Assessment of the Flathead Sole-Bering flounder Stock in the   
Bering Sea and Aleutian Islands

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# Executive Summary

"Flathead sole" as currently managed by the North Pacific Fishery Management Council (NPFMC) in the

Bering Sea and Aleutian Islands (BSAI) represents a two-species complex consisting of true flathead sole

(*Hippoglossoides elassodon*) and its morphologically-similar congener Bering flounder (*H. robustus*).

In 2012, the BSAI Groundfish Plan Team moved flathead sole to a biennial stock assessment schedule because it has historically been lightly exploited. A full stock assessment report was produced in 2020 (Monnahan and Haehn, 2020, available online at <https://apps-afsc.fisheries.noaa.gov/refm/docs/2020/BSAIflathead.pdf>). This year, a partial assessment is presented. In partial assessment years, an executive summary is presented to recommend harvest levels for the next two years, along with trends in catch and biomass.

Flathead sole is assessed using an age-structured model and Tier 3 determination. The single species projection model is run using parameter values from the accepted 2020 assessment model, together with updated catch information for 2020 and estimated catches for 2021 and 2022-2023, to predict stock status for flathead sole in 2022 and 2023 and make ABC recommendations for those years.

## Summary of Changes in Assessment Inputs

*Changes in input data*: The updated information for this partial assessment includes replacing the estimated 2020 catch with the final catch value from the Alaska Regional Office (<https://www.fisheries.noaa.gov/sites/default/files/akro/car110_goa2020.html>) (9,392 t), and estimating the 2021-2023 catches. The 2021 projected catch was calculated using the current catch as of 10/28/2021 added to the average October 28 – December 31 catches over the previous 5 years (totaling 9,807 t). The 2022 and 2023 projected catches were calculated as the average catch over the years 2016-2020 (11,141 t).

## Summary of Results

The ABC for the BSAI flathead Sole complex is 64,288 t in 2022 and 65,988 t in 2023 and the OFL is 77,967 t in 2022 and 80,034 t in 2023. The new ABC recommendation and OFL values are similar to those developed in 2020 for 2022 (64,119 t and 77,763 t, respectively). The principal reference values are shown in the following table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Quantity** | As estimated or | | As estimated or  *recommended this* year for: | |
| *specified last* year for: | |
| 2021 | 2022 | 2022\* | 2023\* |
|
| *M* (natural mortality rate) | 0.2 | 0.2 | 0.2 | 0.2 |
| Tier | 3a | 3a | 3a | 3a |
| Projected total (3+) biomass (t) | 602,497 | 608,576 | 608,631 | 612,001 |
| Projected Female spawning biomass (t) | 150,433 | 154,906 | 155,379 | 160,748 |
| *B100%* | 203,658 | 203,658 | 203,658 | 203,658 |
| *B40%* | 81,463 | 81,463 | 81,463 | 81,463 |
| *B35%* | 71,280 | 71,280 | 71,280 | 71,280 |
| *FOFL* | 0.46 | 0.46 | 0.46 | 0.46 |
| *maxFABC* | 0.37 | 0.37 | 0.37 | 0.37 |
| *FABC* | 0.37 | 0.37 | 0.37 | 0.37 |
| OFL (t) | 75,863 | 77,763 | 77,967 | 80,034 |
| maxABC (t) | 62,567 | 64,119 | 64,288 | 65,988 |
| ABC (t) | 62,567 | 64,119 | 64,288 | 65,988 |
| **Status** | As determined *last* year for: | | As determined *this* year for: | |
| 2019 | 2020 | 2020 | 2021 |
| Overfishing | no | n/a | no | n/a |
| Overfished | n/a | no | n/a | no |
| Approaching overfished | n/a | no | n/a | no |

\*Projections are based on estimated catches of 9,807 t used in place of maximum permissible ABC for 2021 and 11,141 t used in place of maximum permissible ABC for 2022 and 2023. The final catch for 2021 was estimated by taking the average tons caught between October 28 and December 31 over the previous 5 years (2016-2020) and adding this average amount to the catch-to-date as of October 28, 2021. The 2022 and 2023 catch was estimated as the average of the total catch in each of the last 5 years (2016-2020).

# Literature Cited

Monnahan, C., and Haehn, R. 2020. 9. Assessment of the flathead sole-Bering flounder stock complex in the Bering Sea and Aleutian Islands. In Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Region. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, Alaska 99510.

# Tables

Table 1. Catch (in tons) of flathead sole and Bering flounder combined (*Hippoglossoides* spp.), flathead sole only, and Bering flounder only in the BSAI as of October 28, 2021. Observer data on species-specific extrapolated weight in each haul was summed over hauls within each year and used to calculate the proportion of the total *Hippoglossoides* spp. catch that was flathead sole or Bering flounder. Proportions were multiplied by the total *Hippoglossoides* spp. (flathead sole and Bering flounder combined) catches reported by AKFIN to obtain total catch of flathead sole separately from that of Bering flounder. Bolded years are not used in base model.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **Total *(Hippo. spp)*** | **Flathead sole** | **Bering Flounder** |  | **Year** | **Total *(Hippo. spp)*** | **Flathead sole** | **Bering Flounder** |
| 1964 | 12,315 |  |  |  | 1999 | 18,573 | 18,553 | 20 |
| 1965 | 3,449 |  |  |  | 2000 | 20,441 | 20,408 | 33 |
| 1966 | 5,086 |  |  |  | 2001 | 17,811 | 17,795 | 16 |
| 1967 | 11,218 |  |  |  | 2002 | 15,575 | 15,550 | 25 |
| 1968 | 12,606 |  |  |  | 2003 | 13,785 | 13,767 | 18 |
| 1969 | 9,610 |  |  |  | 2004 | 17,398 | 17,374 | 24 |
| 1970 | 21,050 |  |  |  | 2005 | 16,108 | 16,077 | 31 |
| 1971 | 26,108 |  |  |  | 2006 | 17,981 | 17,975 | 6 |
| 1972 | 10,380 |  |  |  | 2007 | 18,958 | 18,952 | 6 |
| 1973 | 17,715 |  |  |  | 2008 | 24,540 | 24,526 | 14 |
| 1974 | 13,198 |  |  |  | 2009 | 19,558 | 19,530 | 28 |
| 1975 | 5,011 |  |  |  | 2010 | 20,127 | 20,101 | 26 |
| 1976 | 7,565 |  |  |  | 2011 | 13,558 | 13,538 | 20 |
| 1977 | 7,909 |  |  |  | 2012 | 11,368 | 11,362 | 6 |
| 1978 | 13,864 | 13,734 | 130 |  | 2013 | 17,355 | 17,275 | 80 |
| 1979 | 6,042 | 6,042 | 0 |  | 2014 | 16,512 | 16,479 | 33 |
| 1980 | 8,600 | 8,026 | 574 |  | 2015 | 11,308 | 11,274 | 33 |
| 1981 | 10,609 | 10,599 | 10 |  | 2016 | 10,313 | 10,301 | 12 |
| 1982 | 8,417 | 8,397 | 20 |  | 2017 | 9,111 | 9,108 | 3 |
| 1983 | 5,518 | 5,509 | 9 |  | 2018 | 11,007 | 11,001 | 5 |
| 1984 | 4,458 | 4,395 | 63 |  | 2019 | 15,880 | 15,879 | 1 |
| 1985 | 5,636 | 5,626 | 10 |  | 2020 | 9,392 | 9,389 | 3 |
| 1987 | 3,595 | 3,479 | 116 |  | **2021**\* | 9,609 | 9,696 | 2 |
| 1988 | 6,783 | 6,697 | 86 |  | \*2021 catches are current as of October 29, 2021 | | | |
| 1989 | 3,604 | 3,594 | 10 |  |  |  |  |  |
| 1990 | 20,245 | 19,264 | 981 |  |  |  |  |  |
| 1991 | 14,197 | 14,176 | 21 |  |  |  |  |  |
| 1992 | 14,407 | 14,347 | 60 |  |  |  |  |  |
| 1993 | 13,574 | 13,463 | 111 |  |  |  |  |  |
| 1994 | 17,006 | 16,987 | 19 |  |  |  |  |  |
| 1995 | 14,715 | 14,710 | 4 |  |  |  |  |  |
| 1996 | 17,346 | 17,341 | 5 |  |  |  |  |  |
| 1997 | 20,683 | 20,678 | 5 |  |  |  |  |  |
| 1998 | 24,387 | 24,381 | 7 |  |  |  |  |  |

**Table 2.** Survey biomass in tons and coefficient of variation (CV) of *Hippoglossoides* spp. combined (flathead sole and Bering flounder) across the entire BSAI; flathead sole only in the Aleutian Islands, *Hippoglossoides* spp. combined in the Eastern Bering Sea (EBS) shelf survey, flathead sole only in EBS shelf survey, and Bering flounder only in the EBS shelf survey. The base assessment model used a single survey index of "total" *Hippoglossoides spp.* biomass that included the EBS “standard” survey areas and AI survey areas for the years 1982-2018 (Table 2). As in the 2020 assessment, a linear regression is used to estimate a relationship between EBS shelf *Hippoglossoides spp.* survey biomass estimates and AI survey biomass estimates; this relationship is used to estimate AI survey biomass in years when no AI survey occurred (by using the linear equation to find an AI biomass estimate in a particular year based on the EBS biomass estimate for that year). There was no AI survey conducted in 2021 and AI biomass was estimated with the linear equation. The 2021 total BSAI estimate was 671,580 t, an increase over the 2019 estimate of 604,446 t. Slight discrepancies in totals may occur due to rounding. Bolded years are not included in base model.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | ***Hippoglossoides* spp. EBS-AI Combined (used in assessment)** | | **Aleutian Islands** | | ***Hippoglossoides* spp. EBS Only** | | **EBS Flathead Sole Only** | | **EBS Bering Flounder Only** | |
| **Year** | **Biomass** | **CV** | **Biomass** | **CV** | **Biomass** | **CV** | **Biomass** | **CV** | **Biomass** | **CV** |
| 1982 | 195,048 | 0.09 |  |  | 192,037 | 0.09 | 192,037 | 0.09 | 0 |  |
| 1983 | 272,185 | 0.10 | 1,213 | 0.19 | 270,972 | 0.10 | 252,612 | 0.11 | 18,359 | 0.20 |
| 1984 | 290,513 | 0.08 |  |  | 285,849 | 0.08 | 270,794 | 0.09 | 15,054 | 0.21 |
| 1985 | 269,732 | 0.07 |  |  | 265,428 | 0.07 | 252,046 | 0.08 | 13,382 | 0.12 |
| 1986 | 363,208 | 0.09 | 5,245 | 0.16 | 357,963 | 0.09 | 344,002 | 0.09 | 13,962 | 0.17 |
| 1987 | 400,150 | 0.09 |  |  | 393,588 | 0.09 | 379,394 | 0.10 | 14,194 | 0.14 |
| 1988 | 571,393 | 0.08 |  |  | 561,868 | 0.09 | 538,770 | 0.09 | 23,098 | 0.22 |
| 1989 | 529,948 | 0.08 |  |  | 521,140 | 0.08 | 502,310 | 0.09 | 18,830 | 0.20 |
| 1990 | 603,587 | 0.09 |  |  | 593,504 | 0.09 | 574,174 | 0.09 | 19,331 | 0.15 |
| 1991 | 552,949 | 0.08 | 6,939 | 0.20 | 546,010 | 0.08 | 518,380 | 0.08 | 27,630 | 0.22 |
| 1992 | 628,857 | 0.10 |  |  | 618,338 | 0.11 | 603,140 | 0.11 | 15,198 | 0.21 |
| 1993 | 618,057 | 0.07 |  |  | 607,724 | 0.07 | 585,400 | 0.07 | 22,324 | 0.21 |
| 1994 | 700,088 | 0.07 | 9,935 | 0.22 | 690,153 | 0.07 | 664,396 | 0.07 | 25,757 | 0.19 |
| 1995 | 604,520 | 0.09 |  |  | 594,421 | 0.09 | 578,945 | 0.09 | 15,476 | 0.18 |
| 1996 | 626,947 | 0.09 |  |  | 616,460 | 0.09 | 604,427 | 0.09 | 12,034 | 0.20 |
| 1997 | 795,463 | 0.21 | 11,554 | 0.23 | 783,909 | 0.21 | 769,783 | 0.21 | 14,126 | 0.19 |
| 1998 | 695,296 | 0.20 |  |  | 683,627 | 0.20 | 675,766 | 0.21 | 7,861 | 0.21 |
| 1999 | 407,889 | 0.09 |  |  | 401,194 | 0.09 | 387,995 | 0.09 | 13,199 | 0.18 |
| 2000 | 401,723 | 0.09 | 8,906 | 0.23 | 392,817 | 0.09 | 384,592 | 0.09 | 8,225 | 0.19 |
| 2001 | 524,068 | 0.10 |  |  | 515,362 | 0.10 | 503,943 | 0.11 | 11,419 | 0.21 |
| 2002 | 563,230 | 0.17 | 9,898 | 0.24 | 553,333 | 0.18 | 548,401 | 0.18 | 4,932 | 0.19 |
| 2003 | 523,566 | 0.10 |  |  | 514,868 | 0.10 | 509,156 | 0.11 | 5,712 | 0.21 |
| 2004 | 625,587 | 0.08 | 13,298 | 0.14 | 612,289 | 0.09 | 604,186 | 0.09 | 8,103 | 0.31 |
| 2005 | 622,883 | 0.08 |  |  | 612,467 | 0.09 | 605,350 | 0.09 | 7,116 | 0.28 |
| 2006 | 644,948 | 0.09 | 9,665 | 0.17 | 635,283 | 0.09 | 621,390 | 0.09 | 13,893 | 0.31 |
| 2007 | 572,105 | 0.09 |  |  | 562,568 | 0.09 | 552,114 | 0.09 | 10,453 | 0.21 |
| 2008 | 554,706 | 0.14 |  |  | 545,470 | 0.14 | 535,359 | 0.14 | 10,111 | 0.19 |
| 2009 | 425,818 | 0.12 |  |  | 418,812 | 0.12 | 412,163 | 0.12 | 6,649 | 0.17 |
| 2010 | 507,047 | 0.14 | 11,812 | 0.30 | 495,235 | 0.15 | 488,626 | 0.15 | 6,610 | 0.15 |
| 2011 | 593,203 | 0.18 |  |  | 583,300 | 0.18 | 576,498 | 0.19 | 6,802 | 0.15 |
| 2012 | 387,043 | 0.11 | 5,566 | 0.15 | 381,477 | 0.12 | 374,842 | 0.12 | 6,635 | 0.14 |
| 2013 | 499,472 | 0.17 |  |  | 491,191 | 0.17 | 485,486 | 0.17 | 5,705 | 0.14 |
| 2014 | 532,886 | 0.13 | 13,436 | 0.14 | 519,450 | 0.14 | 509,801 | 0.14 | 9,649 | 0.17 |
| 2015 | 399,748 | 0.11 |  |  | 393,194 | 0.11 | 382,173 | 0.12 | 11,021 | 0.17 |
| 2016 | 453,060 | 0.07 | 6,759 | 0.15 | 446,300 | 0.07 | 433,469 | 0.07 | 12,831 | 0.23 |
| 2017 | 549,717 | 0.08 |  |  | 540,567 | 0.08 | 531,291 | 0.08 | 9,275 | 0.22 |
| 2018 | 495,345 | 0.08 | 6,930 | 0.11 | 488,415 | 0.08 | 484,890 | 0.08 | 3,524 | 0.16 |
| 2019 | 604,445 | 0.14 |  |  | 594,348 | 0.14 | 592,257 | 0.14 | 2,092 | 0.32 |
| **2021** | 671,580 | 0.11 |  |  | 660,321 | 0.12 | 658,632 | 0.12 | 1,688 | 0.31 |

**Table 3.** Northern Bering Sea survey biomass (t) and coefficient of variation (CV) for flathead sole, Bering flounder, and the two combined (Hippoglossoides spp.). Data accessed via Oracle database query on 05 October, 2021. These data are not included in the base model and are presented here for reference only.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | ***Hippoglossoides* spp*.*** | | **Flathead sole** | | **Bering Flounder** | |
| **Year** | **Biomass** | **CV** | **Biomass** | **CV** | **Biomass** | **CV** |
| 2010 | 12,355 | 0.17 |  |  | 12,355 | 0.17 |
| 2017 | 19,882 | 0.21 | 79 | 0.65 | 19,803 | 0.21 |
| 2019 | 18,989 | 0.18 | 463 | 0.33 | 18,526 | 0.19 |
| 2021 | 8,522 | 0.21 | 138 | 0.78 | 8,384 | 0.22 |

# Figures

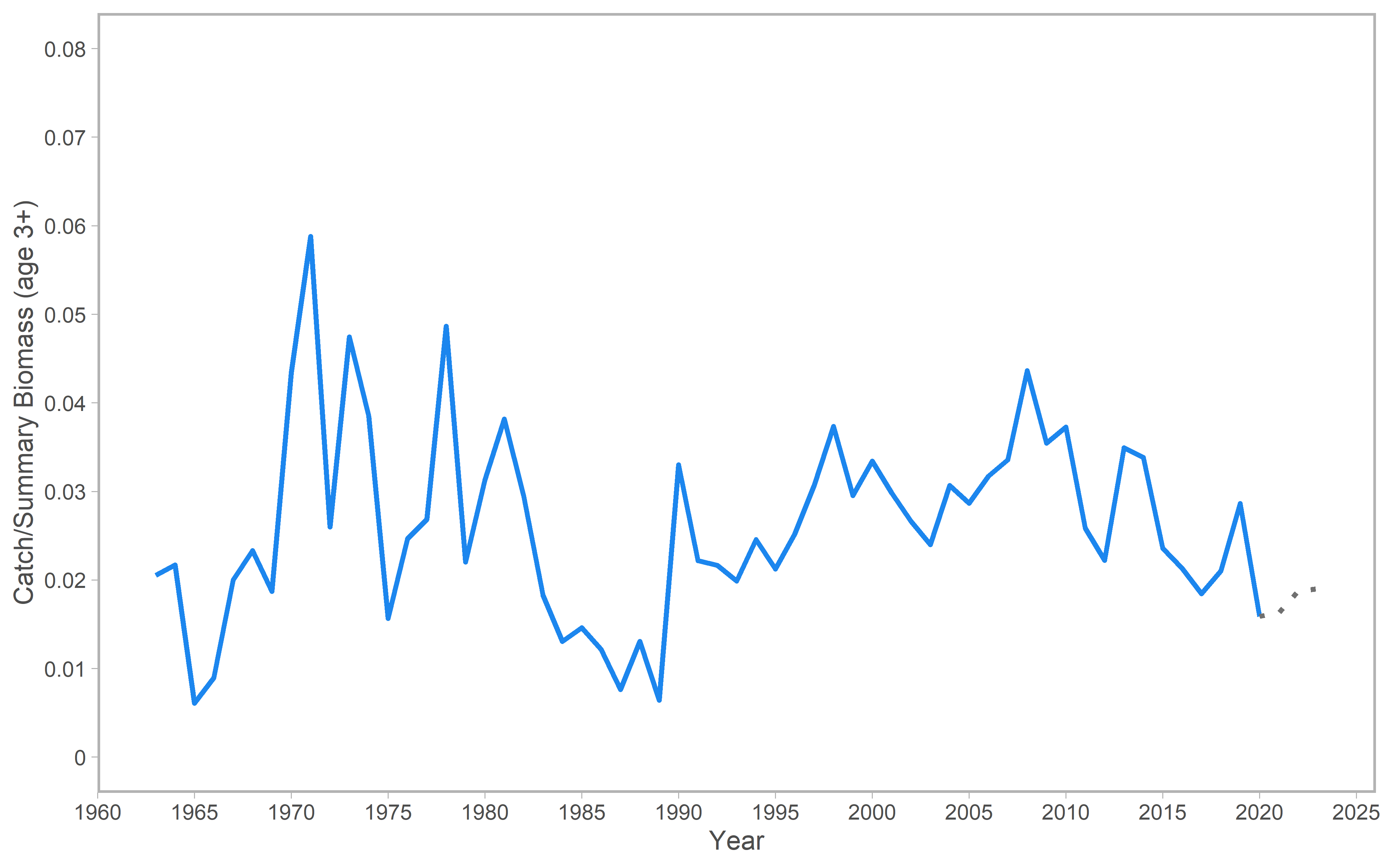
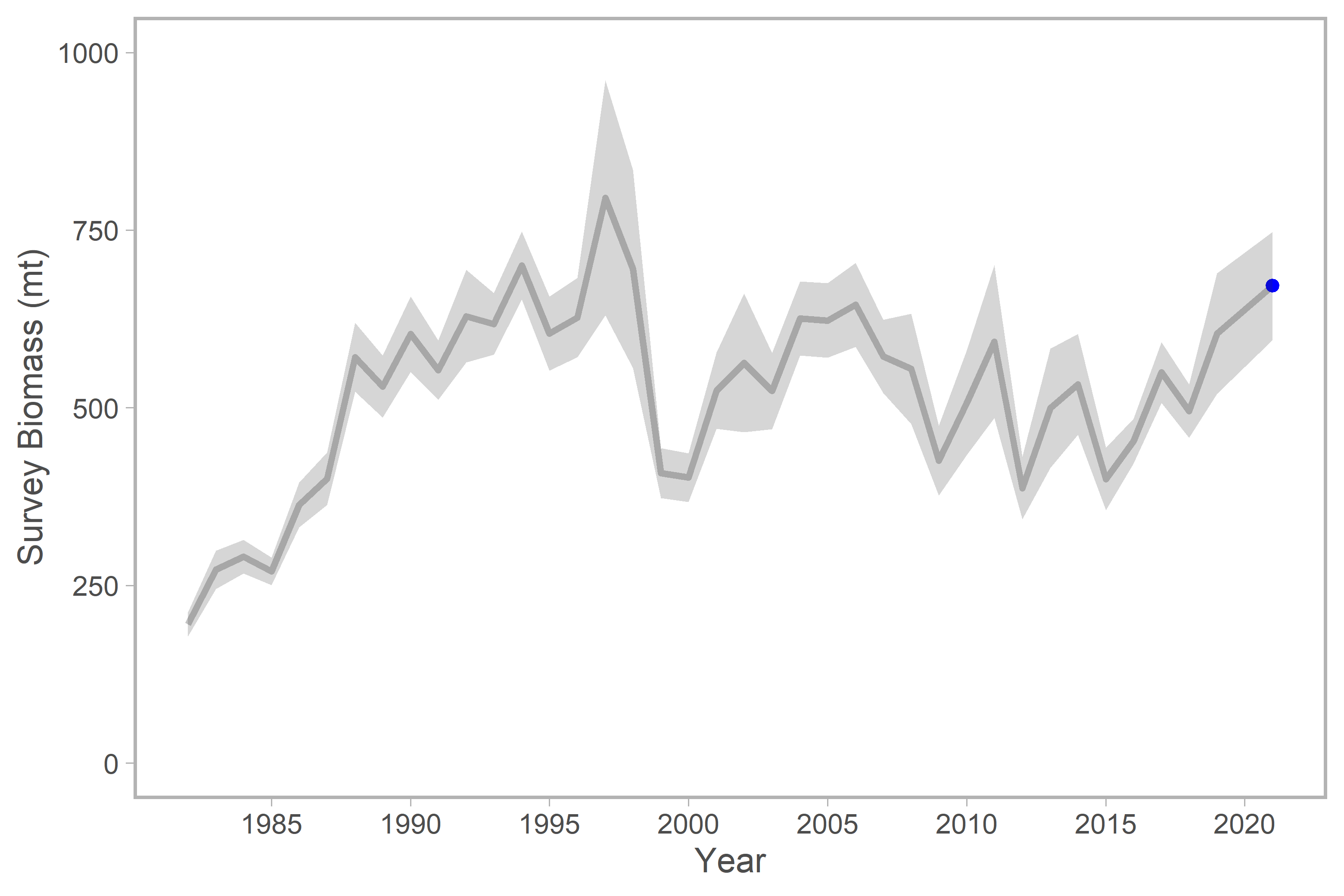


Figure 1. Catch to total biomass ratio using total biomass for age 3+ individuals for flathead sole in the Bering Sea and Aleutian Islands. Dotted grey lines represent observed catches for 2020 and projected catches for 2021-2023.

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**Figure 2.** Survey biomass from the EBS shelf and Aleutian Islands surveys for station depths less than or equal to 200 meters. A linear regression is used to estimate a relationship between EBS shelf *Hippoglossoides spp.* survey biomass estimates and AI survey biomass estimates; this relationship is used to estimate AI survey biomass in years when no AI survey occurred (by using the linear equation to find an AI biomass estimate in a particular year based on the EBS biomass estimate for that year). Grey shading indicates ± 1 standard error. The blue point was the observed survey biomass in 2021, which is not included in the base assessment model.