Fisheries and Oceans Canada | Pêches et Océans Canada
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Canadian Science Advisory Secretariat
Maritimes Region **Science Response 2023/039**

STOCK STATUS UPDATE OF ARCTIC SURFCLAM (*MACTROMERIS POLYNYMA*) ON BANQUEREAU AND GRAND BANK TO THE END OF THE 2022 FISHING SEASON

Context

An update on the status of the offshore Arctic Surfclam (*Mactromeris polynyma*) resource was requested by Maritimes Region Resource Management to support harvest level decisions in the Arctic Surfclam fishery. Surfclam is assessed on a multi-year assessment schedule, with Stock Status Updates produced in interim years. The basis for assessing Arctic Surfclam on Banquereau and Grand Bank was examined at a framework review meeting on June 28–29, 2016. During the framework review, a fisheries-dependent assessment methodology was developed for Banquereau using a spatially disaggregated surplus production model (Hubley and Heaslip 2018). This method was used to provide an assessment of the stock status on Banquereau and potential harvest levels based on two removal values. This report updates fisheries information (landings, catch per unit effort, fishery footprint) and secondary indicators to the end of the 2022 fishing season for both Grand Bank and Banquereau, as well as biomass model results from Banquereau, and assesses them against agreed upon reference points and thresholds. These banks were last assessed in 2017 (DFO 2017, Hubley et al. 2020) with updates conducted annually from 2018 to 2022 (DFO 2022b).

This Science Response Report results from the regional peer review of August 29, 2023, on the Stock status updates for Arctic Surfclam.

Background

The offshore Arctic Surfclam fishery takes place on Banquereau and Grand Bank (Figure 1). Grand Bank refers to the Eastern Grand Banks fishing area, in North Atlantic Fisheries Organization (NAFO) Area 3LNO, with some restrictions as outlined in the licence conditions. Historically, the banks were managed with Total Allowable Catches (TACs) set based on bank-wide estimates of biomass. These biomass estimates were made from scientific surveys, the most recent of which was one survey conducted over three years in 2006, 2008, and 2009 for Grand Bank (Roddick et al. 2011) and 2010 for Banquereau (Roddick et al. 2012). In the absence of new survey data, an assessment approach was developed for Banquereau that restricted biomass estimates to areas of commercially viable densities (a historically fished area) identified from Vessel Monitoring System (VMS) satellite positional data. This method is not currently applied to Grand Bank since fishing effort, specifically swept area, is less than on Banquereau and is dispersed over a larger bank. The stock on Grand Bank is monitored with a set of fishery-dependent secondary indicators for biomass, fishery footprint, and size composition.

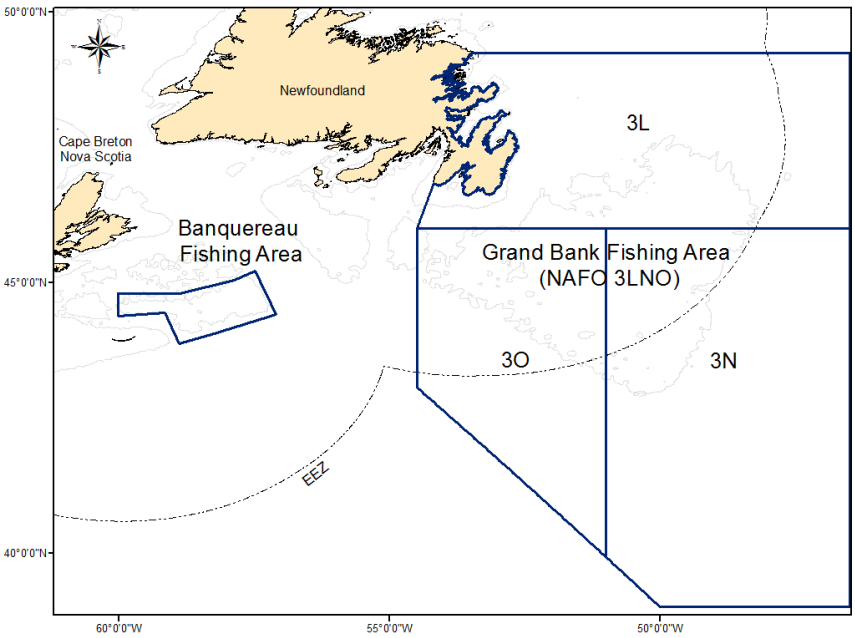

Figure 1. Banquereau and Grand Bank Arctic Surfclam fishing areas (solid lines) from licence conditions.

Description of the fishery

Following a three-month test fishery in 1986, an Offshore Clam Enterprise Allocation Program was developed for Arctic Surfclam on Banquereau. The fishery expanded to Grand Bank in 1989, after exploratory fishing on that Bank in 1987 and 1988. In 2022, there were three licences for offshore clam (multispecies), and three vessels fishing. Currently, quota is transferable between licences but not between banks. Effort has moved between the banks over time, with effort currently split between the two banks. Fishing is conducted from large freezer processors using hydraulic dredges on sandy substrates located at 50 to 110 m depth. The main management tools for the offshore clam fishery are limited entry licences, TAC divided into enterprise allocations, 100% industry-funded dockside monitoring, mandatory logbooks, and 100% VMS coverage (DFO 2020a). Observer requirements are one trip per bank per year (DFO 2020a). On Banquereau in 2022, 0.88 (22 of 25 days) of a trip was Observed. The other 3 days of the trip occurred in the 2023 fishing year or on Sable Bank. There were two fully Observed trips on Grand Bank in 2022. The protocols for fisheries at-sea observers and the companies doing the work have changed many times over the span of the fisheries on both banks. Work is still ongoing to reconcile differences in protocols, especially with respect to how discards were recorded for retained species. On both banks, Arctic Surfclam comprises the largest proportion of the landed species while the composition of the other landed species varies between the banks (Tables A1 and A2). On Banquereau in 2022, the top three discard taxa were Sand Dollars, whelks, and Ocean Quahog which in total accounted for 18.2% of the discards by weight (Table A3). On Grand Bank in 2022, the top three discard taxa were Sand Dollars, Greenland Cockle, and whelks, which in total accounted for 22.6% of discards by weight (Table A4).

Fishery Data Types and Conversion Factors

Landings in the offshore clam fishery are in the form of products (Table 1). These Arctic Surfclam partial weight product types are converted to round weights (i.e., whole animal weight)

using conversion factors. Not all landed product types (e.g., mantle) count against the TAC because the product is already accounted for in the conversion of foot product to round weight. The fishery creates three mixed-species products. C-grade is a mixed product that can contain Surfclam foot, but also parts of other species. A component factor for the C-grade product was developed and used starting in the 2019 fishing year, and reviewed and updated in 2020 (Table 1). The other mixed species products (recovery and mantle mix) in this fishery do not contain Surfclam foot, and do not have component factors or count against the quota. Although C-grade counts against the TAC for quota monitoring purposes, it is not currently included by DFO Science in the stock assessment model.

Table 1. Arctic Surfclam product types landed in the offshore clam fishery and the component and conversion factors applied to the product type. NA indicates no conversion factor is required for that product because it does not count against the TAC.

Product Type	Component (%) and Conversion Factor
Blanched foot (tongue)	6.51
Blanched mantle	NA
C-grade (mixed species product; 2019-2020)	80% × 6.51
C-grade (mixed species product; 2021-present)	86% × 6.51

The other commonly retained species in the offshore clam fishery are Northern Propeller Clam (*Cyrtodaria siliqua*), Greenland Smooth Cockle (*Serripes groenlandicus*), and Ocean Quahog (*Arctica islandica*). These are also landed as products and converted to a round weight for monitoring (Table 2). Conversion factors for these species are based on a Statistical Coordinating Committee for the Atlantic Coast report (STACAC 1984). In 2021, component factors for the Greenland Cockle portion of the C-grade product were developed for Banquereau and Grand Bank (DFO 2022a). The Northern Propeller Clam portion of the C-grade was found to be negligible (< 0.13%) and a component factor is not used for that species (DFO 2022a).

Table 2. Other species product types landed in the offshore clam fishery and the component and conversion factors applied to the product types. Conversion factors apply to both banks unless otherwise stated.

Species	Product Type	Component (%) and Conversion Factor
Northern Propeller Clam	Blanched siphon	5.5
Greenland Cockle	Blanched foot (tongue)	5.5
Greenland Cockle	Raw foot (tongue)	5.5
Greenland Cockle (Banquereau)	C-grade (mixed species product)	12% × 5.5
Greenland Cockle (Grand Bank)	C-grade (mixed species product)	8.8% × 5.5
Ocean Quahog	Foot (tongue)	6.0

Fishery Data Management and Data Review

Commercial data used in this assessment are stored in the Offshore Clam Data Archival (CLAM) database. Fishing data are supplied to DFO Science directly from industry and loaded into the CLAM database. Before and during loading, the raw data are validated against data integrity checks (e.g., expected ranges for certain values, expected unit types) and potential errors are discussed with industry and corrected before being stored in the database. This database is separate from the databases used in the two regions to store commercial data for quota monitoring: the Maritime Fishery Information System 1.0 and 2.0 (MARFIS) and Newfoundland and Labrador Region's Catch and Effort database. Unless otherwise noted in the document, data being used are from the CLAM database.

Analysis and Response

Commercial Fishery

In 2022, Arctic Surfclam landings in the MARFIS and Catch and Effort databases were 21,962 t against a TAC of 20,943 t for Banquereau and 14,778 t against a TAC of 14,756 t for Grand Bank. On Grand Bank, the mean Catch Per Unit Effort (CPUE) in 2022 was 213 g/m^2, an increase from 192 g/m^2 in 2021. On Banquereau in 2022, mean CPUE was 177 g/m^2, an increase from 156 g/m^2 in 2021. The 2022 CPUE on Banquereau marks a high in the time series. Landings and CPUE times series for both banks are shown in Figure 2. Since 2015, CPUE on Banquereau has been increasing steadily while effort has generally decreased. This is likely due to the increasing efficiency of the fleet on this Bank.

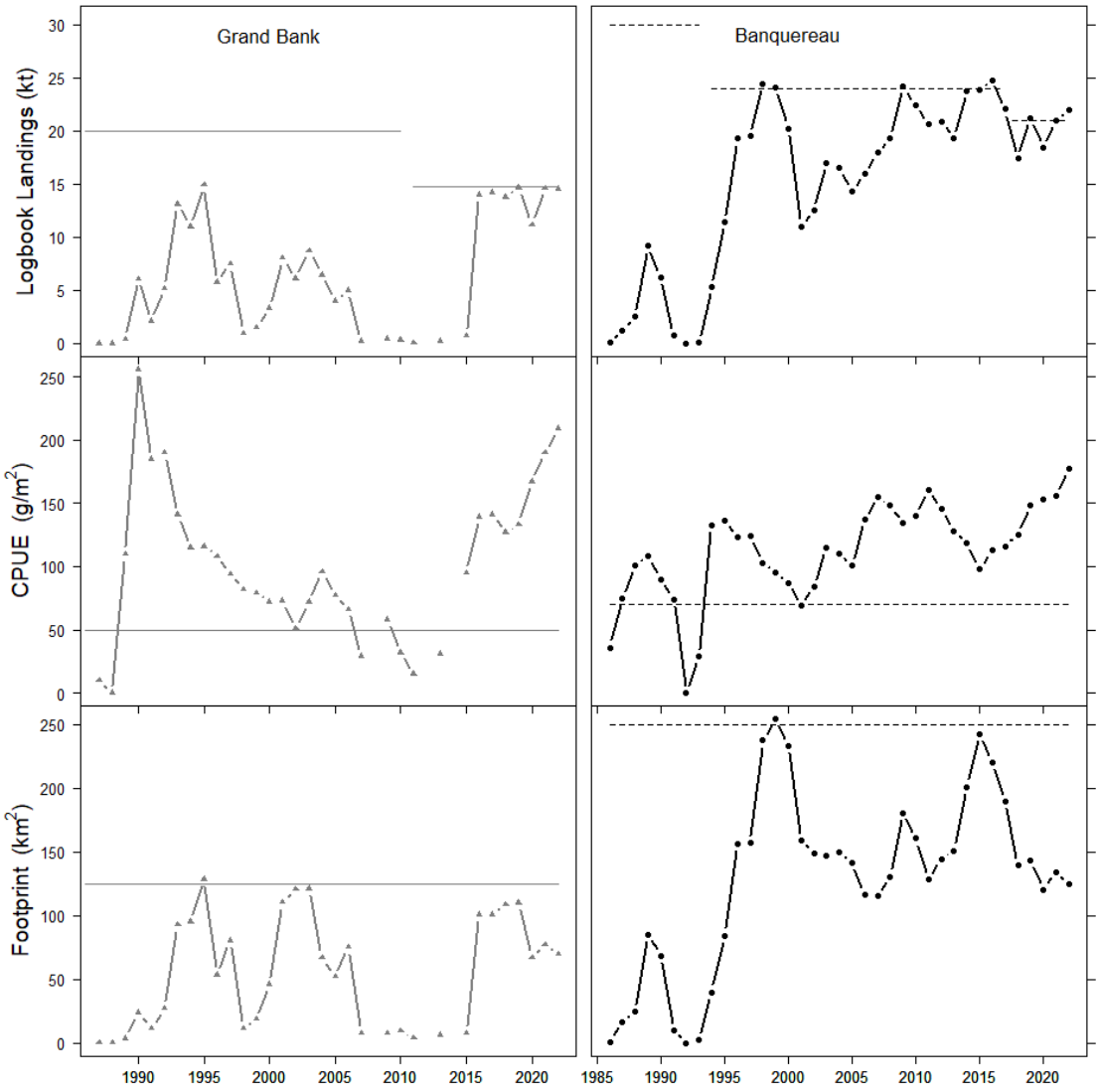

Figure 2. Landings in kilotonnes (kt), Catch Per Unit Effort (CPUE; g/m^2), and fishery footprint (km^2) for Grand Bank (left) from 1987 to 2022 and Banquereau (right) from 1986 to 2022. Horizontal lines represent Bank-specific total allowable catch (top panels) or threshold levels for secondary indicators (bottom four panels; see: Indicators of Stock Status). Gaps in the Grand Bank data indicate years in which no fishing occurred.

Spatial Production Model for Banquereau

Following the 2016 Framework (Hubley and Heaslip 2018), the stock definition for Banquereau has been restricted to the area directly under exploitation. Five spatial assessment areas are used to divide Banquereau (Figure 3). Within these areas, the fished (exploited) areas are determined using VMS data, which are used as a proxy for Surfclam habitat (Figure 4). For each of the five assessment areas, a surplus production model was fit to a time series of CPUE data. Areal expansion of the Surfclam density (g/m^2) was limited to the fished area.

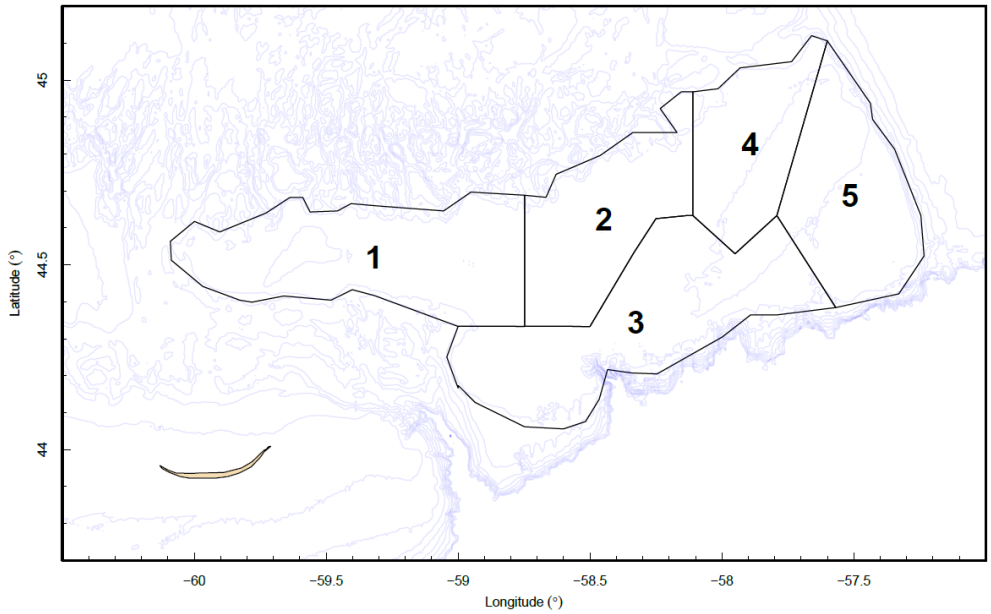

Figure 3. Five spatial assessment areas on Banquereau used in the assessment.

Figure 4. Vessel Monitoring System (VMS) density on Banquereau estimated from a kernel smoothed intensity function with a standard deviation of 0.2 on a 100 m^2 resolution. The scale bar shows VMS intensity expressed as the number of transmissions (pings) per km^2 for 2004–2016. The colored region shows the area where VMS intensity is greater than 30 pings/km^2.

The annual CPUE index used in the model is shown in Figure 5. Mean catch rates from 2021 to 2022 in areas 3 and 4 increased by 14% and 27%, respectively. Catch rates in all other areas decreased or stayed the same in 2022. Area 5 had the highest catch rates in 2022 at 218 t/km^2.

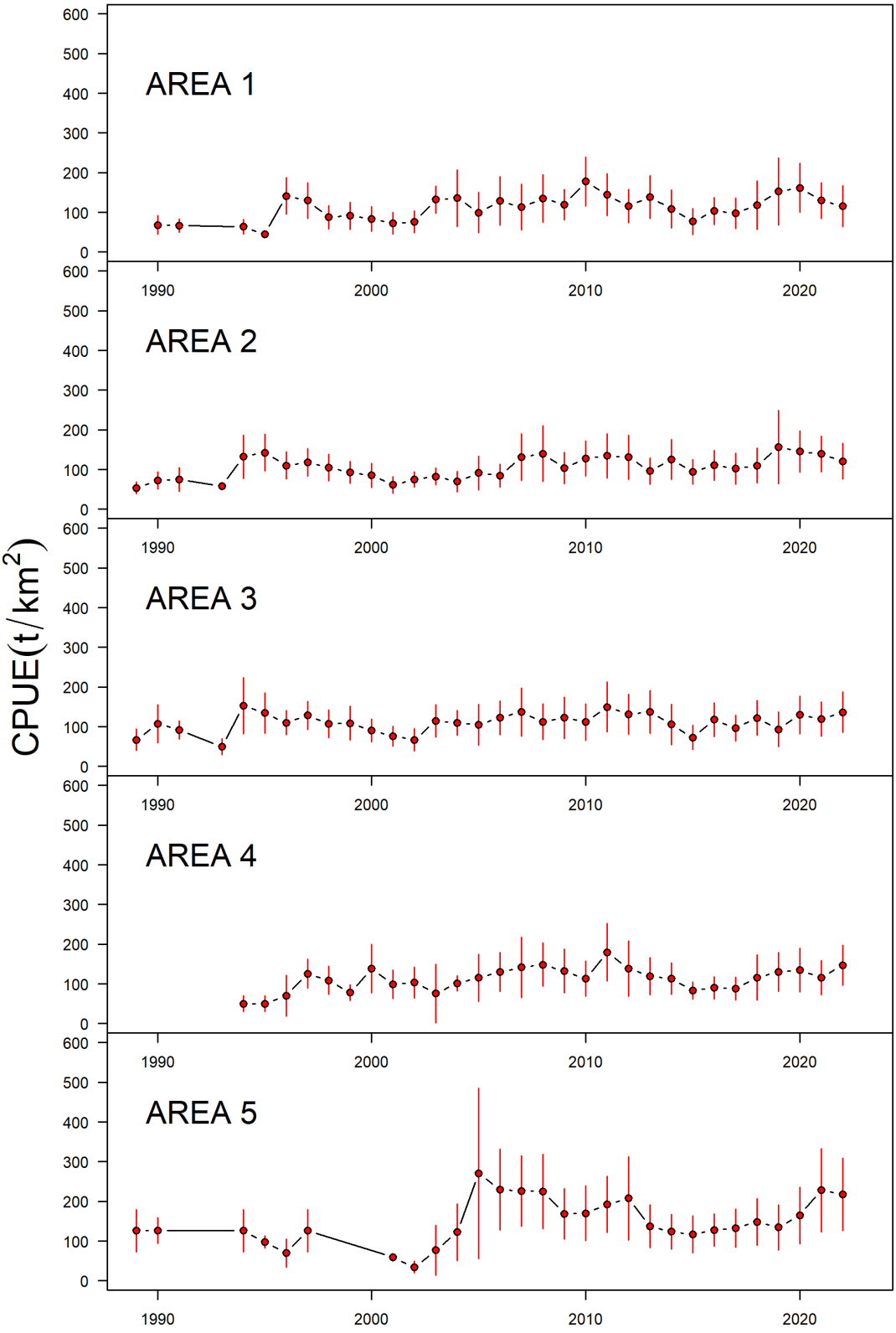

Figure 5. Banquereau Catch Per Unit Effort (CPUE; tonnes per km^2) by spatial assessment area (1 to 5) showing the annual mean values (red points) ± 1 standard error (red lines).

The modelled estimate of exploitation rates (catch divided by biomass, from the model) for each assessment area demonstrates the movement of the fishery among the different areas in different years (Figure 6). Increases in exploitation rate within an assessment area are generally followed by a reduced rate in subsequent years. In 2022, exploitation rates increased in areas 4 and 5, decreased in area 1, and were similar to 2021 in other areas. The exploitation rate in area 5 was the highest overall at 0.113. Exploitation rates in the other areas ranged from 0.007 to 0.022.

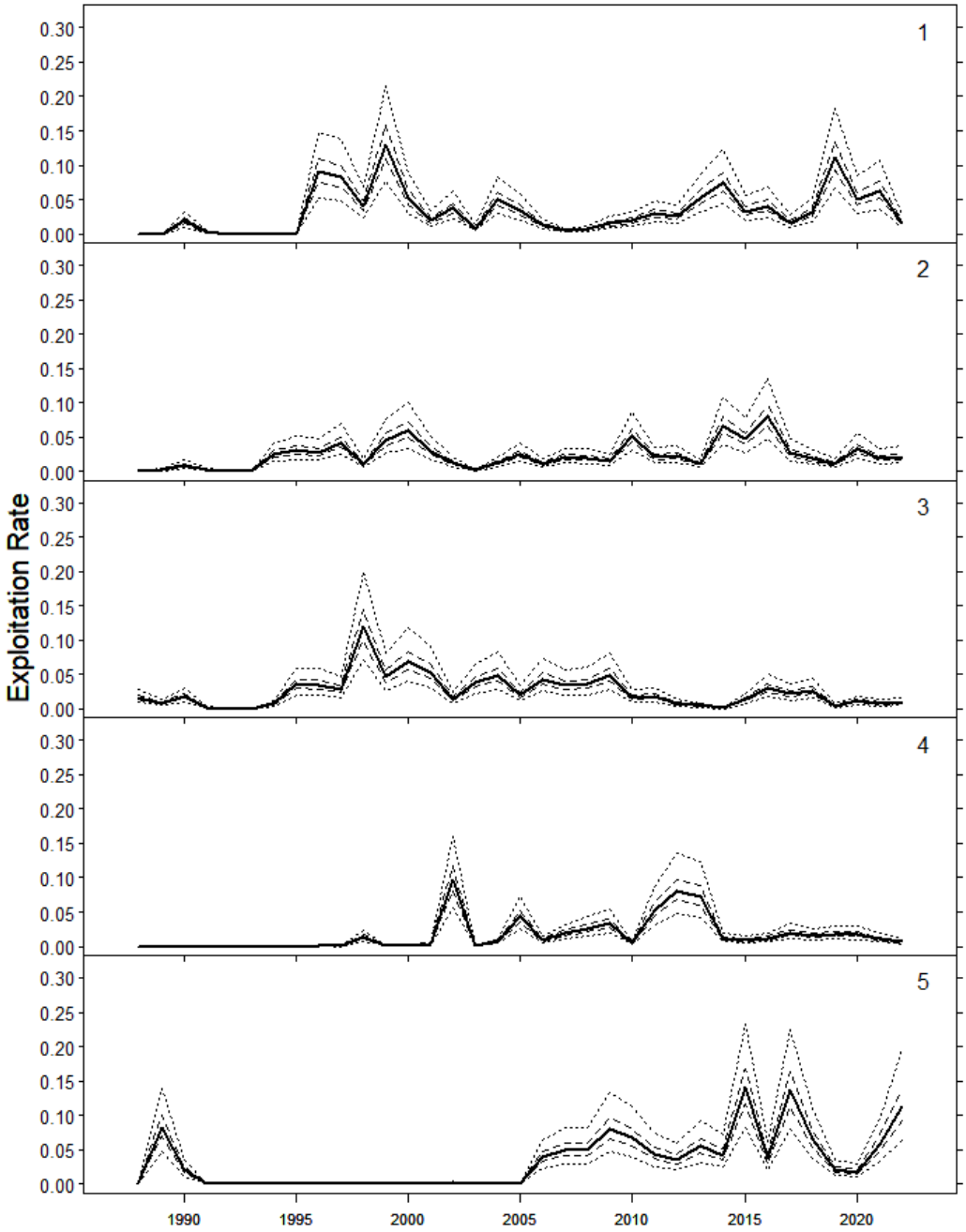

Figure 6. Estimates of exploitation rate on Banquereau for 1988 to 2022 from the spatial production model by assessment area. Lines denote the median (solid), 50% credible interval (dashed), and 95% credible interval (dotted).

Median areal biomass estimates from the model in 2022 indicate all areas are within 8% of the biomass estimates in the previous year (Figure 7).

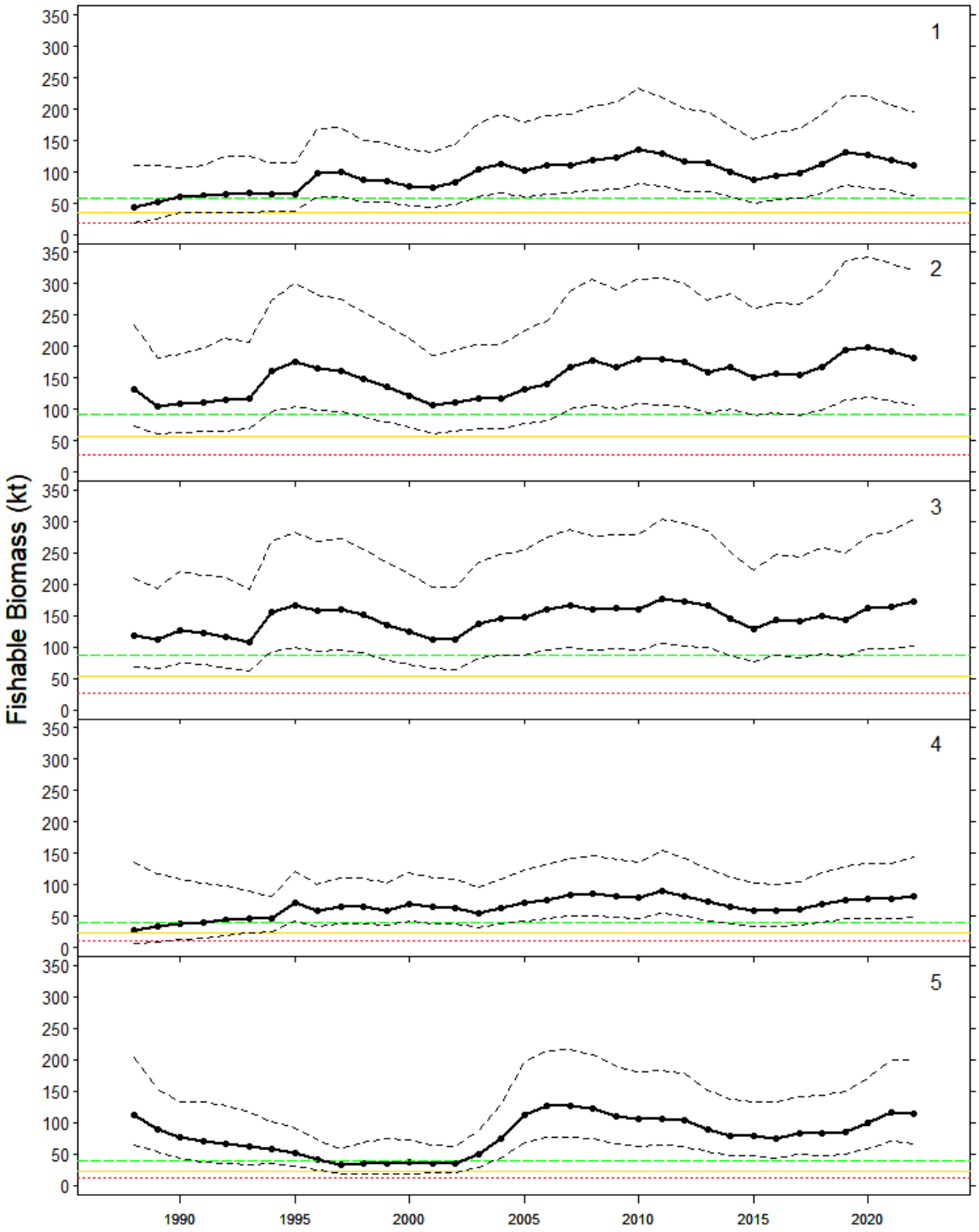

Figure 7. Estimates of fishable biomass (kilotonnes) on Banquereau from the spatial production model by assessment area. Black lines denote the median estimate (solid line with circles) and 95% credible interval (dotted line). The horizontal lines represent (from top to bottom): $CPUE_{70}$ reference (green), upper stock reference (yellow), and limit reference point (red).

Indicators of the stock status

Three secondary indicators of stock status were developed for Banquereau and Grand Bank based on commercial fishery data. Data for the secondary indicators are not restricted to the fished area used for biomass modelling. Catch per unit effort is the biomass indicator, and the thresholds are 70 g/m^2 for Banquereau and 50 g/m^2 for Grand Bank. Both banks were above the CPUE indicator threshold in 2022 (Figure 2). Fishery footprint is calculated as the sum of the area dredged, with no adjustment for overlapping tows. Footprint is an indicator of the spatial extent of the fishery and stock density - as densities decline the footprint will increase as more area is fished to maintain landings, or as the fishery searches for new high density areas. The footprint thresholds are 250 km^2 for Banquereau and 125 km^2 for Grand Bank. Both banks were below the footprint threshold in 2022 (Figure 2). The relative abundance of old, large clams is monitored as the size composition indicator. This maintains older age classes in the stock. Large changes in the size composition indicator between years could be a function of fishing location, as the size composition of the stock can vary across the bank. The size composition indicator is 1% of the unsorted catch being greater than or equal to 120 mm for Banquereau, or 0.5% being greater than or equal to 105 mm for Grand Bank. Both banks were above the size composition indicator threshold in 2022 (Table 3).

Table 3. Percent of large clams in unsorted commercial catch and sample size (n) for Grand Bank and Banquereau. Threshold is 1% for Banquereau and 0.5% for Grand Bank. Only ten years of data shown.

	Grand Bank		Banquereau	
Year	% > 105 mm	n	% > 120 mm	n
2013	6.67	180	2.73	21,501
2014	-	-	1.61	14,327
2015	19.17	600	1.53	15,237
2016	16.97	9,000	2.28	19,667
2017	15.95	7,598	2.51	17,195
2018	11.35	8,000	1.14	16,895
2019	9.72	9,300	2.43	15,599
2020	17.25	6,998	3.81	13,798
2021	10.90	7,493	2.10	15,191
2022	11.12	7,293	1.11	12,785

A dash (-) indicates no data available.

Biomass based reference points have been presented for Banquereau (Hubley et al. 2020) based on the default 0.4 and 0.8 B_{MSY} (Biomass at Maximum Sustainable Yield) often used to define the Limit Reference Point (LRP) and Upper Stock Reference (USR). These biomass reference points are based on the fished area biomass, not the entire bank. Due to the potential that these values are underestimated for this stock, it was proposed that the stock status also be assessed against the previously established CPUE threshold level of 70 g/m^2. This reference value ($CPUE_{70}$) was translated into biomass estimates for each assessment area (i.e., green line in Figure 7). In 2022, the probability that the biomass estimate was above the USR and the $CPUE_{70}$ reference line was greater than 0.99 for all areas (Table 4).

The fishery on Banquereau does not operate based on individual TACs for each assessment area. Fishing can occur anywhere on the Bank; therefore, the TAC is determined from the total biomass in all fished areas of the Bank (Figure 8). In 2022, the estimated median total biomass in the fished areas was 661,417 t (95% CI: 387,455–1,163,599 t). The probability that the total bank biomass from the five assessment areas combined was above the USR and the $CPUE_{70}$ reference line was greater than 0.99 (Table 4).

Table 4. Probability that median biomass estimates are above the Limit Reference Point (LRP), Upper Stock Reference (USR), and a CPUE of 70 g/m^2 (CPUE$_{70}$) for each assessment area (1–5) and for the total area on Banquereau.

Area	LRP	USR	CPUE$_{70}$
1	> 0.99	> 0.99	> 0.99
2	> 0.99	> 0.99	> 0.99
3	> 0.99	> 0.99	> 0.99
4	> 0.99	> 0.99	> 0.99
5	> 0.99	> 0.99	> 0.99
Total	> 0.99	> 0.99	> 0.99

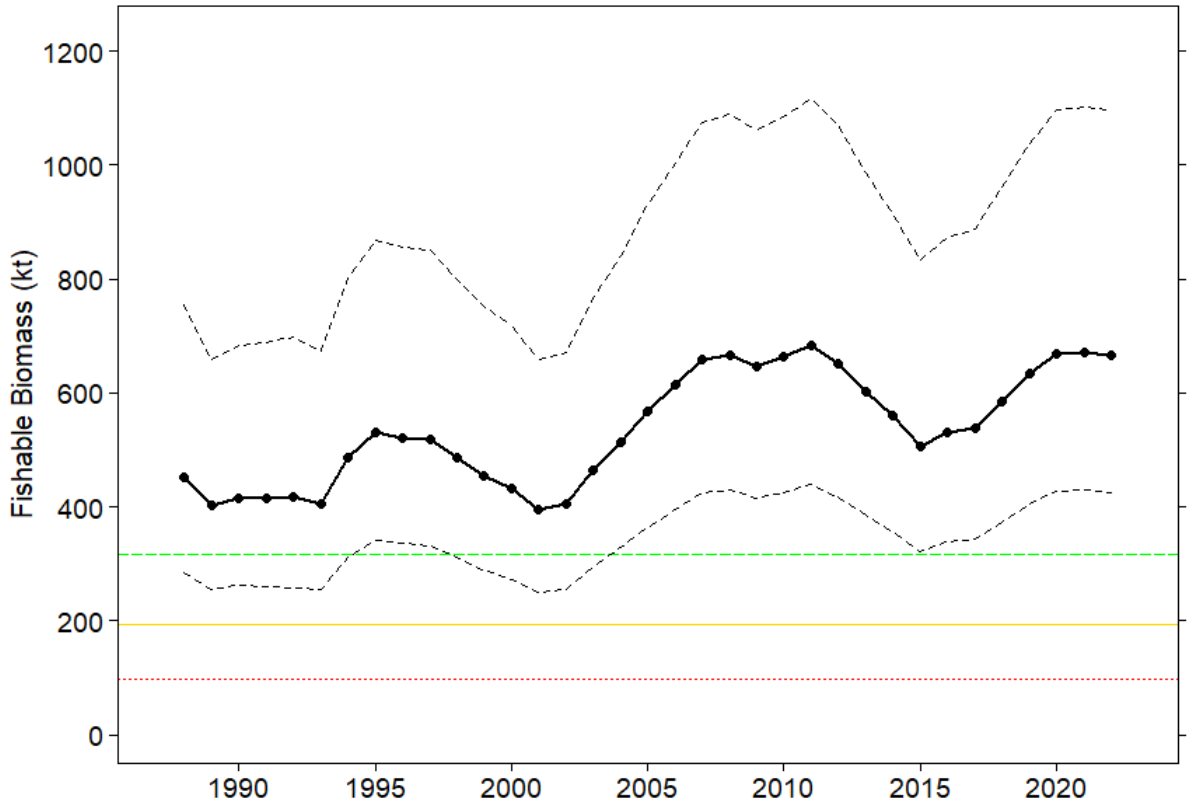

Figure 8. Estimate of fishable biomass (kilotonnes) on Banquereau from 1988 to 2022 from the spatial production model for the total fished area. Black lines denote the median estimate (solid line with circles) and 95% credible interval (dotted line). The horizontal lines represent (from top to bottom): CPUE$_{70}$ reference (green), upper stock reference (yellow), and limit reference point (red).

Other Retained Catch in the Fishery

The Offshore Clams Integrated Fishery Management Plan (DFO 2020a) allows for the retention of other clam species. There are no limits on the bycatch of Northern Propeller Clam or Greenland Cockle. Greenland Cockle landings on Grand Bank increased in 2022 from 2021 and were below the time-series high of 3,673 t in 2019 (Figure 9). Greenland Cockle landings on Banquereau have been increasing slowly since 2016 (Figure 10). On Grand Bank, landings of Northern Propeller Clam increased in 2022 to a new time-series high (4,626 t; Figure 9). Northern Propeller Clam landings on Banquereau increased in 2022 and are below the time-series high of 8,747 t in 2019 (Figure 10). Quahog landings have been minimal on both banks since the late 1990s. Ocean Quahog catch is limited on Grand Bank to 10% of Surfclam catch,

to a maximum of 500 t. On Banquereau, there is an Ocean Quahog TAC of 800 t. In 2022, the TAC was not exceeded for Ocean Quahog on either bank (Figure 9 and Figure 10). In August 2021, the fishery switched from a policy of partial retention of the three above bycatch species to one of 100% retention. Therefore, increases in landings since then are likely reflective of this change and do not necessarily indicate underlying population changes.

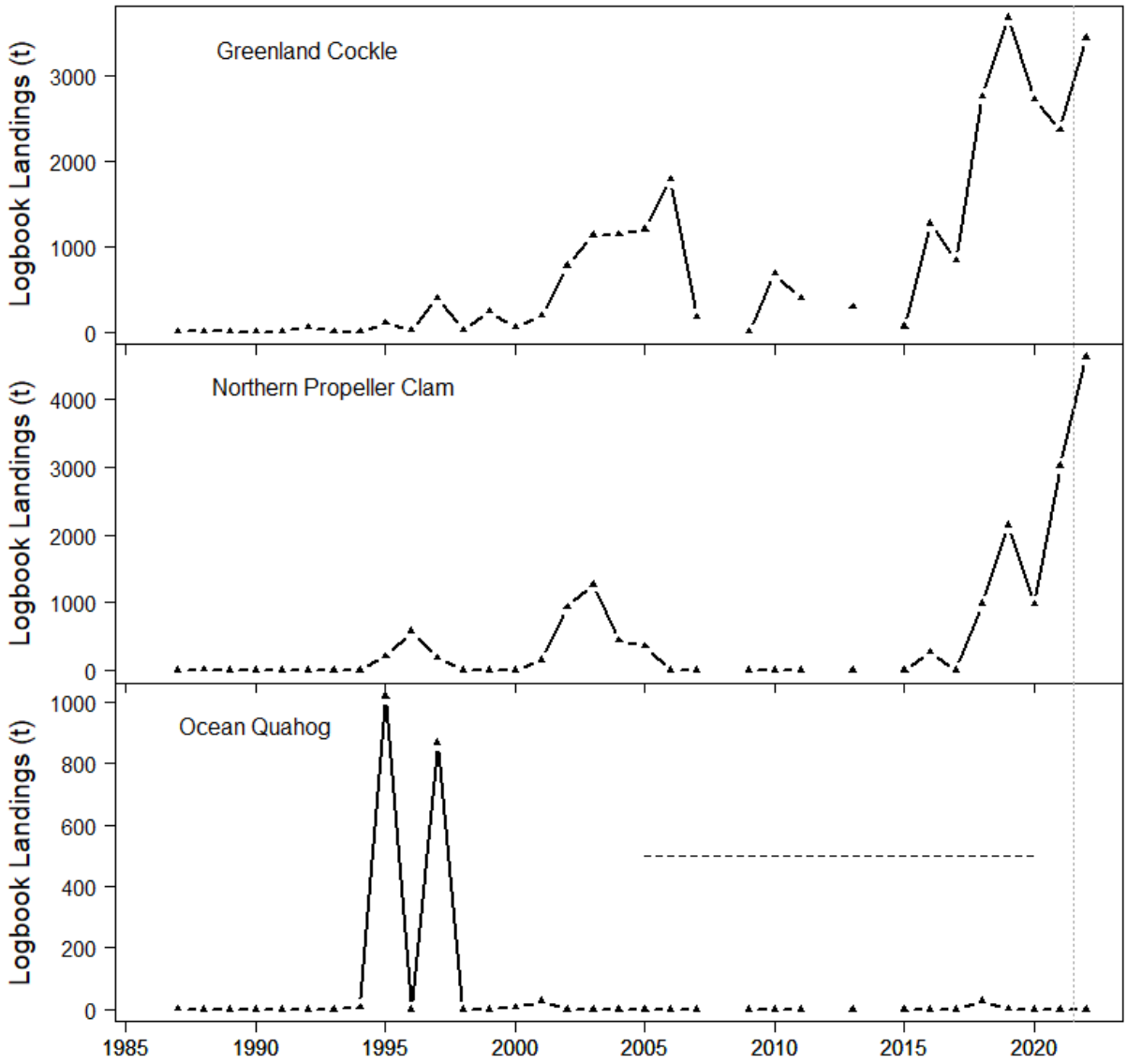

Figure 9. Landings from the fishery logbooks for three other clam species on Grand Bank from 1987 to 2022. Note different axes. Dashed horizontal line is maximum limit for Grand Bank. Dotted vertical line denotes a change from partial to full retention in the fishery.

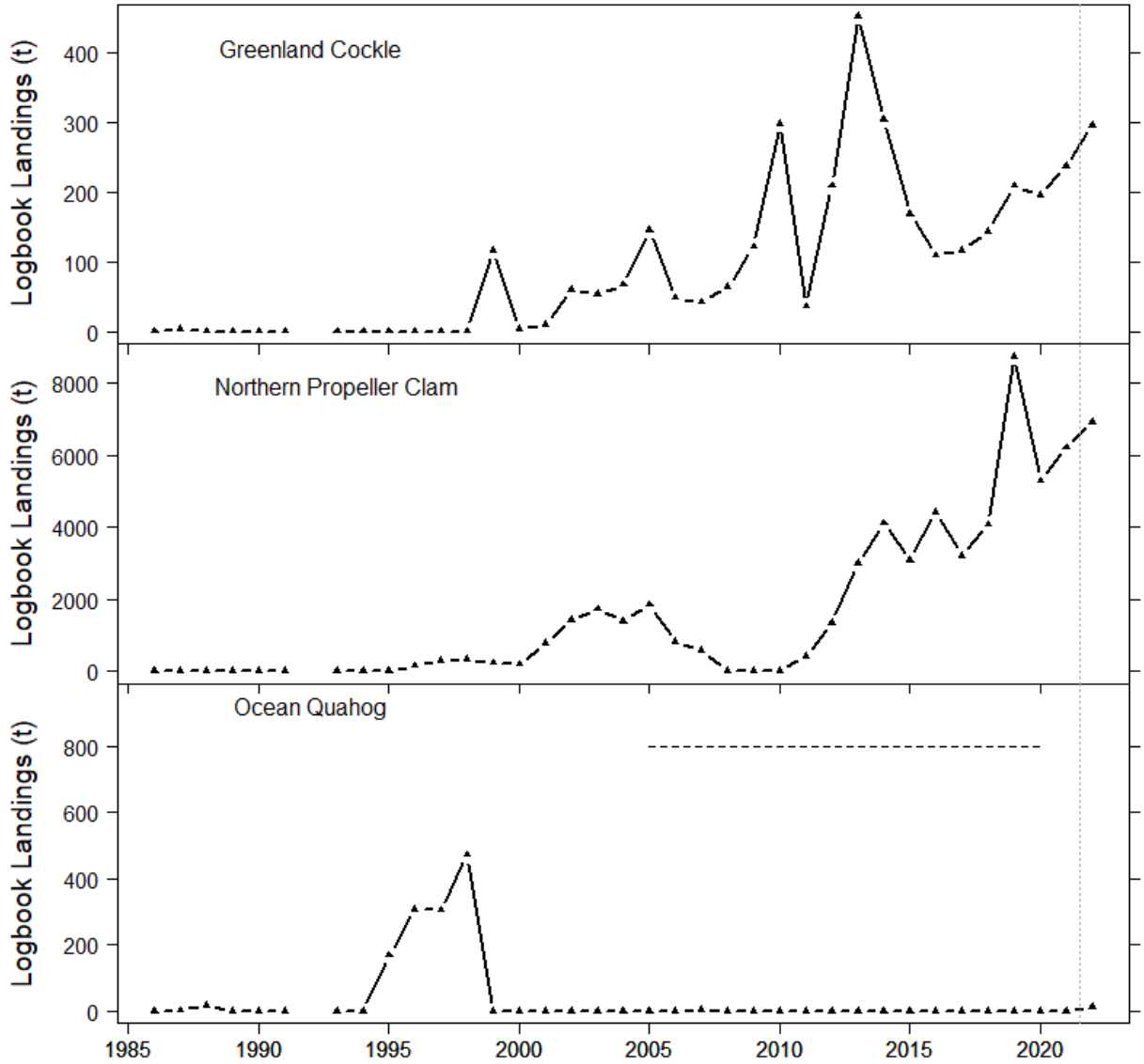

Figure 10. Landings from the fishery logbooks for three other clam species on Banquereau from 1986 to 2022. Note different axes. Dashed horizontal line is total allowable catch for Banquereau. Dotted vertical line denotes a change from partial to full retention in the fishery.

Sources of Uncertainty

This fishery is increasing in efficiency. This is evident in the relationship between CPUE and effort, and is the opinion of industry participants. Efficiencies have been gained in vessel capacity and the use of technology to locate, sort, and process the catch. The increasing ability of industry to maximize their catchability is not accounted for in the current model. These increases in efficiency and catchability can obscure actual biomass trends. There are no recent fishery independent data sources from which to estimate biomass or stock indicators. The last survey on Banquereau was in 2010, and the last surveys on Grand Bank were in 2006, 2008, and 2009.

The spatial production model parameters for growth rate and carrying capacity are partly confounded and potentially biased because a high growth rate and low carrying capacity give

the model more flexibility to fit the data. If the growth rate estimate is too high, and carrying capacity too low, reference points are likely to be overly optimistic (higher F_{MSY}—Fishing Mortality at Maximum Sustainable Yield, and lower B_{MSY}). This is likely happening with the reference points for Banquereau.

Conclusions

The Banquereau fished area stock is considered to be in the Healthy Zone; the 2022 biomass estimate is above the LRP, USR, and $CPUE_{70}$ references and this is supported by the secondary indicators. All the secondary indicators for Grand Bank are positive relative to their respective thresholds.

Potential removals were calculated using the 2022 median biomass estimates from the spatial production model. A removal rate of 0.5 F_{MSY} would result in a TAC (29,153 t) that is greater than the recent TACs for Banquereau (20,943 t since 2018). Recent TACs were lower than the removal amount at 0.5 F_{MSY} (e.g., DFO 2022). A removal rate of 0.33 M, where M is the natural mortality rate of 0.08 (Hubley and Heaslip 2018), would result in a much lower TAC when applied to the fished area biomass (Table 5). Previous analyses based on the surplus production model have estimated F_{MSY} near 0.09; however, catch rates tend to decline when Removal Reference (F) is greater than 0.045 (0.5 F_{MSY}). The removal reference rate of 0.5 F_{MSY} was proposed as an intermediate value between 0.33 M (which was developed for a larger less productive stock area) and F_{MSY}.

Table 5. Areal removals in tonnes for removal reference rates (F) for assessment areas (1–5) on Banquereau calculated using the 2022 median biomass estimates from the spatial production model.

Removal Reference (F)	Area 1	Area 2	Area 3	Area 4	Area 5	Total
0.5 F_{MSY} (0.045)	4,840	8,031	7,642	3,633	5,007	29,153
0.33 M (0.026)	2,823	4,684	4,457	2,119	2,920	17,004

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Appendix 1

Table A1. International Observer Program data on the percent (by weight) composition of landed species from Banquereau by year for the offshore clam fishery. Numbers under the years are the total number of observed trips for that year, partially observed trips are indicated as the proportion of observed days in the trip. Vertical line breaks represent potential changes in observer protocols. Hyphen (-) denotes species not present in that year. Only data collected since 2009 are shown, for older data see DFO2020b.

Common Name	2009	2010	2011	2012	2013	2014	2015	2018	2019	2020	2021	2022
	1.14	0.99	1	2	2	1	2	1	1	1	2	0.88
Arctic Surfclam	98.4	100	98.5	89.8	51.1	95.4	93.2	91.1	85.2	77.1	84.6	92.4
Northern Propeller Clam	-	-	-	7.4	10.9	4.2	6.3	8.9	13.9	22.1	15.0	7.2
Atlantic Surfclam	-	-	-	-	33.7	-	-	-	-	-	-	-
Greenland Smooth Cockle	1.6	-	1.5	2.9	4.3	0.4	0.5	-	0.6	0.8	0.3	0.4
Ocean Quahog	-	-	-	-	< 0.01	0.01	0.03	-	0.3	-	-	-

Table A2. International Observer Program data on the percent (by weight) composition of landed species from Grand Bank by year for the offshore clam fishery. Numbers under the years are the total number of observed trips for that year, partially observed trips are indicated as the proportion of observed days in the trip. Vertical line breaks represent potential changes in observer protocols. Hyphen (-) denotes species not present in that year. Only data collected in the last 20 years are shown, for older data see DFO2020b.

Common Name	2007	2016	2018	2019	2020	2021	2022
	0.59	1	1	1	0.6	0.4	1
Arctic Surfclam	20.8	96.2	90.9	94.2	78.0	68.8	73.4
Greenland Smooth Cockle	79.2	3.8	1.9	5.8	22.0	31.2	5.6
Northern Propeller Clam	-	-	5.7	-	-	-	20.9
Ocean Quahog	-	-	1.5	-	-	-	-
Atlantic Surfclam	-	-	-	-	-	-	-

Table A3. International Observer Program data of percent (by weight) composition of discards in the offshore clam fishery on Banquereau. Only species making up the top 99.99% (by weight) of the catch composition are shown. Numbers under the years are the total number of observed trips for that year, partially observed trips are indicated as the proportion of observed days in the trip. Vertical line breaks represent potential changes in observer protocols. Hyphen (-) denotes species not present in that year. Only data collected since 2009 are shown, for older data see DFO2020b.

Common Name	2009	2010	2011	2012	2013	2014	2015	2018	2019	2020	2021	2022
	1.1	0.99	0.9	2	2	1	2	1	1	1	2	0.88
Shells	-	14.2	34.2	13.6	40.4	24.4	33.8	67.1	26.0	47.1	45.0	75.9
Stones and Rocks	-	7.9	21.8	28.5	14.3	43.4	33.8	9.8	60.2	39.8	14.5	3.6
Sand Dollars	90.9	63.2	38.8	52.3	39.9	22.3	27.3	15.0	6.2	6.5	16.3	16.3
Sea Cucumbers	1.7	9.2	0.3	0.1	0.5	2.9	1.0	3.9	3.7	2.5	1.5	0.1
Whelk - Buccinidae	4.3	1.8	4.3	2.6	3.2	3.3	2.1	1.9	0.4	0.5	4.5	1.1
Sea Mouse	-	-	-	-	-	-	-	0.5	0.8	0.9	2.2	0.5
Sea Urchin - Echinoidea	< 0.1	0.4	0.3	0.4	0.2	1.7	0.3	0.5	0.4	0.3	2.7	0.2
Hermit Crab - Paguridae	< 0.1	< 0.1	0.1	0.2	0.2	0.3	0.2	0.1	0.5	0.3	2.0	0.2
Ocean Quahog	-	-	-	-	-	-	-	-	-	0.1	2.3	0.8
Sand Lances	-	0.1	0.1	0.2	-	0.2	0.1	0.1	0.3	0.3	1.3	0.1
Sea Star	0.5	-	< 0.1	0.3	0.1	1.1	0.3	0.1	0.5	0.3	0.5	0.1
Mussel	0.4	0.1	-	0.1	0.1	0.1	0.2	-	-	< 0.1	1.2	0.4
Thorny Skate	< 0.1	1.8	< 0.1	< 0.1	< 0.1	0.2	0.1	< 0.1	-	< 0.1	1.3	0.1
Scallop	< 0.1	0.7	-	-	0.1	-	< 0.1	0.7	-	-	0.5	0.1
Giant Sea Scallop	0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	-	0.4	0.3	0.1	-
Sea Anemone	-	-	-	-	-	-	< 0.1	< 0.1	0.2	0.2	0.4	0.1
Thorny-headed Worms	-	-	-	-	-	-	-	< 0.1	0.1	0.2	0.4	< 0.1
Iceland Scallop	0.2	< 0.1	0.1	< 0.1	< 0.1	0.1	< 0.1	-	< 0.1	0.1	0.6	-
Snow or Queen Crab	1.3	-	0.1	0.1	0.1	< 0.1	0.1	-	< 0.1	0.1	0.3	< 0.1
Greenland Smooth Cockle	-	-	-	-	-	-	-	-	-	0.2	0.2	-
Brittle Stars	-	-	-	< 0.1	-	-	-	-	-	-	0.3	< 0.1
Witch Flounder	< 0.1	-	-	-	-	-	-	-	-	-	0.3	-

Common Name	2009	2010	2011	2012	2013	2014	2015	2018	2019	2020	2021	2022
	1.1	0.99	0.9	2	2	1	2	1	1	1	2	0.88
Atlantic Rock Crab	-	-	-	-	-	-	-	-	0.2	0.1	0.1	-
American Plaice	< 0.1	< 0.1	-	< 0.1	< 0.1	< 0.1	< 0.1	-	< 0.1	< 0.1	0.2	-
Yellowtail Flounder	< 0.1	0.1	< 0.1	0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	-	0.2	-
Northern Propeller Clam	-	-	-	-	-	-	-	-	-	-	0.2	-
Smooth Skate	-	-	-	-	-	< 0.1	< 0.1	-	-	-	0.2	-
Sand	-	-	-	1.0	< 0.1	-	-	-	-	-	-	-
Skates	0.4	< 0.1	< 0.1	0.1	0.1	-	-	-	-	-	0.1	-
Annelid	-	-	-	< 0.1	-	-	0.7	-	-	-	-	-
Longhorn Sculpin	< 0.1	< 0.1	-	-	-	-	-	-	< 0.1	< 0.1	0.1	< 0.1
Polychaete	-	-	-	0.1	0.5	-	-	-	-	-	-	-
Silver Hake	-	-	-	-	-	-	-	-	-	-	0.1	< 0.1
Whelk Eggs	-	-	-	-	-	-	-	-	< 0.1	< 0.1	-	-
Foreign Articles/Garbage	-	-	-	-	-	-	-	-	-	-	0.1	-
Seasnail - *Liparis sp.*	-	-	-	-	-	-	-	-	-	-	0.1	-
Toad Crab - *Hyas sp.*	< 0.1	-	< 0.1	< 0.1	0.1	< 0.1	< 0.1	-	-	-	< 0.1	-
Sponges	-	-	-	-	< 0.1	-	< 0.1	-	-	-	< 0.1	-
Skate Eggs	-	-	-	-	-	-	-	-	-	-	-	0.1
Coral	< 0.1	<0.1	<0.1	-	< 0.1	-	-	-	-	-	< 0.1	-
Razor Clam	-	-	-	-	-	-	-	-	-	-	-	< 0.1
Clams - Heterodonta	-	-	-	-	-	-	-	-	-	-	< 0.1	-

Table A4. International Observer Program data of percent (by weight) composition of discards in the offshore clam fishery on Grand Bank. Only species making up the top 99.99% (by weight) of the catch composition are shown. Numbers under the years are the total number of observed trips for that year, partially observed trips are indicated as the proportion of observed days in the trip. Vertical line breaks represent potential changes in observer protocols. Hyphen (-) denotes species not present in that year. Only data collected in the last 20 years are shown, for older data see DFO2020b.

Common Name	2007	2016	2018	2019	2020	2021	2022
	0.6	1	1	1	0.6	0.4	2
Shells	-	-	69.7	63.4	34.5	13.3	68.8
Sand Dollars	96.8	-	5.7	14.4	54.5	64.3	13.4
Sea Cucumbers	-	93.6	15.2	14.4	-	-	2.5
Stones and Rocks	-	-	6.2	5.2	4.3	1.2	0.5
Northern Propeller Clam	-	-	-	-	5.3	19.7	1.7
Whelk - Buccinidae	-	6.3	0.5	1.1	-	-	3.7
Greenland Smooth Cockle	-	-	-	-	-	-	5.5
Sea Star	-	-	0.4	0.2	0.2	0.4	2.5
Sea Mouse	-	-	0.8	0.4	-	-	0.2
Clams - Heterodonta	-	-	0.5	0.4	-	-	-
Yellowtail Flounder	0.5	-	0.2	< 0.1	< 0.1	< 0.1	0.6
Hermit Crab - Paguridae	-	-	0.2	0.1	< 0.1	< 0.1	0.1
Sea Urchin - Echinoidea	-	-	0.2	0.1	< 0.1	< 0.1	-
Sand Lances	-	-	< 0.1	< 0.1	0.5	0.4	< 0.1
American Plaice	0.5	-	0.2	< 0.1	-	-	-
Snow or Queen Crab	1.4	-	-	< 0.1	0.3	0.2	< 0.1
Thorny Skate	0.4	-	< 0.1	< 0.1	-	0.1	0.1
Eggs Unidentified	-	-	-	-	-	-	0.2
Mussel	-	0.2	< 0.1	< 0.1	-	0	-
Seasnail - *Liparis sp.*	-	-	-	-	0.2	0.1	-
Thorny-headed Worms	-	-	-	0.1	< 0.1	< 0.1	-
Toad Crab - *H. coarctatus*	0.1	-	< 0.1	< 0.1	-	-	-
Spider Crab	-	-	< 0.1	-	-	-	-
Toad Crab - *Hyas araneus*	-	-	-	< 0.1	-	-	< 0.1
Scallop	-	-	-	-	0.1	< 0.1	-
Witch Flounder	0.4	-	< 0.1	-	-	-	-
Sea Anemone	-	-	< 0.1	-	-	-	-

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