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 2016 catch was updated, catches for 2017, 2018, and 2019 included, and catch through 30 October 2020 was included in the assessment.
2) The 2017, 2018 and 2019 Eastern Bering Sea shelf survey and 2018 Aleutian Islands survey biomass estimates for other flatfish species were added to the assessment.

Changes in the Assessment Methodology

There was no change to the assessment methodology.

Summary of Results

A summary of the 2021 recommended ABCs and OFLs relative to the 2020 recommendations for other flatfish in the Bering Sea/Aleutian Islands (BSAI) is as follows:

	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2020	2021	2021	2022
M (natural mortality rate) for rex	0.17	0.17	0.17	0.17
M (natural mortality rate) for Dover	0.085	0.085	0.085	0.085
M (natural mortality rate) for all	0.15	0.15	0.15	0.15
Tier	5	5	5	5
RE Model Combined Biomass (t)	141,325	141,325	146,679	146,679
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	0.128	0.128	0.128	0.128
$maxF_{ABC}$ 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	0.128	0.13	0.128	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)	21,824	21,824	22,919	22,919
maxABC (t)	16,368	16,368	17,189	17,189
ABC (t)	16,368	16,368	17,189	17,189
	As determined *last* year for:		As determined *this* year for:	
Status	2018	2019	2019	2020
Overfishing	no	n/a	no	n/a

Responses to SSC and Plan Team Comments to Assessments in General

From the October 2019 SSC minutes:* "*The SSC recommends the authors complete the risk table and note important concerns or issues associated with completing the table".

The risk table was added to this assessment for the first time this year, as 2019 was a partial assessment. No substantial concerns were raised and no reduction from maxABC is recommended.

Responses to SSC and Plan Team Comments Specific to this Assessment

None pertaining to this assessment.

Introduction

The Bering Sea/Aleutian Islands other flatfish complex has typically included those flatfish besides northern rock sole (*Lepidopsetta polyxystra*), yellowfin sole (*Limanda aspera*), arrowtooth flounder (*Atheresthes stomas*), Kamchatka flounder (*Atheresthes evermanni*) and Greenland turbot (*Reinhardtius hippoglossoides*). Flathead sole (*Hippoglossoides elassodon*) were part of the other flatfish complex until they were removed in 1995, and Alaska plaice (*Pleuronectes quadrituberculatus*) 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 (*Platichthys stellatus*), rex sole (*Glyptocephalus zachirus*), and Dover sole (*Microstomus pacificus*). A full list of the species in the other flatfish complex is shown in Table 11.1. Different areas and depths in the BSAI have different species compositions within the other flatfish complex (Figure 11.1). Starry flounder, longhead dab (*Limanda proboscidea*), butter sole (*Isopsetta isolepis*), and Sakhalin sole (*Limanda sakhalinensis*) occur primarily on the shallower continental shelf. Dover sole and deep sea sole (*Embassichthys bathybius*) are found at greater depth, and English sole (*Parophrys vetulus*) and Dover sole are more abundant in the AI than in the EBS. Rex sole is common on the EBS shelf, the slope, and in the AI. 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 1995-2020 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 and rex sole account for most of the harvest of other flatfish, contributing 96.4% of the harvest of other flatfish in 2019, and 92.2% so far in 2020 (Figure 1). The 2020 catch of 4,060 t through mid-October is well below (25%) the ABC.

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 (*Hippoglossus stenolepis*) 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 complex from the Alaska Regional Office and species catch data from observer sampling to apportion the total catch to individual species. The catch time series for other flatfish, along with ABC and TACs, is listed in Table 11.2. This table also includes estimated catch by species, based on the species composition of observer samples. Throughout its history, the total catch of other flatfish in the BSAI has been only a fraction of the ABC for the complex. In 2019, approximately 23% of the BSAI other flatfish ABC was caught.

Survey:

Bottom trawl surveys are conducted annually on the eastern Bering Sea shelf 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 Sea 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 1987-1995, averaging 50,432 t, and then increased from 1996 to 2003, averaging 76,722 t (Table 11.3, Fig. 11.2). Since 2003, the biomass estimates have been higher, over 80,000 t in most years. The shelf survey biomass was particularly high in 2014 and 2017, albeit with high uncertainty, and these are primarily driven by the biomass estimates for starry flounder on the EBS shelf. The 2016 shelf, slope, and Aleutian Islands surveys combined had an estimated biomass of 124,160 t for the complex.

Individual species biomass estimates for the shelf, slope, and AI surveys are shown in Table 11.4. Time series trends for select species in on the EBS shelf are shown in Fig. 11.3. Notable is the continued decline in the amount of longhead dab on the Bering Sea shelf relative to estimated biomass ten years ago (except for 2017), and a large decline for Sakhalin sole after its highest point in 2016. Dover and rex sole both show much greater abundance in the AI in 2006-2016 than in previous surveys. Butter sole and starry flounder both show decreased abundance during this period, and were both absent from the AI surveys in 2014-2016. Catches of other flatfish on the EBS slope have been stable since 2002. Coefficients of variation on survey biomass estimates are generally 15-25% for the most abundant species in each survey, but are much higher for the rarer species.

Several 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, 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.

At the request of the SSC, the 2015 stock assessment for the other flatfish complex included an analysis of temperature effects on the variance of trawl survey biomass estimates. Hypothesis testing failed to detect any significant relationship between bottom temperature anomalies and the *CV* of survey biomass estimates for rex sole, longhead dab, starry flounder, or butter sole. Only for Sakhalin sole was survey *CV* significantly related to bottom temperatures. Sakhalin sole are typically present in larger numbers in the northern part of the shelf survey area during colder years.

Exploitation rates based on the RE model estimates of biomass for the most abundant species in the other flatfish complex are generally low, between 0.2 and 7.6% (Table 11.5). Exploitation rates for both rex and Dover sole have declined since the early 2000s, while rates for starry flounder have remained steady. The estimated exploitation rates for butter sole are higher, due to very low and variable survey biomass estimates. In 2003 and 2008 the butter sole catch exceeded the trawl survey biomass estimate. However the biomass estimates for butter sole have large sampling variances, with coefficients of variation ranging from 0.6 to 0.85 in recent EBS trawl surveys (Table 11.4), and large swings in estimates of biomass and thus exploitation rates. For instance estimated biomass went from 280.9 t in 2016 to 19,372.1 t in 2019, and the corresponding exploitation rates were 54% and 1%. The actual amount of estimated butter sole caught is relatively consistent and averages 136 t from 2010-2020 (Table 11.2).

Analytic Approach

Model Structure

As Tier 5 constituents, no stock assessment modeling is conducted for the BSAI other flatfish complex.

Modeling Approach

Due to the lack of biological information for other flatfish, assessments for this complex have all used a biomass-based approach based on trawl survey data to calculate ABCs. In past years, averages of survey biomass estimates were used. In 2014, following the recommendations by the Survey Averaging P Working Group and the SSC, methodology for calculating exploitable biomass was changed to the use of a random effects model (RE). This model is used to smooth the time series of trawl survey data, and the most recent biomass predicted by the model is used as the best estimate of exploitable biomass. 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 ≤ 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 below. 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 geographical 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

Amendment 56 Reference Points

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 current biomass estimate.

Starting in 2014 the methodology for calculating ABC for the other flatfish complex changed to using a random effects model, as 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 associated standard errors, and the biomass and variances are summed to calculate an overall biomass time series for the BSAI (Fig. 11.4). The RE model is run separately for each survey, and predicts biomass in the years where there are missing survey values (Fig. 11.5). The estimated biomass value in the terminal year of the random effects time series is used for ABC biomass. Because of differences in estimates of M, model runs were made separately for rex sole, Dover sole, and all other species combined (excluding rex sole and Dover sole). The terminal RE biomass for Rex sole was 51,660 t (95% CI: 31,250 – 86,650 t), for Dover sole 1,790 t (600 – 5,764 t), and for all other species (primarily starry flounder) 93,230 t (61,899 – 143,376 t). These estimates and uncertainties are calculated by summing estimates for each species across the three surveys.

Applying the F_{ABC} and F_{OFL} levels listed below to the random effects model estimates of ABC biomass for each group results in overall ABC and OFL levels of 17,189 and 22,919 t, respectively, for the 2021 fishery.

Species	F_{ABC}	F_{OFL}	Biomass (t)	ABC	OFL
Rex sole	0.13	0.17	51,660	6,587	8,782
Dover sole	0.06	0.09	1,790	114	152
All others	0.11	0.15	93,230	10,488	13,984
	Total other flatfish		146,679	17,189	22,919

Risk Table and ABC Recommendation

<u>Overview</u>

The following template is used to complete the risk table:

	Assessment-related considerations	*Population dynamics considerations*	*Environmental/ecosystem considerations*	*Fishery Performance*
Level 1: Normal	Typical to moderately increased uncertainty/minor unresolved issues in assessment.	Stock trends are typical for the stock; recent recruitment is within normal range.	No apparent environmental/ecosystem concerns	No apparent fishery/resource-use performance and/or behavior concerns
Level 2: Substantially increased concerns	Substantially increased assessment uncertainty/ unresolved issues.	Stock trends are unusual; abundance increasing or decreasing faster than has been seen recently, or recruitment pattern is atypical.	Some indicators showing adverse signals relevant to the stock but the pattern is not consistent across all indicators.	Some indicators showing adverse signals but the pattern is not consistent across all indicators
Level 3: Major Concern	Major problems with the stock assessment; very poor fits to data; high level of uncertainty; strong retrospective bias.	Stock trends are highly unusual; very rapid changes in stock abundance, or highly atypical recruitment patterns.	Multiple indicators showing consistent adverse signals a) across the same trophic level as the stock, and/or b) up or down trophic levels (i.e., predators and prey of the stock)	Multiple indicators showing consistent adverse signals a) across different sectors, and/or b) different gear types
Level 4: Extreme concern	Severe problems with the stock assessment; severe retrospective bias. Assessment considered unreliable.	Stock trends are unprecedented; More rapid changes in stock abundance than have ever been seen previously, or a very long stretch of poor recruitment	Extreme anomalies in multiple ecosystem indicators that are highly likely to impact the stock; Potential for cascading effects on other ecosystem components	Extreme anomalies in multiple performance indicators that are highly likely to impact the stock

	compared to previous patterns.

The table is applied by evaluating the severity of four types of considerations that could be used to support a scientific recommendation to reduce the ABC from the maximum permissible. These considerations are stock assessment considerations, population dynamics considerations, environmental/ecosystem considerations, and fishery performance. Examples of the types of concerns that might be relevant include the following:

1. "Assessment considerations—data-inputs: biased ages, skipped surveys, lack of fishery-independent trend data; model fits: poor fits to fits to fishery or survey data, inability to simultaneously fit multiple data inputs; model performance: poor model convergence, multiple minima in the likelihood surface, parameters hitting bounds; estimation uncertainty: poorly-estimated but influential year classes; retrospective bias in biomass estimates.

2. "Population dynamics considerations—decreasing biomass trend, poor recent recruitment, inability of the stock to rebuild, abrupt increase or decrease in stock abundance.

3. "Environmental/ecosystem considerations—adverse trends in environmental/ecosystem indicators, ecosystem model results, decreases in ecosystem productivity, decreases in prey abundance or availability, increases or increases in predator abundance or productivity.

4. "Fishery performance—fishery CPUE is showing a contrasting pattern from the stock biomass trend, unusual spatial pattern of fishing, changes in the percent of TAC taken, changes in the duration of fishery openings."

Assessment considerations

In several cases, the surveys for some species observed no fish (Table 11.4), and these zero estimates are incompatible with the random effects model. Consequently, and following the lead of previous assessments, these values were dropped before fitting. However, this occurs in species/area combinations with relatively small abundances and thus are not expected to impact the overall determination of stock status. There are no formal model residuals to gauge directly, but the individual RE model fits appear adequate by eye (Fig. 11.5), in the sense that few points lie outside the confidence region and there are no runs in the raw residuals (except perhaps EBS shelf rex sole from 1997-2004). I therefore set the concern to level 1 – no increased concerns for this consideration.

Population dynamics considerations

The population dynamics are informed exclusively by the trends in biomass and are generally increasing or stable. One exception is longhead dab in the EBS shelf (Fig. 11.6) which has a substantial decrease in biomass over the time period modeled. However, this is the only species with a distinct downward trend (Fig. 11.6). Consequently, I set the concern level to 1 – no increased concerns for this consideration.

Environmental/Ecosystem considerations

The BSAI other flatfish complex contains 15 stocks, including Dover sole, rex sole, and starry flounder. In terms of assessing risk to this stock complex, it is difficult to provide specific indicators, which may impact the biomass-dominant versus -inferior stocks differently. Therefore, indicators of ecosystem status are considered with respect to benthic productivity more generally.

Environmental processes: Following two years of physical oceanographic perturbations, the eastern Bering Sea experienced a return to near-normal climatic conditions in 2020. Summer bottom temperatures and spatial extent of the cold pool were average based on the ROMS hindcast model and observations from the 2020 Dyson cruise (Siddon, 2020). Based on the OSCURS model, the 2020 springtime drift pattern, which may impact larval flatfish trajectories, was mixed, with an early period of eastward drift followed by a period of westward drift (Cooper and Wilderbuer, 2020).

Prey: The 2020 springtime drift pattern likely retained flatfish larvae over the southern middle domain (Cooper and Wilderbuer, 2020). In that region, the 2020 spring bloom occurred about a week earlier than the long-term mean while production was below the long-term mean (Nielsen et al., 2020). Depending on the spatial and temporal overlap between larvae and available primary production, this can result in a match or mismatch with favorable feeding conditions.

Prey resources for adult flatfish include benthic infauna as well as epifauna. Direct measurements of infaunal biomass are not available; trends in epifauna reflect infaunal prey availability while also indicating a direct prey resource to flatfish. Trends in the abundance of motile epifauna remained above the long-term mean in 2019 (no 2020 survey), although decreased 10% from 2018 (Whitehouse, 2019). This indicates sufficient prey availability for flatfish over the southern Bering Sea shelf.

In 2019, the condition (as measured by weighted length-weight residuals) of several flatfish stocks over the EBS shelf was above average, especially in the NBS extension of the bottom trawl survey area (Rohan and Laman, 2020), corroborating availability of prey resources for flatfishes.

Predators: No information on major sources of predation for this stock complex exist, beyond pressure from the fishery.

Competitors: Potential competitors to this stock complex include other managed flatfish stocks that comprise the benthic foragers guild and the apex predators guild (Whitehouse, 2019). The trend in biomass of the benthic foragers guild has been declining since approximately 2010 and remained below the long term mean in 2019 (Whitehouse, 2019), suggesting a reduction in prey competition from this guild. The biomass within the apex predator guild increased slightly (2%) from 2018 to 2019 and remains at the long-term mean.

Together, the most recent data available suggest there are no apparent environmental or ecosystem concerns – level 1.

Fishery performance

There is no ESP available for this stock complex. Exploitation rates are generally less than 5% (Table 11.5) and not increasing, and the total catch is substantially lower than the ABC (Table 11.2). Thus, I assign a level 1 concern.

Summary and ABC recommendation

Assessment-related considerations	*Population dynamics considerations*	*Environmental/ ecosystem considerations*	*Fishery Performance considerations*
Level 1: no increased concerns	Level 1: no increased concerns	Level 1: no increased concerns	Level 1: no increased concerns

The low scores in all considerations does not warrant a reduction from the maximum permissible ABC under the relevant harvest control rule.

Status Determination

The stock/complex is not being subjected to overfishing because the aggregate catch in 2019 (3,760 t) is less than the aggregate OFL in 2019 (21,824 t).

Ecosystem Considerations

Ecosystem Effects on the Stock

Summer bottom temperatures and spatial extent of the cold pool were average, indicating a cooler thermal experience for flatfish stocks. Based on the OSCURS model, the 2020 springtime drift pattern was mixed and may have retained larval flatfish over the southern middle domain. The 2020 spring bloom occurred about a week earlier than the long-term mean while production was below the long-term mean. Prey abundance (motile epifauna) remained above the long-term mean in 2019, although decreased 10% from 2018, indicating sufficient prey availability. In 2019, the condition of several flatfish stocks was above average, especially in the NBS, indicating sufficient prey availability. Benthic forager biomass (potential competitors) remained below the long term mean in 2019, suggesting a reduction in prey competition from this guild. Apex predator biomass (potential competitors) increased slightly from 2018 to 2019 and remains at the long term mean.

Fishery Effects on the Ecosystem

There are no directed fisheries for the species in the other flatfish complex. For a discussion of the contribution to discards and offal production or to bycatch of prohibited species, forage fish, HAPC biota, marine mammals, seabirds, sensitive species or non-target species from these fisheries, the reader should refer to the EBS pollock, Pacific cod, and rockfish assessments.

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Tables

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 1995-2020. 2020 catch is through October 30, 2020.

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	1,523	746	113	27	6	<1	0	0	2,415	13,250	3,620
2016	1,598	1,004	152	39	4	<1	0	<1	2,797	13,061	2,500
2017	3,092	937	55	13	5	<1	<1	0	4,102	13,193	2,500
2018	5,428	426	71	17	4	<1	0	0	5,946	13,193	4,000
2019	2,593	1,032	97	33	5	<1	<1	0	3,760	16,368	6,500
2020	2,628	1,117	294	16	5	1	0	<1	4,060	16,368	4,000

Table 11.3. Estimated biomass (t) of other flatfish from the eastern Bering Sea (EBS) shelf, slope, and Aleutian Islands (AI) AFSC trawl surveys.

Year	EBS Shelf	EBS Slope	Aleutian Islands	Total
1986			4231	
1987	49753			
1988	44695			
1989	49440			
1990	47097			
1991	72478		2273	
1992	53937			
1993	44350			
1994	54350		5481	
1995	37790			
1996	60101			
1997	71393		7584	
1998	74581			
1999	70473			
2000	70727		8223	
2001	78920			
2002	98172	8283	8818	115273
2003	89407			
2004	129146	12986	14969	157100
2005	108426			
2006	150480		16445	
2007	133503			
2008	104604	12371		
2009	103573			
2010	114261	12064	13057	139382
2011	94217			
2012	85435	14479	15684	115598
2013	76115			
2014	129024		13937	
2015	69515			
2016	97291	13197	13672	124160
2017	211014			
2018	115989		15150	
2019	116878			

Table 11.4 --Estimated biomass (t) and coefficient of variation (CV; shaded) for the miscellaneous species of the other flatfish management complex in the AFSC Bering Sea shelf, slope, and Aleutian Islands surveys. Years with zero observed biomass are dropped from the RE model.

EBS Shelf survey

Year	Butter sole		Dover sole		Longhead dab		Rex sole		Sakhalin sole		Starry flounder	
1987	2,042.9	0.38	77.4	0.91	11,897.3	0.19	12,923.7	0.18	110.5	0.58	22,701.6	0.63
1988	2,057.9	0.47	39.8	0.58	16,719.0	0.19	15,743.7	0.14	955.8	0.40	9,178.4	0.30
1989	1,304.0	0.54	0.0	-	13,040.8	0.16	12,906.3	0.15	120.8	0.42	22,068.1	0.35
1990	985.7	0.60	46.7	0.60	18,648.9	0.15	11,856.7	0.21	526.3	0.35	15,033.2	0.26
1991	3,055.5	0.50	54.8	0.71	18,670.6	0.14	16,052.3	0.28	341.9	0.68	34,303.1	0.23
1992	1,232.6	0.70	137.4	0.58	10,827.2	0.17	14,001.0	0.24	194.4	0.47	27,544.4	0.22
1993	1,516.5	0.75	35.7	0.74	11,717.1	0.21	14,404.9	0.33	165.7	0.30	16,510.3	0.22
1994	1,094.6	0.97	73.1	0.72	18,533.5	0.26	15,944.7	0.38	487.0	0.52	18,217.5	0.22
1995	1,203.5	0.54	0.0	-	8,403.7	0.15	10,330.1	0.28	200.4	0.27	17,652.3	0.29
1996	683.2	0.53	0.0	-	8,568.1	0.20	10,275.1	0.40	165.1	0.55	40,409.2	0.45
1997	2,884.4	0.43	0.0	-	18,003.0	0.21	8,254.4	0.27	1,232.6	0.84	41,018.4	0.21
1998	1,942.0	0.38	40.7	0.45	14,735.0	0.19	7,587.7	0.22	674.2	0.86	49,601.7	0.30
1999	4,151.7	0.62	15.6	0.66	12,087.0	0.21	8,046.2	0.27	796.4	0.62	45,375.7	0.23
2000	1,728.2	0.56	10.3	1.00	13,514.1	0.30	9,179.8	0.19	430.2	0.44	45,864.7	0.19
2001	801.8	0.50	16.5	0.83	12,920.3	0.26	21,664.0	0.23	106.2	0.32	43,411.8	0.24
2002	2,255.3	0.63	7.0	0.79	9,791.1	0.22	26,005.5	0.20	151.4	0.89	59,961.7	0.23
2003	175.0	0.60	145.3	0.41	8,823.6	0.22	27,464.0	0.15	250.8	0.73	52,548.5	0.17
2004	832.5	0.85	31.2	0.51	11,449.7	0.23	28,786.5	0.19	973.2	0.98	87,072.6	0.37
2005	958.4	0.81	157.2	0.59	11,556.3	0.21	23,242.4	0.19	838.7	0.97	71,673.3	0.26
2006	1,186.0	0.67	90.4	0.52	15,258.0	0.25	21,562.0	0.28	115.3	0.55	112,267.9	0.38
2007	1,018.6	0.43	73.2	0.52	16,732.7	0.24	17,026.3	0.24	28.8	0.34	98,623.7	0.17
2008	418.7	0.62	364.2	0.90	10,883.6	0.22	18,787.5	0.31	73.0	0.35	74,076.7	0.21
2009	532.2	0.60	468.8	0.95	5,011.9	0.23	18,141.9	0.29	52.8	0.45	79,365.8	0.19
2010	1,746.8	0.82	201.1	0.54	11,558.7	0.47	20,319.9	0.32	72.4	0.47	80,361.8	0.25
2011	436.6	0.69	408.0	0.96	10,349.0	0.59	18,525.0	0.32	512.5	0.72	63,985.7	0.23
2012	485.5	0.67	68.1	1.00	9,065.5	0.36	12,810.5	0.25	376.1	0.83	62,628.9	0.16
2013	1,305.7	0.69	26.7	1.00	5,447.8	0.45	9,767.1	0.18	625.3	0.87	58,942.4	0.20
2014	510.3	0.65	619.8	1.00	3,127.6	0.45	13,275.6	0.32	584.5	0.79	110,906.8	0.35
2015	342.3	0.74	5.5	1.00	1,646.8	0.50	9,495.7	0.19	1,835.1	0.75	56,189.5	0.29
2016	280.9	0.67	12.2	0.93	1,580.4	0.39	11,112.2	0.24	2,056.6	0.33	82,249.0	0.36
2017	1,041.3	0.44	0.0	-	7,870.4	0.33	12,060.2	0.29	1,109.3	0.63	188,933.0	0.35
2018	7,166.9	0.49	16.4	0.39	1,735.5	0.31	20,350.2	0.22	116.0	0.94	86,603.7	0.22
2019	19,372.1	0.44	142.9	0.55	1,611.4	0.38	29,818.7	0.15	62.1	0.91	65,870.6	0.22

Table 11.4 – continued,

EBS Slope survey

Year	Deepsea sole		Dover sole		Rex sole	
2002	101.0	0.34	96.8	0.30	8,084.8	0.13
2004	406.5	0.27	140.6	0.17	12,438.6	0.11
2008	485.9	0.29	330.0	0.25	11,555.6	0.13
2010	767.0	0.36	463.2	0.20	10,834.1	0.12
2012	397.4	0.27	701.8	0.36	13,379.9	0.13
2016	402.6	0.25	594.1	0.49	12,200.2	0.14

Aleutian Islands survey

Year	Butter sole		Dover sole		English sole		Rex sole		Starry flounder	
1986	50.2	0.50	95.1	0.31	67.4	0.70	3,977.2	0.20	41.1	0.85
1991	85.6	0.73	224.1	0.40	47.1	0.80	1,773.8	0.18	142.4	0.85
1994	504.9	0.98	437.5	0.41	83.0	0.81	4,321.0	0.15	134.1	0.69
1997	345.8	0.98	373.7	0.35	12.4	0.72	6,393.8	0.16	458.5	0.90
2000	309.7	0.99	629.7	0.38	94.7	0.97	6,598.9	0.18	589.5	0.71
2002	126.8	0.83	575.7	0.28	46.5	0.94	7,398.2	0.15	670.9	0.72
2004	235.2	0.93	868.1	0.28	34.5	1.00	13,707.7	0.18	123.3	0.73
2006	12.8	1.00	2,156.5	0.57	24.7	0.85	14,233.9	0.19	16.6	1.00
2010	180.1	0.69	2,874.1	0.43	154.6	0.67	9,722.3	0.14	126.3	0.83
2012	133.8	1.00	1,213.8	0.24	26.0	0.74	14,101.7	0.24	208.6	0.60
2014	0.0	-	1,025.4	0.31	58.4	0.69	12,853.3	0.13	0.0	-
2016	0.2	1.12	1,459.1	0.36	66.4	0.69	12,146.4	0.12	0.0	-
2018	40.5	0.70	975.1	0.41	240.0	0.58	13,405.9	0.15	488.9	1.00

Table 11.5. Random Effects model estimated biomass (t), harvest amount (t), and exploitation rates (catch/biomass) of rex sole, starry flounder and Dover sole from 2002 to 2020. 2020 catch is through 10/30/2020.

	Dover sole			Rex sole			Starry flounder		
Year	Biomass	Catch	Exp. Rate	Biomass	Catch	Exp. Rate	Biomass	Catch	Exp. Rate
2002	774	34	4.4%	41,372	1,192	2.9%	54,984	1,075	2.0%
2003	975	39	4.0%	46,628	1,399	3.0%	57,853	887	1.5%
2004	1,086	82	7.6%	49,666	1,858	3.7%	68,216	2,062	3.0%
2005	1,361	16	1.2%	47,232	2,001	4.2%	75,111	2,069	2.8%
2006	1,612	10	0.6%	45,532	1,266	2.8%	84,788	1,663	2.0%
2007	1,754	4	0.2%	42,543	812	1.9%	88,604	4,356	4.9%
2008	2,037	10	0.5%	41,630	968	2.3%	80,432	1,978	2.5%
2009	2,266	7	0.3%	40,594	1,143	2.8%	78,174	806	1.0%
2010	2,381	5	0.2%	39,583	510	1.3%	74,758	1,506	2.0%
2011	2,214	10	0.5%	39,119	860	2.2%	68,378	2,168	3.2%
2012	1,982	15	0.8%	37,736	866	2.3%	65,374	2,205	3.4%
2013	1,879	6	0.3%	35,746	579	1.6%	66,348	906	1.4%
2014	1,844	10	0.5%	36,150	770	2.1%	74,877	3,341	4.5%
2015	1,813	6	0.3%	35,273	746	2.1%	74,452	1,523	2.0%
2016	1,852	4	0.2%	36,426	1,004	2.8%	83,541	1,598	1.9%
2017	1,787	5	0.3%	39,340	937	2.4%	94,078	3,092	3.3%
2018	1,726	4	0.2%	45,116	426	0.9%	85,391	5,428	6.4%
2019	1,790	5	0.3%	51,660	1,032	2.0%	76,429	2,593	3.4%
2020	1,790	5	0.3%	51,660	1,117	2.2%	76,429	2,628	3.4%

Figures

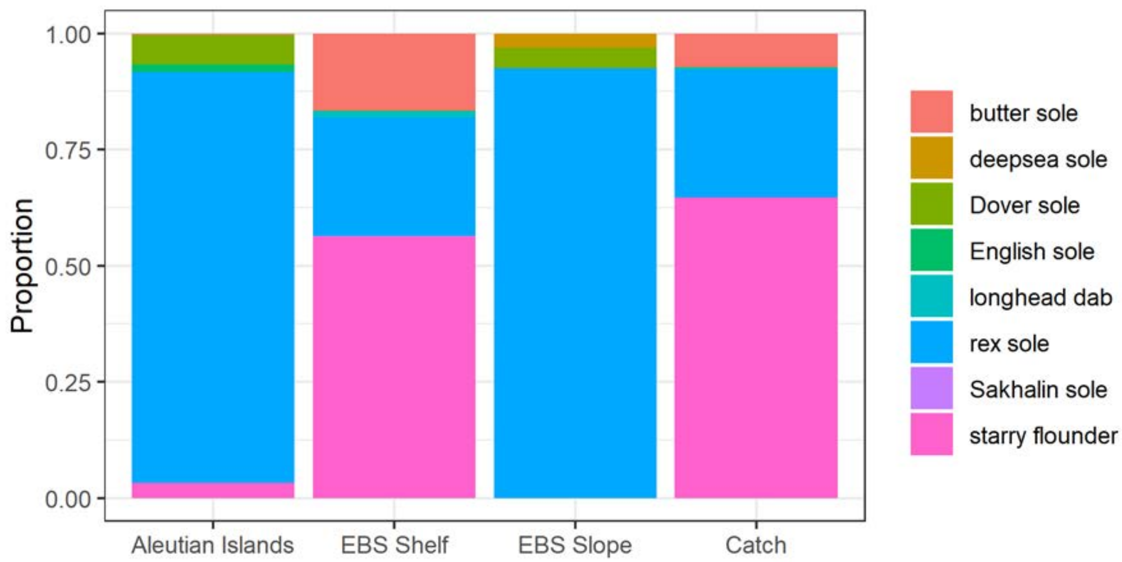

Figure 11.1. Species composition of most recent survey and fishery catch data for BSAI other flatfish. Shown are the 2018 AI survey, 2019 EBS shelf survey, 2016 EBS slope survey, and 2020 catch (through 10/30/2020).

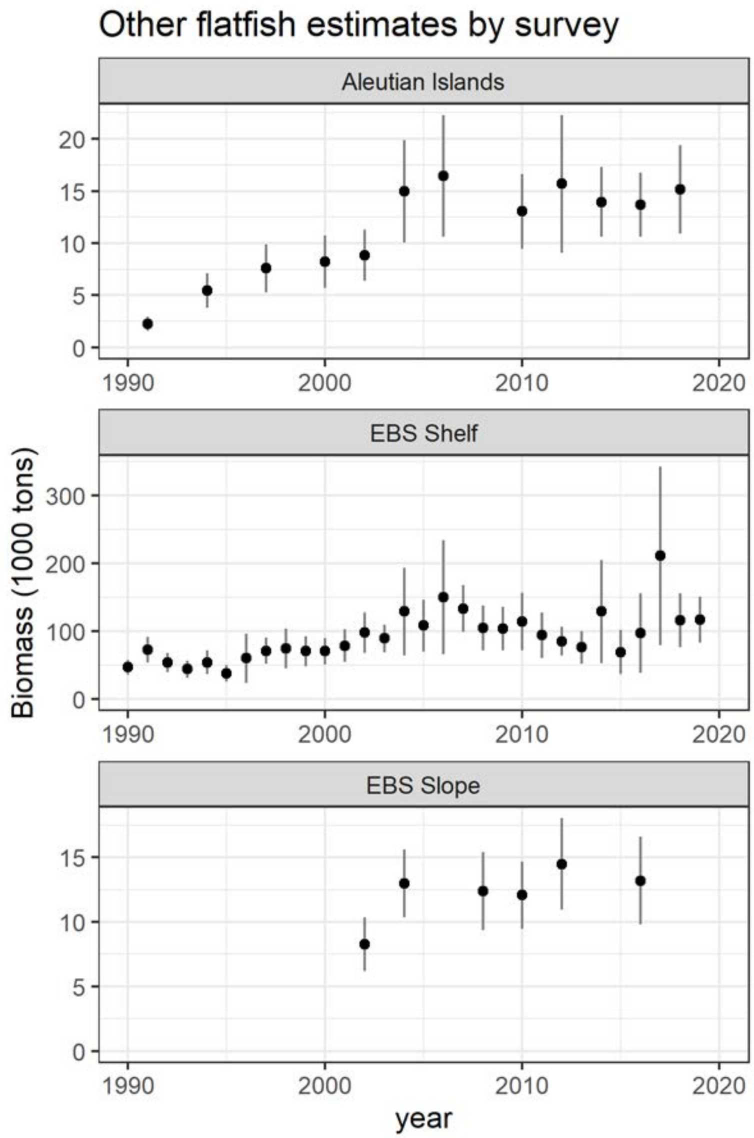

Figure 11.2. BSAI total survey biomass estimates for other flatfish, with 95% confidence intervals. Note that the *y*-axis scales differ.

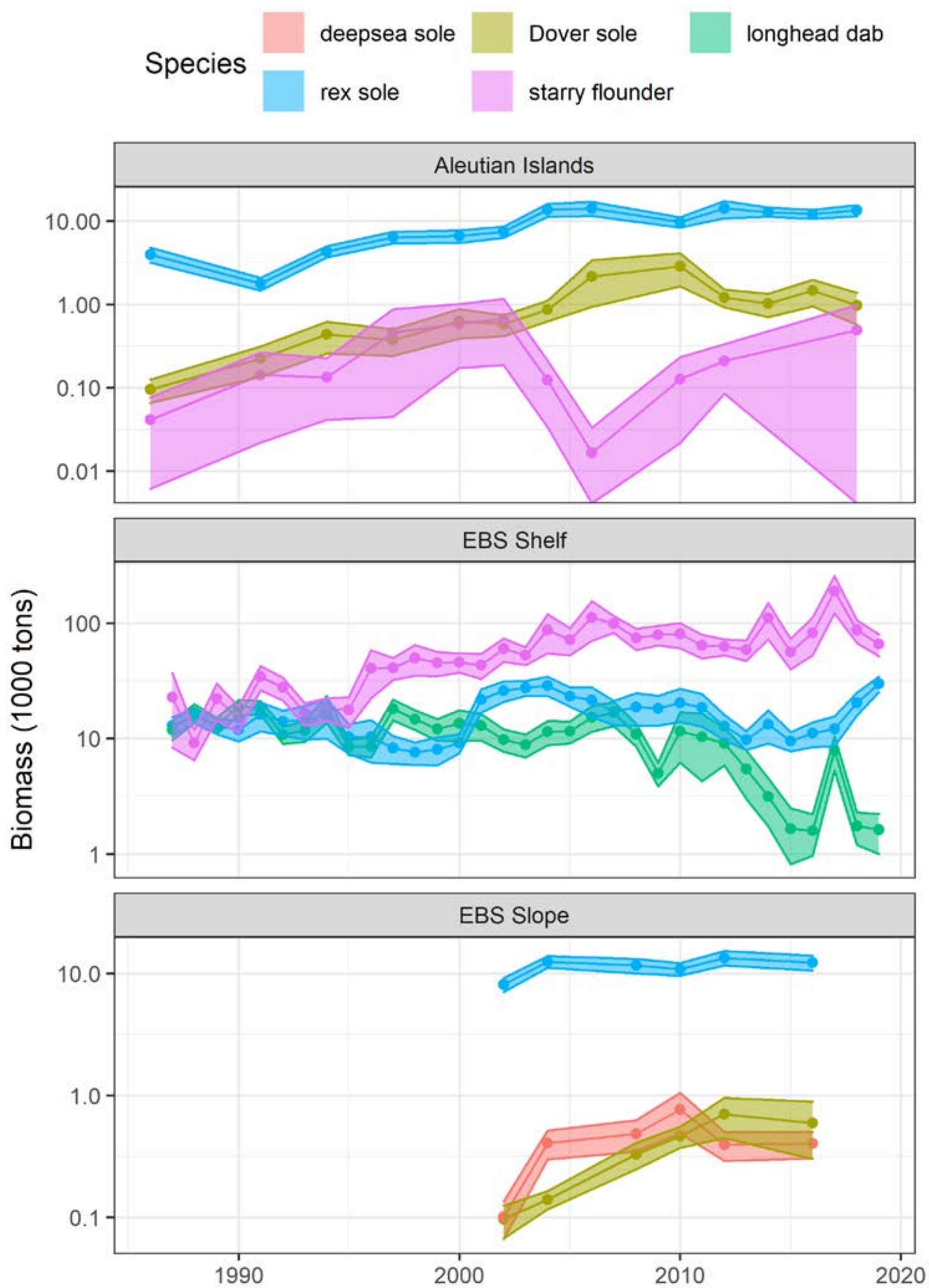

Figure 11.3. Survey estimates of selected species from the three surveys. Note the difference in *y*-axis scales and the log scale. Means are shown as points, and ribbon of mean +/- 1*SE shows the uncertainty.

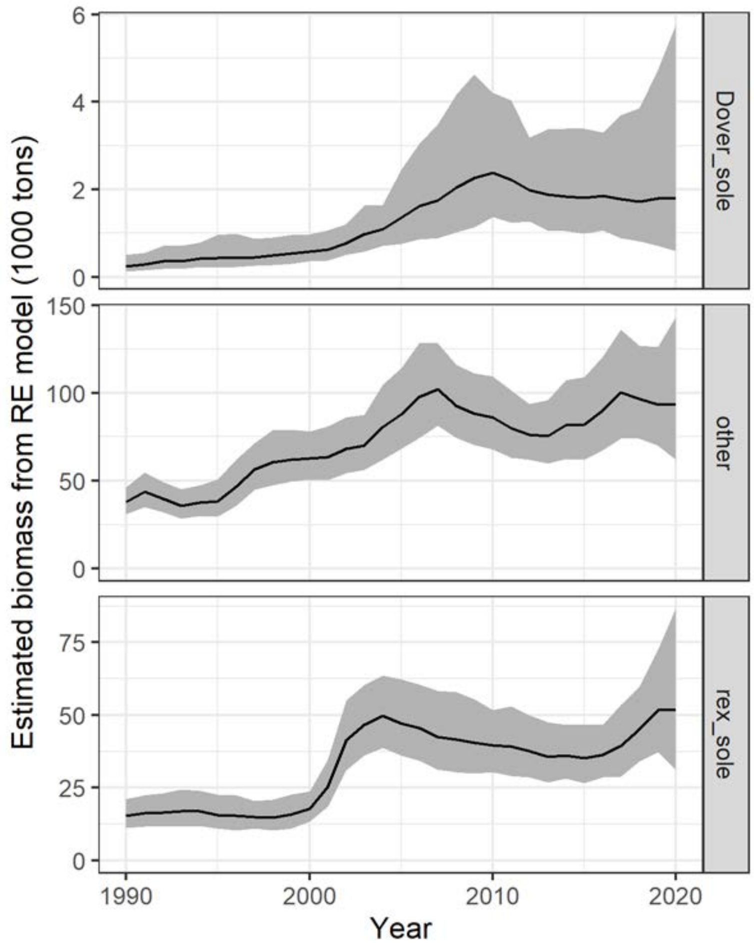

Figure 11.4. Estimated biomass from the random effects model for BSAI Dover sole, rex sole, and all remaining other flatfish combined, summed across the EBS shelf, EBS slope, and Aleutian Islands areas. Biomass (solid black line) and upper and lower 95% confidence intervals (shaded region). Note the difference in *y*-axis scales.

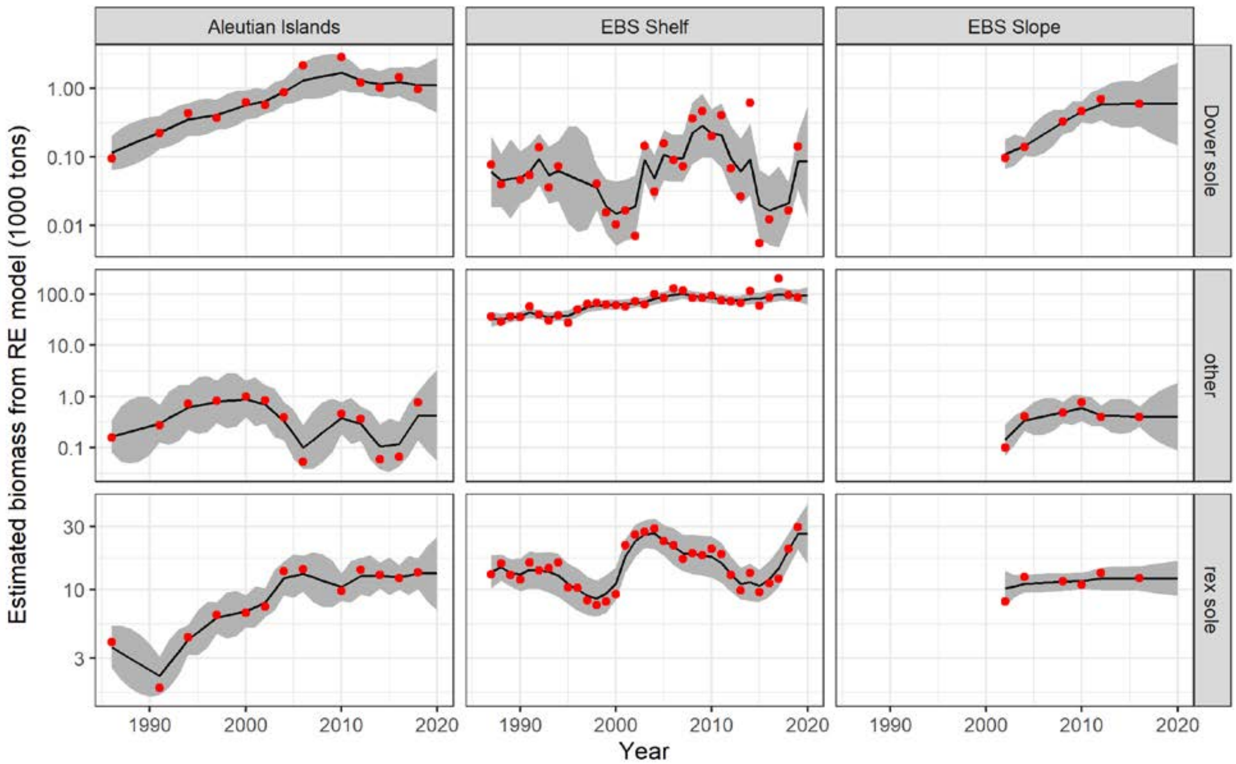

Figure 11.5. Random effects model results for BSAI other flatfish biomass (solid black line) and upper and lower 95% confidence intervals (shaded region) and the survey biomass estimates (red points; uncertainty left off for visual clarity). Shown are results by area (columns) and species group (rows) where "other" represents all other species in the complex except Dover and rex sole. Note the difference in *y*-axis scales and the log-scale. A few values of zero observed biomass are left off and also not included in the RE model (Table. 11.4).

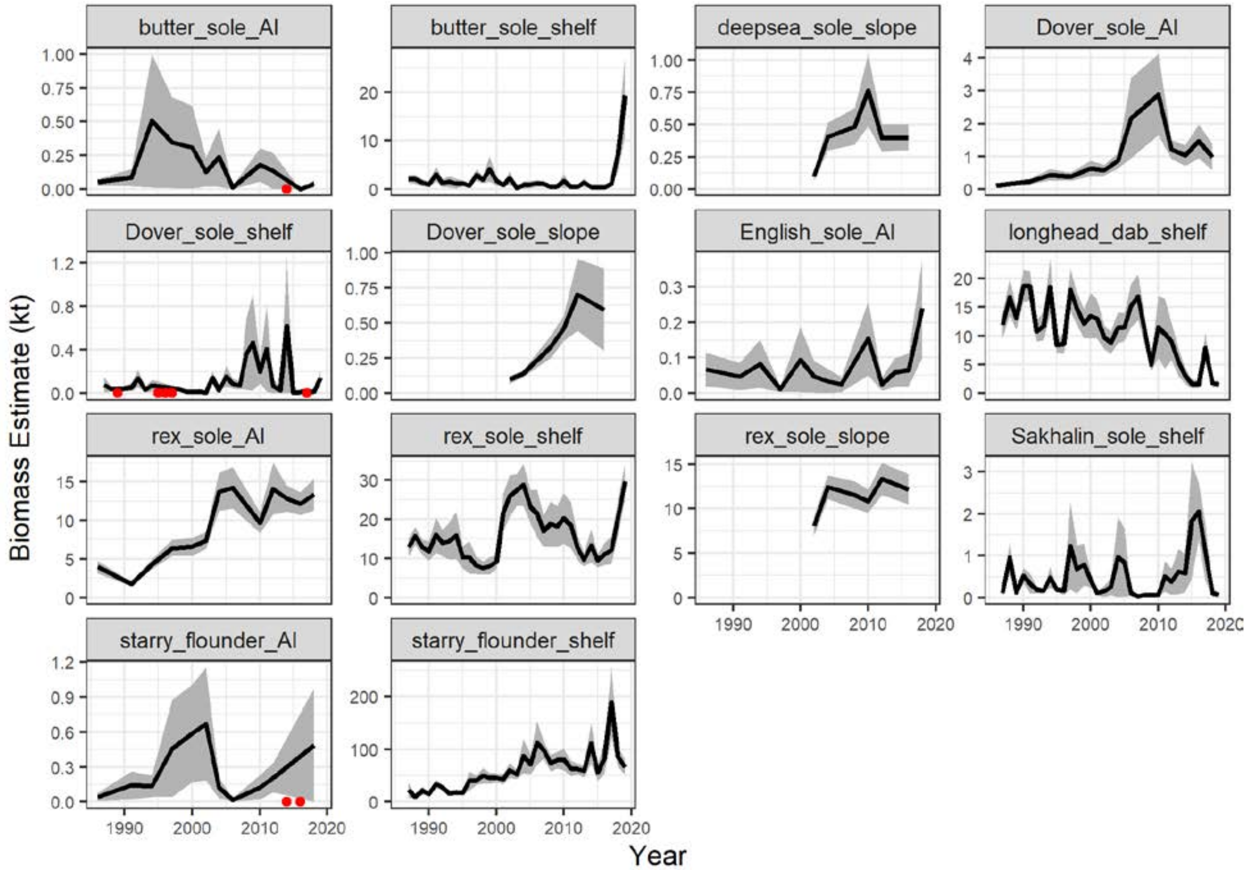

Figure 11.6. Survey estimates of biomass for each species and survey combination. The think line is the mean and the shading shows +/- one standard deviation. Negative confidence intervals are truncated to zero, and red points show years with estimates of 0 which are left out of the model