Fisheries and Oceans Canada | Pêches et Océans Canada
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Canadian Science Advisory Secretariat
Maritimes Region **Science Response 2020/057**

STOCK STATUS UPDATE OF ARCTIC SURFCLAM (*MACTROMERIS POLYNYMA*) ON BANQUEREAU AND GRAND BANK TO THE END OF THE 2019 FISHING SEASON

Context

An update on the status of the offshore Arctic Surfclam 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 meeting on June 28–29, 2016. During the framework, 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 2019 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), and an update was conducted in 2019 (DFO 2019).

This Science Response Report results from the Science Response Process of June 9, 2020, on the Stock Status Update of Arctic Surf Clam.

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 the Northwest 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 were 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 area. The stock on Grand Bank is monitored with a set of fishery-dependent secondary indicators for biomass, fishery footprint, and size composition.

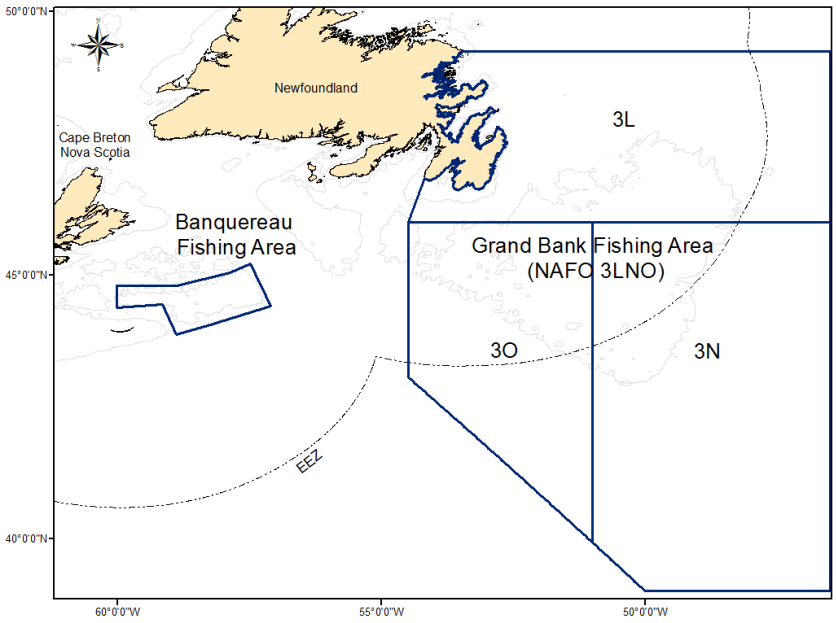

Figure 1. Banquereau and Grand Bank Arctic Surfclam fishing areas (solid lines) from licence conditions.

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 2019, there were three licences for offshore clam 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 60 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 2014). Observer requirements as identified in the Integrated Fisheries Management Plan (DFO 2014) were met in 2019 with one at-sea Fisheries Observer trip conducted per bank. The protocols for fisheries at-sea observers and the companies doing the work has 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 2019, the top three discard taxa were sand dollars, sea cucumber, and sea mouse, which in total accounted for 10.7% of the discards by weight (Table A3). On Grand Bank, in 2019, the top three discard taxa were sand dollars, sea cucumber, and whelk, which in total in total accounted for 29.9% of discards by weight (Table A4). 0,30

Fishery Data Types and Conversion Factors

Landings in the offshore clam fishery are in the form of products (Table 1). These products are converted to a round weight (i.e., whole animal weight) using conversion factors (DFO 2014). Not all landed product types (e.g., mantle) count against the TAC because the mantle 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. An additional component factor of 80% (i.e., 80% of the C-grade product is Surfclam, and 20% is not) was developed for this product and used for the first time in the 2019 fishery. The other mixed species products (recovery and mantle mix) in this fishery do not contain Surfclam foot and do not have conversion 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 or secondary indicators.

Table 1. Arctic Surfclam product types landed in the Offshore Clam fishery and the conversion factors applied to the product type. NA indicates no conversion factor is required for that product.

Product Type	Conversion Factor
Blanched foot (tongue)	6.51
Blanched mantle	NA
C-grade (mixed species product)	80% * 6.51

The other commonly retained species in the Offshore Clam fishery are Northern Propellerclam (*Cyrtodaria silique*), 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 currently based on a Statistical Coordinating Committee for the Atlantic Coast report (STACAC 1984), and work is underway to review and update if necessary.

Table 2. Other species product types landed in the Offshore Clam fishery and the conversion factors applied to the product types.

Species	Product Type	Conversion Factor
Northern propellerclam	Blanched siphon	5.5
Greenland cockle	Blanched foot (tongue)	5.5
Greenland cockle	Raw foot (tongue)	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, 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 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.

In 2019, industry representatives noted that landings data being presented by DFO Science did not match their own records. This prompted a comparison of the industry records with the CLAM database and discrepancies were noted for product weights across all species. Data from the end of 2010 onward were reviewed in detail and two systemic errors in the data that had been submitted to DFO Science were identified. After the causes of the discrepancies were identified, the correct landings data were loaded into the CLAM database. Data from the end of 2010 onward were corrected. These data covered 200 trips across four vessels and two banks.

Data presented in this document may differ from previous documents, which is due to the changes resulting from the data review. The data correction did not retroactively change any recent determinations of stock status.

Analysis and Response

Commercial Fishery

In 2019, Arctic Surfclam landings in the MARFIS and Catch and Effort Database were 21,126 t against a TAC of 20,943 t for Banquereau and 14,925 t against a TAC of 14,756 t for Grand Bank. On Grand Bank, the mean Catch Per Unit Effort (CPUE) in 2019 was 134 g/m^2, an increase from 129 g/m^2 in 2018. On Banquereau, in 2019, mean CPUE was 147.9 g/m^2, an increase from 125 g/m^2 in 2018. 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 decreased or stayed the same. This is likely due to the increasing efficiency of the fleet on this bank.

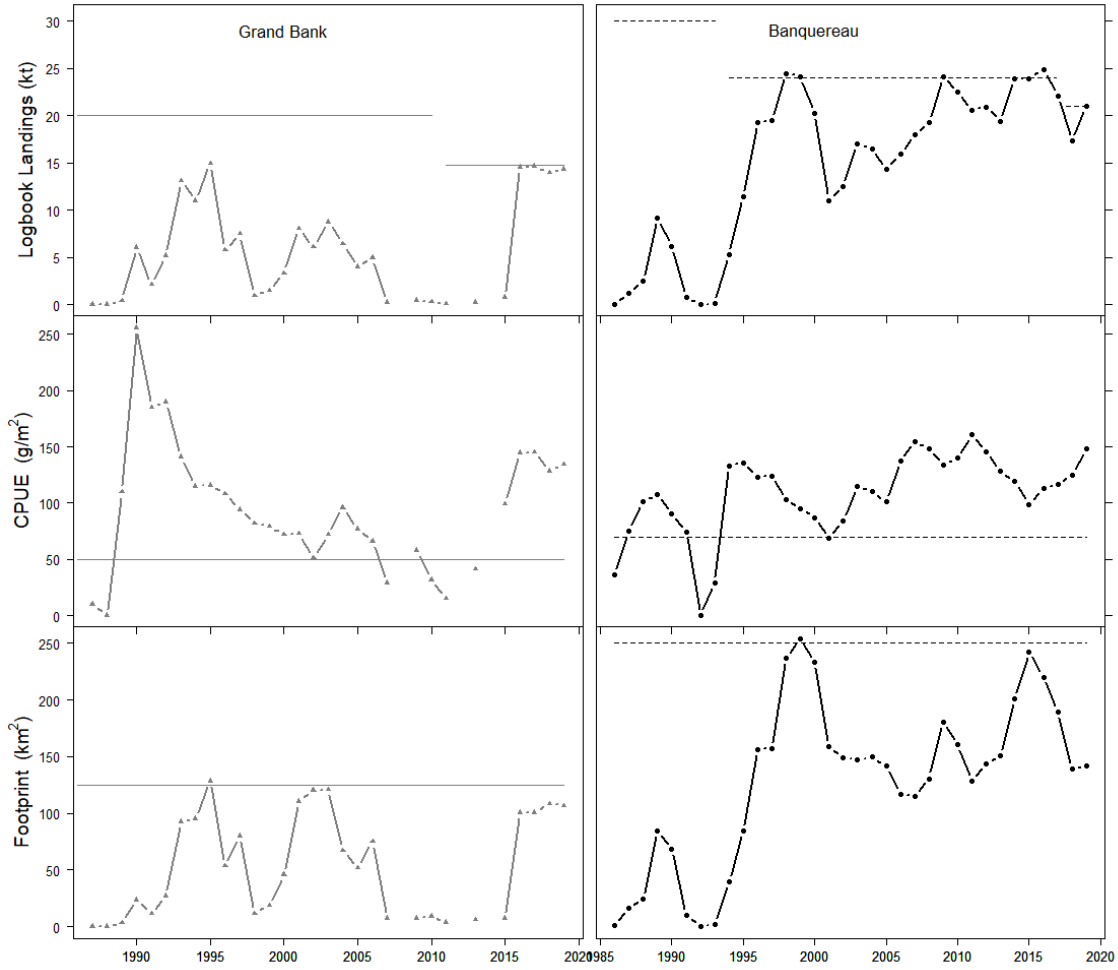

Figure 2. Landings in kilotonnes (kt), catch per unit effort (CPUE; g/m^2), and fishery footprint (km^2) for Grand Bank (left) from 1987 to 2019 and Banquereau (right) from 1986 to 2019. Horizontal lines represent bank-specific total allowable catch (top panels) or threshold levels for secondary indicators (bottom four panels; see: Indicators of Stock Status).

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 is 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.

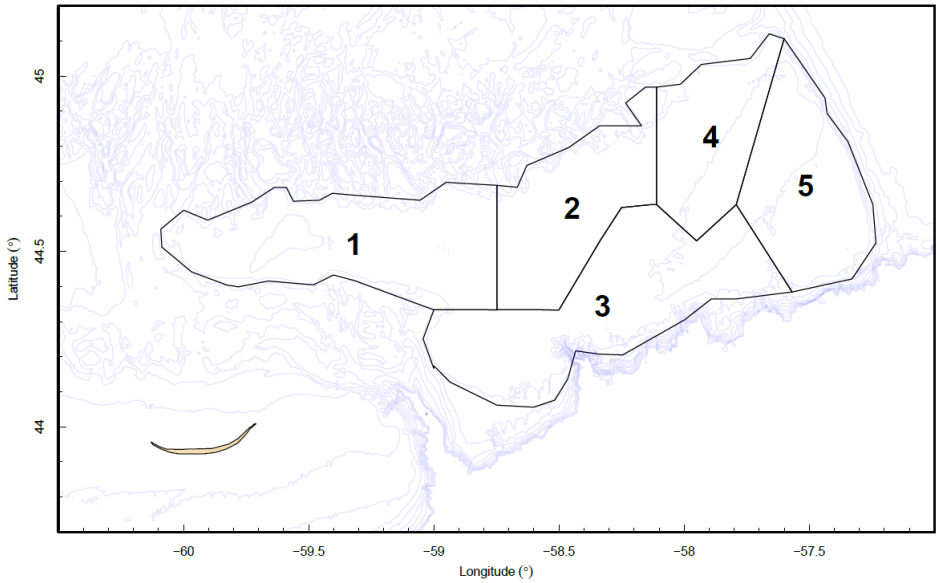

Figure 3. Five spatial assessment areas on Banquereau used in the assessment.

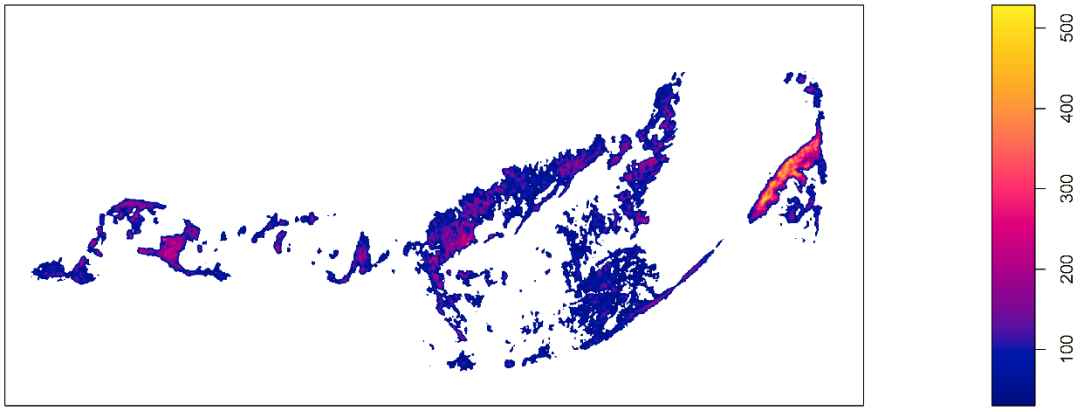

Figure 4. Vessel Monitoring System (VMS) density on Banquereau estimated from a kernel smoothed intensity function with a standard deviation of 0.2 on a 100 m^2 resolution. The scale bar shows VMS intensity expressed as the number of transmissions (pings) per km^2 for 2004–2016. The colored region shows 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. In 2019, catch rates increased in three of the five areas and decreased in the other two. The highest catch rates and the largest increase was in Area 2, where catch rates increased from 110.1 t/km^2 in 2018 to 156.4 t/km^2 in 2019.

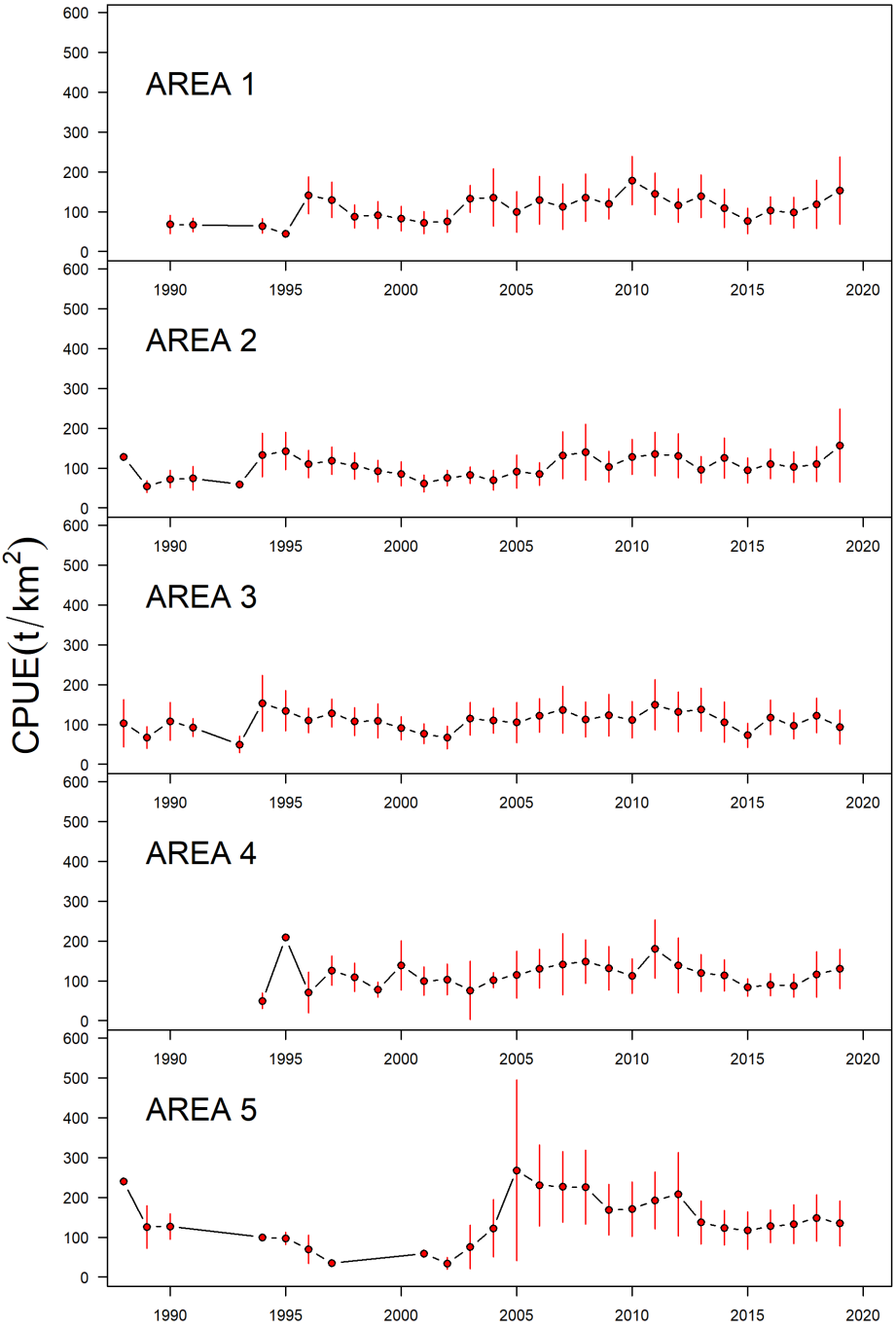

Figure 5. Banquereau Catch Per Unit Effort (CPUE; tonnes per km^2) by spatial assessment area (1 to 5) showing the annual mean values (red points) ±1 standard error (red lines).

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, and they do not typically occur in multiple areas in the same year. In 2019, exploitation rates increased in Areas 1 and 4, and they decreased in

the other areas. Exploitation rate in Area 1 was the highest overall at 0.12. Exploitation rates in the other areas ranged from 0.005 to 0.024.

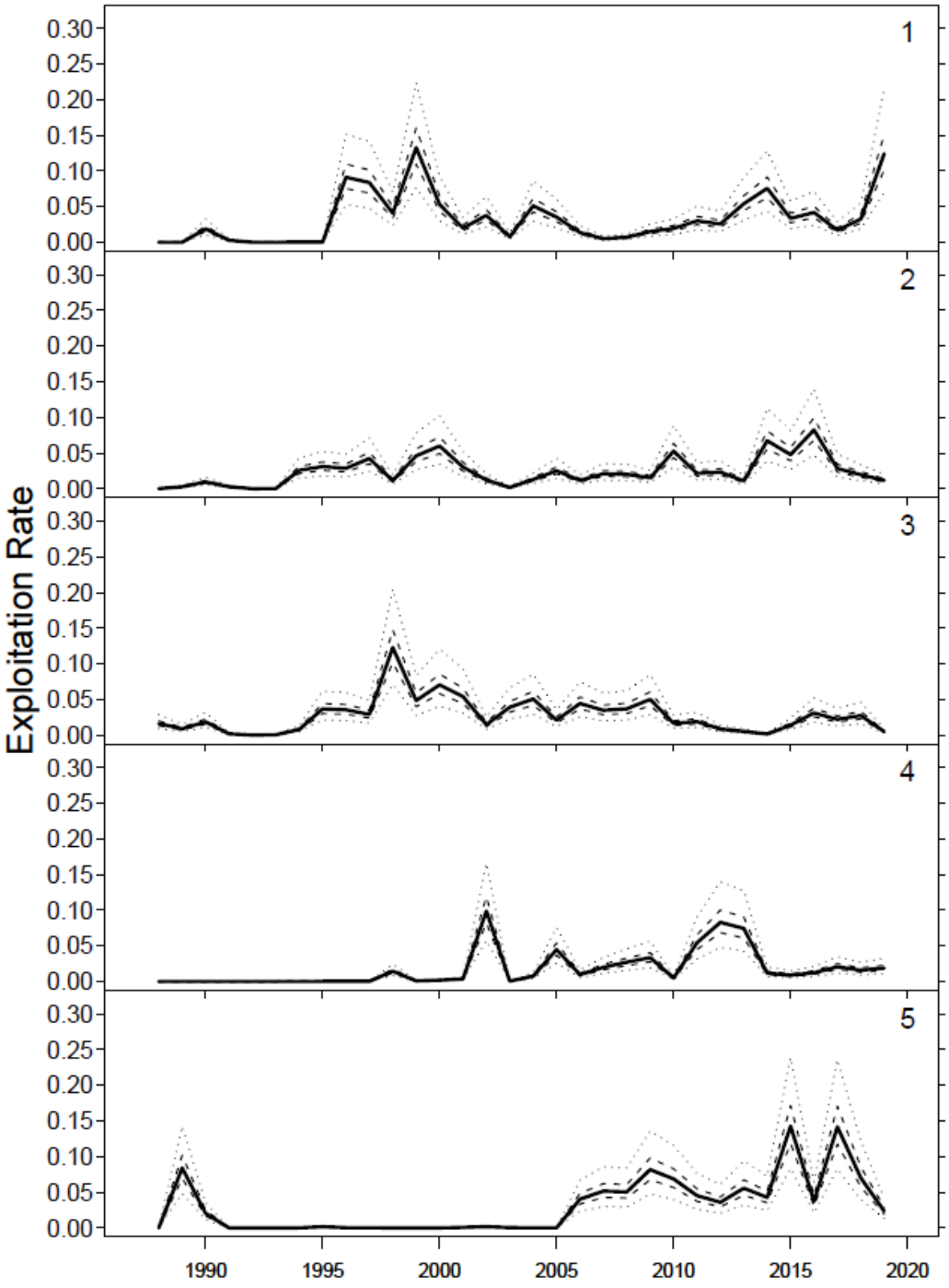

Figure 6. Estimates of exploitation rate on Banquereau for 1988–2019 from the spatial production model by assessment area. Lines denote the median (solid), 50% credible interval (dashed), and 95% credible interval (dotted).

Median areal biomass estimates from the model in 2019 indicate all areas are within 10% of the biomass estimates in the previous year (Figure 7), except for Area 2, which increased by 13%.

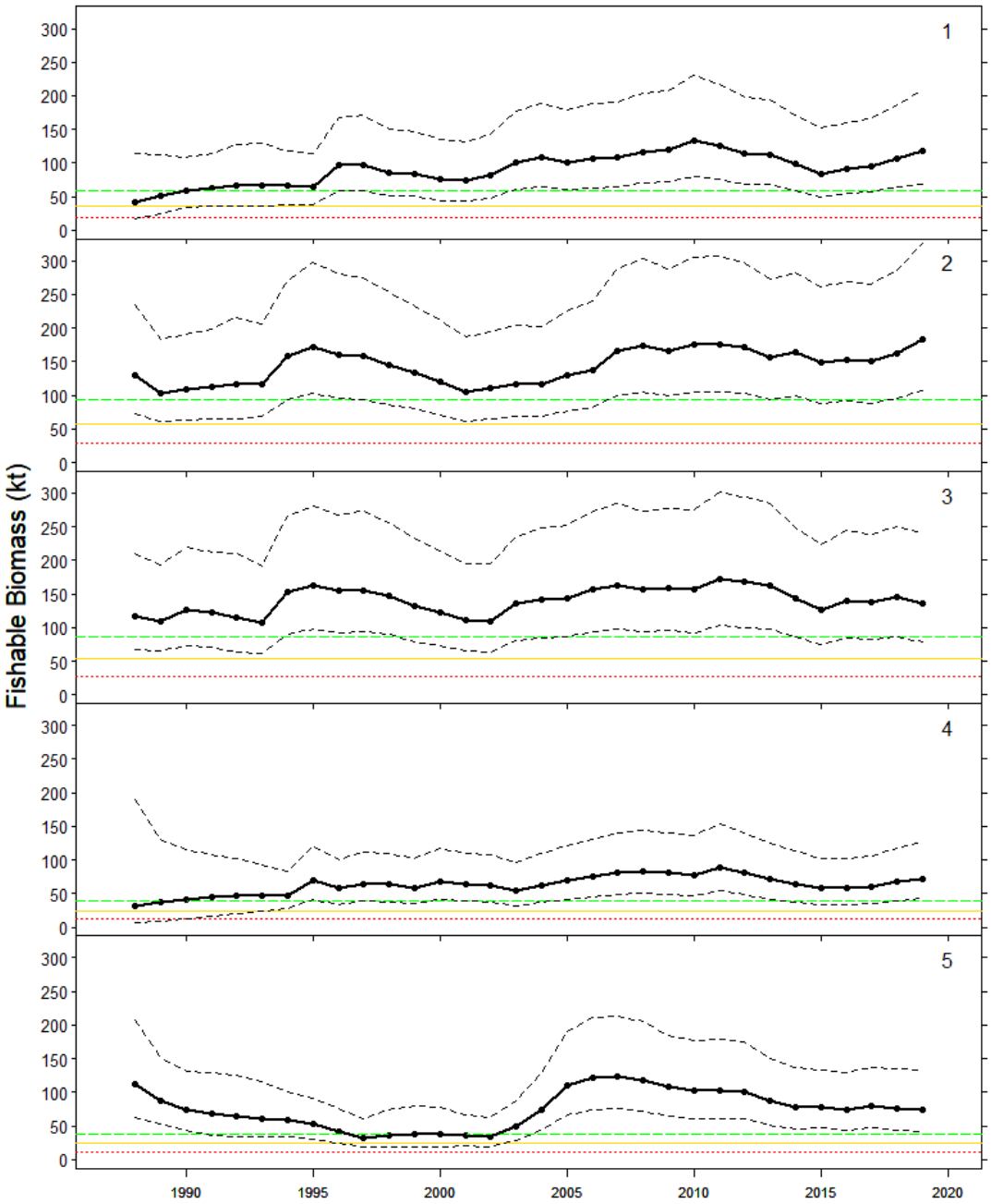

Figure 7. Estimates of fishable biomass (kilotonnes) on Banquereau from the spatial production model by assessment area. Black lines denote the median estimate (solid line with circles) and 95% credible interval (dotted line). The horizontal lines represent (from top to bottom): $CPUE_{70}$ reference (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. CPUE 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 2019 (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 needs to be 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 2019 (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 105 mm for Grand Bank. Both banks were above the size composition indicator threshold in 2019 (Table 3). During the analysis of the size data, it was discovered that some length-frequency samples had no location information and, therefore, had not been accounted for in previous analyses. These samples were assigned to a bank based on the trip in which they were collected. The inclusion of these samples caused some small changes (± <0.1%) to the percentage values in the affected years.

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

Year	Grand Bank % >105 mm	n	Banquereau % >120 mm	n
2010	1.34	224	3.64	16,683
2011	0	251	7.31	10,841
2012	-	-	4.46	12,244
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

- 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 2019, the probability that the biomass estimate was above the USR and the $CPUE_{70}$ reference line was 0.95 or greater 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 2019, the estimated median total biomass in the fished areas was 583,514 t (95% CI: 337,550–1,035,889 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 >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 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	0.95
4	>0.99	>0.99	0.99
5	>0.99	>0.99	0.99
Total	>0.99	>0.99	>0.99

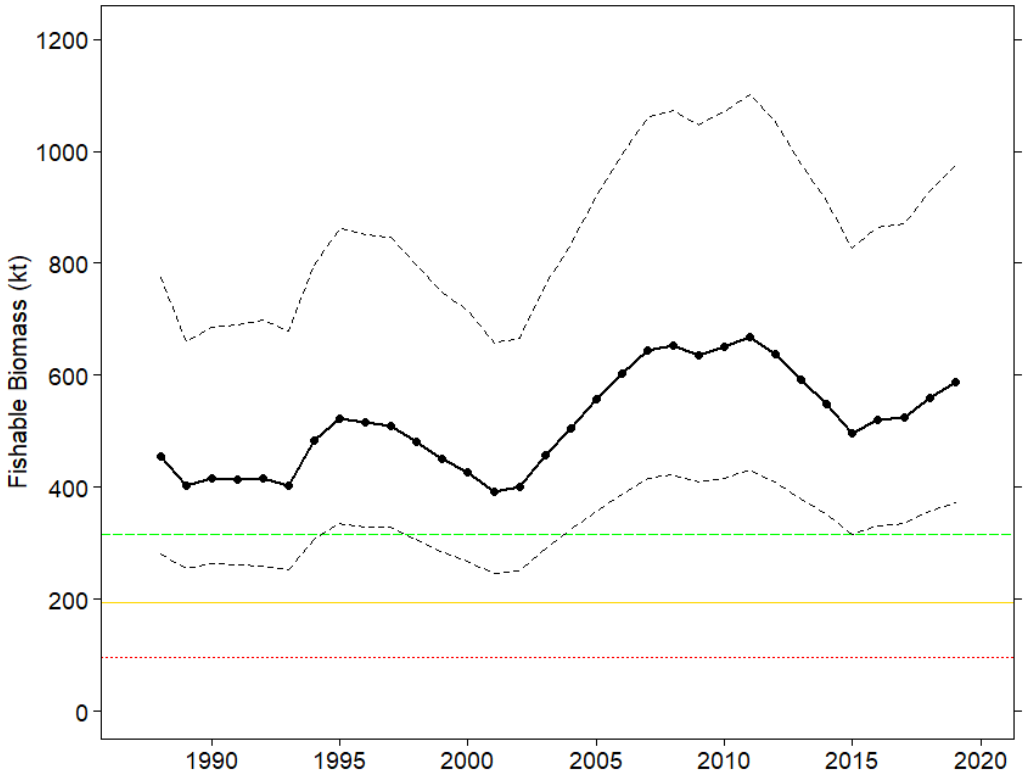

Figure 8. Estimate of fishable biomass (kilotonnes) on Banquereau from 1988 to 2019 from the spatial production model for the total fished area. The black lines denote the median estimate (solid line with circles) and 95% credible interval (dotted line). The horizontal lines represent (from top to bottom): $CPUE_{70}$ 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 2014) allows for the retention of other clam species. Since 2005, there has been no limit on the bycatch of Northern Propellerclam or Greenland Cockle. Greenland Cockle is more often caught on Grand Bank than Banquereau. Greenland Cockle landings on Grand Bank increased substantially from 2015 (170 t) to 2019 (3,712 t). Northern Propellerclam is caught more frequently on Banquereau, where landings increased annually from 2010 to 2014. Since 2014, landings on Banquereau have fluctuated but remained high relative to earlier years. Landings of Northern Propellerclam on Banquereau in 2019 (8,524 t) are nearly double 2018 landings (4,303 t). On Grand Bank,

landings of Northern Propellerclam more than doubled from 987 t in 2018 to 2,143 t in 2019. Ocean 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 2019, the TAC was not exceeded for Ocean Quahog on either bank (Figure 9).

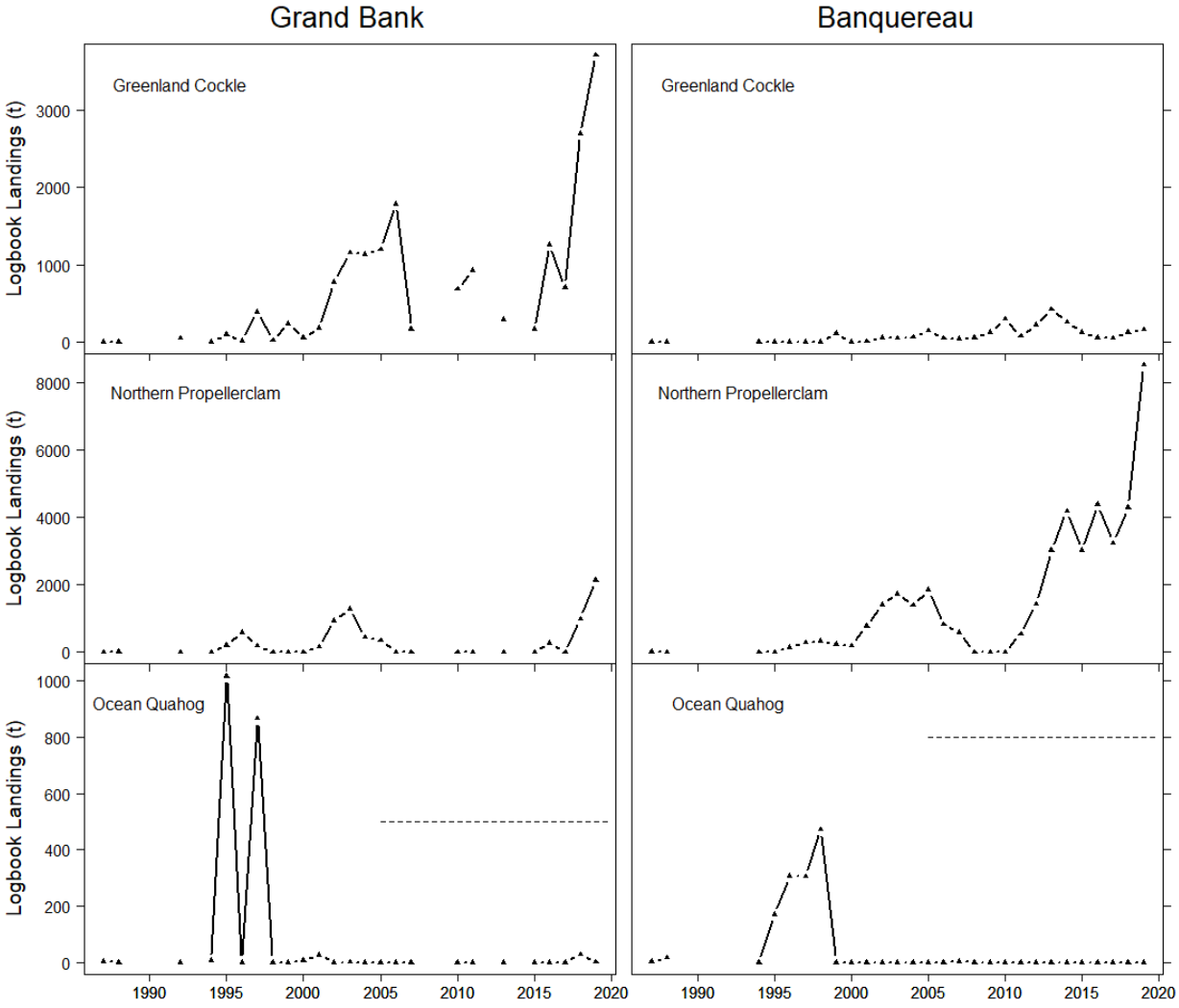

Figure 9. Landings from the fishery logbooks for three other clam species on Grand Bank (left column) and Banquereau (right column) from 1987 to 2019. Dashed horizontal line is maximum limit for Grand Bank and total allowable catch for Banquereau. Note different axes.

Sources of Uncertainty

This fishery is increasing in efficiency. This is evident in the relationship between CPUE and effort, and this is also the opinion of industry participants as well. Efficiencies have been gained in both finding the animals but also, increasingly, in onboard sorting and processing. 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 estimates or

stock indicators. The last survey on Banquereau was in 2010, and the last survey on Grand Bank was 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 2019 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 removal amounts were calculated using the 2019 biomass estimates from the spatial production model. A removal level of 0.5 F_{MSY} would result in a TAC (25,676 t) that is greater than the 2020 TAC for Banquereau (20,943 t). The 2020 TAC was lower than the removal amount at 0.5 F_{MSY} (DFO 2019). A removal level 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 level 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 levels (F) for assessment areas (1–5) on Banquereau calculated using the 2019 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)	5,173	8,122	5,970	3,171	3,240	25,676
0.33 M (0.026)	3,017	4,737	3,482	1,850	1,890	14,976

Contributors

Name	Affiliation
Leslie Nasmith (Lead)	DFO Science, Maritimes Region
Monica Bravo	DFO Science, Maritimes Region
Freya Keyser	DFO Science, Maritimes Region
Brad Hubley	DFO Science, Maritimes Region
Lottie Bennett	DFO Science, Maritimes Region
Carl MacDonald	DFO Resource Management, Maritimes Region
Martin Henri	DFO Resource Management, Newfoundland and Labrador Region

Approved by

Alain Vézina
Regional Director of Science
DFO Maritimes Region
Dartmouth, Nova Scotia
Phone: 902-426-3490
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Sources of Information

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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. Vertical line breaks represent potential changes in observer protocols. Hyphen (-) denotes species not present in that year.

Common Name	1990	1991	1993	1994	1995	1998	1999	2007	2009	2010	2011	2012	2013	2014	2015	2018	2019
	8	1	1	2	2	2	2	2	2	2	1	2	2	1	2	1	1
Arctic Surfclam	99.8	100	99.3	100	99.5	95.7	96.4	92.1	98.4	100	98.5	89.8	51.1	95.4	93.2	91.1	85.2
Northern Propellerclam	0.1	-	-	0.01	0.3	4.3	3.6	1.4	-	-	-	7.4	10.9	4.2	6.3	8.9	13.9
Atlantic Surfclam	-	-	-	-	-	-	-	-	-	-	-	-	33.7	-	-	-	-
Greenland Smooth Cockle	-	-	0.7	0.01	0.2	-	-	6.5	1.6	-	1.5	2.9	4.3	0.4	0.5	-	0.6
Ocean Quahog	0.1	-	-	-	-	-	-	-	-	-	-	-	<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. Vertical line breaks represent potential changes in observer protocols. Hyphen (-) denotes species not present in that year.

Common Name	1990	1991	1992	1993	1994	1995	1996	1997	2007	2016	2018	2019
	18	5	8	1	3	4	3	2	1	1	1	1
Arctic Surfclam	100	97.3	93.0	96.0	95.7	96.1	92.9	94.3	20.8	96.2	90.9	94.2
Greenland Smooth Cockle	-	2.7	7.0	4.0	4.3	3.58	-	5.7	79.2	3.8	1.9	5.8
Northern Propellerclam	-	-	-	-	-	0.3	7.1	-	-	-	5.7	-
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. Vertical line breaks represent potential changes in observer protocols. Hyphen (-) denotes species not present in that year.

Common Name	1990	1991	1993	1994	1995	1998	1999	2007	2009	2010	2011	2012	2013	2014	2015	2018	2019
	8	1	1	2	2	2	2	2	2	2	1	2	2	1	2	1	1
Shells	-	-	-	-	-	-	-	-	-	14.2	34.2	13.6	40.4	24.4	33.8	67.1	26.0
Stones and Rocks	14.4	0.5	-	1.2	-	2.2	25.6	-	-	7.9	21.8	28.5	14.3	43.4	33.8	9.8	60.2
Sand Dollars	18.8	21.9	70.8	42.6	-	18.3	9.6	98.5	90.9	63.2	38.8	52.3	39.9	22.3	27.3	15.0	6.2
Foreign Articles/Garbage	62.3	76.6	-	53.2	-	76.2	46.6	-	-	-	-	-	-	-	-	-	-
Sea Cucumbers	2.6	-	12.8	0.3	59.4	0.4	10.9	-	1.7	9.2	0.3	0.1	0.5	2.9	1.0	3.9	3.7
Whelk - Buccinidae	0.3	-	-	0.1	-	1.0	0.9	-	4.3	1.8	4.3	2.6	3.2	3.3	2.1	1.9	0.4
Sea Mouse	0.1	-	-	0.2	-	0.4	0.7	-	-	-	-	-	-	-	-	0.5	0.8
Sea Urchin - Echinoidea	0.3	<0.1	0.7	0.1	3.2	0.3	0.3	-	<0.1	0.4	0.3	0.4	0.2	1.7	0.3	0.5	0.4
Sea Star	0.2	-	<0.1	0.1	-	0.2	0.4	-	0.5	-	<0.1	0.3	0.3	1.1	0.3	0.1	0.5
Sand	-	-	-	1.9	-	-	3.1	-	-	-	-	1.0	<0.1	-	-	-	-
Hermit Crab - Paguridae	-	-	-	<0.1	-	-	-	-	<0.1	<0.1	0.1	0.2	0.2	0.3	0.2	0.1	0.5
Scallop	-	-	-	<0.1	1.2	<0.1	<0.1	-	<0.1	0.7	-	-	0.1	-	<0.1	0.7	-
Giant Sea Scallop	-	-	0.3	-	-	<0.1	<0.1	-	0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	-	0.4
Sand Lances	<0.1	-	-	<0.1	-	<0.1	<0.1	-	-	0.1	0.1	0.2	-	0.2	0.1	0.1	0.3
Skates	0.2	<0.1	-	<0.1	1.1	-	-	-	0.4	<0.1	<0.1	0.1	0.1	-	-	-	-
Snow or Queen Crab	-	-	<0.1	<0.1	-	<0.1	<0.1	1.5	1.3	-	0.1	0.1	0.1	<0.1	0.1	-	<0.1
Sea Anemone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.1	0.2
Thorny Skate	-	-	3.3	-	19.3	<0.1	<0.1	-	<0.1	1.8	<0.1	<0.1	<0.1	0.2	0.1	<0.1	-
Annelid	-	-	-	-	-	-	-	-	-	-	-	<0.1	-	-	0.7	-	-
Atlantic Rock Crab	-	-	-	-	-	-	<0.1	-	-	-	-	-	-	-	-	-	0.2
Acanthocephala	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.1	0.1
Polychaete	-	-	-	-	-	-	-	-	-	-	-	0.1	0.5	-	-	-	-
Mussel	-	-	0.2	-	1.9	-	-	-	0.4	0.1	-	0.1	0.1	0.1	0.2	-	-
Cockles	-	-	-	<0.1	-	0.8	0.5	-	-	-	-	-	-	-	-	-	-
Iceland Scallop	-	-	1.1	<0.1	0.4	-	0.3	-	0.2	<0.1	0.1	<0.1	<0.1	0.1	<0.1	-	<0.1
Yellowtail Flounder	<0.1	<0.1	0.1	<0.1	0.4	-	<0.1	-	<0.1	0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1
Whelk Eggs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.1
Iceland Cockle	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toad Crab – *Hyas* sp.	-	-	-	-	-	-	-	-	<0.1	-	<0.1	<0.1	0.1	<0.1	<0.1	-	-
American Plaice	<0.1	-	0.3	<0.1	1.0	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1
Northern Quahog	<0.1	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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. Vertical line breaks represent potential changes in observer protocols. Hyphen (-) denotes species not present in that year.

Common Name	1990	1991	1992	1993	1994	1995	1996	1997	2007	2016	2018	2019
	18	5	8	1	3	4	3	2	1	1	1	1
Shells	-	-	-	-	-	-	-	-	-	-	69.7	63.4
Sand Dollars	34.7	52.2	83.2	-	-	3.3	8.9	-	96.8	-	5.7	14.4
Sea Cucumbers	<0.1	<0.1	<0.1	-	1.1	-	0.1	-	-	93.6	15.2	14.4
Foreign Articles/Garbage	51.7	40.0	7.5	-	-	16.8	78.7	-	-	-	-	-
Stones and Rocks	6.7	4.7	3.6	-	-	21.8	3.3	-	-	-	6.2	5.2
Cockles	0.5	-	4.7	-	-	52.9	2.1	-	-	-	<0.1	-
Whelk - Buccinidae	-	-	<0.1	-	0.2	-	0.22	-	-	6.3	0.5	1.1
Sea Mouse	-	-	-	-	-	-	-	-	-	-	0.8	0.4
Clams	-	2.2	-	-	-	-	<0.1	-	-	-	0.5	0.4
Sea Star	0.1	<0.1	-	-	-	<0.1	0.4	-	-	-	0.4	0.2
Sea Urchin - Echinoidea	-	<0.1	<0.1	57.3	0.3	0.1	0.1	-	-	-	0.2	0.1
Hermit Crab - Paguridae	-	-	-	-	-	<0.1	<0.1	-	-	-	0.2	0.1
Sand	0.2	-	-	-	-	-	4.7	-	-	-	-	-
American Plaice	<0.1	<0.1	<0.1	5.3	3.8	<0.1	<0.1	-	0.5	-	0.2	<0.1
Yellowtail Flounder	-	-	<0.1	-	-	-	<0.1	-	0.5	-	0.2	<0.1
Iceland Cockle	2.9	-	-	-	-	-	0.1	-	-	-	-	-
Toad Crab - *Hyas araneus*	-	-	-	-	17.5	3.1	0.6	-	-	-	-	<0.1
Sand Lances	0.9	0.2	0.3	-	-	0.1	0.2	-	-	-	<0.1	<0.1
Offshore Sand Lance	-	0.5	0.5	-	21.5	0.3	<0.1	-	-	-	-	-
Mussel	-	-	-	-	-	-	-	-	-	0.2	<0.1	<0.1
Conchs	1.5	-	-	-	-	-	-	-	-	-	-	-
Thorny Skate	-	-	<0.1	6.7	-	<0.1	<0.1	-	0.4	-	<0.1	<0.1
Spinytail Skate	-	-	-	-	48.0	-	-	-	-	-	-	-
Toad Crab - *H. coarctatus*	-	-	-	-	-	-	-	-	0.1	-	<0.1	<0.1
Spider Crab	-	-	-	-	-	-	-	-	-	-	<0.1	-
Toad Crab - *Hyas* sp.	-	-	-	-	-	0.6	-	96.6	-	-	-	-
Snow or Queen Crab	<0.1	<0.1	<0.1	28.0	6.4	<0.1	-	-	1.4	-	-	<0.1
Thorny-headed Worms	-	-	-	-	-	-	-	-	-	-	-	0.1
Nutclam - *Nuculana sp.*	0.4	-	-	-	-	-	0.2	-	-	-	-	-
Brachiuran Crabs	<0.1	<0.1	0.1	-	-	0.4	<0.1	-	-	-	-	-

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Center for Science Advice (CSA)
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Fisheries and Oceans Canada
Bedford Institute of Oceanography
1 Challenger Drive, PO Box 1006
Dartmouth, Nova Scotia B2Y 4A2

Telephone: 902-426-7070
E-Mail: MaritimesRAP.XMAR@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

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