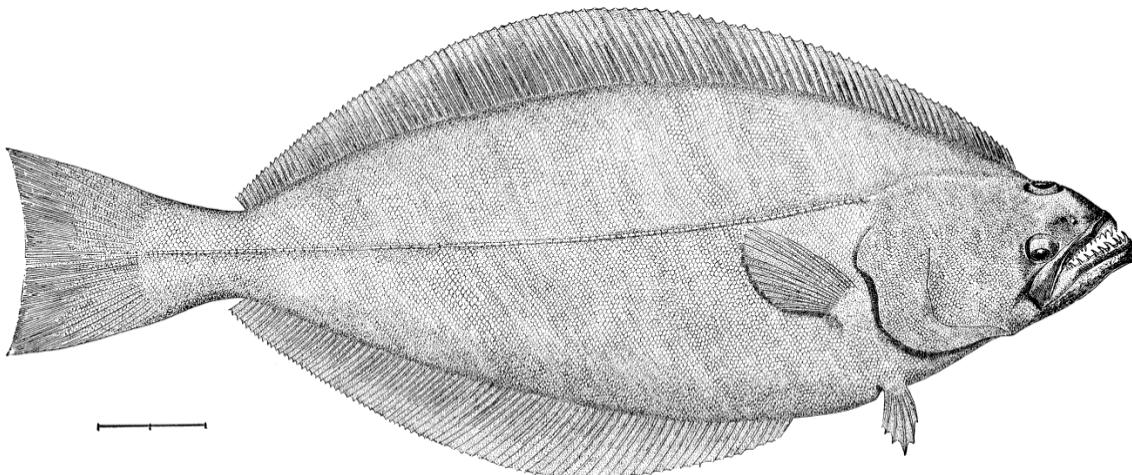


5. Assessment of the Greenland turbot stock in the Bering Sea and Aleutian Islands



THE GREENLAND TURBOT.

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Executive Summary

Bering Sea and Aleutian Islands (BSAI) Greenland turbot is assessed biennially according to the stock assessment prioritization schedule. During odd years, an executive summary is presented with recommendations of harvest levels for the next two years for this species. Information regarding the 2020 stock assessment model and results is available online (Bryan et. al, 2020; <https://www.fisheries.noaa.gov/resource/data/2020-assessment-greenland-turbot-stock-bering-sea-and-aleutian-islands>). A full stock assessment document with updated assessment and projection model results will be presented in November, 2022.

A statistical catch-at-age model configured in Stock Synthesis 3 (Methot and Wetzel, 2013) is used as the primary assessment tool for BSAI Greenland turbot, which qualifies as a Tier 3 stock. The assessment model is not run during an off-cycle year, but the projection model is updated with new catch information. This incorporates the most current catch information without re-estimating model parameters and biological reference points.

Summary of changes in the assessment inputs

Changes in the input data: Changes were not made to the assessment model inputs since this was an off-cycle year. New data added to the projection model included a final 2020 catch estimate from the NMFS Alaska Regional Office Catch Accounting System and a preliminary catch estimate for 2021. The 2020 catch input was reduced to 2,326 t from 3,321 t. The 2021 catch input of 3,309 t was calculated as the product of the 2021 total allowable catch (TAC, 6,025 t) and the average proportion of the TAC caught between 2016 and 2020 (54.925%). This follows the procedure used in previous assessments. In previous assessments, the maximum ABC was used as the catch input in the years following the current year. For

the purposes of this assessment, the 2021 catch estimate was also used as the catch input for 2022. This was done in response to the SSC request to use a catch value that is more representative of the current fishery, which has caught 35% of the ABC, on average, over the past 5 years.

Changes in the assessment methodology: Changes were not made to the assessment model.

Summary of results

The recommended maximum ABC for 2022 from the updated projection model is 6,572 t. This is 10.3% lower than the 2021 ABC and 7.1% higher than the 2022 ABC projected from last year's assessment. The corresponding reference values for BSAI Greenland turbot are summarized in the table below. Status is determined by comparing from the most recent complete year (2020) of official catch to the OFL and comparing the projected spawning biomass relative to $B_{35\%}$. The official Greenland turbot, total catch for 2020 (2,326 t) is less than the 2020 OFL (11,319 t) indicating overfishing is not occurring. Spawning biomass is projected to be above $B_{35\%}$ for 2021-2023; hence, the stock is not overfished and it is not approaching an overfished condition.

Quantity	As estimated or <i>specified last year for:</i>		As estimated or <i>recommended this year* for:</i>	
	2021	2022	2022	2023
M (natural mortality rate)	0.112	0.112	0.112	0.112
Tier	3a	3a	3a	3a
Projected total (age 1+)	87,849	79,382	84,341	80,404
Female spawning biomass	51,914	47,197	50,361	47,376
Projected				
$B_{100\%}$	89,054	89,054	89,054	89,054
$B_{40\%}$	35,622	35,622	35,622	35,622
$B_{35\%}$	31,169	31,169	31,169	31,169
F_{OFL}	0.22	0.22	0.22	0.22
$maxF_{ABC}$	0.18	0.18	0.18	0.18
F_{ABC}	0.18	0.18	0.18	0.18
OFL (t)	8,568	7,181	7,687	6,698
maxABC (t)	7,326	6,139	6,572	5,724
ABC (t)	7,326	6,139	6,572	5,724
Status	As determined <i>last year for:</i>		As determined <i>this year for:</i>	
	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 the final catch of 2,326 t in 2020 and estimated catch of 3,309 t in 2021 - 2023. The catch value for 2021-2023 was derived as the product of the 5-year average (2016-2020) proportion of captured TAC and the 2021 TAC.

Region specific ABCs are specified for this species. Apportionment is derived from the biomass estimates from the eastern Bering Sea slope bottom trawl survey and the Aleutian Islands bottom trawl survey. More specifically, biomass estimates from the last four years of overlap were used and the apportionment is as follows: 84.3% for the eastern Bering Sea and 15.7% for the Aleutian Islands. The slope survey has not been conducted since 2016; hence, this ratio has remained unchanged since. The region specific ABCs are in the following table:

Region	2022 ABC (t)	2023 ABC (t)
Bering Sea	5,540	4,825
Aleutian Islands	1,032	899

The catch-biomass ratio has ranged from 0.25 and 0.01 between 1962 and 1992, which corresponds to a period of relatively high catch (Table 5.1 and Figure 5.1). The average ratio during this time was 0.08. The catch-biomass ratio ranged from 0.03 and 0.06 (average = 0.037) between 1993 and 2012, and ~ 0.02 after 2012 (Table 5.1 and Figure 5.1).

The EBS shelf trawl survey and the AFSC's longline survey were conducted in 2021. Biomass on the EBS shelf continues to decline (Figure 5.2). The 2021 biomass estimate of 10,714 t from the EBS trawl survey represents a 33.3% decline from the 2019 biomass estimate of 16,053 t. The relative population numbers from the AFSC longline survey have been at a relatively stable low since 2005 (Figure 5.3). The 2021 RPN value increased by 19% (Figure 5.3). Numbers increased from 17,712 in 2020 to 21,078 in 2021. The EBS shelf trawl survey population numbers have been declining since 2010-2011. The numbers are at their lowest in 2021 (2,754,324 fish) and represents a 46% reduction since 2019 (Figure 5.3). Biomass and number estimates from the EBS slope have not been updated since 2016, the last year the survey was conducted.

Responses to SSC and Plan Team comments on assessments in general

Responses to SSC and Plan Team comments specific to this assessment

First, we recommend a more realistic alternative than the maximum ABC be used for two-year harvest projections, as only roughly one third of the ABC was caught in 2019.

This was addressed in this year's assessment. The estimated catch for 2021 was used as the catch value for 2002 and 2023 in the projection model rather than the estimated maximum ABC.

The SSC emphasizes the importance of the EBS slope survey for Greenland turbot as a key source of trends in adult biomass for this stock, while also recognizing that the SSC recommended that the EBS slope survey have a lower prioritization than other major AFSC surveys if funding is limited. The SSC suggests that it might be useful for the author to explore the use of VAST for the EBS slope and longline surveys, given the recent cancellations and relative paucity of trawl surveys of the slope.

The author will address this during the next full assessment in 2022.

With regard to maturity, recent information (Cooper et al. 2007) suggests that the maturity at size may be larger than estimated from a previous study in the early 1980s, though this recent study had limited samples at smaller sizes. The SSC suggests that pooling the data from these two studies might provide a more defensible approach than the approximation of the D'yakov 1982 results presented in the assessment.

The samples from Cooper et al. (2007) are not available for re-analysis. Future sample collection has been proposed by Todd ten Brink (REFM Age and Growth Program) to aid in better estimation of size and age at maturity.

The SSC appreciates the authors tracking SSC and BSAI GPT recommendations from 2018 and looks forward to the authors addressing them in the next full assessment in 2022, as is practicable. Included in these recommendations were a number of recommendations regarding selectivity. As suggested by both

the BSAI GPT and the SSC in 2018, a rationale for the numerous time blocks used for the time-varying selectivity curves is needed and exploration of consistency of time blocks across surveys should be explored. In addition, the SSC noted the relatively large changes in selectivity among the time blocks for the trawl fishery in particular. These changes are suggestive of dramatic changes in the fishery or in the distribution of the species and the SSC recommends an exploration of whether such changes are reasonable and can be explained. If large shifts are occurring in the fishery, the timing of these shifts may inform what time blocks are appropriate.

The author will address this during the next full assessment in 2022.

There were also several data components that were included in the assessment but did not contribute to the likelihood estimation, and justification should be provided for these decisions in the assessment document. These include the AFSC longline survey length compositions and the shelf survey age compositions.

The author will address this during the next full assessment in 2022.

References

- Bryan, M.D., S.J. Barbeaux, J. Ianelli, S. Zador, and J. Hoff. 2020. Assessment of the Greenland turbot (*Reinhardtius hippoglossoides*) in the Bering Sea and Aleutian Islands. In Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands region as projected for 2019. Section 5. North Pacific Fishery Management Council, Anchorage, AK.
- Methot, R. D. and C.R. Wetzel. 2013 Stock synthesis: a biological and statistical framework for fish stock assessment and fishery management. *Fisheries Research.* 142:86-99.

Tables

Table 5.1. Catch in tons, total biomass in tons, and the corresponding catch-biomass ratios. Catch was obtained from the NMFS AKRO Catch Accounting System. Total biomass is from the 2020 assessment model (1960-2020) and the projection model for 2021. Catch in 2021 is the estimate extrapolated to the end of the year.

Year	Catch (t)	Total Biomass (t)	Catch/biomass
1960	27,632	231,961	0.12
1961	43,011	212,676	0.20
1962	43,670	175,915	0.25
1963	23,679	137,717	0.17
1964	25,675	122,276	0.21
1965	7,535	112,214	0.07
1966	9,829	138,766	0.07
1967	18,197	194,185	0.09
1968	26,584	273,976	0.10
1969	27,193	366,079	0.07
1970	19,976	463,163	0.04
1971	42,214	562,182	0.08
1972	77,384	624,149	0.12
1973	63,946	627,821	0.10
1974	78,442	622,688	0.13
1975	67,789	585,368	0.12
1976	62,590	548,788	0.11
1977	30,161	517,074	0.06
1978	42,189	526,469	0.08
1979	41,409	532,363	0.08
1980	52,552	542,857	0.10
1981	57,321	539,134	0.11
1982	52,122	521,651	0.10
1983	47,558	497,395	0.10
1984	23,120	466,143	0.05
1985	14,731	450,445	0.03
1986	9,864	436,071	0.02
1987	9,585	421,379	0.02
1988	7,108	403,380	0.02
1989	8,822	385,414	0.02
1990	12,696	363,383	0.03
1991	7,863	336,135	0.02
1992	3,752	314,567	0.01
1993	8,470	297,937	0.03
1994	10,272	276,483	0.04
1995	8,194	252,549	0.03
1996	6,556	231,044	0.03
1997	7,200	211,651	0.03
1998	8,757	192,111	0.05
1999	5,853	171,679	0.03
2000	6,974	155,018	0.04
2001	5,312	138,197	0.04
2002	3,636	124,445	0.03

Table 5.1. Continued.

Year	Catch (t)	Total Biomass (t)	Catch/biomass
2003	3,111	114,172	0.03
2004	2,259	106,020	0.02
2005	2,608	99,905	0.03
2006	1,989	93,979	0.02
2007	2,004	88,990	0.02
2008	2,911	84,192	0.03
2009	4,515	79,178	0.06
2010	4,136	74,547	0.06
2011	3,675	73,546	0.05
2012	4,717	76,034	0.06
2013	1,768	79,219	0.02
2014	1,656	85,934	0.02
2015	2,201	92,031	0.02
2016	2,240	96,170	0.02
2017	2,841	98,487	0.03
2018	1,833	98,362	0.02
2019	2,860	97,392	0.03
2020	2,326	93,970	0.02
2021	3,309	88,813	0.04

Table 5.2. Northern Bering Sea biomass estimates and 95% confidence interval (lower and upper), the number of hauls with positive catch rates (N_{pos}), and the total number of hauls (N_{total}) from the NBS trawl survey.

Year	Biomass	Lower	Upper	N_{pos}	N_{total}
2010	123.78	26.87	220.69	18	141
2017	58.46	0	148.28	3	143
2019	423.58	60.45	786.71	6	144

Figures

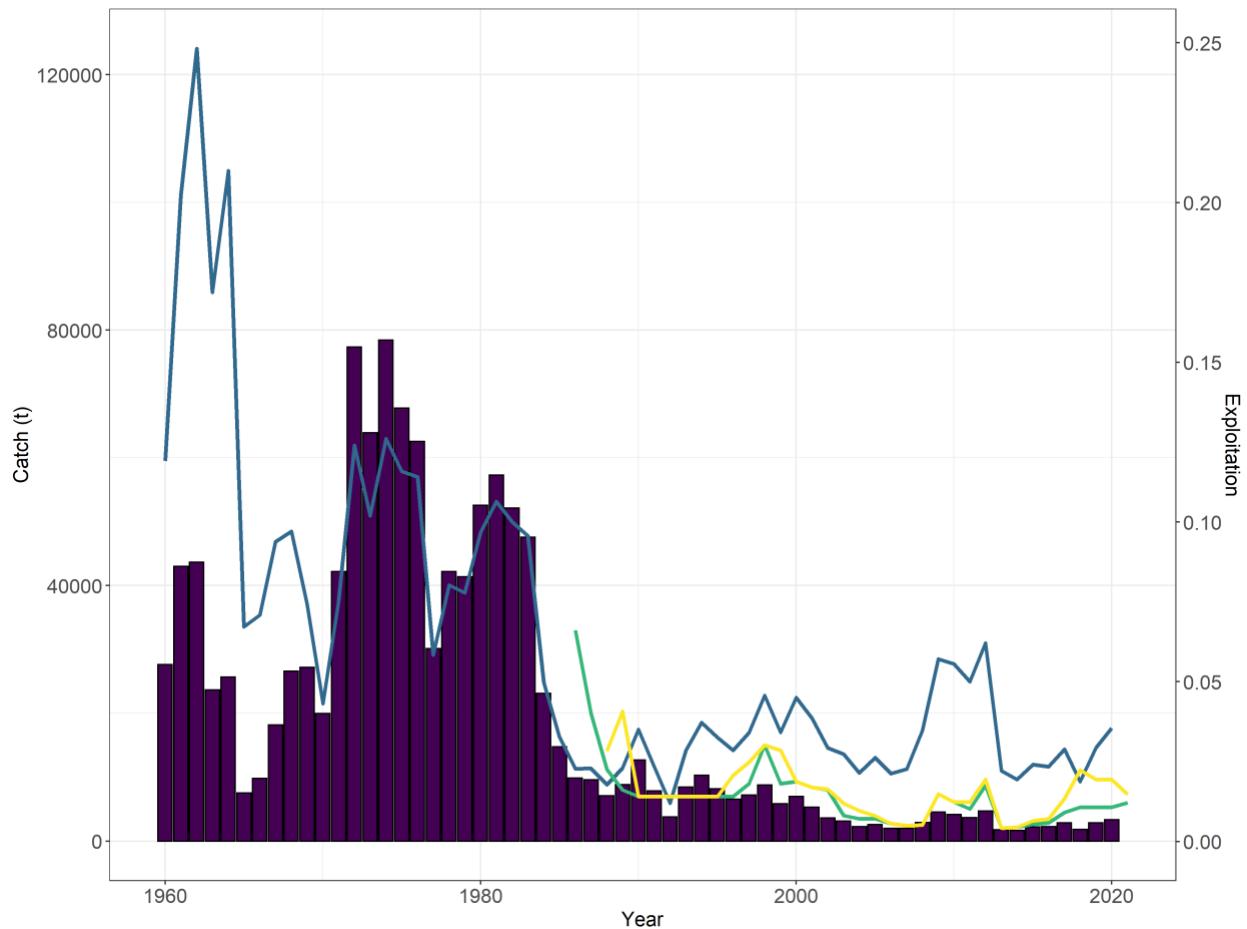


Figure 5.1. Time series of catch in tons (purple bars) and exploitation rate (catch/total biomass, blue line), annual ABC (yellow line, start year = 1988), and annual TAC (green line, start year = 1986).

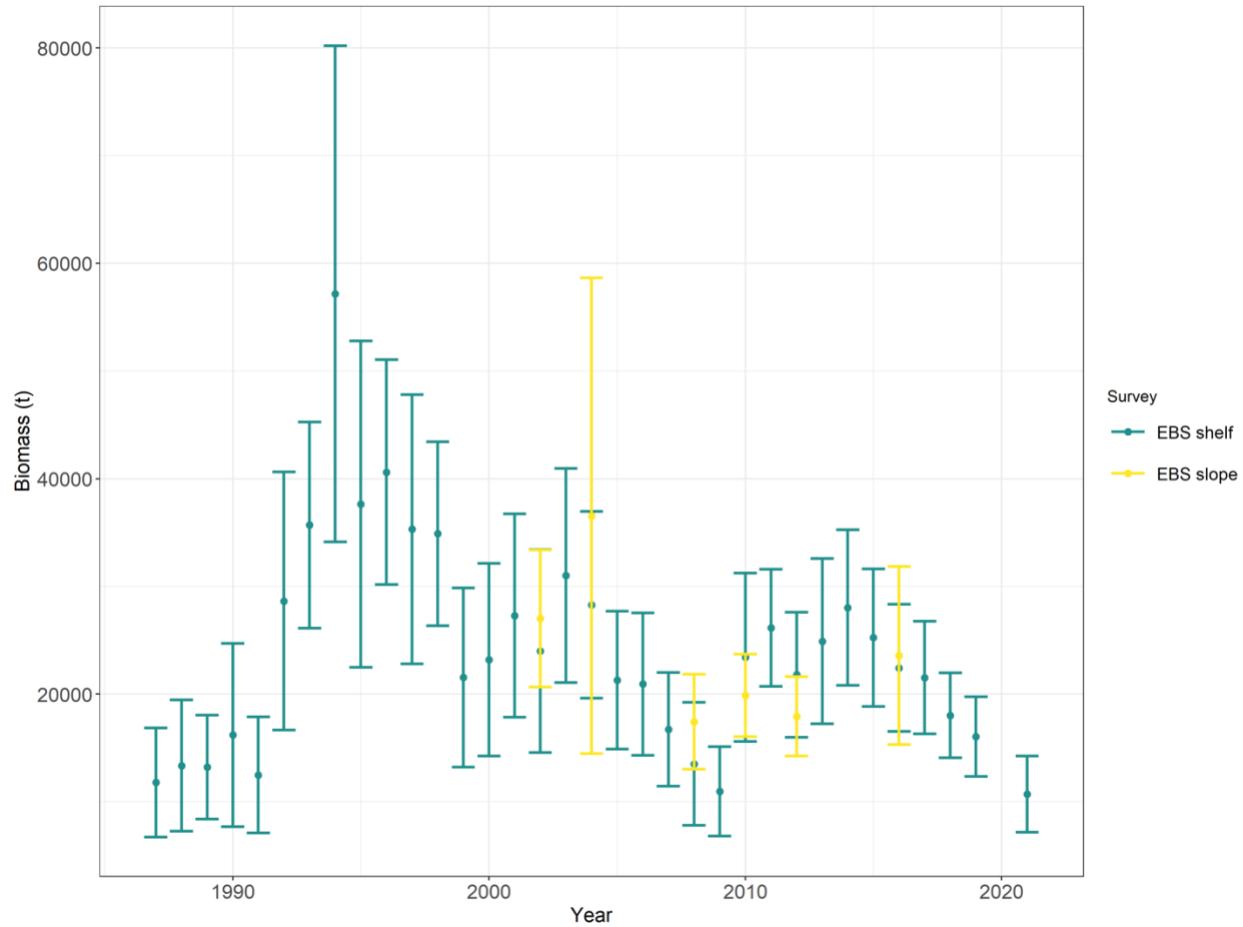


Figure 5.2. Biomass estimates from the Eastern Bering Sea shelf and slope bottom trawl surveys. The shelf survey was not conducted in 2020 due to the pandemic.

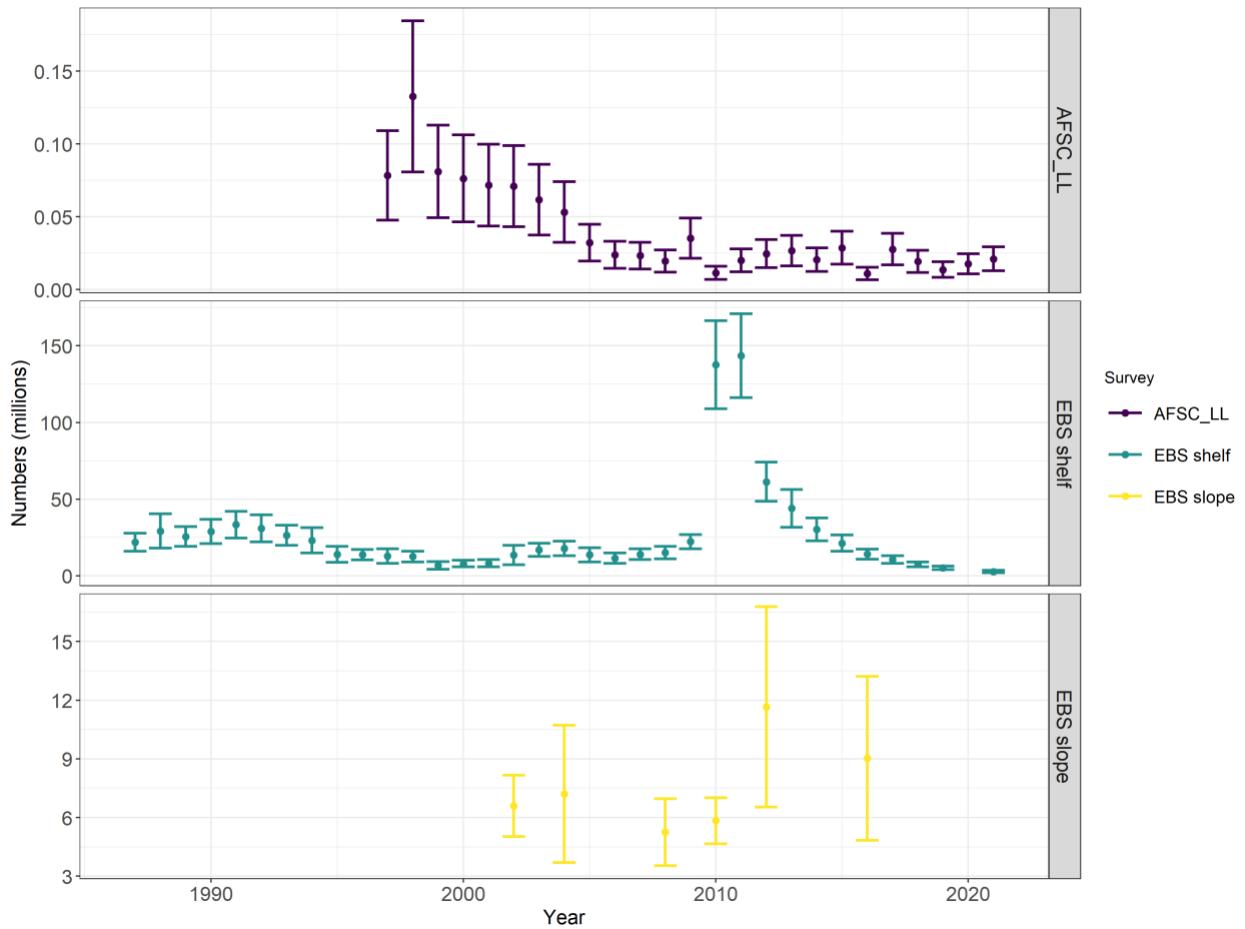


Figure 5.3. Relative population numbers from the AFSC longline survey and the population number estimates from the Eastern Bering Sea shelf and slope bottom trawl surveys. Note the differences in the y-axis scale.