bertalannfy growth parameters. Unbiased estimates of mean length at age were generated from multiplying the survey length composition by the age-length key in order to produce a matrix of estimated population numbers by age and length, from which an unbiased average length for each age can be determined. Preliminary analyses did not reveal any patterns by year and subarea within the AI survey areas, so the mean length at age from each survey year from 1986 to 2010 was used to fit the growth curve. The estimated von Bertalannfy parameters are as follows, and were used to create a conversion matrix and a weight-at-age vector:

L_{inf}	K	t_0
51.18	0.06	-4.07

A conversion matrix was created to convert modeled number at ages to modeled number at length bin, and consists of the proportion of each age that is expected in each length bin. This matrix was created by fitting a second-order polynomial model to the observed standard deviation in length at each age (obtained from the aged fish from the 1980-2010 surveys), and the predicted relationship was used to produce variation around the predicted size at age from the von Bertalanffy relationship. The resulting CVs of length at age of the conversion matrix decrease from 0.16 at age 3 to 0.10 at age 45.

A length-weight relationship of the form $W = aL^b$ was fit from the survey data, and produced estimates of $a = 6.60 \times 10^{-6}$ and $b = 3.24$. This relationship was used in combination with the von Bertalanffy growth curve to obtain the estimated weight at age vector of the population (Table 12).

The following table summarizes the data available for the both the AI and combined BSAI rougheye rockfish assessment models:

Component	BSAI
Fishery catch	1977-2012
Fishery age composition	2004-2005, 2007-2008, 2009, 2011
Fishery size composition	1979, 1990, 1992, 1993, 2003, 2010
Survey age composition	1986, 1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010
Survey length composition	2012
Survey biomass estimates	1980, 1983, 1986, 1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012

Analytic Approach

Model structure

The assessment model for rougheye rockfish is very similar to that currently used for other BSAI rockfish, which was used as a template for the current model. Population size in numbers at age a in year t was modeled as

$$N_{t,a} = N_{t-1,a-1} e^{-Z_{t-1,a-1}} \qquad 3 \le a < A, \quad 1977 < t \le T$$

where *Z* is the sum of the instantaneous fishing mortality rate ($F_{t,a}$) and the natural mortality rate (*M*), *A* is the maximum number of age groups modeled in the population (defined as 45), and *T* is the terminal year of the analysis (defined as 2012). The numbers at age *A* are a "pooled" group consisting of fish of age *A* and older, and are estimated as

$$N_{t,A} = N_{t-1,A-1} e^{-Z_{t-1,A-1}} + N_{t-1,A} e^{-Z_{t-1,A}}$$

The numbers at age in the first year are estimated as

$$N_a = R_0 e^{-M(a-3)+\gamma_a}$$

where R_0 is the mean number of age 3 recruits prior to the start year if the model, and γ_a is an age-dependant deviation assumed to be normally distributed with mean of zero and a standard deviation equal to σ_r, the recruitment standard deviation. Estimation of the vector of age-dependant deviations from average recruitment allows estimation of year class strength.

The total numbers of age 3 fish from 1977 to 2009 are estimated as parameters in the model, and are modeled with a lognormal distribution

$$N_{t,3} = e^{(\mu_R + \nu_t)}$$

where ν_t is a time-variant deviation. Little information exists to estimate the recruitment in the most recent years due to the relatively late age of recruitment to both the fishery and survey, and recruitment for 2010-2012 was specified as the median recruitment.

The fishing mortality rate for a specific age and time ($F_{t,a}$) is modeled as the product of a fishery age-specific selectivity (*fishsel*) that increases asymptotically with age and a year-specific fully-selected fishing mortality rate *f*. The fully selected mortality rate is modeled as the product of a mean (μ_f) and a year-specific deviation (ε_t), thus $F_{t,a}$ is

$$F_{t,a} = fishsel_a * f_t \equiv fishsel_a * e^{(\mu_f + \varepsilon_t)}$$

The logistic curve is used to model fishery selectivity at age:

$$fishsel_a = \frac{1}{1 + \exp(-slope(a - a_{50\%}))}$$

where the $a_{50\%}$ and *slope* parameters control the age at 50% selectivity and the slope of the curve at this point, respectively. Survey selectivity and maturity are also modeled with the logistic function.

The mean number at age for each year was computed as

$$\overline{N}_{t,a} = N_{t,a} * (1 - e^{-Z_{t,a}}) / Z_{t,a}$$

The predicted length composition data were calculated by multiplying the mean numbers at age by a conversion matrix, which gives the proportion of each age (rows) in each length group (columns). The age bins range from 3 to 45 and the length bins range from 12 to 50, with the terminal bin being a plus group that includes all older (or larger) fish. The mean number of fish at age available to the survey or fishery is multiplied by the aging error matrix to produce the observed survey or fishery age compositions.

Catch biomass at age was computed as the product of mean numbers at age, instantaneous fishing mortality, and weight at age. The predicted trawl survey biomass (*pred_biom*) was computed as

$$pred\_biom_t = qsurv \sum_a \left(\overline{N}_{t,a} * survsel_a * W_a \right)$$

where W_a is the population weight at age, $survsel_a$ is the survey selectivity, and *qsurv* is the trawl survey catchability.

To facilitate parameter estimation, prior distributions were used for the survey catchability and the natural mortality rate *M*. A lognormal distribution was also used for the natural mortality rate *M*, with the mean set to 0.03 and with the coefficient of variation (CV) set to 0.05. The prior distribution for *qsurv* followed a lognormal distribution with a mean of 1.0 and a CV of 0.05, essentially fixing *qsurv* at 1.0. In previous assessments, attempts to obtain reasonable estimates of survey catchability have not been successful.

In previous assessments, the standard deviation of log recruits, σ_r, was fixed at 0.75 after conducting several runs to obtain a likelihood profile on σ_r and also comparing the consistency between σ_r and the root mean square error (RMSE; defined below) of the recruitment residuals.

Several quantities were computed in order to compare the variance of the residuals to the assumed input variances. The root mean squared error (RMSE) should be comparable to the assumed coefficient of variation of a data series. This quantity was computed for the AI trawl survey and the estimated recruitments, and for lognormal distribution is defined as

$$RMSE = \sqrt{\frac{\sum_n (\ln(y) - \ln(\hat{y}))^2}{n}}$$

where y and $\hat{y}$ are the observed and estimated values, respectively, of a series length n. The standardized deviation of normalized residuals (SDNR) is closely related to the RMSE; values of SDNR approximately at 1 indicate that the model is fitting a data component as well as would be expected for a given specified input variance. The normalized residuals for a given year i of the AI trawl survey data were computed as

$$\delta_i = \frac{\ln(B_i) - \ln(\hat{B}_i)}{\sigma_i}$$

where σ_i is the input sampling standard deviation of the estimated survey biomass. For age or length composition data assumed to follow a multinomial distribution, the normalized residuals for age/length group a in year i were computed as

$$\delta_{i,a} = \frac{(y_{i,a} - \hat{y}_{i,a})}{\sqrt{\hat{y}_{i,a}(1 - \hat{y}_{i,a}) / n_i}}$$

where y and $\hat{y}$ are the observed and estimated proportion, respectively, and n is the input assumed sample size for the multinomial distribution. The effective sample size was also computed for the age and length compositions modeled with a multinomial distribution, and for a given year i was computed as

$$E_i = \frac{\sum_a \hat{y}_a * (1 - \hat{y}_a)}{\sum_a (\hat{y}_a - y_a)^2}.$$

An effective sample size that is nearly equal to the input sample size can be interpreted as having a model fit that is consistent with the input sample size.

Parameters Estimated Outside the Assessment Model

The parameters estimated independently include the age error matrix, the age-length conversion matrix, individual weight at age, and proportion mature females at age. The derivation of the age error matrix, the age-length conversion matrix, and the weight at age vector are described above. The proportion of females mature at age (Table 12) was obtained from data on Gulf of Alaska rougheye rockfish in McDermott (1994).

Parameters Estimated Inside the Assessment Model

Parameter estimation is facilitated by comparing the model output to several observed quantities, such as the age and length composition of the survey and fishery catch, the survey biomass, and the catch biomass. The general approach is to assume that deviations between model estimates and observed quantities are attributable to observation error and can be described with statistical distributions. Each data component provides a contribution to a total log-likelihood function, and parameter values that minimize the negative log-likelihood are selected.

The negative log-likelihood of the initial recruitments were modeled with a lognormal distribution

$$\lambda_1 \left[\sum_{t=1}^{n} \frac{\left(\nu_t + \sigma_r^{\ 2}/2\right)^2}{2\sigma_r^{\ 2}} + n\ln(\sigma_r) \right]$$

where n is the number of year where recruitment is estimated. The adjustment of adding $\sigma_r^2/2$ to the deviation was made in order to produce deviations from the mean, rather than the median, recruitment. If σ_r is fixed, the term $n \ln(\sigma_r)$ adds a constant value to the negative log-likelihood. The negative log-likelihood of the recruitment of cohorts represented in the first year (excluding age 3, which is included in the recruitment negative log-likelihood) of the model is treated in a similar manner:

$$\lambda_1 \left[\sum_{a=4}^{A} \frac{\left(\gamma_a + \sigma_r^{\ 2}/2\right)^2}{2\sigma_r^{\ 2}} + (A-3)\ln(\sigma_r) \right]$$

The negative log-likelihoods of the fishery and survey age and length compositions were modeled with a multinomial distribution. The log of the multinomial function (excluding constant terms) for the fishery length composition data, with the addition of a term that scales the likelihood, is

$$-n_{f,t,l} \sum_{s,t,l} (p_{f,t,l} \ln(\hat{p}_{f,t,l}) + p_{f,t,l} \ln(p_{f,t,l}))$$

where n is the number of hauls that produced the data, and $p_{f,t,l.}$ and $\hat{p}_{f,t,l}$ are the observed and estimated proportion at length in the fishery by year and length. The negative log-likelihood for the age and length proportions in the survey, $p_{surv,t,a}$ and $p_{surv,t,l}$, respectively, follow similar equations.

The negative log-likelihood of the survey biomass was modeled with a lognormal distribution:

$$\lambda_2 \sum_t (\ln(obs\_biom_t) - \ln(pred\_biom_t))^2 / 2cv_t^{\,2}$$

where obs_biom_t is the observed survey biomass at time t, cv_t is the coefficient of variation of the survey biomass in year t, and λ_2 is a weighting factor. The negative log-likelihood of the catch biomass was modeled with a lognormal distribution:

$$\lambda_3 \sum_t (\ln(obs\_cat_t) - \ln(pred\_cat_t))^2$$

where obs_cat_t and $pred\_cat_t$ are the observed and predicted catch. Because the catch biomass is generally thought to be observed with higher precision than other variables, λ_3 is given a very high weight so as to fit the catch biomass nearly exactly. The overall negative log-likelihood function (excluding the catch component) is

$$\begin{aligned}
&\lambda_1 \left[\sum_{t=1}^{n} \frac{\left(\nu_t + \sigma_r^{\,2}/2\right)^2}{2\sigma_r^{\,2}} + n\ln(\sigma_r) \right] + \\
&\lambda_1 \left[\sum_{a=4}^{A} \frac{\left(\gamma_a + \sigma_r^{\,2}/2\right)^2}{2\sigma_r^{\,2}} + (A-3)\ln(\sigma_r) \right] + \\
&\lambda_2 \sum_t \left(\ln(obs_biom_t) - \ln(pred_biom_t)\right)^2 / 2cv_t^2 + \\
&- n_{f,t,l} \sum_{s,t,l} (p_{f,t,l} \ln(\hat{p}_{f,t,l}) + p_{f,t,l} \ln(p_{f,t,l})) + \\
&- n_{f,t,a} \sum_{s,t,l} (p_{f,t,a} \ln(\hat{p}_{f,t,a}) + p_{f,t,a} \ln(p_{f,t,a})) + \\
&- n_{surv,t,a} \sum_{s,t,a} (p_{surv,t,a} \ln(\hat{p}_{surv,t,a}) + p_{surv,t,a} \ln(p_{surv,t,a})) + \\
&- n_{surv,t,l} \sum_{s,t,a} (p_{surv,t,l} \ln(\hat{p}_{surv,t,l}) + p_{surv,t,l} \ln(p_{surv,t,l})) + \\
&\lambda_3 \sum_t \left(\ln(obs_cat_t) - \ln(pred_cat_t)\right)^2
\end{aligned}$$

For the model runs in this assessment, λ_1, λ_2, and λ_3 were assigned weights of 1,1, and 50, reflecting the strong emphasis on fitting the catch data. The sample sizes for the age and length compositions were set to the number of hauls from which these demographic data were obtained, but capped so as not to exceed 150. Additionally, the fishery length and age compositions were assigned one-half the weight of the survey age composition as it was generally perceived as a less reliable source of information. In the results below, comparisons of effective sample size to input sample size were made after scaling the input sample sizes by their weights (Table 13).

The negative log-likelihood function was minimized by varying the following parameters:

Parameter type	***Number***
1) fishing mortality mean	1
2) fishing mortality deviations	36
3) recruitment mean	1
4) recruitment deviations	33
5) historic recruitment	1
6) first year recruitment deviations	42
7) biomass survey catchability	1
8) natural mortality rate	1
9) survey selectivity parameters	2
10) fishery selectivity parameters	2
Total number of parameters	120

Results

Model Evaluation

A series of model runs were conducted to evaluate the choice of the age plus group on the fits to age composition data and the model results. The choice of the age plus group affected the survey and fishery compositions, the ageing error matrix, and the age-length conversion matrix. Data files were created for age plus groups from 23 to 70, and the criteria for evaluation was the total likelihood and likelihood for the age compositions, and the standard deviation of normalized residuals for the age and length composition data.

The total likelihood and the survey and fishery age likelihood both increased monotonically as the age for the plus group increased (Figure 4a), which is expected because of the additional number of data points that contribute to the likelihood. The standard deviation of normalized residuals give a measure of the fit to the data that is independent of the number of data points, as a relatively poor fit will be characterized by larger residuals and a higher standard deviations of the normalized residuals. The standard deviation of normalized residuals for the length composition data, and the survey age composition data, is relatively invariant to the plus group age larger than about 30 (Figure 4b). The fishery age composition data shows a decrease in standardized deviation of normalized residuals with the plus group age. This results from the strong 1998 and 1999 year classes observed in the fishery age composition data being diminished in relative strength as an increased number of ages are binned in the plus group. This perceived diminishment of the 1998 and 1999 year classes also results in reduced estimated end-year total biomass with low plus group ages (Figure 4c). However, for plus group ages greater than about 45, there was relatively little change in the total likelihood or the model results (as indicated by the end-year total biomass). As with previous assessments, the age for the plus group was set at 45.

Time series results

In this assessment, spawning biomass is defined as the biomass estimate of mature females age 3 and older. Total biomass is defined as the biomass estimate of all blackspotted/rougheye rockfish age 3 and older. Recruitment is defined as the number of age 3 blackspotted/rougheye rockfish.

A retrospective analysis was conducted to evaluate the effect of recent data on estimated spawning stock biomass. For the current assessment model, a series of model runs were conducted in which the end year of the model was varied from 2012 to 2002, and this was accomplished by sequentially dropping age and length composition data, the survey biomass estimates, and the catch from the input data files.

The plot of retrospective estimates of spawning biomass is shown in Figure 5. The largest changes in estimated survey biomass occurred in years 2004, 2006, and 2010, when both survey biomass estimates and survey age composition data are added to the model. The current estimated time series of spawning biomass is approximately centrally located within the suite of 2002-2012 spawning biomass time series. Mohn's rho can be used to evaluate the severity of any retrospective pattern, and compares an estimated quantity (in this case, spawning stock biomass) in the terminal year of each retrospective model run with the estimated quantity in the same year of the model using the full data set . The absence of any retrospective pattern would result in a Mohn's rho of 0, and would result from either identical estimates from the model runs, or from positive deviations from the reference model being offset by negative deviations. The Mohn's rho for these retrospective runs was 0.15, indicating a minimal retrospective bias.

The negative log-likelihood associated with the various data components of the model (unscaled by the various λ terms or weights) is shown in Table 13. The model fit the age and length composition data better than would be expected based on the input multinomial sample sizes, and indicated by the relatively large effective sample sizes and the standard deviation of normalized residuals less than 1.

The estimated survey biomass decreases from 10,455 t in 1977 to 7,871 t in 1980 due to large catches in the late 1970s, increased to 12,474 t in 1989, declined throughout the 1990s and has gradually increased to 13,751 t in 2010 (Figure 6). The total and spawning biomass also show a decline in the late 1970s, increases throughout the 1980s, and a decline during most of the 1990s. Since 1999, the spawning biomass has increased from 5,382 to 6,488 in 2012, and the total biomass has increased from 15,109 t to 27,040 t over this period (Figures 7). The more rapid recent increase of total biomass relative to spawning stock biomass reveals that much of this increase can be attributed to relatively recent year classes that have not fully matured, such as the 1998 and 199 year classes. The time series of estimated total biomass, spawner biomass, and recruitment are shown in Table 14.

The model fits to the fishery age and size compositions are shown in Figures 8 and 9 and the model fits to the survey age and length compositions are shown in Figures 10 and 11. The model does not fit the unusually strong 1998 and 1999 year classes observed in the 2009 fishery age composition data, but does fit these year classes better in the 2008 and 2011 data. The 2010 fishery length composition data indicate that higher proportions of relatively small rougheye (i.e., 33-36 cm) are caught by the fishery, which corresponds to fish approximately 14-17 years old and the 1993-1996 year classes. Because these year classes are not consistently observed in other age and length compositions, the model does not produce a strong fit the 2010 fishery length composition data. The 2010 survey age composition data also indicates relatively strong 1998 and 1999 years classes which the model fit well. The 1999 year class appears stronger in the 2010 survey age composition than in the 2006 survey age composition data, which results in a weaker fit to this data point. In contrast to the 2010 fishery length composition data, the 2012 survey length composition data indicate that the bulk of the survey fish are larger than 40 cm.

The CVs of 5% for the priors on survey catchability and natural mortality constrained these parameters to values of 1.079 and 0.0333, respectively, a slight increase from the prior distribution means of 1.0 and 0.03, respectively.

Similar asymptotic selection curves were obtained for the AI survey and fishery, with an age at 50% selection for the fishery and AI survey of 17.8 years and 20.5 years, respectively (Figure 12). The estimated age at 50% selection for the fishery has decreased from the estimated value 19.2 years in the 2010 assessment due to the 2009 and 2011 fishery age composition data showing relatively high catch of younger fish. The age of 50% selection in the fishery is now estimated as lower than the age of 50% maturity (18.38 years).

The estimates of instantaneous fishing mortality rate are shown in Figure 13. Very high rates of fishing mortality are required in 1978 and 1979 to account for the high catches during these years, followed by rapid decreases in the early 1980s. Fishing mortality rates began to increase during the late 1980s, and were high for several years between the late 1980s and mid 1990s. Fishing mortality rates began to decline in late 1990s, and have been below the $F_{35\%}$ reference rate since 2000 (with the exception if 2001). A plot of fishing mortality rates and spawning stock biomass in reference to the ABC and OFL harvest control rules indicates that the current rate of fishing stock is currently below $F_{35\%}$ and the spawning stock biomass is above $B_{40\%}$ (Figure 14).

Recruitment strengths by year class are shown in Figure 15. There is little information to discern strong recruitments in the early years of the model, although relatively strong year classes were estimated for 1976 and 1981 and were observed in several years of survey sampling. As mentioned above, the 1998 and 199 year classes appear relatively strong in the 2009 fishery age composition data, as well as the 2006 and 2010 survey age composition data. The plot of recruitment against spawning stock biomass is shown in Figure 16.

Harvest Recommendations

Amendment 56 reference points for AI blackspotted/rougheye rockfish

The reference fishing mortality rate for blackspotted/rougheye rockfish is determined by the amount of reliable population information available (Amendment 56 of the Fishery Management Plan for the groundfish fishery of the Bering Sea/Aleutian Islands). Estimates of $F_{0.40}$, $F_{0.35}$, and $SPR_{0.40}$ were obtained from a spawner-per-recruit analysis. In the 2010 assessment, estimated recruitment from post-1995 year classes were not used to estimate equilibrium recruitment for future years (Figure 17). A similar approach was adopted in this assessment, and the average recruitment from the 1977-1997 year classes estimated in this assessment is assumed to represents a reliable estimate of equilibrium recruitment, then an estimate of $B_{0.40}$ is calculated as the product of $SPR_{0.40}$ * equilibrium recruits, and this quantity is 5,196 t. The year 2013 spawning stock biomass is estimated as 6,836 t.

Specification of OFL and maximum permissible ABC for AI blackspotted/rougheye rockfish

Since reliable estimates of the 2013 spawning biomass (B), $B_{0.40}$, $F_{0.40}$, and $F_{0.35}$ exist and $B>B_{0.40}$ (6,836 t > 5,196 t), rougheye rockfish reference fishing mortality is defined in tier 3a. For this tier, F_{ABC} maximum permissible F_{ABC} is $F_{0.40}$, and F_{OFL} is equal to $F_{0.35}$. The values of $F_{0.40}$ and $F_{0.35}$ are 0.035 and 0.043, respectively. The 2013 ABC and OFL for the AI blackspotted/rougheye resulting from these rates are 525 t and 632 t, respectively. A summary of these values is below.

2013 SSB estimate (B)	= 6,836 t
$B_{0.40}$	= 5,196 t
$F_{0.40}$	= 0.035
F_{ABC}	= 0.035
$F_{0.35}$	= 0.043
F_{OFL}	= 0.043

Alternate ABC for AI blackspotted/rougheye rockfish

The ABC listed above is based upon spawning biomass reference points that exclude recent year classes from the estimation of average recruitment. This procedure was utilized for the first time in the 2010 assessment, with the rationale that the 1998 year class and other recent year classes are imprecisely estimated. Estimates of recruitment are similar between the 2010 and 2012 assessment models, with a difference being that the 1999 year class is estimated as larger in the 2012 assessment model. However, in both the 2010 and 2012 assessment models, the large year classes (1998 year class in the 2010 model, and 1998 and 1999 year class in the 2012 model) have among the lowest coefficients of variation for estimated recruitment (Figure 17).

The increase in population size between the 2010 and 2012 assessments largely reflects the large 1998 and 1999 cohorts increasing in age and size. A comparison of the estimated total biomass produced from the 2010 assessment with the total biomass estimated from the 2012 assessment indicates that estimates of the total biomass without the 1998-1999 cohorts is similar between the two assessments (Figure 18). However, the estimated total biomass of the 1998-1999 cohorts is larger in the 2012 assessment, and currently comprises 34% of the estimated 2013 total biomass. This suggests that the increase in ABC for 2012 is based largely on the increase in abundance of the 1998-1999 cohorts. The recruitment strengths for these cohorts was determined to be sufficiently variable to warrant exclusion from the calculation of mean recruitment in the 2010 assessment, which resulted in a larger ABC than would occur if these cohorts were included in the estimate of mean recruitment. It would not be consistent to exclude the 1998 and 1999 year classes from the calculation of the harvest control rule on the grounds that they are imprecisely estimated while also increasing the ABC base largely on the increased estimated biomass of the same cohorts. As noted above, the recruitment estimates for the 1998 and 199 year classes have relatively low coefficients of variation.

Additionally, the recent 2010 fishery length composition, and 2009 and 2011 fishery age compositions, indicates that a relatively large portion of harvest consists of immature individuals, resulting in the age at 50% fishery selection now being less that the age of 50% maturity. The estimates of age and length at 50% maturity from McDermott (1994) are 44 cm and 18.5 years. The 2010 fishery length composition showed 75% of the fish was less than 44 cm. The 2009 and 2011 fishery age compositions showed 55% and 29% of the fish less than 18 years, respectively. A high proportion of harvest on immature fish could potentially compromise reproductive capacity, although this may become more of an issue with high fishing rates and/or consistent harvesting of immature fish over time.

Finally, the issue of disproportionate harvesting in the western Aleutians continues to exist, and is exacerbated by the 2012 survey biomass estimate of 335 t, which is the lowest on record (Table 9). The disproportionate harvesting represents a mismatch between the catch and survey data in that a high proportion of the catch in the AI management area occurs in the western AI (43% from 2004 to 2012), which accounts for a small portion of the survey biomass in the AI management area (8%). More detailed comparisons of the survey and catch data in the western Aleutians, and hypotheses for the underlying causes, are explored in Appendix A. Until the apparent pattern of disproportionate harvesting can be satisfactorily attributed to something other than high exploitation rates, we recommend applying precaution in setting the harvest specifications.

The population projections below are based on the full ABC value of 525 t, but the Plan Team may wish to discuss the alternative of “rolling over” the 2012 ABC of 475 t so as not to increase the ABC based on the considerations above.

Amendment 56 reference points for EBS blackspotted/rougheye rockfish

The age-structured model pertains to the AI management area, and management reference points for the EBS management area were obtained from applying Tier 5 methods to the survey data in the EBS management area. Tier 5 reference points specify F_{abc} = 0.75*M and F_{ofl} = M, and current estimates of M for blackspotted/rougheye rockfish obtained from the AI age structured model (0.033) were used, resulting in F_{abc} and F_{ofl} levels of 0.248 and 0.033. The ABC and OFL levels for the EBS blackspotted/rougheye rockfish were obtained by multiplying the F_{abc} and F_{ofl} values by estimated biomass. The available survey biomass estimates for EBS blackspotted and rougheye rockfish includes the southern Bering Sea portion of the AI survey and the EBS slope survey estimates. For each survey, weights of 4-6-9 are used to compute a weight average of survey biomass by area from the three most recent surveys, with higher weights given to more recent years. A weighted average of the three most recent biomass estimates of the southern Bering Sea (2006, 2010, and 2012) is 520 t, and was added to a weighted average of the three most recent EBS slope survey estimates of 1,254 t, yielding an EBS biomass estimate of 1,774 t, and the calculations described above result in ABC and OFL of 44 t and 59 t, respectively. Summing the EBS ABC and OFL values with those obtained from the age-structured model for the AI portion of the population results in an overall BSAI ABC and OFL of 569 t and 691 t, respectively.

Population Projections for AI blackspotted/rougheye rockfish

Age-structured population projections are not possible for the EBS portion of the blackspotted/rougheye rockfish, and were conducted only for the AI blackspotted/rougheye rockfish. A standard set of projections is required for each stock managed under Tiers 1, 2, or 3 of Amendment 56. This set of projections encompasses seven harvest scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Policy Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

For each scenario, the projections begin with the vector of 2012 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2013 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2012. In each subsequent year, the fishing mortality rate is prescribed on the basis of the spawning biomass in that year and the respective harvest scenario. In each year, recruitment is drawn from an inverse Gaussian distribution whose parameters consist of maximum likelihood estimates determined from recruitments estimated in the assessment. Spawning biomass is computed in each year based on the time of peak spawning and the maturity and weight schedules described in the assessment. Total catch is assumed to equal the catch associated with the respective harvest scenario in all years. This projection scheme is run 1000 times to obtain distributions of possible future stock sizes, fishing mortality rates, and catches.

Five of the seven standard scenarios will be used in an Environmental Assessment prepared in conjunction with the final SAFE. These five scenarios, which are designed to provide a range of harvest alternatives that are likely to bracket the final TAC for 2011, are as follow ("*max* F_{ABC}" refers to the maximum permissible value of F_{ABC} under Amendment 56):

> *Scenario 1*: In all future years, F is set equal to *max* F_{ABC}. (Rationale: Historically, TAC has been constrained by ABC, so this scenario provides a likely upper limit on future TACs.)
>
> *Scenario 2*: In all future years, F is set equal to a constant fraction of *max* F_{ABC}, where this fraction is equal to the ratio of the F_{ABC} value for 2013 recommended in the assessment to the *max*

F_{ABC} for 2013. (Rationale: When F_{ABC} is set at a value below *max* F_{ABC}, it is often set at the value recommended in the stock assessment.)

Scenario 3: In all future years, F is set equal to 50% of max F_{ABC}. (Rationale: This scenario provides a likely lower bound on F_{ABC} that still allows future harvest rates to be adjusted downward when stocks fall below reference levels.)

Scenario 4: In all future years, F is set equal to the 2007-2011 average F. (Rationale: For some stocks, TAC can be well below ABC, and recent average F may provide a better indicator of F_{TAC} than F_{ABC}.)

Scenario 5: In all future years, F is set equal to zero. (Rationale: In extreme cases, TAC may be set at a level close to zero.)

Two other scenarios are needed to satisfy the MSFCMA's requirement to determine whether a stock is currently in an overfished condition or is approaching an overfished condition. These two scenarios are as follow (for Tier 3 stocks, the MSY level is defined as $B_{35\%}$):

Scenario 6: In all future years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be above 1) above its MSY level in 2012 or 2) above ½ of its MSY level in 2012 and above its MSY level in 2022 under this scenario, then the stock is not overfished.)

Scenario 7: In 2013 and 2014, F is set equal to *max* F_{ABC}, and in all subsequent years F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is expected to be above its MSY level in 2025 under this scenario, then the stock is not approaching an overfished condition.)

The recommended F_{ABC} and the maximum F_{ABC} are equivalent in this assessment, and projections of the mean harvest and spawning stock biomass for the remaining six scenarios are shown in Table 15.

Status Determination

In addition to the seven standard harvest scenarios, Amendments 48/48 to the BSAI and GOA Groundfish Fishery Management Plans require projections of the likely OFL two years into the future. While Scenario 6 gives the best estimate of OFL for 2013, it does not provide the best estimate of OFL for 2014, because the mean 2014 catch under Scenario 6 is predicated on the 2013 catch being equal to the 2013 OFL, whereas the actual 2013 catch will likely be less than the 2013 OFL. The executive summary contains the appropriate one- and two-year ahead projections for both ABC and OFL.

Under the MSFCMA, the Secretary of Commerce is required to report on the status of each U.S. fishery with respect to overfishing. This report involves the answers to three questions: 1) Is the stock being subjected to overfishing? 2) Is the stock currently overfished? 3) Is the stock approaching an overfished condition?

Is the stock being subjected to overfishing? The official BSAI catch estimate for the most recent complete year (2011) is 170 t. This is less than the 2011 BSAI OFL of 549 t. Therefore, the stock is not being subjected to overfishing.

Harvest Scenarios #6 and #7 are intended to permit determination of the status of a stock with respect to its minimum stock size threshold (MSST). Any stock that is below its MSST is defined to be *overfished*. Any stock that is expected to fall below its MSST in the next two years is defined to be *approaching* an overfished condition. In this assessment, determination of whether the stock is overfished is complicated in that the age-structured model is applied only to the AI portion of the population; thus an estimate of MSST is only available for this portion of the population. Because current management regulations use a single OFL for the BSAI area, a meaningful measure of MSST and overfished status would need to reflect the entire BSAI population. However, the AI portion of the population composes the majority of the BSAI blackspotted/rougheye rockfish, and evaluation of its population size relative the MSST computed for the AI provides a useful index of stock condition. Harvest Scenarios #6 and #7 are used in these determinations for the AI portion of the population as follows:

Is the AI portion of the population currently below its MSST? This depends on the estimated spawning biomass in 2012:
a. If spawning biomass for 2012 is estimated to be below ½ $B_{35\%}$, the stock is below its MSST.
b. If spawning biomass for 2012 is estimated to be above $B_{35\%}$ the stock is above its MSST.
c. If spawning biomass for 2012 is estimated to be above ½ $B_{35\%}$ but below $B_{35\%}$, the stock's status relative to MSST is determined by referring to harvest Scenario #6 (Table 15). If the mean spawning biomass for 2022 is below $B_{35\%}$, the stock is below its MSST. Otherwise, the stock is above its MSST.

Is the AI portion of the population projected to go below its MSST? This is determined by referring to harvest Scenario #7:
a. If the mean spawning biomass for 2015 is below 1/2 $B_{35\%}$, the stock is approaching an overfished condition.
b. If the mean spawning biomass for 2015 is above $B_{35\%}$, the stock is not approaching an overfished condition.
c. If the mean spawning biomass for 2015 is above 1/2 $B_{35\%}$ but below $B_{35\%}$, the determination depends on the mean spawning biomass for 2025. If the mean spawning biomass for 2025 is below $B_{35\%}$, the stock is approaching an overfished condition. Otherwise, the stock is not approaching an overfished condition.

The results of these two scenarios indicate that the AI portion of the blackspotted/rougheye rockfish stock is neither below its MSST or projected to go below its MSST. With regard whether this portion of the stock is currently below its MSST, the expected stock size in the year 2012 of Scenario 6 is 1.25 times its $B_{35\%}$ value of 5,196 t. With regard to whether AI portion of the blackspotted/rougheye is to go below its MSST, the expected stock size in 2015 of Scenario 7 is 1.47 times the $B_{35\%}$ value.

Area Allocation of Harvests

The BSAI blackspotted/rougheye ABC is currently allocated with an subarea ABC for the western AI-central AI area, and a separate subarea ABC for the eastern AI-eastern Bering Sea area. As described above, the estimated 2013 ABC for the EBS area is 44 t. Within the AI management area, weighted averages of subarea biomass from the 2006, 2010, and 2012 Aleutian Islands surveys were used to compute average biomass. Weights of 4-6-9 were used, with higher weights given to more recent years. The proportions from these averages were then applied to the 2013 AI ABC of 525 t. The results of these calculations are shown below:

	Area		
	WAI	CAI	EAI
Weighted average biomass (2006,2010,2012)	773	5,667	3,874
Proportion of AI biomass	7.5%	54.9%	37.6%
Area ABC	39	289	197

The resulting subarea ABC are:

Western and Central AI ABC:	39 t + 289 t = 328 t
Eastern AI and EBS ABC:	197 t + 44 t = 241 t

Data Gaps and Research Priorities

Little information is known regarding most aspects of the biology of blackspotted and rougheye rockfish, particularly in the Aleutian Islands. Distinguishing blackspotted rockfish from rougheye rockfish in the field is a pressing issue, particularly along the EBS slope where both species are found. Further studies to examine the distribution and movement of early life-history stages are needed. Given the results of recent genetic work, further information on the population structure associated with distinctive oceanographic features such as Aleutian Island passes is needed. Finally, given the relatively unusual reproductive biology of rockfish and its importance in establishing management reference points, data on reproductive capacity should be collected on a periodic basis.

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Table 1. Total allowable catch (TAC), acceptable biological catch (ABC), and catch of the species groups used to manage blackspotted and rougheye rockfish from 1988 to 2012. The "other red rockfish" group includes, shortraker rockfish, rougheye rockfish, northern rockfish, and sharpchin rockfish. The "POP complex" includes the other red rockfish species plus POP.

Year	Area	Management Group	ABC (t)	TAC (t)	Catch (t)
1988	BS	POP Complex	6,000		1,509
	AI	POP Complex	16,600		2,629
1989	BS	POP Complex	6,000		2,873
	AI	POP Complex	16,600		3,780
1990	BS	POP Complex	6,300		7,231
	AI	POP Complex	16,600		15,224
1991	BS	Other Red Rockfish	1,670	1,670	942
	AI	Rougheye/Shortraker	1,245	1,245	388
1992	BS	Other Red Rockfish	1,400	1,400	467
	AI	Rougheye/Shortraker	1,220	1,220	1,470
1993	BS	Other Red Rockfish	1,400	1,200	1,226
	AI	Rougheye/Shortraker	1,220	1,100	1,139
1994	BS	Other Red Rockfish	1,400	1,400	129
	AI	Rougheye/Shortraker	1,220	1,220	925
1995	BS	Other Red Rockfish	1,400	1,260	344
	AI	Rougheye/Shortraker	1,220	1,098	559
1996	BS	Other Red Rockfish	1,400	1,260	207
	AI	Rougheye/Shortraker	1,250	1,125	959
1997	BS	Other Red Rockfish	1,050	1,050	218
	AI	Rougheye/Shortraker	938	938	1,043
1998	BS	Other Red Rockfish	267	267	112
	AI	Rougheye/Shortraker	965	965	685
1999	BS	Other Red Rockfish	356	267	238
	AI	Rougheye/Shortraker	1,290	965	514
2000	BS	Other Red Rockfish	259	194	253
	AI	Rougheye/Shortraker	1,180	885	480
2001	BSAI	Rougheye/Shortraker	1,028		
	BS	Rougheye/Shortraker		116	72
	AI	Rougheye/Shortraker		912	722
2002	BSAI	Rougheye/Shortraker	1,028		
	BS	Rougheye/Shortraker		116	105
	AI	Rougheye/Shortraker		912	478
2003	BSAI	Rougheye/Shortraker	967		
	BS	Rougheye/Shortraker		137	124
	AI	Rougheye/Shortraker		830	306
2004	BSAI	Rougheye	195	195	208
2005	BSAI	Rougheye	223	223	90
2006	BSAI	Rougheye	224	224	203
2007	BSAI	Rougheye	202	202	167
2008	BSAI	Rougheye	202	202	213
2009	BSAI	Rougheye	539	539	209
2010	BSAI	Rougheye	547	547	256
2011	BSAI	Rougheye	454	454	170
2012*	BSAI	Rougheye	475	475	185

*Catch data through October 6, 2012, from NMFS Alaska Regional Office.

Table 2. Catch of blackspotted and rougheye rockfish (t) in the BSAI area.

	Eastern Bering Sea			Aleutian Islands			BSAI
Year	Foreign	JV	Domestic	Foreign	JV	Domestic	Total
1977	2	0		155	0		157
1978	99	0		2,423	0		2,522
1979	477	0		3,077	0		3,553
1980	160	0		660	0		820
1981	283	0		595	0		878
1982	124	0		189	0		312
1983	53	0		56	2		111
1984	79	0		31	4		114
1985	18	0		1	9		27
1986	3	1	48	0	2	19	74
1987	1	2	96	0	3	76	179
1988	0	1	110	0	5	70	185
1989	0	2	202	0	0	381	585
1990			369			1,619	1,988
1991			106			137	243
1992			77			1,181	1,258
1993			146			924	1,070
1994			22			749	770
1995			28			395	423
1996			34			816	850
1997			15			954	969
1998			16			526	542
1999			9			385	394
2000			26			280	307
2001			15			550	565
2002			12			273	284
2003			17			174	191
2004			24			185	209
2005			12			78	90
2006			7			196	203
2007			10			157	167
2008			29			185	214
2009			12			197	209
2010			34			222	256
2011			39			131	170
2012*			19			166	185

*Catch data through October 6, 2012, from NMFS Alaska Regional Office.

Table 3. Area-specific catches of rougheye rockfish (t) in the BSAI area, obtained from the North Pacific Groundfish Observer Program, NMFS Alaska Regional Office. BSAI subareas are the western Aleutians Islands (WAI), central Aleutian Islands (CAI), and eastern Aleutian Islands (EAI), and eastern Bering Sea (EBS).

Year	WAI	CAI	EAI	EBS	Total
1994	49	197	503	22	770
1995	43	100	252	28	423
1996	446	184	186	34	850
1997	513	138	303	15	969
1998	109	232	185	16	542
1999	88	161	136	9	394
2000	103	139	39	26	307
2001	128	133	289	15	565
2002	96	63	114	12	284
2003	66	58	51	17	191
2004	115	58	12	24	209
2005	43	24	11	12	90
2006	109	45	42	7	203
2007	44	42	71	10	167
2008	61	74	50	29	214
2009	74	84	39	12	209
2010	94	52	76	34	256
2011	46	31	54	39	170
2012*	66	52	48	19	185

* Estimated removals through October 6, 2012.

Table 4. Estimated retained, discarded, and percent discarded of other red rockfish (ORR), shortraker/rougheye (SR/RE), and rougheye (RE) from the eastern Bering Sea (EBS) and Aleutian Islands (AI) regions.

Area	Species Group	Year	Catch (t) Retained	Discard	Total	Percentage
EBS	ORR	1993	916	308	1226	25.2%
		1994	29	100	129	77.6%
		1995	273	70	343	20.4%
		1996	58	149	207	71.9%
		1997	43	174	217	80.0%
		1998	42	70	112	62.4%
		1999	75	162	238	68.4%
		2000	111	141	252	55.9%
EBS.	RE/SR	2001	27	16	43	37.8%
		2002	50	54	104	52.0%
		2003	66	58	124	46.8%
AI	RE/SR	1993	737	403	1,139	35.3%
		1994	701	224	925	24.2%
		1995	456	103	559	18.4%
		1996	751	208	959	21.7%
		1997	733	310	1,043	29.7%
		1998	447	238	685	34.8%
		1999	319	195	514	38.0%
		2000	285	196	480	40.8%
		2001	476	246	722	34.1%
		2002	333	146	478	30.4%
		2003	214	92	306	29.9%
AI	RE	2004	83	102	185	55.1%
		2005	72	6	78	8.1%
		2006	166	30	196	15.2%
		2007	127	30	157	19.1%
		2008	142	43	185	23.5%
		2009	162	35	197	17.8%
		2010	187	34	222	15.5%
		2011	115	16	131	11.9%
		2012*	151	15	166	8.9%
EBS	RE	2004	15	9	24	39.1%
		2005	3	9	12	73.0%
		2006	5	2	7	29.7%
		2007	7	3	10	29.4%
		2008	12	17	29	58.3%
		2009	9	3	12	25.5%
		2010	20	14	34	42.1%
		2011	31	9	39	22.1%
		2012*	14	5	19	23.9%

* Estimated removals through October 6, 2012.

Table 5. Aleutian Islands and eastern Bering Sea cumulative catch (t) of blackspotted and rougheye rockfish from top gear and target combinations by management area and target fishery in 2004-2012, from the NMFS Alaska Regional Office catch accounting system database.

Aleutian Islands

		Management Area			
Target	Gear	541	542	543	Total
Rockfish	Bottom trawl	204.72	180.51	506.59	891.82
Pacific cod	Longline	25.39	123.12	73.72	222.22
Atka mackerel	Bottom trawl	33.58	92.07	66.34	191.99
Arrowtooth	Bottom trawl	73.71			73.71
Kamchatka	Bottom trawl	37.17			37.17
Sablefish	Longline	13.26	19.78		33.04
Halibut	Longline	9.05	15.01	3.80	27.85
Arrowtooth	Longline	0.02	16.31		16.33
Turbot	Longline	0.10	9.84		9.95
Pacific cod	Bottom trawl	2.69	4.36	0.35	7.40
Total (all targets and gears)		403.33	462.03	651.58	1516.94

Eastern Bering Sea

						Management Area					
Target	Gear	509	513	514	517	518	519	521	523	524	Total
Arrowtooth	Bottom trawl				15.99	18.53	8.00	3.40	0.11	0.75	46.77
Pacific cod	Longline	0.02	0.03		3.40	0.07	2.12	27.92	3.42	0.26	37.24
Rockfish	Bottom trawl				19.91	10.53	1.02	2.90	0.80		35.17
Halibut	Longline			0.02	1.73	9.85	1.24	3.75	2.09	3.53	22.20
Turbot	Longline				0.10	0.08	0.05	9.82	3.08	0.10	13.23
pollock pelagic	Pelagic trawl	0.15	0.04		5.25		1.94	1.38	0.01	0.03	8.81
Other flatfish	Bottom trawl				3.09		3.40				6.49
Flathead sole	Bottom trawl		1.07		1.02			0.46	0.48		3.03
Kamchatka	Bottom trawl					2.28	0.13			0.26	2.67
Pacific cod	Bottom trawl	0.10	0.00		0.69		0.62	0.34	0.28		2.02
Pollock bottom	Pelagic trawl	0.02	0.01		0.41		1.03	0.02			1.49
Sablefish	Longline				0.60	0.17	0.49	0.04	0.06		1.36
Atka mackerel	Bottom trawl						1.19				1.19
Total (all targets and gears)		0.27	1.16	0.02	55.45	42.33	21.79	50.28	10.42	4.94	186.66

Table 6. Samples sizes of blackspotted/rougheye lengths from fishery sampling, with the number of hauls from which these data were collected, from 1977-2011.

	EBS		AI		BSAI	
Year	Lengths	Hauls	Lengths	Hauls	Lengths	Hauls
1977						
1978			54	6	54	6
1979	2340	132	4406	93	6746	225
1980						
1981						
1982						
1983			33	1	33	1
1984						
1985						
1986						
1987						
1988						
1989						
1990	800	29	1161	20	1961	49
1991	95	16	49	1	144	17
1992	61	1	1182	67	1243	68
1993	2	2	1046	39	1048	41
1994			27	1	27	1
1995	42	3			42	3
1996	14	3			14	3
1997						
1998						
1999	4	2	53	4	57	6
2000	4	1	160	21	164	22
2001	10	1	277	42	287	43
2002			336	49	336	49
2003	76	18	832	100	908	118
2004	215	41	1265	242	1480	283
2005	71	39	314	94	385	133
2006	61	16	266	56	327	72
2007	104	40	716	160	820	200
2008	38	20	371	105	409	125
2009	16	10	1002	211	1018	221
2010	103	46	1904	375	2007	421
2011	158	81	692	170	850	251

Table 7. Samples sizes of blackspotted/rougheye otoliths from fishery sampling, with the number of hauls from which these data were collected, from 1977-2011.

	Otoliths Sampled			Otoliths Read			Hauls (Otoliths Read)		
Year	EBS	AI	BSAI	EBS	AI	BSAI	EBS	AI	BSAI
1977									
1978									
1979	440	383	823	14	38	52	6	4	10
1980									
1981									
1982									
1983									
1984									
1985									
1986									
1987									
1988									
1989									
1990	54	0	54						
1991									
1992		50	50						
1993									
1994									
1995									
1996									
1997									
1998									
1999	4	4	8						
2000	2	24	26						
2001	2	76	78						
2002		67	67						
2003	19	120	139						
2004	14	147	161	14	146	160	11	90	101
2005	37	100	137	35	97	132	23	65	88
2006	5	83	88		82	82		47	47
2007	14	138	152	14	134	148	10	83	93
2008	17	125	142	17	121	138	13	74	87
2009	13	138	151	6	138	144	6	90	96
2010	26	172	198						
2011	22	155	177	15	154	169	9	85	94

Table 8. Estimated biomass (t) of blackspotted/rougheye rockfish from the EBS slope survey and AI trawl survey (by management), with the coefficient of variation (CV) shown in parentheses.

	AI survey			EBS Slope survey
Year	AI	S. Bering Sea	Total	
1979				1053
1980	8,987 (0.07)	6 (1.00)	8,993 (0.07)	
1981				816
1982				605
1983	13,104 (0.19)	2,111 (0.33)	15,215 (0.17)	
1984				
1985				1716
1986	57,351 (0.51)	2,724 (0.49)	60,076 (0.49)	
1987				
1988				876 (0.32)
1989				
1990				
1991	10,638 (0.47)	676 (0.12)	11,314 (0.44)	884 (0.30)
1992				
1993				
1994	13,415 (0.28)	1,208 (0.49)	14,623 (0.26)	
1995				
1996				
1997	10,905 (0.22)	561 (0.66)	11,466 (0.21)	
1998				
1999				
2000	14,240 (0.23)	1,054 (0.26)	15,294 (021)	
2001				
2002	8,423 (0.21)	1,251 (0.48)	9,674 (0.20)	553 (0.20)
2003				
2004	14,386 (0.26)	654 (0.31)	15,039 (0.25)	646 (0.16)
2005				
2006	8,281 (0.25)	1,224 (0.33)	9,505 (0.23)	
2007				
2008				829 (0.24)
2009				
2010	8,541 (0.26)	221 (0.28)	8,762 (0.26)	999 (0.25)
2011				
2012	12,401 (0.38)	405 (0.27)	12,807 (0.37)	1,613 (0.50)

Table 9. Blackspotted/rougheye subarea biomass estimates (t) from the 1991-2012 Aleutian Islands trawl surveys.

	Aleutian Islands Survey Sub-Areas			
Year	Western AI	Central AI	Eastern AI	Southern Bering Sea
1991	3,037	2,380	5,221	676
1994	2,908	3,470	7,037	1,208
1997	3,373	4,607	2,925	561
2000	683	9,333	4,224	1,054
2002	1,390	3,934	3,099	1,251
2004	1,185	7,681	5,520	654
2006	519	4,959	2,803	1,224
2010	1,601	2,238	4,702	221
2012	335	8,268	3,798	405
Weighted Average (2006-2012)	773	5,667	3,874	519

Table 10. Samples sizes of blackspotted/rougheye lengths from the Aleutian Island trawl survey, with the number of hauls from which these data were collected, from 1980-2012.

	Lengths			Hauls		
Year	SBS	AI	Total	SBS	AI	Total
1980	440	5009	5449	6	68	74
1981						
1982						
1983	602	3312	3914	8	84	92
1984						
1985						
1986	622	3768	4390	7	54	61
1987						
1988						
1989						
1990						
1991	79	981	1060	5	30	35
1992						
1993						
1994	412	1963	2375	14	90	104
1995						
1996						
1997	90	1727	1817	13	108	121
1998						
1999						
2000	165	1508	1673	18	101	119
2001						
2002	258	1030	1288	19	79	98
2003						
2004	103	1419	1522	13	104	117
2005						
2006	177	1082	1259	20	102	122
2007						
2008						
2009						
2010	27	959	986	10	82	92
2011						
2012	129	1227	1356	25	94	119

Table 11. Samples sizes of blackspotted/rougheye otoliths from the Aleutian Island (AI) trawl survey, with the number of hauls from which these data were collected, from 1980-2012. SBS is the southern Bering Sea, which is the portion of Aleutian Islands trawl survey from 165° W to 170 W°.

	Otoliths sampled			Otoliths Read			Hauls (Otoliths Read)		
Year	SBS	AI	Total	SBS	AI	Total	SBS	AI	Total
1980									
1981									
1982									
1983	0	36	36	0	0	0	0	0	0
1984									
1985									
1986	70	343	413	64	341	405	2	11	13
1987									
1988									
1989									
1990									
1991	79	401	480	79	397	476	6	23	29
1992									
1993									
1994	194	535	729	130	356	486	13	55	68
1995									
1996									
1997	76	790	866	52	526	578	9	83	92
1998									
1999									
2000	116	376	492	115	375	490	16	71	87
2001									
2002	114	359	473	114	337	451	15	66	81
2003									
2004	103	372	475	102	370	472	14	83	97
2005									
2006	120	339	459	120	339	459	19	83	102
2007									
2008									
2009									
2010	27	464	491	15	227	242	9	61	70
2011									
2012	92	468	560						

Table 12. Predicted weight and proportion mature at age for BSAI rougheye rockfish.

Age	Predicted weight (g)	Proportion mature
3	65	0
4	91	0
5	122	0
6	157	0.001
7	197	0.001
8	239	0.003
9	286	0.008
10	334	0.015
11	385	0.03
12	438	0.053
13	492	0.09
14	548	0.141
15	604	0.209
16	660	0.29
17	717	0.378
18	773	0.467
19	829	0.551
20	885	0.625
21	939	0.689
22	993	0.742
23	1046	0.785
24	1097	0.82
25	1147	0.847
26	1196	0.87
27	1243	0.888
28	1289	0.902
29	1333	0.914
30	1376	0.924
31	1417	0.932
32	1457	0.939
33	1495	0.944
34	1531	0.949
35	1567	0.953
36	1600	0.956
37	1633	0.959
38	1663	0.962
39	1693	0.964
40	1721	0.966
41	1748	0.968
42	1774	0.969
43	1798	0.97
44	1822	0.971
45+	2039	0.977

Table 13. Negative log likelihood of model components, average effective and input sample sizes, root mean squared errors and standard deviation of normalized residuals.

Component	Negative log likelihood
Recruitment	13.88
AI survey biomass	13.44
Catch	0.00
F penalty	5.76
Fishery ages	1672.58
Fishery lengths	1461.95
Survey ages	1880.67
Survey lengths	570.23
Prior for *q_srv*	1.21
Prior for *M*	2.25
Total likelihood	5394.31
Average Effective Sample Size	
Fishery ages	61.81
Fishery lengths	243.59
Survey ages	125.60
Survey lengths	136.83
Average Sample Sizes	
Fishery ages	54.11
Fishery lengths	52.11
Survey ages	79.41
Survey lengths	118.67
Root Mean Squared Error	
Survey	0.54
Recruitment	0.79
Standard Deviation of Normalized Residuals	
Fishery ages	0.95
Fishery lengths	0.68
Survey ages	0.70
Survey lengths	0.75
AI trawl survey	1.45

Table 14. Estimated time series of AI blackspotted rougheye total biomass (t), spawner biomass (t), and recruitment (thousands).

	Total Biomass (ages 3+) Assessment Year		Spawner Biomass (ages 3+) Assessment Year		Recruitment (age 3) Assessment Year	
Year	2012	2010	2012	2010	2012	2010
1977	18,520	18,574	5,299	5,490	1,062	997
1978	19,106	19,124	5,474	5,652	1,265	1,187
1979	17,341	17,334	4,833	4,978	1,797	1,711
1980	14,849	14,823	4,132	4,241	1,509	1,373
1981	14,833	14,772	4,193	4,279	1,079	976
1982	14,869	14,774	4,289	4,353	1,078	986
1983	15,332	15,206	4,523	4,569	1,323	1,254
1984	15,948	15,776	4,803	4,830	1,591	1,338
1985	16,580	16,353	5,093	5,104	1,448	1,114
1986	17,221	16,932	5,390	5,388	1,166	874
1987	17,820	17,469	5,677	5,662	833	664
1988	18,339	17,925	5,943	5,916	712	585
1989	18,840	18,359	6,181	6,144	705	572
1990	18,998	18,449	6,207	6,161	616	487
1991	17,797	17,207	5,881	5,829	475	392
1992	18,133	17,478	6,009	5,946	401	356
1993	17,344	16,642	5,774	5,699	380	362
1994	16,798	16,048	5,640	5,550	397	394
1995	16,411	15,621	5,592	5,485	464	498
1996	16,374	15,557	5,638	5,511	600	758
1997	15,887	15,060	5,518	5,364	730	1,030
1998	15,258	14,455	5,372	5,188	1,019	1,537
1999	15,109	14,388	5,382	5,167	1,650	2,605
2000	15,105	14,414	5,439	5,195	1,533	1,392
2001	15,838	15,434	5,501	5,228	10,990	12,541
2002	16,673	15,610	5,466	5,154	13,342	2,337
2003	17,410	16,334	5,538	5,196	2,118	3,981
2004	18,314	17,064	5,612	5,260	2,339	1,720
2005	19,369	17,813	5,674	5,306	3,566	1,740
2006	20,494	18,695	5,756	5,378	1,549	1,611
2007	21,603	19,526	5,837	5,443	1,252	1,419
2008	22,695	20,349	5,889	5,495	1,329	
2009	23,777	21,159	5,951	5,563	1,581	
2010	24,857	21,953	6,048	5,665		
2011	25,907	22,759	6,208			
2012	27,040		6,488			
2013	28,079					

Table 15. Projections of AI spawning biomass (t), catch (t), and fishing mortality rate for each of the several scenarios resulting from the AI model. The values of $B_{40\%}$ and $B_{35\%}$ are 5,196 t and 4,546 t, respectively.

Catch	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2012	212	212	212	212	212	212	212
2013	525	525	264	208	0	632	525
2014	551	551	281	222	0	659	551
2015	583	583	301	238	0	694	701
2016	618	618	323	257	0	733	740
2017	656	656	347	276	0	774	782
2018	694	694	371	296	0	815	822
2019	729	729	394	315	0	853	860
2020	760	760	415	333	0	885	892
2021	786	786	435	349	0	911	917
2022	806	806	451	363	0	929	935
2023	819	819	464	375	0	939	945
2024	827	827	474	384	0	943	950
2025	830	830	483	392	0	943	948
Sp. Biomass	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2012	6,488	6,488	6,488	6,488	6,488	6,488	6,488
2013	6,836	6,836	6,853	6,857	6,870	6,829	6,836
2014	7,212	7,212	7,333	7,359	7,455	7,163	7,212
2015	7,683	7,683	7,911	7,961	8,147	7,591	7,676
2016	8,209	8,209	8,552	8,627	8,912	8,072	8,156
2017	8,757	8,757	9,224	9,328	9,721	8,572	8,655
2018	9,287	9,287	9,890	10,025	10,540	9,051	9,133
2019	9,771	9,771	10,522	10,691	11,341	9,479	9,560
2020	10,189	10,189	11,098	11,304	12,103	9,838	9,917
2021	10,536	10,536	11,613	11,859	12,819	10,125	10,202
2022	10,801	10,801	12,051	12,339	13,468	10,328	10,403
2023	10,987	10,987	12,411	12,741	14,047	10,453	10,525
2024	11,110	11,110	12,708	13,082	14,570	10,516	10,585
2025	11,179	11,179	12,951	13,369	15,044	10,528	10,595
F	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2012	0.015	0.015	0.015	0.015	0.015	0.015	0.015
2013	0.035	0.035	0.018	0.014	0	0.043	0.035
2014	0.035	0.035	0.018	0.014	0	0.043	0.035
2015	0.035	0.035	0.018	0.014	0	0.043	0.043
2016	0.035	0.035	0.018	0.014	0	0.043	0.043
2017	0.035	0.035	0.018	0.014	0	0.043	0.043
2018	0.035	0.035	0.018	0.014	0	0.043	0.043
2019	0.035	0.035	0.018	0.014	0	0.043	0.043
2020	0.035	0.035	0.018	0.014	0	0.043	0.043
2021	0.035	0.035	0.018	0.014	0	0.043	0.043
2022	0.035	0.035	0.018	0.014	0	0.043	0.043
2023	0.035	0.035	0.018	0.014	0	0.043	0.043
2024	0.035	0.035	0.018	0.014	0	0.043	0.043
2025	0.035	0.035	0.018	0.014	0	0.043	0.043

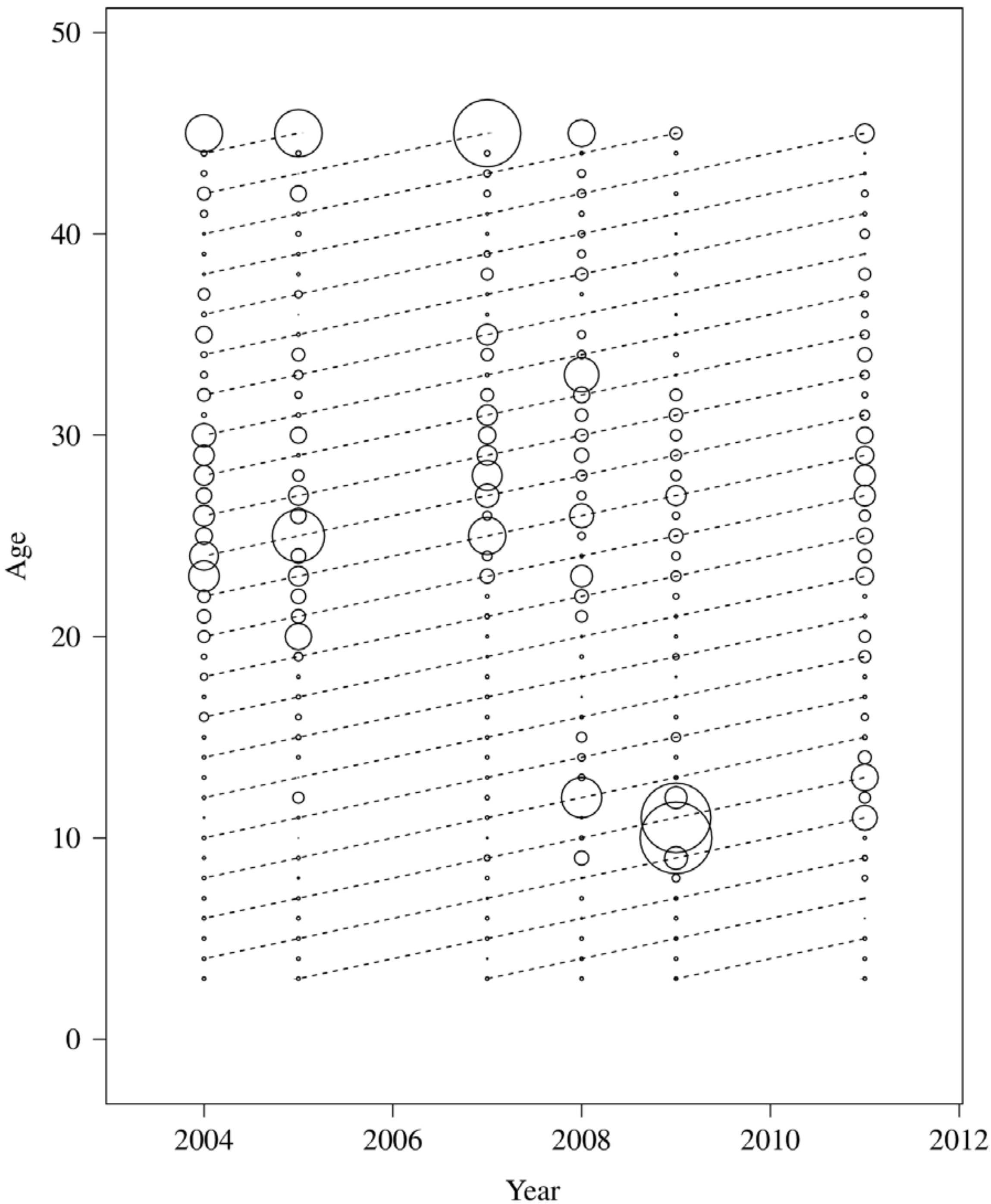

Figure 1. Fishery age composition data for the Aleutian Islands; bubbles are scaled within each year of samples; and dashed lines denote cohorts.

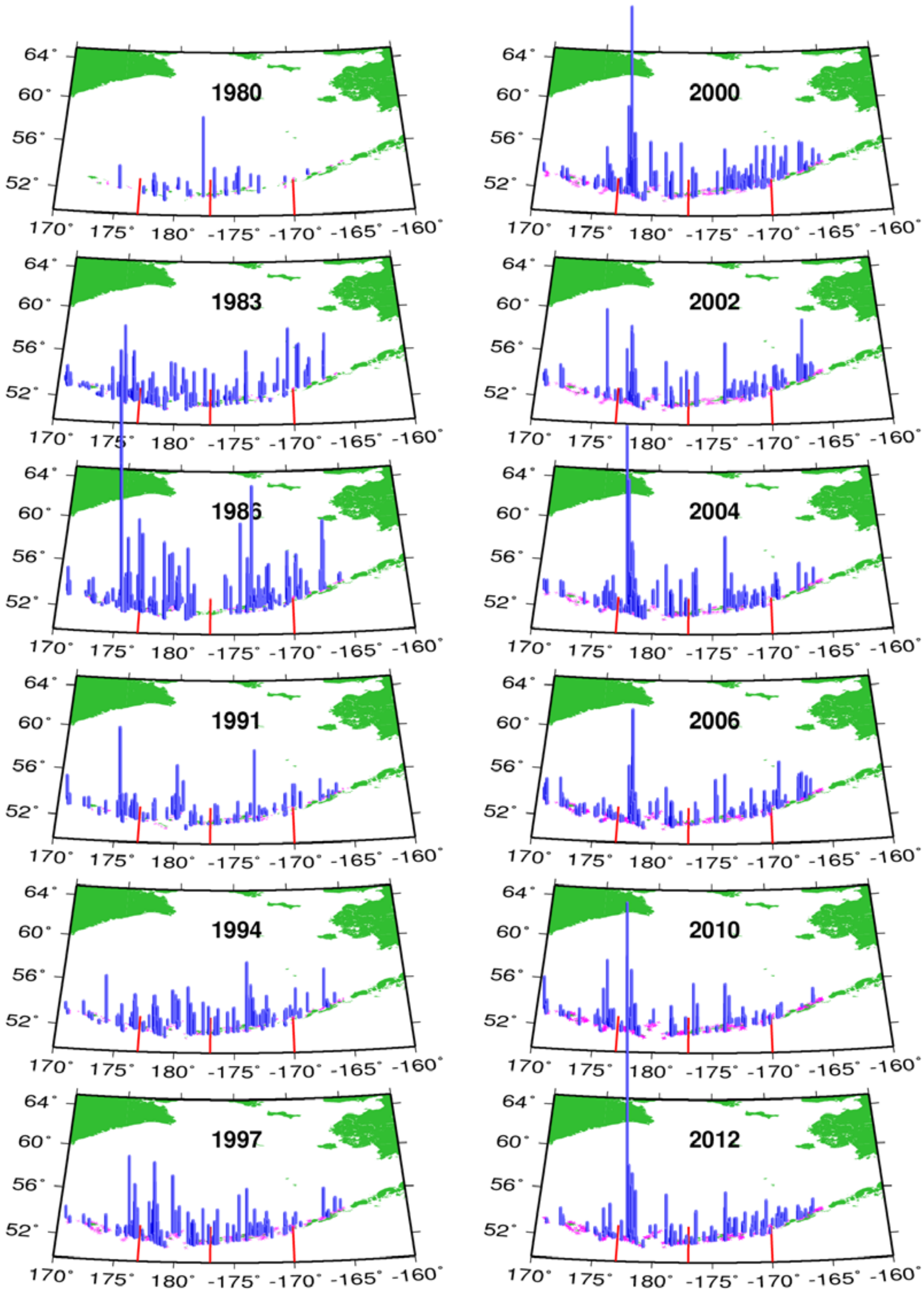

Figure 2. Scaled AI survey combined blackspotted and rougheye rockfish CPUE (square root of kg/km^2)from 1980-2012; the symbol × denotes tows with no catch. The red lines indicate boundaries between the WAI, CAI, EAI, and EBS areas.

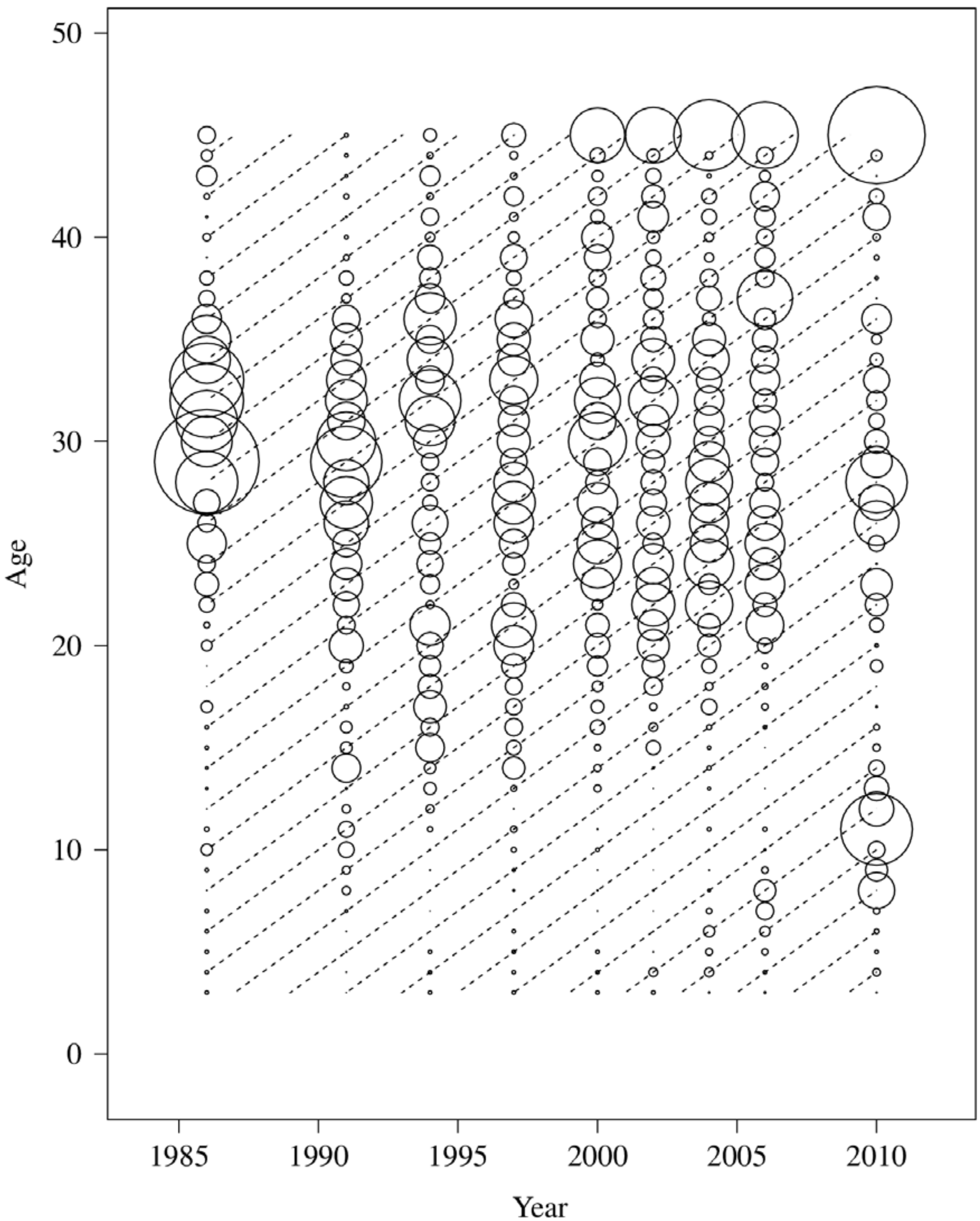

Figure 3. Age composition data from the Aleutian Islands trawl survey; bubbles are scaled within each year of samples; and dashed lines denote cohorts.

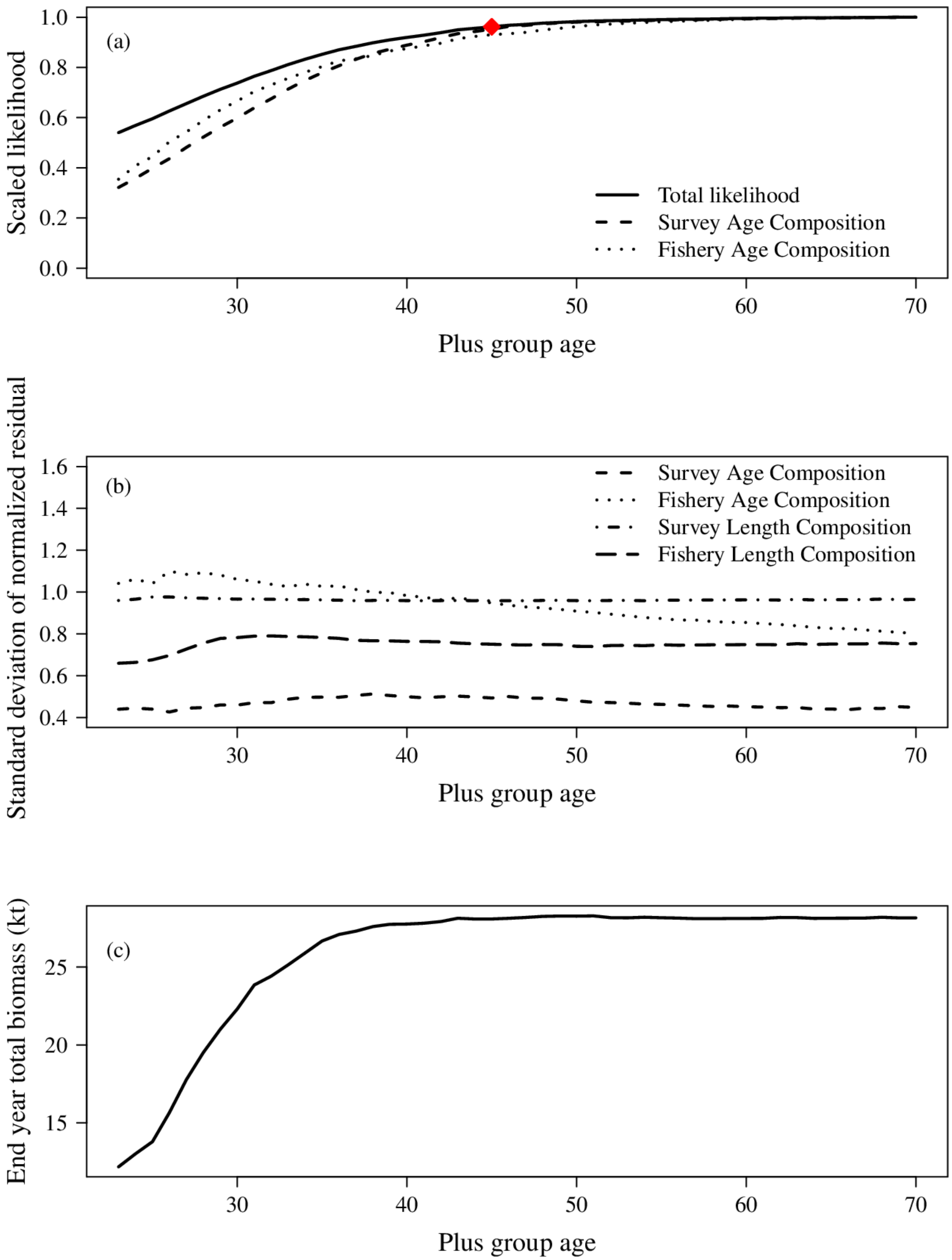

Figure 4. Scaled total likelihood and age compositions components (a), standard deviations of normalized residuals (b), and end year total biomass (c) as a function of the plus group age. The plus group selected for the model was 45+, denoted by the red diamond.

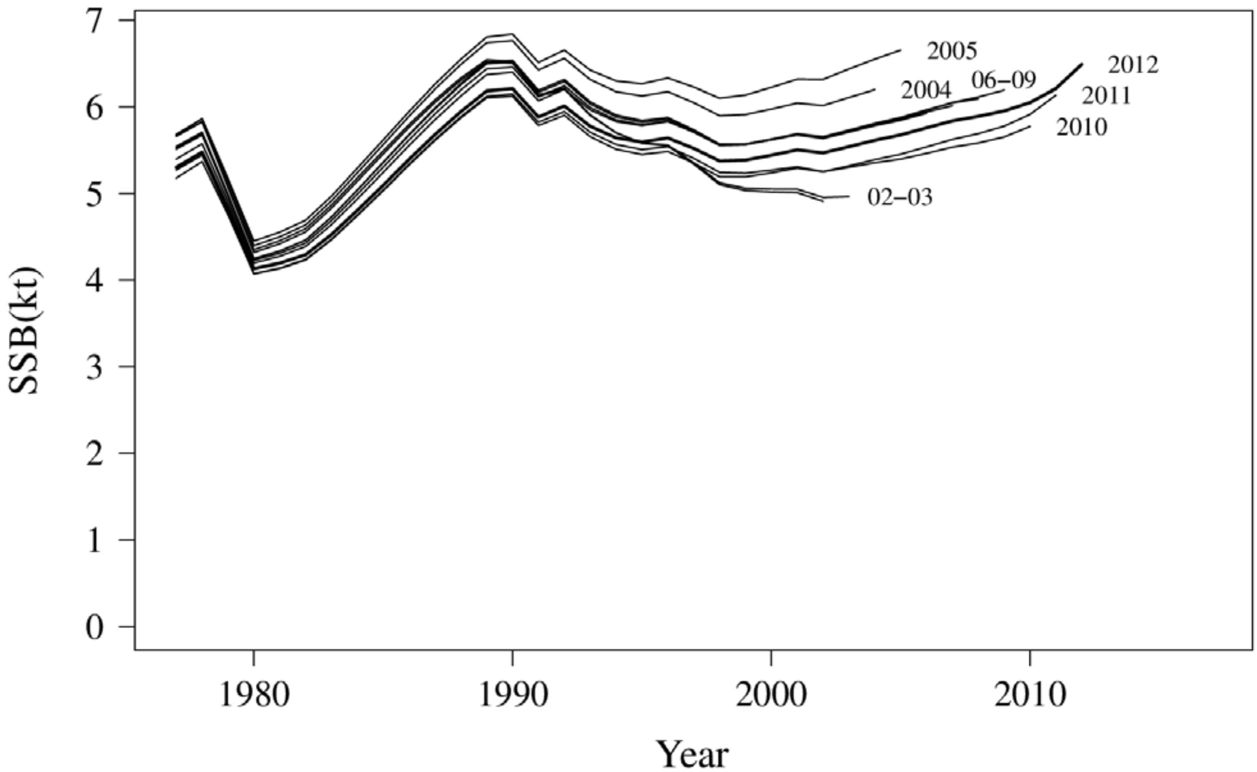

Figure 5. Retrospective estimates of spawning stock biomass for model runs with end years of 2002 to 2012.

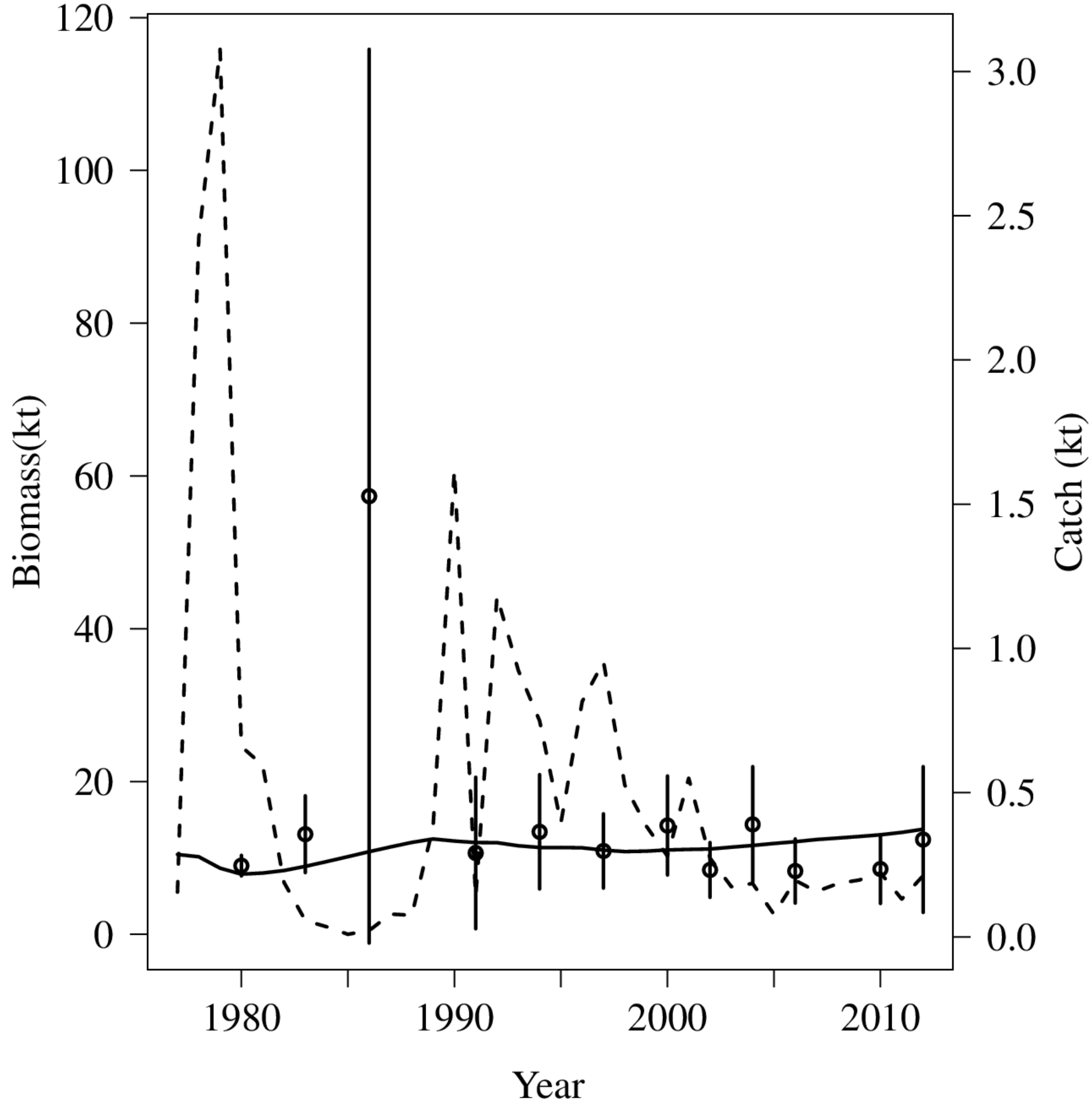

Figure 6. Observed AI survey biomass(data points, +/- 2 standard deviations), predicted survey biomass(solid line), and AI harvest (dashed line).

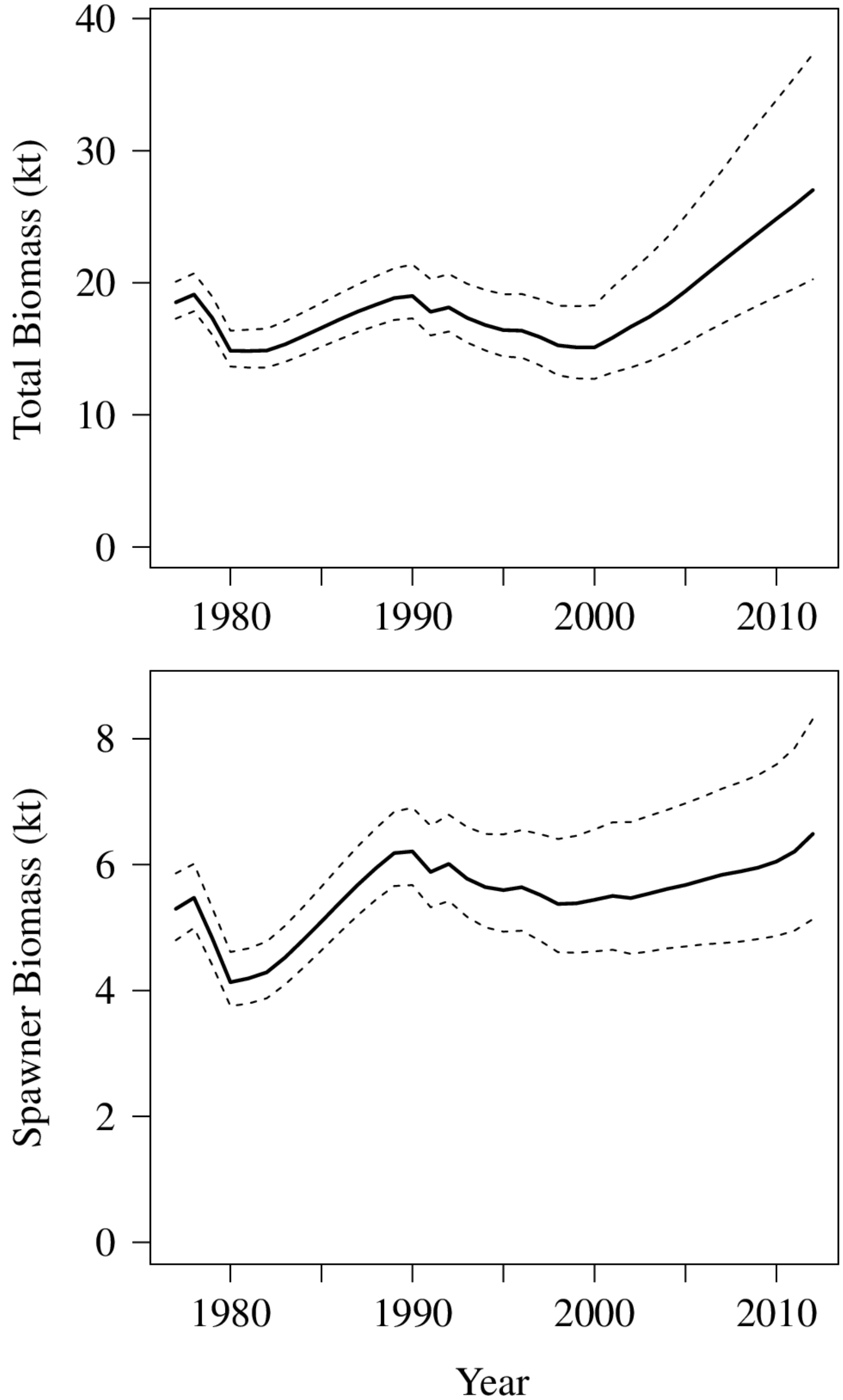

Figure 7. Total and spawner biomass for AI rougheye rockfish, with 95% confidence intervals from MCMC integration.

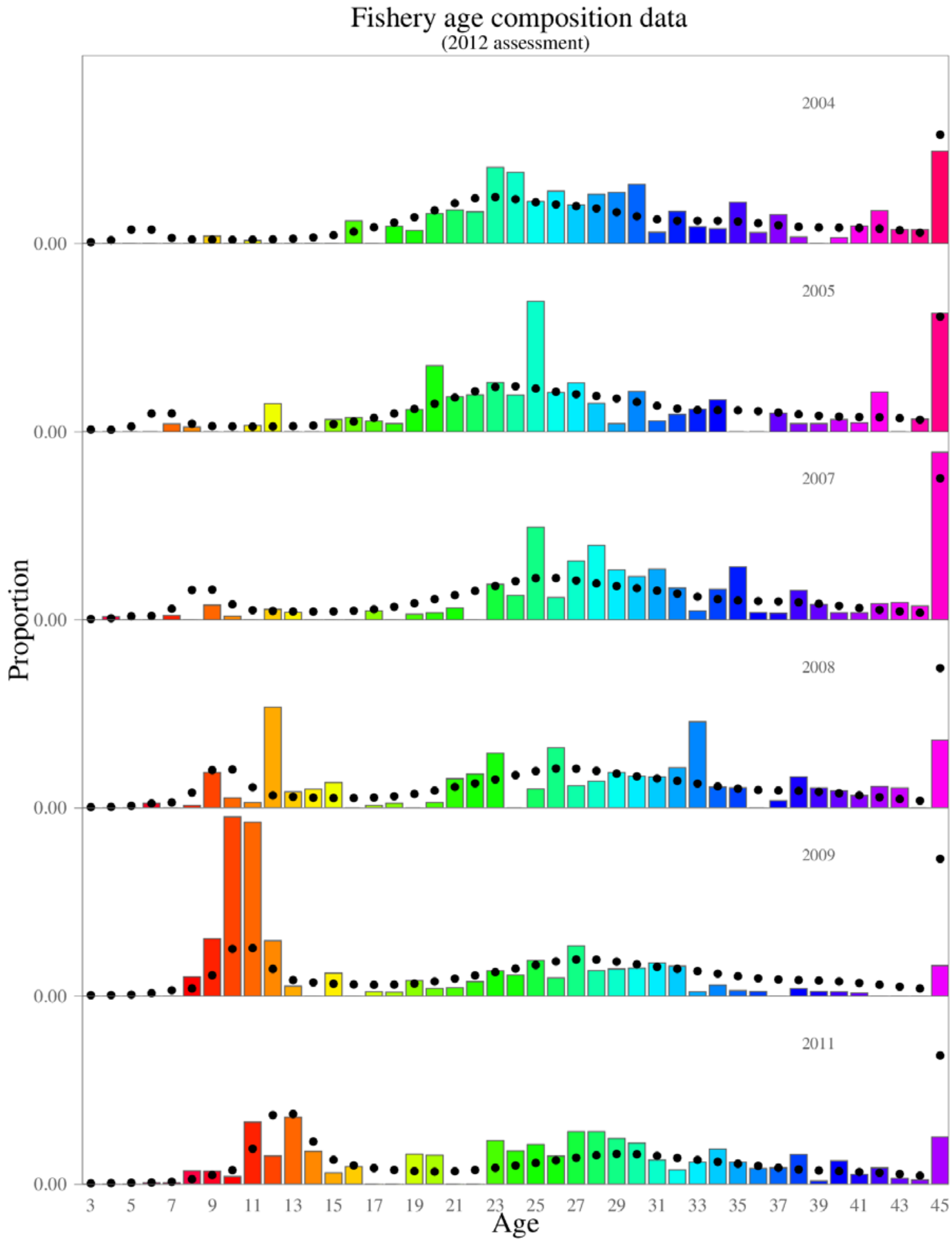

Figure 8. Model fits (dots) to the fishery age composition data (columns) for AI blackspotted/rougheye rockfish, 2004-2011. Colors of the bars correspond to cohorts (except for the 45+ group).

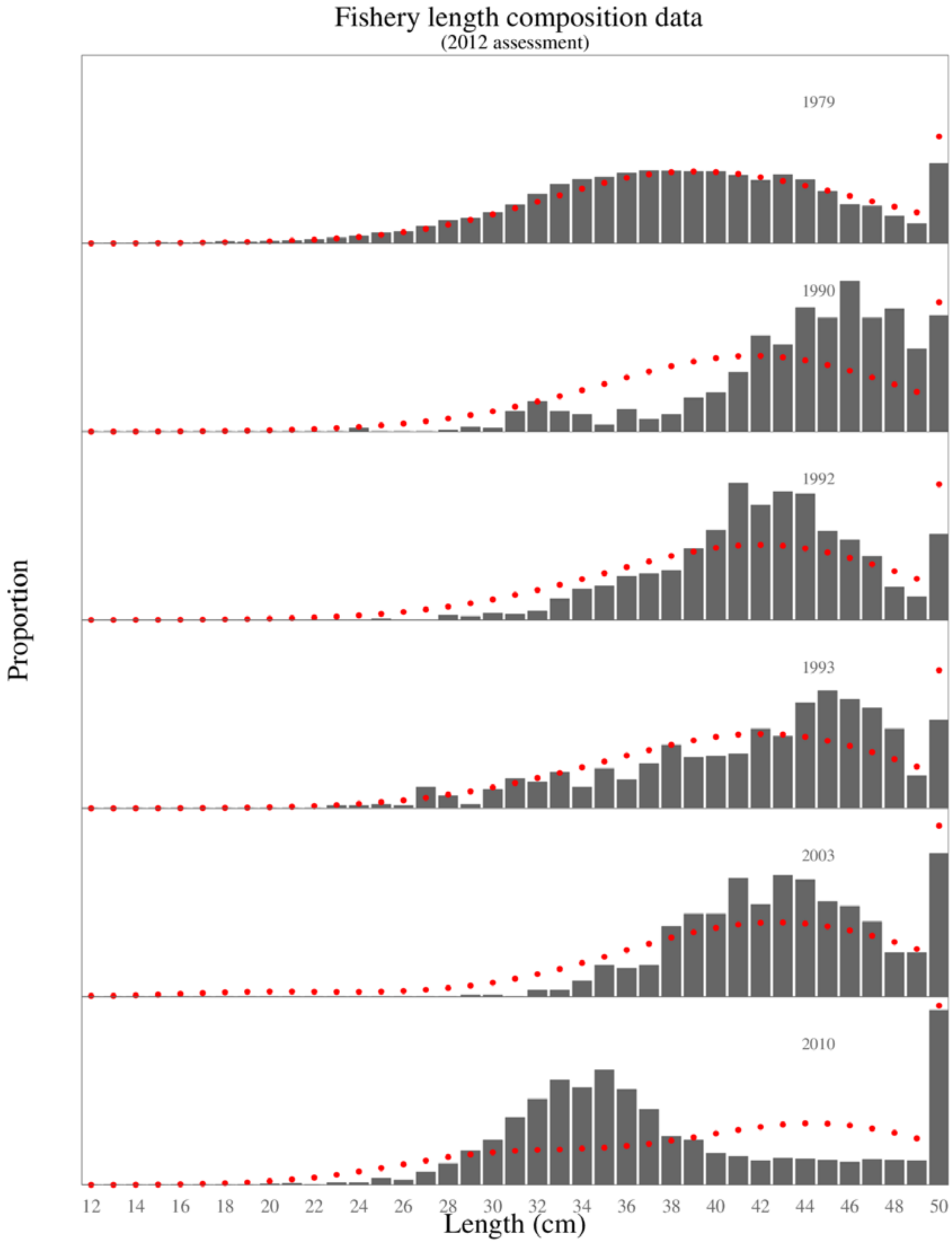

Figure 9. Model fits (dots) to the fishery length composition data (columns) for AI blackspotted/rougheye rockfish, 1979-2010.

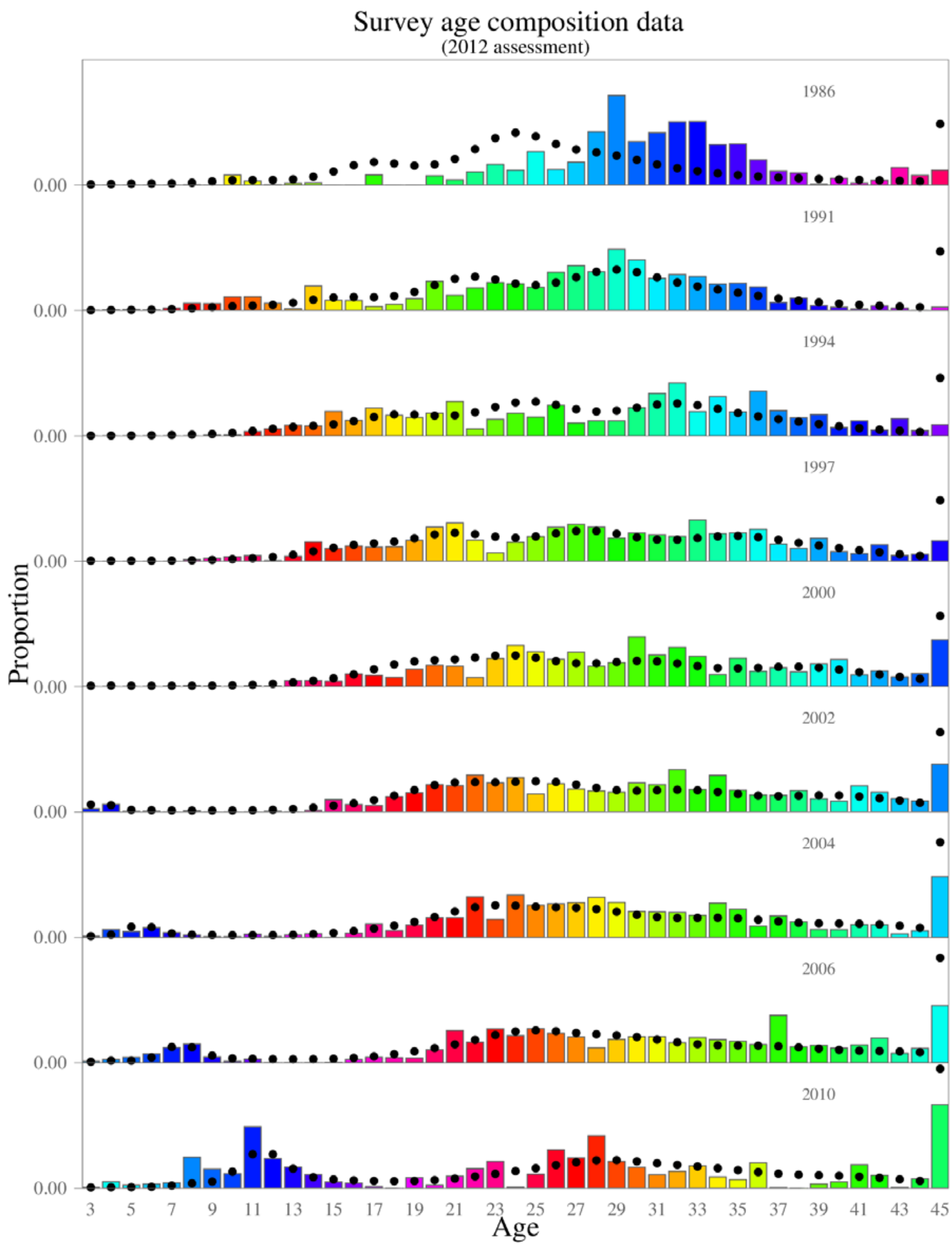

Figure 10. Model fits (dots) to the survey age composition data (columns) for AI blackspotted/rougheye rockfish, 1986-2010. Colors of the bars correspond to cohorts (except for the 45+ group).

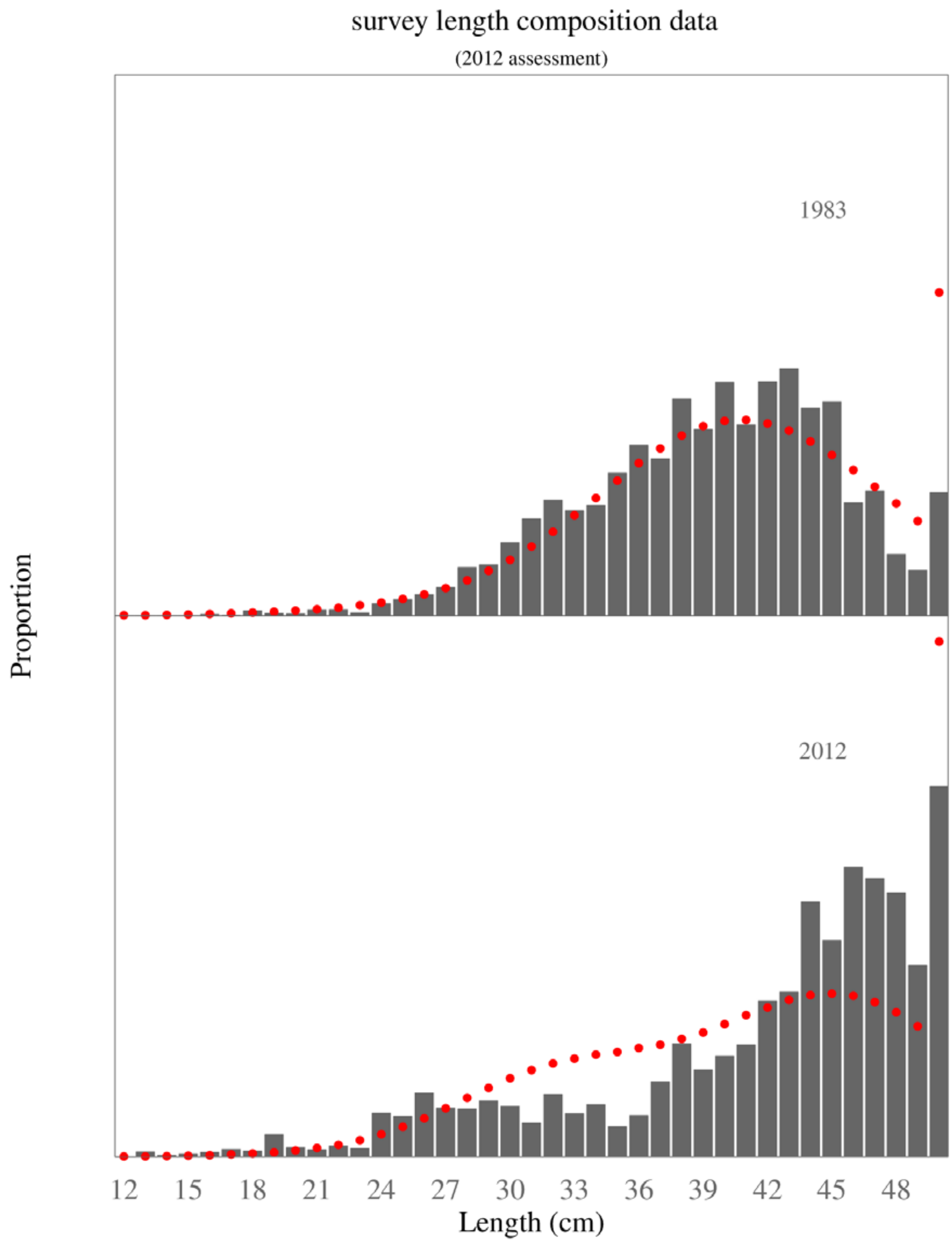

Figure 11. Model fits (dots) to the 1983 and 2012 AI survey length composition data (columns) for AI blackspotted/rougheye rockfish.

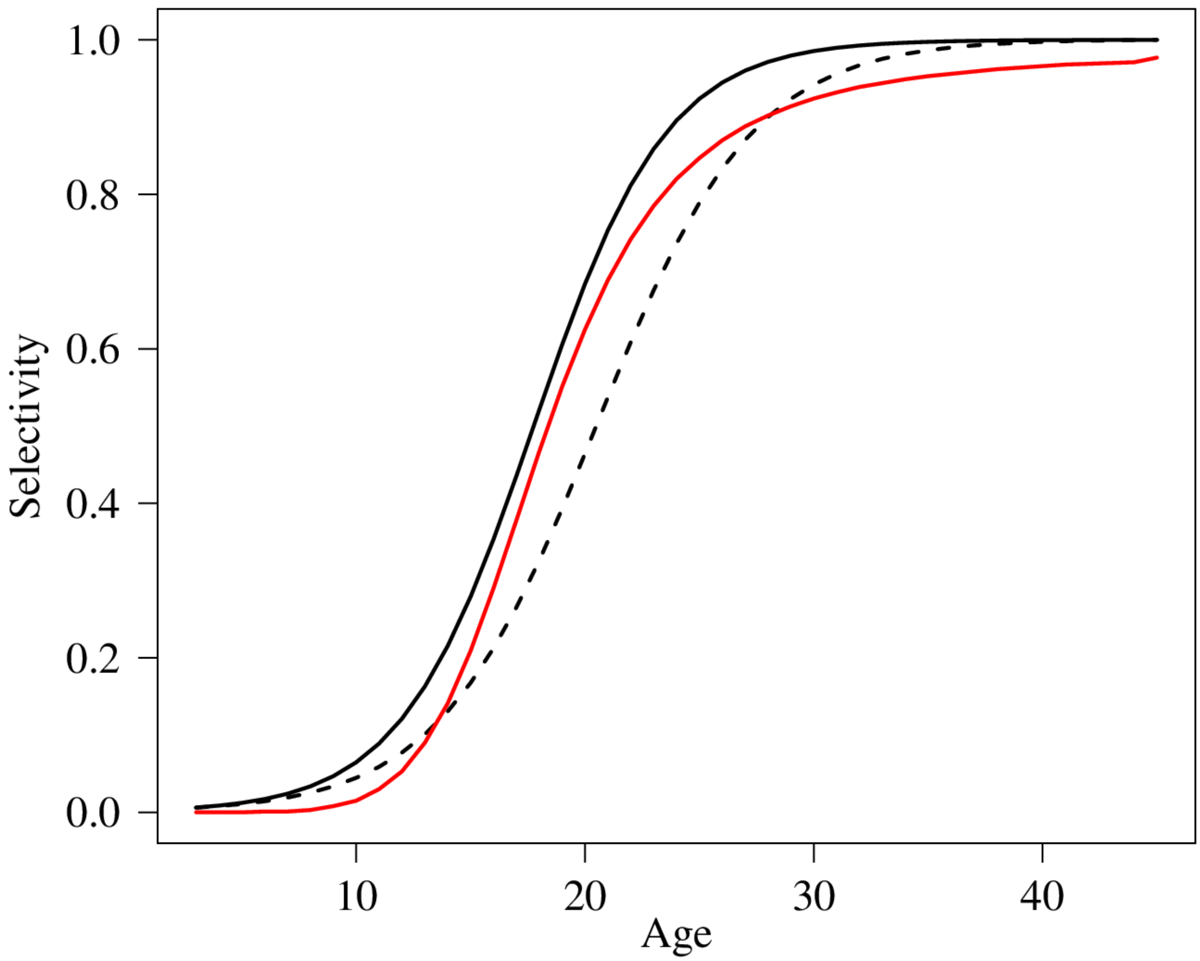

Figure 12. Estimated fishery (solid line) and survey (dashed line) selectivity curve by age, with the maturity curve shown in red.

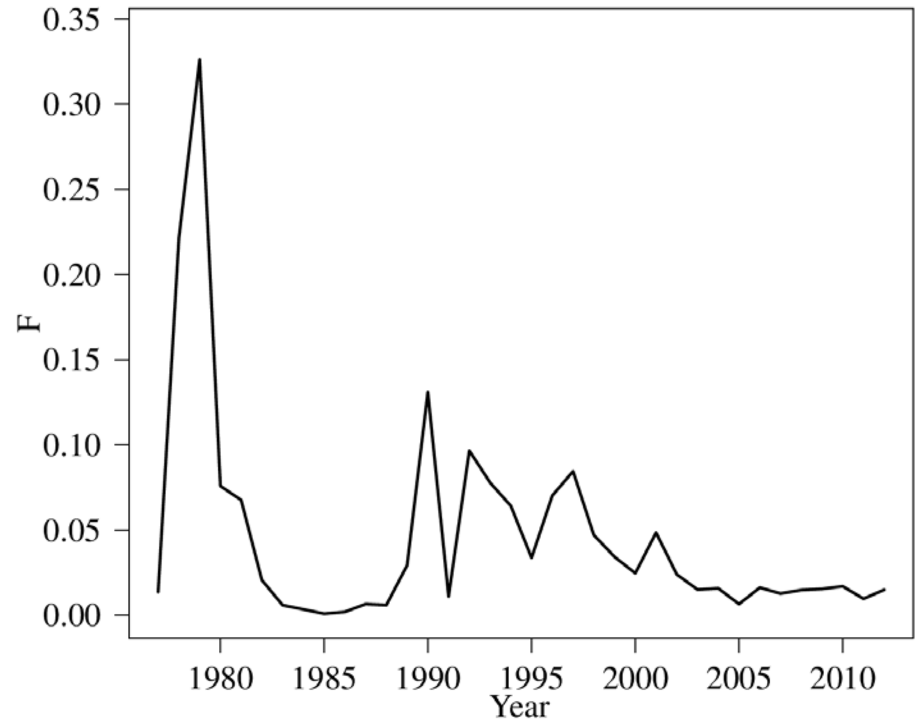

Figure 13. Estimated fully selected fishing mortality for AI rougheye rockfish.

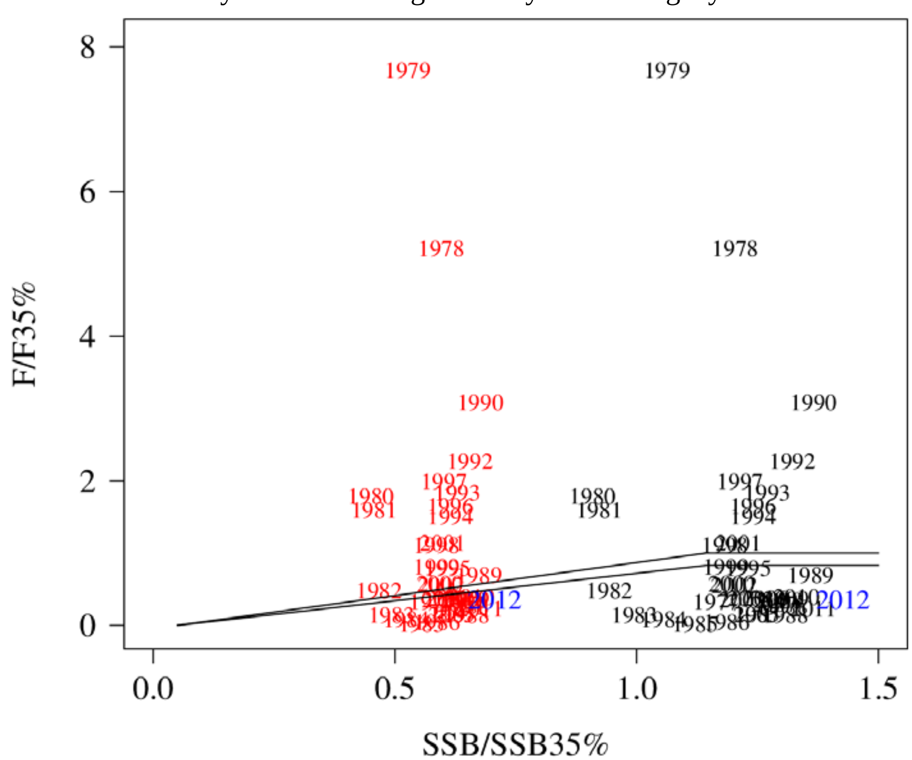

Figure 14. Estimated fishing mortality and SSB in reference to OFL (upper line) and ABC (lower line) harvest control rules, with the effect of including and excluding the post-1997 year classes shown in red and black, respectively. For each case, 2012 is shown in blue.

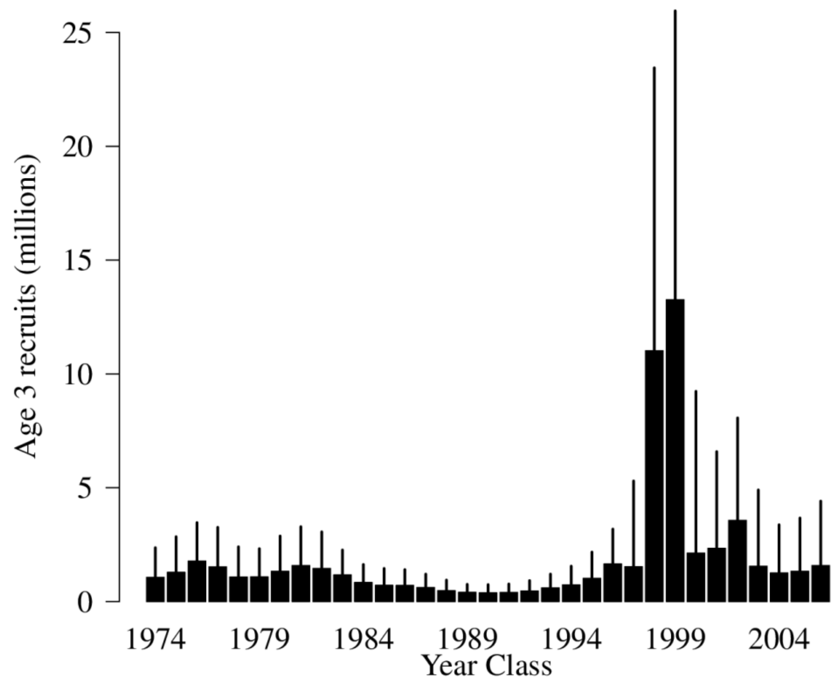

Figure 15. Estimated recruitment (age 3) of AI rougheye rockfish, with 95% CI limits obtained from MCMC integration.

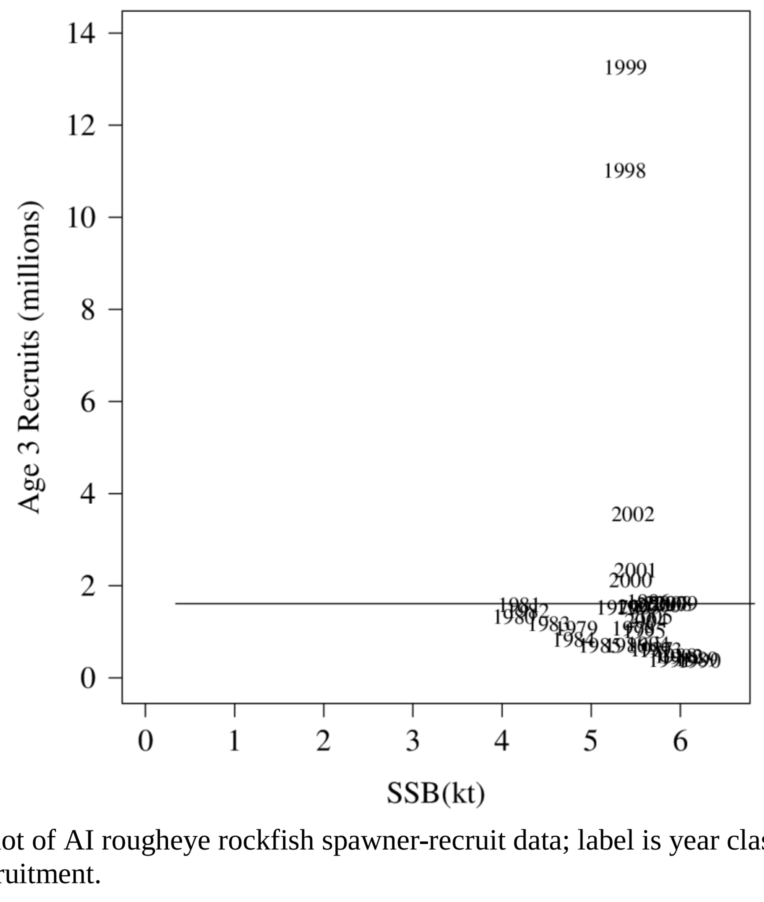

Figure 16. Scatterplot of AI rougheye rockfish spawner-recruit data; label is year class. Horizontal line is median recruitment.

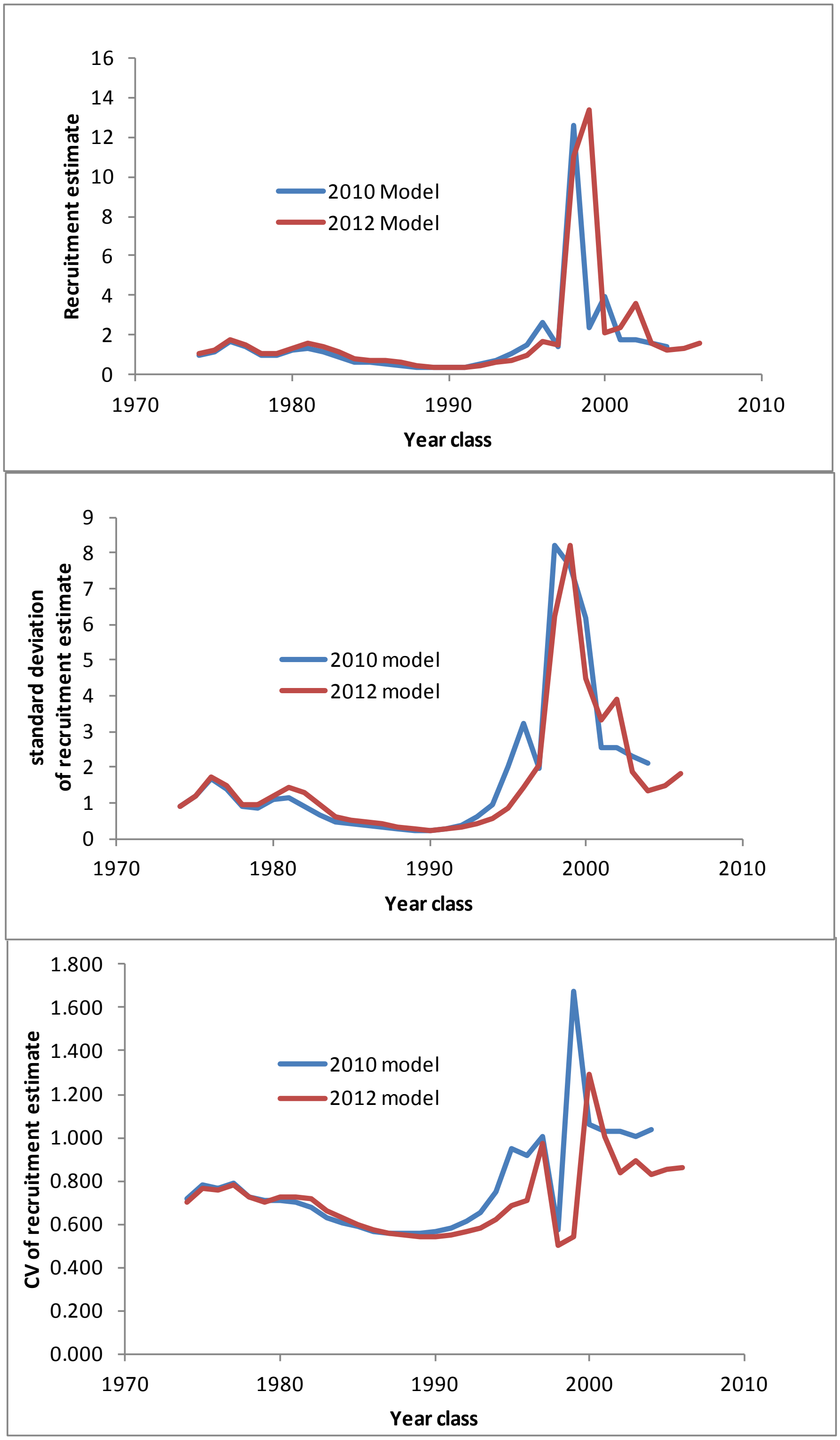

Figure 17. Recruitment estimates, standard deviations (from the Hessian matrix), and coefficient of variation of recruitment estimate for the 2010 and 2012 assessment models.

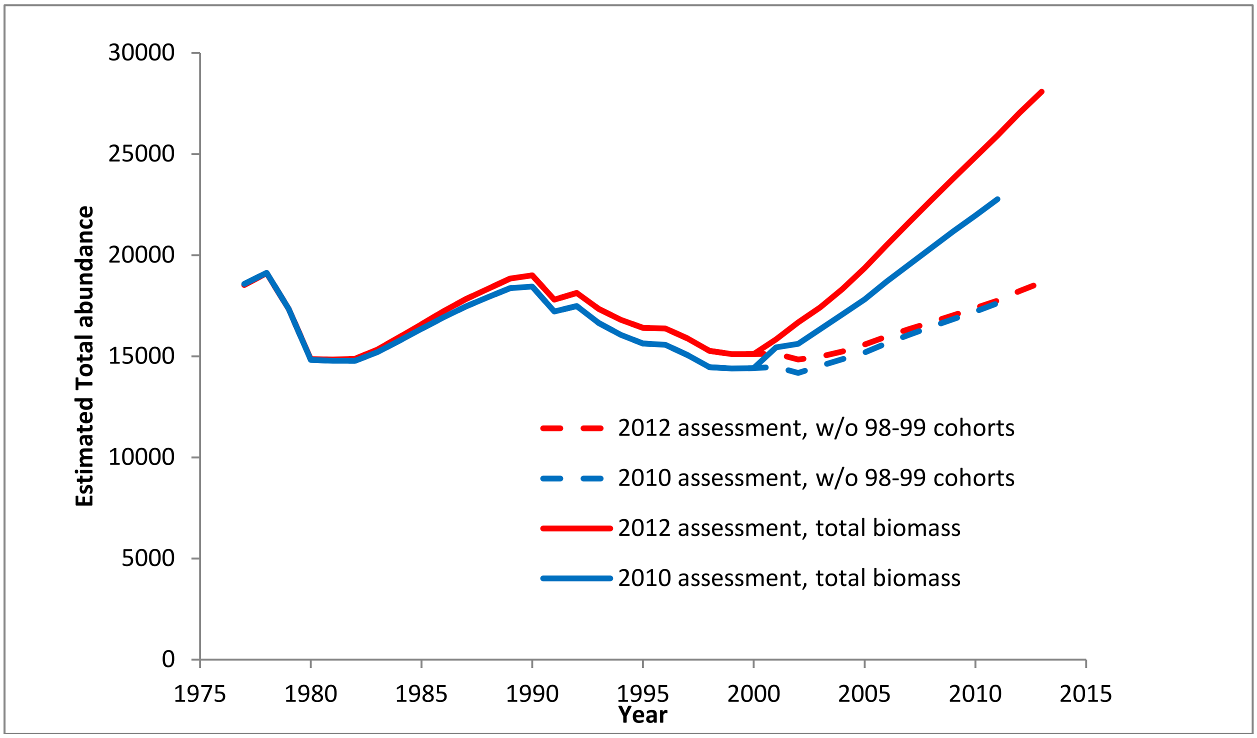

Figure 18. Estimates total biomass, with and without the 1998-199 year classes, from the 2010 and 2012 assessment models.

Appendix A. Area-specific exploitation rates for Bering Sea/Aleutian Islands blackspotted/rougheye rockfish

Executive summary

An evaluation of stock structure for BSAI blackspotted/rougheye rockfish was conducted in 2010, and resulted in the BSAI Groundfish Plan Team partitioning the ABC for this stock in into two areas. At the 2010 Plan Team meeting, an examination of spatial harvest patterns by INPFC subareas within the BSAI areas was also conducted. This analysis consisted of comparing the catch by subarea to a 'theoretical' subarea ABC value that would have been obtained by partitioning the BSAI ABC in accordance with the spatial distribution of survey biomass. Because this presentation of the data may have obscured the potential impact of harvest upon the population, the purpose of the document is to examine area-specific exploitation rates.

Exploitation rates for the western Aleutian Islands have been at or above $U_{F40\%}$ (the exploitation rate which would occur from fishing at $F_{40\%}$) each year from 2004 to 2012, with the exception of 2011. This reflects a large proportion of the catch occurring in the WAI, but only small portion of the survey biomass occurring in this area. For example, from 2004-2012, 43% of the harvest in the AI management area occurred in the WAI but only 8% of the survey abundance for the AI management area. Because the WAI exploitation rates exceed the assumed production of the stock, reductions in stock biomass would be expected to occur unless the local abundance was replenished by neighboring areas. However, the available information on stock structure for blackspotted/rougheye rockfish suggest that the spatial scale of the dispersal is relatively small. Underlying survey trends in the WAI are difficult to discern given the survey variability, but each of the biomass estimates from 2000 – 2010 (averaging 1,059 t) is below each of the biomass estimates from 1991-1997 (averaging 3,156 t), and the 2012 survey estimate for the WAI has declined to 335 t.

Examination of spatial patterns within the WAI indicate that fishery catches are broadly distributed in the WAI but the survey abundance occurs within a relatively small area, indicating that fishery catches within the WAI are occurring in areas with relatively little survey abundance. Possible explanations include a different spatial association between POP and blackspotted/rougheye in the areas fished in the WAI relative to the areas surveyed, and/or spatial differences in catchability and availability between the survey tows and the fishery tows. Additional studies would be required to evaluate these hypotheses.

Using the available survey and catch data as the best available information, the distinct patterns observed between the WAI and CAI may be masked by the current use of a single ABC for combined WAI-CAI area. While this partitioning of ABC is at a finer spatial scale than a BSAI-wide ABC, management of a combined WAI-CAI area would not be expected to address the spatially disparate exploitation rates between the WAI and CAI areas. Monitoring of spatial harvest patterns in the WAI would be enhanced by separation of the WAI and CAI ABCs.

Introduction

In 2010, a report on the stock structure for the BSAI blackspotted/rougheye rockfish was presented to the BSAI Plan Team, and included an evaluation of spatial harvest relative to abundance for the EBS and AI areas. Information on spatial harvest relative to abundance with AI subareas was also presented at the September, 2010, meeting of the BSAI Groundfish Plan team, and was motivated by genetic information suggesting that the spatial structure of blackspotted rockfish was smaller than the AI area. In both cases, this information consisted of comparisons between subarea catch and a "theoretical" ABC, which was defined as an ABC level which would result from allocating the stock-wide ABC in accordance to the proportions of survey biomass across the subareas. However, examination of the catch levels (in tons) relative to theoretical ABC, without explicit consideration of the underlying biomass, may have obscured the potential impact of catch upon the population. The purpose of this report is to consider the potential impacts of this disproportionate harvesting upon the population by estimating area-specific exploitation rates and comparing them to exploitation rates which would result from current fishing reference points. In addition, I also examine the spatial variation of bycatch rates of blackspotted/rougheye rockfish in their target fisheries, and the spatial scale of harvesting within subareas that have high exploitation rates.

This report pertains to the two-species blackspotted/rougheye complex, as fish historically referred to as "rougheye" rockfish are now recognized as consisting of two separate species (Orr and Hawkins 2008), with rougheye rockfish retaining the name *Sebastes aleutianus* and resurrection of a new species, blackspotted rockfish (*S. melanostictus*). However, several studies have used genetic (Hawkins et al. 2005, Gharrett et al. 2005, Gharrett et al. 2007) and morphometric (Orr and Hawkins 2008) analyses to document the scarcity of rougheye rockfish west of the eastern Aleutian Islands (AI) and the occurrence of blackspotted rockfish throughout the BSAI area, with the result that the two-species complex is composed predominately of blackspotted rockfish throughout most of the Aleutian Islands.

Methods

The spatial concentration of harvest relative to abundance was evaluated by calculating area-specific exploitation rates from 2004 to 2012. For each year and subarea, exploitation rates were obtained by dividing the yearly catch by the estimate of biomass at the beginning of the year. The subarea biomass for each year was obtained by partitioning the estimated biomass at the beginning of the year (obtained from 2012 BSAI blackspotted/rougheye stock assessment) into the subareas. The biomass estimates from the 2012 stock assessment are assumed to be the best available information on the biomass time series, and using the results from the 2012 assessment can be considered a "retrospective" look at past exploitation rates. For each year, a weighted average of the subarea biomass from the three most recent surveys Aleutian Islands and eastern Bering Sea slope trawl survey (weights of 4, 6, and 9, with recent surveys higher weights) was computed, and the proportions from these averages were used to partition the biomass into subareas. Catches of blackspotted/rougheye were obtained from the Catch Accounting System database, with 2012 catch data through October 6, 2012.

To evaluate to the potential impact upon the population, exploitation rates were compared to various measures of stock productivity. A common measure of stock productivity is the estimated natural mortality rate (M), which (for Tier 5 stocks) forms the basis for the acceptable biological catch (ABC) and overfishing level (OFL) fishing rate reference points of $F_{abc} = 0.75*M$ and $F_{ofl} = M$. Because BSAI blackspotted/rougheye are managed as a Tier 3 stock, the F_{abc} and F_{ofl} reference points are based on conserving 40% and 35% of the lifetime spawning stock biomass produced per recruit for an unfished stock, and these reference points reflect maturity, fishery selectivity, and size at age. For comparison with the subarea exploitation rates, the exploitation rate for each year that would result from applying a fishing rate of $F_{40\%}$ to the estimated beginning-year numbers was computed, and this rate is defined as $U_{F40\%}$.

Because blackspotted/rougheye rockfish are taken as bycatch in other fisheries (predominately the POP trawl fishery), high estimates of area-specific exploitation rates could suggest that the association between blackspotted/rougheye rockfish and the target species of the fisheries that capture them differs between areas. The bycatch rate of blackspotted/rougheye rockfish in tows targeting POP (i.e., the tons of blackspotted/rougheye caught per ton of POP caught) was calculated for BSAI subareas from hauls sampled by fishery observers from 2001 to 2012.

Results

Survey and catch data

The survey biomass estimates of blackspotted/rougheye rockfish is highest in the central and eastern AI survey areas, with an average biomass from 1991-2012 of 5,208 t and 4,370 t, respectively (Figure A1). The average rougheye biomass from 1991-2012 in the western AI and the southern Bering Sea portions of the AI survey were 1,670 t and 806 t, respectively. The average blackspotted/rougheye biomass in EBS slope surveys from 2002-2012 is 928 t. The average of the survey coefficient of variation (CV) from the western AI from 1991 – 2012 was 0.44, and ranged between 0.32 and 0.36 for the other subareas of the AI survey. Higher CV values for the eastern AI and SBS subareas were occasionally found in the 1991-1997 surveys (Figure A2). Using the weighted averages of the most recent three surveys produces relative stable estimates of area proportions, which ranged from 0.076 to 0.127 in the WAI and from 0.379 to 0.488 in the CAI (Figure A3).

Catches of blackspotted/rougheye rockfish from 2004-2012 are lowest in the eastern Bering Sea (averaging 21 t). The catches in WAI averages 72 t during this period, whereas the average catch for the CAI and EAI subareas averaged 49 t and 45 t respectively. The WAI catches in 2004, 2006, and 2010 were the largest subarea catches from 2004-2012, each exceeding 94 t; the next largest subarea catches were from the CAI in 2009 (84 t) and the EAI in 2010 (76 t) (Figure A4).

From 2004-2012, 43% of the catch in the AI management area was obtained the WAI but only 8% of the survey biomass (using an unweighted average). In contrast, approximately 57% of the catch in the AI management area was obtained in the CAI and EAI, and these areas accounted for 92% of the survey biomass (see table below).

Area	Catch Proportion	Survey biomass Proportion
WAI	0.43	0.08
CAI	0.30	0.53
EAI	0.27	0.39

Exploitation rates

Exploitation rates for the western Aleutian Islands have been at or above $U_{F40\%}$ each year from 2004 to 2012, with the exception of 2011 (Figure A5). The values of $U_{F40\%}$ are similar to 0.75*M, and have decreased slightly in recent years because a large portion of the catch weight is derived from relatively young fish where the fishery selectivity (and thus fishing mortality) is relatively low. The 2011 WAI catch of 46 t is the lowest since 2007, lowering the ratio of exploitation rate/ $U_{F40\%}$ ratio to 0.80. However, the 2012 catch (through Oct 6) in the WAI has increased to 66 t. The exploitation rates from 2004-2012 for the other subareas do not exceed $U_{F40\%}$ with the exception of the EBS in 2010 and 2011.

Bycatch rates

Blackspotted/rougheye rockfish in the Aleutian Islands are captured predominately as bycatch in the POP trawl fishery, and high estimates of area-specific exploitation rates could suggest that the association between blackspotted/rougheye and POP differs between areas. The bycatch rate of blackspotted/rougheye rockfish in tows targeting POP (i.e., the tons of blackspotted/rougheye rockfish caught per ton on POP caught) was calculated for AI subareas from hauls sampled by fishery observers from 2001 to 2012 (Figure A6). Bycatch rates were relatively high in the WAI, CAI, and EAI in 2001 and have since declined. The average bycatch rates from 2004-2012 for the WAI was 9.7×10^{-3} and 8.8×10^{-3} and 6.7×10^{-3} for the CAI and EAI, respectively. One would expect the bycatch of blackspotted/rougheye to be lower in areas with lower abundance of blackspotted/rougheye. For example, the SBS and EBS subareas have the lowest abundances and the lowest byctach rates. However, the average 2004-2012 bycatch rates in the WAI exceeds those in the CAI and EAI despite the WAI having lower survey abundance of each of the other two areas (Figure A6).

Spatial pattern of catch within the WAI

The high exploitation rate within the WAI could potentially be less of a concern if the both catch and harvest occurred within a relatively small area within the WAI that was in close proximity to neighboring areas with high abundance. The AI survey tows of blackspotted/rougheye rockfish catch from 1991-2012 in the WAI and the western CAI are shown in Figure A7, with each degree of longitude marked to examine the distribution. The boundary between the WAI and CAI occurs at 177° E, and high survey catches are often observed in the western part of the CAI, near Amchitka and Kiska Islands. Similarly, when large survey tows occur in the WAI, they are most often found in the Tahoma Bank-Buldir Island area, close to the WAI-CAI boundary. Relatively few large survey catches have been observed in the central and western portion of the WAI, resulting in the majority of the survey abundance occurring within 2 degrees of longitude of the WAI-CAI boundary.

In contrast, the fishery catches of blackspotted/rougheye rockfish are more evenly spread throughout the WAI, with catches occurring in areas that have relatively low survey abundance. The fishery tows cannot be shown because of confidentiality restrictions, and Figure A8 shows the proportion of fishery catch within each year from 2002-2012 that occurs within each of the 5 degrees of longitude from 172° E - 177° E. In several years, a relatively large portion of the catch occurs near Agattu and Attu Islands, 3-4 degrees of longitude from the WAI-CAI border.

The correspondence between fishery catch and survey abundance can be considered by comparing the proportion of survey abundance to the proportion of catch for each longitude bin for recent years (Figure A9). Because the survey strata and abundance estimates are not defined for longitude bins, the relative abundance was obtained by summing the survey CPUE by longitude bin (from 177° E to 172° E) for each survey from 2002-2012 (this reflects that longitude bins with greater survey area typically have larger number of survey tows), and then averaging across the survey years. The catches of blackspotted/rougheye rockfish from hauls sampled by fishery observers from 2002-2012 were summed by year and longitude, and then averaged across years within each degree of longitude. Both the catch and survey data were then rescaled to produce relative proportions. Approximately 66% of the survey abundance occurs between 177° E and 176° E, but only 53% of the catch. In contrast, the two bins of longitude between 176° E and 174° E account for 18% of the survey biomass but 43% of the survey catch.

Based on the available data, it does not appear that both catch and survey abundance occurs within a relatively small area within the WAI. Additionally, there is a mismatch between the distributions of survey abundance and catch within the WAI such that relatively high levels of fishery catch are being obtained from areas with relatively low survey abundance.

Catches in WAI from 2004-2012 appears to be decreasing, with the two highest catches occurring in 2004 and 2006. This could potentially be explained by a combination of the fishery improving their avoidance of blackspotted/rougheye rockfish bycatch, and also a potential reduction in population size. Changes in the seasonal fishing pattern could potentially affect bycatch, and the POP fishery in the WAI in the 2011 and 2012 occurred in the late spring and summer, whereas in earlier years fishing occurred throughout much of the year. The bycatch rate and catch decreased between 2010 and 2011, but then increased between 2011 and 2012. Discerning a true population trend in the WAI is hindered by the relatively high coefficient of variation. However, the point estimates of biomass in this area are consistent with a decline in abundance, as the average biomass from the 1991-1997 surveys was 3,156 t and the average from the 2000-2010 surveys was 1,059 t. In the 2012 survey, the biomass estimate was further reduced to 355 t. High catches in the WAI also occurred in the mid-1990s, consistent with the trend in survey biomass estimates.

Conclusions and implications for conservation

The purpose of spatially allocating harvest specifications in accordance with the distributions of survey abundance is to help ensure that harvest is not disproportionate to abundance. However, for BSAI blackspotted/rougheye rockfish a high proportion of the catch occurs in the WAI, but only a small percentage of the biomass occurs in this area. This has led to subarea exploitation rates that often substantially exceed M and $U_{F40\%}$.

The exploitation rates are based upon the available survey biomass data, and examination of survey tows and fishery catches in the WAI reveal a pattern where catches are being obtained from areas with low survey abundance. Given that the catch of blackspotted/rougheye rockfish is obtained as bycatch in the POP fishery rather than directed fishing, one would expect that the survey data and the bycatch data would be similar. One potential explanation is that the association between blackspotted/rougheye and POP is different in the WAI than in other subareas (i.e., blackspotted/rougheye are more likely to occur in the areas fished for POP in the WAI than in other subareas), as this would explain the high bycatch rates (relative to survey abundance) in the WAI.

Comparison between the survey and fishery tows is complicated in that there are likely differences in the spatial and depth distribution of tows, the habitats towed, the seasonal patterns of tows, and the catchability of the nets. Clearly, the relatively broad distribution of catches in the WAI indicates that there must have been some blackspotted/rougheye in order for these catches to occur – the question regards the numbers of blackspotted/rougheye that remain in the water and are *not* caught by the fishery. It is possible that the survey abundance is an underestimate of the true abundance. However, unless this underestimation occurred only in some spatial areas, there would still be a pattern of the distribution of catches being disproportionate to relative survey abundance. Additional detailed spatial data will be required to evaluate these hypotheses.

Using the current survey data as the best available information, the pattern of high exploitation rates in the WAI pose a potential conservation concern because the available information on stock structure suggests that reductions in abundance on the scale of the WAI would not be expected to be replenished quickly from neighboring areas. In 2010, the BSAI Plan Team adopted an ABC for the combined WAI-CAI, and a separate ABC that combined the remaining EAI and EBS areas. While this partitioning of ABC is at a finer spatial scale than a BSAI-wide ABC, management of a combined WAI-CAI area would not be expected to address the spatially disparate exploitation rates between the WAI and CAI areas.

References

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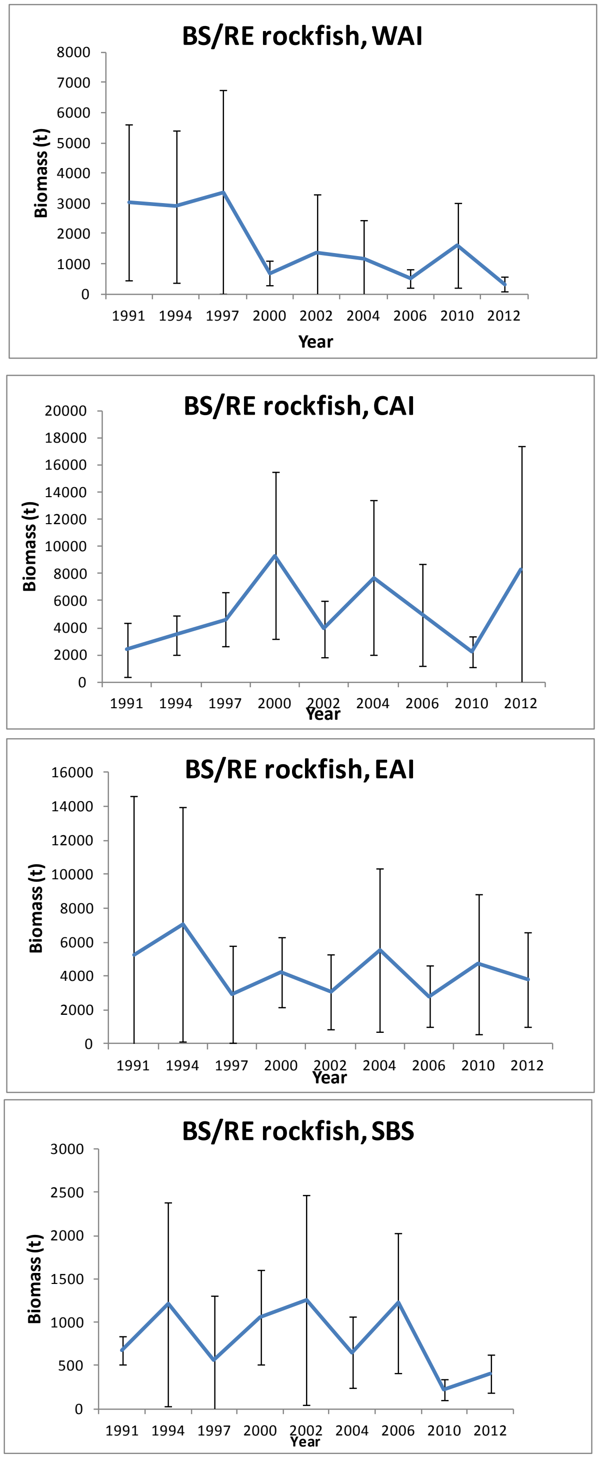

Figure A1 Blackspotted/rougheye rockfish biomass estimates from the Aleutian Islands survey.

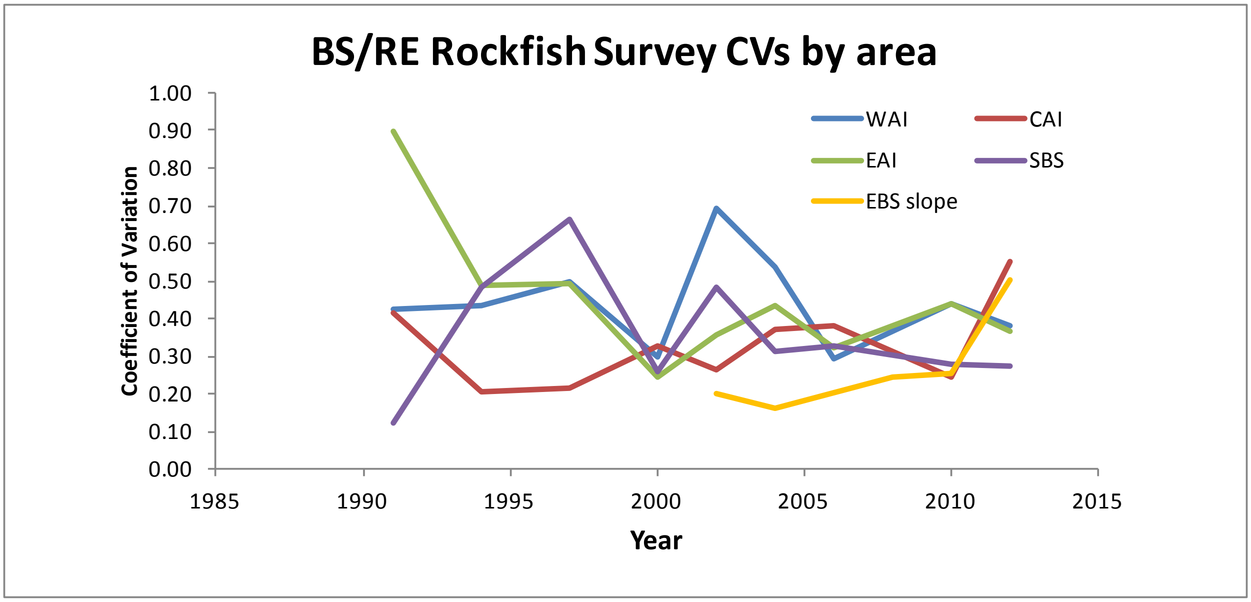

Figure A2. Coefficients of variation (CV) for blackspotted/rougheye rockfish biomass estimates from the Aleutian Islands survey.

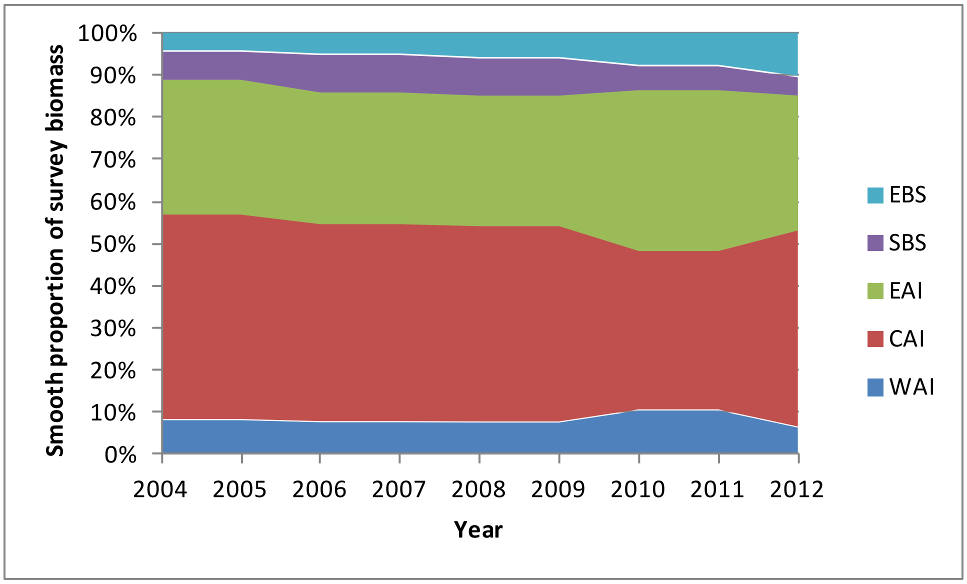

Figure A3. Estimated proportions of blackspotted/rougheye rockfish biomass for Aleutian Islands survey subareas, 2004-2012. For each year, the proportions were computed from weighted averages of the three most recent surveys.

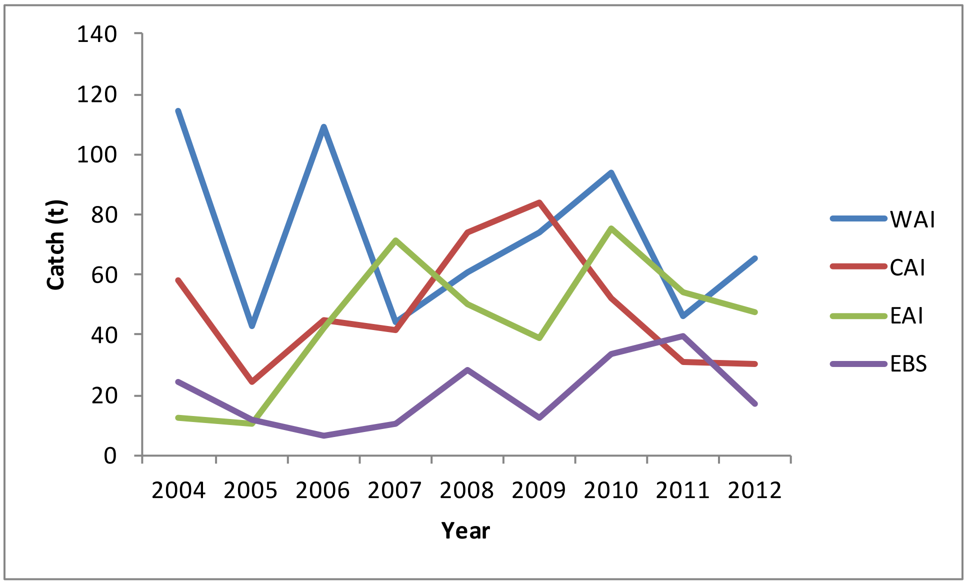

Figure A4. Catch (t) of blackspotted/rougheye rockfish by BSAI subarea, 2004-2012; 2012 catch is through October 6.

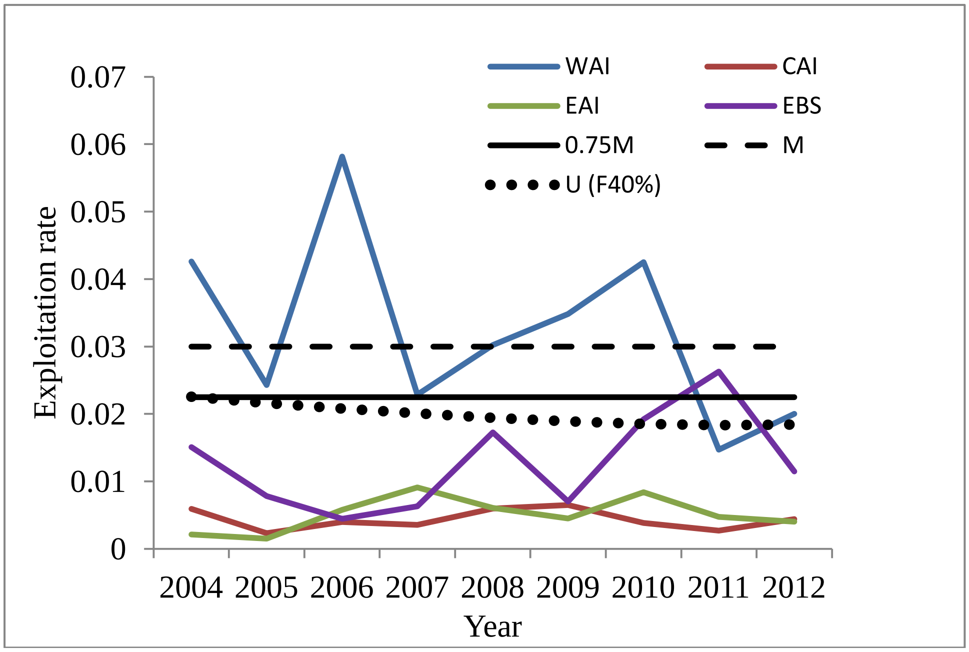

Figure A5. Estimated blackspotted/rougheye rockfish exploitation rates by area from 2004-2012; 2012 exploitation rates are based on catches through October 6.

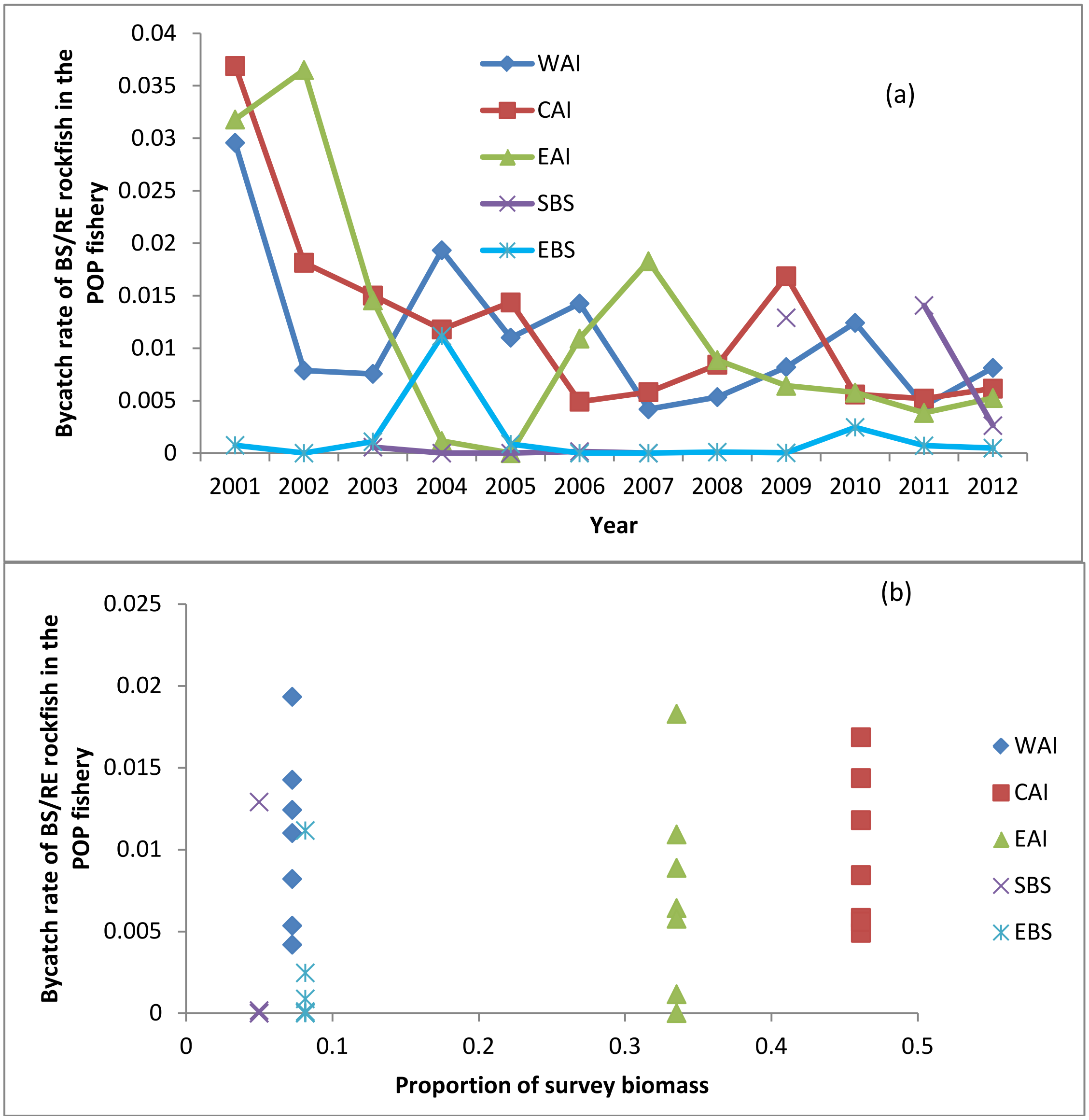

Figure A6. Blackspotted/rougheye rockfish bycatch rates from 2001-2012 (a), and from 2004-2012 as function of average proportion of Aleutian Islands survey biomass. Bycatch rates were computed as the tons of blackspotted/rougheye rockfish caught per ton of POP caught in hauls sampled by fishery observers.

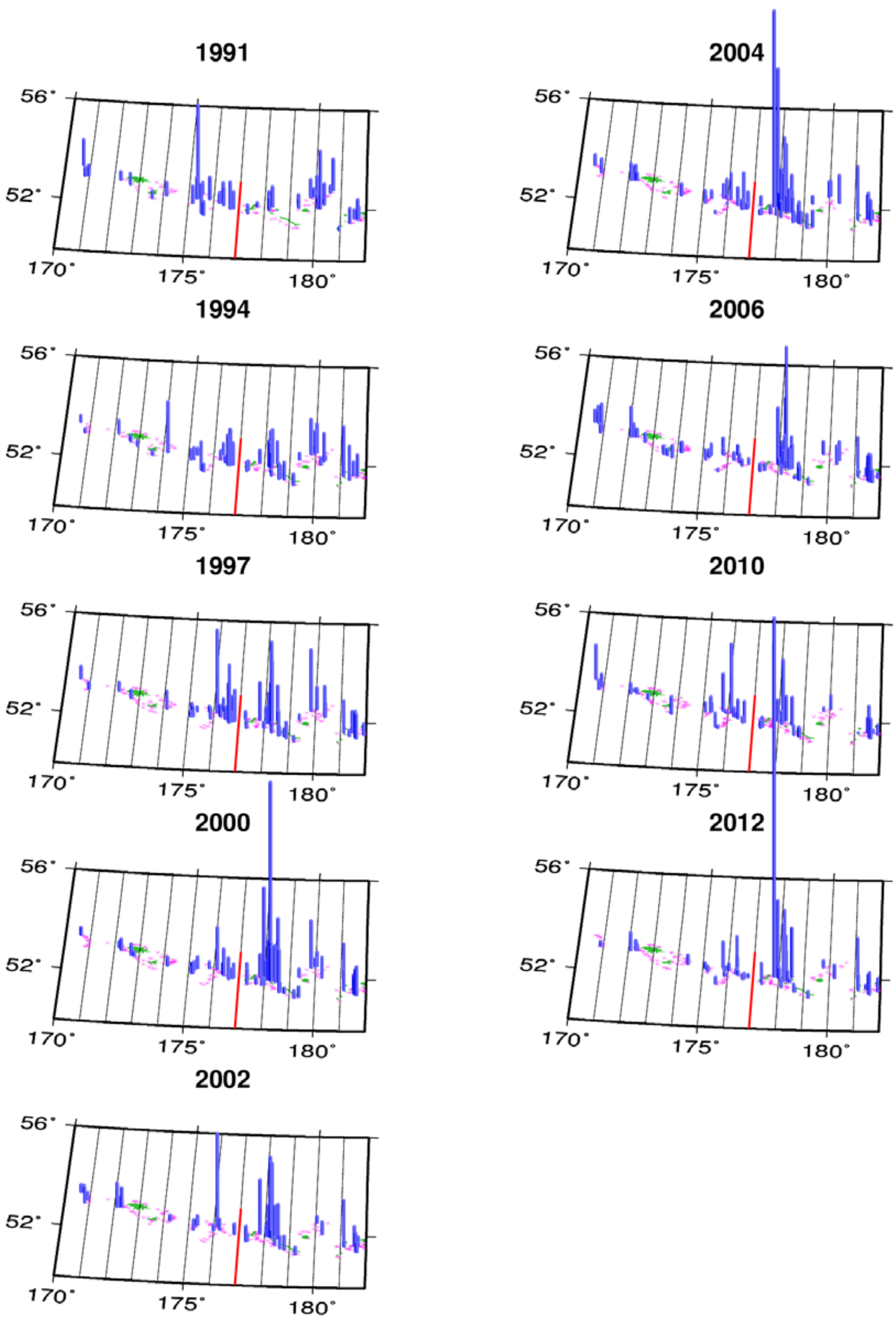

Figure A7. Spatial pattern of the scaled survey CPUE (square root of kg/km^2) of blackspotted/rougheye rockfish in the WAI and western portion of the CAI (the red line is the boundary between the WAI and CAI).

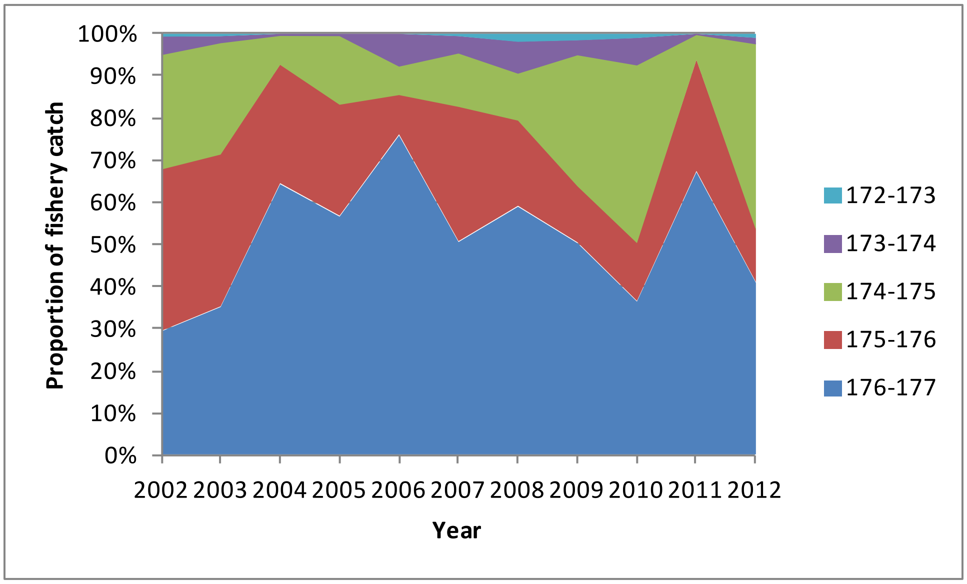

Figure A8. Proportion of fishery catch of blackspotted/rougheye, by year from 2002-2012, within each of the 5 degrees of longitude from 172° E – 177° E.

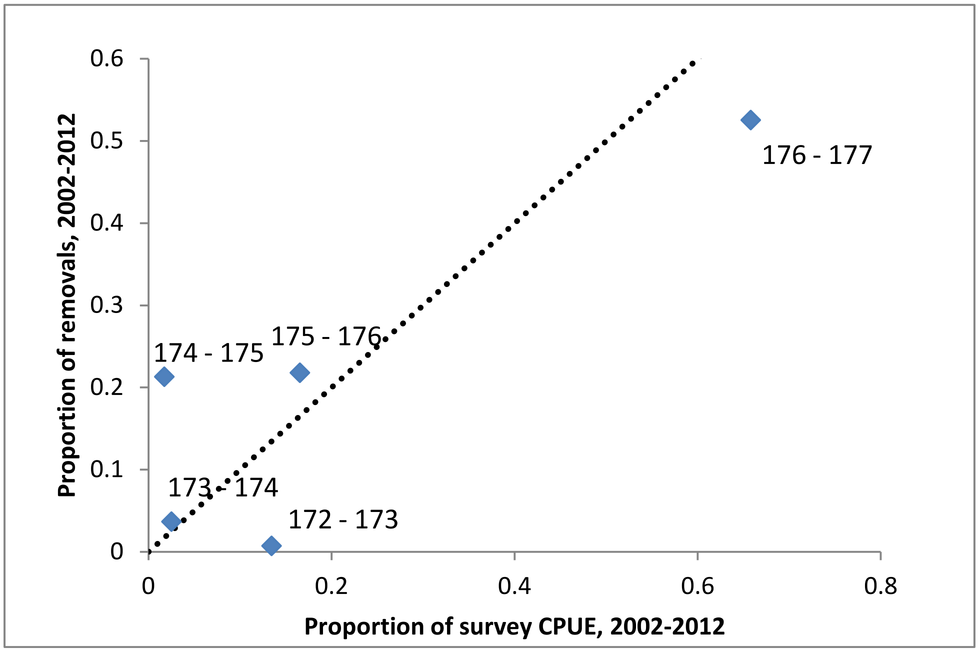

Figure A9. Relative survey abundance and catch within the WAI by longitude bin from 2002-2012; labels indicate the longitude boundaries of each bin.

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. In these datasets, blackspotted /rougheye rockfish are often reported as rougheye rockfish. The first dataset, non-commercial removals, estimates total removals that do not occur during directed groundfish fishing activities (Table B1). 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 BSAI blackspotted/rougheye rockfish, these estimates can be compared to the trawl research removals reported in previous assessments. Blackspotted/rougheye rockfish research removals are small relative to the fishery catch. The majority of removals are taken by the Alaska Fisheries Science Center's (AFSC) biennial bottom trawl survey which is the primary research survey used for assessing the population status of BSAI blackspotted/rougheye rockfish. Other research activities that harvest blackspotted/rougheye rockfish include other trawl research activities and minor catches occur in longline surveys conducted by the International Pacific Halibut Commission and the AFSC. Some catches of blackspotted/rougheye in the AFSC longline survey are reported as "shortraker/rougheye". There was no recorded recreational harvest or harvest that was non-research related in 2010 and 2011. Total removals of blackspotted /rougheye rockfish and the group "shortraker/rougheye rockfish" were less than 2 t and 1 t in 2010 and 2011, respectively, which represent less than 0.5% of the ABC in these years. Research harvests in even years beginning in 2000 (excluding 2008, when the AI trawl survey was canceled) are higher due to the biennial cycle of the AFSC bottom trawl survey in the Aleutian Islands. These catches have varied between 0.1 and 3.5 t. An unusually large research catch was observed in 1986, which is likely attributable to the cooperative trawl survey in that year.

The second dataset, 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). 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 will become available following restructuring of the Observer Program in 2013, when all vessels >25 ft will be monitored for groundfish catch.

The HFICE estimates of BSAI blackspotted/rougheye rockfish catches are variable, ranging between 0.2 and 11.9 t from 2001 -2010 with an average 3.6 t (Table B2). Years with relatively high catches are caused by increased catches in the eastern and central Aleutian Islands.

Appendix Table B1. Removals of BSAI blackspotted/rougheye rockfish from activities other than groundfish fishing. Trawl and longline include research survey and occasional short-term projects. “Other” is recreational, personal use, and subsistence harvest.

		Blackspotted/Rougheye			Shortraker/Rougheye	
Year	Source	Trawl	Longline	Other	Trawl	Longline
1977	NMFS-AFSC survey databases	0.000				
1978		0.002				
1979		0.468				
1980		6.844				
1981		1.086				
1982		0.963				
1983		9.780				
1984		0.000				
1985		3.719				
1986		24.241				
1987		0.006				
1988		0.200				
1989		0.001				
1990		0.018				
1991		1.994				
1992		0.014				
1993		0.000				
1994		2.769				
1995		0.003				
1996		0.001				
1997		2.596				
1998		0.000				2.174
1999		0.010				0.494
2000		3.343				2.066
2001		0.001				0.422
2002		2.276				1.649
2003		0.011				0.376
2004		3.499				1.680
2005		0.001				0.347
2006		1.976				3.367
2007		0.001				0.429
2008		0.205				1.544
2009		0.006				0.571
2010	NMFS-Alaska Regional Office	0.133	0.424		0.018	1.546
2011		0.005	0.154			0.411

Appendix Table B2. Estimates BSAI blackspotted/rougheye rockfish catch (t) from the Halibut Fishery Incidental Catch Estimation (HFICE) working group.

Year	Eastern AI	Central AI	Western AI	Central/Western AI	Total
2001	0.89	4.77	1.67	0.00	7.33
2002	0.00	0.42	0.13	0.00	0.55
2003	2.67	6.49	0.90	0.00	10.06
2004	7.25	0.61	4.02	0.00	11.88
2005	0.00	0.00	0.19	0.00	0.19
2006	1.18	0.00	0.29	0.00	1.47
2007	0.74	0.44	0.02	0.00	1.20
2008	1.56	0.01	0.00	0.00	1.57
2009	0.55	0.00	0.00	1.37	1.92
2010	0.10	0.05	0.07	0.00	0.22
Average	1.49	1.42	0.81	1.37	3.64

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