# 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 2020 catch was updated, catches for 2021, 2022, and 2023 included, and 2024 catch which was pulled on 21 October 2024 was included in the assessment.
2) The 2021, 2022, 2023 and 2024 Eastern Bering Sea shelf survey and 2022 and 2024 Aleutian Islands survey biomass estimates for other flatfish species were added to the assessment.

*Changes in the Assessment Methodology*

The *rema* modeling framework (Sullivan et al. 2022) was adopted in 2024, which extends usage from the previous RE model in ADMB.

## Summary of Results

A summary of the 2025 recommended ABCs and OFLs relative to last year's recommendations for other flatfish in the Bering Sea/Aleutian Islands (BSAI) is as follows:

| Quantity | As estimated or *specified last* year for: 2024 | 2025 | As estimated or *recommended this* year for: 2025 | 2026 |
|---|---|---|---|---|
| *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 other species | 0.15 | 0.15 | 0.15 | 0.15 |
| Tier | 5 | 5 | 5 | 5 |
| RE Model Combined Biomass (t) | 141,325 | 141,325 | 164,955 | 164,955 |
| $F_{OFL}$ ($F$=$M$) 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 | 26,083 | 26,083 |
| maxABC (t) | 16,368 | 16,368 | 19,562 | 19,562 |
| ABC (t) | 16,368 | 16,368 | 19,562 | 19,562 |
| **Status** | As determined *last* year for: 2022 | 2023 | As determined *this* year for: 2023 | 2024 |
| Overfishing | no | n/a | no | n/a |

## Responses to SSC and Plan Team Comments to Assessments in General

None pertaining to this assessment this year.

## Responses to SSC and Plan Team Comments Specific to this Assessment

None pertaining to this assessment this year.

# 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 1995-2024 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 83.9% of the harvest of other flatfish in 2023, and 82.1% so far in 2024 (Figure 1). The 2024 catch of 2,909 t through mid-October is well below (17%) 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 2023, approximately 18% 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 much reduced rates. The biomass of the other flatfish complex on the eastern Bering Sea shelf was relatively stable from 1987-1995, averaging 50,709 t, and then increased from 1996 to 2003, averaging 77,143 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 124,906 t for the complex.

Individual species biomass estimates for the EBS 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 increase in the amount of longhead dab on the EBS shelf which were estimated relatively low from 2015-2019 (except for 2017) and a previous concern, and a large decline for Sakhalin sole after its highest point in 2016. Dover sole estimates from the AI survey were the lowest since 1991, continuing a downward trend since 2016. Butter sole and starry flounder both show decreased abundance during this period, and were both absent in some AI surveys since 2014. Catches of other flatfish on the EBS slope have been stable since 2002, although no survey has been conducted since 2016. 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, as expected.

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.

# 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 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. Starting in 2024 the 'rema' package was used which allows for pooling estimates of process errors together more easily (Sullivan et al. 2022), instead of estimation of individual species/groups by survey regions. Various *rema* configurations were used to produce output grouped at different levels. For the main results where Dover sole, rex sole, and other flatfish groups were estimated by survey, a single process error was found parsimonious using AIC (compared to three for groups or nine for the unique group and survey combinations).

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 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

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 7.5% (Table 11.5). Exploitation rates for Dover sole have increased in the last few years, but remain within historical bounds, while rates for rex sole and starry flounder have remained steady. The estimated exploitation rates for butter sole are higher, due to very low and variable survey biomass estimates. However, the biomass estimates for butter sole have large sampling variances, with coefficients of variation ranging from 0.26 to 0.83 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 283.2 t in 2016 to 19,507.5 t in 2019, and the corresponding exploitation rates were 25% and 1%. The actual amount of estimated butter sole caught is relatively consistent and averages 210 t from 2014-2024 (Table 11.2).

## 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 *rema* model is run separately for each survey and species group, 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 *rema* biomass for Rex sole was 70,878 t (95% CI: 48,293 – 104,327 t), for Dover sole 1,204 t (378 – 5,046 t), and for all other species (primarily starry flounder) 92,872 t (69,855 – 126,021 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 19,562 and 26,083 t, respectively, for the 2025 fishery (note that numbers may differ slightly due to rounding).

| Species | $F_{ABC}$ | $F_{OFL}$ | Biomass (t) | ABC | OFL |
|---|---|---|---|---|---|
| Rex sole | 0.13 | 0.17 | 70,878 | 9,037 | 12,049 |
| Dover sole | 0.06 | 0.09 | 1,204 | 77 | 102 |
| All others | 0.11 | 0.15 | 92,872 | 10,448 | 13,931 |
| | Total other flatfish | | 164,955 | 19,562 | 26,083 |

*Risk Table and ABC Recommendation*

Since 2020, the SSC has requested that full or update assessments fill out a risk table with assessment, population dynamics, environmental and ecosystem, and fishery performance considerations to inform potential reductions from maximum permissible ABC. The guidelines for risk table definitions are now available to reference in the Introduction to the BSAI SAFE.

Assessment considerations

In several cases, the surveys for some species observed no fish (Table 11.4), and these zero estimates are incompatible with the standard approach for random effects model (i.e., a zero cannot be fit assuming a lognormal distribution). Consequently, and following the lead of previous assessments, these values were dropped before fitting, although a Tweedie option could be investigated in the future (Sullivan et al. 2022). However, this occurs in species/area combinations with relatively small abundances and thus are not expected to impact the overall determination of stock status. 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 – normal 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 – normal 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:**

The eastern Bering Sea (EBS) experienced a prolonged period of above-average thermal conditions from 2014 through 2021. Since 2021, and continuing from August 2023–August 2024, thermal conditions in the EBS have been close to historical baselines of many metrics. There have been no sustained marine heatwaves over the southeastern or northern Bering Sea shelves since January 2021 (Callahan and Lemagie, 2024), and observed (Rohan and Barnett, 2024) modeled (Kearney, 2024) EBS bottom temperatures were mostly near-normal over the past year. Sea surface temperatures (SSTs) and bottom temperatures were near the long-term means in all regions by summer 2024. Notable deviations include (i) warm SSTs in the outer domain from fall 2023 through spring 2024 and (ii) unusually warm bottom temperatures in the northern outer domain since spring 2024 that may indicate an intrusion of shelf water (Callahan et al., 2024).

Atmospheric conditions are one of the primary drivers that impact the oceanographic setting in the EBS. Both the North Pacific Index (NPI) and Aleutian Low Index (ALI) provide complementary views of the atmospheric pressure system in the North Pacific. During winter 2023-2024, the NPI was average (Siddon, 2024) and the strength and location of the Aleutian Low Pressure System were both near climatological averages (Overland and Wang, 2024). Thus, despite delayed formation of sea ice in fall 2023 (Thoman, 2024), cold winds from the Arctic helped advance sea ice to near-normal extent by mid-winter. Near-normal sea ice extent and thickness (Thoman, 2024b, 2024c) may have contributed to a cold pool (<2°C water) of average spatial extent (Siddon, 2024), though the footprint of the coldest waters (<0°C) in 2024 was 75% smaller than in 2023 (Rohan and Barnett, 2024b).

December 2023 had significant along-shelf winds (to the southeast) that could have driven offshore Ekman transport. Weaker, but more sustained winds that also favored offshore transport occurred from March to May 2024 (Hennon, 2024). Beginning in May and continuing through summer 2024, persistent storms resulted in a deeper mixed layer, which entrained deeper, cooler water, such that SSTs remained cooler through at least August 2024 (Stabeno, 2024).

For projections into 2025, the National Multi-Model Ensemble (NMME) predicts that SSTs over the EBS are expected to be near normal (anomalies within <0.5°C of the 1982–2010 baseline) (Lemagie, 2024). With the expected transition to La Niña, cooler conditions in the EBS may follow. Relatively cool SSTs may contribute to earlier formation of sea ice than has been observed over the last several years (Thoman, 2024b).

**Prey**:
Prey resources for adult flatfish include benthic infauna as well as epifauna. Direct measurements of infaunal and epifaunal abundance trends are not available, however, abundance trends of motile epifauna that also consume infauna (i.e., indirect measurements) are quantified from the bottom trawl survey. Trends in motile epifauna biomass indicate benthic productivity, although individual species and/or taxa may reflect varying time scales of productivity. The biomass of motile epifauna increased from 2023 to 2024 and remains above the long term mean (Siddon, 2024). No direct or indirect measures of prey availability exist for the northern Bering Sea shelf.

**Competitors:**
Potential competitors to this stock complex include other managed flatfish stocks that comprise the benthic foragers guild and the apex predators guild (Siddon, 2024). The trend in biomass of the benthic foragers guild from the standard bottom trawl survey grid increased from 2023 to 2024, but remained below the time series mean. Trends in benthic forager biomass indirectly indicate availability of infauna (i.e., prey of these species), suggesting competition for prey resources remains low in 2024 (Siddon, 2024). The biomass of apex predators measured during the standard bottom trawl survey in 2024 was nearly equal to their value in 2023 and below their long term mean. However, the trend in the apex predator guild is largely driven by Pacific cod, which decreased 5.5% from 2023 (Siddon, 2024).

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

*Summary for Environmental/Ecosystem considerations:*

- **Environment:** The EBS shelf experienced oceanographic conditions that were largely average based on historical time series of multiple metrics over the past year (August 2023 - August 2024).
- **Prey:** Sufficient prey may have been available for flatfish over the SEBS based on indirect measurements of motile epifauna.
- **Competition:** The trends in biomass of the benthic forager and apex predator guilds both remain below their long-term mean, indicating competition for prey resources remains low in 2024.
- **Predators**: No information on major sources of predation for this stock complex exist, beyond pressure from the fishery.

*Together, the most recent data available suggest an ecosystem risk Level 1 – Normal: "No apparent ecosystem concerns related to biological status (e.g., environment, prey, competition, predation), or minor concerns with uncertain impacts on the stock."*

Fishery performance considerations related to health of the stock

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 related to the health of the stock* |
|---|---|---|---|
| Level 1: normal | Level 1: normal | Level 1: normal | Level 1: normal |

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 2023 (3,020 t) is less than the aggregate OFL in 2023 (22,919 t).

# Ecosystem Considerations

## Ecosystem Effects on the Stock

Observed and modeled summer bottom temperatures and the spatial extent of the cold pool have been near-average since 2021, indicating a cooler thermal experience for flatfish stocks relative to the recent warm phase (2014-2021). Winds during March-May have favored offshore transport in 2023 and 2024; offshore transport is correlated with below average recruitment for some winter-spawning flatfish. Prey abundance (motile epifauna) remained above the long term mean in 2024. The condition of select flatfish species has been mixed since 2021, showing no clear trends of increasing or decreasing, with estimates of biomass also being mixed in 2024. Taken together, this indicates sufficient prey availability. Benthic forager biomass (potential competitors) increased from 2023 to 2024, but remained below the time series mean. Apex predator biomass (potential competitors) was also below the time series mean in 2024. Taken together, this indicates competition for prey resources remains low in 2024.

## 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 1995-2024. TAC before 2007 may not reflect in season adjustments and will be updated in future years. 2024 catch was pulled on October 21, 2024.

| Year | Starry Founder | Rex Sole | Butter Sole | longhead dab | Dover sole | English sole | deep sea sole | Sakhalin sole | Total | ABC | OFL | TAC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1995 | 398 | 673 | 157 | 7 | 59 | 26 | 4 | 0 | 1,324 | 117,000 | 137,000 | 19,540 |
| 1996 | 1,171 | 1,148 | 218 | 175 | 6 | 0 | 0 | 30 | 2,748 | 102,000 | 120,000 | 35,000 |
| 1997 | 1,043 | 687 | 448 | 211 | 53 | 0 | 29 | 6 | 2,490 | 97,500 | 150,000 | 50,750 |
| 1998 | 402 | 998 | 229 | 93 | 41 | 0 | 0 | 0 | 1,765 | 164,000 | 253,000 | 89,434 |
| 1999 | 725 | 998 | 230 | 56 | 81 | 27 | 0 | 0 | 2,117 | 154,000 | 248,000 | 154,000 |
| 2000 | 1,151 | 1,069 | 458 | 277 | 66 | 4 | 0 | 0 | 3,027 | 117,000 | 141,000 | 83,813 |
| 2001 | 755 | 869 | 244 | 62 | 70 | 4 | 6 | 0 | 2,028 | 122,000 | 147,000 | 28,000 |
| 2002 | 1,075 | 1,192 | 222 | 107 | 34 | 0 | 1 | 0 | 2,631 | 18,100 | 21,800 | 3,000 |
| 2003 | 887 | 1,399 | 296 | 125 | 39 | 2 | 0 | 0 | 2,749 | 16,000 | 21,400 | 3,000 |
| 2004 | 2,062 | 1,858 | 514 | 146 | 82 | 6 | 0 | 0 | 4,669 | 21,400 | 28,500 | 3,500 |
| 2005 | 2,069 | 2,001 | 487 | 25 | 16 | 1 | 0 | 0 | 4,599 | 21,400 | 28,500 | 3,500 |
| 2006 | 1,663 | 1,266 | 261 | 33 | 10 | 0 | 0 | 0 | 3,233 | 18,100 | 24,200 | 3,500 |
| 2007 | 4,356 | 812 | 579 | 87 | 4 | 2 | <1 | <1 | 5,840 | 21,400 | 28,500 | 8,500 |
| 2008 | 1,978 | 968 | 618 | 47 | 10 | 2 | <1 | <1 | 3,623 | 21,600 | 28,800 | 18,360 |
| 2009 | 806 | 1,143 | 198 | 7 | 7 | 2 | 0 | <1 | 2,163 | 17,400 | 23,100 | 14,790 |
| 2010 | 1,506 | 510 | 162 | 9 | 5 | <1 | <1 | <1 | 2,194 | 17,300 | 23,000 | 14,705 |
| 2011 | 2,168 | 860 | 107 | 18 | 10 | 13 | 0 | <1 | 3,176 | 14,500 | 19,500 | 2,550 |
| 2012 | 2,205 | 866 | 191 | 9 | 15 | 5 | 0 | 0 | 3,292 | 12,700 | 17,100 | 2,720 |
| 2013 | 906 | 579 | 30 | 15 | 6 | 0 | 0 | <1 | 1,536 | 13,300 | 17,800 | 2,975 |
| 2014 | 3,341 | 770 | 219 | 20 | 10 | 0 | 0 | 0 | 4,391 | 12,400 | 16,700 | 2,253 |
| 2015 | 1,522 | 746 | 113 | 27 | 6 | <1 | 0 | 0 | 2,415 | 13,250 | 17,700 | 3,077 |
| 2016 | 1,597 | 1,004 | 152 | 38 | 4 | <1 | 0 | <1 | 2,795 | 13,061 | 17,414 | 2,862 |
| 2017 | 3,091 | 937 | 55 | 13 | 5 | <1 | <1 | 0 | 4,102 | 13,193 | 17,591 | 4,175 |
| 2018 | 5,426 | 426 | 71 | 17 | 4 | <1 | 0 | 0 | 5,944 | 13,193 | 17,591 | 4,100 |
| 2019 | 2,617 | 1,042 | 97 | 33 | 5 | <1 | <1 | 0 | 3,796 | 16,368 | 21,824 | 5,525 |
| 2020 | 2,646 | 1,209 | 296 | 16 | 6 | 1 | 0 | 0 | 4,174 | 16,368 | 21,824 | 4,121 |
| 2021 | 1,477 | 1,014 | 115 | 27 | 5 | 1 | 0 | 0 | 2,638 | 17,189 | 22,919 | 5,525 |
| 2022 | 1,122 | 1,059 | 344 | 17 | 16 | 1 | 0 | 0 | 2,559 | 17,189 | 22,919 | 8,500 |
| 2023 | 950 | 1,584 | 393 | 38 | 17 | 38 | 0 | 0 | 3,020 | 17,189 | 22,919 | 3,825 |
| 2024 | 1,157 | 1,231 | 458 | 36 | 28 | <1 | <1 | 0 | 2,909 | 17,189 | 22,919 | 3,825 |

Table 11.3. Estimated biomass (t) and coefficient of variation (CV) of other flatfish from the eastern Bering Sea (EBS) shelf, slope, and Aleutian Islands (AI) AFSC trawl surveys. Totals across all three areas are only shown when all three surveys were completed. There were no surveys in 2020.

| Year | EBS Shelf | EBS Slope | Aleutian Islands | Total |
|---|---|---|---|---|
| 1987 | 49,908 (0.3) | | | |
| 1988 | 45,891 (0.11) | | | |
| 1989 | 49,605 (0.17) | | | |
| 1990 | 47,242 (0.11) | | | |
| 1991 | 72,757 (0.13) | | 2,273 (0.16) | |
| 1992 | 54,113 (0.14) | | | |
| 1993 | 44,461 (0.15) | | | |
| 1994 | 54,490 (0.16) | | 5,481 (0.15) | |
| 1995 | 37,918 (0.16) | | | |
| 1996 | 60,451 (0.31) | | | |
| 1997 | 71,885 (0.14) | | 7,584 (0.15) | |
| 1998 | 75,142 (0.2) | | | |
| 1999 | 70,930 (0.16) | | | |
| 2000 | 71,220 (0.14) | | 8,223 (0.16) | |
| 2001 | 79,237 (0.15) | | | |
| 2002 | 98,532 (0.15) | 8,400 (0.13) | 8,818 (0.14) | 115,750 (0.13) |
| 2003 | 89,744 (0.11) | | | |
| 2004 | 129,666 (0.25) | 13,021 (0.1) | 14,969 (0.17) | 157,656 (0.21) |
| 2005 | 109,024 (0.18) | | | |
| 2006 | 151,533 (0.29) | | 16,445 (0.18) | |
| 2007 | 134,419 (0.13) | | | |
| 2008 | 105,185 (0.16) | 12,514 (0.13) | | |
| 2009 | 104,159 (0.16) | | | |
| 2010 | 114,935 (0.19) | 12,239 (0.11) | 13,057 (0.14) | 140,231 (0.16) |
| 2011 | 94,723 (0.18) | | | |
| 2012 | 85,908 (0.13) | 14,654 (0.12) | 15,689 (0.21) | 116,251 (0.1) |
| 2013 | 76,602 (0.16) | | | |
| 2014 | 129,976 (0.3) | | 13,937 (0.12) | |
| 2015 | 69,911 (0.24) | | | |
| 2016 | 97,903 (0.31) | 13,331 (0.13) | 13,672 (0.11) | 124,906 (0.24) |
| 2017 | 212,920 (0.32) | | | |
| 2018 | 116,811 (0.17) | | 15,151 (0.14) | |
| 2019 | 117,312 (0.15) | | | |
| 2021 | 149,498 (0.15) | | | |
| 2022 | 175,783 (0.12) | | 11,797 (0.14) | |
| 2023 | 143,986 (0.15) | | | |
| 2024 | 135,788 (0.18) | | 11,625 (0.14) | |

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 *rema* model.

**EBS Shelf survey**

| Year | Butter sole | | Dover sole | | Longhead dab | | Rex sole | | Sakhalin sole | | Starry flounder | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1987 | 2,056.3 | 0.38 | 75.9 | 0.91 | 12,010.5 | 0.19 | 12,800.6 | 0.18 | 109.8 | 0.58 | 22,854.7 | 0.63 |
| 1988 | 2,070.1 | 0.47 | 39.0 | 0.58 | 16,869.5 | 0.19 | 15,566.3 | 0.15 | 954.6 | 0.40 | 9,251.0 | 0.29 |
| 1989 | 1,312.9 | 0.54 | 0.0 | - | 13,164.3 | 0.16 | 12,766.6 | 0.15 | 120.5 | 0.42 | 22,240.6 | 0.34 |
| 1990 | 991.7 | 0.60 | 46.7 | 0.60 | 18,815.9 | 0.15 | 11,688.5 | 0.21 | 525.7 | 0.35 | 15,173.3 | 0.26 |
| 1991 | 3,074.0 | 0.50 | 54.1 | 0.70 | 18,836.1 | 0.14 | 15,827.9 | 0.28 | 340.1 | 0.68 | 34,624.7 | 0.23 |
| 1992 | 1,240.1 | 0.69 | 135.3 | 0.58 | 10,910.1 | 0.17 | 13,832.3 | 0.24 | 194.2 | 0.47 | 27,800.6 | 0.22 |
| 1993 | 1,525.0 | 0.75 | 35.0 | 0.74 | 11,825.8 | 0.21 | 14,239.4 | 0.32 | 165.2 | 0.30 | 16,670.2 | 0.22 |
| 1994 | 1,100.0 | 0.97 | 72.8 | 0.72 | 18,709.5 | 0.26 | 15,724.9 | 0.38 | 486.0 | 0.52 | 18,396.8 | 0.22 |
| 1995 | 1,214.5 | 0.54 | 0.0 | - | 8,478.1 | 0.15 | 10,206.0 | 0.28 | 199.8 | 0.27 | 17,820.0 | 0.29 |
| 1996 | 689.2 | 0.53 | 0.0 | - | 8,642.8 | 0.20 | 10,129.6 | 0.40 | 164.9 | 0.55 | 40,824.6 | 0.45 |
| 1997 | 2,910.1 | 0.43 | 0.0 | - | 18,167.6 | 0.21 | 8,148.0 | 0.27 | 1,232.1 | 0.84 | 41,426.8 | 0.21 |
| 1998 | 1,959.2 | 0.38 | 40.7 | 0.45 | 14,871.5 | 0.19 | 7,497.3 | 0.22 | 674.1 | 0.86 | 50,099.5 | 0.30 |
| 1999 | 4,193.2 | 0.62 | 15.5 | 0.67 | 12,205.6 | 0.21 | 7,951.5 | 0.27 | 796.1 | 0.62 | 45,768.0 | 0.24 |
| 2000 | 1,740.6 | 0.56 | 10.1 | 1.00 | 13,650.8 | 0.30 | 9,060.4 | 0.19 | 429.4 | 0.44 | 46,329.2 | 0.19 |
| 2001 | 809.1 | 0.50 | 16.1 | 0.83 | 13,051.8 | 0.26 | 21,399.5 | 0.23 | 106.1 | 0.32 | 43,854.5 | 0.24 |
| 2002 | 2,274.9 | 0.63 | 6.9 | 0.79 | 9,889.1 | 0.22 | 25,659.7 | 0.20 | 151.4 | 0.89 | 60,549.9 | 0.23 |
| 2003 | 176.1 | 0.60 | 145.7 | 0.41 | 8,912.7 | 0.22 | 27,189.0 | 0.15 | 250.5 | 0.74 | 53,068.0 | 0.17 |
| 2004 | 837.2 | 0.85 | 30.8 | 0.51 | 11,560.1 | 0.24 | 28,494.1 | 0.19 | 973.2 | 0.98 | 87,770.8 | 0.37 |
| 2005 | 963.9 | 0.81 | 157.7 | 0.60 | 11,666.9 | 0.21 | 23,022.9 | 0.18 | 838.8 | 0.97 | 72,374.2 | 0.26 |
| 2006 | 1,195.3 | 0.67 | 89.2 | 0.52 | 15,409.0 | 0.25 | 21,330.7 | 0.28 | 115.2 | 0.55 | 113,393.6 | 0.38 |
| 2007 | 1,025.4 | 0.43 | 72.8 | 0.52 | 16,902.3 | 0.24 | 16,864.2 | 0.24 | 28.7 | 0.34 | 99,526.0 | 0.17 |
| 2008 | 422.2 | 0.62 | 357.5 | 0.90 | 10,993.2 | 0.22 | 18,545.3 | 0.31 | 72.8 | 0.35 | 74,794.0 | 0.21 |
| 2009 | 536.5 | 0.60 | 460.3 | 0.95 | 5,062.5 | 0.23 | 17,939.3 | 0.29 | 52.5 | 0.45 | 80,107.9 | 0.19 |
| 2010 | 1,764.2 | 0.82 | 199.4 | 0.54 | 11,678.9 | 0.47 | 20,082.9 | 0.32 | 72.3 | 0.47 | 81,136.9 | 0.25 |
| 2011 | 438.9 | 0.69 | 400.1 | 0.96 | 10,457.3 | 0.59 | 18,293.3 | 0.31 | 512.4 | 0.72 | 64,621.3 | 0.23 |
| 2012 | 488.2 | 0.67 | 66.8 | 1.00 | 9,160.3 | 0.36 | 12,667.1 | 0.25 | 375.9 | 0.83 | 63,150.2 | 0.16 |
| 2013 | 1,314.3 | 0.69 | 26.9 | 1.00 | 5,505.2 | 0.45 | 9,637.7 | 0.18 | 625.1 | 0.87 | 59,492.7 | 0.20 |
| 2014 | 512.9 | 0.65 | 607.7 | 1.00 | 3,160.2 | 0.45 | 13,111.5 | 0.31 | 584.4 | 0.79 | 111,999.4 | 0.35 |
| 2015 | 344.1 | 0.74 | 5.5 | 1.00 | 1,664.3 | 0.50 | 9,382.7 | 0.19 | 1,834.7 | 0.75 | 56,679.7 | 0.30 |
| 2016 | 283.2 | 0.68 | 12.3 | 0.93 | 1,597.0 | 0.39 | 10,996.6 | 0.24 | 2,055.9 | 0.33 | 82,945.3 | 0.36 |
| 2017 | 1,050.2 | 0.44 | 0.0 | - | 7,951.9 | 0.33 | 11,922.3 | 0.29 | 1,108.9 | 0.63 | 190,887.0 | 0.35 |
| 2018 | 7,218.7 | 0.49 | 16.3 | 0.40 | 1,752.8 | 0.31 | 20,135.6 | 0.22 | 116.0 | 0.94 | 87,439.2 | 0.22 |
| 2019 | 19,507.5 | 0.44 | 141.4 | 0.54 | 1,628.0 | 0.38 | 29,505.7 | 0.15 | 62.0 | 0.91 | 66,435.6 | 0.22 |
| 2020 | - | - | - | - | - | - | - | - | - | - | - | - |
| 2021 | 12,227.0 | 0.27 | 468.8 | 0.39 | 11,764.9 | 0.25 | 41,723.8 | 0.23 | 15.5 | 0.63 | 83,294.8 | 0.23 |
| 2022 | 20,118.4 | 0.38 | 867.2 | 0.77 | 20,421.4 | 0.29 | 41,405.8 | 0.22 | 176.2 | 0.97 | 92,651.7 | 0.19 |
| 2023 | 10,754.1 | 0.33 | 332.7 | 0.40 | 12,216.5 | 0.33 | 39,163.5 | 0.20 | 20.7 | 0.66 | 81,383.0 | 0.24 |
| 2024 | 11,650.8 | 0.35 | 236.7 | 0.70 | 6,328.1 | 0.26 | 59,845.3 | 0.32 | 15.5 | 0.37 | 57,240.2 | 0.24 |

Table 11.4 – continued,

**EBS Slope survey**

| Year | Deepsea sole | | Dover sole | | Rex sole | |
|---|---|---|---|---|---|---|
| 2002 | 102.7 | 0.33 | 96.8 | 0.30 | 8,200.8 | 0.13 |
| 2004 | 409.3 | 0.26 | 140.6 | 0.17 | 12,470.9 | 0.11 |
| 2008 | 484.4 | 0.29 | 330.0 | 0.25 | 11,700.0 | 0.13 |
| 2010 | 775.8 | 0.36 | 463.2 | 0.20 | 10,999.9 | 0.12 |
| 2012 | 406.9 | 0.26 | 701.8 | 0.36 | 13,544.1 | 0.13 |
| 2016 | 416.0 | 0.24 | 594.1 | 0.49 | 12,319.5 | 0.14 |

**Aleutian Islands survey**

| Year | Butter sole | | Dover sole | | English sole | | Rex sole | | Starry flounder | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1991 | 85.7 | 0.73 | 224.2 | 0.40 | 47.2 | 0.80 | 1,773.6 | 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 | 373.6 | 0.35 | 12.4 | 0.72 | 6,393.5 | 0.16 | 458.5 | 0.90 |
| 2000 | 309.7 | 0.99 | 629.9 | 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 | 7,398.1 | 0.15 | 670.9 | 0.72 |
| 2004 | 235.2 | 0.93 | 868.1 | 0.28 | 34.5 | 1.00 | 13,707.8 | 0.18 | 123.3 | 0.73 |
| 2006 | 12.8 | 1.00 | 2,156.6 | 0.57 | 24.7 | 0.85 | 14,233.8 | 0.19 | 16.6 | 1.00 |
| 2010 | 180.1 | 0.69 | 2,874.0 | 0.43 | 154.6 | 0.67 | 9,722.0 | 0.14 | 126.3 | 0.83 |
| 2012 | 133.8 | 1.00 | 1,213.9 | 0.24 | 26.1 | 0.74 | 14,101.8 | 0.24 | 208.6 | 0.60 |
| 2014 | 0.0 | - | 1,025.2 | 0.31 | 58.4 | 0.69 | 12,853.3 | 0.13 | 0.0 | - |
| 2016 | 0.2 | 1.00 | 1,459.3 | 0.36 | 66.4 | 0.69 | 12,146.5 | 0.12 | 0.0 | - |
| 2018 | 40.5 | 0.70 | 975.0 | 0.41 | 240.1 | 0.58 | 13,405.8 | 0.15 | 488.9 | 1.00 |
| 2022 | 0.0 | - | 367.9 | 0.26 | 173.9 | 0.47 | 11,250.4 | 0.14 | 0.0 | - |
| 2024 | 13.8 | 0.89 | 277.8 | 0.43 | 565.1 | 0.34 | 10,754.5 | 0.15 | 0.0 | - |

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 2024. 2024 catch was pulled on 10/21/2024.

| | Dover sole | | | Rex sole | | | Starry flounder | | |
|---|---|---|---|---|---|---|---|---|---|
| **Year** | **Biomass** | **Catch** | **Exp. Rate** | **Biomass** | **Catch** | **Exp. Rate** | **Biomass** | **Catch** | **Exp. Rate** |
| 2002 | 772 | 34 | 4.4% | 41,279 | 1,192 | 2.9% | 55,469 | 1,075 | 1.9% |
| 2003 | 974 | 39 | 4.0% | 46,431 | 1,399 | 3.0% | 58,599 | 887 | 1.5% |
| 2004 | 1,087 | 82 | 7.5% | 49,328 | 1,858 | 3.8% | 68,494 | 2,062 | 3.0% |
| 2005 | 1,368 | 16 | 1.2% | 46,940 | 2,001 | 4.3% | 75,398 | 2,069 | 2.7% |
| 2006 | 1,628 | 10 | 0.6% | 45,268 | 1,266 | 2.8% | 84,562 | 1,663 | 2.0% |
| 2007 | 1,771 | 4 | 0.2% | 42,368 | 812 | 1.9% | 88,500 | 4,356 | 4.9% |
| 2008 | 2,053 | 10 | 0.5% | 41,513 | 968 | 2.3% | 81,117 | 1,978 | 2.4% |
| 2009 | 2,283 | 7 | 0.3% | 40,545 | 1,143 | 2.8% | 78,775 | 806 | 1.0% |
| 2010 | 2,401 | 5 | 0.2% | 39,595 | 510 | 1.3% | 75,339 | 1,506 | 2.0% |
| 2011 | 2,216 | 10 | 0.5% | 39,069 | 860 | 2.2% | 69,285 | 2,168 | 3.1% |
| 2012 | 1,973 | 15 | 0.8% | 37,619 | 866 | 2.3% | 66,318 | 2,205 | 3.3% |
| 2013 | 1,858 | 6 | 0.3% | 35,673 | 579 | 1.6% | 67,357 | 906 | 1.3% |
| 2014 | 1,810 | 10 | 0.6% | 36,115 | 770 | 2.1% | 75,306 | 3,341 | 4.4% |
| 2015 | 1,748 | 12 | 0.7% | 35,260 | 1,480 | 4.2% | 75,436 | 3,019 | 4.0% |
| 2016 | 1,754 | 6 | 0.3% | 36,442 | 1,649 | 4.5% | 83,967 | 2,624 | 3.1% |
| 2017 | 1,609 | 3 | 0.2% | 39,300 | 722 | 1.8% | 93,674 | 2,381 | 2.5% |
| 2018 | 1,483 | 4 | 0.3% | 45,182 | 410 | 0.9% | 86,491 | 5,226 | 6.0% |
| 2019 | 1,413 | 5 | 0.4% | 52,305 | 995 | 1.9% | 79,065 | 2,499 | 3.2% |
| 2020 | 1,396 | 3 | 0.2% | 56,737 | 631 | 1.1% | 80,861 | 1,381 | 1.7% |
| 2021 | 1,509 | 4 | 0.3% | 62,031 | 845 | 1.4% | 82,699 | 1,230 | 1.5% |
| 2022 | 1,542 | 19 | 1.2% | 64,067 | 1,313 | 2.0% | 83,990 | 1,393 | 1.7% |
| 2023 | 1,311 | 20 | 1.5% | 65,293 | 1,857 | 2.8% | 77,721 | 1,114 | 1.4% |
| 2024 | 1,204 | 15 | 1.2% | 70,878 | 651 | 0.9% | 69,920 | 611 | 0.9% |

# Figures

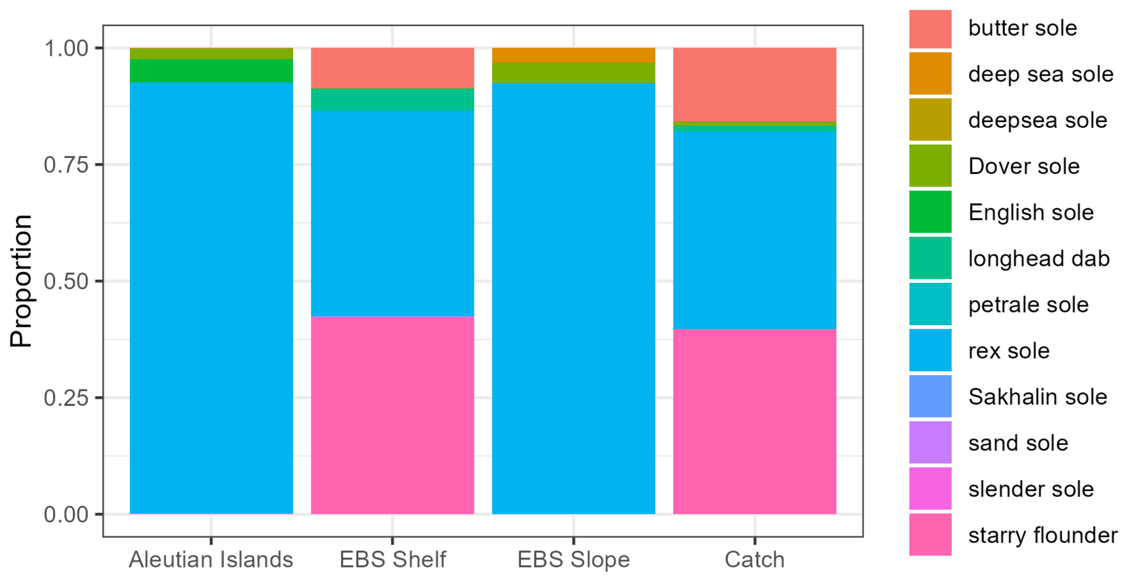


Figure 11.1. Species composition of most recent survey and fishery catch data for BSAI other flatfish. Shown are the 2024 AI survey, 2024 EBS shelf survey, 2016 EBS slope survey, and 2024 catch (pulled on 10/21/2024).

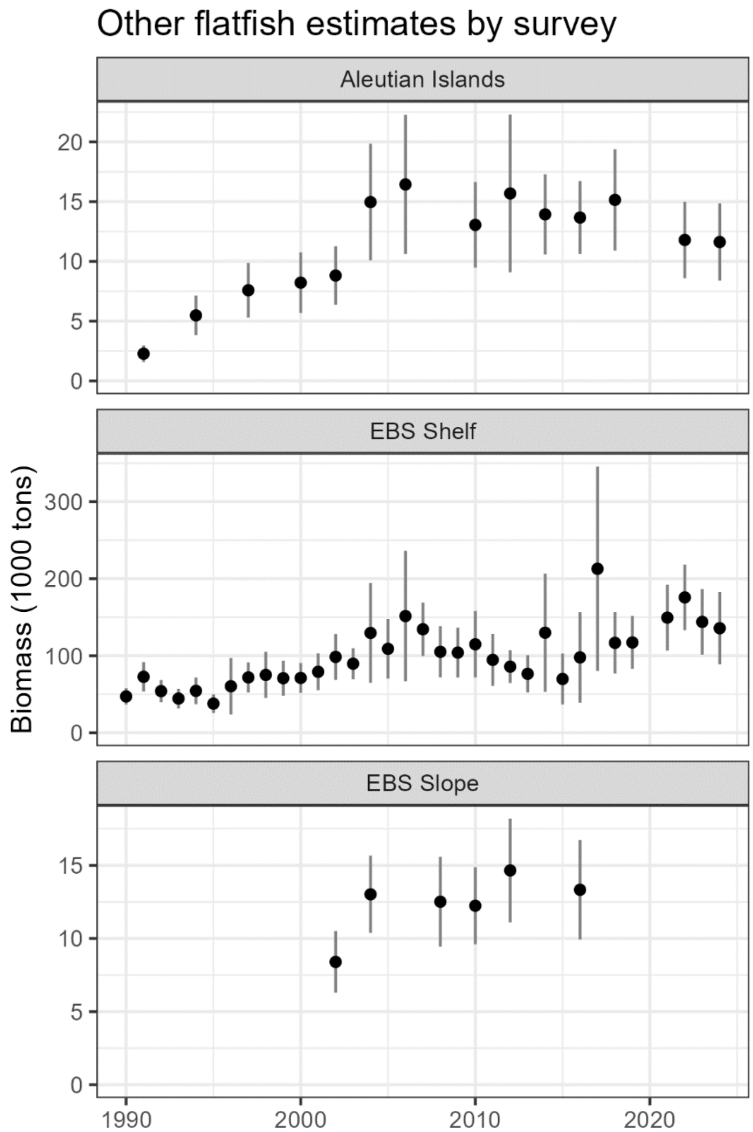


Figure 11.2. BSAI total survey biomass estimates for other flatfish, with 95% confidence intervals. Note that the *y*-axis scales differ among rows.

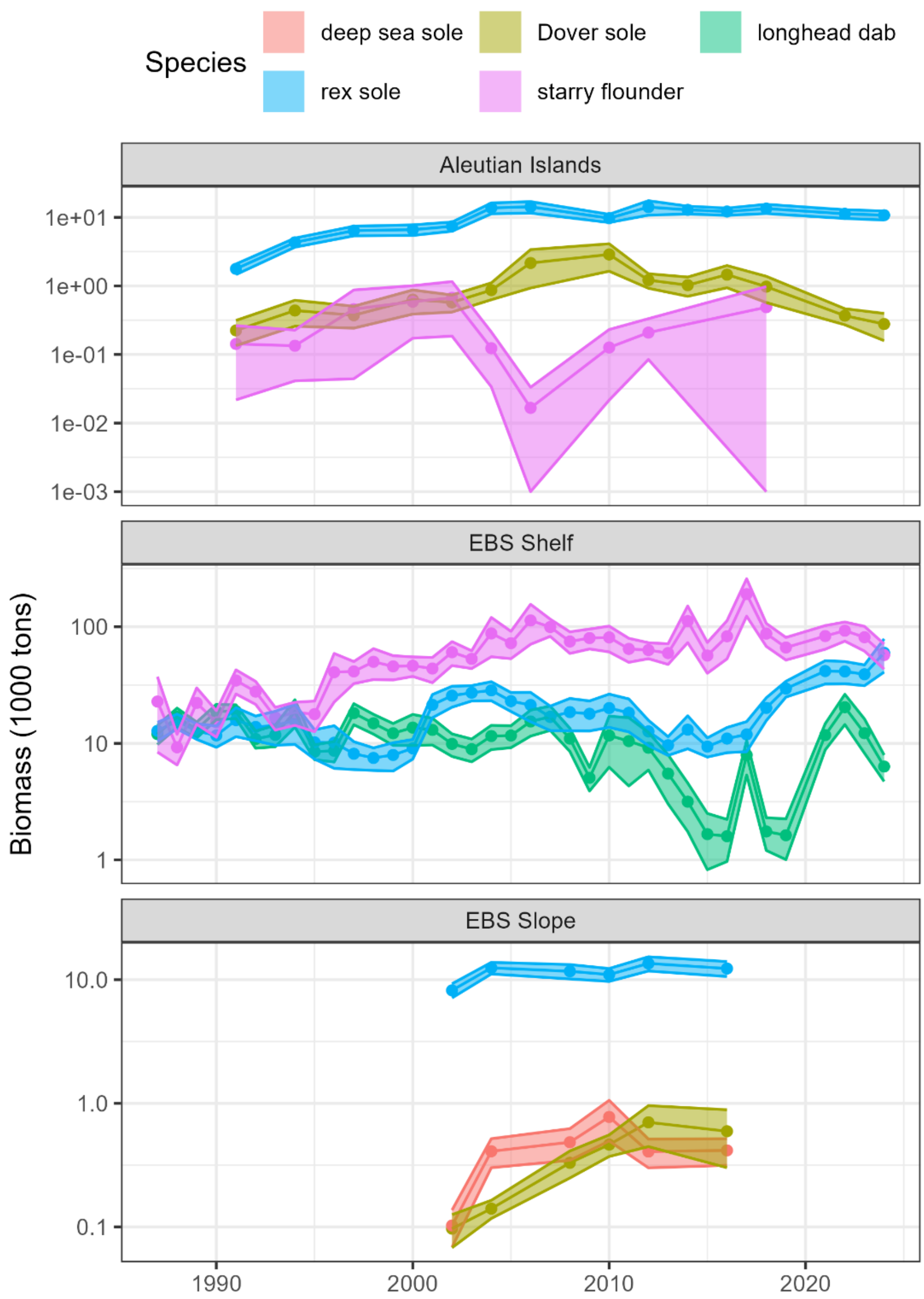


Figure 11.3. Survey estimates of selected species from the three surveys. Note the difference in *y*-axis scales and the log scale. Means are shown as points, and ribbon of mean +/- 1*SE shows the uncertainty.

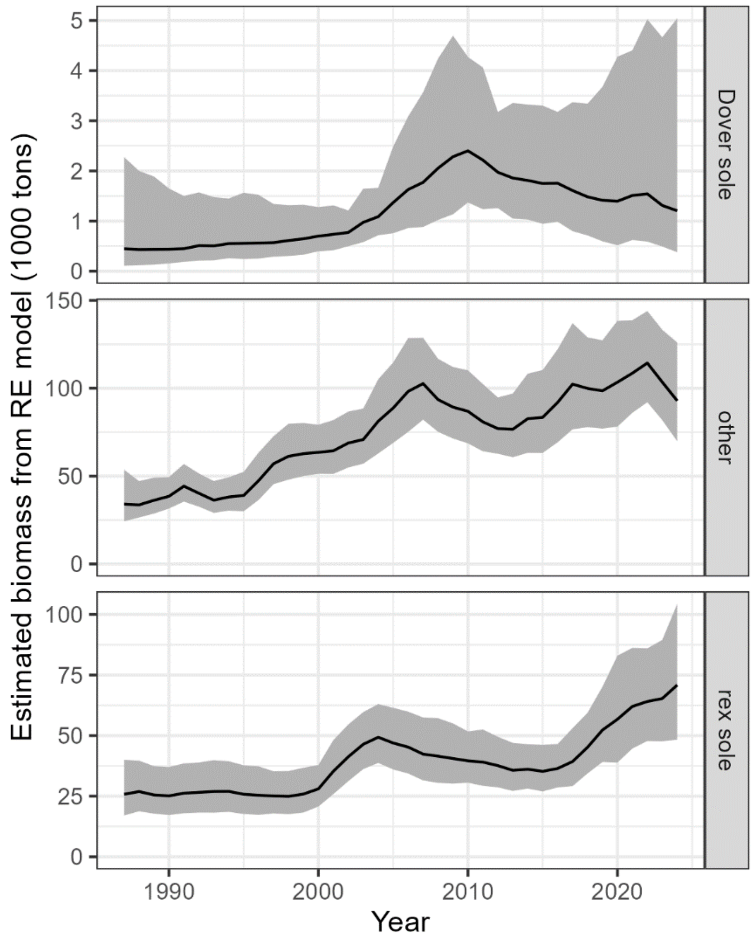


Figure 11.4. Estimated biomass from the random effects model for BSAI Dover sole, rex sole, and all remaining other flatfish combined, summed across the EBS shelf, EBS slope, and Aleutian Islands areas. Biomass (solid black line) and upper and lower 95% confidence intervals (shaded region). Note the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

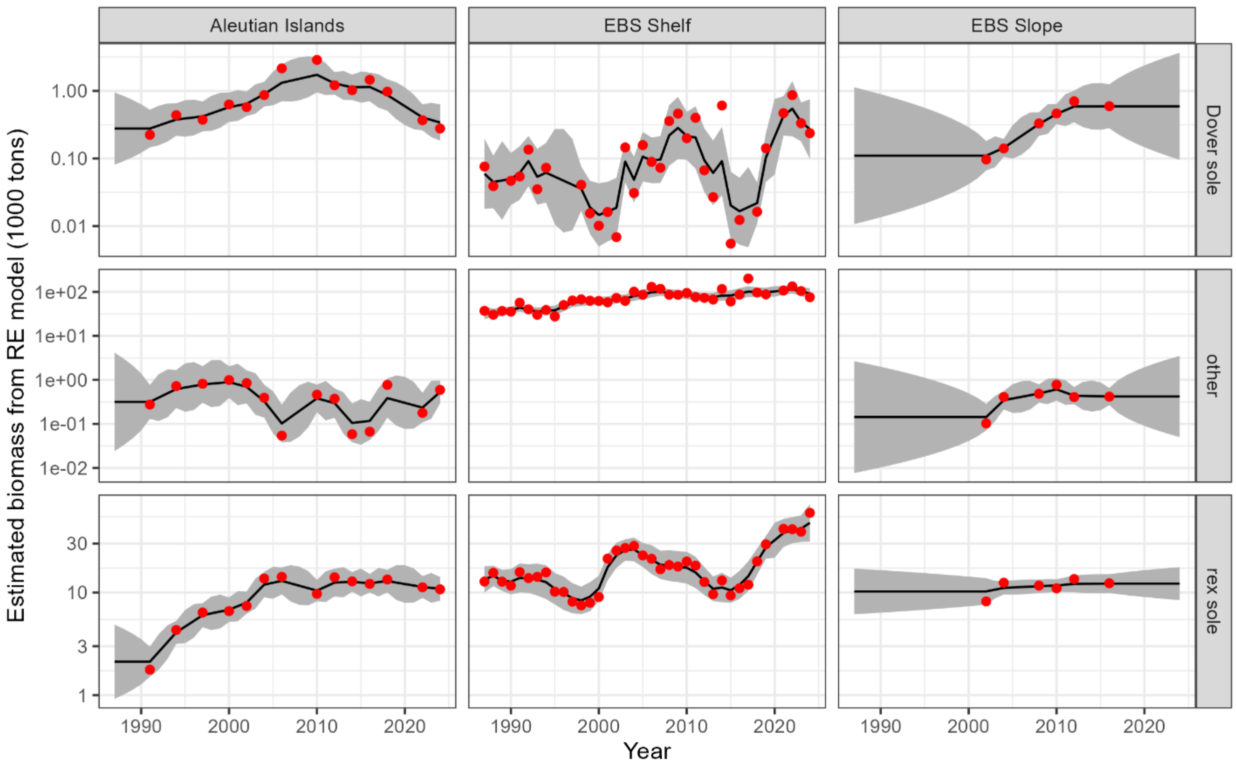


Figure 11.5. *rema* model results for BSAI other flatfish biomass (solid black line) and upper and lower 95% confidence intervals (shaded region) and the survey biomass estimates (red points; uncertainty left off for visual clarity). Shown are results by area (columns) and species group (rows) where “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 model (Table. 11.4).

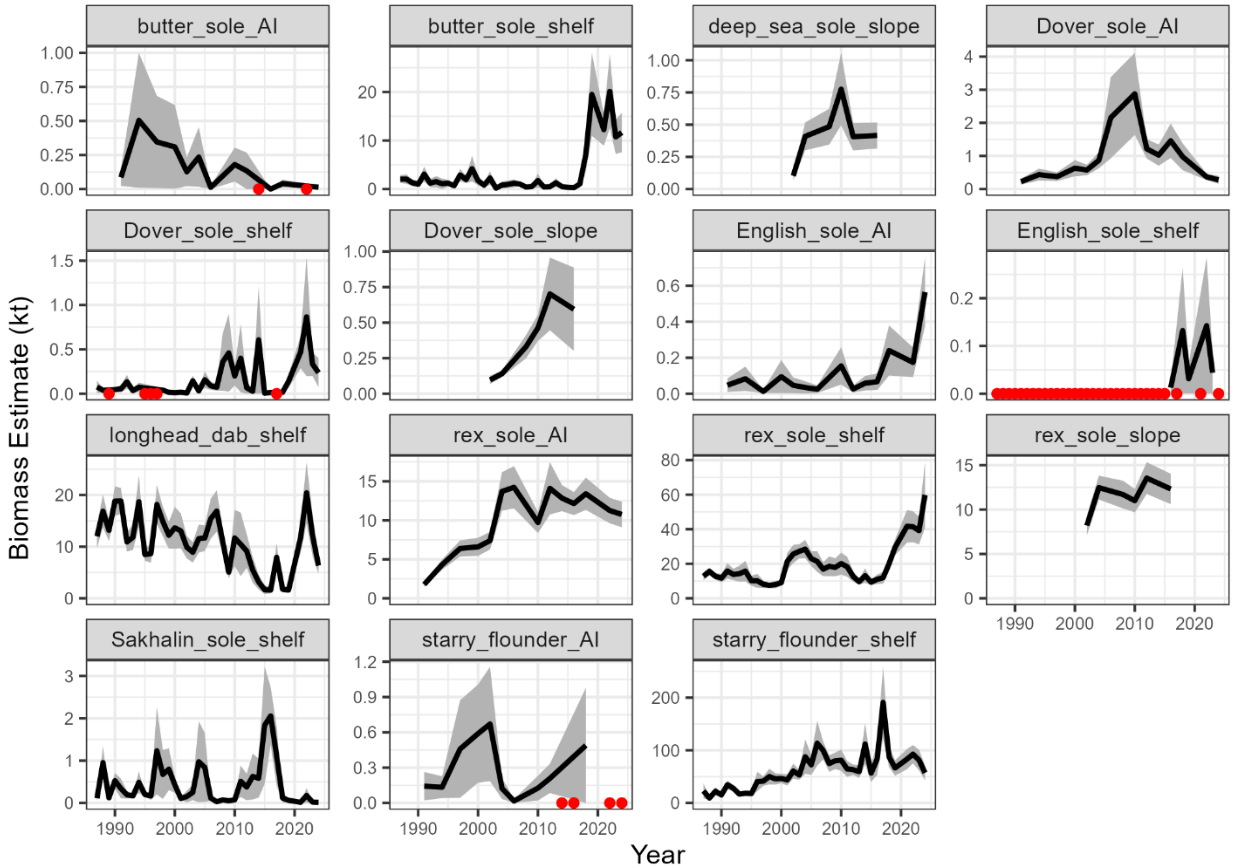


Figure 11.6. Survey estimates of biomass for each species and survey combination. The thin line is the mean and the shading shows +/- one standard deviation. Negative confidence intervals are truncated to zero, and red points show years with estimates of 0 which are left out of the model