11. Assessment of the other flatfish stock complex in the Bering Sea and Aleutian Islands

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Executive Summary

Summary of Changes in Assessment Inputs

Changes in the Input Data

1) The 2015 catch (total and discarded) was updated, and catch through 17 October, 2015 were included in the assessment.

2) The 2015 Eastern Bering Sea shelf survey biomass estimate and standard error of the other flatfish species are included in the assessment.

Changes in the Assessment Methodology

No changes were made to the assessment methodology.

Summary of Results

A summary of the 2015 recommended ABCs and OFLs (in bold) relative to the 2014 recommendations for Other flatfish in the Bering Sea/Aleutian Islands (BSAI) is as follows:

Quantity	As estimated or *specified last* year for: 2015	2016	As estimated or *recommended this* year for: 2016	2017
M (natural mortality rate) for rex sole	0.17	0.17	0.17	0.17
M (natural mortality rate) for Dover sole	0.085	0.085	0.085	0.085
M (natural mortality rate) for all others	0.15	0.15	0.15	0.15
Tier	5	5	5	5
Survey Biomass (t)	143,000	143,000	**102,300**	102,300
F_{OFL} (F=M) for rex sole	0.17	0.17	0.17	0.17
F_{OFL} (F=M) for Dover sole	0.085	0.085	0.085	0.085
F_{OFL} (F=M) for all other species	0.15	0.15	0.15	0.15
$maxF_{ABC}$ for rex sole	0.13	0.13	0.13	0.13
$maxF_{ABC}$ for Dover sole	0.064	0.064	0.064	0.064
$maxF_{ABC}$ for all other species	0.113	0.113	0.113	0.113
F_{ABC} for rex sole	0.13	0.13	0.13	0.13
F_{ABC} for Dover sole	0.064	0.064	0.064	0.064
F_{ABC} for all other species	0.113	0.113	0.113	0.113
OFL (t)	17,700	17,700	**17,414**	17,414
maxABC (t)	13,250	13,250	**13,061**	13,061
ABC (t)	13,250	13,250	**13,061**	13,061

Status	As determined *last* year for: 2013	2014	As determined *this* year for: 2014	2015
Overfishing	n/a	n/a	n/a	n/a

Responses to SSC and Plan Team Comments to Assessments in General

The SSC requests that stock assessment authors utilize the following model naming conventions in SAFE chapters:

Model 0: last years' model with no new data,
Model 1: last years' model with updated data, and
Model numbers higher than 1 are for proposed new models.

The SSC also requests that stock assessment authors utilize the random effects model for area apportionment of ABCs.

Not directly applicable to this Tier 5 assessment.

Responses to SSC and Plan Team Comments Specific to this Assessment

For the next assessment, the SSC continues to recommend that the assessment authors consider the potential effects of temperature on the variance of survey catches of other flatfish. The SSC also requests the authors clarify how the FABC and FOFL were averaged for the complex.

A new section was added that considers the effect of annual bottom temperature on the variance of the shelf survey biomass estimates for the primary species of the "Other flatfish" complex.

Plan Team: We recommend that the random effects model continue to be used for this complex in future years' assessments.

The random effects model was used in this assessment to provide biomass estimates for ABC and OFL

Introduction

The Bering Sea/Aleutian Islands "other flatfish" group have typically included those flatfish besides northern rock sole, yellowfin sole, arrowtooth flounder, Kamchatka flounder and Greenland turbot. Flathead sole (*Hippoglossoides elassodon*) were part of the other flatfish complex until they were removed in 1995, and Alaska plaice was removed from the complex in 2002, as sufficient biological data exists for these species to construct age-structured population models. In contrast, survey biomass estimates are the principal data source used to assess the remaining other flatfish. Although over a dozen species of flatfish are found in the BSAI area, the other flatfish biomass consists primarily of starry flounder, rex sole, longhead dab, Dover sole and butter sole. A full list of the species in the other flatfish complex is shown in Table 11.1. With the exception of Dover sole and rex sole, most of the species inhabit shallower continental shelf waters and are also found in other management areas. At present, no evidence of stock structure is evident for these species in the Bering Sea/Aleutian Islands region, although no formal genetic or tagging study has been conducted on these species in this region.

Fishery

The miscellaneous species of the other flatfish species category are listed in Table 11.1, and their catches from 1995-2015 are shown in Table 11.2 (with historical ABC and TAC). These species are not pursued as fishery targets but are captured in fisheries for other flatfish species and Pacific cod. Catch from 1995-2003 were obtained from the NMFS Regional Office "blend" data, and the catch for some species are reported by species and in an aggregate flatfish group. The catch estimates for these years were produced by applying the proportional catch, by species, from fishery observer data to the estimated total catch for the aggregate other flatfish group, and adding this total to the catch that was reported by species. In the current catch accounting system (in use since 2003), catches of other flatfish are reported only in an aggregate group, and the catch estimates for these years were produced by applying the proportional catch, by species, from fishery observer data to the estimated total catch of the aggregate group. In recent years, starry flounder (*Platichthys stellatus*) and rex sole (*Glyptocephalus zachirus*) account for most of the harvest of other flatfish, contributing 94% of the harvest of other flatfish in 2015. The 2015 catch of 2,367 t through mid-October is well below (18%) the ABC of 13,250 t.

Other flatfish fisheries are grouped with Alaska plaice, rock sole, and flathead sole in a single prohibited species group (PSC) classification, with seasonal and total annual allowances of prohibited bycatch applied to the group. In past years, this group of fisheries was closed due to the bycatch of halibut but since the implementation of Amendment 80 in 2008 there have been no closures.

Data

Fishery

Data from the fishery includes blend estimates of total catch for the combined "other flatfish" species from the Alaska Regional office and species catch data from observer sampling to apportion the total catch to individual species. Detailed catch information for "other flatfish" is listed in Table 11.2.

Survey

Bottom trawl surveys are conducted annually on the eastern Bering Sea shelf starting in 1982 and provide most of the available information on other flatfish, including estimates of absolute abundance (biomass) and population length compositions. The Aleutian Islands and Bering slope surveys also capture some of the deeper dwelling species of this complex, although at a much reduced number. The biomass of the other flatfish complex on the eastern Bering Sea shelf was relatively stable from 1983-1995, averaging 54,274 t, and then increased from 1996 to 2003, averaging 84,137 t (Table 11.3, Fig. 11.1). Since 2003, the biomass estimates have been at a higher, averaging 125,800 t. The 2014 shelf and Aleutian Islands (slope survey not conducted in 2014) surveys combined estimate of 143,000 t was the highest level of the past 7 years and third highest overall for the time-series but declined in 2015 by one third to 102,300 t. The estimated increases and then decrease from the past five years are primarily due to the fluctuating biomass estimates for starry flounder on the Eastern Bering Sea shelf. The AI and BS slope surveys are conducted in alternating years. In years when an AI survey was not conducted, (all odd years since 2000), total BSAI biomass was calculated by fitting a linear trend to the observed Aleutian Islands survey data (1991-2014 for this assessment), and then adding the predicted AI biomass estimate to the observed EBS estimate. For this assessment, the linear model estimates were used to calculate the 2015 biomass since an Aleutian Islands survey was not conducted. Individual species biomass estimates for the EBS and AI areas from 1997-2015 are shown in Table 11.4. Notable for 2013 and 2014 is the marked decline in the amount of rex sole on the Bering Sea shelf relative to estimated biomass ten years ago, the highest estimate ever for Sakhalin sole and the second largest biomass of starry flounder ever observed in 2014, but largely reduced in 2015. Estimates of total BSAI biomass (Table 11.5) were then used to compute species-specific exploitation rates (catch/biomass).

Exploitation rates for starry flounder and rex sole have been low, not exceeding 0.05 from 1997 to 2015 (Table 11.5). The exploitation rates for butter sole have been higher, exceeding 0.14 in 1997, 2000, 2001, 2003-2009 2011-2012 and also 2014 and 2015. In 2008 the butter sole catch exceeded the trawl survey biomass estimate. However these biomass estimates calculated for butter sole have large sampling variances, with coefficients of variation ranging from 0.44 to 0.86 in recent EBS trawl surveys dating back to 1999. The 2013 exploitation rate was only 0.02, as only 29 t are estimated to have been caught, but was higher again in 2014 with an exploitation rate of 0.43 and 0.35 in 2015.

Closer inspection of the butter sole biomass variability suggests that occasional high exploitation rates may be an artifact of survey sampling. The 2003 and 2008 biomass estimates of butter sole were 429 t and 541 t, respectively, unusually low relative to biomass estimates from the past 20 years. These estimates are less than one-fourth the 2002 estimate of 2,382 t, and result in an estimated exploitation rate of nearly 70% in 2003 and 1.14 in 2008. However, butter sole were only captured in four hauls in the 2003 EBS trawl survey and in six hauls in the 2008 survey, causing a large coefficient of variation of 0.61 for the estimated biomass. Thus, it is likely that the population of butter sole is larger than that indicated from the survey, and the comparison of survey biomass to harvest should be interpreted accordingly. Biomass estimates since 2003 have been much higher, and variable. The 2012 biomass estimate of 619 t for butter sole was fairly low relative to the time-series since 1991 (4th lowest) and had a high CV (0.62).

The timing of the butter sole fishery catches do not overlap with survey sampling and came primarily from waters less than 50 m in January and February, a depth and time not covered by the trawl survey. Butter sole are mostly caught by non-pelagic trawl catcher-processors in the rock sole and Pacific cod target fisheries in NMFS areas 509 and 516. The center of abundance for butter sole in Alaska is in the Gulf of Alaska whereas the survey and fishery catches on the north side of the Alaska Peninsula represent butter sole captured at the periphery of their distribution, where they are relatively rare.

Several other species in this management category are relatively rare on the EBS shelf, including Dover sole, Sakhalin sole, and English sole, and it is useful to identify whether the EBS represents the edge of the distribution for these species. The distribution of English sole has been identified as Baja California to Unimak Island, and the distribution of Dover sole has been identified as from Baja California to the Bering Sea (Hart 1973). Thus, the eastern Bering Sea can be considered the periphery of the range for these species. They are much more abundant in the Gulf of Alaska. For example, the abundance of Dover sole in the 1984-2011 GOA surveys has fluctuated between 63,000 t and 99,000 t, the abundance of butter sole has ranged between 17,000 t and 31,000 t, and the abundance of English sole has varied between 3,000 t and 18,600 t (Turnock et al. 2011). Dover sole and English sole were most common in the eastern portion of the GOA, consistent with their reported distribution along the west coast of North America. In the case of Sakhalin sole, which prefer colder water and are caught at the northern extent of the survey, their perceived abundance from survey biomass estimates may be related to annual mean bottom water temperature, discussed below as they tended to be more abundant in colder years during the 1980s and 1990s. The recent trend from trawl surveys estimates Sakhalin sole at low abundance, however, sampling of the northern Bering Sea in 2010 indicated that their primary distribution is located to the north of the standard survey area (Fig. 11.2). The northern Bering Sea biomass estimate of Sakhalin sole is 2,180 t compared to the 786 t average for the past 5 years estimated for the standard survey area.

Temperature effects

Temperature effects on the variance of trawl survey biomass estimates for five of the species of the other flatfish complex were examined. Plots were made of bottom temperature anomalies versus the CV of survey biomass estimates (CV's were used because variance is related to stock size) for rex sole,

longhead dab, starry flounder, butter sole and Sakhalin sole and the resulting trend lines fit to the data were tested to determine if the slopes were significantly different from zero. (Fig. 11.3). Only for The null hypothesis could only be rejected for Sakhalin sole, therefore indicating that there was no significant relationship between survey CV and bottom temperature. Sakhalin sole, being a cold-preferring northern species, typically are present in larger numbers in the northern part of the standard survey area in colder years. However, this pattern was broken this year (2015) when the largest historical biomass estimated for Sakhalin sole occurred in an anomalously warm year.

Correlation analysis indicates that rex sole, longhead dab and butter sole are negatively correlated with annual bottom water temperature and that Sakhalin sole are mildly correlated.

Correlations of biomass with temperature anomalies

rex sole	longhead dab	Sakhalin sole	starry flounder	butter sole
-0.324	-0.057	0.412	0.289	-0.103

Correlations of biomass with actual avg bottom temperature

rex sole	longhead dab	Sakhalin sole	starry flounder	butter sole
-0.329	-0.057	0.412	0.289	-0.103

Analytic Approach

Model Structure

As Tier 5 constituents, no stock assessment modeling is conducted for the BSAI Other Flatfish.

Modeling approach

Due to the lack of biological information for other flatfish, recent assessments have all used a biomass-based approach based on trawl survey data to calculate ABCs. We continue to use this approach in the present assessment, however, following the recommendations by the Survey Averaging Plan Team and the SSC, methodology for calculating exploitable biomass has changed to the use of a random effects model (RE). Estimates were made using the 1982-2015 BSAI trawl survey time series for biomass and estimates of uncertainty. Other flatfish in the BSAI are managed under Tier 5, where OFL = M * exploitable biomass, where M represents natural mortality, and F_{ABC} is estimated by 0.75 * M. The acceptable biological catch (ABC) is obtained by multiplying F_{ABC} by the estimated biomass, ABC $\leq$ 0.75 * M * biomass. M is assumed to vary by species as discussed further in the following section.

Parameter Estimates

Natural mortality values for rex and Dover sole are available from age-structured assessments in the Gulf of Alaska SAFE document (Turnock et al. 2005; Stockhausen et al. 2005) and those published values are used for rex and Dover sole in this stock assessment. For the remaining flatfish species, where less information is available, an assumption of M = 0.15 appears reasonable given the range of values shown above. For the case of starry flounder where estimates are available from a west coast stock assessment (Ralston 2005), the high estimates of M (male = 0.45, female = 0.3) are not used here due to the uncertainty of the estimates and the large spatial difference between the two management areas.

The natural mortality rates used in age-structured BSAI flatfish assessments can be used as guidance and are presented below:

Species	Natural mortality rate used for stock assessment
BSAI yellowfin sole	0.12
BSAI northern rock sole	0.15
BSAI flathead sole	0.20
BSAI Alaska plaice	0.13
GOA rex sole	0.17
GOA Dover sole	0.085

Results

Harvest Recommendations

Other flatfish are assessed under Tier 5 of Amendment 56 to the BSAI groundfish management plan, and thus have harvest recommendations which are directly calculated from estimates of biomass and natural mortality. The estimates of F_{abc} and F_{ofl} under tier 5 are 0.75 x M and M, respectively, and the ABC and OFL levels are the product of the fishing mortality rate and the biomass estimate.

Biomass used to calculate the next year's ABC and OFL had, up to last year, used the sum of the current year point estimates of biomass from each survey for all individual species. Starting last year the ABC methodology changed to using a random effects model, recommended for all Tier 5 stocks managed by the North Pacific Fisheries Management Council. For the BSAI "other flatfish" complex, the model uses as input the time-series of biomass point-estimates from each survey and their attendant standard errors where the biomass and variances are summed over each species in the complex to calculate an annual ABC biomass (Fig. 11.4). In the years where there are missing survey values because the BS slope and Aleutian Islands surveys were not conducted, biomass and variance estimates were estimated using linear extrapolation (biomass) from the time-series and averaging of adjacent years (for variance). The estimated biomass value in the terminal year of the random effects time series is used for ABC biomass. Runs were made separately for rex sole, Dover sole, and all other species combined (not rex sole and Dover sole).

Applying the F_{abc} and F_{ofl} levels listed below to the random effects model estimate of ABC biomass of 112,104 t, results in ABC and OFL levels of 13,061 and 17,414 t, respectively, for the 2016 fishery.

Results from Random Effects Model

	F_{ABC}	**F_{OFL}**	**ABC**	**OFL**
Rex sole	0.13	0.17	4,924	6,566
Dover sole	0.064	0.085	171	227
Others	0.1125	0.15	7,966	10,621
Total Other flatfish			**13,061**	**17,414**

Ecosystem Considerations

Data Gaps and Research Priorities

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Table 11.1. Flatfish species of the Bering Sea/Aleutian Islands "other flatfish" management complex.

Common Name	Scientific Name
Arctic flounder	*Liopsetta glacialis*
butter sole	*Isopsetta isolepis*
curlfin sole	*Pleuronectes decurrens*
deepsea sole	*Embassichths bathybius*
Dover sole	*Microstomus pacificus*
English sole	*Parophrys vetulus*
longhead dab	*Limanda proboscidea*
Pacific sanddab	*Citharichthys sordidus*
petrale sole	*Eopsetta jordani*
rex sole	*Glyptocephalus zachirus*
roughscale sole	*Clidodoerma asperrimum*
sand sole	*Psettichthys melanostictus*
slender sole	*Lyopsetta exilis*
starry flounder	*Platichthys stellatus*
Sakhalin sole	*Limanda sakhalinensis*

Table 11.2. Harvest (t) of other flatfish from 1995-2015. 2015 catch is through October 25, 2015.

Year	Starry Founder	Rex Sole	Butter Sole	longhead dab	Dover sole	English sole	deep sea sole	Sakhalin sole	Total	ABC	TAC
1995	398	673	157	7	59	26	4	0	1,324	117,000	19,540
1996	1,171	1,148	218	175	6	0	0	30	2,748	102,000	35,000
1997	1,043	687	448	211	53	0	29	6	2,490	97,500	50,750
1998	402	998	229	93	41	0	0	0	1,765	164,000	89,434
1999	725	998	230	56	81	27	0	0	2,117	154,000	154,000
2000	1,151	1,069	458	277	66	4	0	0	3,027	117,000	83,813
2001	755	869	244	62	70	4	6	0	2,028	122,000	28,000
2002	1,075	1,192	222	107	34	0	1	0	2,631	18,100	3,000
2003	887	1,399	296	125	39	2	0	0	2,749	16,000	3,000
2004	2,062	1,858	514	146	82	6	0	0	4,669	13,500	3,000
2005	2,069	2,001	487	25	16	1	0	0	4,599	21,400	3,500
2006	1,663	1,266	261	33	10	0	0	0	3,233	18,100	3,500
2007	4,356	812	579	87	4	2	<1	<1	5,840	21,400	10,000
2008	1,978	968	618	47	10	2	<1	<1	3,623	21,600	21,600
2009	806	1,143	198	7	7	2	0	<1	2,163	17,400	17,400
2010	1,506	510	162	9	5	<1	<1	<1	2,194	17,300	17,300
2011	2,168	860	107	18	10	13	0	<1	3,176	14,500	3,000
2012	2,205	866	191	9	15	5	0	0	3,292	12,700	3,200
2013	906	579	30	15	6	0	0	<1	1,536	13,300	3,500
2014	3,341	770	219	20	10	0	0	0	4,391	13,300	3,500
2015	1,598	617	118	29	5	<1	0	<1	2,367	13,250	3,620

Table 11.3. Estimated biomass (t) of other flatfish from the eastern Bering Sea (EBS) and Aleutian Islands (AI) AFSC trawl surveys. Species included are Dover sole, longhead dab, rex sole, Sakhalin sole, starry flounder, deepsea sole and butter sole. A linear regression between EBS and AI survey abundance was used to predict AI abundance in years in which an AI survey did not occur.

	Area			
Year	EBS	AI	slope	total
1982	112362			112362
1983	59022			59022
1984	58926			58926
1985	34572			34572
1986	42037			42037
1987	49753			49753
1988	45933			45933
1989	49440			49440
1990	47097			47097
1991	72478	2144		74622
1992	53937	5153		59090
1993	44350	5711		50061
1994	54350	5466		59816
1995	37790	6826		44616
1996	60101	7383		67484
1997	71393	7580		78973
1998	74581	8499		83080
1999	70473	9056		79529
2000	70727	8149		78877
2001	78920	10171		89092
2002	98172	8801	9379	116353
2003	89407	11287	16518	117212
2004	129146	14980	24268	168394
2005	108426	12402	16831	137659
2006	150480	16440	17165	184085
2007	133503	13517	17500	164520
2008	104604	14074	12372	131050
2009	103573	14632	90639	208844
2010	114261	13076	89335	216672
2011	94217	15747	57484	167448
2012	85435	15685	24888	126007
2013	76115	16862	24815	117793
2014	129024	13936	25150	168110
2015	69515	17978	25484	112976

Table 11.4 --Estimated biomass (t) and coefficient of variation (in parentheses) for the miscellaneous species of the "other flatfish" management complex in the Bering Sea and Aleutian Islands trawl surveys.

Eastern Bering Sea Shelf survey

Year	Dover Sole	Rex Sole	longhead dab	Sakhalin sole	starry flounder	butter sole	slender sole	sand sole
1982	--	5,994 (0.16)	103,806 (0.16)	--	7,781 (0.32)	182 (0.82)	--	--
1983	--	7,272 (0.18)	51,386 (0.38)	--	7,436 (0.25)	37 (0.45)	--	1,559(0.94)
1984	--	13,058 (0.28)	35,308 (0.16)	137 (0.43)	8,913 (0.36)	2,231 (0.64)	--	--
1985	10 (1.04)	10,751 (0.20)	9,107 (0.13)	102 (0.37)	12,181 (0.24)	2,421 (0.83)	--	--
1986	15 (1.00)	12,886 (0.22)	10,889 (0.14)	274 (0.48)	9,112 (0.33)	6,341 (0.58)	--	--
1987	81 (0.91)	12,931 (0.19)	11,897 (0.19)	110 (0.58)	22,702 (0.63)	2,043 (0.38)	--	--
1988	38 (0.59)	15,445 (0.15)	16,710 (0.19)	1,061 (0.40)	9,222 (0.30)	2,083 (0.47)	--	1,128(1.0)
1989	--	12,939 (0.15)	13,086 (0.16)	129 (0.57)	22,205 (0.35)	1,304 (0.54)	--	--
1990	47 (0.58)	11,857 (0.21)	18,601 (0.15)	587 (0.36)	15,048 (0.26)	986 (0.60)	--	--
1991	55 (0.70)	16,014 (0.28)	18,680 (0.14)	345 (0.68)	34,303 (0.23)	3,056 (0.50)	--	--
1992	137 (0.58)	14,001 (0.24)	10,827 (0.17)	212 (0.48)	27,544 (0.22)	1,233 (0.70)	--	--
1993	37 (0.75)	14,567 (0.32)	11,690 (0.21)	179 (0.31)	16,510 (0.22)	1,517 (0.75)	--	--
1994	73 (0.72)	15,943 (0.38)	18,533 (0.26)	506 (0.52)	18,218 (0.22)	1,095 (0.97)	--	--
1995	--	10,420 (0.28)	8,402 (0.15)	214 (0.27)	17,652 (0.29)	1,203 (0.54)	--	--
1996	--	10,532 (0.40)	8,567 (0.20)	185 (0.56)	40,409 (0.45)	683 (0.53)	--	--
1997	--	8,233 (0.27)	18,003 (0.21)	1,407 (0.84)	41,018 (0.21)	2,884 (0.43)	--	--
1998	41 (0.44)	7,588 (0.22)	14,737 (0.19)	770 (0.86)	49,605 (0.30)	1,942 (0.38)	--	--
1999	16 (0.65)	8,020 (0.28)	12,087 (0.21)	907 (0.63)	43,375 (0.25)	4,152 (0.62)	--	--
2000	11 (1.02)	9,348 (0.19)	13,511 (0.30)	473 (0.43)	45,810 (0.19)	1,713 (0.56)	--	--
2001	16 (0.84)	21,660 (0.23)	12,764 (0.26)	117 (0.32)	43,026 (0.25)	796 (0.50)	--	--
2002	7 (0.80)	26,053 (0.20)	9,740 (0.22)	173 (0.90)	59,877 (0.23)	2,254 (0.64)	--	--
2003	350 (0.66)	28,023 (0.15)	8,827(0.22)	280 (0.75)	52,893 (0.17)	179 (0.61)	3	
2004	31(0.51)	28,762 (0.19)	11,290 (0.23)	1,118 (0.98)	86,698 (0.38)	841 (0.86)	--	--
2005	157(0.19)	23,171(0.19)	11,556 (0.21)	961(0.97)	71,673(0.26)	958(0.81)	--	--
2006	90(0.53)	21,515(0.28)	13,204(0.25)	125(0.58)	96,900(0.37)	1,091(0.53)	--	--
2007	73(0.53)	17,025(0.25)	16,733(0.24)	30(0.34)	98,623(0.17)	1,018(0.44)	--	--
2008	364(0.90)	18,788(0.31)	10,884(0.22)	77(0.36)	74,077(0.21)	418(0.44)	--	--
2009	469(0.95)	18,142(0.39)	5,011(0.23)	55(0.44)	79,366(0.19)	532(0.60)	--	--
2010	201(0.54)	20,320(0.32)	11,557(0.47)	78(0.49)	80,351(0.25)	1,746(0.82)	--	--
2011	4,08(0.96)	18,525(0.32)	10,348(0.59)	513(0.72)	63,986(0.23)	437(0.69)	--	--
2012	1,921(0.7)	39,695(0.25)	9,065(0.23)	37(0.29)	62,837(0.27)	619(0.62)	--	--
2013	27(1)	9,767(0.18)	5,448(0.45)	625(0.87)	58,942(0.2)	1,306(0.69)	--	--
2014	620 (1)	13,276 (0.32)	3,129 (0.45)	584 (0.79)	110,907 (0.35)	510 (0.65)	--	--
2015	5 (1)	9,496 (0.19)	1,647 (0.5)	1,835 (0.75)	56,190 (0.29)	342 (0.74)		

Table 11.4 . continued. Estimated biomass (t) and coefficient of variation (in parentheses) for the miscellaneous species of the "other flatfish" management complex in the Aleutian Islands surveys.

Aleutian Islands survey

Year	Dover Sole	Rex Sole	starry flounder	butter sole	English sole
1991	174 (0.45)	1,694 (0.18)	142 (0.85)	86 (0.73)	47 (0.80)
1994	438 (0.41)	4,306 (0.15)	134 (0.69)	505 (0.98)	83 (0.81)
1997	386 (0.34)	6,378 (0.16)	459 (0.9)	346 (0.98)	12 (0.72)
2000	630 (0.38)	6,526 (0.18)	590 (0.71)	310 (0.99)	95 (0.97)
2002	575 (0.28)	7,381 (0.15)	671 (0.72)	127 (0.83)	47 (0.94)
2004	870 (0.28)	13,717 (0.18)	123 (0.72)	235 (0.93)	35 (1.00)
2006	2,155 (0.57)	14,230 (0.19)	17 (0.97)	13(0.98)	25 (0.84)
2010	2,853 (0.43)	9,762 (0.14)	127 (0.14)	180 (0.69)	15 4(0.67)
2012	1,214 (0.24)	14,102(0.24)	209 (0.6)	134 (0.1)	26 (0.73)
2014	1,025 (0.31)	12,853 (0.13)	0	0	58 (0.69)

Table 11.4 . continued. Estimated biomass (t) and coefficient of variation (in parentheses) for the miscellaneous species of the "other flatfish" management complex from Bering Sea slope surveys.

Bering Sea slope survey

Year	Dover sole	Rex sole	deep sea sole	sum of slope surveys
2002	97 (0.30)	8085 (0.13)	102 (0.34)	8284
2004	141 (0.17)	12439 (0.11)	406 (0.27)	12986
2008	330 (0.25)	11556 (0.13)	486 (0.29)	12372
2010	463 0.13)	10800 (0.12)	767 (0.36)	12030
2012	707 (0.36)	12783 (0.32)	391 (1.55)	13881

Table 11.5. Estimated biomass (t), harvest amount (t), and exploitation rates of rex sole, starry flounder and butter sole from 1997 to 2015.

	Rex sole			Starry Flounder			Butter sole		
Year	Biomass (t)	Harvest (t)	Exp. Rate	Biomass (t)	Harvest (t)	Exp. Rate	Biomass (t)	Harvest (t)	Exp. Rate
1997	14,611	401	0.03	41,477	814	0.02	3,230	336	0.10
1998	14,250	569	0.04	49,950	242	0.00	2,210	157	0.07
1999	15,415	516	0.03	43,750	597	0.01	4,416	167	0.04
2000	15,874	569	0.04	46,400	770	0.02	2,023	266	0.13
2001	30,524	507	0.02	43,829	479	0.01	1,059	147	0.14
2002	33,411	1,227	0.04	60,633	1,023	0.02	2,382	187	0.08
2003	38,349	1,399	0.04	53,353	887	0.02	429	296	0.69
2004	42,479	1,858	0.04	86,821	2,062	0.02	1,076	514	0.48
2005	34,963	1,830	0.05	72,176	1,892	0.03	1,201	445	0.37
2006	35,745	1,266	0.04	96,917	1,663	0.02	1,104	261	0.24
2007	31,052	812	0.03	98,941	4,356	0.04	1,153	579	0.50
2008	33,613	961	0.03	74,397	1,964	0.03	541	614	1.14
2009	33,766	1,132	0.03	79,688	797	0.01	642	196	0.31
2010	30,082	491	0.02	80,478	1,148	0.02	1,926	156	0.08
2011	32,544	826	0.03	64,218	2,082	0.03	562	103	0.18
2012	39,695	866	0.02	62,837	2,205	0.04	619	191	0.31
2013	9,767	569	0.015	58,942	889	0.015	1,306	29	0.02
2014	26,129	769	0.03	111,116	3,366	0.03	510	219	0.43
2015	38,598	617	0.02	56,320	1,598	0.03	342	118	0.35

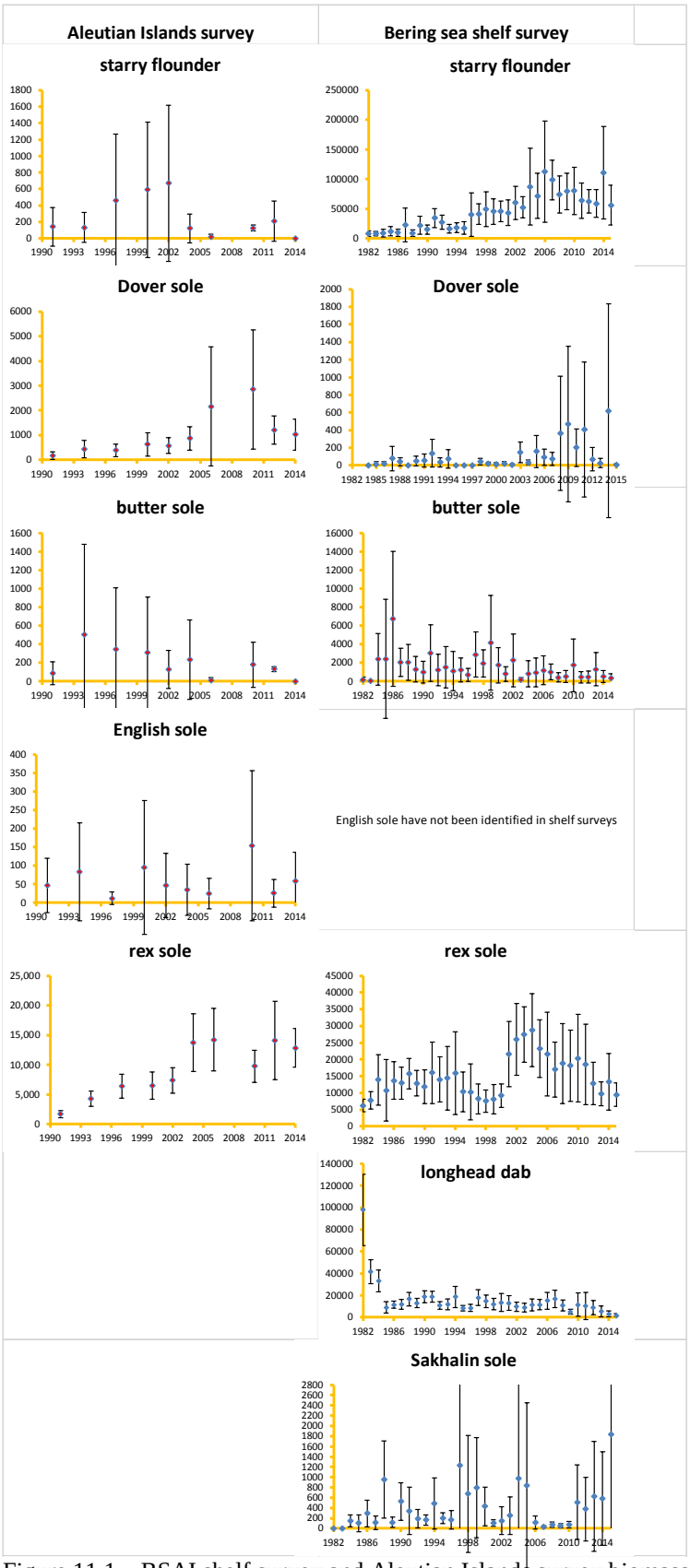

Figure 11.1. BSAI shelf survey and Aleutian Islands survey biomass estimates with 95% confidence intervals.

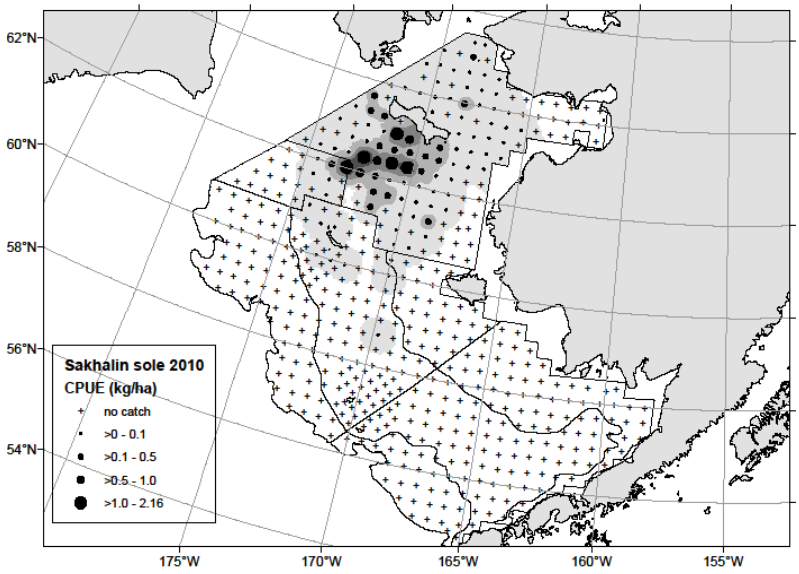

Figure 11.2-Distribution and abundance of Sakhalin sole in the 2010 from summertime sampling of the northern Bering Sea.

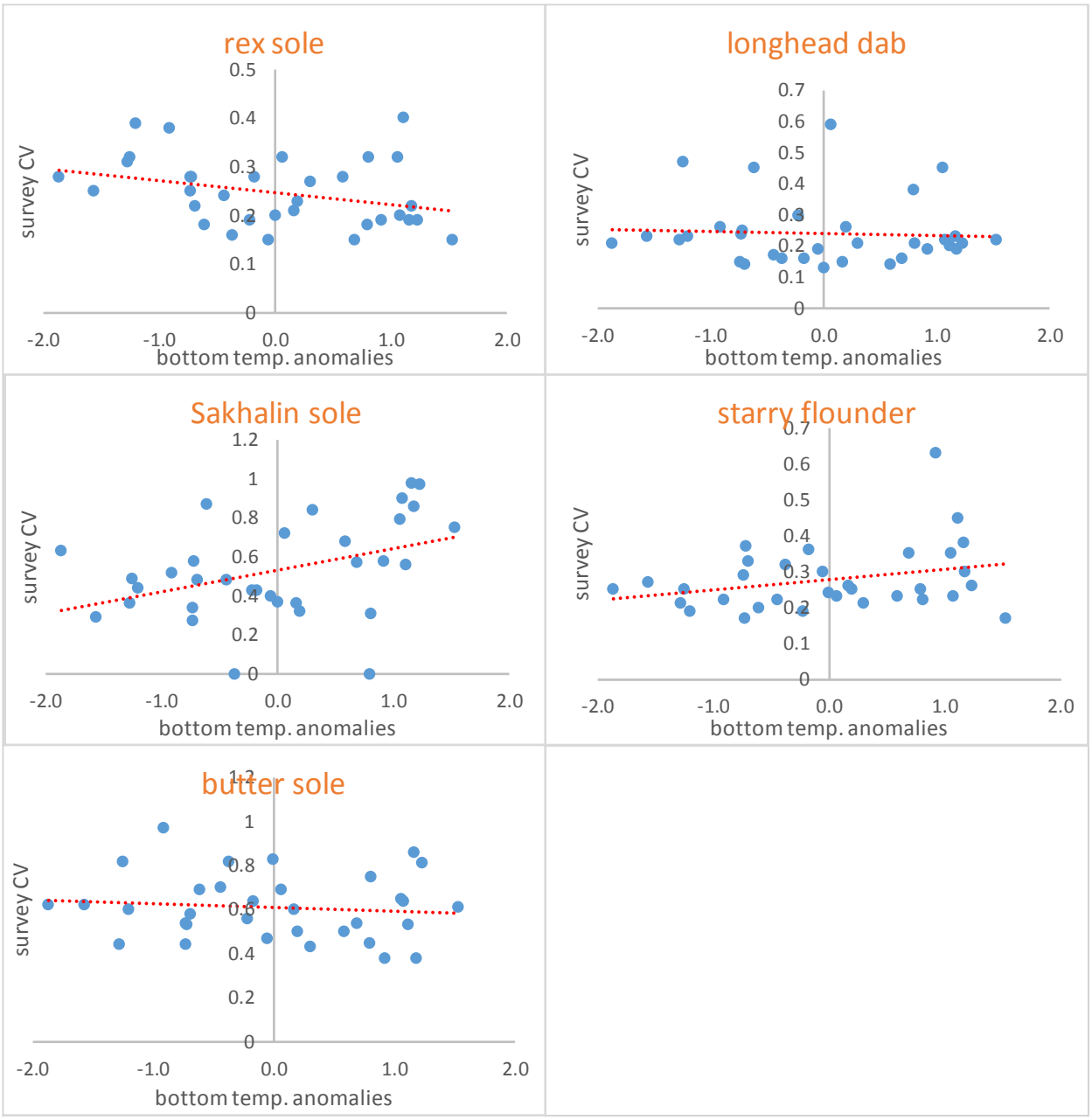

Figure 11.3—Relationship between bottom temperature anomalies and survey CV and fitted trend line for five species of the "other flatfish" complex. Only Sakhalin sole were found to have a trend line slope significantly different than zero.

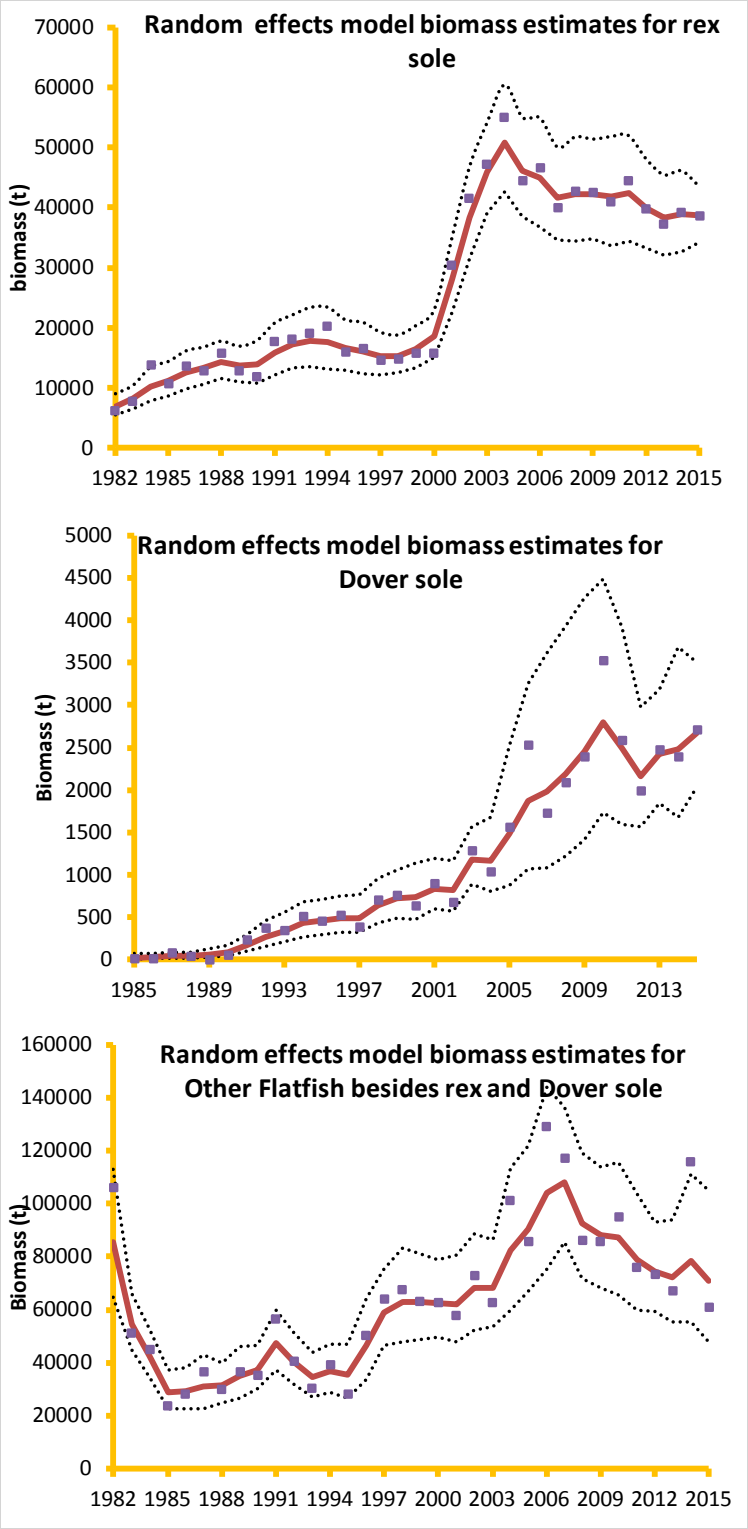

Figure 11.4. Random effects model results for BSAI Other Flatfish biomass (solid red line) and upper and lower 95% confidence intervals (dashed lines). Purple squares are the sum of survey biomasses for species other than rex and Dover sole (bottom panel), rex sole (top panel) and Dover sole (middle panel) biomass.

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