draft working paper for peer review only

Cape Cod-Gulf of Maine yellowtail flounder

2022 Management Track Assessment Report

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National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts

Compiled November 2022

This assessment of the Cape Cod-Gulf of Maine yellowtail flounder (Limanda ferruginea) stock is an operational assessment of the existing 2019 VPA assessment (Alade 2019). The last benchmark for this stock was in 2008 (Legault et al., 2008). Based on the previous assessment the stock was not overfished, and overfishing was not occurring. This 2022 assessment updates commercial fishery catch data, research survey indices of abundance, weights at age, and the analytical VPA assessment model and reference points through 2021. Additionally, stock projections have been updated through 2025.

State of Stock: Based on this updated assessment, Cape Cod-Gulf of Maine yellowtail flounder (*Limanda ferruginea*) stock is not overfished and overfishing is not occurring (Figures 1-2). Retrospective adjustments were made to the model results. Spawning stock biomass (SSB) in 2021 was estimated to be 3,058 (mt) which is 100% of the biomass target (SSB_{MSY} *proxy* = 3,068; Figure 1). The 2021 fully selected fishing mortality was estimated to be 0.1035 which is 32% of the overfishing threshold proxy (F_{MSY} *proxy* = 0.3204; Figure 2).

Table 1: Catch and model results for Cape Cod-Gulf of Maine yellowtail flounder. All weights are in (mt), recruitment is in (000s) and F_{Full} is the average fishing mortality on ages (ages 4 and 5). Model results below are from the current updated VPA assessment **without** any retrospective adjustment.

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Data										
Commercial discards	146	86	54	45	66	50	45	44	35	71
Commercial landings	946	590	421	306	302	314	226	184	156	294
Total Catch for Assessment	1,092	676	475	351	368	365	271	228	192	365
Model Results										
Spawning Stock Biomass	1,039	725	705	964	1,126	1,216	1,299	2,119	3,873	5,987
F_{Full}	1.127	1.209	0.644	0.36	0.272	0.28	0.233	0.155	0.06	0.05
Recruits (age 1)	2,271	3,412	2,923	2,357	3,953	6,517	13,357	20,854	9,269	10,413

Table 2: Comparison of reference points estimated in the previous assessment and from the current assessment update. An $F_{40\%}$ proxy was used for the overfishing threshold and SSB_{MSY} *proxy* was based on long-term stochastic projections.

	2019	2022
F_{MSY} *proxy*	0.3204	0.3201
SSB_{MSY} (mt)	3,439	3,068 (2,108 - 4,751)
MSY (mt)	1,138	1,008 (696 - 1,554)
Median recruits (age 1) (000s)	5,781	6,417
Overfishing	No	No
Overfished	No	No

Projections: Short term projections of biomass were derived by sampling an empirical cumulative distribution function of 35 recruitment estimates from the VPA model results. The most recent two years (2021 and 2022) were not included in the series of recruitment values due to high uncertainty in these estimates. The annual fishery selectivity, maturity ogive, and mean weights at age used in projection are the most recent 5 year averages. Retrospective adjustments were applied in the projections.

Table 3: Short term projections of total fishery catch and spawning stock biomass for Cape Cod-Gulf of Maine yellowtail flounder based on a harvest scenario of fishing at F_{MSY} *proxy* between 2024 and 2025. Catch in 2022 was assumed to be 350 (mt).

Year	Catch (mt)	SSB (mt)	F_{Full}
2022	350	4,334 (3,512 - 5,360)	0.077

Year	Catch (mt)	SSB (mt)	F_{Full}
2023	1,436 (1,129 - 1,784)	4,433 (3,475 - 5,534)	0.320
2024	1,197 (955 - 1,494)	3,666 (2,929 - 4,542)	0.320
2025	1,059 (828 - 1,434)	3,269 (2,546 - 4,469)	0.320

Special Comments:

- What are the most important sources of uncertainty in this stock assessment? Explain, and describe qualitatively how they affect the assessment results (such as estimates of biomass, F, recruitment, and population projections).

  Retrospective patterns remain a source of uncertainty in the assessment. This has persisted for a number of years causing a decrease in estimates of spawning stock biomass (SSB) and and an increase in fishing mortality (F) when more years of data are added. The magnitude of these retrospective biases in this assessment have notably increased for both F and SSB compared to the previous 2019 Management Track assessment. With the exception of the 2020 MENH fall survey index, another potential source of uncertainty is the missing 2020 fall (NEFSC, MADMF) and spring (NEFSC, MADMF and MENH) survey data indices in the model.

  In this assessment, the 2020 survey indices were assigned as missing in the VPA model due to unavailable surveys data in 2020 as a reulst of COVID-19. The treatment of missing data in the VPA model was not based on any form of imputations but rather the model was allowed to generate a survey prediction based on neigboring observed values. However, the model fit to the missing 2020 survey indices does not contribute to the overall objection function in the model.

  The VPA model assumes catch is known without error, which is the case for this assessment and certainly not a valid assumption. The VPA model framework provides very little opportunity to levergae data undertainty into estimates of population quantities produced by the model.

- Does this assessment model have a retrospective pattern? If so, is the pattern minor, or major? (A major retrospective pattern occurs when the adjusted SSB or F_{Full} lies outside of the approximate joint confidence region for SSB and F_{Full}; see Table **??**).

  The 7-year Mohn's ρ, relative to SSB, was 0.30 in the 2019 assessment and was 0.96 in 2021. The 7-year Mohn's ρ, relative to F, was -0.15 in the 2019 assessment and was -0.52 in 2021. There was a major retrospective pattern for this assessment because the ρ adjusted estimates of 2021 SSB (SSB_ρ=3058) and 2021 F (F_ρ=0.1035) were outside the approximate 90% confidence region around SSB (4,976 - 7,428) and F (0.04 - 0.06). A retrospective adjustment was made for both the determination of stock status and for projections of catch in 2023. The retrospective adjustment changed the 2021 SSB from 5,987 to 3,058 and the 2021 F_{Full} from 0.05 to 0.1035.

- Based on this stock assessment, are population projections well determined or uncertain?

  Population projections for Cape Cod-Gulf of Maine yellowtail flounder are uncertain for reasons associated with the retrospective bias in this updated assessment. The 2021 estimates of SSB from this assessment is not within the bound of values projected in the 2019 Management Track assessment. The 2019 estimate of SSB from the current assessment is below the the 2019 rho-adjusted SSB from the 2019 Management Track assessment, indicating the rho-adjustment applied in 2019 assessment was not large enough.

- Describe any changes that were made to the current stock assessment (e.g., catch efficiency studies), beyond incorporating additional years of data and the effect these changes had on the assessment and stock status.

  Minor changes in addition to the incorporation of new data were made to the Cape Cod-Gulf of Maine yellowtail flounder assessment for this update. The NEFSC spring and fall indices were revised from 2009 to 2022 to account for tow-specific area swept. The data source for commercial landings changed to the Catch Accounting and Monitoring System (CAMS) beginning in 2020 and were used to produce commercial landings estimates for 2020 and 2021.

  In the previous 2019 Management track assessment (NEFSC, 2022), The 2019 spring MADMF survey age composition was derived by borrowing from the 2019 spring NEFSC ALK due to unavailable 2019 spring MADMF ages at the time of the assessment. In this assessment, the 2019 spring survey age composition was revised to use the MADMF Age-length keys (ALK), consistent with the previous assessment and the benchmark formulation in 2008 (GARM III). A sensitivity run was conducted to evaluate the impact of this change. The revision to the 2019 spring MADMF survey age composition resulted in little to no effect on the assessment results.

  The incorporation of new data (2019-2021) to the model resulted in rescaling of SSB and F which partially explains the cause of retrospective pattern in the model.

- If the stock status has changed a lot since the previous assessment, explain why this occurred.

  The stock status for Cape Cod-Gulf of Maine yellowtail flounder is now rebuilt due increses in the survey biomass. Based on this assessment, estimated $S\bar{S}B$ *in 2021 is above both the* $SSB_{Threshold}$ *and* SSB_{Target}. *The stock is in a rebuilding plan with a rebuild date of 2023. Based on the the 2022 assessment, the stock is rebuilt and continues to be in the 3-yr projections.*

- Provide qualitative statements describing the condition of the stock that relate to stock status.

  All indices has shown increases in recent years. CCGOM yellowtail stock show no truncation in the age structure. There has been some moderate expansion in the older age groups which is also supported by the surveys. There is an above average estimated 2018 and 2020 incoming year classes which has contributed to the increase in total biomass. Estimates of commercial catch continue are still levels compared to historical catches and consistent with increase in stock biomass.

- Indicate what data or studies are currently lacking and which would be needed most to improve this stock assessment in the future.

  The Cape Cod-Gulf of Maine yellowtail flounder assessment could be improved with a change in model platform that incorporates statistical fits and accounts for measures of uncertainty in the model. Additionally, this assessment could benefit from updated growth and maturity studies. The current maturity and growth parameters are based on GARM III estimates (NEFSC 2008) which are over a decade old. It should be noted that the Cape Cod-Gulf of Maineyellowtail assessment is currently undergoing a Research Track assessment, scheduled for 2024.

- Are there other important issues?

  None.

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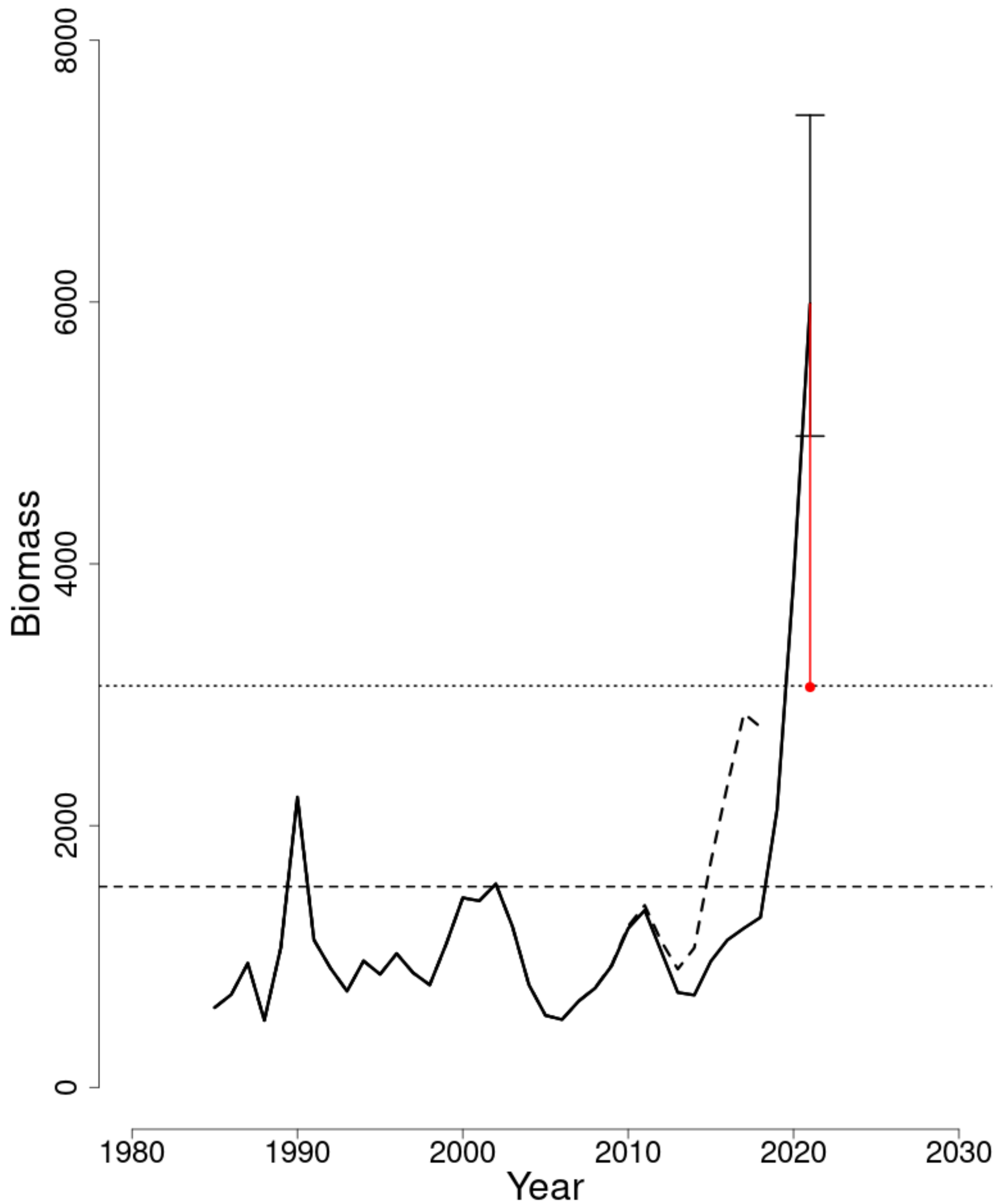

Figure 1: Trends in spawning stock biomass of Cape Cod-Gulf of Maine yellowtail flounder between 1985 and 2021 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ ($\frac{1}{2}$ SSB_{MSY} *proxy*; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} *proxy*; horizontal dotted line) based on the 2022 assessment. Biomass was adjusted for a retrospective pattern and the adjustment is shown in red. The 90% bootstrap probability intervals are shown.

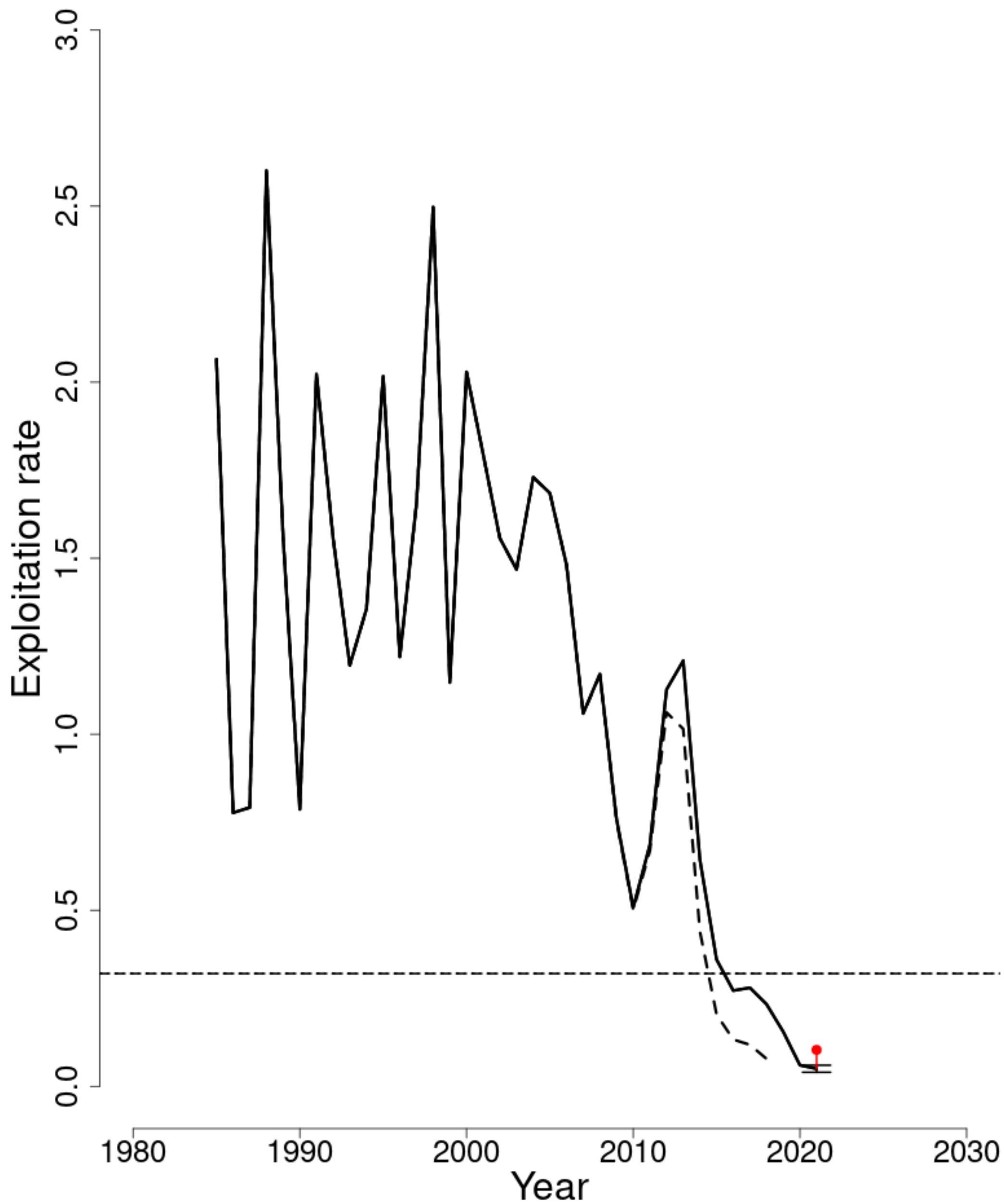

Figure 2: Trends in the fully selected fishing mortality (F_{Full}) of Cape Cod-Gulf of Maine yellowtail flounder between 1985 and 2021 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (F_{MSY} *proxy*=0.3204; horizontal dashed line). F_{Full} was adjusted for a retrospective pattern and the adjustment is shown in red based on the 2022 assessment. The 90% bootstrap probability intervals are shown.

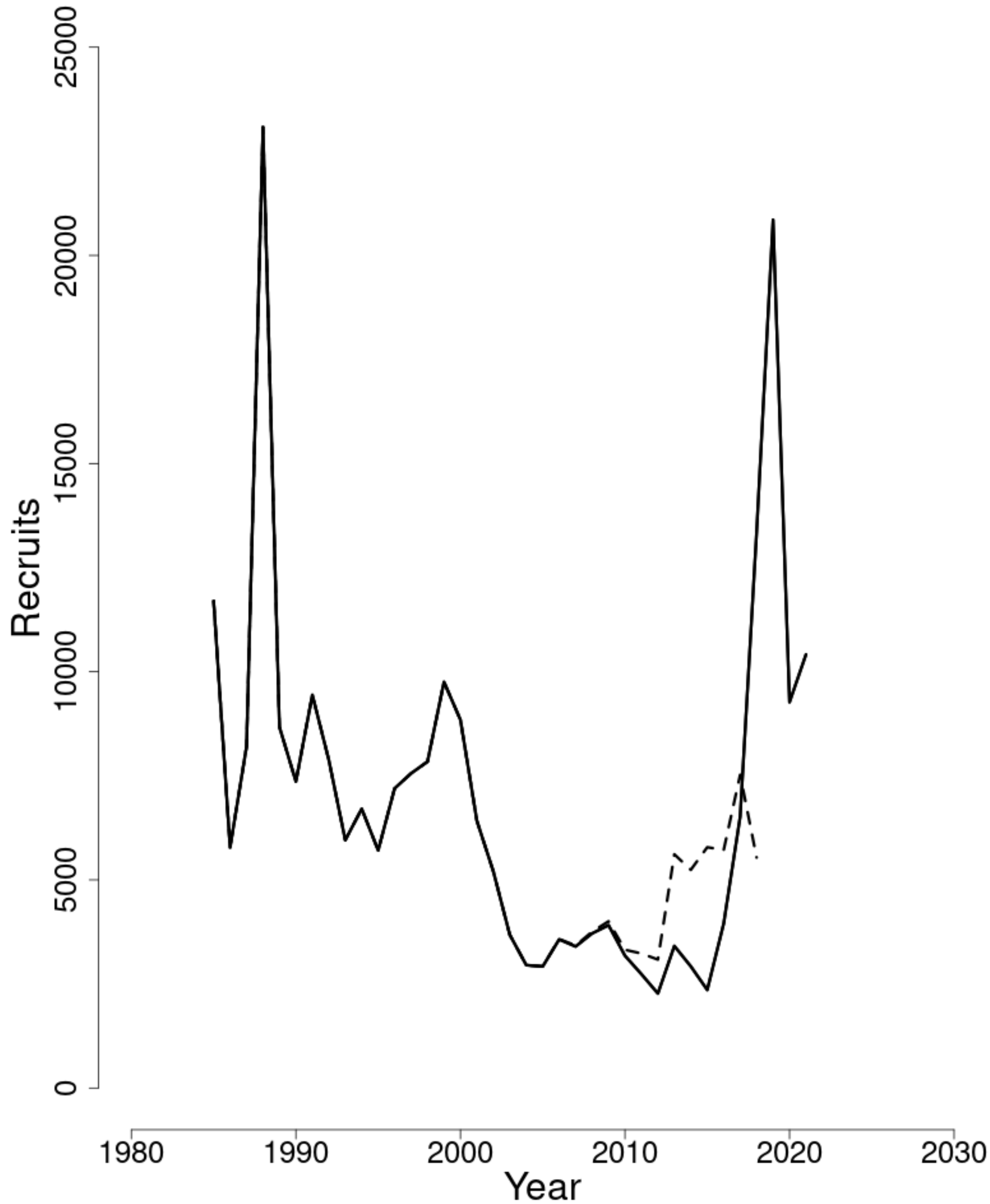

Figure 3: Trends in Recruits (age 1) (000s) of Cape Cod-Gulf of Maine yellowtail flounder between 1985 and 2021 from the current (solid line) and previous (dashed line) assessment. The 90% bootstrap probability intervals are shown.

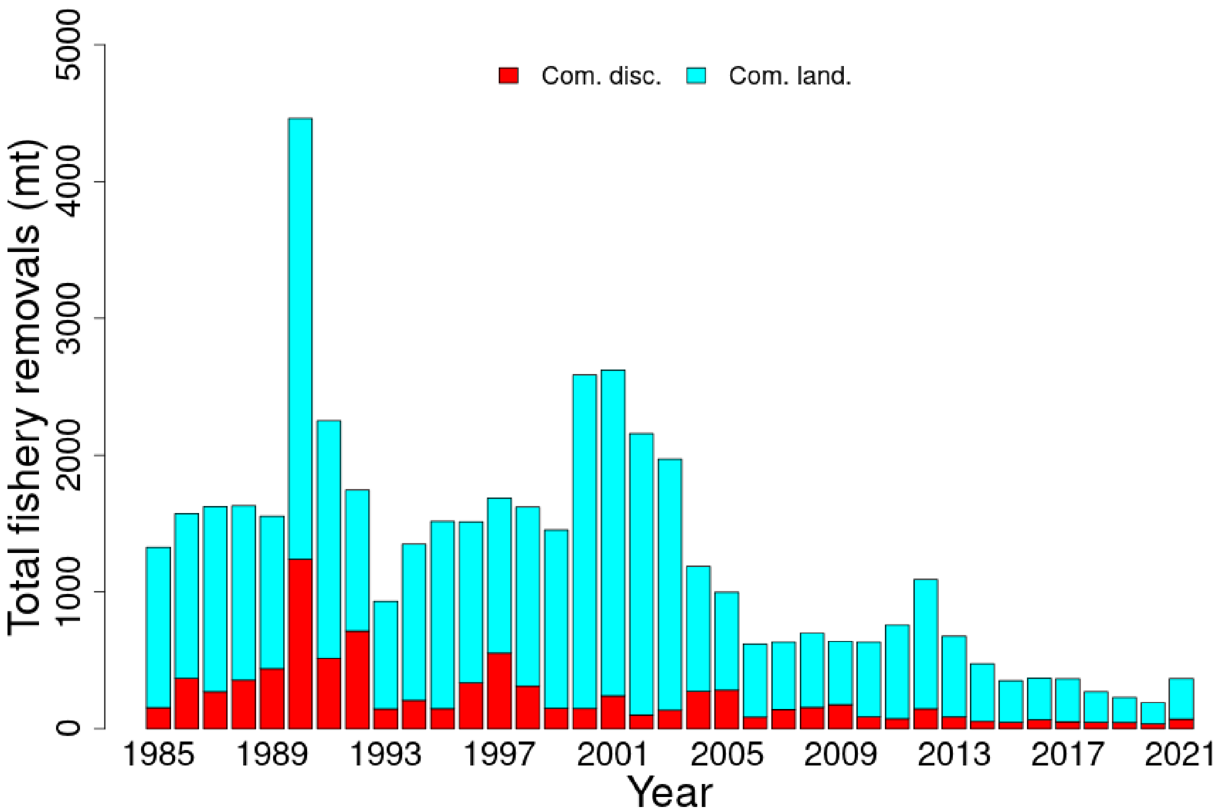

Figure 4: Total catch of Cape Cod-Gulf of Maine yellowtail flounder between 1985 and 2021 by disposition (landings and discards).

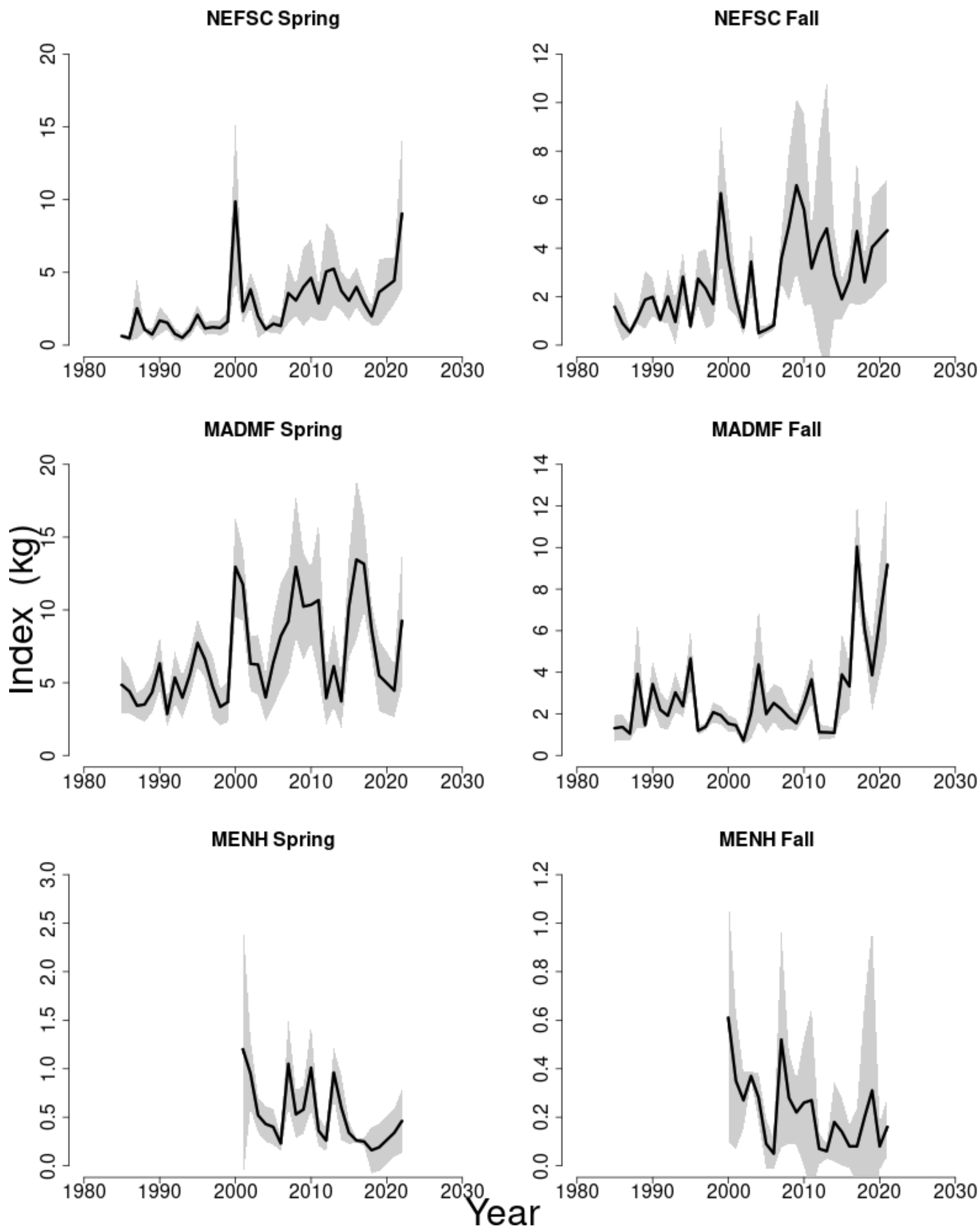

Figure 5: Indices of biomass for the Cape Cod-Gulf of Maine yellowtail flounder between 1985 and 2022 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys, Massachusetts Department of Marine Fisheries (MADMF) inshore state spring and fall bottom trawl surveys,and the Maine New Hampshire inshore state spring and fall state surveys. The 90% bootstrap probability intervals are shown.