draft working paper for peer review only

Atlantic surfclam

2024 Management Track Assessment Report

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

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This assessment of the Atlantic surfclam (Spissula solidissima) stock is a management track assessment of the existing 2020 Stock Synthesis (SS) management track assessment (NEFSC 2022). Based on the previous assessment, the stock was not overfished, and overfishing was not occurring. This assessment updates commercial fishery catch, research survey indices of abundance, commercial length composition, survey length composition and conditional age at length data as well as the analytical SS assessment model and reference points through 2023. Stock projections have been updated through 2030.

State of Stock: Based on this updated assessment, the Atlantic surfclam (*Spissula solidissima*) stock is not overfished and overfishing is not occurring (Figures 1-2). Retrospective adjustments were not made to the model results. Spawning stock biomass (SSB) in 2023 was estimated to be 984 ('000 mt) which is 95% of the biomass target (SSB_{MSY} *proxy* = 1,036; Figure 1). The 2023 fully selected fishing mortality was estimated to be 0.028 which is 18.1% of the overfishing threshold proxy (F_{MSY} *proxy* = 0.153; Figure 2).

Table 1: Catch and status table for Atlantic surfclam. All data weights are in (mt) model results are ratios relative to reference points. Model results are from the current SS assessment.

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
					Data					
Landings South	14,992	15,014	13,502	12,083	12,325	11,739	9,755	11,399	11,708	9,587
Landings North	3,236	4,104	4,837	4,819	3,962	3,244	2,276	1,397	263	1,065
Discards South	2	75	44	22	252	26	3	4	3	8
Discards North	0	20	16	9	81	7	2	3	2	10
Catch for Assessment	18,230	19,213	18,399	16,933	16,620	15,016	12,035	12,803	11,976	10,670
					Model Results					
$\frac{SSB}{SSB_{Threshold}}$	2.42	2.41	2.37	2.31	2.23	2.13	2.04	1.97	1.93	1.9
$\frac{F}{F_{Threshold}}$	0.261	0.272	0.257	0.237	0.237	0.22	0.183	0.205	0.201	0.181
$\frac{R}{R_0}$	0.737	0.501	0.393	0.309	0.817	0.53	0.753	0.831	0.794	0.985

Table 2: Comparison of reference points estimated in an earlier assessment and from the current assessment update. An F_{MSY} proxy was used for the overfishing threshold and was based on a simulation study and scaled to the current assessment. The $SSB_{Threshold}$ is $\frac{1}{2}$ of SSB_{MSY}.

	2020	2024
F_{MSY} *proxy*	0.141	0.153 (0.103 - 0.226)
SSB_{MSY} ('000 mt)	1027	1036 (601 - 1472)
Overfishing	No	No
Overfished	No	No

Projections: Short term projections of biomass were derived by assumming average recruitment in each forecast year. Growth was assumed to be equal to the growth in the final year of each area. Fishery selectivity for each fleet and maturity ogive were constant over time for each area. Three projection scenarios were developed for use in management: status quo, which sets annual catch in each forecast year equal to the average catch over the last five years in each area; quota in which the current quota is caught each year and the proportions taken from each area are equal to the average proportions removed from each area over the last five years, and finally, OFL in which the catch is equal to the OFL applied to the terminal biomass in each area. These projections are available in the document entitled 'ReviewerReportAtlanticSurfclamMT2024.pdf' and found on the SASINF

Table 3: Short term projections of total fishery catch and spawning stock biomass for Atlantic surfclam based on a harvest scenario of fishing at F_{MSY} *proxy* between 2024 and 2030.

Year	Catch (mt)	SSB ('000 mt)	$\frac{F}{F_{Threshold}}$
2024	62033	964	1.02

Year	Catch (mt)	SSB ('000 mt)	$\frac{F}{F_{Threshold}}$
2025	58221	974	1.02
2026	55326	991	1.02
2027	53687	1016	1.02
2028	52960	1043	1.02
2029	52867	1070	1.02
2030	53133	1097	1.02

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).

  Estimates of recruitment remain uncertain as both the survey and commercial gear do not select for younger animals. Uncertainty in recruitment is relatively unimportant in this stock due to species longevity, and relatively low fishing mortality overall.

- 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}).

  Traditional retrospective ananlysis is not an appropriate diagnostic for this stock because removing years of data causes a shift in scale. That is, the entire time series is shifted up or down while the trend is generally preserved. The tendency for scale to shift is why Atlantic surfclam reference points are based on trend rather than absolute scale. A modified version of the retrospective diagnostic in which successive peels are compared to each corresponding estimate of SSB_0 shows no retrospective pattern and can be seen in the document entitled 'ReviewerReportAtlanticSurfclamMT2024.pdf' and found at SASINF.

- Based on this stock assessment, are population projections well determined or uncertain? If this stock is in a rebuilding plan, how do the projections compare to the rebuilding schedule?

  Projections for this stock may be somewhat optimistic due to the possibility that natural mortality on larger animals may be increasing with temperature. Initial attempts to model increasing natural mortality led to implausibly high estimates of m. If the stock continues to decline despite relatively low fishing pressure, time varying m should be explored further.

- Describe any changes that were made to the current stock assessment, beyond incorporating additional years of data and the effect these changes had on the assessment and stock status.

  Minor changes were made to the Atlantic surfclam assessment for this update. The most significant of these was to include additional time variant growth parameters. In the last assessment, size at Lmax, the SS equivalent to the Von Bertalanffy (L_∞), parameter was allowed to vary through time in the south. In this assessment, the k parameter was allowed to vary through time in both regions. Other minor changes involved alterations to parameter priors and bounds to help with model convergence. These are discussed in more detail in the section 'Build a Bridge' in the document entitled 'ReviewerReportAtlanticSurfclamMT2024.pdf' and found at SASINF.

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

  Stock status did not change.

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

  The Atlantic surfclam stock remains lightly fished and at relatively high abundance. The scale of the abundance is similar to the swept area abundance estimates for each area (see the section 'Plan B Assessment' in the document entitled 'ReviewerReportAtlanticSurfclamMT2024.pdf' at SASINF.

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

  While the overall abundance of Atlantic surfclam remains at or above it's target abundance, the clam industry may be concerned about declining catch rates as the remaining dense aggregations of Atlantic surfclam are fished down. If reduced density makes the Atlantic surfclam fishery economically non-viable, the fishery could contract or even collapse without the stock ever being overfished or experiencing overfishing. Some management on smaller spatial scales, with the objective of maintaining dense aggregations, may be waranted, and should probably be investigated. Further investigation of the effects of increased temperature on mortality by size would be useful as a starting point for the stock assessment and could allow for the modeling of direct links to bottom temperature.

- Are there other important issues?

  Atlantic surfclam mature very quickly (<2 years) and are not selected by commercial gear until they are 5 to 7 years old. A traditional F_{MSY} reference point will therefore be nearly infinite. A trend based alternative has been used here, and in the previous assessment, but the methods for deriving it should perhaps be revisited given the presumed changes in growth. Previous assumptions regarding growth under warming conditions (faster growth to a smaller maximum size) may not be correct. The model estimated here shows a reduced Von Bertalanffy k parameter, as well as a reduced average maximum size over time in the southern area. This would be consistent with slower growth to a smaller maximum size. There is new research supporting this hypothesis. Pousse et al (2020, 2022) and Czaja et al. (2023, 2024) have worked on Atlantic surfclam under increased temperature and acidification and their results indicate that growth may have a more complex relationship with environmental conditions than was previously believed. For example, larval growth increases with temperature if enough food is available, but decreases under high temperature and increased acidification. Furthermore, while Atlantic surfclam larvae can grow faster at higher temperature, they persist in the water column for less time, which will affect dispersal. Finally, the current low stock size in the northern area may provide a basis for estimating the steepness parameter of the stock recruitment relationship in Atlantic surfclam, which has not previously been possible due to the lack of any observed low stock abundance condition. A new management strategy evaluation of Atlantic surfclam may be warranted.

References:

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Pousse, E., M. E. Poach, D. H. Redman, G. Sennefelder, L. E. White, J. M. Lindsay, D. Munroe, D. Hart, D. Hennen, M. S. Dixon, et al. (2020). Energetic response of atlantic surfclam spisula solidissima to ocean acidification. Marine Pollution Bulletin 161, 111740.

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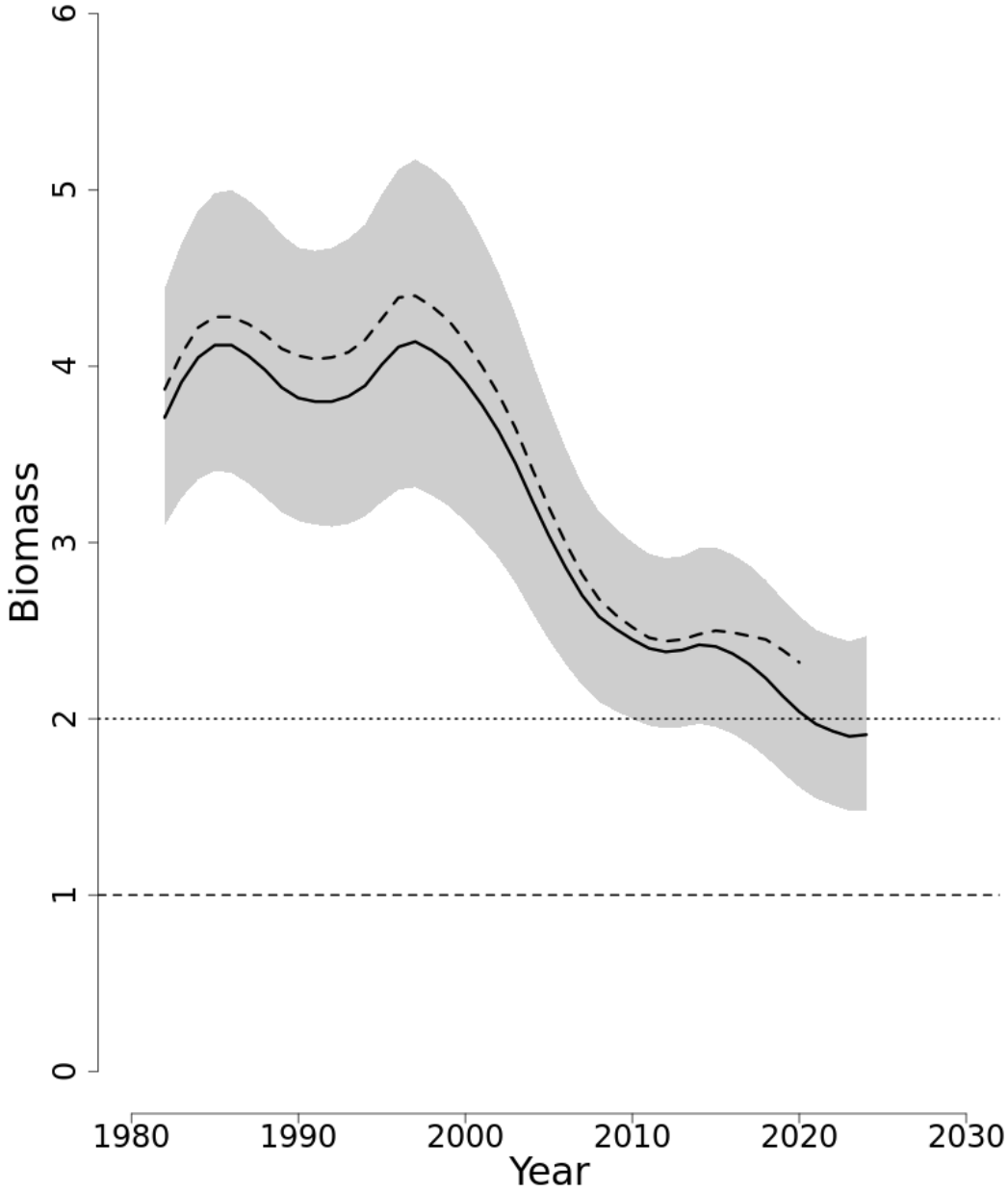

Figure 1: Trends in spawning stock biomass of Atlantic surfclam between 1982 and 2024 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ ($\frac{1}{2}$ SSB_{MSY} *proxy*; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} *proxy*; horizontal dotted line) based on the 2024 assessment. Units of SSB are the ratio of annual biomass to the biomass threshold ($\frac{SSB}{SSB_{Threshold}}$). The approximate 90% lognormal confidence intervals are shown.

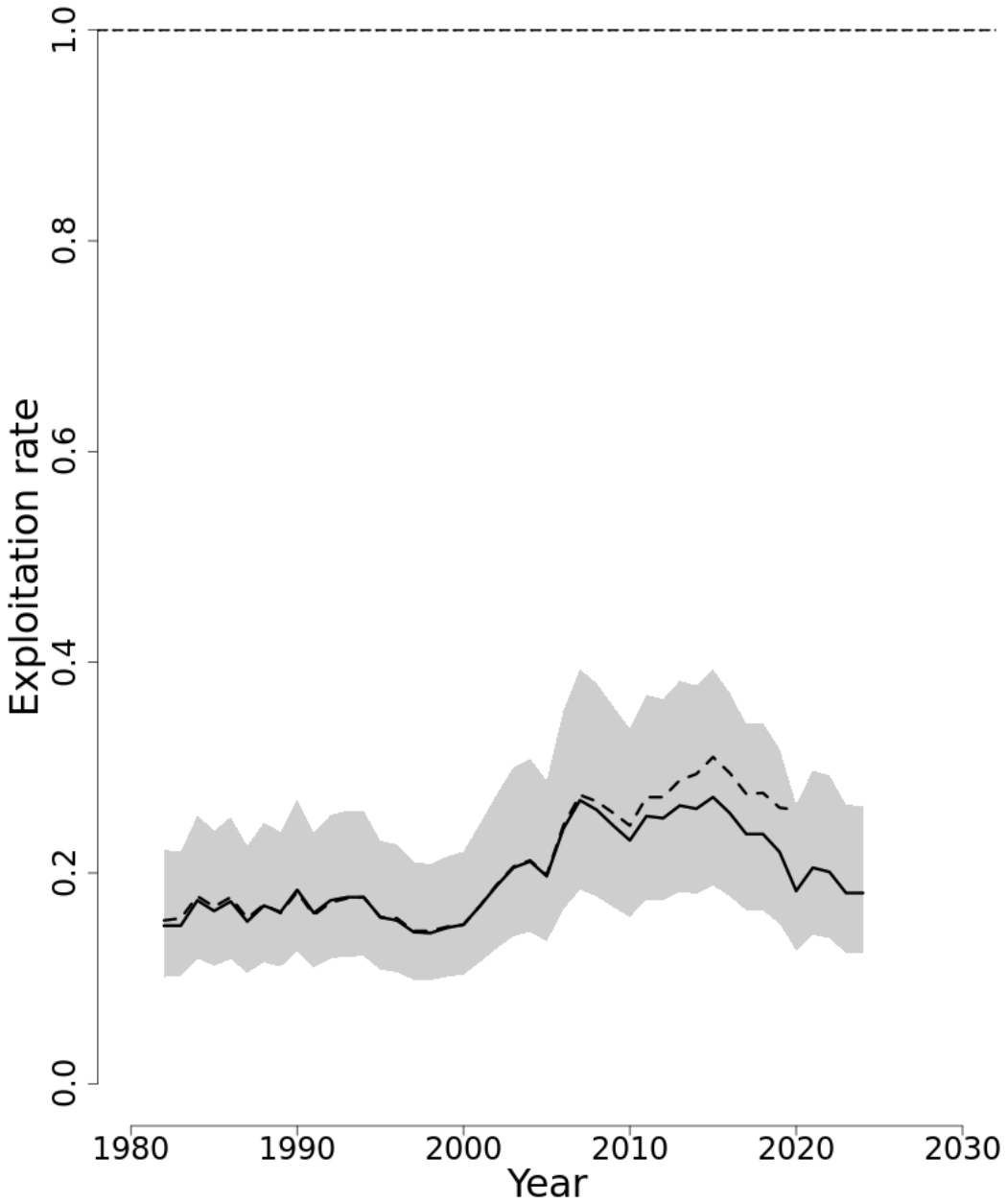

Figure 2: Trends in the fully selected fishing mortality (F_{Full}) of Atlantic surfclam between 1982 and 2024 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (F_{MSY} *proxy*=0.153; horizontal dashed line), based on the 2024 assessment. Units of fishing mortality are the ratio of annual F to the F threshold ($\frac{F}{F_{Threshold}}$). The approximate 90% lognormal confidence intervals are shown.

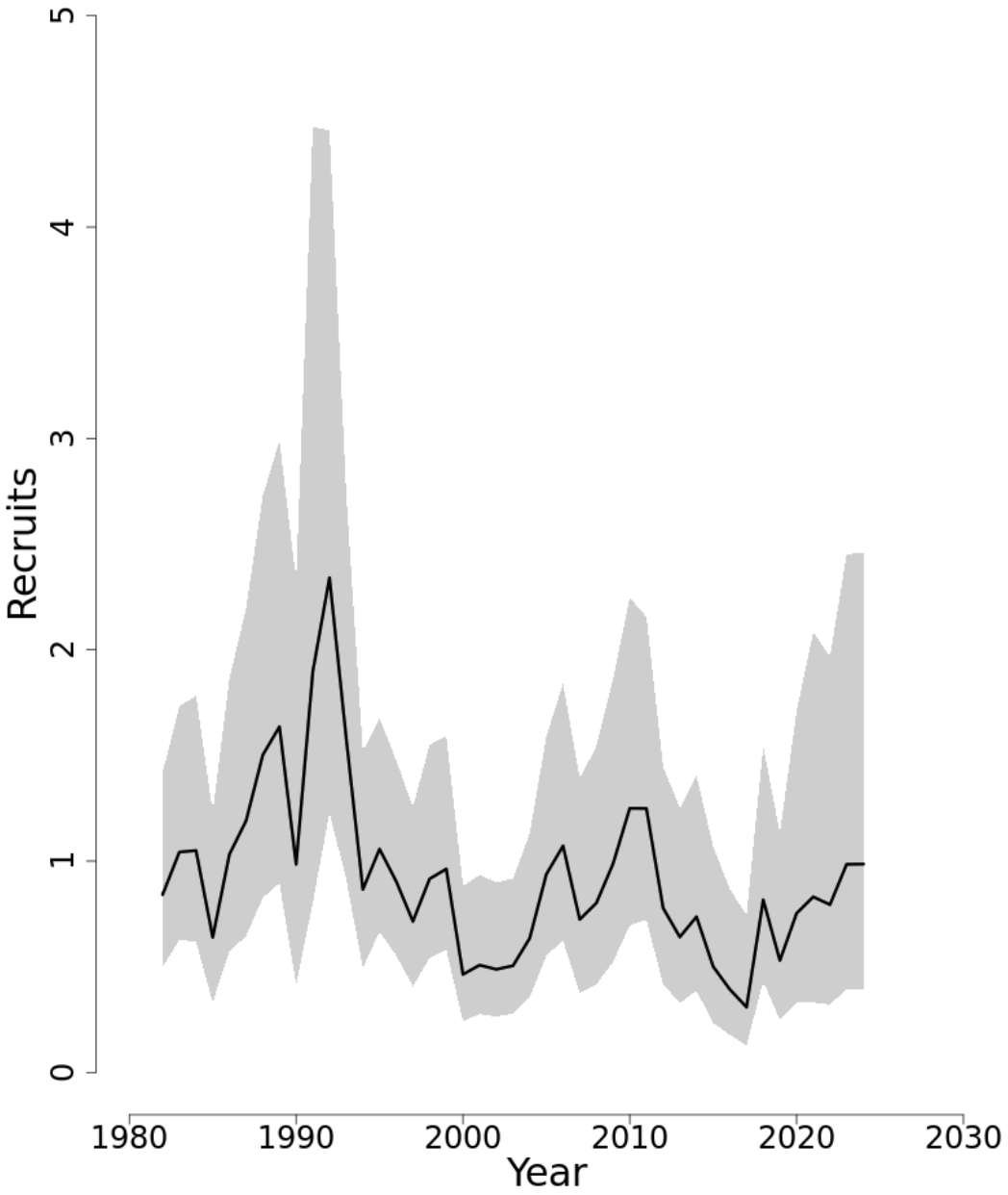

Figure 3: Trends in $\frac{R}{R_0}$ of Atlantic surfclam between 1982 and 2024 from the current (solid line) and previous (dashed line) assessment. Units of recruitment are the ratio of annual R to the unfished R ($\frac{R}{R_0}$). The approximate 90% lognormal confidence intervals are shown.

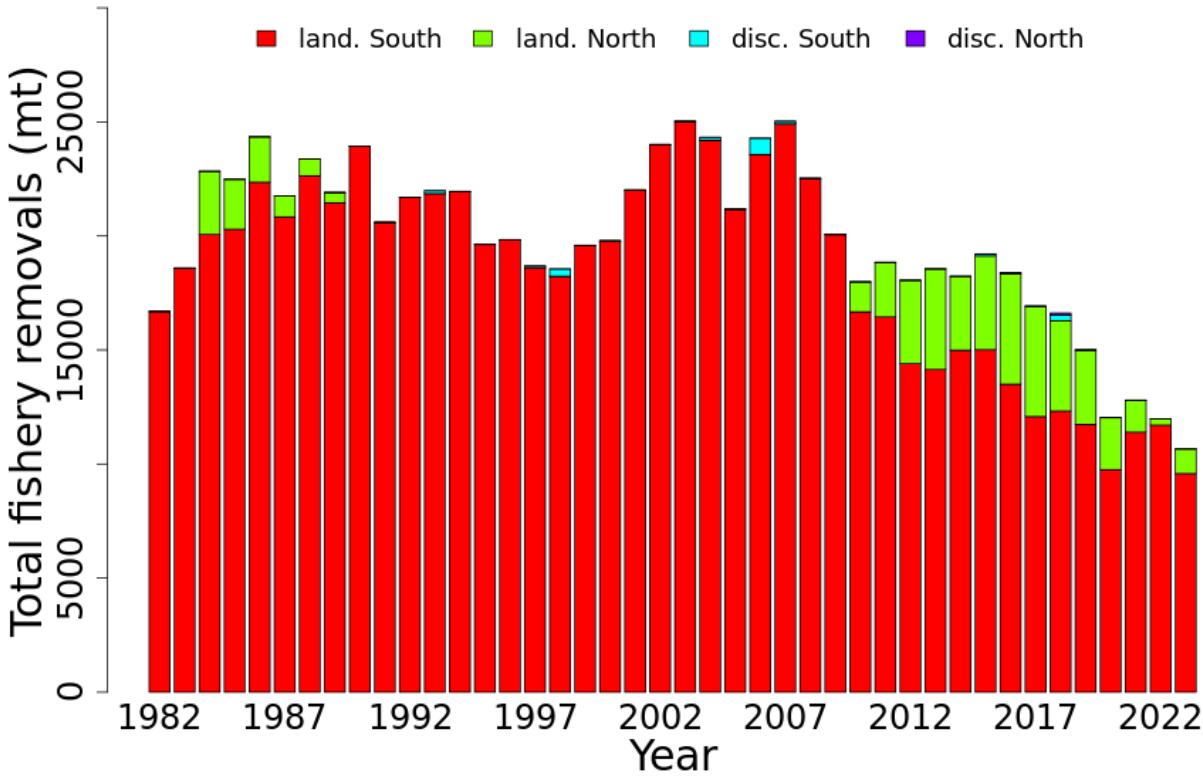

Figure 4: Total catch of Atlantic surfclam between 1982 and 2024 by fleet and disposition (landings and discards).

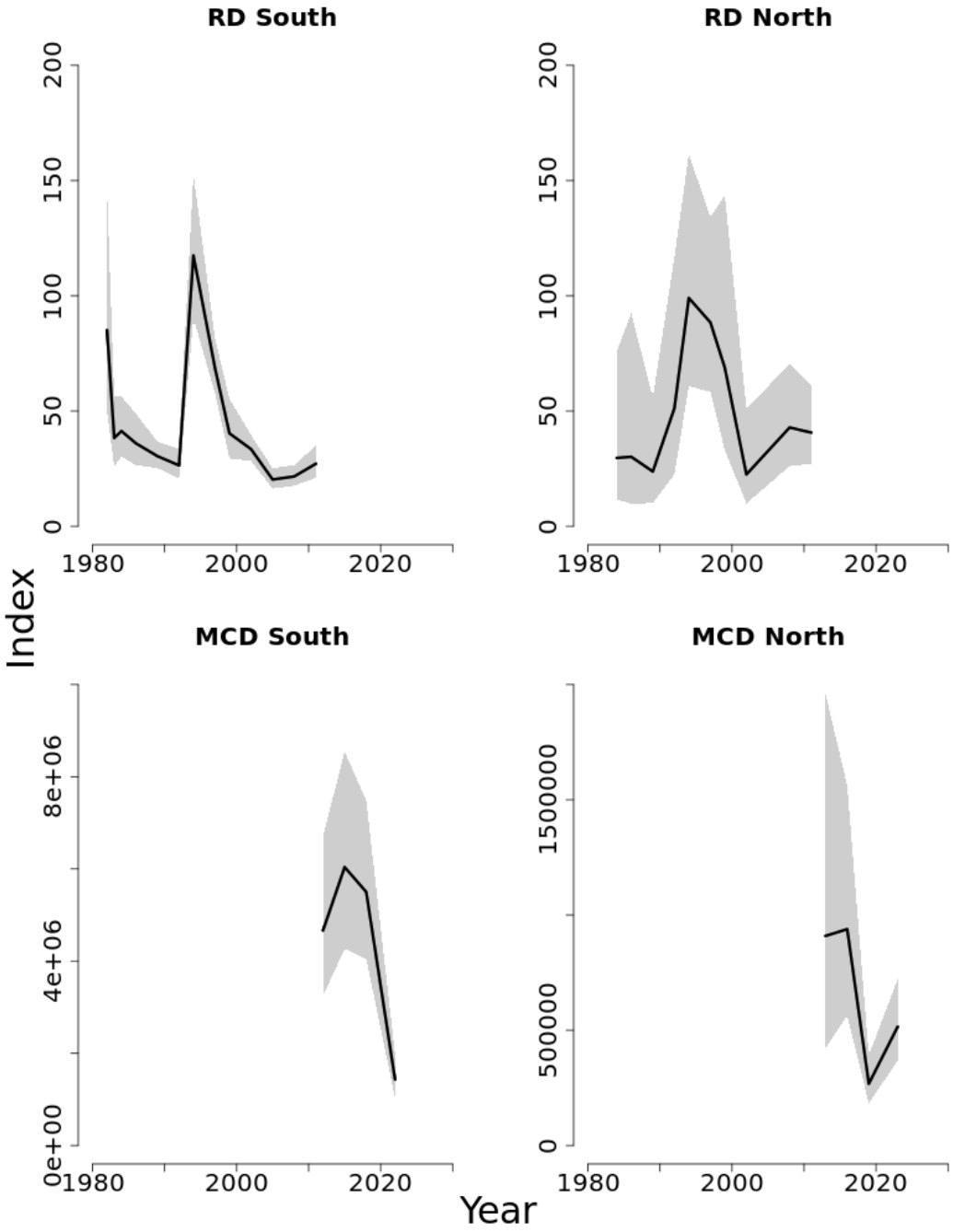

Figure 5: Indices of biomass for the Atlantic surfclam between 1982 and 2023 for the Northeast Fisheries Science Center (NEFSC) clam surveys in the north and south. The RD survey units are weight per tow (kg) and the MCD survey units are swept area numbers (n). The approximate 90% lognormal confidence intervals are shown.