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 esassodon*) and its morphologically-similar congener Bering flounder (*Hippoglossoides spp.*). 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 most recently produced in 2019 (Monnahan and Haehn, 2019, available online [here](https://apps-afsc.fisheries.noaa.gov/refm/docs/2019/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 2019 assessment model, together with updated catch information for 2019-2021 and estimated catches for 2022 and 2023-2024, to predict stock status for Flathead sole in 2022 and 2023 and make ABC recommendations for those years.

## Summary of Changes in Assessment Inputs

This assessment used a single survey index of “total” Hippoglossoides spp. biomass that included the EBS “standard” survey areas and AI survey areas for the years 1982-2022 (Table 2). As was done in the 2021 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 2022 and AI biomass was estimated with the linear equation. The 2022 total BSAI estimate was 710,804 t, a roughly round((last(surv$obs)-surv$obs[surv$year == 2021])/surv$obs[surv$year == 2021]\*100,0) % increase over the 2021 estimate of 670,091 t.

To run the projection model to predict ABCs for 2023 and 2024, estimates are required for the total catches in 2022-2024 The final catch for 2022 (14,240 t) was estimated by adding the average catch between Oct 1 and December 31 over the years 2017-2021 to the 2022 catch as of Oct 1, 2022. The 2023 and 2024 catches (11,130 t) were estimated as the average catch over the previous 5 years (2017-2021).

To ensure consistency with the most recent full assessment (Monnohan et al., 2020), the projection model was parameterized using mean recruitment and stock spawning biomass for all years included in the assessment model (1964 onwards). Future full assessments for BS/AI Flathead sole can consider updating these inputs in light of the Oct 4, 1999 memorandum by R. Marasco indicating that projections of future stock states should be based on year classes 1977 and forward. Changing the projection inputs will affect the scale of the projected biomass, and result in discontinuities between assessment cycles.

## Summary of Results

Based on the updated projection model results, the recommended ABCs for 2023 and 2024 are listed in the table below; the new ABC recommendation and OFL for both 2023 and 2024 are both slightly higher than those projected during the last full assessment (2021).

\*Projections are based on estimated catches of 11,130t used in place of maximum permissible ABC for 2022 and 11,130 t used in place of maximum permissible ABC for 2023-2024. The final catch for 2022 was estimated by taking the average tons caught between Oct 1 and December 31 over the previous 5 years (2017-2021 and adding this average amount to the catch-to-date as of Oct 1, 2022. The 2023 and 2024 catch was estimated as the average of the total catch in each of the last 5 years.

|  | 2022 | 2023 | 2023 | 2024 |
| --- | --- | --- | --- | --- |
| M | 0.2 | 0.2 | 0.2 | 0.2 |
| Tier | 3a | 3a | 3a | 3a |
| Projected total (3+) biomass (t) | 608,631 | 612,001 | 606,894 | 606,407 |
| Projected Female spawning biomass (t) | 155,379 | 160,748 | 159,151 | 164,769 |
| 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) | 77,967 | 80,034 | 79,338 | 81,243 |
| maxABC (t) | 64,288 | 65,988 | 65,412 | 66,989 |
| ABC (t) | 64,288 | 65,988 | 65,412 | 66,989 |
| Overfishing | no | NA | NA | no |
| Overfished | NA | no | NA | no |
| Approaching Overfished | NA | no | NA | no |

# Tables

#### Catch by Spp.

Table 1. Catch (in tons) of flathead sole and Bering flounder combined Hippoglossoides esassodon and Flathead sole only, and Hippoglossoides spp. only in the BSAI as of Oct 1, 2022 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. 2022 catches are current as of Oct 1, 2022 and do not include projections through the end of the year.

| Year | Total Hippoglossoides spp. | Flathead sole | Bering flounder |
| --- | --- | --- | --- |
| 1992 | 4 | 4 | 0 |
| 1995 | 14,715 | 14,710 | 4 |
| 1996 | 17,346 | 17,341 | 5 |
| 1997 | 20,683 | 20,678 | 5 |
| 1998 | 24,387 | 24,381 | 7 |
| 1999 | 18,573 | 18,553 | 20 |
| 2000 | 20,441 | 20,408 | 33 |
| 2001 | 17,811 | 17,795 | 16 |
| 2002 | 15,575 | 15,550 | 25 |
| 2003 | 13,785 | 13,767 | 18 |
| 2004 | 17,398 | 17,374 | 24 |
| 2005 | 16,108 | 16,077 | 31 |
| 2006 | 17,981 | 17,975 | 6 |
| 2007 | 18,958 | 18,952 | 6 |
| 2008 | 24,540 | 24,526 | 14 |
| 2009 | 19,558 | 19,530 | 28 |
| 2010 | 20,127 | 20,101 | 26 |
| 2011 | 13,557 | 13,536 | 20 |
| 2012 | 11,365 | 11,359 | 6 |
| 2013 | 17,353 | 17,272 | 80 |
| 2014 | 16,511 | 16,478 | 33 |
| 2015 | 11,306 | 11,273 | 33 |
| 2016 | 10,313 | 10,301 | 12 |
| 2017 | 9,111 | 9,107 | 3 |
| 2018 | 11,007 | 11,001 | 5 |
| 2019 | 15,880 | 15,879 | 1 |
| 2020 | 9,392 | 9,389 | 3 |
| 2021 | 10,259 | 10,255 | 4 |
| 2022 | 13,621 | 13,618 | 3 |

#### Survey Biomass and CV (EBS/AI)

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. Slight discrepancies in totals may occur due to rounding. Bolded years are not included in base model.'Data accessed via Oracle database query on Sep 28, 2022.

| Year | Total | CV (Total) | Biomass (AI) | CV (AI) | Biomass (EBS, all) | CV (EBS, all) | Biomass (EBS, flathead) | CV (EBS, flathead) | Biomass (EBS, Bering Flounder) | CV (EBS, Bering Flounder) |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1982 | 194,495 | 0.09 |  |  | 191,343 | 0.09 | 191,343 | 0.09 | 0 |  |
| 1983 | 271,475 | 0.10 | 1213 | 0.19 | 270,262 | 0.10 | 251,978 | 0.11 | 18,283 | 0.2 |
| 1984 | 289,521 | 0.08 |  |  | 284,782 | 0.08 | 269,777 | 0.09 | 15,005 | 0.21 |
| 1985 | 269,266 | 0.07 |  |  | 264,865 | 0.07 | 251,534 | 0.08 | 13,332 | 0.12 |
| 1986 | 362,170 | 0.09 | 5245 | 0.16 | 356,925 | 0.09 | 343,011 | 0.09 | 13,914 | 0.17 |
| 1987 | 399,227 | 0.09 |  |  | 392,657 | 0.09 | 378,525 | 0.10 | 14,132 | 0.14 |
| 1988 | 569,809 | 0.09 |  |  | 560,392 | 0.09 | 537,372 | 0.09 | 23,020 | 0.22 |
| 1989 | 528,394 | 0.08 |  |  | 519,668 | 0.08 | 500,932 | 0.09 | 18,737 | 0.2 |
| 1990 | 601,749 | 0.09 |  |  | 591,798 | 0.09 | 572,543 | 0.09 | 19,256 | 0.15 |
| 1991 | 552,288 | 0.08 | 6939 | 0.2 | 545,349 | 0.08 | 517,825 | 0.08 | 27,524 | 0.22 |
| 1992 | 626,811 | 0.10 |  |  | 616,443 | 0.10 | 601,311 | 0.11 | 15,131 | 0.21 |
| 1993 | 617,258 | 0.07 |  |  | 607,049 | 0.07 | 584,834 | 0.07 | 22,215 | 0.21 |
| 1994 | 699,446 | 0.07 | 9935 | 0.22 | 689,511 | 0.07 | 663,853 | 0.07 | 25,658 | 0.19 |
| 1995 | 603,875 | 0.09 |  |  | 593,889 | 0.09 | 578,457 | 0.09 | 15,432 | 0.18 |
| 1996 | 626,314 | 0.09 |  |  | 615,954 | 0.09 | 603,979 | 0.09 | 11,975 | 0.2 |
| 1997 | 794,426 | 0.21 | 11554 | 0.23 | 782,871 | 0.21 | 768,815 | 0.21 | 14,056 | 0.19 |
| 1998 | 693,723 | 0.20 |  |  | 682,237 | 0.20 | 674,412 | 0.20 | 7,825 | 0.21 |
| 1999 | 407,164 | 0.09 |  |  | 400,462 | 0.09 | 387,311 | 0.09 | 13,151 | 0.18 |
| 2000 | 401,106 | 0.09 | 8906 | 0.23 | 392,199 | 0.09 | 384,011 | 0.09 | 8,188 | 0.19 |
| 2001 | 522,844 | 0.10 |  |  | 514,211 | 0.10 | 502,853 | 0.11 | 11,358 | 0.21 |
| 2002 | 562,073 | 0.17 | 9898 | 0.24 | 552,175 | 0.18 | 547,271 | 0.18 | 4,904 | 0.19 |
| 2003 | 522,935 | 0.10 |  |  | 514,300 | 0.10 | 508,617 | 0.11 | 5,684 | 0.21 |
| 2004 | 624,805 | 0.08 | 13298 | 0.14 | 611,507 | 0.09 | 603,449 | 0.09 | 8,058 | 0.31 |
| 2005 | 622,249 | 0.08 |  |  | 611,956 | 0.09 | 604,878 | 0.09 | 7,078 | 0.28 |
| 2006 | 643,731 | 0.09 | 9664 | 0.17 | 634,067 | 0.09 | 620,215 | 0.09 | 13,852 | 0.31 |
| 2007 | 571,280 | 0.09 |  |  | 561,838 | 0.09 | 551,415 | 0.09 | 10,423 | 0.21 |
| 2008 | 553,591 | 0.14 |  |  | 544,445 | 0.14 | 534,364 | 0.14 | 10,080 | 0.19 |
| 2009 | 425,216 | 0.12 |  |  | 418,213 | 0.12 | 411,584 | 0.12 | 6,629 | 0.17 |
| 2010 | 506,197 | 0.14 | 11812 | 0.3 | 494,386 | 0.15 | 487,798 | 0.15 | 6,588 | 0.15 |
| 2011 | 593,351 | 0.18 |  |  | 583,540 | 0.18 | 576,761 | 0.19 | 6,779 | 0.15 |
| 2012 | 386,892 | 0.11 | 5566 | 0.15 | 381,326 | 0.12 | 374,716 | 0.12 | 6,610 | 0.14 |
| 2013 | 498,784 | 0.17 |  |  | 490,553 | 0.17 | 484,866 | 0.17 | 5,687 | 0.14 |
| 2014 | 532,889 | 0.13 | 13436 | 0.14 | 519,453 | 0.14 | 509,842 | 0.14 | 9,611 | 0.17 |
| 2015 | 399,247 | 0.11 |  |  | 392,677 | 0.11 | 381,696 | 0.12 | 10,981 | 0.17 |
| 2016 | 452,785 | 0.07 | 6759 | 0.15 | 446,026 | 0.07 | 433,243 | 0.07 | 12,783 | 0.23 |
| 2017 | 549,293 | 0.08 |  |  | 540,218 | 0.08 | 530,982 | 0.08 | 9,236 | 0.22 |
| 2018 | 494,579 | 0.08 | 6930 | 0.11 | 487,649 | 0.08 | 484,144 | 0.08 | 3,505 | 0.16 |
| 2019 | 604,109 | 0.14 |  |  | 594,119 | 0.14 | 592,039 | 0.14 | 2,080 | 0.32 |
| 2021 | 670,091 | 0.11 |  |  | 659,000 | 0.11 | 657,321 | 0.12 | 1,679 | 0.31 |
| 2022 | 710,804 | 0.18 | 10897 | 0.19 | 699,906 | 0.18 | 697,296 | 0.18 | 2,610 | 0.27 |

#### Survey biomass and CV (NBS)

Table 3. Northern Bering Sea survey biomass (t) and coefficient of variation (CV) for flathead sole, Bering flounder, and the two combined (Hippoglossoides spp.). These data are not included in the base model and are presented here for reference only. Data accessed via Oracle database query on Sep 28, 2022.

| Year | Biomass (Total) | CV (Total) | Biomass (NBS, flathead) | CV (NBS, flathead) | Biomass (NBS, Bering Flounder) | CV (NBS, Bering Flounder) |
| --- | --- | --- | --- | --- | --- | --- |
| 2010 | 12,355 | 0.17 | 0 |  | 12,355 | 0.17 |
| 2017 | 19,882 | 0.21 | 79 | 0.65 | 19,804 | 0.21 |
| 2019 | 18,989 | 0.18 | 463 | 0.33 | 18,526 | 0.19 |
| 2021 | 8,523 | 0.21 | 138 | 0.78 | 8,384 | 0.22 |
| 2022 | 6,039 | 0.15 | 129 | 0.6 | 5,910 | 0.15 |

# Figures

#### Catch vs. Total Biomass

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| --- |
| 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 2021 and projected catches for 2022-2024, none of which are included in the base model. |

#### Survey Biomass (EBS/AI)

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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. Grey and blue points include true observations. A linear regression was used to estimate a relationship between EBS shelf Hippoglossoides spp. survey biomass estimates and AI survey biomass estimates in years when no AI survey occurred (grey ‘x’ marks). Grey shading indicates ± 1 standard error. Blue points indicate the observed survey biomass in 2021 and 2022, and are not included in the base assessment model. |