10. Assessment of the Northern Rockfish stock in the Gulf of Alaska

by

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Executive Summary

Rockfish are assessed on a biennial stock assessment schedule to coincide with the availability of new survey data. For Gulf of Alaska rockfish in on-cycle (odd) years, we present a full stock assessment document with updated assessment and projection model results. However, due to the 2013 government shutdown, we do not present alternative model configurations in this year's assessment. Additionally, some sections may not have been fully updated from the 2011 assessment document.

As in 2011, the general model structure for GOA northern rockfish is a separable age-structured model as used for Gulf of Alaska Pacific ocean perch, dusky rockfish, and rougheye/blackspotted rockfish. This consists of an assessment model, which uses survey and fishery data to generate a historical time series of population estimates, and a projection model, which uses results from the assessment model to predict future population estimates and recommended harvest levels. GOA rockfish are assessed on a biennial stock assessment schedule to coincide with new survey data. For Gulf of Alaska rockfish in alternate (even) years, we present only an executive summary to recommend harvest levels for the next (odd) year. For this on-cycle year, we update the 2011 assessment model with new data acquired since 2011.

Summary of Changes in Assessment Inputs

Changes in input data: The input data were updated to include the 2013 trawl survey biomass estimate, final catch for 2012, preliminary catch for 2013, survey age compositions for 2011, and final fishery length compositions for 2011.

Changes in the assessment methodology: The assessment methodology is the same as the 2011 assessment with updated input data.

Summary of Results

The 2014 projected age 2+ biomass is 102,893 t. The recommended ABC for 2014 is 5,324 t, the maximum allowable ABC under Tier 3a. This ABC is 4% higher than the 2013 ABC of 5,132 t. The OFL is 6,349 t. The corresponding reference values for northern rockfish recommended for this year and the following year are summarized in the table below along with corresponding values from last year's SAFE. Overfishing is not occurring, the stock is not overfished, and it is not approaching an overfished condition.

Quantity	As estimated or specified *last* year for: 2013	2014	As estimated or recommended *this* year for: 2014	2015[1]
M (natural mortality)	0.06	0.06	0.06	0.06
Tier	3a	3a	3a	3a
Projected total (age 2+) biomass (t)	99,089	95,690	102,893	98,572
Female spawning biomass (t)				
Projected[2]				
Upper 95% confidence interval			91,994	84,810
Point Estimate	40,452	37,935	42,960	40,004
Lower 95% confidence interval			17,755	16,706
$B_{100\%}$	72,983	72,983	75,183	75,183
$B_{40\%}$	29,193	29,193	30,073	30,073
$B_{35\%}$	25,544	25,544	26,314	26,314
F_{OFL}	0.074	0.074	0.073	0.073
$maxF_{ABC}$	0.062	0.062	0.061	0.061
F_{ABC}	0.062	0.062	0.061	0.061
OFL (t)	**6,124**	5,791	**6,349**	5,978
maxABC (t)	5,132	4,852	**5,324**	5,012
ABC (t)	**5,132**	4,852	**5,324**	5,012
Status	As determined *last* year for: 2011	2012	As determined *this* year for: 2012	2013
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

[1]Projected ABCs and OFLs for 2014 and 2015 are derived using estimated catch of 4,770 for 2013, and projected catches of 4,248 t and 3,999 t for 2014 and 2015 based on realized catches from 2010-2012. This calculation is in response to management requests to obtain more accurate projections

[2]Projected upper and lower 95% confidence intervals for female spawning biomass are derived from the MCMC estimated posterior distribution as presented in Table 10.14.

The following table shows the recommended apportionment for 2014.

	Western	Central	Eastern*	Total
Area Apportionment	24.52%	75.45%	0.03%	100.00%
Area ABC (t)	**1,305**	**4,017**	**2**	**5,324**

*For management purposes the small ABC in the Eastern area is combined with other rockfish.

Summaries for Plan Team

Species	Year	Biomass[1]	OFL	ABC	TAC	Catch[2]
Northern rockfish	2012	104,155	6,574	5,507	5,507	5,063
	2013	99,089	6,124	5,130	5,130	4,569
	2014	102,893	6,349	5,324		
	2015	98,572	5,978	5,012		

Stock/ Assemblage	Area	2013 OFL	ABC	TAC	Catch[2]	2014 OFL	ABC	2015 OFL	ABC
Northern rockfish	W		2,008	2,008	2,400		1,305		1,229
	C		3,122	3,122	2,169		4,017		3,781
	E*						2		2
	Total	6,124	5,130	5,130	4,569	6,349	5,324	5,978	5,012

[1]Total biomass estimates from the age structured model.
[2]Current as of October 5, 2013 Source: NMFS Alaska Regional Office via the Alaska Fisheries Information Network (AKFIN).
* For management purposes, the small ABC for northern rockfish in the Eastern Gulf of Alaska is combined with other slope rockfish.

SSC and Plan Team Comments on Assessments in General

Because of the government shutdown, there was only sufficient time to compile SSC and Plan Team comments. For the next full assessment, we will respond to all previous comments.

"The SSC is pleased to see that many assessment authors have examined retrospective bias in the assessment and encourages the authors and Plan Teams to determine guidelines for how to best evaluate and present retrospective patterns associated with estimates of biomass and recruitment. We recommend that all assessment authors (Tier 3 and higher) bring retrospective analyses forward in next year's assessments." (SSC, December 2011)

"The SSC concurs with the Plan Teams' recommendation that the authors consider issues for sablefish where there may be overlap between the catch-in-areas and halibut fishery incidental catch estimation (HFICE) estimates. In general, for all species, it would be good to understand the unaccounted for catches and the degree of overlap between the CAS and HFICE estimates, and to discuss these at the Plan Team meetings next September." (SSC, December 2011)

"The Teams recommend that authors continue to include other removals in an appendix for 2013. Authors may apply those removals in estimating ABC and OFL; however, if this is done, results based on the approach used in the previous assessment must also be presented. The Teams recommend that the "other" removals data set continue to be compiled, and expanded to include all sources of removal." (Plan Team, September 2012)

"For the November 2012 SAFE report, the Teams recommend that authors conduct a retrospective analysis back 10 years (thus, back to 2002 for the 2012 assessments), and show the patterns for spawning biomass (both the time series of estimates and the time series of proportional changes relative to the 2012 run). This is consistent with a December 2011 NPFMC SSC request for stock assessment authors to conduct a retrospective analysis. The base model used for the retrospective analysis should be the author's recommended model, even if it differs from the accepted model from previous years." (Plan Team, September 2012)

SSC and Plan Team Comments Specific to this Assessment

"The Team asks the [rockfish] *authors to investigate whether the conversion matrix has changed over time. Additionally, the Team requests that the criteria for omitting data in stock assessment models be*

based upon the quality of the data (e.g. bias, sampling methods, information content, redundancy with other data, etc.) rather than the effect of the data on modeled quantities." (Plan Team, November 2011)

"The SSC also looks forward to an update of weight-at-age, length and age transition matrices, ageing error matrix, and length bins for fishery length compositions during the next assessment cycle." (SSC, December 2011)

"The SSC supports the inclusion of the maturity data within the model to estimate an intermediate maturity schedule as an interim solution to dealing with two conflicting studies. However, we encourage the authors to further explore the reasons for differences seen between the two studies of maturity that formed the basis of the estimated maturity schedule in the model." (SSC, December 2011)

Introduction

Biology and distribution

The northern rockfish, *Sebastes polyspinis*, is a locally abundant and commercially valuable member of its genus in Alaskan waters. As implied by its common name, northern rockfish has one of the most northerly distributions among the 60+ species of *Sebastes* in the North Pacific Ocean. It ranges from extreme northern British Columbia around the northern Pacific Rim to eastern Kamchatka and the northern Kuril Islands and also north into the eastern Bering Sea (Allen and Smith 1988). Within this range, northern rockfish are most abundant in Alaska waters, from the western end of the Aleutian Islands to Portlock Bank in the central Gulf of Alaska (Clausen and Heifetz 2002).

Little is known about the life history of northern rockfish. Northern rockfish are presumed to be viviparous with internal fertilization. There have been no studies on fecundity of northern rockfish. Observations during research surveys in the Gulf of Alaska indicate that parturition (larval release) occurs in the spring and is completed by summer. Larval northern rockfish cannot be unequivocally identified to species at this time, even using genetic techniques, so information on larval distribution and length of the larval stage is unknown. The larvae metamorphose to a pelagic juvenile stage, but there is no information on when these juveniles become demersal.

Little information is available on the habitat of juvenile northern rockfish. Studies in the eastern Gulf of Alaska and Southeast Alaska using trawls and submersibles have indicated that several species of juvenile (< 20 cm) red rockfish (*Sebastes spp.*) associate with benthic nearshore living and non-living structure and appear to use the structure as a refuge (Carlson and Straty 1981; Kreiger 1993). Freese and Wing (2003) also identified juvenile (5 to 10 cm) red rockfish (*Sebastes spp.*) associated with sponges (primarily *Aphrocallistes spp.*) attached to boulders 50 km offshore in the GOA at 148 m depth over a substrate that was primarily a sand and silt mixture. Only boulders with sponges harbored juvenile rockfish, and the juvenile red rockfish appeared to be using the sponges as shelter (Freese and Wing 2003). Although these studies did not specifically observe northern rockfish, it is likely that juvenile northern rockfish also utilize similar habitats. Length frequencies of northern rockfish captured in NMFS bottom trawl surveys and observed in commercial fishery bottom trawl catches indicate that older juveniles (>20 cm) are found on the continental shelf, generally at locations inshore of the adult habitat (Pers. comm. Dave Clausen).

Northern rockfish are generally planktivorous. They eat mainly euphausiids and calanoid copepods in both the GOA and the Aleutian Islands (Yang 1993; Yang 1996; Yang and Nelson 2000). There is no indication of a shift in diet over time or a difference in diet between the GOA and AI (Yang 1996, Yang and Nelson 2000). In the Aleutian Islands, calanoid copepods were the most important food of smaller-sized northern rockfish (< 25 cm), while euphausiids were the main food of larger sized fish (> 25 cm) (Yang 1996). The largest size group also consumed myctophids and squids (Yang 2003). Arrow worms, hermit crabs, and shrimp have also been noted as prey items in much smaller quantities (Yang 1993, 1996). Large offshore euphausiids are not directly associated with the bottom, but rather, are thought to be advected onshore near bottom at the upstream ends of underwater canyons where they become easy prey for planktivorous fishes (Brodeur 2001). Predators of northern rockfish are not well documented, but likely include larger fish, such as Pacific halibut, that are known to prey on other rockfish species.

Trawl surveys and commercial fishing data indicate that the preferred habitat of adult northern rockfish in the Gulf of Alaska is relatively shallow rises or banks on the outer continental shelf at depths of about 75-150 m (Clausen and Heifetz 2002). The highest concentrations of northern rockfish from NMFS trawl survey catches appear to be associated with relatively rough (variously defined as hard, steep, rocky or uneven) bottom on these banks (Clausen and Heifetz 2002). Heifetz (2002) identified rockfish as among the most common commercial fish captured with gorgonian corals (primarily *Callogorgia, Primnoa, Paragorgia, Fanellia, Thouarella*, and *Arthrogorgia*) in NMFS trawl surveys of Gulf of Alaska and

Aleutian waters. Krieger and Wing (2002) identified six rockfish species associated with gorgonian coral (*Primnoa spp.*) from a manned submersible in the eastern Gulf of Alaska. However, neither Heifetz (2002) nor Krieger and Wing (2002) specifically identified northern rockfish in their studies, and more research is required to determine if northern rockfish are associated with living structure, including corals, in the Gulf of Alaska, and the nature of those associations if they exist.

Recent work on black rockfish (*Sebastes melanops*) has shown that larval survival may be higher from older female spawners (Berkeley et al. 2004). The black rockfish population has shown a distinct reduction in the proportion of older fish in recent fishery samples off the West Coast of North America, raising concerns if larval survival diminishes with spawner age. De Bruin et al. (2004) examined Pacific ocean perch (*S. alutus*) and rougheye rockfish (*S. aleutianus*) for senescence in reproductive activity of older fish and found that oogenesis continues at advanced ages. Leaman (1991) showed that older individuals have slightly higher egg dry weight than their middle-aged counterparts. However, relationships on fecundity or larval survival at age have not yet been evaluated for northern rockfish or other rockfish in Alaska. Stock assessments for Alaska groundfish have assumed that the reproductive success of mature fish is independent of age.

Evidence of stock structure

Gulf of Alaska northern rockfish grow significantly faster and reach a larger maximum length than Aleutian Islands northern rockfish (Clausen and Heifetz 2002). Also, Aleutian Islands northern rockfish are slightly older (maximum age 72) than Gulf of Alaska northern rockfish (maximum age 67), the difference in age could be due to sampling variability. Genetic studies of stock structure have provided conflicting results. One study of northern rockfish provided no evidence for genetically distinct stock structure when comparing samples from near the western Aleutian Islands, the western Gulf of Alaska, and Kodiak Island (Gharrett et al. 2003). The results from that study were considered preliminary, and sample sizes were small. Consequently, the lack of evidence for stock structure did not necessarily confirm stock homogeneity. A more recent study did find spatial structure on a relatively small scale for northern rockfish sampled from several locations in the Aleutian Islands and Bering Sea (Gharrett et al. 2012).

Results of an analysis of localized depletion based on Leslie depletion estimators on targeted rockfish catches detected relatively few localized depletions for northern rockfish (Hanselman et al. 2007). Several significant depletions occurred in the early 1990s for northern rockfish, but were not detected again by the depletion analysis. However, when fishery and survey CPUEs were plotted over time for a geographic block of high rockfish fishing intensity that contained the “Snakehead” area, the results indicated there were year-after-year drops in both fishery and survey CPUE for northern rockfish. The significance of these observations depends on the migratory and stock structure patterns of northern rockfish. If fine-scale stock structure is determined in northern rockfish, or if the area is essential to northern rockfish reproductive success, then these results would suggest that current apportionment of ABC may not be sufficient to protect northern rockfish from localized depletion. Provisions to guard against serial depletion in northern rockfish should be examined in the Gulf of Alaska rockfish rationalization plan. The extension of the fishing season that has been implemented may spread out the fishery in time and space and reduce the risk of localized serial depletion on the “Snakehead” and other relatively shallow (75 – 150 m) offshore banks on the outer continental shelf where northern rockfish are concentrated.

If there is relatively small scale stock structure (120 km) in Gulf of Alaska northern rockfish, then recovery from localized depletion, as indicated above for a region known as the “Snakehead,” could be slow. Analysis of otolith microchemistry may provide a useful tool, in addition to genetic analysis, for identifying small scale (120 km) stock structure of northern rockfish relative to their overall range. Berkeley et al. (2004) suggests that, in addition to the maintenance of age structure, the maintenance of spatial distribution of recruitment is essential for long-term sustainability of exploited rockfish populations. In particular, Berkeley et al. (2004) outline Hedgecock's "sweepstakes hypothesis" to explain small-scale genetic heterogeneity observed in some widely distributed marine populations. According to Berkeley et al. (2004), "most spawners fail to produce surviving offspring because their reproductive activity is not matched in space and time to favorable oceanographic conditions for larval survival during a given season. As a result of this mismatch the surviving year class of new recruits is produced by only a small minority of adults that spawned within those restricted temporal and spatial oceanographic windows that offered good conditions for larval survival and subsequent recruitment". However, Miller and Shanks (2004) found limited larval dispersal (120 km) in black rockfish off the Pacific coast with an analysis of otolith microchemistry. In particular, these results suggest that black rockfish exhibit some degree of stock structure at very small scales (120 km) relative to their overall range. Localized genetic stocks of Pacific ocean perch have also been found in northern B.C. (Withler et al. 2001), and Kamin et al. (2013) concluded that fine-scale genetic heterogeneity for Pacific ocean perch in Alaska was not the influence of a sweepstakes effect. Limited larval dispersal contradicts Hedgecock's hypothesis and suggests that genetic heterogeneity in rockfish may be the result of stock structure rather than the result of the sweepstakes hypothesis.

Description of management units/measures

From 1988-1993, the North Pacific Fishery Management Council (NPFMC) managed northern rockfish in the Gulf of Alaska as part of the slope rockfish assemblage. In 1991, the NPFMC divided the slope rockfish assemblage in the Gulf of Alaska into three management subgroups: Pacific ocean perch, shortraker/rougheye rockfish, and a complex of all other species of slope rockfish, including northern rockfish. In 1993, a fourth management subgroup, northern rockfish, was also created. In 2004, rougheye rockfish and shortraker rockfish were also split and managed separately. These subgroups were established to protect Pacific ocean perch, shortraker/rougheye, and northern rockfish (the four most sought-after commercial species in the assemblage) from possible overfishing. Each subgroup is now assigned an individual ABC (acceptable biological catch) and TAC (total allowable catch). Prior to 1991, an ABC and TAC were assigned to the entire assemblage. ABC and TAC for each subgroup, including northern rockfish, is apportioned to the three management areas of the Gulf of Alaska (Western, Central, and Eastern) based on a weighted average of the proportion of biomass by area from the three most recent Gulf of Alaska trawl surveys. Northern rockfish are scarce in the eastern Gulf of Alaska, and the ABC apportioned to the Eastern Gulf management area is small. This translates to a TAC that is too difficult to be managed effectively as a directed fishery. Since 1999, the ABC for northern rockfish apportioned to the Eastern Gulf management area is included in the West Yakutat ABC for "other slope rockfish."

Amendment 41, which took effect in 2000, prohibited trawling east of 140 degrees W. longitude in the Eastern GOA. However, trawling did not occur in this area starting in 1998. Since most slope rockfish, especially Pacific ocean perch, are caught exclusively with trawl gear, this amendment could have concentrated fishing effort for slope rockfish in the Eastern area in the relatively small area between 140 degrees and 147 degrees W. longitude that remained open to trawling. This probably does not have a major effect on northern rockfish populations because their abundance in the Eastern area is low.

In November, 2006, NMFS issued a final rule to implement Amendment 68 of the GOA groundfish Fishery Management Plan for 2007 through 2011. This action implemented the Central GOA Rockfish Pilot Program (RPP). The intention of this Program was to enhance resource conservation and improve economic efficiency for harvesters and processors in the rockfish fishery. An additional objective was to spread out the fishery in time and space, allowing for enhanced market conditions for product and reducing the pressure of what was an approximately two-week fishery in July. The primary rockfish management groups in this program are northern rockfish, Pacific ocean perch, and pelagic shelf rockfish. Potential effects of this program on northern rockfish include: 1) Extended fishing season lasting from May 1 – November 15, 2) changes in spatial distribution of fishing effort within the Central GOA, 3) improved at-sea and plant observer coverage for vessels participating in the rockfish fishery, and 4) a higher potential to harvest 100% of the TAC in the Central GOA region. In a comparison of catches in the four years before the RPP to the four years after, it appears that average catches have increased overall (although, this may be due to increased observer coverage) and have spread out spatially in the western and central Gulf (Figure 10.1). The authors will pay close attention to the benefits and consequences of this action.

A summary of key management measures and a time series of catch, ABC and TAC are provided in Table 10.1.

Fishery

Description of the directed fishery

In the Gulf of Alaska, northern rockfish are generally caught with bottom trawls identical to those used in the Pacific ocean perch fishery. Many of these nets are equipped with so-called “tire gear,” in which automobile tires are attached to the footrope to facilitate towing over rough substrates. Most of the catch has been taken during July, as the directed rockfish trawl fishery in the Gulf of Alaska has traditionally opened around July 1. Rockfish trawlers usually direct their efforts first toward Pacific ocean perch because of its higher value relative to other rockfish species. After the TAC for Pacific ocean perch has been reached and NMFS closes directed fishing for this species, trawlers switch and target northern rockfish. With implementation of the Central Gulf Rockfish Pilot Project in 2007, catches have been spread out more throughout the year.

Historically, bottom trawls have accounted for nearly all the commercial harvest of northern rockfish in the Gulf of Alaska. In the years 1990-98, bottom trawls took over 99% of the catch (Clausen and Heifetz 2002). Before 1996, most of the slope rockfish trawl catch (>90%) was taken by large factory-trawlers that processed the fish at sea. A significant change occurred in 1996, however, when smaller shore-based trawlers began taking a sizeable portion of the catch in the Central Gulf for delivery to processing plants in Kodiak. Factory trawlers continued to take nearly all the northern rockfish catch in the Western area during this period.

A study of the northern rockfish fishery for the period 1990-98 showed that 89% of northern rockfish catch was taken from just five relatively small fishing grounds: Portlock Bank, Albatross Bank, an unnamed bank south of Kodiak Island that fishermen commonly refer to as the “Snakehead,” Shumagin Bank, and Davidson Bank (Clausen and Heifetz 2002). The Snakehead accounted for 46% of the northern rockfish catch during these years. All of these grounds can be characterized as relatively shallow (75–150 m) offshore banks on the outer continental shelf.

Data from the observer program for 1990-98 indicated that 82% of the northern rockfish catch during that period came from directed fishing for northern rockfish and 18% was taken as incidental catch in fisheries for other species (Clausen and Heifetz 2002).

Description of the catch time series

Total commercial catch (t) of northern rockfish in the GOA for the years 1961-2013 is summarized by foreign, joint venture, and domestic fisheries (Table 10.2 and Figure 10.2).

Catches of GOA northern rockfish during the years 1961-1976 were estimated as 5% of the foreign GOA Pacific ocean perch catch in the same years. A Pacific ocean perch trawl fishery by the U.S.S.R. and Japan began in the Gulf of Alaska in the early 1960's. This fishery developed rapidly with massive efforts by the Soviet and Japanese fleets. Catches peaked in 1965 when a total of nearly 350,000 metric tons (t) were caught, but declined to 45,500 t by 1976 (Ito 1982). Some northern rockfish were likely taken in this fishery, but there are no available summaries of northern rockfish catches for this period. Foreign catches of all rockfish were often reported simply as "Pacific ocean perch" with no attempt to differentiate species. The only detailed analysis of bycatch in slope rockfish fisheries of the Gulf of Alaska is that of Ackley and Heifetz (2001) who examined data from the observer program for the years 1993-95. Consequently, our best estimate of northern rockfish catch from 1961-1976 comes from analysis of the ratio of northern rockfish catch to Pacific ocean perch catch in the years 1993-1995. For hauls targeting on Pacific ocean perch, northern rockfish composed 5% of the catch (Ackley and Heifetz 2001).

Catches of GOA northern rockfish during the years 1977-1983 were available from NMFS foreign and joint venture fisheries observer data. With the advent of a NMFS observer program aboard foreign fishing vessels in 1977, enough information on species composition of rockfish catches was collected so that estimates of the northern rockfish catch were made for 1977-83 from extrapolation of catch compositions from the foreign observer program (Clausen and Heifetz 2002). The relatively large catch estimates for the foreign fishery in 1982-83 are an indication that at least some directed fishing for northern rockfish probably occurred in those years. Joint venture catches of northern rockfish, however, appear to have been relatively modest.

Catches of GOA northern rockfish during the years 1984-1989 were estimated as 8% of the domestic slope rockfish catch during the same years. A completely domestic trawl fishery for rockfish in the Gulf of Alaska began in 1984 but a domestic observer program was not implemented until 1990. Domestic catches of GOA northern rockfish during the years 1984-1989 were estimated from the ratio of domestic northern rockfish catch to domestic slope rockfish catch (8%) reported by the 1990 NMFS observer program:

$$\text{northern rockfish catch}_i = \frac{\text{northern rockfish catch}_{1990}}{\text{slope rockfish assemblage catch}_{1990}} * \text{ slope rockfish assemblage catch}_i$$

Catches of GOA northern rockfish during the years 1990-1992 were estimated from extrapolation of catch compositions from the domestic observer program (Clausen and Heifetz 2002). Catch estimates of northern rockfish increased greatly from about 1,700 t in 1990 to nearly 7,800 t in 1992. The increases for 1991 and 1992 can be explained by the removal of Pacific ocean perch and shortraker/rougheye rockfish from the slope rockfish management group. As a result of this removal, relatively low TAC's were adopted for these three species, and the rockfish fleet redirected more of its effort to northern rockfish in 1991 and 1992.

Catches of GOA northern rockfish during the years 1993-present were available directly from NMFS domestic fisheries observer data. Northern rockfish were removed from the slope rockfish assemblage and managed with an individual TAC beginning in 1993. As a consequence, directly reported catch for northern rockfish has been available since 1993. Catch of northern rockfish was reduced after the implementation of a northern specific TAC in 1993. Most of the catch since 1993 has been taken in the Central area, where the majority of the northern rockfish exploitable biomass is located. Gulfwide catches for the years 1993-2013 have ranged from 2,935 t to 5,966 t. Annual ABCs and TACs have been relatively consistent during this period and have varied between 4,362 t and 5,760 t. In 2001, catch of northern rockfish was below TAC because the maximum allowable bycatch of Pacific halibut was reached in the central Gulf of Alaska for "deep water trawl species," which includes northern rockfish. Catches of northern rockfish have been near their TAC's in more recent years, 2003 - 2013. Catch increased to 5,063 t in 2012 as a result of an increase to TAC.

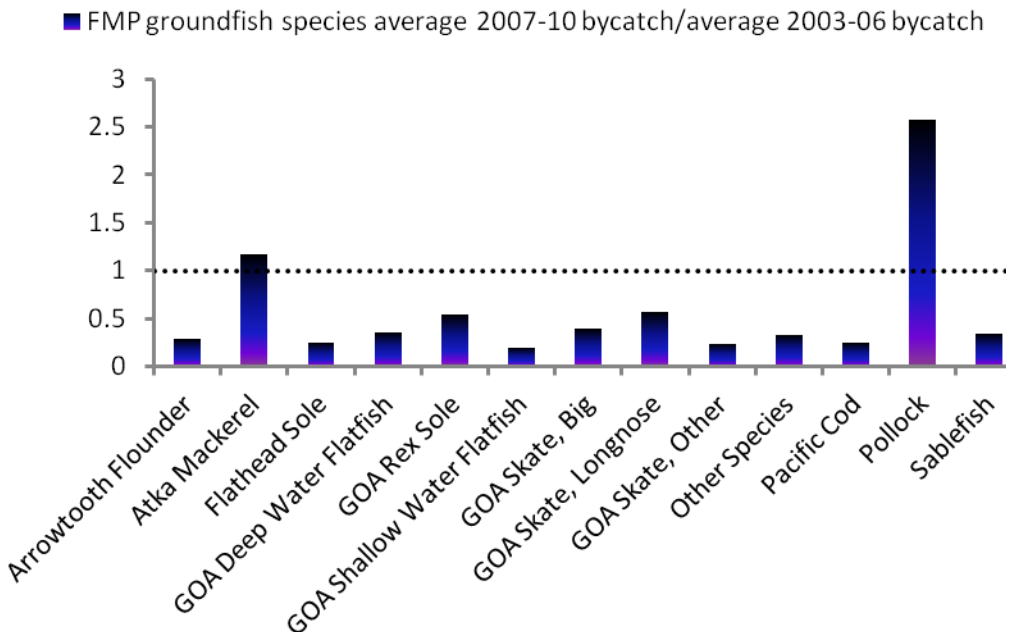
Research catches of northern rockfish have been relatively small and are listed in Table 10A.1 in Appendix 10A.

Bycatch and discards

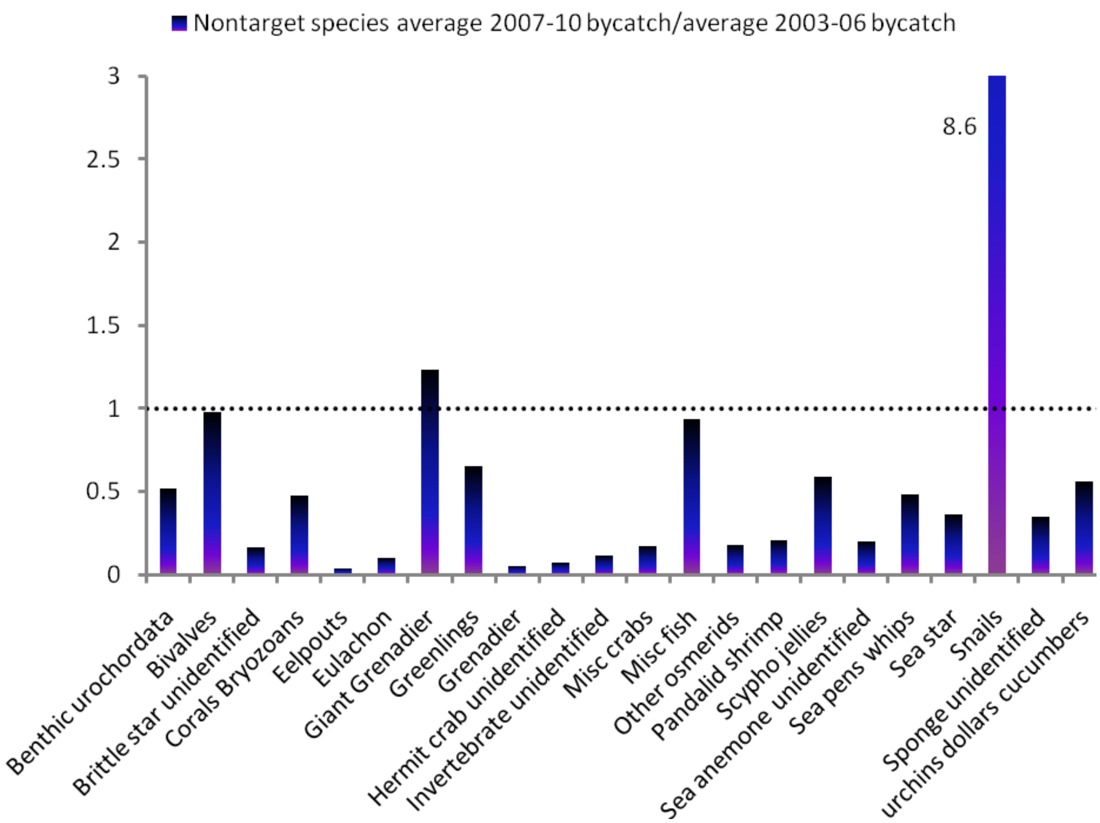
The only detailed analysis of incidental catch in slope rockfish fisheries of the Gulf of Alaska is that of Ackley and Heifetz (2001) who examined data from the observer program for the years 1993-95. For hauls targeting on northern rockfish, the predominant incidental species were dusky rockfish, distantly followed by “other slope rockfish,” Pacific ocean perch, and arrowtooth flounder.

Total FMP groundfish catch estimates targeted in the GOA rockfish fishery from 2008-2013 are shown in Table 10.3. For the GOA rockfish fishery during 2008-2013, the largest non-rockfish bycatch groups are Atka mackerel (1,591 t/year), pollock (818 t/year), arrowtooth flounder (581 t/year), and Pacific cod (558 t/year).

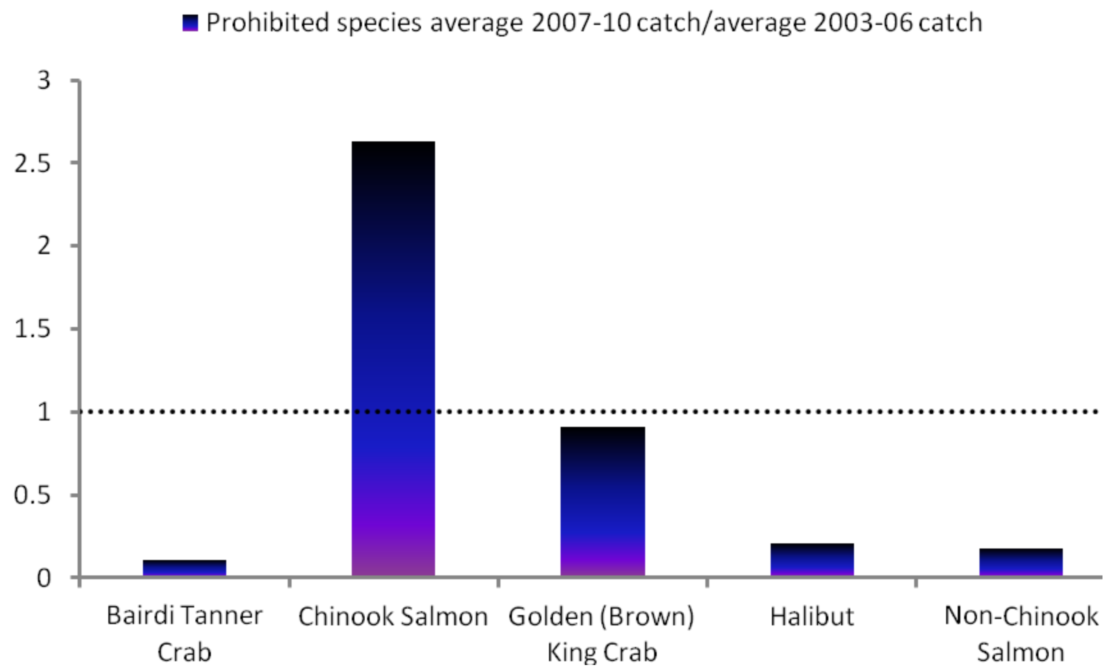
We compared bycatch in the central GOA from pre-2006 and post-2007 (the year of the Central GOA Rockfish Pilot Program implementation) for the rockfish fishery by dividing the average post-2007 bycatch (2007-2010) by the average pre-2006 bycatch (2003-2006) for non-rockfish species that had available information in both time periods. For the majority of FMP groundfish species, bycatch in the central GOA has reduced since 2007, with the exception of Atka mackerel (214 t/year pre-2006 compared to 251 t/year post-2007) and walleye pollock (136 t/year pre-2006 compared to 352 t/year post-2007):



Non-FMP species catch in the rockfish target fisheries is dominated by giant grenadier (161 – 836 t), miscellaneous fish (135 – 196 t), and ocassionally dark rockfish (recently removed from FMP to state management, 13 – 112 t) (Table 10.4). Only 2 of 23 nontarget species in the central GOA showed an increase in bycatch post-2007 compared to pre-2006, giant grenadier (127 t/year pre-2006 compared to 156 t/year post-2007) and snails (0.3 t/year pre-2006 compared to 2.6 t/year post-2007):



Prohibited species catch in the GOA rockfish fishery has been lower than average in 2011 and 2012 for all major species. The catch of golden king crab drecreased dramatically from over 3,000 animals in 2009 and 2010, to just over 100 in 2011 and 2012. (Table 10.5). Bycatch since 2007 in the central GOA rockfish fishery has decreased for all of the prohibited species, with the exception of chinook salmon (600 fish/year pre-2006 compared to 1,578 fish/year post-2007):



Gulfwide discard rates (% discarded) for northern rockfish in the commercial fishery for 1993-2010 are as follows:

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001
% Discarded	26.5	17.7	12.7	16.6	28	18.4	11.3	10	17.7

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010
% Discarded	10	9.4	7.9	4.3	9.2	2.6	4.9	3.1	1.5

These discard rates are generally similar to those in the Gulf of Alaska for Pacific ocean perch and dusky rockfish.

Data

The following table summarizes the data used in the stock assessment model for northern rockfish (bold denotes new data for this assessment):

Source	Data	Years
Fisheries	Catch	1961-**2013**
NMFS bottom trawl surveys	Biomass index	1984, 1987, 1990, 1993, 1996, 1999, 2001, 2003, 2005, 2007, 2009, 2011, **2013**
NMFS bottom trawl surveys	Age	1984, 1987, 1990, 1993, 1996, 1999, 2001, 2003, 2005, 2007, 2009, **2011**
U.S. trawl fisheries	Age	1998, 1999, 2000, 2001, 2002, 2004, 2005, 2006, 2008, 2010
U.S. trawl fisheries	Length	1990,1991,1992, 1993, 1994, 1995, 1996, 1997, 2003, 2007, 2009, **2011**

Fishery data

Catch

Catch of northern rockfish range from 185 t to 17,430 t during 1961 to 2013. Detailed description of catch is provided above (within the "*Description of the catch time series*" section) and in Table 10.2 and Figure 10.2.

Age and Size composition

Observers aboard fishing vessels and at onshore processing facilities have provided data on length and age compositions of the commercial catch of northern rockfish. Length compositions are presented in Table 10.6 and Figure 10.3 and age compositions are presented in Table 10.7 and Figure 10.4; these tables also include associated annual sample sizes and number of hauls sampled for the age and length compositions. The fishery age compositions indicate that stronger than average year-classes occurred around the year 1976 and 1984. The fishery age compositions from 2004 and 2006 also indicate that the 1996-1998 year-classes were strong. The clustering of several large year-classes in each period is most likely due to aging error. Recent fishery length compositions (2003-present) indicate that a large proportion of the northern rockfish catch are found to be larger than 38 cm, which is the current plus length bin. Similarly, since 2006 the proportion of fish older than 33 (the current plus age group) has been increasing in comparison to the proportion of fish older than 33 prior to 2006.

Survey Data

Biomass Estimates from Trawl Surveys

Bottom trawl surveys were conducted in the Gulf of Alaska triennially from 1984 – 1999 and biennially from 1999 – 2013. The surveys provide an index of biomass, size and age composition data, and growth characteristics. The trawl surveys have used a stratified random design to sample fishing stations that cover all areas of the Gulf of Alaska out to a depth of 1,000 m (in some surveys only to 500 m). Generally, attempts have been made through the years to standardize the survey design and the fishing nets used, but there have been some exceptions to this standardization. In particular, much of the survey effort in 1984 and 1987 was by Japanese vessels that used a very different net design than what has been the standard used by U.S. vessels throughout the surveys. To deal with this problem, fishing power comparisons of rockfish catches have been done for the various vessels used in the surveys (for a discussion see Heifetz et al. 1994). Results of these comparisons have been incorporated into the biomass estimates listed in this report, and the estimates are believed to be the best available. Even so, the use of Japanese vessels in 1984 and 1987 introduced an element of uncertainty as to the standardization of these two surveys. Also, a different survey design was used in the eastern Gulf of Alaska in 1984, and the eastern Gulf of Alaska was not covered by the 2001 survey. These data inconsistencies for the eastern Gulf of Alaska have had little effect on the survey results for northern rockfish, as relative abundance of northern rockfish is very low in the eastern Gulf of Alaska.

The trawl survey indices of biomass for northern rockfish have been highly variable from survey to survey (Table 10.8 and Figure 10.5). In particular, the 2011 biomass estimate (173,642 t) was 93% larger than the 2009 estimate (89,896 t) while the 2009 biomass estimate was 60% smaller than the 2007 estimate (227,069 t).The 2007 biomass estimate was 36% smaller than the 2005 estimate (358,998 t), which was over 440% larger than the 2003 estimate (66,310 t). The 2013 biomass estimate (370,454 t) is the highest estimated biomass on record and is similar to the 2005 estimate. This increase is explained by a three-fold increase in the Chirikof region (Table 10.8). Such large fluctuations in biomass do not seem reasonable given the long life, slow growth, low natural mortality, late maturity, and relatively modest level of commercial catch of northern rockfish.

The precision of some of the biomass estimates has been low and is reflected in the large 95% confidence intervals and high CVs associated with some survey biomass estimates of northern rockfish that are the result of few very large catches during the survey (Table 10.8 and Figure 10.5). In both 1999 and 2001, a single very large survey haul of northern rockfish greatly increased the biomass estimates and resulted in wide confidence bounds. The haul in 2001 was the largest individual catch (14 t) of northern rockfish ever taken during a Gulf of Alaska survey. In contrast, the 2005 and 2007 survey had several large hauls of northern rockfish in the Central Gulf and confidence bounds were narrower (Figure 10.5). The 2009 survey did not have any very large hauls and the biomass estimate was lower and more precise than the 2005 and 2007 estimates. The 2011 survey had several large hauls and the confidence bounds are comparable to 2007. The 2013 survey had several large catches in the Chirikof region but relatively low catches in other areas resulting in a CV of 60% (Figure 10.6). The highly variable biomass estimates for northern rockfish suggest that an alternative to the stratified random design may be needed to reduce the variability in biomass estimates.

Age and Size composition

Ages for northern rockfish were determined from the break-and-burn method (Chilton and Beamish 1982). These age compositions (Table 10.9 and Figure 10.7) indicate that recruitment of northern rockfish is highly variable. Several surveys (1984, 1987, 1990, and 1996) show especially strong year-classes from the period around 1975-77; although they differ as to which specific years were greatest, likely due to age determination errors. The 1993, 1996, and 1999 age compositions also indicate that the 1983-85 year-classes may be stronger than average. Recent age compositions (2005, 2007, 2009 and 2011) indicate that the 1996-98 year-classes may also be stronger than average, which is in agreement with recent age compositions obtained from the commercial fishery described above. Trawl surveys provide size composition data for northern rockfish but are not used directly in the current age structured assessment model (Table 10.10 and Figure 10.8). In years with age readings, trawl survey size composition data are multiplied by an age-length key (computed from length-stratified otolith collections) to obtain survey age compositions (Figure 10.9). Similar to the fishery length compositions discussed above, a large proportion of northern rockfish lengths are greater than the current plus length bin (38 cm); especially in recent years. Also similar to the fishery age compositions, the proportion of fish older than age 33 (the current plus age group) has been increasing since the mid to early 2000s. The proportion of fish older than age 33 from the trawl survey in 2011 was 0.364, nearly twice as large as the greatest plus age group proportion prior to 2011 (0.202 in 2005).

Maturity Data

In previous stock assessments for northern rockfish, age at maturity was been based on a logistic curve fit to ovarian samples collected from female northern rockfish in the central Gulf of Alaska (GOA) in the spring of 1996 (*n*=75, C. Lunsford pers. comm. July 1997, Heifetz et al. 2009). A more recent study reevaluating maturity of northern rockfish (Chilton 2007, *n*=157) has been published, providing additional information for maturity-at-age. This study collected ovarian samples from female northern rockfish throughout the year in both 2000 and 2001. In a report submitted to the GOA Groundfish Plan Team in September 2010, the two studies were compared and the advantages and disadvantages of the different approaches for studying maturity were discussed (Rodgveller et al. 2010). In this year's assessment, as in the 2011 assessment, we combine the data from both studies to estimate maturity of northern rockfish. Due to the relatively small sample sizes for each study, the close proximity in time for each study (4 years apart compared to the 51 year time series used in this assessment), and the large difference in the age at 50% maturity (12.8 years used in previous assessments compared to 8 years obtained by Chilton 2007), we combine these data and estimate an intermediate maturity-at-age rather than consider time-dependent changes in maturity (Figure 10.11). There could be time-dependent changes in maturity-at-age for northern rockfish, although, additional data would be necessary to evaluate this hypothesis.

Analytic Approach

Model structure

The basic model for Gulf of Alaska northern rockfish is described as a separable age-structured model (Box 1) and was implemented using AD Model Builder software (Fournier et al. 2012). The assessment model is based on a generic rockfish model developed in a workshop held in February 2001 (Courtney et al. 2007) and follows closely the GOA Pacific ocean perch model. The northern rockfish model is fit to time series extending from 1961-2013. As with other rockfish age-structured models, this model does not attempt to fit a stock-recruitment relationship but estimates a mean recruitment, which is adjusted by estimated recruitment deviations for each year.

The parameters, population dynamics, and equations of the model are shown in Box 1. In 2011, we incorporated a method to estimate maturity dependently, so that uncertainty in maturity parameters are linked to uncertainty in model results, and extended the plus age group to 33+ (see Hulson et al. 2011 for further details).

Parameters Estimated Outside the Assessment Model

A von Bertalanffy growth curve was fitted to survey size at age data from 1984-2007. Sexes were combined. A size to age transition matrix was then constructed by adding normal error with a standard deviation equal to the survey data for the probability of different ages for each size class (Courtney et al. 1999, Figure 10.9). Previous parameters are available from Heifetz and Clausen (1991), Courtney et al. (1999), and Malecha et al. (2007). The estimated parameters for the growth curve are shown below:

L_∞=39.9 cm κ=0.18 t_0=-0.22 n=3870

Weight-at-age was constructed with weight at age data from the same data set as the length at age. The estimated growth parameters are shown below.

W_∞=984 g a=9.16 x 10^{-6} b=3.09 n=3432

Aging error matrices were constructed by assuming that the break-and-burn ages were unbiased but had a given amount of normal error around each age based on between-reader percent agreement tests conducted at the AFSC Age and Growth lab (Figure 10.10). We fix the variability of recruitment deviations (σ_r) at 1.5 which allows highly variable recruitment.

Parameters Estimated Inside the Assessment Model

The estimates of natural mortality (M) and catchability (q) are estimated with the use of lognormal prior distributions as penalties that are added to the overall objective function in order to constrain parameter estimates to reasonable values and to speed model convergence. Arithmetic means and standard errors (μ, σ) for the lognormal distributions were provided as input to the model. The standard errors for selected model parameters were estimated based on multivariate normal approximation of the covariance matrix. The prior mean for natural mortality of 0.06 is based on the estimate provided by Heifetz and Clausen (1991) using the method of Alverson and Carney (1975). Natural mortality is notoriously a difficult parameter to estimate within the model so we assign a "tight" prior CV of 5%. Catchability is a parameter that is somewhat unknown for rockfish, so while we assign it a prior mean of 1 (assuming all fish in the area swept are captured and there is no herding of fish from outside the area swept, and that there is no effect of untrawlable grounds), we assign it a less precise CV of 45%. This allows the parameter more freedom than that allowed to natural mortality. This is identical to that used in the Gulf of Alaska Pacific ocean perch and dusky rockfish assessments. Maturity-at-age is modeled with the logistic function, similar to selectivity-at-age for the survey and fishery. The fit to the two studies that have provided maturity data for northern rockfish from the model is shown in Figure 10.11.

The numbers of estimated parameters from the model are shown below. Other derived parameters are described in Box 1.

Parameter name	Symbol	Number
Natural mortality	M	1
Catchability	q	1
Log-mean-recruitment	μ_r	1
Recruitment deviations	τ_y	83
Spawners-per-recruit levels	$F_{35\%}, F_{40\%}, F_{50\%}$	3
Average fishing mortality	μ_f	1
Fishing mortality deviations	ϕ_y	53
Logistic fishery selectivity	$a_{f50\%}, \delta_f$	2
Logistic survey selectivity	$a_{s50\%}, \delta_s$	2
Logistic maturity-at-age	$a_{m50\%}, \delta_m$	2
Total		149

Uncertainty approach

Evaluation of model uncertainty has recently become an integral part of the "precautionary approach" in fisheries management. In complex stock assessment models such as this model, evaluating the level of uncertainty is difficult. One way is to examine the standard errors of parameter estimates from the Maximum Likelihood (ML) approach derived from the Hessian matrix. While these standard errors give some measure of variability of individual parameters, they often underestimate their variance and assume that the joint distribution is multivariate normal. An alternative approach is to examine parameter distributions through Markov Chain Monte Carlo (MCMC) methods (Gelman et al. 1995). When treated this way, our stock assessment is a large Bayesian model, which includes informative (e.g., lognormal natural mortality with a small CV) and noninformative (or nearly so, such as a parameter bounded between 0 and 10) prior distributions. In the model presented in this SAFE report, the number of parameters estimated is 149. In a low-dimensional model, an analytical solution might be possible, but in one with this many parameters, an analytical solution is intractable. Therefore, we use MCMC methods to estimate the Bayesian posterior distribution for these parameters. The basic premise is to use a Markov chain to simulate a random walk through the parameter space, which will eventually converge to a stationary distribution which approximates the posterior distribution. Determining whether a particular chain has converged to this stationary distribution can be complicated, but generally if allowed to run long enough, the chain will converge (Jones and Hobert 2001). The "burn-in" is a set of iterations removed at the beginning of the chain. This method is not strictly necessary but we use it as a precautionary measure. In our simulations we removed the first 2,000,000 iterations out of 20,000,000 and "thinned" the chain to one value out of every four thousand, leaving a sample distribution of 4,500. Further assurance that the chain had converged was to compare the mean of the first half of the chain with the second half after removing the "burn-in" and "thinning". Because these two values were similar we concluded that convergence had been attained. We use these MCMC methods to provide further evaluation of uncertainty in the results below including 95% confidence intervals for some parameters.

BOX 1. AD Model Builder Model Description

Parameter definitions	
y	Year
a	Age classes
l	Length classes
w_a	Vector of estimated weight at age, $a_0 \rightarrow a_+$
m_a	Vector of estimated maturity at age, $a_0 \rightarrow a_+$
a_0	Age at first recruitment
a_+	Age when age classes are pooled
μ_r	Average annual recruitment, log-scale estimation
μ_f	Average fishing mortality
σ_r	Annual recruitment deviation
ϕ_y	Annual fishing mortality deviation
fs_a	Vector of selectivities at age for fishery, $a_0 \rightarrow a_+$
ss_a	Vector of selectivities at age for survey, $a_0 \rightarrow a_+$
M	Natural mortality
$F_{y,a}$	Fishing mortality for year y and age class a ($fs_a \mu_f e^{\varepsilon}$)
$Z_{y,a}$	Total mortality for year y and age class a ($=F_{y,a}+M$)
$\varepsilon_{y,a}$	Residuals from year to year mortality fluctuations
$T_{a,a'}$	Aging error matrix
$T_{a,l}$	Age to length transition matrix
q	Survey catchability coefficient
SB_y	Spawning biomass in year y, ($=m_a\, w_a\, N_{y,a}$)
q_{prior}	Prior mean for catchability coefficient
$\sigma_{r(prior)}$	Prior mean for recruitment deviations
σ_q^2	Prior CV for catchability coefficient
$\sigma_{\sigma_r}^2$	Prior CV for recruitment deviations

BOX 1 (Continued)

Equations describing the observed data

$$\hat{C}_y = \sum_a \frac{N_{y,a} * F_{y,a} * \left(1 - e^{-Z_{y,a}}\right)}{Z_{y,a}} * w_a$$ Catch equation

$$\hat{I}_y = q * \sum_a N_{y,a} * \frac{s_a}{\max(s_a)} * w_a$$ Survey biomass index (t)

$$\hat{P}_{y,a'} = \sum_a \left(\frac{N_{y,a} * s_a}{\sum_a N_{y,a} * s_a} \right) * T_{a,a'}$$ Survey age distribution
Proportion at age

$$\hat{P}_{y,l} = \sum_a \left(\frac{N_{y,a} * s_a}{\sum_a N_{y,a} * s_a} \right) * T_{a,l}$$ Survey length distribution
Proportion at length

$$\hat{P}_{y,a'} = \sum_a \left(\frac{\hat{C}_{y,a}}{\sum_a \hat{C}_{y,a}} \right) * T_{a,a'}$$ Fishery age composition
Proportion at age

$$\hat{P}_{y,l} = \sum_a \left(\frac{\hat{C}_{y,a}}{\sum_a \hat{C}_{y,a}} \right) * T_{a,l}$$ Fishery length composition
Proportion at length

Equations describing population dynamics

Start year

$$N_a = \begin{cases} e^{\left(\mu_r + \tau_{styr - a_0 - a - 1}\right)}, & a = a_0 \\ e^{\left(\mu_r + \tau_{styr - a_0 - a - 1}\right)} e^{-(a - a_0)M}, & a_0 < a < a_+ \\ \dfrac{e^{(\mu_r)} e^{-(a - a_0)M}}{\left(1 - e^{-M}\right)}, & a = a_+ \end{cases}$$

Number at age of recruitment

Number at ages between recruitment and pooled age class

Number in pooled age class

Subsequent years

$$N_{y,a} = \begin{cases} e^{\left(\mu_r + \tau_y\right)}, & a = a_0 \\ N_{y-1,a-1} * e^{-Z_{y-1,a-1}}, & a_0 < a < a_+ \\ N_{y-1,a-1} * e^{-Z_{y-1,a-1}} + N_{y-1,a} * e^{-Z_{y-1,a}}, & a = a_+ \end{cases}$$

Number at age of recruitment

Number at ages between recruitment and pooled age class

Number in pooled age class

Formulae for likelihood components	**BOX 1 (Continued)**
$L_1 = \lambda_1 \sum_y \left(\ln\left[\frac{C_y + 0.01}{\hat{C}_y + 0.01} \right] \right)^2$	Catch likelihood
$L_2 = \lambda_2 \sum_y \frac{\left(I_y - \hat{I}_y\right)^2}{2 * \hat{\sigma}^2\left(I_y\right)}$	Survey biomass index likelihood
$L_3 = \lambda_3 \sum_{styr}^{endyr} -n^*{}_y \sum_a^{a+} \left(P_{y,a} + 0.001\right) * \ln\left(\hat{P}_{y,a} + 0.001\right)$	Fishery age composition likelihood
$L_4 = \lambda_4 \sum_{styr}^{endyr} -n^*{}_y \sum_l^{l+} \left(P_{y,l} + 0.001\right) * \ln\left(\hat{P}_{y,l} + 0.001\right)$	Fishery length composition likelihood
$L_5 = \lambda_5 \sum_{styr}^{endyr} -n^*{}_y \sum_a^{a+} \left(P_{y,a} + 0.001\right) * \ln\left(\hat{P}_{y,a} + 0.001\right)$	Survey age composition likelihood
$L_6 = \lambda_6 \sum_{styr}^{endyr} -n^*{}_y \sum_l^{l+} \left(P_{y,l} + 0.001\right) * \ln\left(\hat{P}_{y,l} + 0.001\right)$	Survey size composition likelihood
$L_7 = \frac{1}{2\sigma_q^2}\left(\ln \frac{q}{q_{prior}} \right)^2$	Penalty on deviation from prior distribution of catchability coefficient
$L_8 = \frac{1}{2\sigma_{\sigma_r}^2}\left(\ln \frac{\sigma_r}{\sigma_{r(prior)}} \right)^2$	Penalty on deviation from prior distribution of recruitment deviations
$L_9 = \lambda_9 \left[\frac{1}{2 * \sigma_r^2} \sum_y \tau_y^2 + n_y * \ln\left(\sigma_r\right) \right]$	Penalty on recruitment deviations
$L_{10} = \lambda_{10} \sum_y \phi_y^2$	Fishing mortality regularity penalty
$L_{11} = \lambda_{11} \bar{s}^2$	Average selectivity penalty (attempts to keep average selectivity near 1)
$L_{12} = \lambda_{12} \sum_{a_0}^{a_+} \left(s_i - s_{i+1}\right)^2$	Selectivity dome-shapedness penalty – only penalizes when the next age's selectivity is lower than the previous (penalizes a downward selectivity curve at older ages)
$L_{13} = \lambda_{13} \sum_{a_0}^{a_+} \left(FD(FD(s_i - s_{i+1})\right)^2$	Selectivity regularity penalty (penalizes large deviations from adjacent selectivities by adding the square of second differences)
$L_{total} = \sum_{i=1}^{13} L_i$	Total objective function value

Results

Model Evaluation

This model is identical in all aspects to the model accepted in 2011 except for inclusion of new data. When we present alternative model configurations, our usual criteria for choosing a superior model are: (1) the best overall fit to the data (in terms of negative log-likelihood), (2) biologically reasonable patterns of estimated recruitment, catchabilities, and selectivities, (3) a good visual fit to length and age compositions, and (4) parsimony. Because the 2011 and 2013 models are identical and we are not providing alternative model configurations for comparison with the current model, we will only evaluate the 2013 model based on changes in results from 2011.

The model generally produces good visual fits to the data, and biologically reasonable patterns of recruitment, abundance, and selectivities. The model does not fit the 2013 survey estimate well, likely due to the large increase in this estimate, with associated large uncertainty. Such large fluctuations are difficult to explain for a long-lived species with our current model configuration. The 2013 update shows recent recruitment is low but stable, and there was a slight increase in spawning and total biomass from previous projections. Therefore the, 2013 model is utilizing the new information effectively, and we use it to recommend 2014 ABC and OFL.

Time Series Results

Key results have been summarized in Tables 10.11 to 10.15. Model predictions fitted the data well (Figures 10.2 to 10.5 and 10.7) and most parameter estimates have remained similar to the last assessment's results.

Definitions

Spawning biomass is the biomass estimate of mature females. Total biomass is the biomass estimate of all northern rockfish age two and greater. Recruitment is measured as the number of age two northern rockfish. Fishing mortality is fully-selected *F*, meaning the mortality at the age the fishery has fully selected the fish.

Biomass and exploitation trends

The estimates of current population abundance indicate that it is dominated by older fish from the 1976 and 1984 year class, and the above average 1993 and 1997 year-classes (Table 10.12). Since the early 1990s the total biomass estimated in the model has been decreasing from a high of over 190,000 t in 1991. Similarly, the spawning biomass estimated in the model has also been decreasing since 1998. However, the fit to the survey biomass index fails to capture the apparent increase in northern rockfish abundance indicated by point estimates of the 2005, 2007, 2011, and 2013 trawl surveys (Figure 10.5). This is not surprising given the wide confidence intervals associated with these surveys (the most recent trawl survey in 2013 has a 60% coefficient of variation). Overall, the current status of the stock appears to be reasonably healthy and about equal to stock levels estimated last year and for the late 1970s (Figure 10.12 and Table 10.13).

Goodman et al. (2002) suggested that stock assessment authors use a "management path" graph as a way to evaluate management and assessment performance over time. In the management path we plot the ratio of fishing mortality to F_{OFL} ($F_{35\%}$) and the estimated spawning biomass relative to $B_{35\%}$. Harvest control rules based on $F_{35\%}$ and $F_{40\%}$ and the tier 3b adjustment are provided for reference. The historical management path for northern rockfish has been above the F_{OFL} adjusted limit for only a few years in the 1960s. In recent years, northern rockfish have been above $B_{35\%}$ and below $F_{35\%}$ (Figure 10.13).

Parameter estimates from this year's model were similar to the previous northern rockfish assessment (Table 10.11). The $F_{40\%}$ reference value changed slightly from 0.062 to 0.061. The trajectory of fishing mortality has remained below the $F_{40\%}$ level most of the time and below $F_{35\%}$ in all years except 1964-66 during the period of intense fishing for Pacific ocean perch (Figure 10.13). Selectivity estimates for the fishery and the survey are similar, but with the survey being somewhat more gradual with age. Compared to the maturity at age curve that is estimated, selectivity occurs at slightly younger ages than the age of maturity (Table 10.12 and Figure 10.14).

Recruitment

Recruitment estimates show a high degree of uncertainty, but indicate several large year-classes (Table 10.13 and 10.14 and Figure 10.15). Fits to the fishery and survey age compositions were reasonable but the "plus group" (age 33 and older) remain underestimated in recent years compared to the observed values (Figures 10.4 and 10.7). The model did not fit the fishery size comps well in the 1990s but fits very well in the 2000s (Figure 10.3). The pattern of stock-recruitment suggests that environmental variability plays a large role in determining recruitment strengths (Figure 10.16).

Uncertainty results

From the MCMC chains described in the *Uncertainty Approach* section, we summarize the posterior densities of key parameters for the recommended model using histograms (Figure 10.17). We also use these posterior distributions to show uncertainty around time series estimates such as spawning biomass (Table 10.14 and Figures 10.12 and 10.18). Table 10.15 shows the maximum likelihood estimate (MLE) of key parameters with their corresponding standard deviations derived from the Hessian matrix compared to the standard deviations derived from MCMC methods. The Hessian and MCMC standard deviations are similar for q and M, but the MCMC standard deviations are larger for the estimates of $F_{40\%}$, ABC, and female spawning biomass. These larger standard deviations indicate that these parameters are more uncertain than indicated by the standard estimates. The distributions of $F_{40\%}$, *ABC*, total biomass, and spawning biomass are skewed, indicating there is a possibility of biomass being higher than model estimates.

Harvest Recommendations

Amendment 56 Reference Points

Amendment 56 to the GOA Groundfish Fishery Management Plan defines the "overfishing level" (OFL), the fishing mortality rate used to set OFL (F_{OFL}), the maximum permissible ABC, and the fishing mortality rate used to set the maximum permissible ABC. The fishing mortality rate used to set ABC (F_{ABC}) may be less than this maximum permissible level, but not greater. Because reliable estimates of reference points related to maximum sustainable yield (MSY) are currently not available but reliable estimates of reference points related to spawning per recruit are available, Northern rockfish in the GOA are managed under Tier 3 of Amendment 56. Tier 3 uses the following reference points: $B_{40\%}$, equal to 40% of the equilibrium spawning biomass that would be obtained in the absence of fishing; $F_{35\%}$,,equal to the fishing mortality rate that reduces the equilibrium level of spawning per recruit to 35% of the level that would be obtained in the absence of fishing; and $F_{40\%}$, equal to the fishing mortality rate that reduces the equilibrium level of spawning per recruit to 40% of the level that would be obtained in the absence of fishing.

Estimation of the $B_{40\%}$ reference point requires an assumption regarding the equilibrium level of recruitment. In this assessment, it is assumed that the equilibrium level of recruitment is equal to the average of age-2 recruitments between 1979 and 2011. Because of uncertainty in very recent recruitment estimates, we lag 2 years behind model estimates in our projection. Other useful biomass reference points which can be calculated using this assumption are $B_{100\%}$ and $B_{35\%}$, defined analogously to $B_{40\%}$. The 2013 estimates of these reference points are:

$B_{100\%}$	$B_{40\%}$	$B_{35\%}$	$F_{40\%}$	$F_{35\%}$
75,183	30,073	26,314	0.061	0.073

Specification of OFL and Maximum Permissible ABC

Female spawning biomass for 2014 is estimated at 42,960 t. This is above the $B_{40\%}$ value of 30,073 t. Under Amendment 56, Tier 3, the maximum permissible fishing mortality for ABC is $F_{40\%}$ and fishing mortality for OFL is $F_{35\%}$. Applying these fishing mortality rates for 2014, yields the following ABC and OFL:

$F_{40\%}$	0.061
ABC	5,324
$F_{35\%}$	0.073
OFL	6,349

Projections and Status Determination

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 2013 numbers at age as estimated in the assessment. This vector is then projected forward to the beginning of 2014 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2013. 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 after 2013 is assumed to equal the catch associated with the respective harvest scenario in all years. This projection scheme is run 1,000 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 2014, 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 2014 and 2015, F is set equal to a constant fraction of *max* F_{ABC}, where this fraction is equal to the ratio of the realized catches in 2010-2012 to the ABC recommended in the assessment for each of those years. For the remainder of the future years, maximum permissible ABC is used. (Rationale: In many fisheries the ABC is routinely not fully utilized, so assuming an average ratio catch to ABC will yield more realistic projections.)

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 2009-2013 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 follows (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 1) above its MSY level in 2013 or 2) above ½ of its MSY level in 2013 and above its MSY level in 2023 under this scenario, then the stock is not overfished.)

Scenario 7: In 2014 and 2015, F is set equal to *max* F_{ABC}, and in all subsequent years F is set to 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 2026 under this scenario, then the stock is not approaching an overfished condition.)

Spawning biomass, fishing mortality, and yield are tabulated for the seven standard projection scenarios (Table 10.16). The difference for this assessment for projections is in Scenario 2 (Author's F); we use pre-specified catches to increase accuracy of short-term projections in fisheries where the catch is usually less than the ABC. This was suggested to help management with setting preliminary ABCs and OFLs for two-year ahead specifications.

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 2014, it does not provide the best estimate of OFL for 2015, because the mean 2014 catch under Scenario 6 is predicated on the 2014 catch being equal to the 2014 OFL, whereas the actual 2014 catch will likely be less than the 2014 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 catch estimate for the most recent complete year (2012) is 5,063 t. This is less than the 2012 OFL of 6,574 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. Harvest Scenarios #6 and #7 are used in these determinations as follows:

Is the stock currently overfished? This depends on the stock's estimated spawning biomass in 2013:
a. If spawning biomass for 2013 is estimated to be below ½ $B_{35\%}$, the stock is below its MSST.
b. If spawning biomass for 2013 is estimated to be above $B_{35\%}$ the stock is above its MSST.
c. If spawning biomass for 2013 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 10.16). If the mean spawning biomass for 2023 is below $B_{35\%}$, the stock is below its MSST. Otherwise, the stock is above its MSST.

Is the stock approaching an overfished condition? This is determined by referring to harvest Scenario #7:
a. If the mean spawning biomass for 2016 is below 1/2 $B_{35\%}$, the stock is approaching an overfished condition.
b. If the mean spawning biomass for 2016 is above $B_{35\%}$, the stock is not approaching an overfished condition.
c. If the mean spawning biomass for 2016 is above 1/2 $B_{35\%}$ but below $B_{35\%}$, the determination depends on the mean spawning biomass for 2026. If the mean spawning biomass for 2026 is below $B_{35\%}$, the stock is approaching an overfished condition. Otherwise, the stock is not approaching an overfished condition.

Based on the above criteria and Table 10.16, the stock is not overfished and is not approaching an overfished condition.

Specified catch estimation

In response to Gulf of Alaska Plan Team minutes in 2010, we have established a consistent methodology for estimating current-year and future-year catches in order to provide more accurate two-year projections of ABC and OFL to management. In the past, two standard approaches in rockfish models have been employed; assume the full TAC will be taken, or use a certain date prior to publication of assessments as a final estimate of catch for that year. Both methods have disadvantages. If the author assumes the full TAC is taken every year, but it rarely is, the ABC will consistently be underestimated. Conversely, if the author assumes that the catch taken by around October is the final catch, and substantial catch is taken thereafter, ABC will consistently be overestimated. Therefore, going forward in the Gulf of Alaska rockfish assessments, for current year catch, we are applying an expansion factor to the official catch on or near October 1 by the 3-year average of catch taken between October 1 and December 31 in the last three complete catch years (e.g. 2010-2012 for this year, see example Figures below). For northern rockfish, the expansion factor for 2013 catch is 1.04.

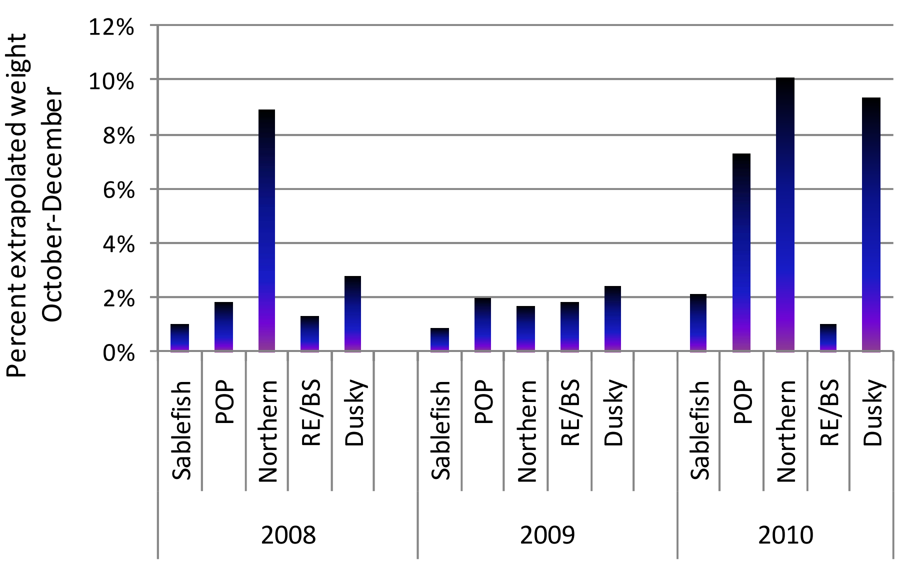


Figure. Extrapolated catch that occurs between October and December, 2008-2010.

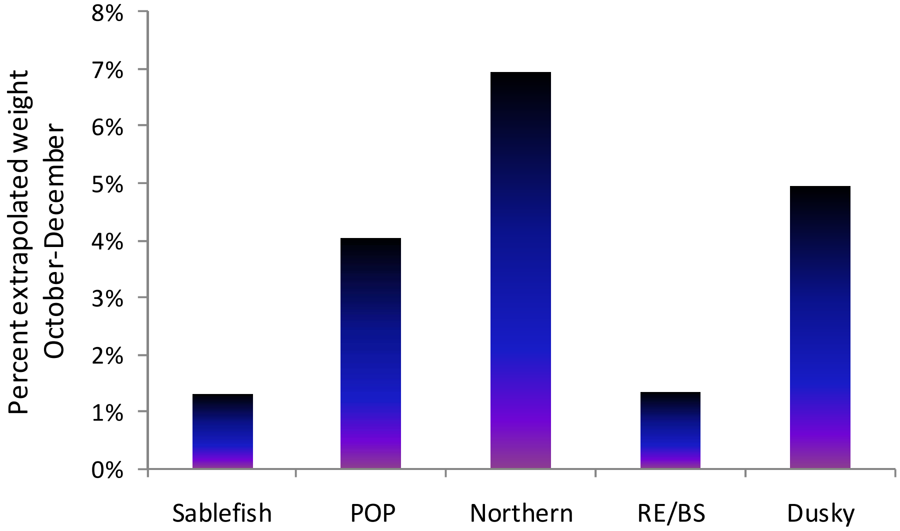


Figure. Examples of mean proportion of catch between October-December, 2008-2010.

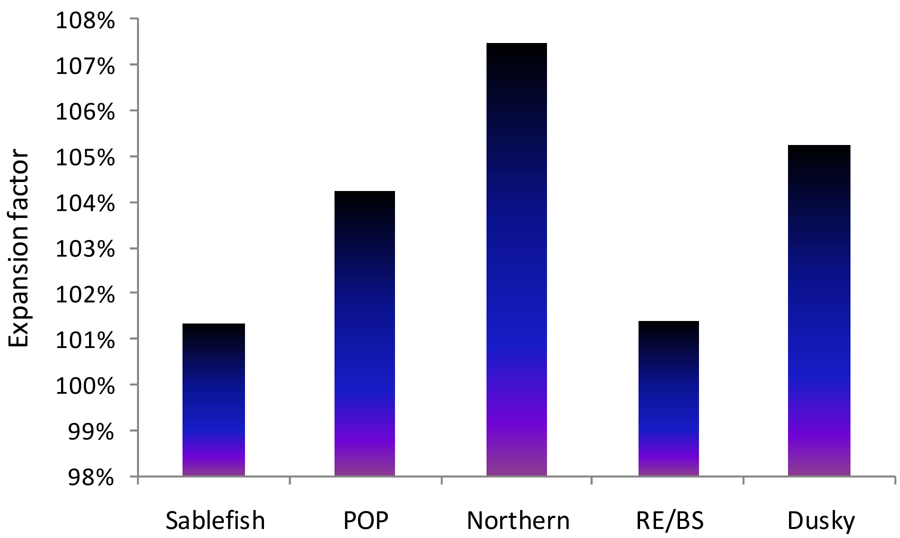


Figure. Expansion factor: $x = \sum_1^{12} C_y / \sum_1^{9} C_y$, where C_y is catch in month *y*.

For catch projections into the next two years, we are using the ratio of the last three official catches to the last three TACs multiplied against the future two years' ABCs (if TAC is normally the same as ABC). This method results in slightly higher ABCs in each of the future two years of the projection, based on both the lower catch in the first year out, and based on the amount of catch taken before spawning in the projection two years out.

Alternate Projection

During the 2006 rockfish CIE review, it was suggested that projections should account for uncertainty in the entire assessment, not just recruitment from the endpoint of the assessment. We continue to present an alternative projection scenario using the uncertainty of the full assessment model, harvesting at maxABC which is analogous to Alternative 1. This projection propagates uncertainty throughout the entire assessment procedure and is based on an MCMC chain of 20,000,000. The projection shows wide credibility intervals on future spawning biomass (Figure 10.18). The $B_{35\%}$ and $B_{40\%}$ reference points are based on the 1977-2009 year classes, and this projection predicts that the median spawning biomass will eventually dip to $B_{35\%}$ harvesting at maxABC in future years.

Apportionment of ABC

Since 1996 for slope rockfish including northern rockfish, the apportionment of ABC among areas has been determined from the weighted average of the proportion of exploitable biomass by area in the most recent three triennial trawl surveys. Assuming that survey error contributes 2/3 of the total variability in predicting the distribution of biomass, the weight of a prior survey should be 2/3 the weight of the preceding survey. This results in weights of 4:6:9 for the 2009, 2011, and 2013 surveys, respectively.

Based on the tables below, area apportionments for Gulf of Alaska northern rockfish are 24.52% for the Western area, 75.45% for the Central area, and 0.03% for the Eastern area. Applying these apportionments to the recommended ABC for northern rockfish results in 1,305 t for the Western area, 4,017 t for the Central area, and 2 t for the Eastern area. In comparison to the previous apportionments in 2011, the addition of the 2013 trawl biomass estimate results in an increase in apportionment for the Central area and a decrease for the Western area. For management purposes, the small ABC of northern rockfish in the Eastern area is combined with other slope rockfish.

Estimated trawl survey biomass by area for northern rockfish in the Gulf of Alaska.

	Western	Central		Eastern		
Year	Shumagin	Chirikof	Kodiak	Yakutat	Southeast	Total
2009	44,693	8,842	36,291	70	0	89,896
2011	47,082	91,774	34,757	28	0	173,641
2013	42,936	304,516	22,927	76	0	370,454

Percentage of trawl survey biomass by area and 2012 apportionment of ABC for northern rockfish in the Gulf of Alaska.

		Western	Central		Eastern		
Year	Weights	Shumagin	Chirikof	Kodiak	Yakutat	Southeast	Total
2009	4	49.72%	9.84%	40.37%	0.08%	0.00%	100%
2011	6	27.11%	52.85%	20.02%	0.02%	0.00%	100%
2013	9	11.59%	82.20%	6.19%	0.02%	0.00%	100%
Weighted average		24.52%	75.45%		0.03%		100%
Area ABC		**1,305**	**4,017**		**2**		**5,324**

Ecosystem Considerations

In general, a determination of ecosystem considerations for slope rockfish is hampered by the lack of biological and habitat information. A summary of the ecosystem considerations presented in this section is listed in Table 10.17.

Ecosystem Effects on the Stock

Prey availability/abundance trends: Similar to many other rockfish species, stock condition of slope rockfish appears to be influenced by periodic abundant year-classes. Availability of suitable zooplankton prey items in sufficient quantity for larval or post-larval northern rockfish may be an important determining factor of year-class strength. Unfortunately, there is no information on the food habits of larval or post-larval rockfish to help determine possible relationships between prey availability and year-class strength. Moreover, identification to the species level for field collected larval slope rockfish is difficult. Visual identification is not possible, though genetic techniques allow identification to species level for larval slope rockfish (Gharrett et al. 2001). Some juvenile rockfish found in inshore habitat feed on shrimp, amphipods, and other crustaceans, as well as some mollusk and fish (Byerly 2001). Adult slope rockfish such as Pacific ocean perch and northern rockfish feed on euphausiids. Adult rockfish such as shortraker and rougheye are probably opportunistic feeders with more mollusks and fish in their diet. Little if anything is known about abundance trends of likely rockfish prey items. Euphausiids are also a major item in the diet of walleye pollock. Changes in the abundance of walleye pollock could lead to a corollary change in the availability of euphausiids, which would then have an impact on Pacific ocean perch and northern rockfish.

Predator population trends: Rockfish are preyed on by a variety of other fish at all life stages and to some extent by marine mammals during late juvenile and adult stages. Whether or not the impact of any particular predator is significant or dominant is unknown. Predator effects would likely be more important on larval, post-larval, and small juvenile slope rockfish, but information on these life stages and their predators is nil.

Changes in physical environment: Strong year-classes corresponding to the period around 1977 have been reported for many species of groundfish in the Gulf of Alaska, including Pacific ocean perch, northern rockfish, sablefish, and Pacific cod. Therefore, it appears that environmental conditions may have changed during this period in such a way that survival of young-of-the-year fish increased for many groundfish species, including slope rockfish. Pacific ocean perch appear to have had a strong 1986 or 1987 year-class, and northern rockfish appear to have had a strong 1984 year-class. There may be other years when environmental conditions were especially favorable for rockfish species. The environmental mechanism for this increased survival remains unknown. Changes in water temperature and currents could have effects on prey item abundance and success of transition of rockfish from pelagic to demersal stage. Rockfish in early juvenile stage have been found in floating kelp patches which are subject to ocean currents.

Changes in bottom habitat due to natural or anthropogenic causes could alter survival rates by altering available shelter, prey, or other functions. Submersible studies on the GOA shelf observed juvenile red rockfish closely associated with sponges that were growing on boulders (Freese and Wing 2003). The Essential Fish Habitat Environmental Impact Statement (EFH EIS) (NMFS 2005) concluded that the effects of commercial fishing on the habitat of groundfish is minimal or temporary based largely on the the criterion that groundfish stocks were above Minimum Stock Size Threshold (MSST). However, such criteria is inadequate to make such a conclusion (Drinkwater 2004). While proof of adverse effects on habitat would be difficult to obtain, the lack of an increasing trend in stock abundance and relatively low levels of recent recruitment are not supportive of the EIS conclusions.

Rockfish fishery effects on the ecosystem

Fishery-specific contribution to bycatch of HAPC biota: In the Gulf of Alaska, bottom trawl fisheries for pollock, deepwater flatfish, and Pacific ocean perch account for most of the observed bycatch of coral, while rockfish fisheries account for little of the bycatch of sea anemones, sea whips, and sea pens. The bottom trawl fisheries for Pacific ocean perch and Pacific cod and the pot fishery for Pacific cod account for most of the observed bycatch of sponges (Table 10.4).

Fishery-specific concentration of target catch in space and time relative to predator needs in space and time (if known) and relative to spawning components: The directed slope rockfish trawl fishery that begins in July is concentrated in known areas of abundance and typically lasts only a few weeks. The annual exploitation rates on rockfish are thought to be quite low. Insemination is likely in the fall or winter, and parturition is likely mostly in the spring. Hence, reproductive activities are probably not directly affected by the commercial fishery.

Fishery-specific effects on amount of large size target fish: No evidence for targeting large fish.

Fishery contribution to discards and offal production: Fishery discard rates of northern rockfish during 2002-2010 have been 1.5 – 10.0%.

Fishery-specific effects on age-at-maturity and fecundity of the target fishery: Unknown.

Fishery-specific effects on EFH living and non-living substrate: Unknown, but the heavy-duty "rockhopper" trawl gear commonly used in the fishery can disturb seafloor habitat. Table 10.4 shows the estimated bycatch of living structure such as benthic urochordates, corals, sponges, sea pens, and sea anemones by the GOA rockfish fisheries. The average bycatch of corals/bryozoans (0.78 t), and sponges (2.98 t) by rockfish fisheries are a large proportion of the catch of those species taken by all Gulfwide fisheries.

Data Gaps and Research Priorities

Life history and habitat utilization

There is little information on larval, post-larval, or early life history stages of northern rockfish. Habitat requirements for larval, post-larval, and early stages are mostly unknown. Habitat requirements for later stage juvenile and adult fish are anecdotal or conjectural. Research needs to be done on the bottom habitat of the major fishing grounds, on what HAPC biota are found on these grounds, and on what impact bottom trawling may have on these biota.

Assessment Data

The highly variable biomass estimates for northern rockfish suggest that the stratified random design of the surveys does a relatively poor job of assessing stock condition of northern rockfish and that a different survey approach may be needed to reduce the variability in biomass estimates. In particular, the CIE review report recommended that assumptions about extending area-swept estimates of biomass in trawlable versus untrawlable grounds may impact catchability assumptions. The AFSC is currently undertaking a study on habitat classifications so that assumptions about catchability, in particular, time-dependent changes in catchability, can be more rigorously established.

Given the substantial influence of maturity-at-age on management quantities (i.e., ABC) we strongly suggest that continued research be devoted to collecting maturity-at-age data for northern and other Gulf of Alaska rockfish. A study is currently underway in which a larger sample size for northern rockfish has been collected compared to previous studies, with this additional study we intend to investigate possible time-dependent maturity. However, to fully understand changes in maturity over time, continued effort would be required to collect and analyze rockfish maturity samples.

For northern rockfish and the other Gulf of Alaska rockfish assessed with age-structured models, we plan to become more consistent and optimize methods for 1) determining multinomial sample sizes, 2) assigning age and length bin compositions, and 3) examining changes in growth over time.

We plan to follow the recommendations listed in the various working group reports (e.g. the methods for averaging surveys report) submitted to the Plan Team in September 2012. In addition, we anticipate that many of the comments specific to the northern rockfish assessment during the 2013 Center for Independent Experts (CIE) Alaska rockfish scientific peer review will be incorporated. Please refer to the Summary and response to the 2013 CIE review of AFSC rockfish document presented to the September 2013 Plan Team for further details.

Summary

A summary of biomass levels, exploitation rates and recommended ABCs and OFLs for northern rockfish is in the following table:

Quantity	As estimated or specified *last* year for: 2013	2014	As estimated or recommended *this* year for: 2014	2015[1]
M (natural mortality)	0.06	0.06	0.06	0.06
Tier	3a	3a	3a	3a
Projected total (age 2+) biomass (t)	99,089	95,690	102,893	98,572
Female spawning biomass (t)				
Projected[2]				
Upper 95% confidence interval			91,994	84,810
Point Estimate	40,452	37,935	42,960	40,004
Lower 95% confidence interval			17,755	16,706
$B_{100\%}$	72,983	72,983	75,183	75,183
$B_{40\%}$	29,193	29,193	30,073	30,073
$B_{35\%}$	25,544	25,544	26,314	26,314
F_{OFL}	0.074	0.074	0.073	0.073
$maxF_{ABC}$	0.062	0.062	0.061	0.061
F_{ABC}	0.062	0.062	0.061	0.061
OFL (t)	**6,124**	5,791	**6,349**	5,978
maxABC (t)	5,132	4,852	**5,324**	5,012
ABC (t)	**5,132**	4,852	**5,324**	5,012
Status	As determined *last* year for: 2011	2012	As determined *this* year for: 2012	2013
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

[1]Projected ABCs and OFLs for 2014 and 2015 are derived using estimated catch of 4,770 for 2013, and projected catches of 4,248 t and 3,999 t for 2014 and 2015 based on realized catches from 2010-2012. This calculation is in response to management requests to obtain more accurate projections

[2]Projected upper and lower 95% confidence intervals for female spawning biomass are derived from the MCMC estimated posterior distribution as presented in Table 10.14.

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Table 10.1. A summary of key management measures and the time series of catch, ABC and TAC for northern rockfish in the Gulf of Alaska.

Year	Catch (t)	ABC	TAC		Management Measures
1988*	1,107				The slope rockfish assemblage, including northern rockfish, was one of three management groups for *Sebastes* implemented by the North Pacific Management Council. Previously, *Sebastes* in Alaska were managed as "Pacific ocean perch complex" or "other rockfish"
1989*	1,527				
1990*	1,716				
1991*	4,528				Slope assemblage split into three management subgroups with separate ABCs and TACs: Pacific ocean perch, shortraker/rougheye rockfish, and all other slope species
1992*	7,770				
1993	4,820	5,760	5,760		Northern rockfish designated as a subgroup of slope rockfish with separate ABC and TAC
1994	5,966	5,760	5,760		
1995	5,635	5,270	5,270		
1996	3,340	5,720	5,270		
1997	2,935	5,000	5,000		
1998	3,055	5,000	5,000		
1999	5,409	4,990	4,990		Eastern GOA divided into West Yakutat and East Yakutat/Southeast Outside in response to trawl closure in Eastern GOA. Because northern rockfish are scarce in Eastern GOA, the ABC and TAC for northern rockfish in Eastern GOA allocated to West Yakutat ABC as part of "other slope rockfish".
2000	3,333	5,120	5,120		Amendment 41 became effective which prohibited trawling in the Eastern Gulf east of 140 degrees W. Preliminary age-structured model results presented for northern rockfish.
2001	3,133	4,880	4,880		Assessment and harvest recommendations now based on using an age structured model constructed with AD Model Builder software.
2002	3,339	4,770	4,770		
2003	5,256	5,530	5,530		
2004	4,811	4,870	4,870		
2005	4,522	5,091	5,091		
2006	4,958	5,091	5,091		
2007	4,187	4,938	4,938		Amendment 68 created the Central Gulf Rockfish Pilot Project
2008	4,052	4,549	4,549		
2009	3,952	4,362	4,362		
2010	3,902	5,098	5,098		
2011	3,440	4,854	4,854		
2012	5,063	5,507	5,507		
2013	4,569	5,130	5,130		

* Northern rockfish managed as part of the slope rockfish assemblage and not assigned separate ABC/TAC

Table 10.2. Commercial catch (t) and management action for northern rockfish in the Gulf of Alaska, 1961-present. The *Description of the catch time series* Section describes procedures used to estimate catch during 1961-1993. Catch estimates for 1993-2013 are from NMFS Observer Program and Alaska Regional Office updated through October 5, 2013.

Year	Foreign	Joint venture	Domestic	Total	TAC	%TAC
1961	800	-	-	800	-	-
1962	3,250	-	-	3,250	-	-
1963	6,815	-	-	6,815	-	-
1964	12,170	-	-	12,170	-	-
1965	17,430	-	-	17,430	-	-
1966	10,040	-	-	10,040	-	-
1967	6,000	-	-	6,000	-	-
1968	5,010	-	-	5,010	-	-
1969	3,630	-	-	3,630	-	-
1970	2,245	-	-	2,245	-	-
1971	3,875	-	-	3,875	-	-
1972	3,880	-	-	3,880	-	-
1973	2,820	-	-	2,820	-	-
1974	2,550	-	-	2,550	-	-
1975	2,520	-	-	2,520	-	-
1976	2,275	-	-	2,275	-	-
1977	622	-	-	622	-	-
1978	553	-	-	554	-	-
1979	666	3	-	670	-	-
1980	809	tr	-	810	-	-
1981	1,469	-	-	1,477	-	-
1982	3,914	-	-	3,920	-	-
1983	2,705	911	-	3,618	-	-
1984	494	497	10	1,002	-	-
1985	tr	115	70	185	-	-
1986	tr	11	237	248	-	-
1987	-	56	427	483	-	-
1988[1]	-	tr	1,107	1,107	-	-
1989	-	-	1,527	1,527	-	-
1990	-	-	1,697	1,716	-	-
1991[2]	-	-	4,528	4,528	-	-
1992	-	-	7,770	7,770	-	-

[1] 1988 - Slope rockfish assemblage management implemented by NPFMC.
[2] 1991 - Slope rockfish divided into 3 management subgroups: Pacific ocean perch, shortraker/ rougheye, and other slope rockfish.

Table 10.2 (continued). Commercial catch (t) and management action for northern rockfish in the Gulf of Alaska, 1961-present. The *Description of the catch time series* Section describes procedures used to estimate catch during 1961-1993. Catch estimates for 1993-2013 are from NMFS Observer Program and Alaska Regional Office updated through October 5, 2013.

Year	Foreign	Joint venture	Domestic	Total	TAC	%TAC
1993[3]	-	-	4,820	4,820	5,760	84%
1994	-	-	5,966	5,966	5,760	104%
1995	-	-	5,635	5,635	5,270	107%
1996	-	-	3,340	3,340	5,270	63%
1997	-	-	2,935	2,935	5,000	59%
1998	-	-	3,055	3,055	5,000	61%
1999	-	-	5,409	5,409	4,990	108%
2000	-	-	3,333	3,333	5,120	65%
2001	-	-	3,133	3,133	4,880	64%
2002	-	-	3,339	3,339	4,770	70%
2003	-	-	5,256	5,256	5,530	95%
2004	-	-	4,811	4,811	4,870	99%
2005	-	-	4,522	4,522	5,091	89%
2006	-	-	4,958	4,958	5,091	97%
2007[4]	-	-	4,187	4,187	4,938	85%
2008	-	-	4,052	4,052	4,549	89%
2009	-	-	3,952	3,952	4,362	91%
2010	-	-	3,902	3,902	5,098	77%
2011	-	-	3,440	3,440	4,854	71%
2012	-	-	5,063	5,063	5,507	92%
2013*	-	-	4,569	4,569	5,130	89%

[3] 1993 – A fourth management subgroup, northern rockfish, was created
[4] 2007 – Central Gulf Rockfish Pilot Project implemented for rockfish fishery.
* Catch as of 10/5/2013.

Table 10.3. FMP groundfish species caught in rockfish targeted fisheries in the Gulf of Alaska from 2008-2013. Conf. = Confidential because of less than three vessels. Source: NMFS AKRO Blend/Catch Accounting System via AKFIN 11/7/2013.

	Estimated Catch (t)					
Group Name	2008	2009	2010	2011	2012	2013
Pacific Ocean Perch	12,135	12,397	14,974	13,120	13,953	10,969
Northern Rockfish	3,805	3,855	3,833	3,163	4,883	4,365
Pelagic Shelf Rockfish	3,521	2,956	2,965	2,324	-	-
Dusky Rockfish	-	-	-	-	3,642	2,711
Atka Mackerel	1,744	1,913	2,148	1,404	1,173	1,161
Pollock	390	1,280	1,046	811	574	806
Arrowtooth Flounder	517	502	706	340	763	659
Pacific Cod	445	631	734	560	404	573
Other Rockfish	632	736	737	657	889	473
Sablefish	503	404	388	440	469	448
Rougheye Rockfish	104	97	179	286	219	269
Shortraker Rockfish	231	247	134	239	303	263
Demersal Shelf Rockfish	43	72	30	26	110	135
Thornyhead Rockfish	248	185	106	161	130	94
Shark	0	0	0	5	5	88
Rex Sole	67	83	93	51	72	83
Sculpin	0	0	0	39	55	69
Shallow Water Flatfish	71	53	47	48	65	26
Deep Water Flatfish	29	30	48	57	54	24
Flathead Sole	19	32	24	13	16	24
Skate, Longnose	12	17	12	25	23	20
Skate, Other	10	14	28	14	20	19
Squid	0	0	0	12	15	9
Skate, Big	4	4	14	8	13	2
Octopus	0	0	0	1	1	1

Table 10.4. Non-FMP species bycatch estimates in tons for Gulf of Alaska rockfish targeted fisheries 2008 - 2013. Conf. = Confidential because of less than three vessels. Source: NMFS AKRO Blend/Catch Accounting System via AKFIN 11/7/2013.

	Estimated Catch (t)					
Group Name	2008	2009	2010	2011	2012	2013
Benthic urochordata	0.27	Conf.	0.08	Conf.	Conf.	Conf.
Birds	Conf.	0.03	-	Conf.	Conf.	6.48
Bivalves	0.00	Conf.	0.01	0.01	0.01	Conf.
Brittle star unidentified	0.04	0.03	0.02	0.01	0.03	0.03
Capelin	-	0.00	-	-	-	0.02
Corals Bryozoans	0.47	0.59	0.42	0.38	0.59	0.2
Dark Rockfish	17.86	46.98	112.03	12.82	59.03	42.28
Eelpouts	0.35	0.00	0.05	Conf.	0.3	Conf.
Eulachon	0.01	0.03	0.00	0.00	0.01	0.13
Giant Grenadier	161.3	684.57	539.49	418.91	347.87	836.31
Greenlings	14.73	8.1	9.52	7.91	9.05	7.35
Grenadier	3.43	3.11	34.94	110.49	89.67	9.00
Hermit crab unidentified	0.01	0.01	0.01	0.02	Conf.	0.03
Invertebrate unidentified	0.24	0.30	5.05	0.36	3.86	0.18
Lanternfishes	-	0.00	Conf.	-	-	Conf.
Misc crabs	0.07	0.10	0.07	0.04	0.05	0.01
Misc crustaceans	-	1.74	0.02	Conf.	-	Conf.
Misc deep fish	0.00	-	-	-	-	Conf.
Misc fish	195.64	134.74	167.1	133.25	156.73	160.98
Misc inverts (worms etc)	0.01	Conf.	-	Conf.	-	-
Other osmerids	Conf.	0.16	0.00	-	Conf.	0.00
Pacific Sand lance	-	-	-	Conf.	-	-
Pandalid shrimp	0.11	0.09	0.22	0.06	0.06	0.04
Polychaete unidentified	-	-	-	-	-	Conf.
Scypho jellies	0.11	0.70	1.87	0.00	0.16	0.47
Sea anemone unidentified	0.69	3.24	1.56	4.10	6.33	4.01
Sea pens whips	Conf.	0.01	0.01	0.04	-	0.02
Sea star	1.16	1.86	1.38	1.53	0.98	0.89
Snails	0.18	10.63	0.20	0.23	1.26	0.15
Sponge unidentified	2.97	6.65	3.66	4.41	1.39	1.32
Stichaeidae	-	0.01	-	-	-	Conf.
urchins dollars cucumbers	0.26	1.53	0.22	0.44	0.31	0.25

Table 10.5. Prohibited Species Catch (PSC) estimates reported in tons for halibut and herring, and thousands of animals for crab and salmon, by year, for the GOA rockfish fishery. Source: NMFS AKRO Blend/Catch Accounting System PSCNQ via AKFIN 11/7/2013.

Group Name	2007	2008	2009	2010	2011	2012	Average
Bairdi Crab	0.16	0.06	0.62	0.10	0.03	0.09	0.18
Blue King Crab	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chinook Salmon	2.03	2.28	1.39	1.57	1.02	1.60	1.65
Golden K. Crab	0.13	0.34	3.28	3.00	0.13	0.11	1.17
Halibut	137	160	112	141	108	109	128
Herring	0.02	0.04	0.00	0.15	0.00	0.00	0.04
Other Salmon	0.72	0.50	0.47	0.37	0.21	0.31	0.43
Opilio Crab	0.00	0.00	0.14	0.00	0.00	0.00	0.02
Red King Crab	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 10.6. Fishery length (cm) compositions used in the assessment model for northern rockfish in the Gulf of Alaska (at-sea and port samples combined).

Length class (cm)	Year										
	1991	1992	1993	1994	1995	1996	1997	2003	2007	2009	2011
15	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21	0.000	0.000	0.005	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	0.001	0.000	0.005	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
23	0.002	0.000	0.006	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
24	0.002	0.000	0.008	0.001	0.002	0.001	0.002	0.001	0.000	0.001	0.000
25	0.002	0.000	0.008	0.002	0.004	0.002	0.006	0.001	0.001	0.000	0.000
26	0.004	0.000	0.007	0.006	0.007	0.006	0.014	0.004	0.001	0.001	0.000
27	0.005	0.000	0.008	0.008	0.011	0.007	0.020	0.006	0.002	0.002	0.000
28	0.008	0.001	0.012	0.013	0.011	0.005	0.021	0.007	0.003	0.002	0.000
29	0.011	0.003	0.015	0.013	0.013	0.007	0.021	0.016	0.006	0.003	0.001
30	0.023	0.006	0.018	0.016	0.017	0.011	0.019	0.027	0.012	0.007	0.001
31	0.041	0.015	0.028	0.025	0.021	0.010	0.014	0.044	0.016	0.016	0.002
32	0.071	0.032	0.046	0.038	0.029	0.019	0.015	0.064	0.033	0.021	0.005
33	0.122	0.053	0.074	0.070	0.049	0.036	0.029	0.083	0.046	0.030	0.011
34	0.179	0.094	0.100	0.111	0.085	0.061	0.054	0.083	0.065	0.044	0.023
35	0.194	0.139	0.140	0.161	0.126	0.109	0.115	0.085	0.088	0.079	0.051
36	0.144	0.157	0.148	0.183	0.151	0.151	0.159	0.072	0.104	0.093	0.076
37	0.090	0.154	0.113	0.157	0.156	0.169	0.173	0.076	0.118	0.105	0.103
38+	0.102	0.346	0.238	0.193	0.317	0.406	0.337	0.431	0.505	0.595	0.725
Sample size	15,466	15,207	12,525	8,905	12,370	12,496	5,262	7,387	7,944	6,408	5,121
# Hauls	147	125	94	90	121	108	73	374	489	422	403

Table 10.7. Fishery age compositions for northern rockfish in the Gulf of Alaska. All age compositions are based on "break and burn" reading of otoliths.

Age	Year									
	1998	1999	2000	2001	2002	2004	2005	2006	2008	2010
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.006	0.002	0.000	0.000	0.001	0.000	0.000	0.000	0.000
6	0.004	0.003	0.024	0.011	0.000	0.015	0.000	0.006	0.000	0.000
7	0.006	0.006	0.005	0.055	0.032	0.008	0.021	0.002	0.006	0.000
8	0.034	0.000	0.015	0.024	0.151	0.036	0.045	0.046	0.020	0.012
9	0.022	0.042	0.019	0.031	0.070	0.111	0.066	0.064	0.026	0.024
10	0.032	0.013	0.043	0.038	0.055	0.176	0.147	0.070	0.078	0.032
11	0.058	0.029	0.031	0.049	0.042	0.050	0.164	0.132	0.068	0.060
12	0.070	0.039	0.058	0.042	0.044	0.035	0.052	0.070	0.048	0.115
13	0.094	0.049	0.053	0.053	0.047	0.036	0.017	0.048	0.093	0.072
14	0.094	0.062	0.048	0.051	0.032	0.028	0.031	0.034	0.076	0.052
15	0.068	0.127	0.074	0.040	0.031	0.027	0.038	0.034	0.030	0.068
16	0.078	0.065	0.094	0.053	0.047	0.032	0.026	0.020	0.022	0.052
17	0.034	0.058	0.067	0.084	0.068	0.015	0.019	0.016	0.012	0.028
18	0.034	0.042	0.060	0.060	0.067	0.025	0.031	0.038	0.006	0.018
19	0.022	0.019	0.024	0.044	0.032	0.046	0.026	0.028	0.012	0.016
20	0.026	0.023	0.022	0.027	0.026	0.058	0.033	0.020	0.022	0.024
21	0.044	0.032	0.010	0.035	0.023	0.035	0.045	0.040	0.020	0.022
22	0.050	0.029	0.043	0.018	0.021	0.029	0.024	0.050	0.016	0.032
23	0.036	0.075	0.034	0.033	0.013	0.023	0.026	0.036	0.038	0.014
24	0.030	0.042	0.046	0.033	0.029	0.011	0.009	0.024	0.050	0.014
25	0.022	0.010	0.022	0.044	0.044	0.012	0.009	0.010	0.028	0.034
26	0.024	0.026	0.029	0.042	0.028	0.021	0.005	0.012	0.030	0.030
27	0.012	0.016	0.014	0.013	0.011	0.039	0.026	0.018	0.022	0.016
28	0.010	0.042	0.021	0.020	0.008	0.029	0.031	0.018	0.006	0.020
29	0.026	0.036	0.024	0.009	0.010	0.012	0.024	0.034	0.014	0.014
30	0.020	0.023	0.041	0.018	0.011	0.017	0.028	0.032	0.026	0.024
31	0.006	0.029	0.019	0.020	0.011	0.011	0.007	0.022	0.028	0.014
32	0.010	0.013	0.014	0.013	0.011	0.008	0.002	0.006	0.034	0.024
33+	0.030	0.042	0.046	0.038	0.034	0.054	0.047	0.070	0.165	0.173
Sample size	498	308	585	451	616	746	422	500	497	503
# Hauls	51	160	187	156	187	270	211	206	311	311

Table 10.8. Biomass estimates (t), by statistical area, for northern rockfish in the Gulf of Alaska based on triennial and biennial trawl surveys. Gulfwide CV's are also listed.

Year	Statistical areas					Total	CV
	Shumagin	Chirikof	Kodiak	Yakutat	South-eastern		
1984	27,716	5,165	6,448	5	0	39,334	29%
1987	45,038	13,794	77,084	500	0	136,417	29%
1990	32,898	5,792	68,044	343	0	107,076	42%
1993	13,995	40,446	49,998	41	0	104,480	35%
1996	28,114	40,447	30,212	192	0	98,965	27%
1999	45,457	29,946	166,665	118	0	242,187	61%
2001	93,291	24,490	225,833	117[a]	0[a]	343,731	60%
2003	9,146	49,793	7,336	5	0	66,310	48%
2005	231,110	102,605	25,123	160	0	358,998	37%
2007	114,222	92,250	20,559	38	0	227,069	38%
2009	44,693	8,842	36,290	70	0	89,896	32%
2011	47,082	91,774	34,757	28	0	173,641	39%
2013	42,936	304,516	22,927	76	0	370,454	60%

[a]Biomass estimates are not available for the Yakutat and Southeastern areas in 2001 because these areas were not sampled that year. Substitute values are listed in this table and were obtained by averaging the biomass estimates for each of these areas in the 1993, 1996, and 1999 surveys.

Table 10.9. Survey age compositions for northern rockfish in the Gulf of Alaska. All age compositions are based on "break and burn" reading of otoliths.

Age	Year											
	1984	1987	1990	1993	1996	1999	2001	2003	2005	2007	2009	2011
2	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.003	0.001	0.003	0.002	0.000	0.005	0.001	0.000	0.000	0.000	0.000
4	0.000	0.018	0.002	0.003	0.001	0.002	0.003	0.001	0.001	0.000	0.000	0.001
5	0.014	0.055	0.029	0.009	0.002	0.011	0.006	0.035	0.001	0.001	0.003	0.000
6	0.040	0.041	0.054	0.011	0.011	0.003	0.013	0.021	0.014	0.007	0.000	0.000
7	0.091	0.030	0.027	0.011	0.006	0.009	0.041	0.014	0.037	0.004	0.007	0.000
8	0.191	0.003	0.041	0.063	0.021	0.009	0.016	0.096	0.052	0.029	0.015	0.002
9	0.112	0.029	0.054	0.120	0.041	0.042	0.038	0.126	0.047	0.090	0.023	0.003
10	0.051	0.101	0.045	0.065	0.053	0.028	0.072	0.056	0.061	0.057	0.050	0.015
11	0.046	0.112	0.058	0.103	0.085	0.079	0.061	0.036	0.047	0.073	0.071	0.019
12	0.026	0.112	0.035	0.044	0.076	0.069	0.040	0.029	0.033	0.063	0.054	0.023
13	0.071	0.034	0.054	0.049	0.077	0.054	0.063	0.021	0.011	0.082	0.060	0.040
14	0.067	0.043	0.082	0.040	0.040	0.056	0.049	0.051	0.021	0.031	0.063	0.040
15	0.063	0.014	0.097	0.024	0.033	0.078	0.050	0.033	0.012	0.017	0.038	0.021
16	0.040	0.037	0.051	0.052	0.039	0.092	0.054	0.043	0.020	0.026	0.034	0.028
17	0.019	0.103	0.051	0.031	0.017	0.016	0.045	0.000	0.032	0.020	0.021	0.059
18	0.019	0.041	0.007	0.040	0.034	0.072	0.058	0.018	0.031	0.010	0.034	0.017
19	0.006	0.080	0.011	0.028	0.054	0.019	0.029	0.030	0.008	0.020	0.033	0.016
20	0.007	0.027	0.066	0.004	0.088	0.013	0.022	0.061	0.039	0.028	0.028	0.023
21	0.003	0.026	0.066	0.023	0.028	0.030	0.017	0.012	0.046	0.033	0.016	0.022
22	0.010	0.007	0.046	0.034	0.031	0.022	0.012	0.021	0.019	0.038	0.010	0.029
23	0.031	0.007	0.019	0.044	0.030	0.025	0.027	0.011	0.012	0.049	0.027	0.021
24	0.021	0.003	0.009	0.045	0.033	0.030	0.045	0.007	0.012	0.011	0.041	0.039
25	0.006	0.004	0.010	0.046	0.027	0.020	0.029	0.014	0.021	0.012	0.046	0.031
26	0.003	0.017	0.034	0.007	0.052	0.015	0.042	0.025	0.025	0.014	0.027	0.015
27	0.010	0.026	0.006	0.017	0.014	0.034	0.012	0.030	0.022	0.027	0.017	0.047
28	0.004	0.012	0.012	0.022	0.015	0.025	0.009	0.054	0.037	0.028	0.014	0.034
29	0.009	0.003	0.002	0.006	0.028	0.024	0.024	0.035	0.036	0.030	0.030	0.018
30	0.000	0.002	0.010	0.000	0.006	0.016	0.021	0.016	0.038	0.034	0.013	0.027
31	0.004	0.005	0.010	0.002	0.007	0.024	0.014	0.000	0.023	0.024	0.012	0.023
32	0.013	0.000	0.009	0.010	0.004	0.045	0.019	0.000	0.040	0.016	0.025	0.022
33+	0.024	0.007	0.005	0.043	0.042	0.038	0.068	0.104	0.202	0.125	0.187	0.364
Sample size	356	497	331	242	462	278	466	216	417	605	646	430
# Hauls	6	17	12	17	19	27	85	22	72	82	69	74

Table 10.10. Survey length (cm) compositions available for northern rockfish in the Gulf of Alaska, 1984-2013. (Note that the number of hauls used for length composition in the current assessment is the number of hauls used to estimate population numbers at length from the NMFS bottom-trawl survey which are limited to good performance survey tows and which may be less than the number of hauls from which specimens were collected for age determination (e.g, 2001).)

Length class (cm)	Year												
	1984	1987	1990	1993	1996	1999	2001	2003	2005	2007	2009	2011	2013
15	0.010	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
16	0.007	0.004	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000
17	0.005	0.005	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.008	0.004	0.000	0.001	0.001	0.000	0.003	0.000	0.000	0.000	0.001	0.000	0.000
19	0.006	0.005	0.001	0.001	0.001	0.001	0.002	0.001	0.000	0.000	0.001	0.000	0.000
20	0.005	0.008	0.001	0.000	0.001	0.001	0.002	0.001	0.000	0.000	0.001	0.000	0.000
21	0.003	0.009	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.000	0.000
22	0.005	0.010	0.003	0.002	0.002	0.002	0.002	0.002	0.000	0.000	0.001	0.000	0.000
23	0.008	0.012	0.005	0.003	0.002	0.003	0.001	0.004	0.000	0.000	0.001	0.001	0.000
24	0.017	0.013	0.012	0.003	0.002	0.002	0.002	0.006	0.001	0.000	0.000	0.000	0.000
25	0.022	0.015	0.011	0.007	0.003	0.002	0.002	0.007	0.000	0.002	0.001	0.000	0.001
26	0.027	0.015	0.030	0.005	0.007	0.006	0.004	0.018	0.001	0.002	0.001	0.000	0.001
27	0.045	0.017	0.024	0.007	0.008	0.002	0.005	0.011	0.001	0.006	0.003	0.000	0.001
28	0.052	0.022	0.017	0.008	0.006	0.006	0.008	0.007	0.001	0.002	0.002	0.001	0.001
29	0.089	0.044	0.017	0.007	0.008	0.002	0.005	0.010	0.063	0.006	0.002	0.000	0.001
30	0.095	0.071	0.013	0.012	0.009	0.003	0.010	0.015	0.034	0.003	0.008	0.000	0.004
31	0.102	0.118	0.022	0.014	0.016	0.002	0.011	0.021	0.012	0.007	0.006	0.001	0.002
32	0.093	0.140	0.038	0.041	0.020	0.027	0.023	0.040	0.013	0.018	0.013	0.002	0.004
33	0.074	0.130	0.090	0.055	0.027	0.031	0.017	0.064	0.021	0.038	0.012	0.004	0.005
34	0.060	0.122	0.126	0.091	0.034	0.035	0.053	0.077	0.025	0.061	0.032	0.015	0.012
35	0.051	0.087	0.139	0.147	0.059	0.054	0.051	0.063	0.031	0.069	0.040	0.012	0.013
36	0.058	0.067	0.118	0.162	0.121	0.078	0.121	0.078	0.052	0.083	0.056	0.018	0.034
37	0.049	0.034	0.102	0.123	0.118	0.128	0.127	0.071	0.055	0.091	0.082	0.044	0.040
38+	0.110	0.044	0.229	0.311	0.552	0.614	0.549	0.503	0.686	0.609	0.735	0.900	0.880
Sample size	4,235	9,584	3,091	4,384	4,239	3,471	3,810	2,941	4,556	4,723	2,849	2,460	3,138
# Hauls	50	82	48	106	131	124	106	126	147	139	132	89	86

Table 10.11. Summary of results (including likelihood components and key parameter estimates) from the 2013 model compared with 2011 results.

	2011	2013
Catch	0.05	0.04
Survey Biomass	10.09	11.10
Fishery Ages	24.87	25.53
Survey Ages	35.38	45.71
Fishery Sizes	40.82	41.59
Maturity Likelihood	70.20	70.20
Data-Likelihood	181.41	194.21
Penalties/Priors		
Recruitment Devs	6.30	7.38
Fishery Selectivity	0	0
Survey Selectivity	0	0
Fish-Sel Domeshape	0	0
Survey-Sel Domeshape	0	0
Average Selectivity	0	0
F Regularity	4.50	4.67
σ_r prior	0	0
q prior	0.40	0.66
M prior	0.01	0.04
Objective Fun Total	192.62	206.96
Parameter Estimates		
Active parameters		
q	0.67	0.60
M	0.06	0.06
σ_r	1.5	1.5
Mean recruitment (millions)	16.92	17.27
$F_{40\%}$	0.06	0.06
Total Biomass	104,155	102,893
Spawning Biomass	43,414	42,960
$B_{0\%}$	72,983	75,183
$B_{40\%}$	29,193	30,073
ABC ($F_{40\%}$)	5,509	**5,324**
$F_{35\%}$	0.07	0.07
OFL ($F_{35\%}$)	6,574	6,349

Table 10.12. Estimated numbers (thousands) in 2013, fishery selectivity, and survey selectivity of northern rockfish in the Gulf of Alaska based on Model 3. Also shown are schedules of age specific weight and female maturity.

Age	2013 numbers (thousands)	Percent mature	Weight (g)	Fishery selectivity	Survey selectivity
2	10,568	0	29	0.000	0.008
3	9,962	1	74	0.000	0.018
4	8,907	1	134	0.001	0.039
5	8,018	3	205	0.006	0.085
6	7,112	5	281	0.033	0.173
7	5,341	9	358	0.159	0.322
8	3,810	16	433	0.509	0.517
9	2,616	26	502	0.850	0.708
10	1,595	40	566	0.969	0.846
11	1,530	56	624	0.994	0.925
12	2,294	71	675	0.999	0.966
13	2,501	83	720	1.000	0.984
14	2,333	90	759	1.000	0.993
15	10,279	95	793	1.000	0.997
16	6,928	97	822	1.000	0.999
17	3,727	98	847	1	0.999
18	6,894	99	868	1	1
19	14,533	100	886	1	1
20	1,508	100	902	1	1
21	2,112	100	915	1	1
22	2,385	100	926	1	1
23	3,239	100	935	1	1
24	1,479	100	943	1	1
25	2,998	100	950	1	1
26	2,632	100	955	1	1
27	1,377	100	960	1	1
28	3,035	100	964	1	1
29	7,207	100	967	1	1
30	1,090	100	970	1	1
31	4,105	100	972	1	1
32	2,176	100	974	1	1
33+	21,649	100	976	1	1

Table 10.13. Estimated time series of female spawning biomass, 95% confidence bounds on female spawning biomass, 6+ biomass (age 6 and greater), catch/(6+ biomass), and the number of age two recruits for northern rockfish in the Gulf of Alaska for this year's model results compared to 2011.

	Spawning Biomass (t)		6+ total biomass (t)		Catch / (6+ total biomass)		Age Two Recruits (millions)	
Year	Current	Previous	Current	Previous	Current	Previous	Current	Previous
1977	25,773	23,171	86,093	77,732	0.007	0.008	14.4	14.0
1978	27,485	24,731	90,413	81,652	0.006	0.007	101.3	87.8
1979	29,923	26,944	94,879	85,614	0.007	0.008	29.4	28.9
1980	32,911	29,637	98,947	89,213	0.008	0.009	19.2	14.2
1981	36,127	32,512	102,278	92,346	0.014	0.016	12.1	11.6
1982	38,991	35,028	123,823	110,854	0.032	0.035	17.8	16.7
1983	40,594	36,289	130,434	116,799	0.028	0.031	26.3	26.9
1984	42,319	37,656	134,821	119,681	0.007	0.008	46.1	41.0
1985	45,545	40,476	139,478	123,791	0.001	0.001	11.3	10.7
1986	49,712	44,167	145,100	128,903	0.002	0.002	68.0	63.2
1987	54,275	48,201	151,744	135,546	0.003	0.004	26.0	23.4
1988	58,629	52,042	162,216	144,928	0.007	0.008	10.7	10.1
1989	62,152	55,136	164,896	147,424	0.009	0.01	18.7	16.6
1990	64,884	57,548	178,667	160,186	0.010	0.011	19.5	17.5
1991	67,210	59,644	184,482	165,402	0.024	0.027	8.9	8.2
1992	68,306	60,555	183,489	164,277	0.042	0.047	17.9	16.0
1993	68,147	60,213	179,810	160,269	0.027	0.03	12.1	11.1
1994	69,266	61,145	178,648	158,829	0.033	0.038	9.8	9.2
1995	69,666	61,367	173,487	153,739	0.032	0.037	6.4	6.3
1996	69,666	61,215	169,853	149,981	0.020	0.022	57.0	53.4
1997	70,005	61,446	167,001	147,235	0.018	0.02	24.7	23.6
1998	69,894	61,280	163,613	144,099	0.019	0.021	12.2	12.4
1999	69,232	60,611	158,923	139,821	0.034	0.039	20.6	19.6
2000	67,161	58,574	162,664	143,257	0.020	0.023	27.9	27.3
2001	65,901	57,383	163,291	144,037	0.019	0.022	5.8	5.9
2002	64,798	56,374	161,555	142,772	0.021	0.023	5.6	5.6
2003	63,908	55,592	161,074	142,564	0.032	0.037	4.7	5.1
2004	62,629	54,428	160,287	142,159	0.030	0.034	2.9	3.6
2005	61,903	53,823	155,403	137,824	0.029	0.033	2.7	3.7
2006	61,394	53,446	150,111	133,089	0.033	0.037	4.1	6.0
2007	60,516	52,729	143,617	127,274	0.029	0.033	5.5	7.8
2008	59,608	52,018	137,022	121,480	0.029	0.033	7.2	9.1
2009	58,265	50,912	130,113	115,460	0.030	0.034	9.0	9.8
2010	56,402	49,330	123,314	109,798	0.032	0.036	9.6	10.3
2011	54,037	47,293	116,783	104,552	0.029	0.032	10.0	10.3
2012	51,492	-	111,153	-	0.045	-	10.6	-
2013	47,949	-	104,520	-	0.046	-	10.6	-

Table 10.14. Estimated time series of number of age 2 recruits (in thousands), total biomass, and female spawning biomass with 95% confidence bounds for northern rockfish in the Gulf of Alaska for this year's model results.

	Recruits (Age 2)			Total Biomass			Spawning Biomass		
Year	Mean	2.50%	97.50%	Mean	2.50%	97.50%	Mean	2.50%	97.50%
1977	14,397	490	99,487	91,333	61,307	151,984	25,773	13,998	47,578
1978	101,255	1,873	198,499	98,716	67,475	162,188	27,485	15,878	49,454
1979	29,401	660	136,050	107,110	74,284	174,002	29,923	18,116	52,567
1980	19,152	447	65,411	116,086	81,309	186,730	32,911	20,759	56,206
1981	12,071	422	52,730	124,864	88,122	200,058	36,127	23,428	60,489
1982	17,818	502	60,635	132,517	93,517	211,704	38,991	25,800	64,909
1983	26,301	700	95,752	137,171	97,066	220,106	40,594	26,965	67,616
1984	46,122	1,033	101,770	142,194	100,123	229,010	42,319	28,161	70,450
1985	11,288	421	81,196	149,202	104,949	239,948	45,545	30,596	75,207
1986	68,008	6,334	142,762	157,893	111,652	252,977	49,712	33,851	81,263
1987	26,009	582	81,525	166,492	118,298	265,417	54,275	37,418	88,116
1988	10,736	439	46,092	174,377	124,009	277,391	58,629	40,826	94,296
1989	18,700	692	52,934	180,976	128,385	287,873	62,152	43,494	99,555
1990	19,504	836	53,780	186,284	131,552	295,792	64,884	45,347	103,420
1991	8,861	445	37,592	190,167	134,051	303,159	67,210	47,005	107,079
1992	17,879	1008	44,419	190,165	132,551	305,521	68,306	47,356	109,392
1993	12,085	698	38,491	185,811	127,246	302,496	68,147	46,292	110,682
1994	9,812	513	28,691	183,427	124,241	302,112	69,266	46,456	113,731
1995	6,436	276	24,807	178,869	119,113	298,742	69,666	46,044	115,851
1996	56,986	26,968	119,902	175,217	114,619	295,271	69,666	45,268	117,520
1997	24,728	865	61,465	174,130	112,661	295,708	70,005	45,159	118,907
1998	12,187	561	50,474	173,580	110,940	297,209	69,894	44,697	119,167
1999	20,639	845	59,317	173,113	109,706	298,738	69,232	43,797	119,005
2000	27,895	4,260	71,466	170,614	106,213	300,079	67,161	41,535	117,144
2001	5,770	317	23,261	169,947	104,236	301,834	65,901	40,312	115,826
2002	5,645	361	19,084	168,992	102,518	302,466	64,798	39,069	115,096
2003	4,726	333	15,948	167,086	100,130	302,226	63,908	38,098	114,698
2004	2,875	208	11,943	162,363	95,078	297,339	62,629	36,378	114,262
2005	2,731	179	11,355	157,215	89,861	291,859	61,903	35,266	114,690
2006	4,086	238	16,866	151,575	84,957	284,924	61,394	34,081	115,157
2007	5,483	231	26,638	144,881	78,871	276,206	60,516	32,703	115,516
2008	7,193	278	43,803	138,569	73,946	267,244	59,608	31,346	115,224
2009	9,014	295	60,348	132,232	68,767	258,762	58,265	29,866	114,380
2010	9,575	309	76,224	126,019	63,547	250,123	56,402	28,182	112,266
2011	10,026	342	101,250	120,051	59,075	242,684	54,037	26,142	109,282
2012	10,569	333	137,465	114,848	54,841	236,515	51,492	23,997	105,532
2013	10,568	326	130,410	108,403	50,725	229,419	47,949	21,105	100,348
2014	17,265	358	123,143	102,893	46,306	226,455	42,960	17,755	91,994
2015	17,265	336	118,808	98,572	-	-	40,004	16,706	84,810

Table 10.15. Estimates of key parameters with Hessian estimates of standard deviation (σ), MCMC standard deviations (σ(MCMC)) and 95% Bayesian credible intervals (BCI) derived from MCMC simulations.

Parameter	μ	μ (MCMC)	Median (MCMC)	σ	σ(MCMC)	BCI-Lower	BCI-Upper
q	0.60	0.60	0.59	0.15	0.15	0.35	0.94
M	0.0592	0.0593	0.0593	0.0028	0.0028	0.0541	0.0648
$F_{40\%}$	0.0606	0.0689	0.0660	0.0156	0.0203	0.0388	0.1183
2014 SSB	42,960	46,154	42,994	17,154	19,482	17,755	91,994
2014 ABC	5,324	6,426	5,751	2,511	3,383	1,809	14,500

Table 10.16. Set of projections of spawning biomass and yield for northern rockfish in the Gulf of Alaska. This set of projections encompasses six harvest scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Protection Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). For a description of scenarios see *Projections and Harvest Alternatives*. All units in t. $B_{40\%}$ = 30,073 t, $B_{35\%}$ = 26,314 t, $F_{40\%}$ = 0.061, and $F_{35\%}$ = 0.073.

Year	Maximum permissible F	Author's F[1] (Estimated catches)	Half maximum F	5-year average F	No fishing	Overfished	Approaching overfished
			Spawning biomass (mt)				
2013	46,234	46,234	46,234	46,234	46,234	46,234	46,234
2014	42,784	42,960	43,215	43,083	43,650	42,613	42,784
2015	39,362	40,004	40,963	40,470	42,629	38,741	39,362
2016	36,352	37,254	38,956	38,147	41,750	35,363	36,208
2017	33,779	34,601	37,247	36,157	41,078	32,490	33,250
2018	31,633	32,379	35,846	34,509	40,639	30,098	30,779
2019	29,895	30,566	34,753	33,195	40,444	28,200	28,795
2020	28,576	29,161	33,963	32,208	40,498	26,828	27,323
2021	27,689	28,184	33,482	31,546	40,816	25,914	26,325
2022	27,189	27,607	33,310	31,207	41,416	25,399	25,739
2023	27,017	27,368	33,426	31,163	42,293	25,215	25,495
2024	27,087	27,382	33,774	31,354	43,399	25,270	25,498
2025	27,310	27,556	34,277	31,702	44,663	25,469	25,655
2026	27,610	27,815	34,864	32,135	46,011	25,737	25,887
			Fishing mortality				
2013	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2014	0.061	0.048	0.030	0.039	-	0.073	0.073
2015	0.061	0.048	0.030	0.039	-	0.073	0.073
2016	0.061	0.061	0.030	0.039	-	0.073	0.073
2017	0.061	0.061	0.030	0.039	-	0.073	0.073
2018	0.061	0.061	0.030	0.039	-	0.073	0.073
2019	0.060	0.061	0.030	0.039	-	0.068	0.068
2020	0.057	0.059	0.030	0.039	-	0.064	0.064
2021	0.055	0.057	0.030	0.039	-	0.062	0.062
2022	0.054	0.055	0.030	0.039	-	0.061	0.061
2023	0.054	0.055	0.030	0.039	-	0.060	0.060
2024	0.054	0.054	0.030	0.039	-	0.060	0.060
2025	0.054	0.054	0.030	0.039	-	0.061	0.061
2026	0.054	0.055	0.030	0.039	-	0.061	0.061
			Yield (mt)				
2013	4,770	4,770	4,770	4,770	4,770	4,770	4,770
2014	5,324	5,324	2,701	3,505	-	6,349	5,324
2015	4,953	5,012	2,588	3,328	-	5,838	4,953
2016	4,644	4,755	2,495	3,182	-	5,413	5,538
2017	4,384	4,485	2,419	3,060	-	5,056	5,168
2018	4,167	4,258	2,357	2,959	-	4,757	4,860
2019	3,972	4,082	2,314	2,885	-	4,243	4,419
2020	3,710	3,855	2,302	2,854	-	3,929	4,068
2021	3,581	3,701	2,321	2,864	-	3,777	3,890
2022	3,535	3,634	2,353	2,890	-	3,725	3,816
2023	3,545	3,626	2,390	2,925	-	3,739	3,813
2024	3,587	3,652	2,429	2,963	-	3,793	3,853
2025	3,640	3,692	2,465	3,000	-	3,861	3,909
2026	3,699	3,742	2,502	3,039	-	3,938	3,976

[1]Projected ABCs and OFLs for 2014 and 2015 are derived using estimated catch of 4,770 for 2013, and projected catches of 4,248 t and 3,999 t for 2014 and 2015 based on realized catches from 2010-2012. This calculation is in response to management requests to obtain more accurate projections.

Table 10.17. Analysis of ecosystem considerations for slope rockfish.

Indicator	*Observation*	*Interpretation*	*Evaluation*
Ecosystem effects on stock			
Prey availability or abundance trends	important for larval and post-larval survival, but no information known	may help to determine year-class strength	possible concern if some information available
Predator population trends	Unknown		little concern for adults
Changes in habitat quality	Variable	variable recruitment	possible concern
Fishery effects on ecosystem			
Fishery contribution to bycatch			
Prohibited species	unknown		
Forage (including herring, Atka mackerel, cod, and pollock)	unknown		
HAPC biota (seapens/whips, corals, sponges, anemones)	fishery disturbing hard-bottom biota, i.e., corals, sponges	could harm the ecosystem by reducing shelter for some species	concern
Marine mammals and birds	probably few taken		little concern
Sensitive non-target species	unknown		
Fishery concentration in space and time	little overlap between fishery and reproductive activities	fishery does not hinder reproduction	little concern
Fishery effects on amount of large size target fish	no evidence for targeting large fish	large fish and small fish are both in population	little concern
Fishery contribution to discards and offal production	discard rates moderate to high for some species of slope rockfish	little unnatural input of food into the ecosystem	some concern
Fishery effects on age-at-maturity and fecundity	fishery is catching some immature fish	could reduce spawning potential and yield	possible concern

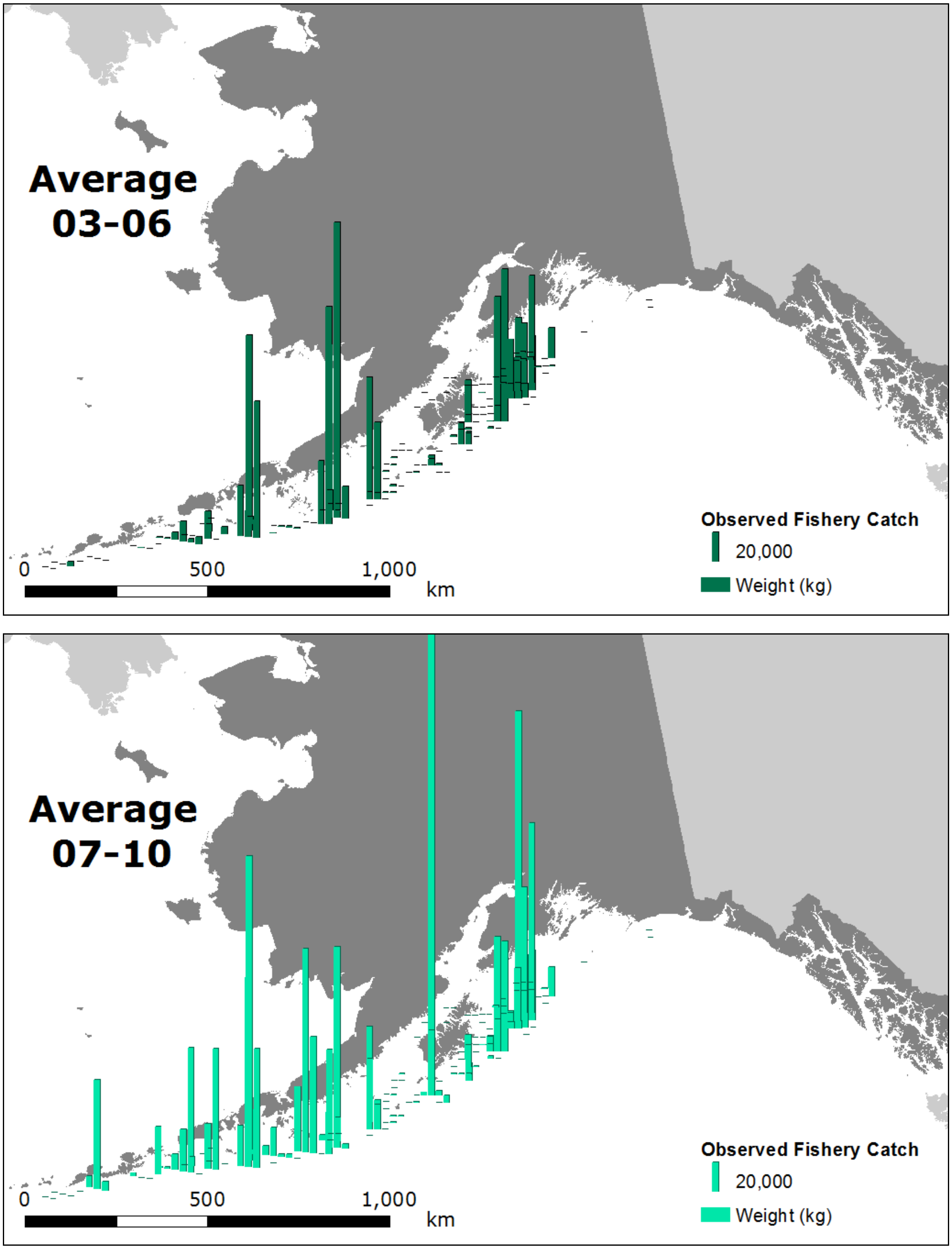

Figure 10.1. Spatial distribution of northern rockfish trawl fishery catch in the Gulf of Alaska (GOA) based on observer data aggregated by 400 km^2 blocks and averaged by (a) four years prior to central GOA Rockfish Pilot Program, 2003-2006, and (b) four years after implementation of program, 2007-2010.

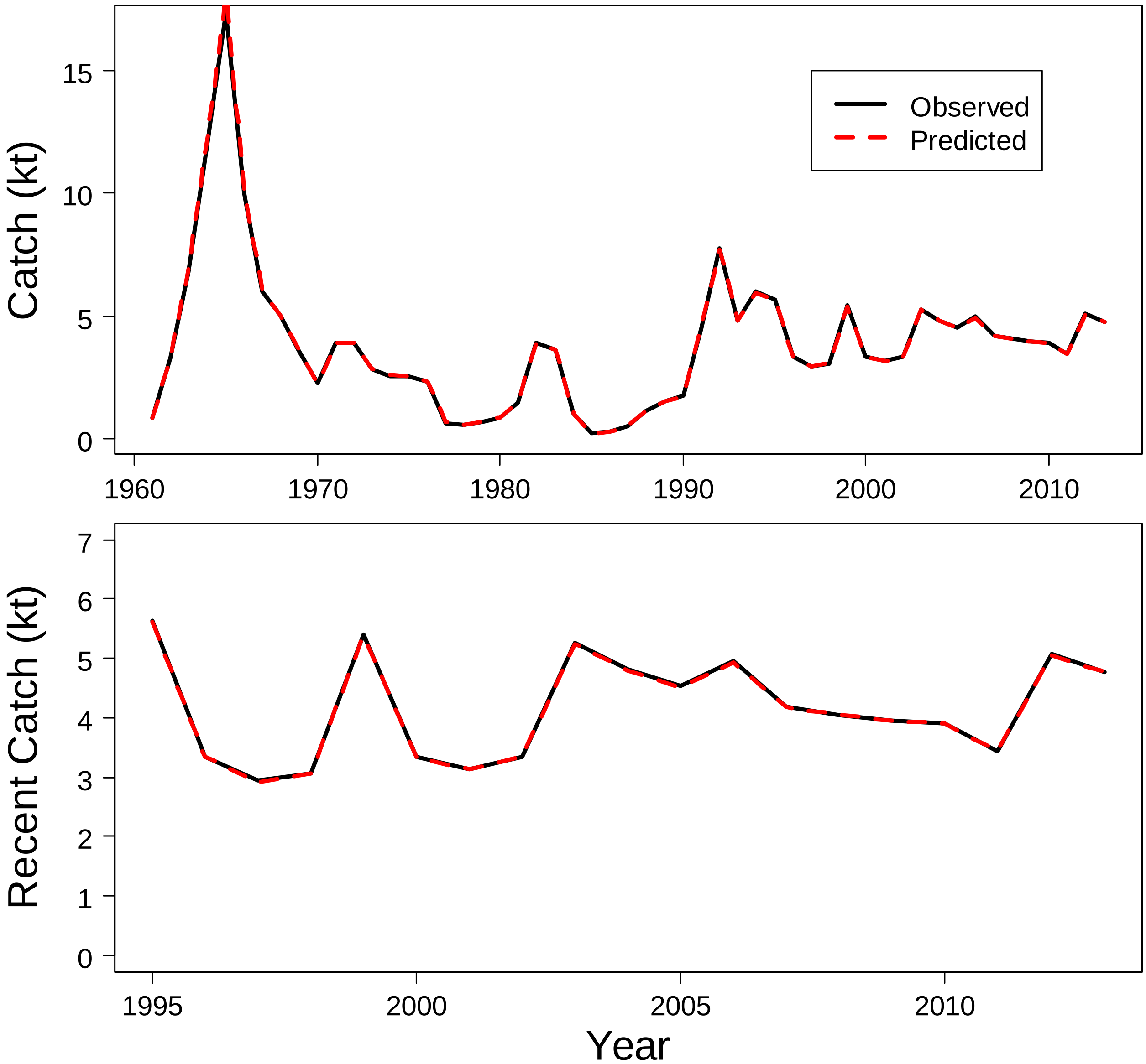

Figure 10.2. Estimated (red dashed lines) and observed (black solid lines) long-term and recent commercial catch of northern rockfish in the Gulf of Alaska. The *Description of the catch time series* section describes the procedures used to estimate catch for the years 1965-1993. Catch for the years 1993-2013 is from NMFS Observer Program and Alaska Regional Office.

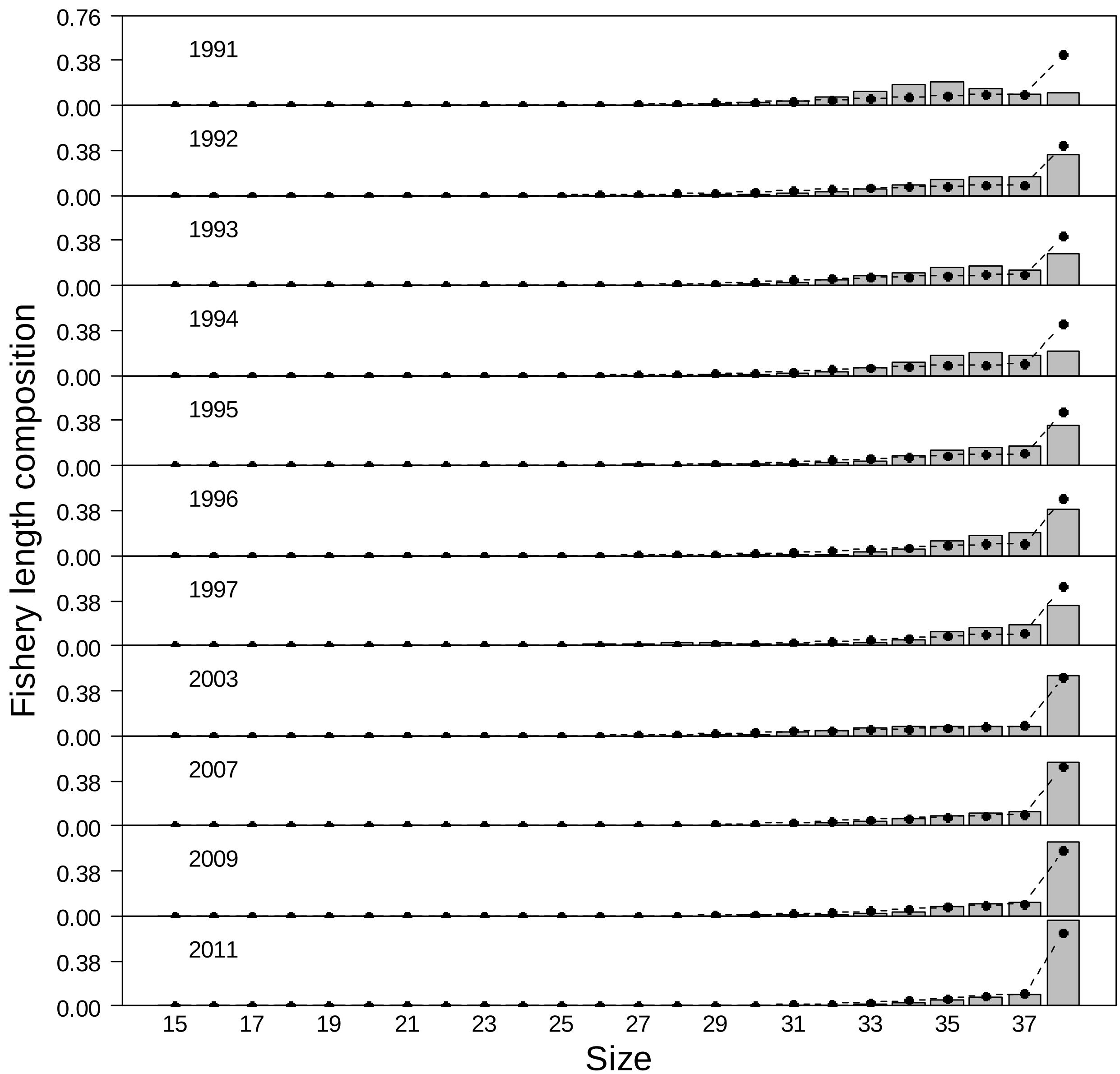

Figure 10.3. Fishery length compositions for GOA northern rockfish. Observed = bars, predicted from author recommended model = line with circles.

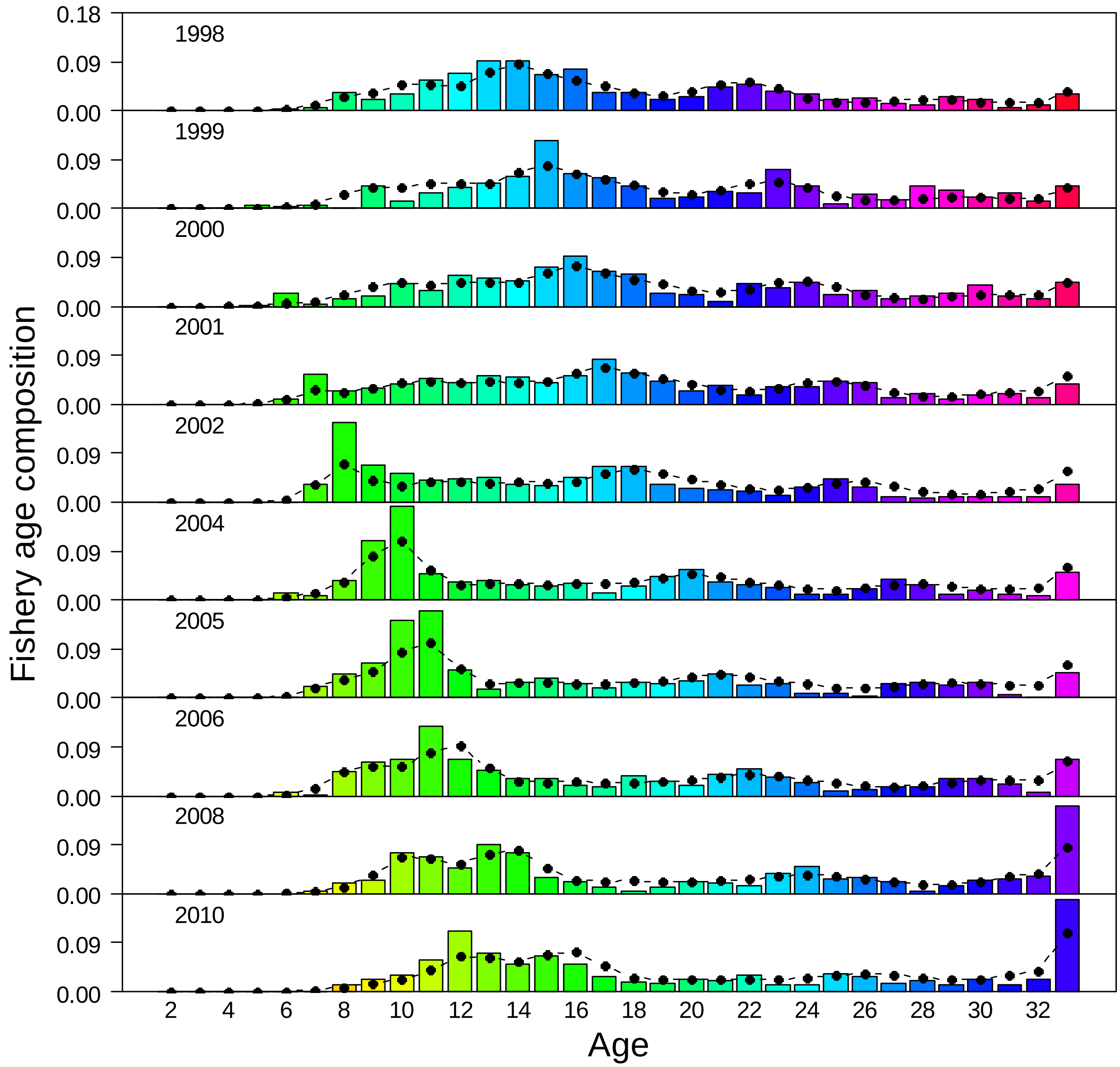

Figure 10.4. Fishery age compositions for GOA northern rockfish. Observed = bars, predicted from author recommended model = line with circles.

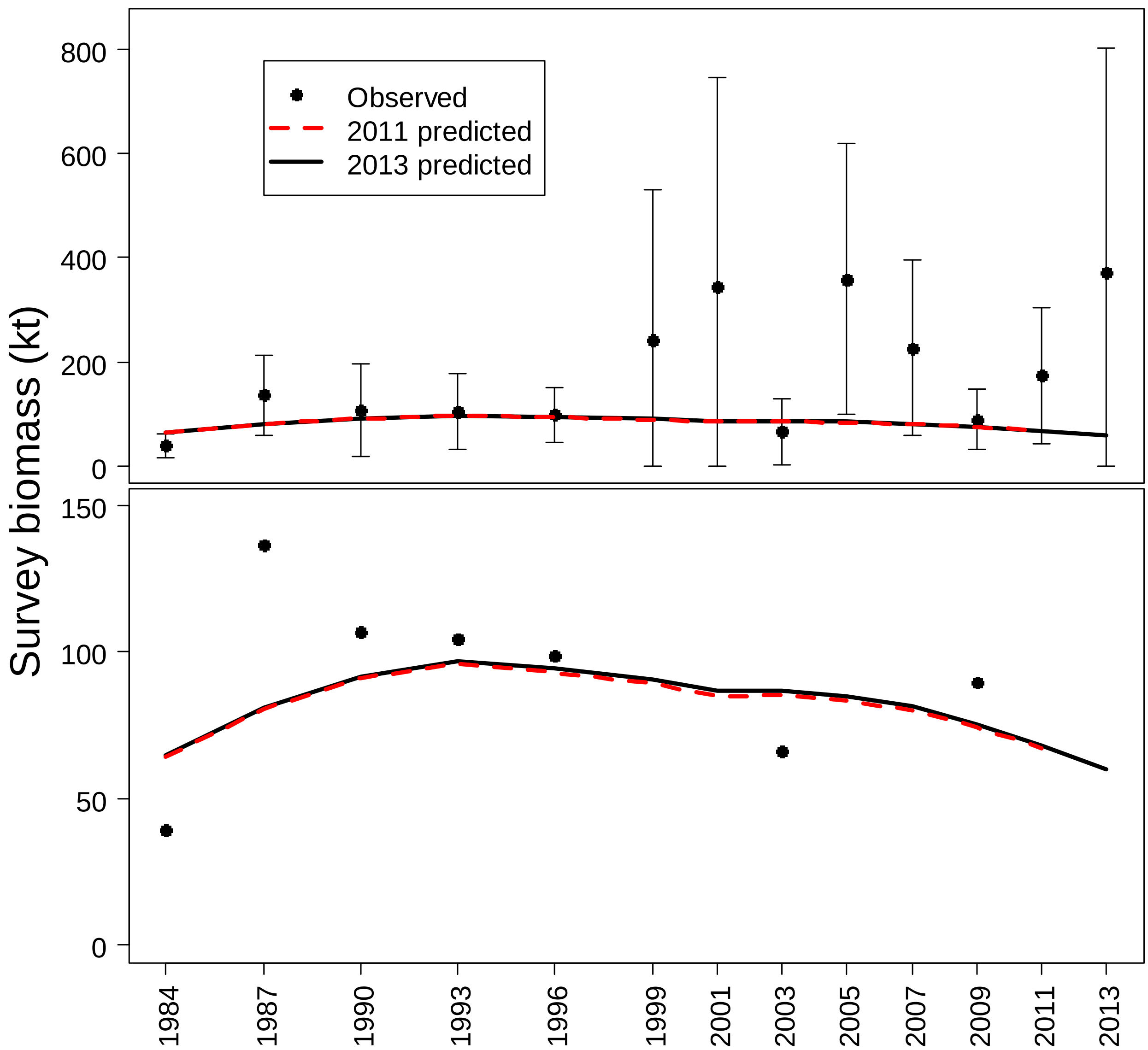

Figure 10.5. Upper panel is observed and predicted GOA northern rockfish trawl survey index of biomass (shown in units of kilotons). Observed biomass=circles with 95% confidence intervals of sampling error. Predictions are from 2011 model and this year's model configurations. Recommended model is black solid line. Bottom panel is an expansion without confidence intervals and the high point estimates of 1999, 2001, 2005, 2007, 2011, and 2013 to look at the fit at a visible scale.

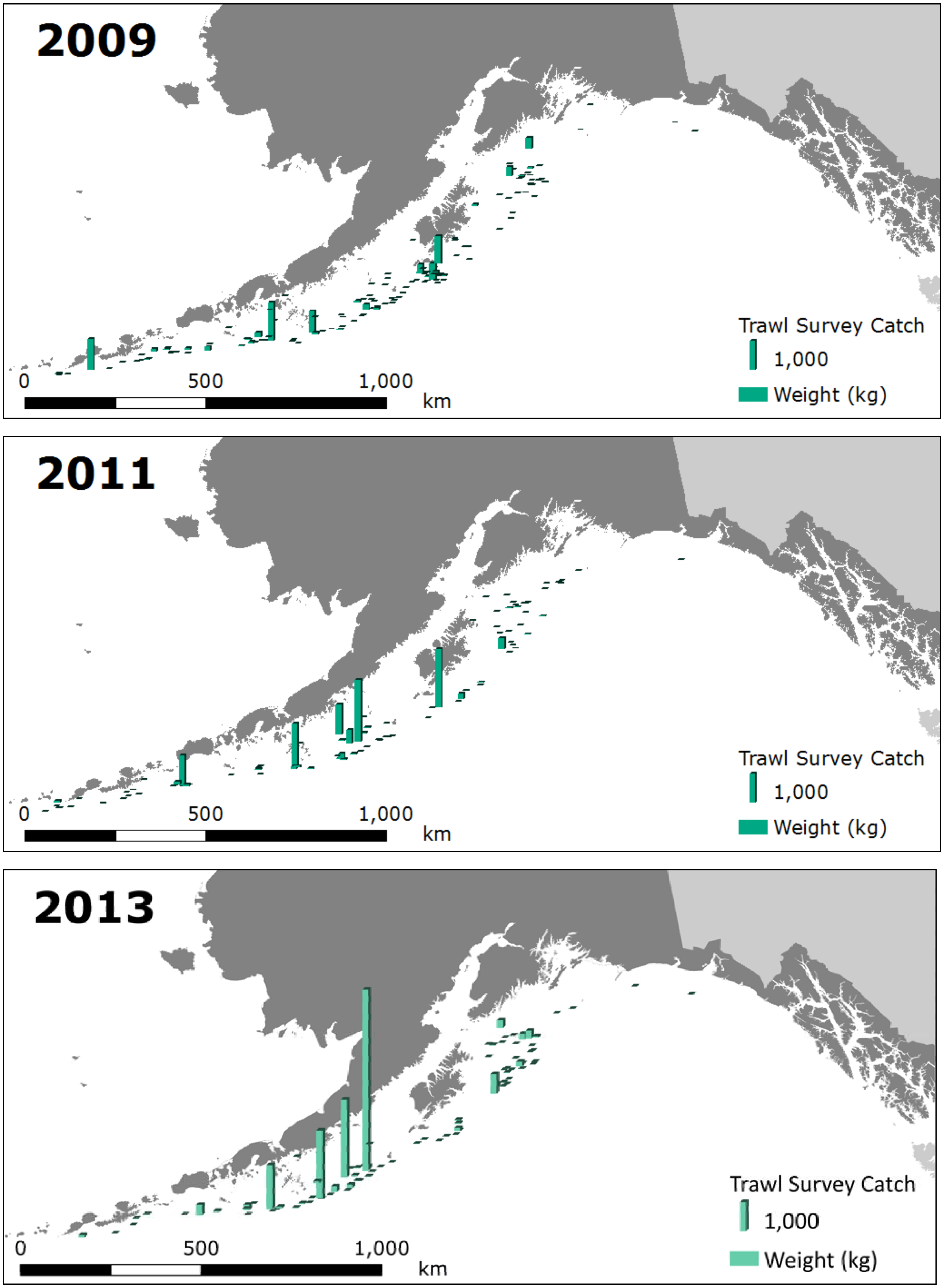

Figure 10.6. Spatial distribution of northern rockfish catch in the Gulf of Alaska during the trawl surveys.

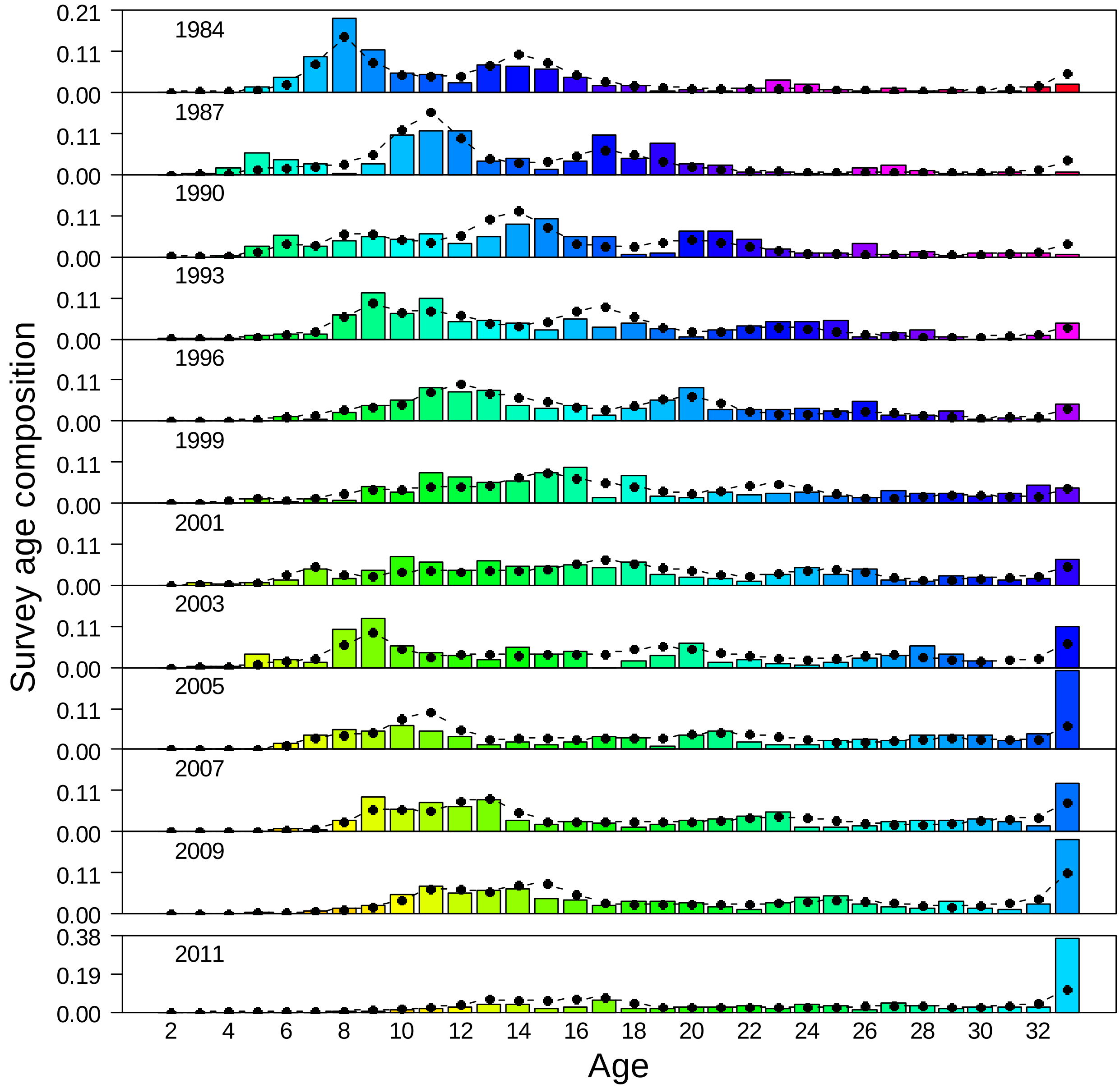

Figure 10.7. Trawl survey age composition by year for GOA northern rockfish. The most recent survey age composition in 2011 is shown on a different scale for the y-axis than the other year's age compositions due to the large plus age proportion. Observed = bars, predicted from author recommended model = line with circles.

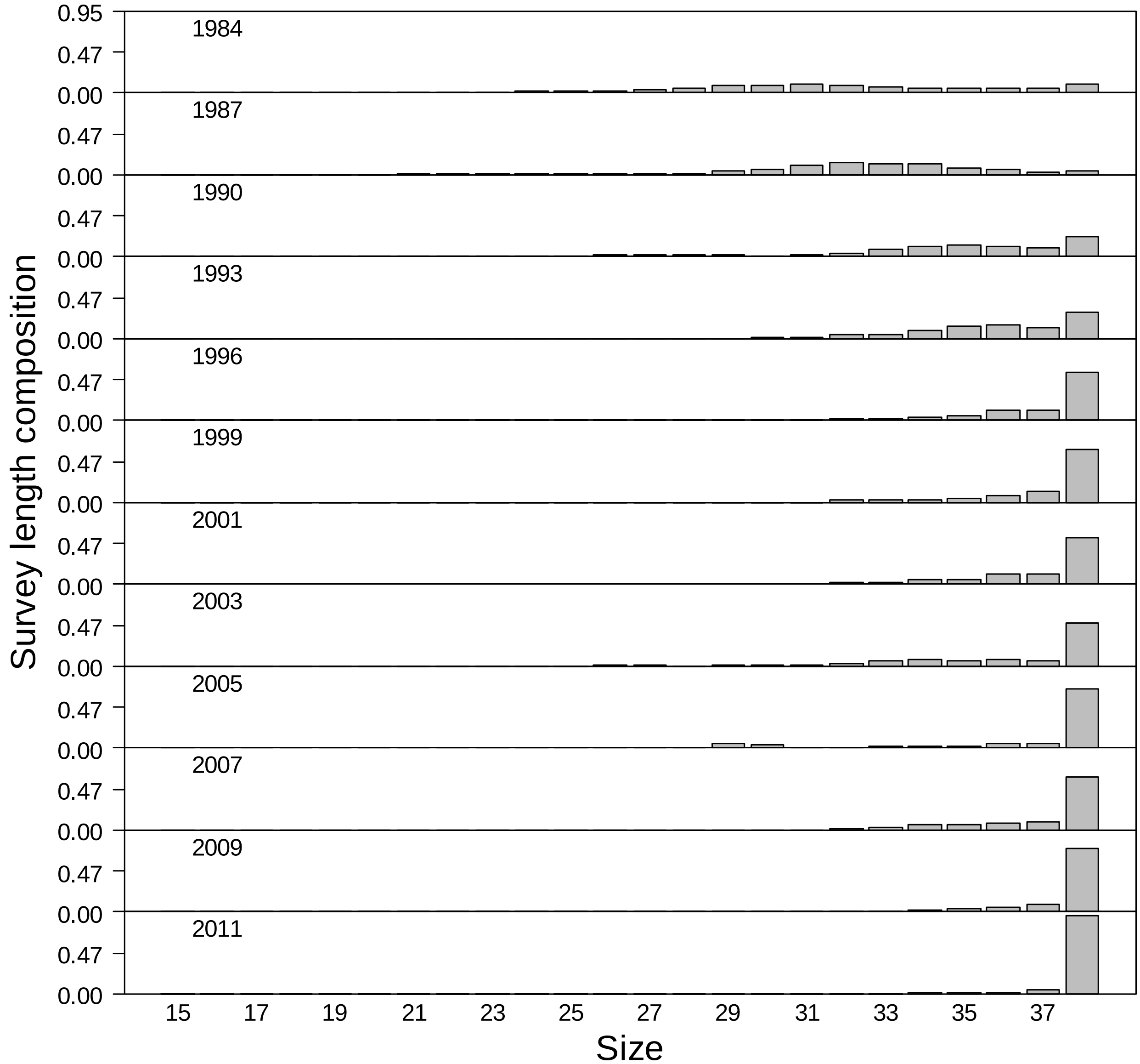

Figure 10.8. Groundfish survey length compositions for GOA northern rockfish. Observed = bars. Survey size distributions not used in the model because survey ages are available for these years.

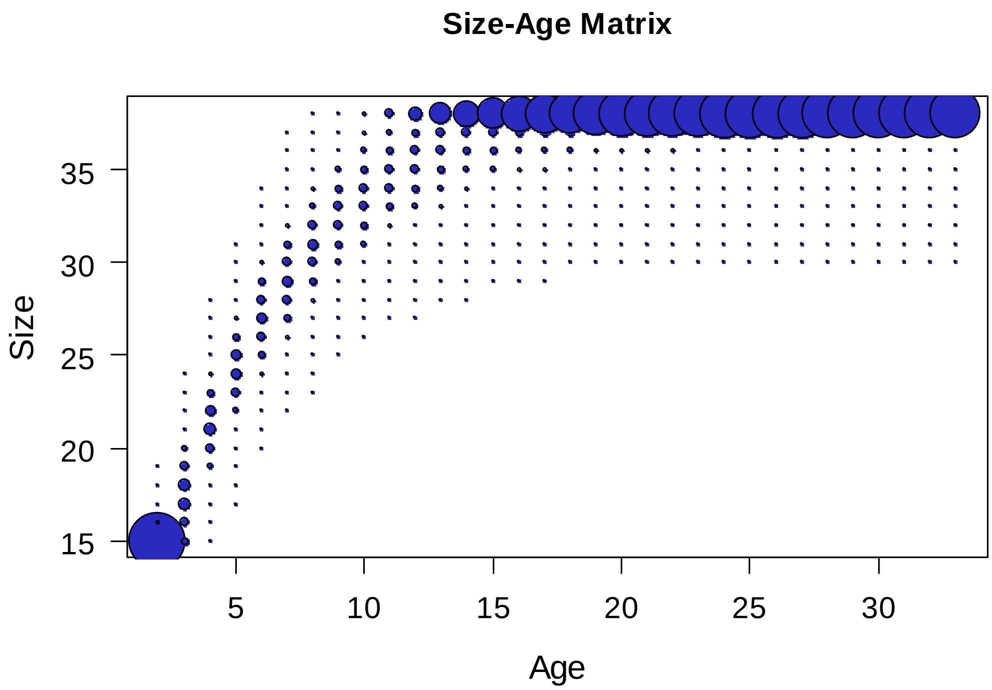

Figure 10.9. Length-age transition matrix used for GOA northern rockfish. The matrix is based on length at age data from trawl surveys.

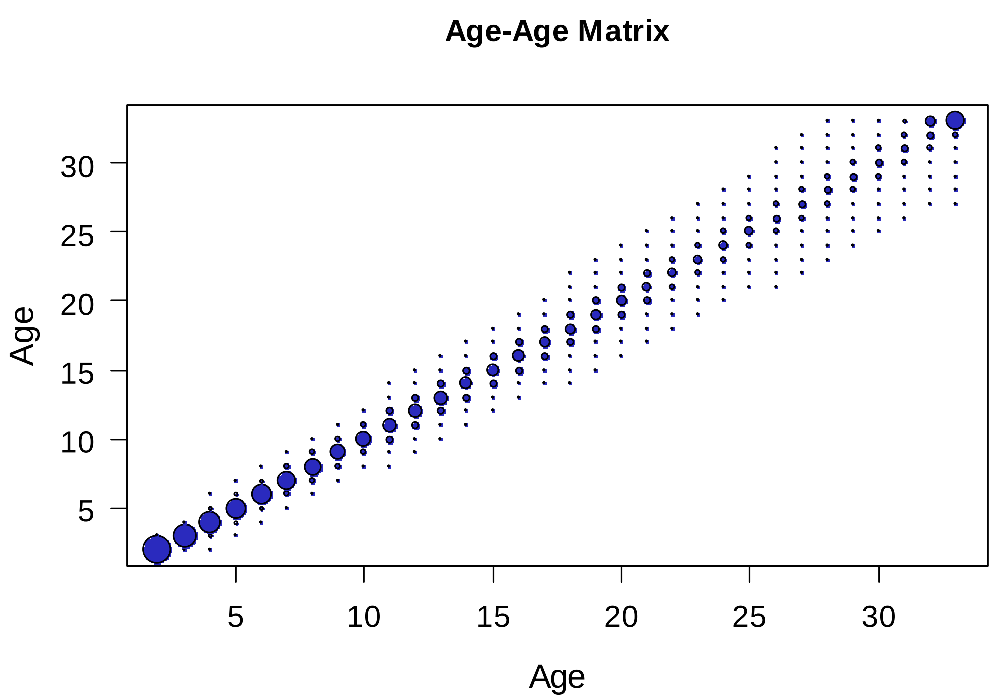

Figure 10.10. Ageing error matrix used for GOA northern rockfish. The matrix is based on percent agreement tests conducted at the AFSC Age and Growth lab.

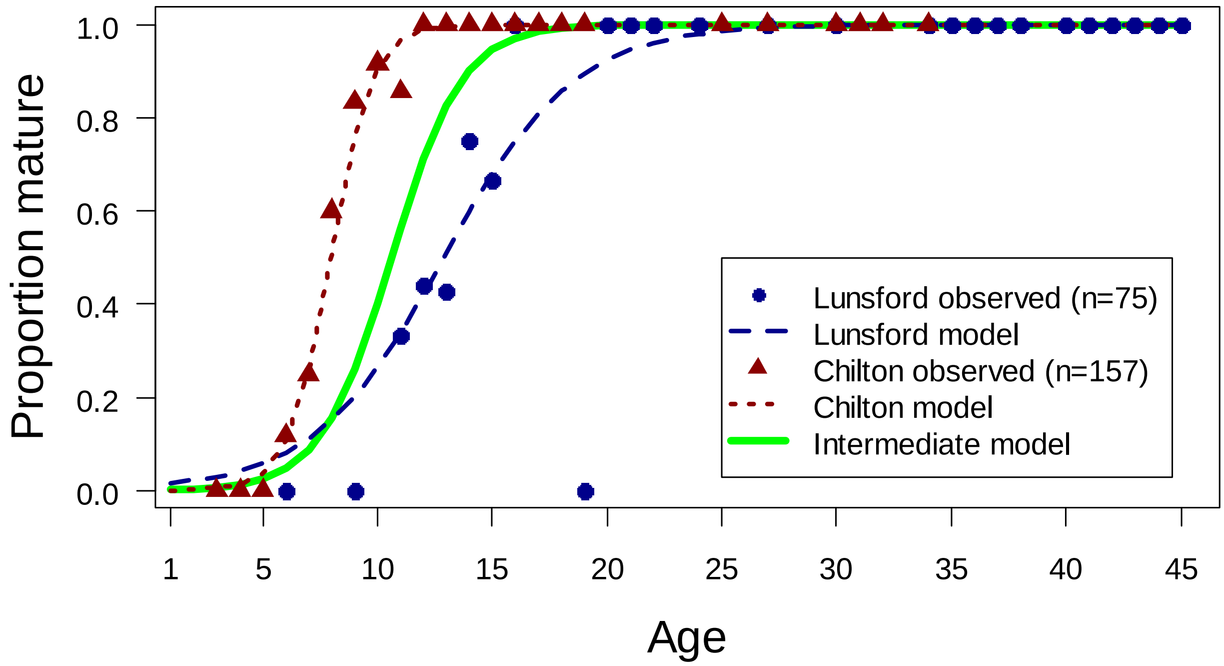

Figure 10.11. Intermediate model fit to combined female northern rockfish maturity data. Also shown are separate model fits to each dataset.

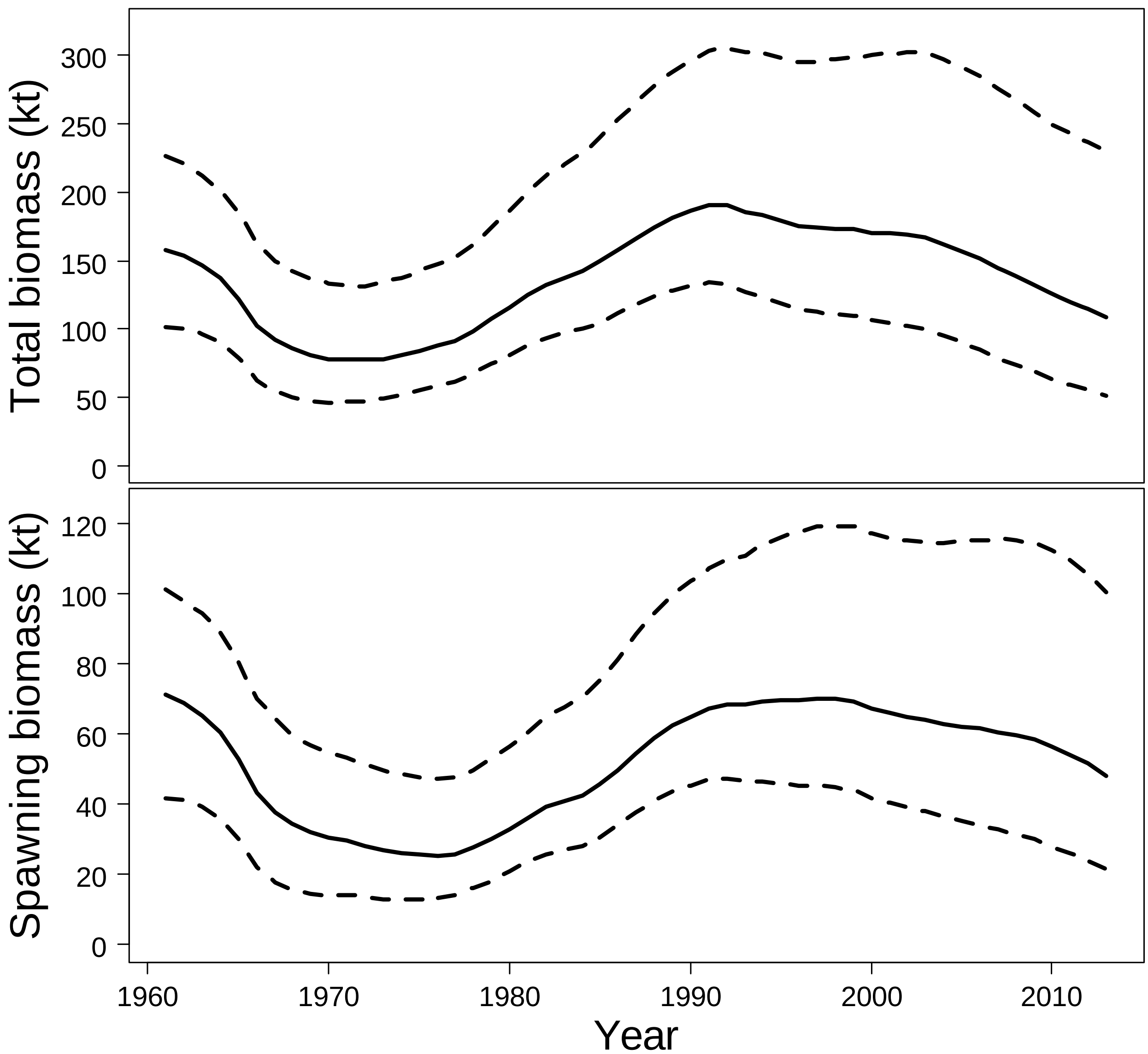

Figure 10.12. Model estimated total biomass and spawning biomass (solid lines) with 95% credible intervals determined by MCMC (dashed line) for Gulf of Alaska northern rockfish.

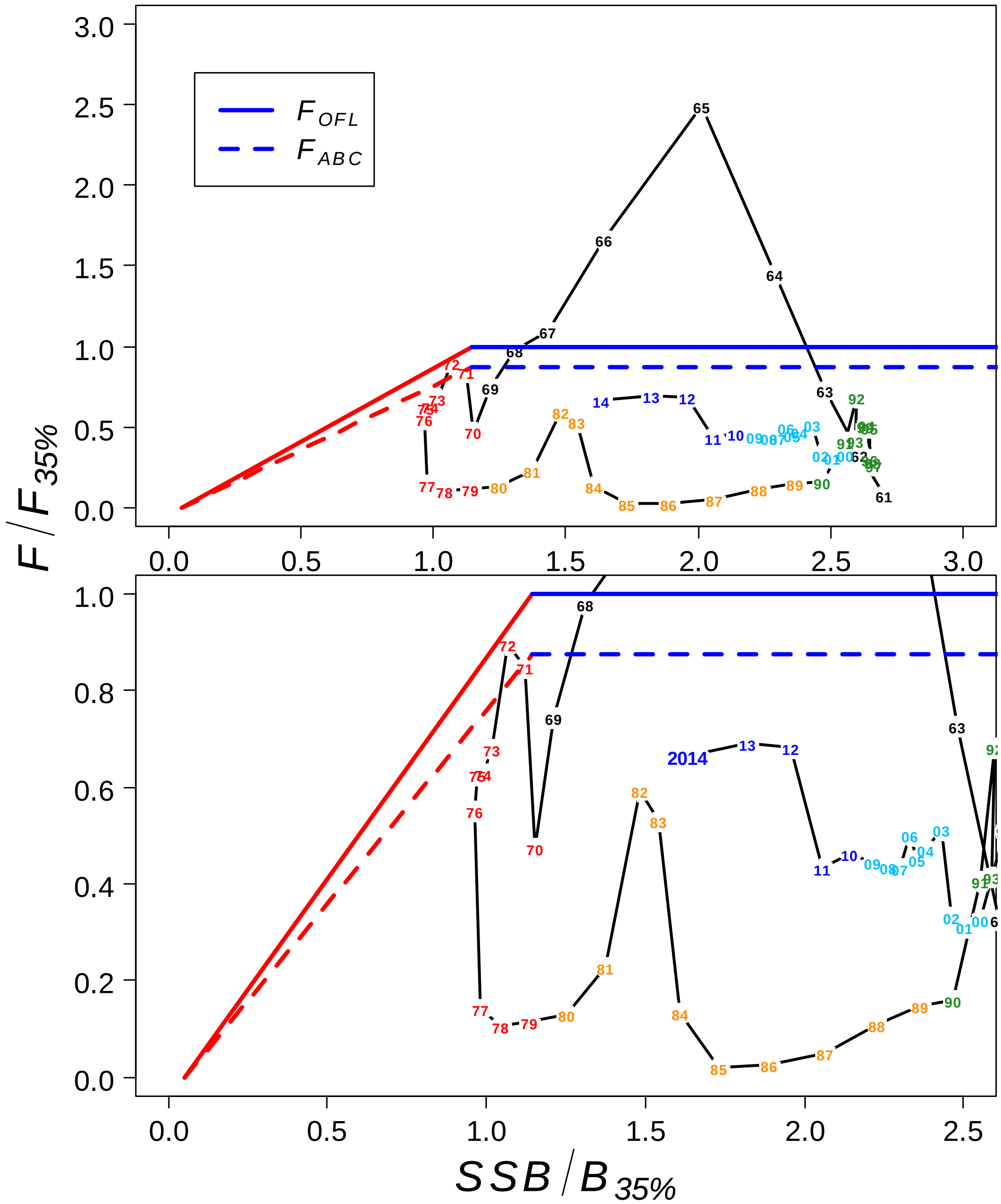

Figure 10.13. Time series of northern rockfish estimated spawning biomass (*SSB*) relative to $B_{35\%}$ and fishing mortality (*F*) relative to $F_{35\%}$ for author recommended model.

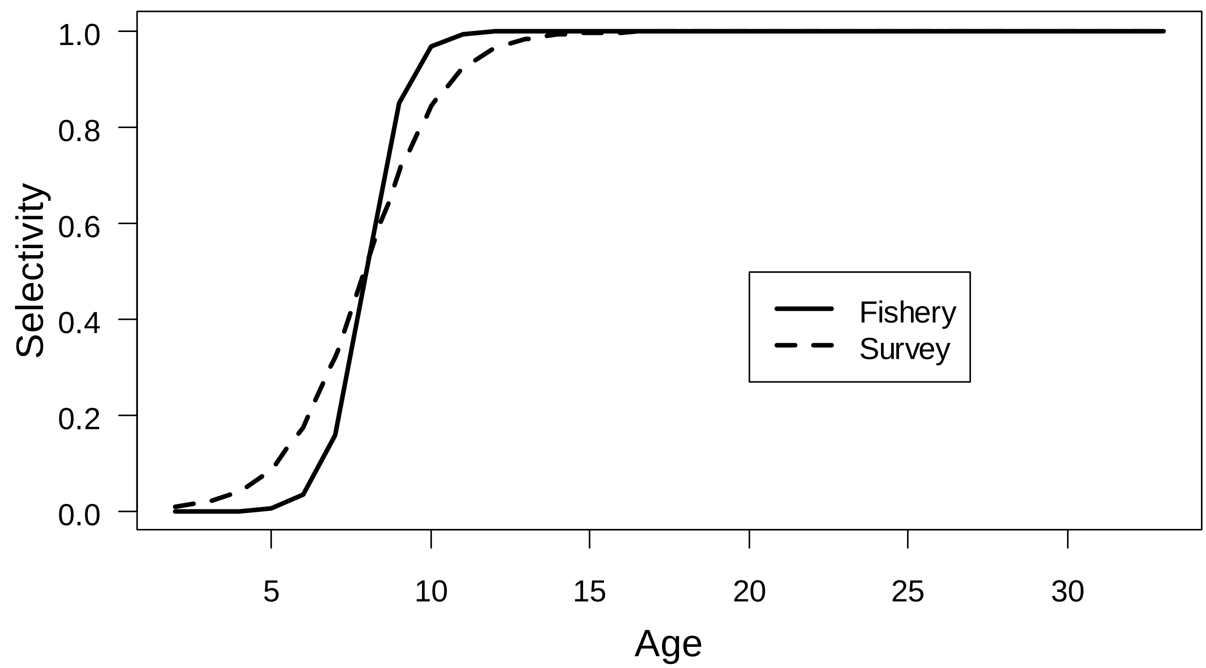

Figure 10.14. Fishery (solid line) and survey (dotted line) estimates of selectivity for GOA northern rockfish based on the authors recommended model.

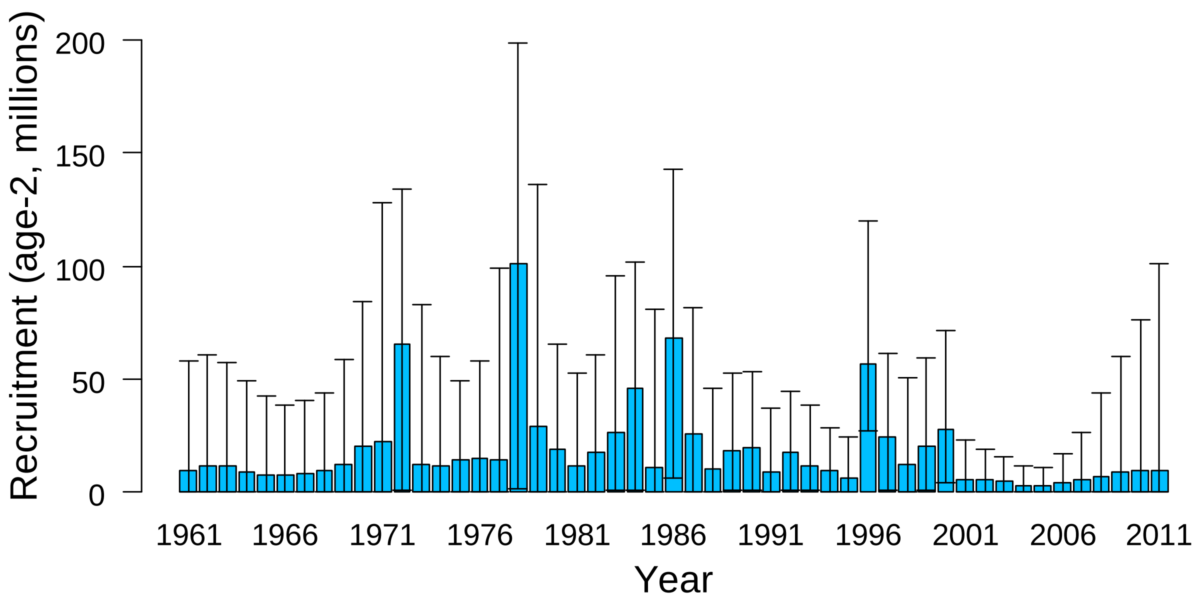

Figure 10.15. Estimates of recruitment (at age-2) and 95% credible intervals for GOA northern rockfish based on the 2013 model.

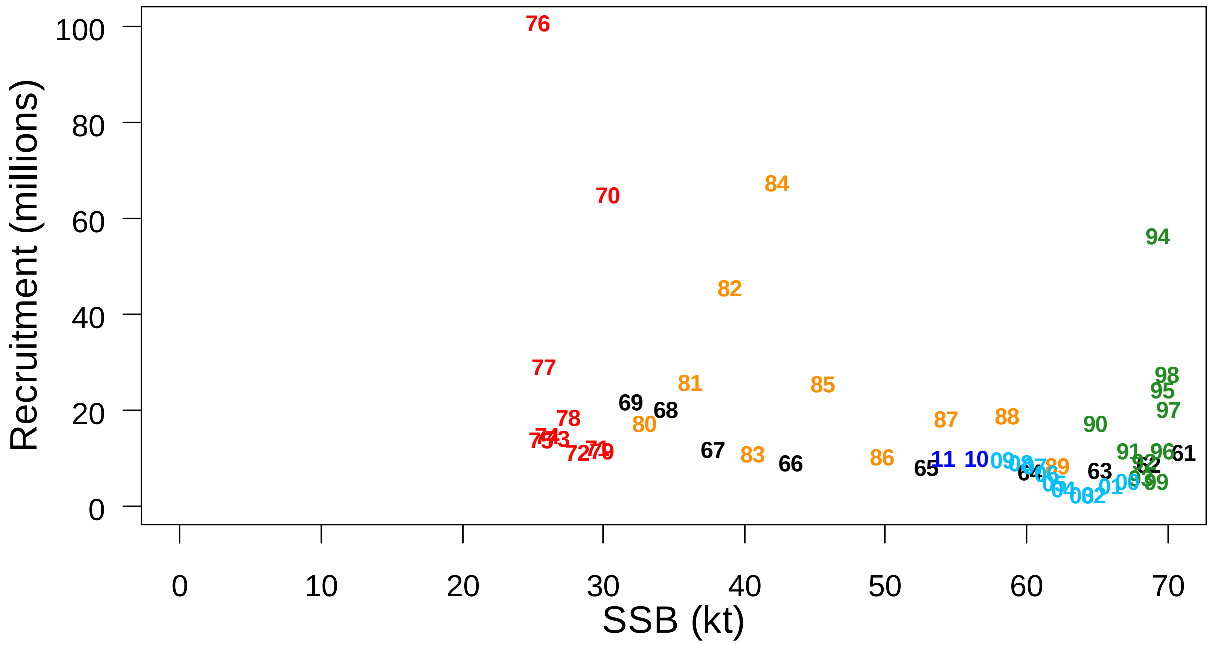

Figure 10.16. Relationship between female spawning stock biomass (SSB) and recruitment (by year class) for GOA northern rockfish based on the 2013 model.

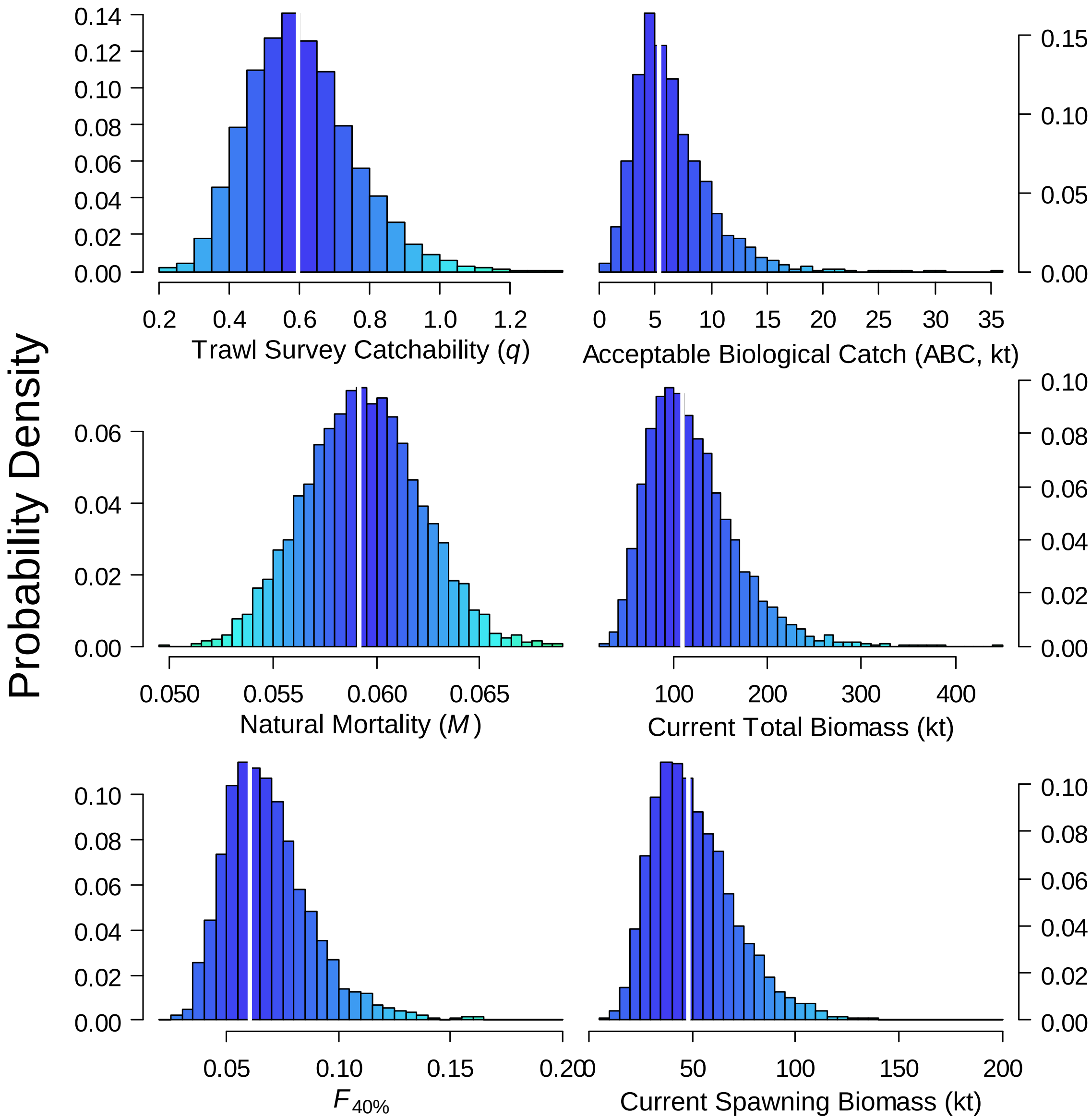

Figure 10.17. Histograms of estimated posterior distributions for key parameters derived from the MCMC for GOA northern rockfish. Vertical white lines represent the maximum likelihood estimate for comparison with the MCMC results.

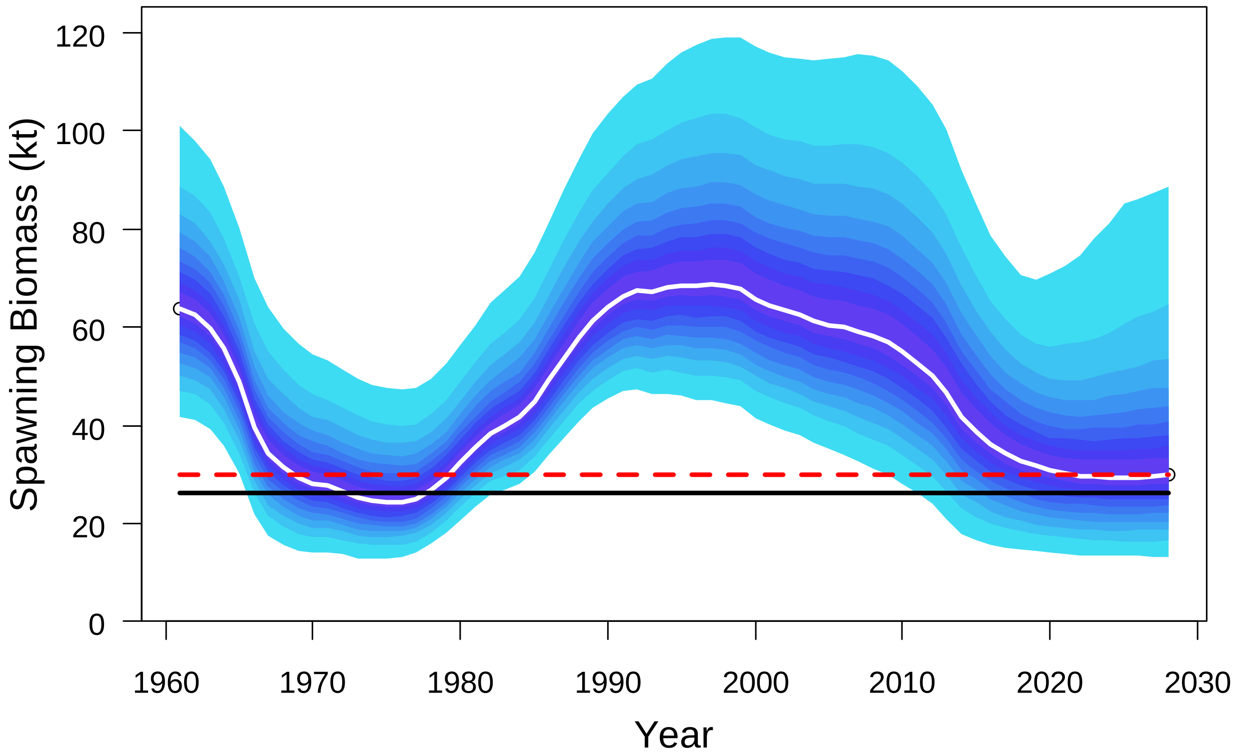

Figure 10.18. Bayesian credible intervals for entire spawning stock biomass series including projections through 2028. Red dashed line is $B_{40\%}$ and black solid line is $B_{35\%}$ based on recruitments from 1977-2011. The white line is the median of MCMC simulations. Each shade is 5% of the posterior distribution.

Appendix 10A.—Supplemental catch data

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

The first dataset, non-commercial removals, estimates total removals that do not occur during directed groundfish fishing activities. 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 (CAS) estimates. For Gulf of Alaska (GOA) northern rockfish, these estimates can be compared to the research removals reported in previous assessments (Heifetz et al. 2009) (Table 10A.1). Northern rockfish research removals are minimal relative to the fishery catch and compared to the research removals for many other species. 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 northern rockfish in the GOA. Other research activities that harvest northern rockfish include other trawl research activities and minor catches occur in longline surveys conducted by the International Pacific Halibut Commission and the AFSC. There was no recorded recreational harvest or harvest that was non-research related of northern rockfish in 2010. Total removals from activities other than a directed fishery were less than 1 t in 2010. This is 0.02% of the 2011 recommended ABC of 4,857 t and represents a very low risk to the northern rockfish stock. Research harvests in recent years are higher in odd years due to the biennial cycle of the AFSC bottom trawl survey in the GOA. These catches vary greatly and in recent years have ranged from 7 – 27 t. Even research catches of this magnitude do not pose a significant risk to the northern rockfish stock in the GOA.

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 may become available following restructuring of the Observer Program in 2013.

The HFICE estimates of GOA northern rockfish catch are minimal indicating the halibut fishery does encounter northern rockfish but catches are likely low (Table 10A.2). The majority of catch likely occurs in the western and central GOA's as there is very little biomass of northern rockfish in the Eastern GOA. Estimated catches are near or below 1 t per year. Based on these estimates, the impact of the halibut fishery on northern rockfish stocks is minimal.

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Heifetz, J., D. Hanselman, J. N. Ianelli, S. K. Shotwell, and C. Tribuzio. 2009. Gulf of Alaska northern rockfish. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska as projected for 2010. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501. pp. 817-874.

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

Table 10A.1. Total removals of Gulf of Alaska northern rockfish (t) from activities not related to directed fishing, since 1977. Trawl survey sources are a combination of the NMFS echo-integration, small-mesh, and GOA bottom trawl surveys, and occasional short-term research projects. Other is longline, personal use, recreational, and subsistence harvest.

Year	Source	Trawl	Other	Total
1977	**Assessment of northern rockfish in the Gulf of Alaska (Heifetz et al. 2009)**	0		0
1978		1		1
1979		1		1
1980		1		1
1981		8		8
1982		6		6
1983		2		2
1984		11		11
1985		11		11
1986		1		1
1987		41		41
1988		0		0
1989		1		1
1990		19		19
1991		0		0
1992		0		0
1993		21		21
1994		0		0
1995		0		0
1996		13		13
1997		1		1
1998		2		2
1999		13		13
2000		0		0
2001		23		23
2002		0		0
2003		7		7
2004		0		0
2005		27		27
2006		0		0
2007		22		22
2008		0		0
2009		7		7
2010	AKRO	<1	<1	1
2011		11	<1	11
2012		<1	<1	1

Table 10A.2. Estimates of Gulf of Alaska northern rockfish catch (t) from the Halibut Fishery Incidental Catch Estimation (HFICE) working group. WGOA = Western Gulf of Alaska, CGOA = Central Gulf of Alaska, EGOA = Eastern Gulf of Alaska, PWS = Prince William Sound.

Area	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
WGOA	0	0	0	<1	0	0	0	0	0	0
CGOA-Shumagin	0	0	0	0	0	0	0	0	<1	0
CGOA-Kodiak	0	0	0	<1	0	0	0	0	0	0
EGOA-Yakutat/PWS*	0	0	0	0	0	0	0	0	0	0
EGOA-Southeast	0	0	0	0	0	0	0	0	0	0
Southeast Inside*	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	1	0	0	0	0	<1	0

*These areas include removals from the state of Alaska waters.

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