2004 BSAI Other Rockfish

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14.0 Executive Summary

(a) 14.0.1 Summary of Major Changes

<u>Changes in the input data</u>

1. New species name for dusky rockfish (*Sebastes variabilis*) formerly light dusky and dark rockfish (*S. ciliatus*) formerly dark dusky.
2. The 2003 landings have been revised and the 2004 landings through October 15th, 2004 have been included in the assessment.
3. Length frequency graphs from the fishery data have been updated for dusky rockfish, shortspine thornyheads and harlequin rockfish.
4. Weight at length data are reported for dusky rockfish, shortspine thornyheads and harlequin rockfish.
5. Responses to SSC comments and Plan Team recommendations included.

<u>Changes in assessment results</u>

6. Author's recommendation on splitting out SST from the other rockfish complex
7. Full assessment of SST and other rockfish minus SST presented within Chapter

Below are the various scenarios for calculating ABC and OFL for Other rockfish, Shortspine thornyheads and Other rockfish minus SST. Author recommended scenarios in bold italics.

Other rockfish complex Tier 5:

Region	M	Exploitable biomass (mt)	ABC (mt)	OFL (mt)
BSAI	**0.07**	**26,649**		**1,865**
EBS		15,406	809	
AI		11,242	590	

Shortspine thornyhead ABC and OFL using model estimates:

Region	M	Exploitable biomass (mt)	ABC (mt)	OFL (mt)
BSAI	**0.07**	**38,027**		**2,662**
EBS		20,281	1,065	
AI		17,746	932	

Shortspine thornyhead ABC and OFL using survey biomass estimates ***(author recommended scenario):***

Region	M	Exploitable biomass (mt)	ABC (mt)	OFL (mt)
BSAI	**0.07**	**24,853**		**1,740**
EBS		14,413	757	
AI		10,440	548	

Other rockfish minus SST (Tier 6: OFL equals average catch 1978-1995) ***(author recommended scenario)***:

Region	ABC (mt)	OFL (mt)
BSAI		**675**
EBS	506	
AI	506	

Other rockfish minus SST (Tier 5 average biomass 1991-2004):

Region	M	Exploitable biomass (mt)	ABC (mt)	OFL (mt)
BSAI	**0.09**	**1,951**		**176**
EBS		1,018	69	
AI		933	63	

(b) 14.0.2 Responses to SSC Comments

During the December 2003 Council meeting the SSC specifically commented on providing further information regarding localized depletion for BSAI rockfish.
Comment:

The SSC requests that additional analysis be provided for rockfish regarding:
a. A listing of species of rockfish which are most likely to be subject to local depletions either due to specific life history characteristics or fishing practices;
b. The availability of data for those species which could be used to evaluate the occurrence of local depletion; and
c. The quality of data that would be needed to detect local depletion with reasonable certainty.

Response:
The authors discussed a list of rockfish species most likely to be subject to localized depletion in the BSAI. At this time the best information we have is based on importance of species to fishery, thus the priority is on species that are targeted by a fishery followed by those caught as bycatch in other fisheries:

1. Pacific Ocean Perch
2. Northern
3. Rougheye
4. Shortraker
5. Dusky
6. Remaining other rockfish

The availability of data is greater for those species most influenced by fishing practices. Higher priority is given to species with data suitable for a depletion analysis. Our analysis focuses on species commonly encountered in fishing operations because the catch time series allows detection of small scale localized depletions (scale of days). Catch records for rockfish species only caught intermittently in the fisheries do not allow for a depletion study on a small temporal and spatial scales. When the temporal scale becomes too large, the certainty of any evidence of localized depletion decreases.

During the October 2004 Council meeting the SSC specifically commented on the preliminary assessment for BSAI shortspine thornyheads.
Comment:

The SSC received a preliminary groundfish SAFE section for BSAI shortspine thornyheads, which had been grouped in the "other rockfish" category and have not previously been assessed. The SSC commends the author for exploring possible methods for assessing this stock. The author attempted to model the available catch and survey biomass data using a surplus production approach, but the fit of the model to the survey biomass estimates was not reasonable. The SSC recommends dropping the surplus production model approach and instead suggest that a refined assessment should be developed using a delay-difference, biomass dynamics, or age-based approach. Age composition data for this stock are expected to become available in two years.

Response:
The authors would like clarification on the alternative modeling methods suggested. The delay-difference model will be reviewed as a method to present to the September 2005 plan team. An age-structured model is currently not feasible for SST, because no age data are available for this species. The Age and Growth Group at the AFSC is currently working towards establishing an acceptable protocol for age estimation of SST. The time necessary to establish this protocol is unknown because it is not a priority task for the Age and Growth group.

SSC October 2004 comment on new taxonomic findings in rockfish.
Comment:
Based on new taxonomic findings, NMFS now recognizes two species of rockfish, dusky rockfish (Sebastes variabilis, formerly light dusky rockfish) and dark rockfish (Sebastes ciliatus, formerly dark dusky rockfish). The SSC received GOA plan team recommendations to remove dark rockfish to state management, both in the Gulf of Alaska and Bering Sea / Aleutian Islands regions. The SSC encourages the Plan Teams to develop a sound rationale for this suggested FMP amendment.

Response:
In this assessment the new nomenclature for dusky and dark rockfish will be used.

14.1 Introduction

The other rockfish complex includes all species of Sebastes and Sebastolobus spp. other than Pacific ocean perch (*Sebastes alutus*) and those species in the other red rockfish complex (northern rockfish, *S. polyspinis*; rougheye rockfish, *S. aleutianus*; and shortraker rockfish, *S. borealis*). This complex is one of the rockfish management groups in the Bering Sea and Aleutian Island (BSAI) regions. Eight out of twenty-eight species of "other rockfish" have been confirmed or tentatively identified in catches from the eastern Bering Sea and Aleutian Islands region, thus these are the only species stocks managed in this complex (Reuter and Spencer 2001, NOAA Fisheries 2002 Report to Congress April 2003). These species have been observed at least once in the hauls of the BSAI surveys and/or have occurred in at least 1% of the hauls where an species from the other rockfish category has been caught (Table 14.1). The two most abundant species for this complex are dusky rockfish (*Sebastes variabilis*) and shortspine thornyheads (*Sebastolobus alascancus*). In 2004 though, the Aleutian Island (AI) Survey estimated that there was a 4,000 mt biomass of Harlequin rockfish (*S. variegatus*), unfortunately this was based mainly on two large hauls of this species thus yielding a very high CV of 0.99.

The distributions of these other rockfishes are not well documented in the BSAI regions. Dusky rockfish are occasionally observed in AFSC research surveys throughout the Aleutian Islands. When observed dusky rockfish are typically captured between 125 -200m (Reuter and Spencer 2001). Catches of shortspine thornyheads in the Aleutian Island (AI) region are observed around the islands along the bathymetric contours between 200 m and 500 m (Reuter and Spencer 2001). In the Eastern Bering Sea (EBS) dusky rockfish are rarely encountered in the catches of either the survey or the fishery. Whereas, the shortspine thornyhead distribution is similar to that found in the AI with most encounters occurring in survey and fishery tows deeper than 200 m (Reuter and Spencer 2001).

Recently, in the Aleutian Islands, bycatch of dusky rockfish is highest near Seguam pass and Petrel Bank. This contrasts with the locations where the AFSC AI survey catch dusky rockfish where in 2002 and 2004 the highest catch was at the western tip of Amchitka Island (Figure 14.1).

Locations of dusky rockfish bycatch in the EBS fisheries are peppered along the slope, and in the region just north of Unalaska Island and Akutan Island in the southern part of the EBS and at the southern tip of Zhemchug canyon in the northern part of the EBS (Reuter and Spencer 2002). In the 2004 Southern Bering Sea (SBS) survey, locations of dusky rockfish catch were similar to fishery bycatch distributions for areas near Unalaska Island and Akutan Island.

In the past shortspine thornyheads (SST) have been grouped in the other rockfish category and make up approximately 90% of the other rockfish complex biomass. Due to conservation concerns for other rockfish species, the authors recommended splitting thornyhead from the other rockfish complex (Reuter and Spencer 2003). In this assessment information will be provided that can be used to assess SST independent from the Other rockfish complex. This step is to allow for discussion in the process of separating SST from the Other rockfish complex. Scenarios showing the ABC and OFL, with the entire Other rockfish complex, SST and Other rockfish complex minus SST will be presented. Furthermore, the assessment of SST was done using a surplus production model and is presented in this chapter.

14.1.1 Fishery

Since 1977, rockfish have been identified to the species level in fishery catches by U.S. observers, providing a means of estimating annual harvests of individual species. The dominant species in the "other rockfish" group are dusky rockfish (*S. variabilis*) and shortspine thornyheads (*Sebastolobus alascanus*).

Historical catches of other rockfish since implementation of the MFCMA are shown in Table 14.2. Catches prior to 1990 are assumed to include discards; whereas, catches during the period 1990-2004 explicitly account for discards based on NMFS Regional Office and observer information. The peak catch of other rockfish in the EBS occurred in 1978 with a removal of 941 mt. In the Aleutian region, peak catch occurred in 1982 with a harvest of 2,114 mt. Note that in 2001 removals from the foreign fishery of other rockfish were revised using the current species complex (Reuter and Spencer 2001).

In recent years in both the AI and EBS, the other rockfish catch of was mainly comprised of dusky rockfish and shortspine thornyheads (Table 14.3). Catches were extrapolated from species compositions recorded by fishery observers. In the AI dusky rockfish account for 40% (1999) to 65% (2001) of the other rockfish catch, whereas in the EBS, SST account for 55% (1998) to 78% (2002) of the other rockfish catch.

The target fisheries that catch these two species are described in Table 14.4. Target fisheries are defined by which species or species group occurred in the greatest abundance based on the total catch of the haul. During 2002 and 2003 in the AI, 76% to 80% of the total dusky rockfish catch was caught during the Atka mackerel (*Pleurogrammus monopterygius*) trawl fishery and 33% to 51% of the total SST catch was caught using longline gear in hauls whose target we describe as “other fish” (grenadiers and/or skates) longline fishery. During the same years in the EBS, 50% of the dusky rockfish bycatch occurred in hauls designated as the pollock (*Theragra chalcogramma*) pelagic trawl fishery. In 2002 and 2003 in the EBS 46% to 66% of the SST catch occurred in hauls described as the Arrowtooth/Kamchatka flounder bottom trawl fishery.

Other rockfish retained and discarded catch are shown in Table 14.5. In the Aleutian Islands on average 48 % of those species in the other rockfish category were discarded. In the Eastern Bering Sea on average 37 % of those species in the other rockfish category were discarded. The difference in discard rates in these areas may be due to the difference in species composition.

Shortspine thornyhead retained and discarded catch are shown in Table 14.6. In both the Eastern Bering sea and the Aleutian Islands shortspine thornyheads have been retained almost 100% for the last ten years. The high rates of retention are due to the high value of shortspine thornyheads. This is especially true if they are caught using fixed-gear which yields a higher quality product than trawl gear (Hiatt, Felthoven and Terry 2002).

Fishery Independent Surveys and Biomass Estimates

Several bottom trawl surveys provide biomass estimates for the EBS and AI regions. The 1979-86 cooperative U.S.-Japan trawl surveys in the EBS were conducted both on the continental shelf and slope. A majority of catches of other rockfish were taken by Japanese research trawlers working the slope regions at depths exceeding 200 m. In 1991 trawl surveys were conducted in both the EBS and Aleutian regions. These surveys, however, were conducted entirely by domestic trawlers and did not include participation by the deeper-water Japanese research trawlers. The most recent trawl surveys occurred in 1997, 2000, 2002 and 2004 in the Aleutian Islands region. Biomass estimates for other rockfish were produced from cooperative U.S.-Japan trawl surveys from 1979-1985 on the eastern Bering Sea slope, and from 1980-1986 in the Aleutian Islands. U.S domestic trawl surveys were conducted in 1988, 1991 and 2002 on the eastern Bering Sea slope, and in 1991,1994, 1997, 2000, 2002 and 2004 in the Aleutian Islands (Table 14.7). The first official EBS slope survey was conducted in 2002 and will be conducted biennially. Biomass estimates from this survey will be used because it provides a better estimate of SST biomass for this region. Unlike other regions, longspine thornyheads (Sebastolobus altivelus) biomass is negligible or non-existent in the BSAI, thus SST are the only thornyheads being assessed separately.

In the AI region, the large change in biomass estimates from the 1980-1986 to the 1991-2004 surveys may be due to the differences in vessel type, gear type and survey methodology (Table 14.7). The spatial coverage and survey methods used during 1980 -1986 and 1991 - 2004 were consistent within a time period. Since 1994, the AI groundfish trawl biomass estimates for other rockfish have been stable and increasing. The AI groundfish trawl biomass estimates for other rockfish increased from 6,668 mt (CV = 0.22) in 1991 to 18,862 mt in 2004 (CV = 0.18). In the SBS region other rockfish biomass has been stable since 1994, but a large catch of harlequin rockfish during the 2004 survey increased the biomass to 6,481 mt (CV=0.67). The 2002 and 2004 Bering Sea slope biomass estimates for other rockfish have been fairly consistent.

For the dusky rockfish the population in the AI has fluctuated between 89 mt in 1994 to 1,233 mt in 2000 (Table 14.8). In 2004 the dusky biomass in the SBS region was the highest observed at 1,358 mt (CV=0.91). Since 1994, the AI groundfish trawl biomass estimates for shortspine thornyhead have been increasing. The AI groundfish trawl biomass estimates for shortspine thornyhead increased from 9,813 mt (CV = 0.15) in 2000 to 14,243 mt (CV = 0.20) in 2002. SST biomass has been increasing in the AI from 6,240 mt in 1994 to 17,283 mt (CV=0.19) in 2004 (Table 14.8). In the SBS, the SST biomass has been stable.

Biomass estimates for SST and Other rockfish minus SST have been provided in Table 14.9. These data show that the coefficient of variation on the biomass estimates of other rockfish increase substantially when SST are removed from the complex, in some cases an increase as high as 0.5 (1994-AI) or as low as 0.10 (2002-AI).

14.2 Data

Fishery

Length frequency

Dusky rockfish:

Prior to 2002 few length frequency data of dusky rockfish were collected. Therefore, the length frequency graphs that are shown in Figure 14.2a may not represent the exploited population. In 2002, observers measured dusky rockfish when they were encountered. The mean length of dusky caught in the fishery has changed very little since 2002. Currently the mean length of dusky rockfish in the AI fishery data is 42 cm.

Shortspine thornyheads:

The exploited portion of the population of shortspine thornyhead in the BSAI region are adequately represented and Figure 14.2b shows that individuals between 30 cm and 60 cm are consistently caught by the fishery. The available data do not span a long enough time period to detect any strong year-classes for long-lived species such as shortspine thornyhead rockfish. Data from 2003-2004 from the EBS fisheries show that the SST caught are a bit smaller than those caught in the AI, mean length 35 cm (Figure 14.3).

Survey

Length frequency

Dusky rockfish:

Although infrequently encountered during the AI surveys, the length frequency histograms of dusky rockfish consistently show that mainly fish over 30 cm are captured with this gear type (mean length is 39 cm, Figure 14.4). In 2004 the mean length increased to about 42 cm and reflected the size distribution from those dusky measured from fishery hauls (Figure 14.4).

Shortspine thornyheads:

Length frequency from the AI trawl survey show that the majority of the specimens sampled were between 20 and 50 cm (Figure 14.5) a size range that is smaller than those caught in the fishery. In the EBS slope survey data, SST as small as 50 cm have been measured, with a bulk of the samples ranging from 16 – 52 cm (Figure 14.6).

Harlequin rockfish:
During the 2004 AI survey, two large hauls of harlequin rockfish occurred. This allowed for sufficient measurements to be collected to create a length frequency graph (Figure 14.7). Size range of the harlequin rockfish caught were between 26 cm –39 cm.

Length at Age
Dusky rockfish:
The only available age data for dusky rockfish are from the 2002 AI survey (n=108). Analysis of these data using a von Bertalanffy growth function result in an L_{inf} of 41.6 cm, K=0.32 and a t_o = 2.5 (Reuter and Spencer 2003). Visual comparison of these results and those from the GOA suggest that dusky rockfish in the AI are smaller at age (Clausen and Heifetz 2002).

Shortspine Thornyheads:
No age data exist for SST because an ageing technique has yet to be satisfactorily determined. Current research within the Age and Growth group at the AFSC will provide valuable information in the next two years.

Weight at Length
Weight at length was calculated for dusky rockfish and shortspine thornyhead rockfish using the formula $W=aL^b$, where W is weight in grams and L is fork length in mm.

Species	Data source	Years sampled	Area	a	b	Sample size
Dusky	Survey	2002, 2004	AI	5×10^{-6}	3.2	283
SST	Survey and Fishery	1983, 1986, 1991, 1994, 1997, 1999, 2000, 2001, 2002, 2004	BSAI	2×10^{-6}	3.27	3,938

Natural mortality

SST
The natural mortality of SST is controversial and can be explained through the difficulty of ageing this species. In the GOA Thornyhead assessment, Gaichas and Ianelli 2003, went through a lengthy discussion regarding the various natural mortality estimates from several studies. The variability in natural mortality stems from the ongoing challenge to estimate ages of SST. Several studies have calculated natural mortality differently due to the age of their oldest sample. Miller (1985) estimated natural mortality to be 0.07 from a sample of SST in Southeast Alaska whose oldest age was 62 years old. Whereas, a study using west coast SST estimated a natural mortality between 0.05-0.07 with the oldest age in the sample being 80 (Kline 1996). Pearson and Gunderson (2003) suggest that SST from Alaska have an M = 0.013, based on a study using the gonadosomatic index to estimate natural mortality. A natural mortality rate that low would suggest that these fish reach ages well over 100 years. The reason for the different rates of natural mortality are based on the different techniques used. Miller used surface ageing and break and burn technique, and found that precision and comparability was low. Kline (1996) on the other hand used a thin section technique that had better inter-reader ageing agreement, and the radiometric verification technique used strongly supported the otolith ageing technique. Subsequent radiometric work by Kastelle et al. (2000), corroborated Kline’s results. Thus, Kline’s methodology and results are presumed to be the most accurate given the uncertainty of ageing SST. Furthermore, the maximum age assumption for Pearson and Gunderson’s (2003) methodology, doesn’t fit life history patterns for any other known deep water fish species. Work is currently being done at the Alaska Fisheries Science Center to determine the best ageing technique to use for SST (personal communication Betty Goetz, Age and Growth group, REFM, AFSC). Historically, the value of M (0.07) has been used to

assess the other rockfish stock, which represents an approximation based on knowledge of rockfish life histories from other areas. This value is based on the estimate for shortspine thornyheads (Ianelli and Ito 1994) since this species evidently comprises well over 90% of the other rockfish biomass (as calculated by survey data). With this and the information from Kline (1996) the authors recommend using the natural mortality value of 0.07 for BSAI SST. This is in contrast to the Gulf of Alaska (GOA) Thornyhead assessment where a natural mortality estimate of 0.03 is used due to the preference of the GOA plan team.

Other rockfish
The value of M for the other rockfish complex has been 0.07, which represents an approximation based on the knowledge of rockfish life history from other areas. If SST are to be removed from the other rockfish complex, then the majority of its biomass will be from Dusky rockfish. The M for Dusky rockfish in the GOA is 0.09, and thus is currently the best estimate of M (Clausen and Heifetz 2002).

14.3 Analytical Approach

14.3.1 Model Structure (Shortspine Thornyheads)

The Schaefer (1954) surplus production model was used to model the BSAI shortspine thornyheads.

$$\hat{B}_{t+1} = \left[\hat{B}_t + r\hat{B}_t\left(1 - \frac{\hat{B}_t}{k}\right) - C_t\right]$$

Where $\hat{B}_{t+1}$ is the estimated biomass at time *t* plus one, $\hat{B}_t$ is the estimated biomass at time *t*, C_t is catch at time *t*, *r* the intrinsic growth rate, and *k* the initial biomass or carrying capacity.

The model was fit using an observation error estimator that uses a form of the biomass dynamic model. Polacheck et al., (1993) showed that observation error, for the Cape Hake stock off northern Namibia, the New Zealand rock lobster and the south Atlantic albacore, provided the least biased and most precise estimates especially for data scenarios where catch but not catch-rate data are available.

$$\hat{I}_t = q\hat{B}_t$$

I_t is an index of relative abundance, in this case the survey biomass estimate assuming the catchability coefficient $q = 1$. The observation error estimator assumes that the Schaefer model is deterministic and that all of the error occurs in the observed index with relative abundance (Polacheck et al., 1993).

The observation error is then calculated under the assumption that the error is multiplicative and log-normal with a constant coefficient of variation:

$$I_t = \hat{I}_t \exp(v_t)$$
$$v_t = \ln(I_t) - \ln(\hat{I}_t)$$

And finally the model parameters, σ_v (the standard deviation of v_t), *r* the intrinsic growth rate and *k* the carrying capacity, are estimated by maximizing the appropriate likelihood function:

$$L(w_v) = \frac{1}{\sigma_v \sqrt{2\pi}} \exp\left(-\frac{v_t^{\,2}}{2\sigma_v^{\,2}} \right)$$

To obtain likelihood profiles for *r* and *k*, PopTools a windows based MS Excel add-in tool that is an analytical and statistical software program developed at CSIRO was used (Hood, 2004). Surplus production S_t, was calculated:

$$S_t = B_{t+1} - B_t + C_t$$

Model results

Only two data sets were considered for runs of the surplus production model. The SBS data set and AI data set were chosen because they have the longest time series of survey biomass estimates. The Bering sea slope survey was not included in the run because the time series begins in 2002.

Data scenario for BSAI model run

Data	Region	Time Series
Groundfish Trawl Survey	SBS	1991, 1994, 1997, 2000, 2002, 2004
Groundfish Trawl Survey	AI	1991, 1994, 1997, 2000, 2002, 2004

Model parameters estimated were *k*, *r* and B_o and results are shown in Table 14.10. The fit to the model estimates to the observed biomass estimates for the BSAI show the model fitting well with the increasing biomass estimates (Figure 14.8). With the data currently available, it shows the SST biomass increasing exponentially with a carrying capacity of 8.8 x 10^8 mt, of course this is most likely not true but the model does fit the observed data well. This is further supported with the *r* and *k* values, whose upper and lower 95% confidence intervals (based on their likelihood profiles) are near their maximum likelihood estimate (MLE) values (Table 14.10). Surplus production of the SST population shows an increase along with the increasing biomass (Figure 14.9).

Figure 14.10 shows a graph of the survey biomass and the data fitted with a Kalman filter provided by Grant Thompson (AFSC/REFM Seattle). The Kalman filter decreases the process and measurement errors of each observation, there is no estimation of carrying capacity and only estimates two parameters (initial abundance and process error standard deviation). This method does not allow for projecting biomass, but is a method of obtaining biomass estimates with smaller confidence intervals. Thus, the biomass estimate for use to obtain ABC and OFL is very similar to just taking the average of the survey biomass estimates.

The 2004 model biomass estimate for the SBS/AI regions was 19,501 mt (Table 14.11). To get the biomass estimates for each region an extrapolation factor was used. This factor is calculated by taking the average of the yearly proportions of each region to the SBS/AI total biomass (since these were the data used in the model). For the AI, the extrapolation factor was 91%, for a total biomass of 17,746 mt. For The biomass for the EBS (20,281 mt) was calculated by adding the SBS biomass (1,755 mt), using an extrapolation factor of 9%, to the Bering Sea slope biomass (18,526 mt), whose extrapolation factor was 95%. Thus, these results were used to obtain ABC and OFL values for SST.

14.4 ABC and OFL recommendations

In the 2003 assessment of Other rockfish, Reuter and Spencer (2003) recommended splitting SST from the other rockfish complex because this species biomass makes up over 90% of the Other rockfish biomass, it is also demographically different than the rest of the complex and the biomass estimates for this species has lower uncertainty (average CV of last 5 AI survey = 0.18) than those for the other rockfish species within the complex (average CV of last 5 AI survey = 0.42). Due to lack of information on stock structure, genetic and otherwise between the EBS and AI regions, it is recommended that there be a BSAI OFL for SST and the remaining other rockfish complex.

Assessment of Other rockfish

The other rockfish complex is assessed at the tier 5 level, because it has a reasonable estimate of biomass and natural mortality. For calculation of the OFL (M x BSAI biomass), the BSAI biomass estimate is calculated by adding the average biomass (1991-2004 surveys) of the AI (11,242 mt) and SBS (1,950 t) regions with the average EBS slope survey (1991, 2002-2004) estimate (13,456 mt). For calculation of ABC ((0.75x0.07) x biomass estimate), the AI biomass estimate is the average biomass from the last six surveys and the EBS biomass is calculated by adding the average SBS biomass estimate with the average EBS slope survey biomass.

Other rockfish complex Tier 5:

Region	M	Exploitable biomass (mt)	ABC (mt)	OFL (mt)
BSAI	**0.07**	**26,649**		**1,865**
EBS		15,406	809	
AI		11,242	590	

Assessment of SST using model results

SST were assessed using the Tier 5 methodology of estimating ABC and OFL. Their Tier 5 designation is due to the low variance in their biomass estimates. Thus, the survey biomass estimates are believed to adequately reflect the SST population abundance.

The biomass estimate for 2005 obtained for the BSAI using the surplus production model. As discussed above, to obtain a biomass estimates for each region an extrapolation factor was used. This factor is calculated by taking the average of the yearly proportions of each region to the SBS/AI total biomass (since these were the data used in the model). For the AI, the extrapolation factor was 91%, for a total biomass of 17,746 mt. For The biomass for the EBS (20,281 mt) was calculated by adding the SBS biomass (1,755 mt), using an extrapolation factor of 9%, to the Bering Sea slope biomass (18,526 mt), whose extrapolation factor was 95%. BSAI OFL and AI and EBS ABC were then calculated.

Shortspine thornyhead ABC and OFL using model estimates:

Region	M	Exploitable biomass (mt)	ABC (mt)	OFL (mt)
BSAI	**0.07**	**38,027**		**2,662**
EBS		20,281	1,065	
AI		17,746	932	

Other Assessment methods (SST and remaining other rockfish)

SST

Despite presenting the surplus model above, the following is a presentation of the assessment of SST using survey biomass estimates. The biomass estimates were calculated similar as for the Other rockfish Tier 5 assessment above, where the estimates are averages of the past 6 surveys in the AI and SBS regions and the last three EBS slope surveys. The BSAI survey biomass estimate (24,853 mt) used was the AI biomass (14,413 mt) added with the average SBS biomass (968 mt) and the average EBS slope biomass (13,445 mt). The AI ABC and EBS ABC were calculated using their respective biomass estimates.

Shortspine thornyhead ABC and OFL using Tier 5 survey biomass estimates:

Region	M	Exploitable biomass (mt)	ABC (mt)	OFL (mt)
BSAI	**0.07**	**24,853**		**1,740**
EBS		14,413	757	
AI		10,440	548	

Other rockfish minus SST assessment

Tier 6 example:
Given that the biomass estimates for the remaining other rockfish have high coefficients of variation (0.30 -0.88) the authors suggest assessing them at the Tier 6 information level. At this level the OFL is calculated as the average catch from 1978-1995. The catch was calculated by taking the proportion of SST to the total Other rockfish catch observed data and subtracting it from the Other rockfish blend data (total catch). The ABC's are the OFL x 0.75.

Other rockfish minus SST (Tier 6: OFL equals average catch 1978-1995):

Region	ABC (mt)	OFL (mt)
BSAI		**675**
EBS	506	
AI	506	

Tier 5 example:
If the Plan Team or other entity deem the remaining other rockfish complex worthy of a Tier 5 information level then the following are provided. This scenario will use an M of 0.09 which is the M for dusky rockfish in the GOA, since dusky make up the majority of the complex (Clausen and Heifetz 2002).

Other rockfish minus SST (Tier 5 average biomass 1991-2004):

Region	M	Exploitable biomass (mt)	ABC (mt)	OFL (mt)
BSAI	**0.09**	**1,951**		**176**
EBS		1,018	69	
AI		933	63	

14.5 Ecosystem Considerations

14.5.1 Ecosystem Effects on Stock

Little to no information is available that would help us understand the effects the ecosystem has on the other rockfish complex. The table below goes over the most probable affects of the ecosystem on the other rockfish complex.

14.5.2 Fishery Effects on the Ecosystem

Analysis of ecosystem considerations for those fisheries that effect the stocks within this complex (see Table 14.4) is given in the respective fisheries SAFE chapter. The other rockfish complex is not a targeted fishery, therefore reference on the effects of the fishery on the ecosystem will be described in those chapters of the fisheries that catch other rockfish incidentally.

Ecosystem effects on *Other Rockfish*			
Indicator	Observation	Interpretation	Evaluation
Prey availability or abundance trends			
Zooplankton	Stomach contents, ichthyoplankton surveys, changes mean wt-at-age	Data non-existent	Unknown
a. Predator population trends			
Marine mammals	Fur seals declining, Steller sea lions increasing slightly	No affect	Probably no concern
Birds	Stable, some increasing some decreasing	No affect	Probably no concern
Fish (Pollock, Pacific cod, halibut)	Stable to increasing	Affects not known	Probably no concern
b. Changes in habitat quality			
Temperature regime	None	Affects not known	Unknown
Winter-spring environmental conditions	None	Probably a number of factors	Unknown
Production	Fairly stable nutrient flow from upwelled BS Basin	Inter-annual variability low	No concern
***Targeted fisheries* effects on ecosystem (see relative chapters)**			

14.5.3 Data gaps and research priorities

Data needed to better understand the life history characteristics, spatial distribution and abundance are those most important in deciding creative management strategies for non-target species. These are the types of data missing for all the species within the other rockfish complex and for SST. These data types include but are not limited to: age data from the fishery for dusky rockfish; spatial and temporal length data from AI fishery for dusky rockfish; improved spatial distribution and abundance data of other rockfish; ageing techniques for SST.

Research priorities for the other rockfish complex and SST are analyses that utilize the above data to suggest stock health, potential fishery impacts and provide suggestions to mitigate concerns on conservation of the stock and localized depletion. Creation of an SST model similar to that used in the GOA is suggested to analyze the potential utility in model results for assessing stock health. Currently, the age and growth group are assessing ageing techniques for SST.

14.6 Summary

Below are various recommended scenarios for ABC and OFL for Other rockfish, Shortspine thornyheads and Other rockfish minus SST:

Shortspine thornyhead survey biomass estimates Tier 5: ***(author recommended scenario)***

Region	M	Exploitable biomass (mt)	ABC (mt)	OFL (mt)
BSAI	**0.07**	**24,853**		**1,740**
EBS		14,413	757	
AI		10,440	548	

Other rockfish minus SST Tier 6: ***(author recommended scenario)***

Region	ABC (mt)	OFL (mt)
BSAI		**675**
EBS	454	
AI	454	

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Table 14.1. The common and scientific names of rockfish in the “other rockfish” reporting category identified, 1990 - 2001, by AFSC research surveys (at least one observation) and U.S. fishery observers (greater than 1% of hauls) in the eastern Bering Sea and Aleutian Islands regions. (~ = none observed, percent of hauls where other rockfish occurred)

		EBS		AI	
Common name	Scientific name	**Survey**	**Fishery**	**Survey**	**Fishery**
Red banded rockfish	*Sebastes babcocki*	~	~	*1%*	*<1%*
Dark dusky rockfish	*Sebastes ciliatus*	~	*1%*	*4%*	*3%*
Dusky rockfish	*Sebastes variabilis*	*18%*	*39%*	*22%*	*45%*
Redstripe rockfish	*Sebastes proriger*	~	*1%*	~	*1%*
Yelloweye rockfish	*Sebastes ruberrimus*	~	*1%*	*<1%*	*1%*
Harlequin rockfish	*Sebastes variegatus*	~	*1%*	*9%*	*5%*
Sharpchin rockfish	*Sebastes zacentrus*	~	*<1%*	*<1%*	*<1%*
Shortspine thornyhead	*Sebastolobus alascanus*	*62%*	*43%*	*61%*	*34%*

Table 14.2.--Summary of catches (mt) of other rockfish in the eastern Bering Sea and Aleutian Islands regions. Source: NMFS/AK regional website.

	Eastern Bering Sea						Aleutian Islands					
	Domestic						Domestic					
Year	For.	JV	DAP	Total	ABC	OFL	For.	JV	DAP	Total	ABC	OFL
1977*	112	--	--	112			700	--	--	700		
1978*	941	--	--	941			212	--	--	212		
1979*	759	--	--	759			1,039	--	--	1,039		
1980	456	3	--	459			420	--	--	420		
1981	331	--	25	356			328	--	--	328		
1982	262	11	3	276			2,114	--	--	2,114		
1983	212	8	--	220			1,041	4	--	1,045		
1984	121	8	47	176			42	14	--	56		
1985	33	3	56	92			2	14	83	99		
1986	4	12	86	102			Tr	15	154	169		
1987	3	4	467	474			0	6	141	147		
1988	0	8	333	341			0	68	210	278		
1989	0	4	188	192			0	0	481	481		
1990	0	0	418	418			0	0	858	858		
1991	0	0	422	422			0	0	343	343		
1992	0	0	600	600			0	0	664	664		
1993	0	0	192	192			0	0	496	496		
1994	0	0	133	133			0	0	292	292		
1995	0	0	288	288			0	0	219	219		
1996	0	0	170	170			0	0	282	282		
1997	0	0	163	163			0	0	305	305		
1998	0	0	188	188			0	0	364	364		
1999	0	0	135	135			0	0	631	631		
2000	0	0	232	232	369	492	0	0	563	563	685	913
2001	0	0	295	295	361	482	0	0	592	592	676	901
2002	0	0	398	398	361	482	0	0	518	518	676	901
2003	0	0	324	324	960	1,280	0	0	401	401	634	846
2004§	0	0	307	307	960	1,280	0	0	311	311	634	846

* These biomass estimates were revised (2001) to show the catch of those species currently in the other rockfish category.

§ Estimated removals through October 15th, 2004.

Table 14.3. Observed fishery catch (mt) of top species in other rockfish group in the Aleutian Islands and eastern Bering Sea from 2000-2004. *Source: North Pacific Observer Database AFSC Seattle WA.*

Aleutian Islands

2004*	E	C	W	Total
Dusky	28	38	7	**73**
Shortspine	11	11	11	**33**
Thorny unid.	6	16	1	**23**
Harlequin	1	12	8	**21**
Total	**56**	**77**	**27**	**150**

2003	E	C	W	Total
Dusky	57	63	16	**136**
Shortspine	17	26	17	**60**
Thorny unid.	10	2	9	**21**
Harlequin	8	18	1	**27**
Total	**92**	**109**	**43**	**234**

2002	E	C	W	Total
Dusky	40	67	83	**190**
Shortspine	37	17	14	**68**
Thorny unid.	10	6	1	**17**
Harlequin	18	18	5	**41**
Rockfish unid.	12	2	5	**19**
Total	**117**	**110**	**108**	**335**

2001	E	C	W	Total
Dusky	145	63	44	**252**
Shortspine	20	13	8	**41**
Harlequin	3	8	12	**23**
Dark Dusky	1	5	4	**10**
Thorny unid.	8	< 1	< 1	**8**
Total	**182.5**	**93**	**112**	**387.5**

2000	E	C	W	Total
Dusky	192	65	6	**263**
Shortspine	46	22	19	**87**
Rockfish unid.	6	26	2	**34**
Harlequin	12	14	2	**28**
Redstripe	<1	<1	8	**8**
Total	**256**	**127**	**37**	**420**

*Observed catch as of October 15, 2004

Eastern Bering Sea

2004*	No. Bering Sea	So. Bering Sea (517-519)	Total
Shortspine thornyhead	17	107	**124**
Dusky	4	19	**23**
Thorny unid.	7	2	**9**
Rockfish unid.	4	2	**6**
Total	**32**	**130**	**162**

2003	No. Bering Sea	So. Bering Sea (517-519)	Total
Shortspine thornyhead	12	111	**123**
Dusky	5	12	**17**
Rockfish unid.	5	10	**15**
Thorny unid.	4	8	**12**
Total	**26**	**141**	**167**

2002	No. Bering Sea	So. Bering Sea (517-519)	Total
Shortspine thornyhead	11	108	**119**
Dusky	9	14	**23**
Redstripe	0	4	**4**
Rockfish unid.	3	3	**6**
Total	**23**	**129**	**152**

2001	No. Bering Sea	So. Bering Sea (517-519)	Total
Shortspine thornyhead	7.5	96	**104**
Dusky	4	18	**22**
Thorny unid.	3.5	5.5	**9**
Rockfish unid.	2	5	**7**
Total	**15**	**120**	**135**

2000	No. Bering Sea	So. Bering Sea (517-519)	Total
Shortspine thornyhead	13	71	**84**
Dusky	6	11	**17**
Rockfish unid.	10	2	**12**
broad banded thorny.	4	< 1	**4**
dark dusky	2	2	**4**
Total	**35**	**86**	**121**

*Observed catch as of October 15, 2004

Table 14.4. Catch (mt) of dusky rockfish and Shortspine thornyhead by target fishery and gear type for 2003, and 2002. *Source: NorPac Database AFSC Seattle WA.*

2003

Aleutian Islands

Dusky rockfish

Target fishery	Geartype			Total
	Trawl	Pot	Longline	
Atka Mackerel	110	-	>1	**110**
POP	14	-	-	**14**
Pacific Cod	6	-	3	**9**
Northern rockfish	5	-	>1	**5**
Total	**135**		**3**	**138**

Shortspine thornyhead

Target fishery	Geartype			Total
	Trawl	Pot	Longline	
Other Fish	>1	>1	35	**35**
POP	15	>1	-	**15**
Sablefish	-	1	4	**5**
Total	**15**	**1**	**39**	**55**

Eastern Bering Sea

Dusky rockfish

Target fishery	Gear type				Total
	Bottom trawl	Pelagic trawl	Pot	Longline	
Pollock	1	7	-	-	**8**
Pacific Cod	2	-	1	5	**8**
Total	**3**	**7**	**1**	**5**	**16**

Shortspine thornyhead

Target fishery	Gear type				Total
	Bottom Trawl	Pelagic trawl	Pot	Longline	
Arrowtooth/ Kamchaka	55	-	>1	>1	**55**
Greenland Turbot	16	-	>1	13	**29**
Other Fish	13	-	>1	9	**22**
SST	12	-	-	-	**12**
Total	**96**		**>1**	**22**	**118**

*Other fish target made up mainly of grenadiers and/or skates

2002

Aleutian Islands

Dusky rockfish

Target fishery	Geartype Trawl	Pot	Longline	Total
Atka Mackerel	143	-	<1	**143**
Pacific Cod	10	-	7	**17**
POP	16	-	-	**16**
Northern rockfish	11	-	-	**11**
Total	**180**	**-**	**7**	**187**

Shortspine thornyhead

Target fishery	Geartype Trawl	Pot	Longline	Total
Other Fish	<1	<1	29	**29**
POP	19	-	-	**19**
Sablefish	-	<1	9	**9**
Total	**19**	**<1**	**38**	**57**

Eastern Bering Sea

Dusky rockfish

Target fishery	Gear type				Total
	Bottom trawl	Pelagic trawl	Pot	Longline	
Pollock	<1	10	-	-	**10**
Pacific Cod	1	-	<1	7	**8**
Dusky	3	-	-	<1	**3**
Total	**4**	**10**	**<1**	**7**	**21**

Shortspine thornyhead

Target fishery	Gear type				Total
	Bottom Trawl	Pelagic trawl	Pot	Longline	
Arrowtooth/ Kamchaka	53	-	<1	< 1	**53**
Greenland Turbot	23	-	<1	9	**32**
Other Fish	13	-	<1	6	**19**
SST	12	-	-	-	**12**
Total	**101**	**-**	**<1**	**15**	**116**

*Other fish target made up mainly of grenadiers and/or skates

Table 14.5. Other rockfish retained and discarded catch (mt) for the Aleutian Islands and the Eastern Bering Sea 1995-2002 and the BSAI for 2003. *Source: NMFS AK Region website.*

Other Rockfish

AI	Retained	Discarded	Total	Percent Discarded
1995	144	75	219	34
1996	155	127	282	45
1997	153	152	305	50
1998	127	237	364	65
1999	250	381	631	60
2000	340	223	563	40
2001	319	272	591	46
2002	267	250	517	48
EBS				
1995	126	162	288	56
1996	97	73	170	43
1997	107	56	163	34
1998	120	67	187	36
1999	78	57	135	42
2000	167	65	232	28
2001	237	57	294	19
2002	286	113	399	28
BSAI				
2003	451	275	726	39

Table 14.6. Shortspine Thornyhead retained and discarded catch (mt) for the Aleutian Islands and the Eastern Bering Sea 1992-2002. *Source: NMFS AK Region* .

Thornyheads

AI	Retained	Discarded	Total
1992	13	0	13
1993	195	5	200
1994	139	1	140
1995	78	2	80
1996	45	2	47
1997	54	0	54
1998	52	0	52
1999	42	4	47
2000	70	1	71
2001	100	0	100
2002	143	14	157

EBS			
1992	2	0	2
1993	29	1	30
1994	25	15	41
1995	60	0	61
1996	23	0	23
1997	15	3	18
1998	29	1	30
1999	25	1	26
2000	63	6	70
2001	68	1	69
2002	110	4	114

Table 14.7. Estimated biomass (mt) of "other rockfish" from the NMFS bottom trawl surveys. Coefficient of variation in parenthesis.

	Eastern Bering Sea (EBS)		
	EBS slope	Aleutians portion of EBS Area 1	Aleutian Region
1979	3,251	--	--
1980	--	1,095	19,078
1981	4,975	--	--
1982	4,381	--	--
1983	--	1,696	15,995
1984	--	--	--
1985	5,127	--	--
1986	--	5,187	20,336
1987	--	--	--
1988	8,759	--	--
1989	--	--	--
1990	--	--	--
1991	4,529	246 (0.49)	6,668 (0.22)
1992	--	--	--
1993	--	--	--
1994	--	1,171 (0.48)	6,449 (0.16)
1995	--	--	--
1996	--	--	--
1997	--	1,683 (0.63)	10,063 (0.17)
1998	--	--	--
1999	--	--	--
2000	--*	1,107 (0.45)	11,170 (0.14)
2001	--	--	--
2002	16,932 (0.11)	1,012 (0.37)	14,243 (0.03)
2003	--	--	--
2004	18,908 (0.09)	6,481 (0.67)	18,862 (0.18)

*Biomass estimates from the 2000 EBS slope survey were not used in stock assessment.

Table 14.8. Biomass estimates (mt) of the main species from the other rockfish group caught during the most recent Aleutian Islands surveys; by species, year and management area. CVs noted in parentheses. *Note: Biomass totals are slightly different than for Other rockfish category.*

2004	**E**	**C**	**W**	**Total AI**	**Southern BS**	**EBS Slope**	**Total BSAI**
Shortspine thornyheads	979	4,302	12,002	17,283(.19)	945(.55)	18,881(.09)	**37,109**
Harlequin	2	94	420	516(.79)	4,167(.99)	-	**4,683**
Dusky	93	403	249	745(.44)	1,358(.91)	13(.57)	**2,116**
Dark	0	2	310	312(.60)	8(.99)	-	**320**
Total				**18,856**	**6,478**	**18,894**	**44,228**

2002	**E**	**C**	**W**	**Total AI**	**Southern BS**	**EBS Slope**	**Total BSAI**
Shortspine thornyheads	543	5,454	8,246	14,243	1,012	16,932 (.11)	**32,187**
Dusky	149	261	36	446	97	25 (.56)	**568**
Dark	0	0	318	318	5		**323**
Total				**15,007**	**1,114**	**16,957**	**33,078**

2000	**E**	**C**	**W**	**Total AI**	**Southern BS**	**EBS Slope§**	**Total BSAI**
Shortspine thornyheads	522	3,815	5,476	9,813	1,051		**10,689**
Dusky	468	579	186	1,233	55		**1,288**
Dark	0	0	99	99	0		**99**
Harlequin	8	15	3	26	0		**26**
Total				**11,171**	**1,116**		**12,102**

1997	**E**	**C**	**W**	**Total AI**	**Southern BS**	**EBS Slope§**	**Total BSAI**
Shortspine thornyheads	159	2,011	6,726	8,896	1,545		**10,441**
Dusky	442	78	54	574	138		**712**
Dark	32	10	482	524	0		**524**
Harlequin	5	53	10	68	0		**68**
Total				**10,062**	**1,683**		**11,745**

1994	**E**	**C**	**W**	**Total AI**	**Southern BS**	**EBS Slope§**	**Total BSAI**
Shortspine thornyheads	187	1,554	4,499	6,240	1,071		**7,311**
Dusky*	7	51	31	89	97		**186**
Dark *	0	1	101	102	2		**104**
Harlequin	5	12	1	18	2		**20**
Total				**6,449**	**1,172**		**7,621**

*1994 dusky and dark biomass determined by proportion (based on 3 more recent survey data) of "dusky" catch. **§** No EBS slope survey

Table 14.9 Biomass estimates and Coefficient of variation, in parentheses, for SST and remaining species in Other rockfish complex used for estimating OFL and ABC.

Aleutian Islands

	1991	1994	1997	2000	2002	2004
SST	6,165 (0.24)	6,240 (0.16)	8,896 (0.18)	9,813 (0.15)	14,243 (0.20)	17,283(0.19)
Other rockfish	502 (0.39)	209 (0.61)	1,165 (0.46)	1,357 (0.32)	785 (0.30)	1,579 (0.35)

Southern Bering Sea

	1991	1994	1997	2000	2002	2004
SST	187 (0.58)	1,071 (0.52)	1,545 (0.68)	1,051 (0.48)	1,012 (0.40)	945 (0.55)
Other rockfish	58 (0.88)	100 (0.49)	138 (0.46)	55 (0.36)	104 (0.34)	5,536 (0.78)

Bering Sea Slope

	1991	2002	2004
SST	4,521	16,932 (0.11)	18,881 (0.09)
Other rockfish	8	25 (0.56)	27 (0.36)

Table 14.10. Likelihood profiles for BSAI model run for Shortspine Thornyheads.

Parameter	MLE	L 95%	U 95%
k	$8.8x10^8$	Not estimable	Not estimable
r	0.11	0.10	0.13
Initial Biomass	5,829	5,134	6,624

Table 14.11. Biomass estimates (mt) for BSAI (no slope data) SST from the surplus production model.

Year	Biomass Estimate	F
1991	6,374	0.06
1992	6,722	0.08
1993	6,978	0.05
1994	7,444	0.04
1995	8,030	0.04
1996	8,644	0.02
1997	9,441	0.03
1998	10,277	0.02
1999	11,272	0.01
2000	12,422	0.02
2001	13,583	0.02
2002	14,878	0.03
2003	16,181	0.02
2004	17,722	0.01
2005	19,501	

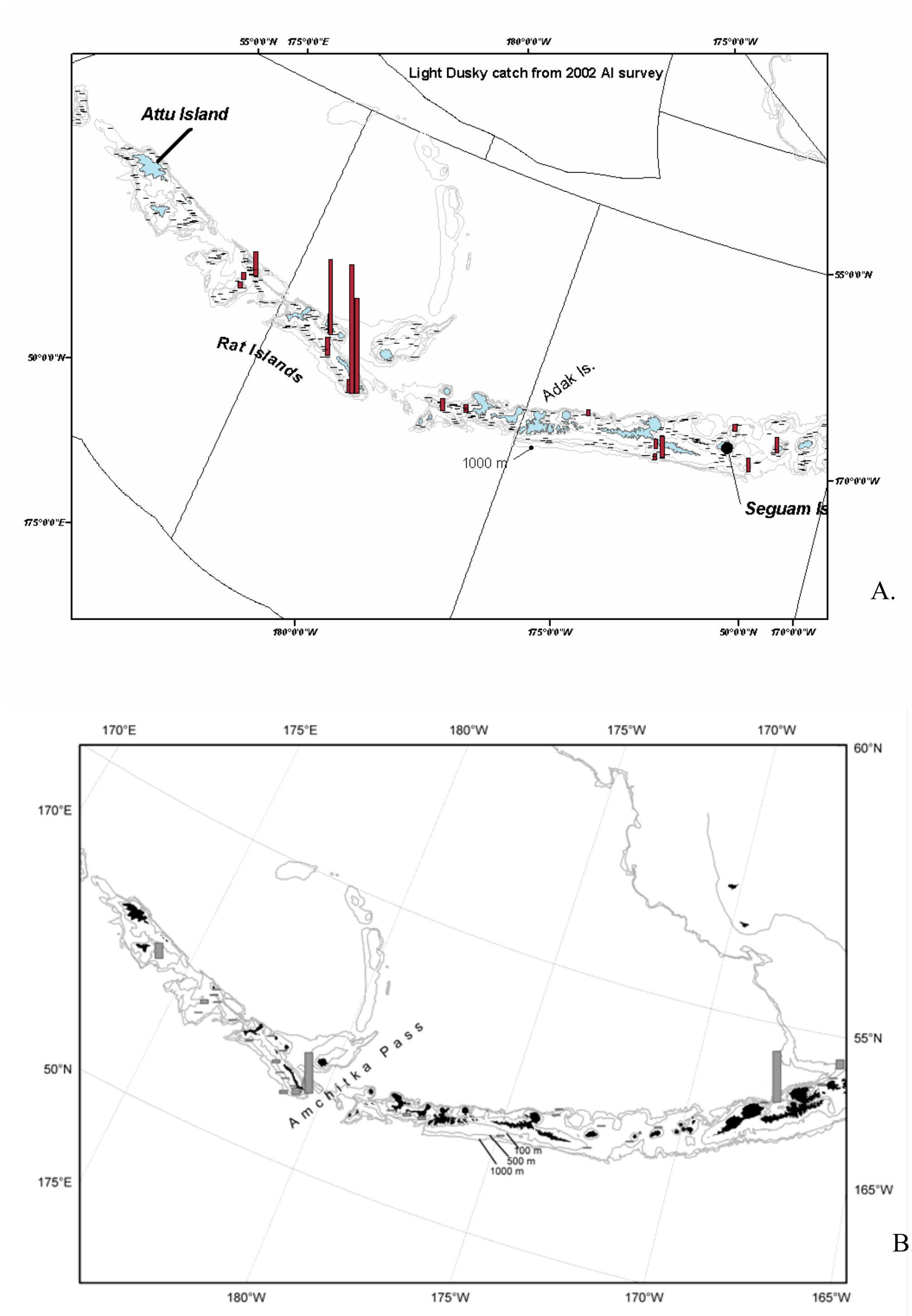

Figure 14.1. Dusky catch locations in the Aleutian Islands from survey data A. 2002 and B. 2004, (data source: AFSC RACE database). *Note: Bars from different years are proportional.*

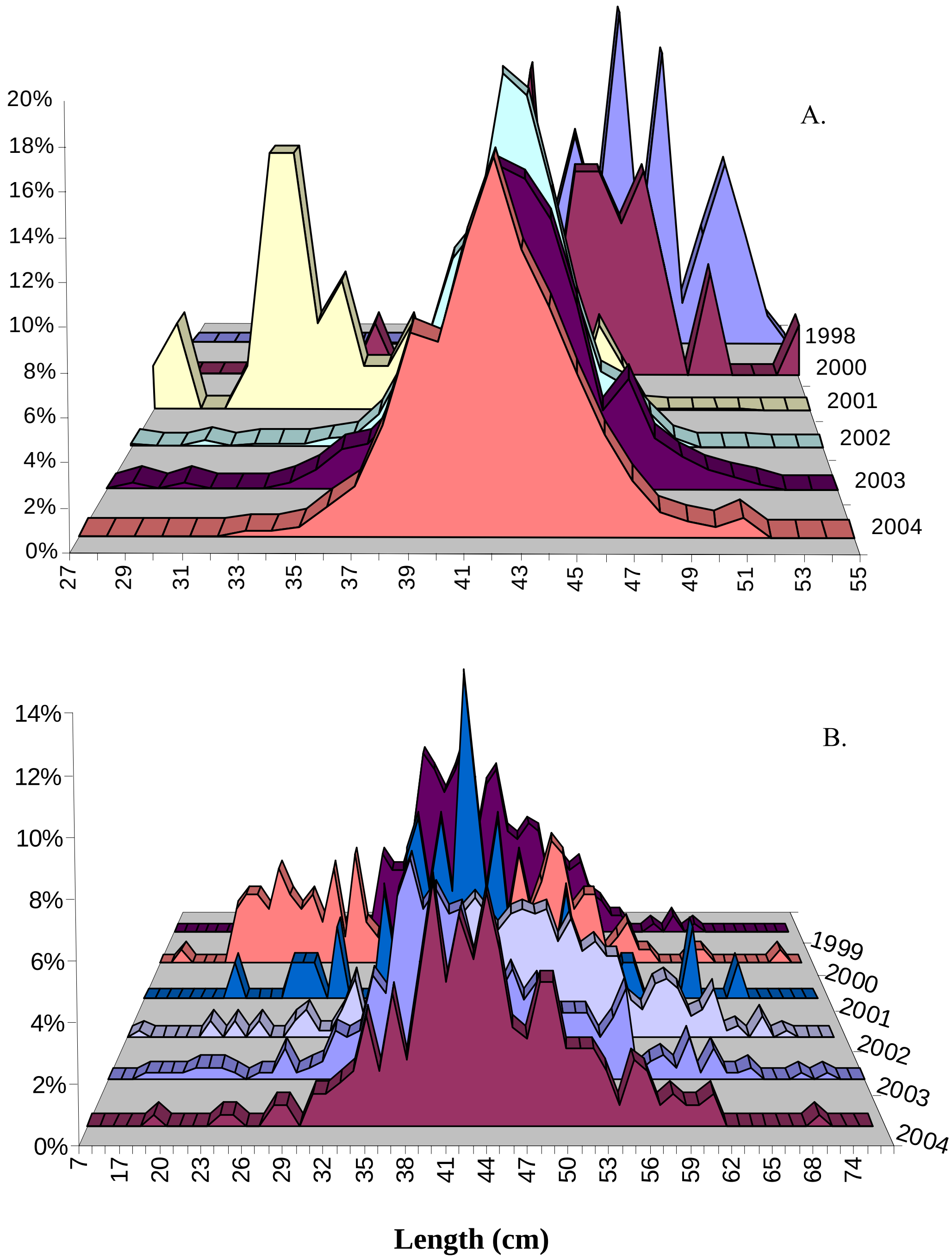

Figure 14.2. Length frequency of A. Dusky rockfish and B. Shortspine thornyhead from fishery data in the Aleutian Islands.
Source: NorPac Database AFSC Seattle WA.

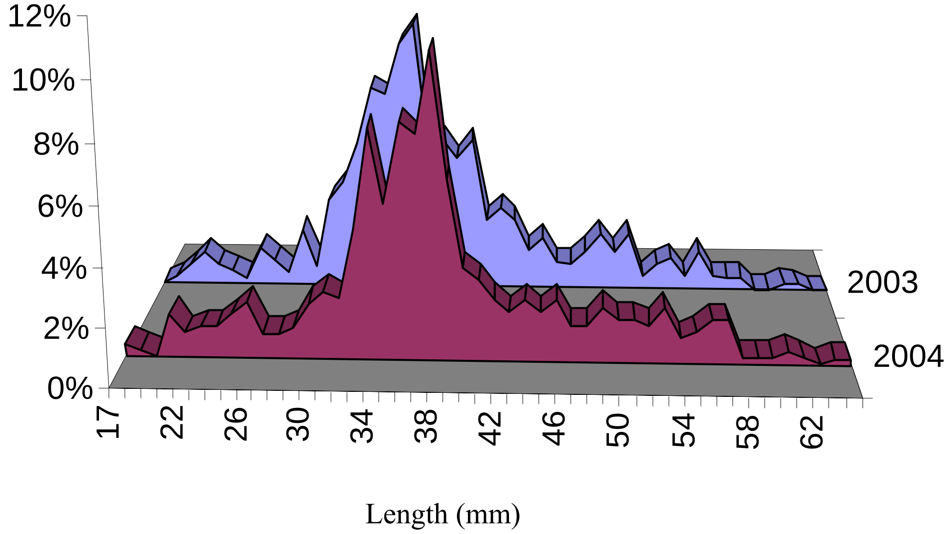

Figure 14.3. Length frequency (mm) for shortspine thornyhead from the Eastern Bering Sea fishery data. *Source: NorPac Database AFSC Seattle WA.*

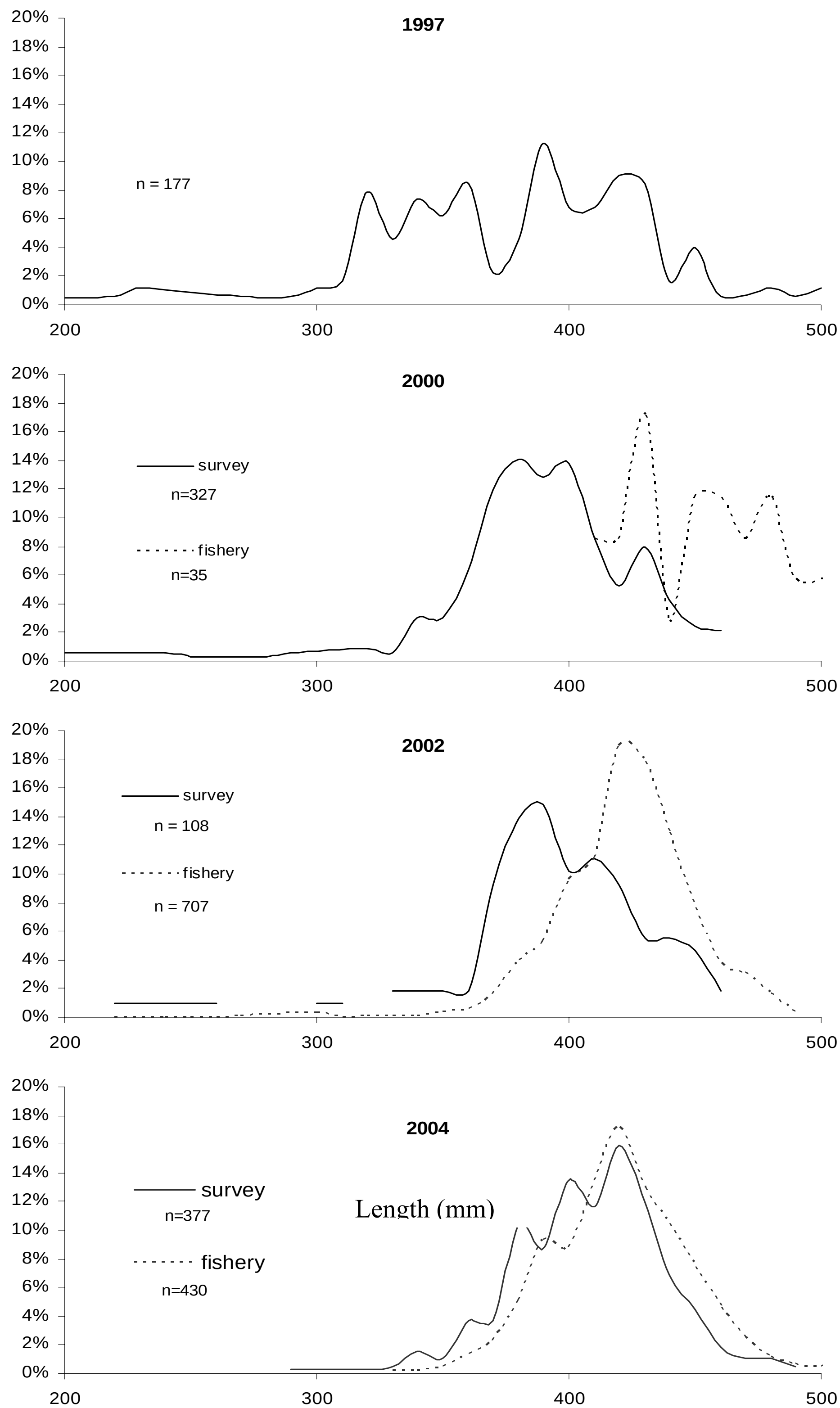

Figure 14.4. Length frequency (mm) for dusky rockfish from the Aleutian Islands research surveys. Fishery data included when available. *Source: AFSC RACE survey data*.

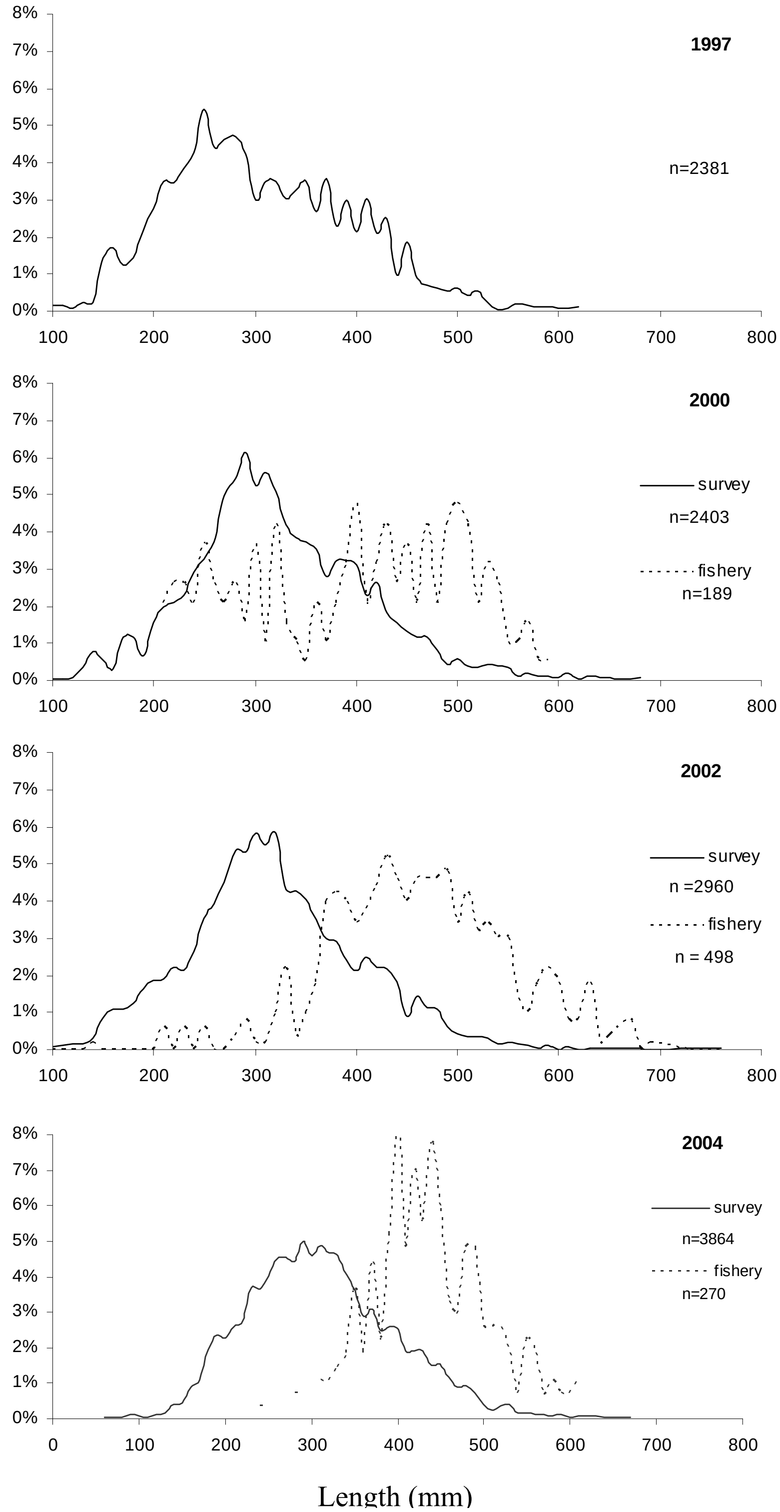

Figure 14.5. Length frequency (mm) for shortspine thornyhead from the Aleutian Islands research surveys. Fishery data included when available. *Source: AFSC RACE survey data.*

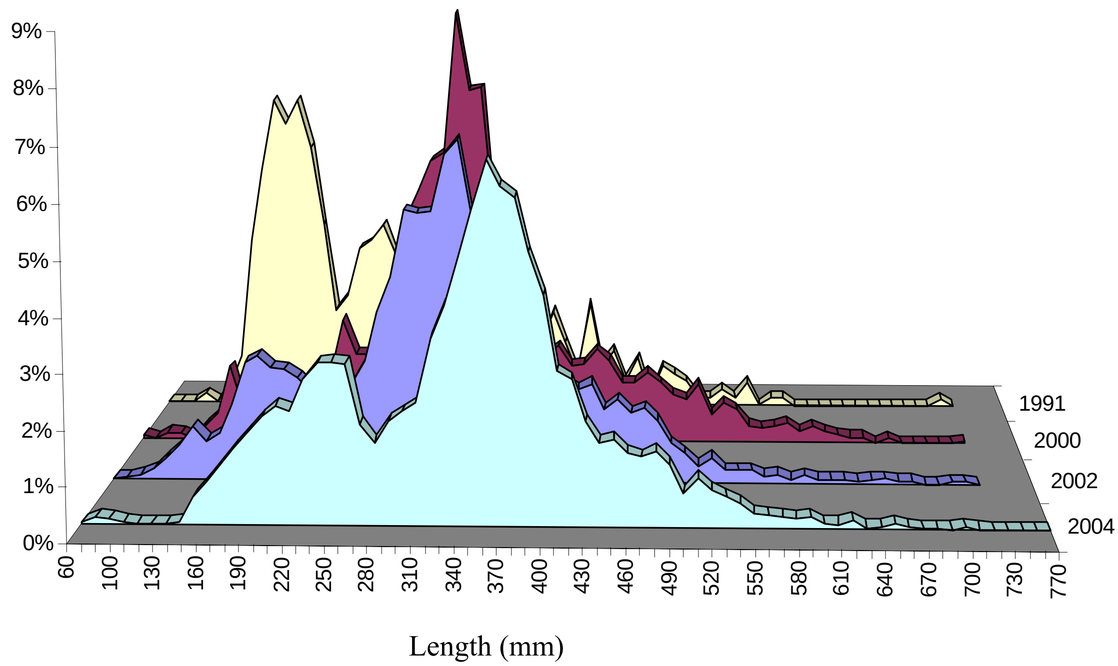

Figure 14.6. Length frequency (mm) for shortspine thornyhead from the Eastern Bering Sea Slope research surveys. *Source: AFSC RACE survey data.*

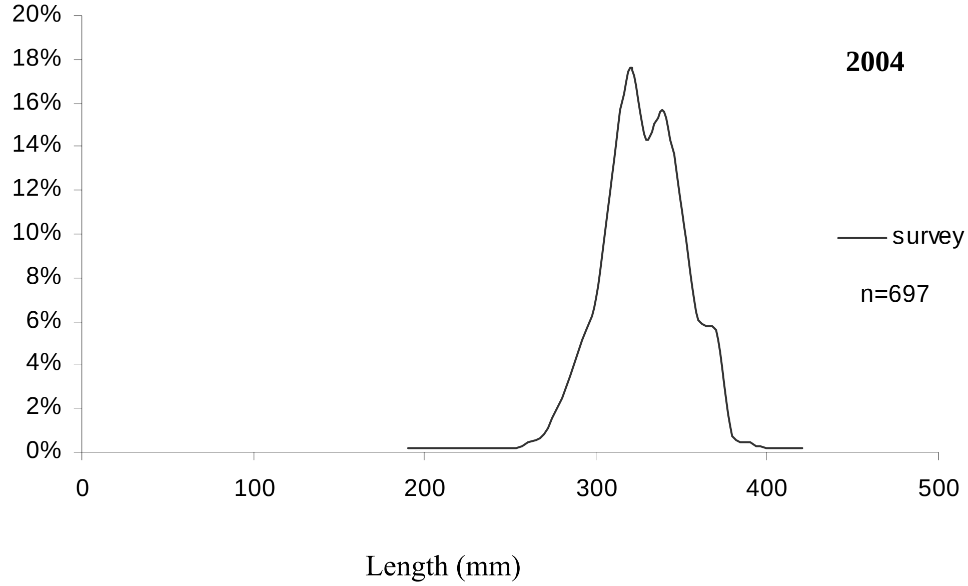

Figure 14.7. Length frequency (mm) for Harlequin rockfish from the 2004 Aleutian Islands research surveys. Fishery data included when available. *Source: AFSC RACE survey data.*

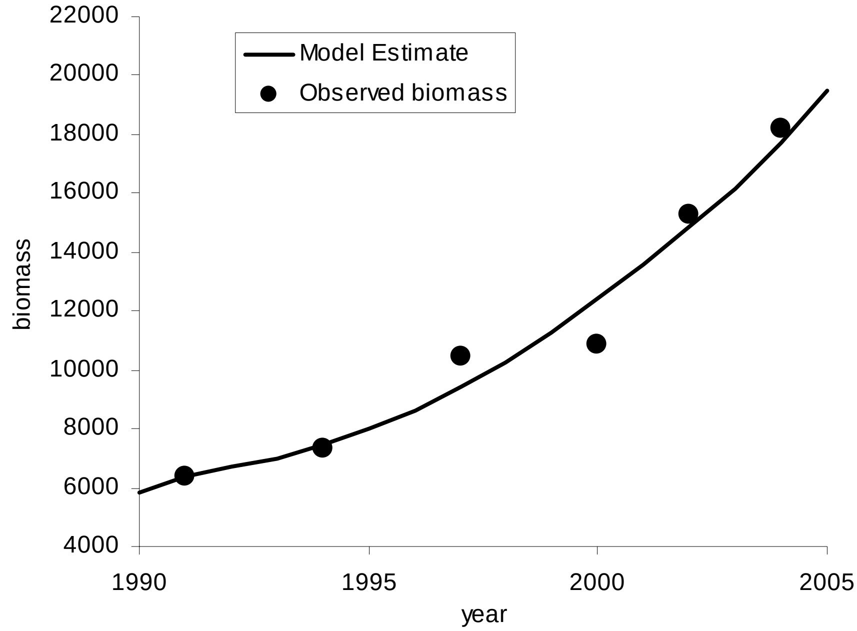

Figure 14.8. Estimated and observed biomass (mt) for SST using Surplus production model.

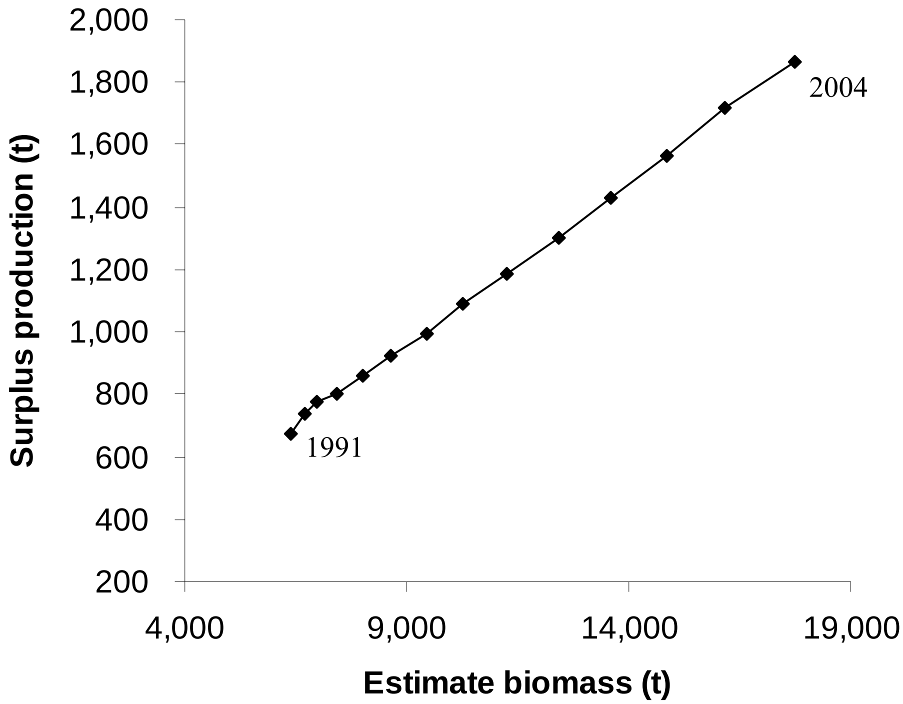

Figure 14.9. Surplus production for 1991-2004 BSAI shortspine thornyheads using data from model run (no EBS slope survey data).

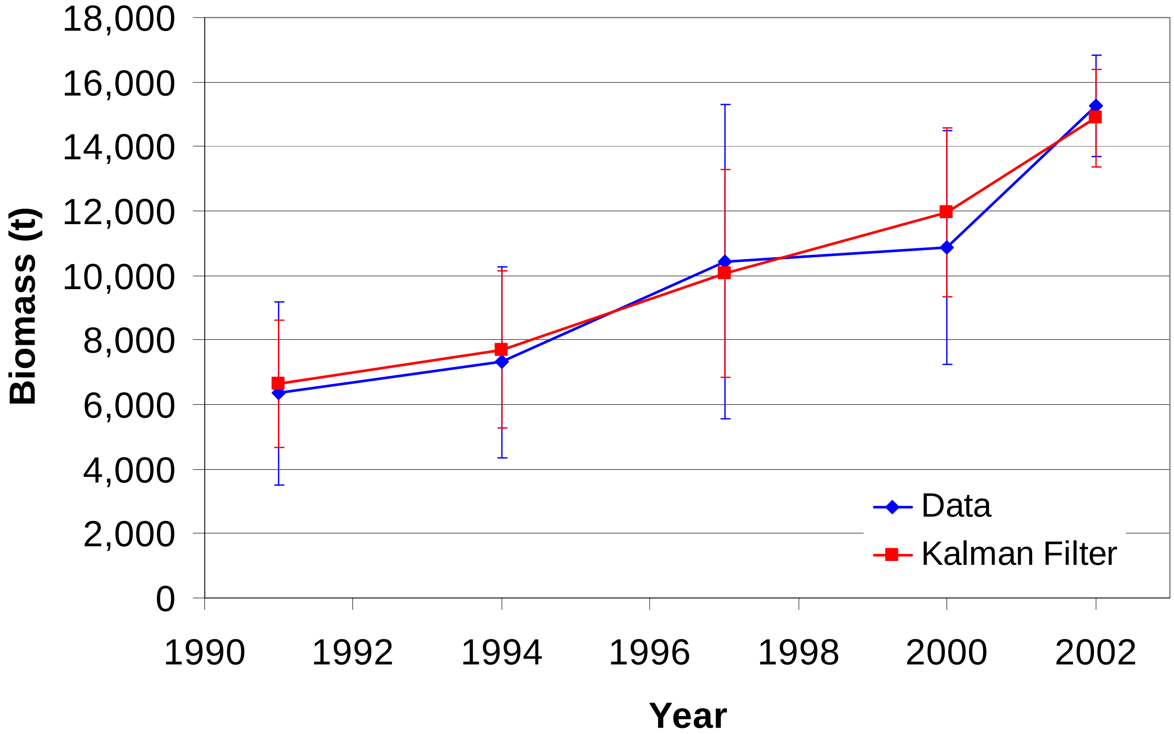

Figure 14.10. Survey biomass (t) and estimated biomass for BSAI Shortspine Thornyheads using Kalman filter (provided by Grant Thompson NMFS/AFSC/REFM).