Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat
Quebec Region | Science Response 2024/008

UNIT 1 REDFISH (*SEBASTES MENTELLA* AND *S. FASCIATUS*) UPDATE IN 2023

CONTEXT

The Fisheries Management Branch of Fisheries and Oceans (DFO) has requested an update of stocks status and advice on the range of potential removals for Unit 1 Redfish. This Science Response Report is from the January 24, 2024 regional peer review on Unit 1 Redfish (*Sebastes mentella* and *S. fasciatus*) update in 2023. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available. Participants included DFO Science, DFO Fisheries Management, harvesters, provincial governments, indigenous communities, and nongovernmental organizations from Gulf, Quebec, Maritimes, and the Newfoundland and Labrador Regions.

SCIENCE ADVICE

Status

- According to the limit reference point (LRP) and proposed upper stock reference point (USR), the stock status of *S. mentella* was in the healthy zone of the precautionary approach (PA) in 2023, with a spawning stock biomass (SSB) of 2,302 kilotonnes (kt) (1,741–2,862 kt, 95% CI), corresponding to 8.7 times the USR. The estimated SSB of *S. fasciatus,* was probably situated in the healthy zone of the PA with a SSB of 181 kt (1–361 kt, 95% CI), slightly above the USR. The status of the *S. fasciatus* stock remains uncertain.

Trends

- The geometric means of the estimated biomass in 2022 and 2023 of *S. mentella* and *S. fasciatus* over 22 cm (the minimum legal size of 22 cm was used to estimate potential removals) were 2,152 kt and 150 kt, respectively. A decline has been observed for *S. mentella* over the last four years, and over the last two years for *S. fasciatus*. However, these values still remain among the highest of the time series.

Environmental and Climate Change Considerations

- The waters in the deep layer of the Gulf of St. Lawrence have reached records for high temperature and low levels of dissolved oxygen. Laboratory experiments are currently underway on *S. fasciatus* to explore the potential consequences on Redfish.

Stock Advice

- Potential removals were determined based on estimates of natural mortality rate and the biomass of fish over 22 cm. A realistic range (between the 25th and 75th percentiles) varied between 88 kt and 318 kt, with a median value of 276 kt for *S. mentella* for the 2024–2025

fishing season. *S. mentella* will very likely remain in the healthy zone in 2024 given this range of removals.

- Given the uncertainty over the status of the *S. fasciatus* stock and the assumptions underlying the proposed method, a range of potential removals could not be determined with certainty.
- Fishing at depths greater than 300 m would target the *S. mentella* over 22 cm.
- Given the low levels of recruitment and growth observed in recent years, even in the absence of fishing, Redfish biomass is expected to decrease in upcoming years due to natural mortality.

BASIS FOR ASSESSMENT

Assessment Details

The last full assessment was in 2022.

Year Assessment Approach was Approved

DFO 2022, Senay et al. 2023

Assessment Type

Full Assessment

Most Recent Assessment Date

Last Full Assessment: 2022, DFO 2022, Senay et al. 2023

Assessment Approach

1. Broad category: Index-based (trends in empirical indices only)
2. Specific category: Index-based (including fishery-dependent and fishery-independent indices)

Stock Structure Assumption

Stock overview information:

Genomic analyses of samples collected from 2001 to 2015 confirmed a pronounced genetic distinction between *S. mentella* and *S. fasciatus*, despite their morphological similarity (Benestan et al. 2021, Senay et al. 2023). A single genetic group of *S. mentella* was identified in Units 1 and 2. Three genetic groups of *S. fasciatus* were identified in Units 1 and 2.

Reference Points

- Limit Reference Point (LRP): empirically estimated as the smallest SSB from which there has been a recovery (Brec), the LRP corresponds to 44 kt for *S. mentella* and 30 kt for *S. fasciatus* (Senay et al. 2023).
- Upper Stock Reference (USR): the proposed USR was estimated empirically as 80% of the geometric mean of SSB during periods when SSB and landings were relatively high. USR corresponds to 265 kt for *S. mentella* and 168 kt for *S. fasciatus* (Senay et al. 2023).
- Removal Reference (RR): n/a

- Target (TRP): n/a

Data

This document uses Redfish biomass estimates (SSB and biomass by size-classes) and estimated length frequencies from the northern Gulf St. Lawrence (nGSL) DFO survey (Senay et al. 2023). During the nGSL DFO survey, anal fin ray counts are recorded, which permits post-hoc attribution of Redfish catches into *S. mentella* and *S. fasciatus* (Senay et al. 2022). In addition, a range of natural mortality rates (*M*) was derived from specific life history traits, such as longevity, growth curve parameters (*k* and t_0), maximum length (L_{inf}), age-at-maturity (A_{50}), as well as water temperature. Landings are also presented based on records contained in the Zonal Interchange File Format (ZIFF) database, as well as fishery length frequency data contained in the at-sea observers (ASO) database.

ASSESSMENT

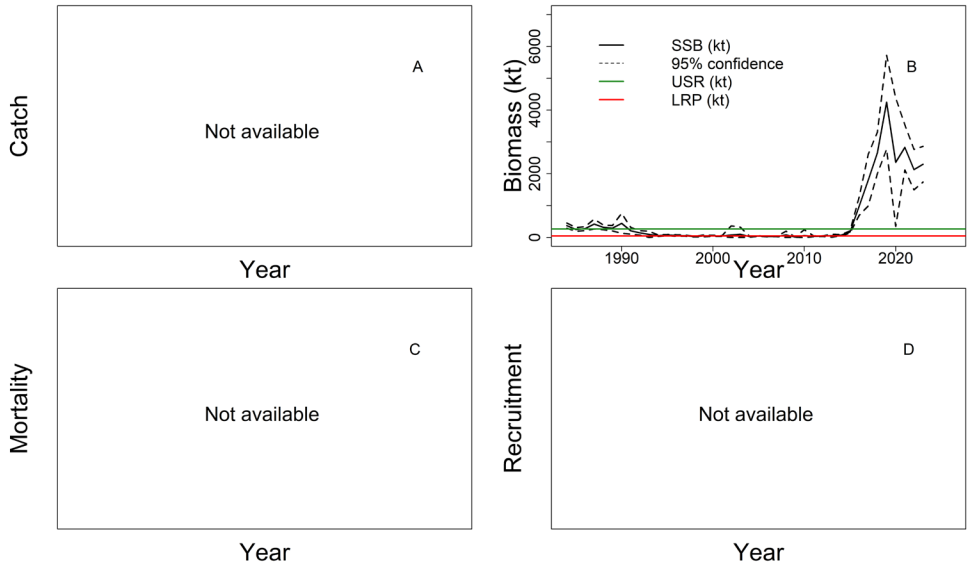

Figure 1. For S. mentella *(A) Commercial catches are not available at the species level, (B) Spawning Stock Biomass (SSB) in relation to the Limit Reference Point (LRP; 44 kt) and (proposed) Upper Stock Reference (USR; 265 kt), (C) Mortality time series is not available, (D) Redfish recruitment is not available at the species level.*

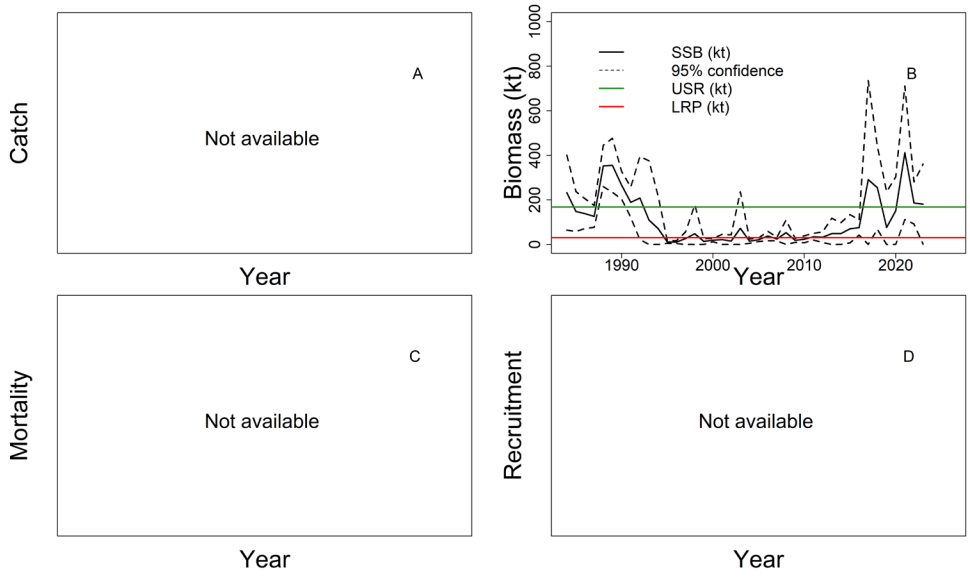

Figure 2. For S. fasciatus*, (A) Commercial catches are not available at the species level, (B) Spawning Stock Biomass (SSB) in relation to the Limit Reference Point (LRP; 30 kt) and (proposed) Upper Stock Reference (USR; 168 kt), (C) Mortality time series is not available, (D) Redfish recruitment is not available at the species level.*

According to the accepted LRPs and proposed USRs, the status of the *S. mentella* stock in 2023 was in the healthy zone of the PA with a SSB of 2,302 kt (1,741-2,862 95% CI), corresponding to 8.7 times the USR (Figure 1). The status of *S. fasciatus* was probably in the healthy zone of the PA with a SSB slightly above the proposed USR (181 kt (1-361 95% CI), Figure 2). The status of the *S. fasciatus* stock remains uncertain.

Recruitment was presented as biomass of Redfish smaller than 11 cm in Senay et al. (2023). For small individuals, species identification based on anal fin ray counts is less reliable, hence recruitment is not provided at the species level.

Historical and Recent Stock Trajectory and Trends

Biomass

Survey biomass indices for *S. mentella* and *S. fasciatus* declined sharply from the late 1980s to 1994. Subsequently, Redfish biomass remained low and stable until the 2010s. The 2011-2013 cohorts, mainly dominated by the 2011 year class, started being caught in the survey in 2013. The biomass of small individuals (< 22 cm, minimum regulatory size) increased as they were growing, until 2018 when it started decreasing as they reached the size of 22 cm. The geometric mean of the 2022 and 2023 biomasses for *S. mentella* and *S. fasciatus* larger than 22 cm were 2,152 kt and 150 kt, respectively A decline has been observed for *S. mentella* over the last four years, and over the last two years for *S. fasciatus*. However, these values still remain among the highest of the time series. The biomass of *S. mentella* larger than 25 cm was at the highest values of the time series, while it was close to the average for *S. fasciatus*.

Recruitment

Redfish recruitment success is highly variable, with large year classes observed at irregular intervals. The 1980 cohort was the last important cohort in Unit 1 prior to the arrival of the large

cohorts born in 2011, 2012, and 2013. These last strong cohorts were the largest ever observed in the survey. Since then, recruitment has remained at low levels.

Length Composition

Based on the at-sea observer data, in the beginning of the 2010s catches were comprised of individuals between 25 and 45 cm. In 2015, a mode appeared between 15 and 20 cm, indicating that the 2011-2013 cohorts started recruiting to the fishery. Since 2019, Redfish larger than 30 cm have been uncommon. The length of Redfish from the 2011-2013 cohorts increased up to 24-25 cm, where it remains since 2021.

History of Landings and TAC

S. mentella and *S. fasciatus* are morphologically similar, therefore landings cannot be presented for each species in Figures 1 and 2. The Unit 1 corresponds to the Northwest Atlantic Fisheries Organization (NAFO) Divisions 4RST and 3Pn4Vn from January to May. Redfish fishery in Unit 1 has been characterized by three episodes of high landings. Average annual landings were 43 kt between 1954-1956, 79 kt between 1965-1976, and 59 kt between 1987-1992 (Figure 3). From 1953 to 1990, landings originated mainly from NAFO Divisions 4RS. After rapid decreases in landings in 1993 and 1994, a moratorium was declared in Unit 1 in 1995. Redfish fishing is still under moratorium in Unit 1 and an index fishery has been authorized since 1998. The total allowable catch for this fishery has been 2,000 tonnes (t) per management year (from May 15th to May 14th of the following year) since 1999. On average from 2010 to 2017, 470 t of Redfish were caught annually in Unit 1. In 2018, an experimental fishery was established with a potential maximal additional allocation of 2,500 t for 2018–2019, 3,950 t for 2019–2020, 3,681 t for 2020–2021, 5,463 t for 2021–2022, 5,944 t for 2022–2023, and 5,000 t for 2023–2024. The objectives of the experimental fishery were to target *S. mentella*, which is more abundant than *S. fasciatus*, to investigate ways to limit bycatch and the harvesting of undersize Redfish, and to better understand the spatiotemporal distribution of Redfish and bycatch species. Since 2018, landings increased along with additional allocations from the experimental fishery (Figure 3). In 2022-2023, preliminary Redfish landings reached 3,059 t in Unit 1, namely 39% of the combined index and experimental fisheries quota. The 2023-2024 fishing season continues until May 14, 2024.

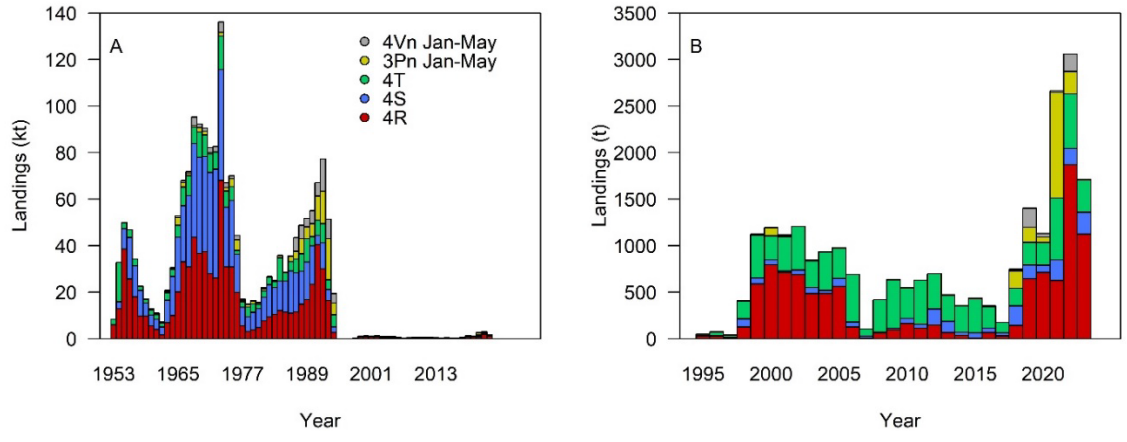

Figure 3. Fisheries annual Redfish landings in Unit 1 per NAFO Division or Subdivision from (A) 1953 to 2023 (thousands of t (kt)) and (B) from 1995 to 2023 (t). Years correspond to fishery management cycle. Data include fisheries directed to all species. No Redfish directed fishery took place from 1995 to 1997. Values for 2017-2023 landings are preliminary.

Future Scenarios

No model is currently being used to assess Redfish stocks, limiting our capacity to estimate natural and fishing mortalities, and to undertake projections and simulations. That said, based on biomass trends, prospects for *S. mentella* are positive due to fish from the large 2011-2013 cohorts that are now mostly larger than the minimum regulatory size of 22 cm. The strong biomass increase may support higher catches of *S. mentella* without posing a conservation risk to the stock.

Environmental and Climate Change Considerations

Since 2009, the deep waters (> 150 m) of the Gulf of St. Lawrence have been warming. The deep waters originate from the entrance of the Laurentian Channel, where the waters of two oceanic currents, the Labrador Current (cold, less saline, highly oxygenated) and the Gulf Stream (warm, more saline, low oxygen) mix, resulting in water for which the temperature, salinity and dissolved oxygen will vary according to the contribution of each current. In recent years, the Gulf Stream contribution to the mix has increased. Temperature is now reaching record highs, while the concentration in oxygen is decreasing. Water temperatures above 7 °C have been recorded since 2012 in the GSL near the Cabot Strait and have occupied a significant proportion of deep waters in recent years (Galbraith et al. 2023). In 2022, concentrations of dissolved oxygen at 200 m, 250 m, and 300 m were again well below normal everywhere along the Laurentian Channel (Blais et al. 2023). For the moment, Redfish seem to cope relatively well with these conditions that are unfavorable to other species, like Northern Shrimp (*Pandalus borealis*), one of its prey. Laboratory experiments are currently underway on *S. fasciatus* to explore the potential consequences of these changes on Redfish.

OTHER MANAGEMENT QUESTIONS

Length Frequency

Based on nGSL survey, modal size for *S. mentella* and *S. fasciatus* was 24 cm for both species since 2021, indicating a slower growth rate than anticipated (Figure 4, Senay et al. 2023). The biomass of *S. mentella*, comprised 2% fish smaller than 22 cm, 61% fish measuring between 22 and 25 cm, and 36% fish larger than 25 cm in 2023 (Figure 5). The biomass of *S. fasciatus* comprised 26% fish smaller than 22 cm, 41% fish measuring between 22 and 25 cm, and 33% fish larger than 25 cm in 2023. No important recruitment was observed since the 2011-2013 cohorts, indicating that no substantial new cohort should recruit to the fishery in the short-term. Similar sizes were also observed in the fishery (Figure 6).

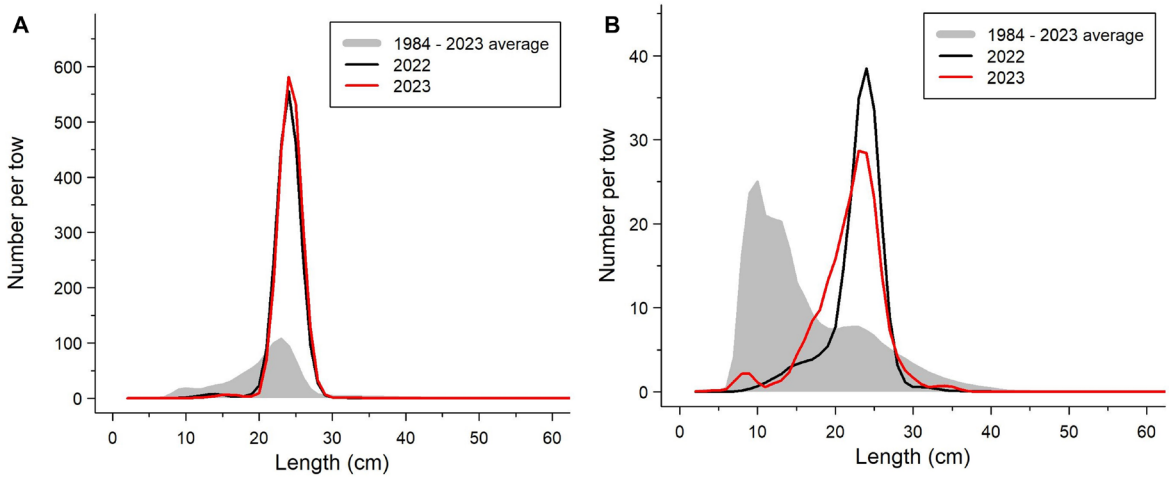

Figure 4. S. mentella *(A) and* S. fasciatus *(B) mean number per tow in the nGSL DFO research surveys for 2022, 2023, and the 1984 to 2023 average. Note the different scales on the y-axis.*

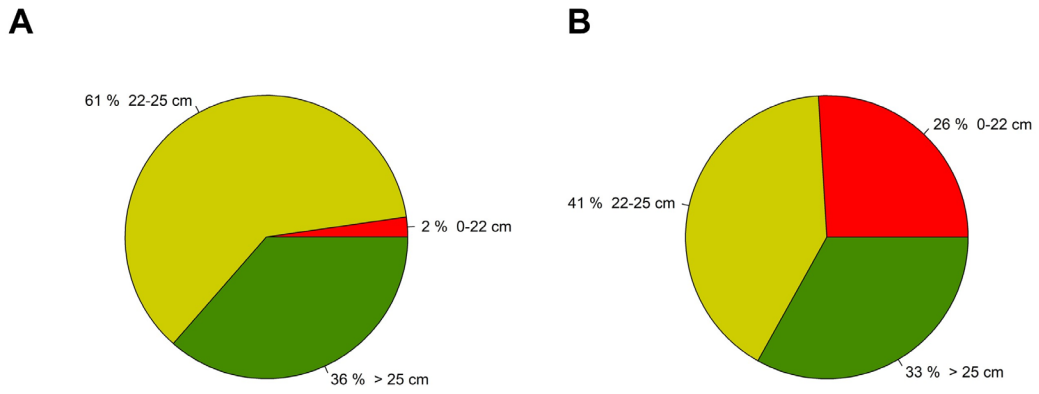

Figure 5. Percentage of minimum trawlable biomass of S. mentella *(A) and* S. fasciatus *(B) in the nGSL DFO survey in 2023 by length classes, 0–22 cm in red, 22–25 cm in yellow, and larger than 25 cm in green.*

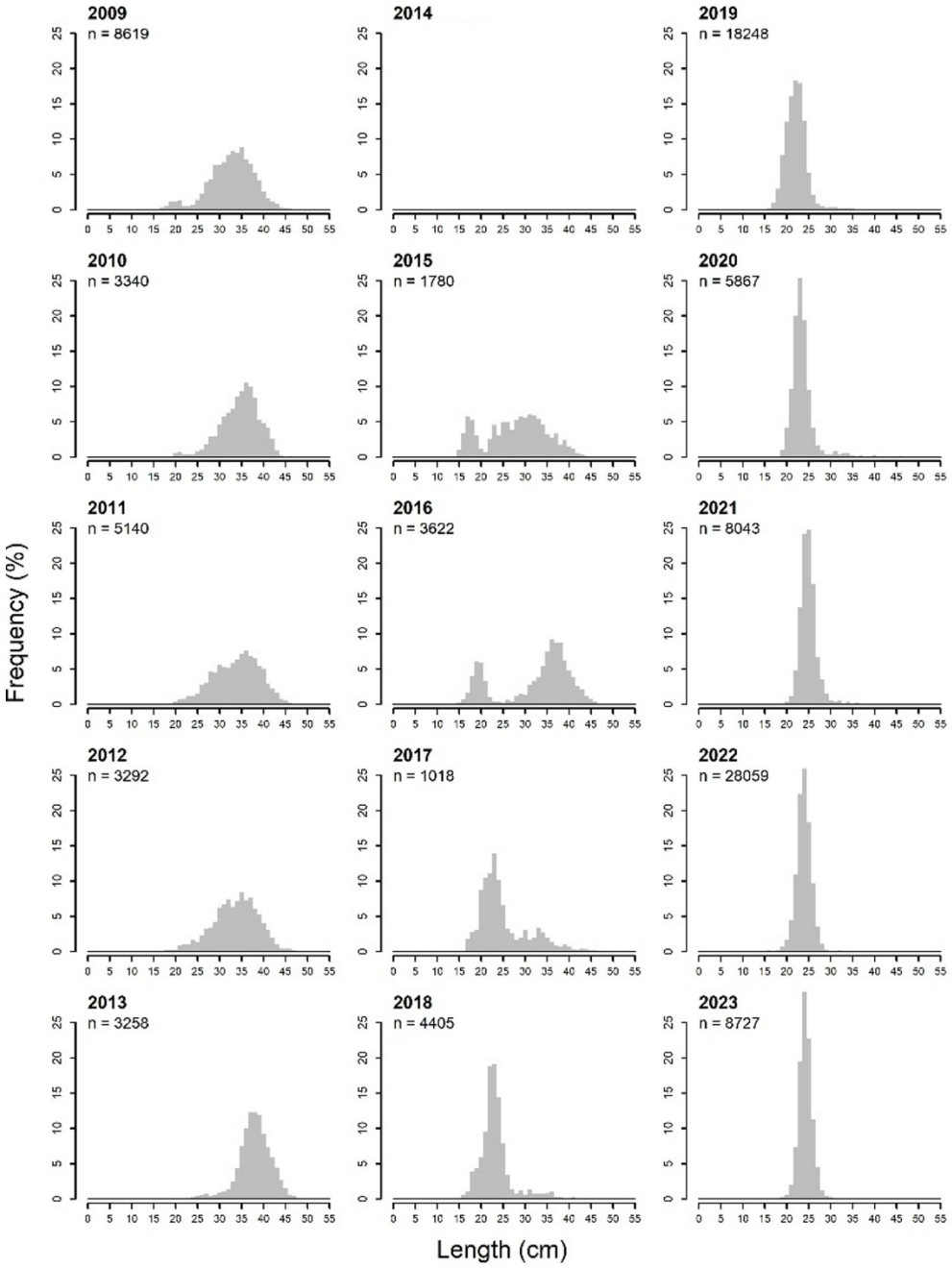

Figure 6. Redfish length frequency (%) in Unit 1 from 2009 to 2023 based on at-sea-observer data from the Redfish index and experimental fisheries. Numbers of fish measured are indicated (n). No fish were sampled in 2014. Values for 2021 and 2023 are preliminary.

Potential Removals

Based on 17 estimates of natural mortality following the method of Cope and Hamel (2022), a range of annual potential removals of 2 to 414 kt, with a median of 276 kt was estimated for *S. mentella* (Figure 7). Given that extreme values of natural mortality are less likely, a more realistic range of potential removals for the 2024-2025 fishing season was defined between the

25th and 75th percentiles of these estimates, corresponding to 88 and 318 kt for *S. mentella*. *S. mentella* will very likely remain in the healthy zone in 2024 given this range of removals. Given the uncertainty over the status of the *S. fasciatus* stock and the assumptions underlying the proposed method, a range of potential removals could not be determined with certainty.

With this approach, given that potential removals are based on current estimates of biomass, the first year of fishing would correspond to the largest removals in the absence of new production (recruitment and growth). Potential removals would have to be updated every year with the updated biomass of fish larger than 22 cm. If some new production happens, it would be considered when determining subsequent potential removals.

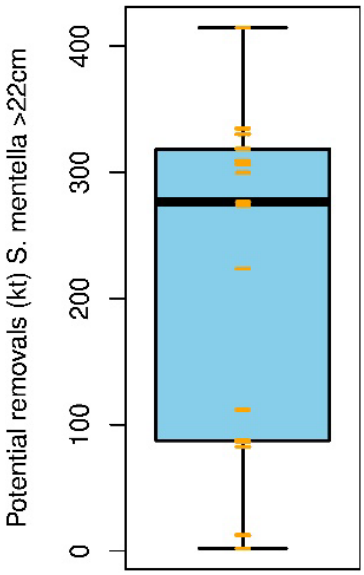

Figure 7. Boxplots representing annual potential removals for the 2024-2025 fishing season in kt for S. mentella*. The different values derived from various estimates of M are indicated by yellow horizontal lines. The blue box is delimitated by the 25th and 75th percentiles and defined a realistic range of potential removals.*

Fishing in deeper areas would target the more abundant species, *S. mentella,* and larger individuals, while fishing in shallower areas would target *S. fasciatus*. Typically in Unit 1, *S. mentella* tends to predominate in the main channels at depths ranging from 350 m to 500 m. In contrast, *S. fasciatus* dominates at depths less than 300 m (Senay et al. 2023).

The median value of *M* (0.275 for both species) was used for all curves showing biomass trajectories under various fishing mortality rate ($F = 0.5 * M$, Froese et al. 2016). In the absence of recruitment and growth, for both species, the median and 75th percentile of *F* provided similar trajectories, with biomass decreasing to less than 10% of the initial biomass in 6 years, compared to 8 years with the 25th percentile of *F,* and 9 years without fishing (Figure 8). A decrease to 10% of initial biomass, corresponding to 215 kt for *S. mentella* and 15 kt for *S. fasciatus* would have different implications for each species relative to their PA.

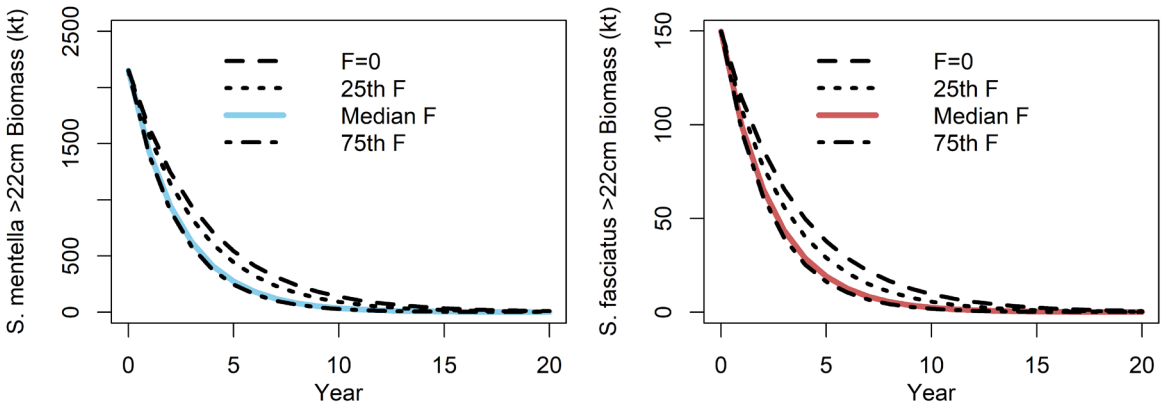

Figure 8. Impact of different fishing mortality (0, as well as 25th percentile, median, and 75th percentile of F) on the trajectories of 2011-2013 cohorts biomass for S. mentella *(left panel) and* S. fasciatus *(right panel) without new production.*

SOURCES OF UNCERTAINTY

The main sources of uncertainty in the present assessment of Redfish stocks are productivity dynamics, especially natural mortality. Little is known on the effects of ongoing ecosystemic conditions on Redfish life-history traits such as recruitment, longevity, and future growth. This is particularly relevant for this exercise that links various life-history traits to natural mortality to determine a range of potential removals in a changing environment.

Uncertainty is also present in the survey biomass estimates. Minimum trawlable biomass was used without consideration of the survey capturability. Therefore potential removals are considered conservative.

S. mentella and *S. fasciatus* stocks include Unit 1 and Unit 2 (Subdivisions 3Ps4Vs4Wfgj, and from June to December Subdivisions 3Pn4Vn). Continued data acquisition and validation in Unit 2 is required to further inform and optimize the PA framework for each stock (which is currently based on Unit 1 information only). This is highly desirable in the short-term to ensure the current PA is applicable to the entire stocks distribution area. A comparative survey in Unit 2 is also a high priority to ensure continuity in the survey biomass time series for the two stocks (*S. mentella* and *S. fasciatus*) from 2020 onwards. The present approach is intended to be used in the short term until a better method is proposed.

Closely monitoring bycatch, notably *S. fasciatus*, will be crucial during the expansion of the Redfish fishery. Contemporary fishery dependent (at-sea observers sampling) and research data (winter surveys) are required to refine the scientific advice on bycatch, particularly as regards vulnerable species.

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