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Canadian Science Advisory Secretariat
Maritimes Region **Science Response 2019/041**

STOCK STATUS UPDATE OF ARCTIC SURFCLAM (*MACTROMERIS POLYNYMA*) ON BANQUEREAU AND GRAND BANK TO THE END OF THE 2018 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 2018 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. 2018) and an update was conducted in 2018 (DFO 2018).

This Science Response Report results from the Science Response Process of May 15, 2019, on the Stock Status Update of Arctic Surf Clam. Additional publications from this meeting will be posted on the DFO Science Advisory Schedule as they become available.

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 Northwest Atlantic Fisheries Organization (NAFO) Area 3LNO, with some restrictions as outlined in the license 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 one survey in 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.

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 2018, there were three licences for offshore clam, with two vessels fishing on Banquereau and one vessel fishing on Grand Bank. 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 – 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 2018 with one at-sea fisheries observer trip conducted per bank. There is a commitment for DFO Science to review observer data annually and report if there is a substantial change in bycatch trends (DFO 2017). Data from the 2018 trips are under review. See Hubley et al. (2018) for the most recent review of at-sea observer data.

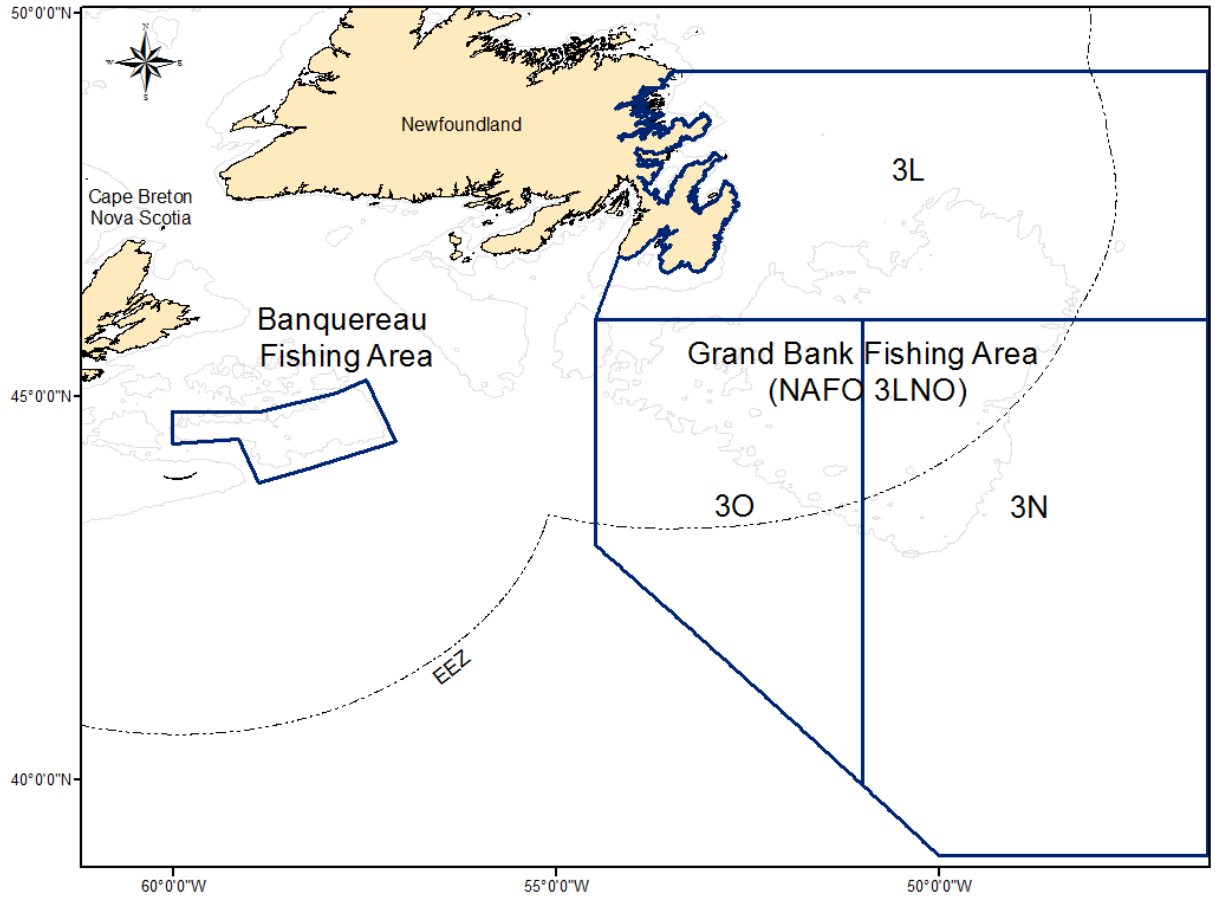

Figure 1. Banquereau and Grand Bank Arctic Surfclam fishing areas (solid lines) from licence conditions.

Analysis and Response

Commercial Fishery

From 2007 to 2015, fishing effort and landings on Grand Bank were low (range: 0 – 730 t). Effort and landings increased in 2016 and were sustained in 2017. In 2018, landings from the logbook records on Grand Bank were 14,100 tonnes (t) against a TAC of 14,756 t. The mean Catch Per

Unit Effort (CPUE) was 130 g/m^2, a decrease from 145 g/m^2 in 2017. In 2018, landings from the logbook records on Banquereau were 17,553 t against a TAC of 20,943 t. The mean CPUE was 126 g/m^2, an increase from 116 g/m^2 in 2017. Landings and CPUE time series for both banks are shown in Figure 2. The 2018 landings for Banquereau are a decrease from the previous year's landings and the TAC was not fully subscribed in 2018. This result is likely a reflection of management decisions in the allocation of the TAC and not indicative of changes in the fishery or stock.

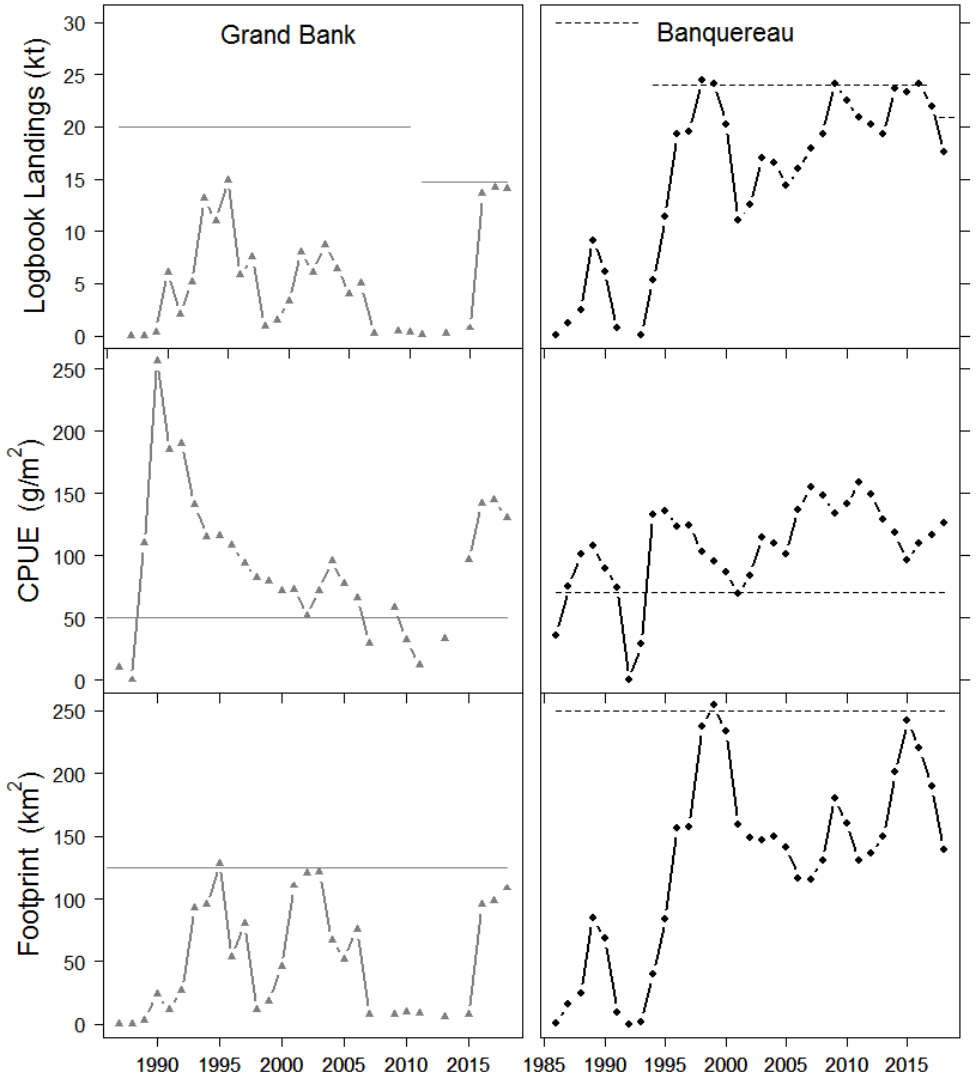

Figure 2. Logbook landings in kilotonnes (kt), catch per unit effort (CPUE; g/m^2), and fishery footprint (km^2) for Grand Bank (left) from 1987 to 2018 and Banquereau (right) from 1986 to 2018. Horizontal lines represent Bank-specific total allowable catch (top panels) or threshold levels for secondary 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 and areal expansion of the Surfclam density (g/m^2) was limited to the fished area.

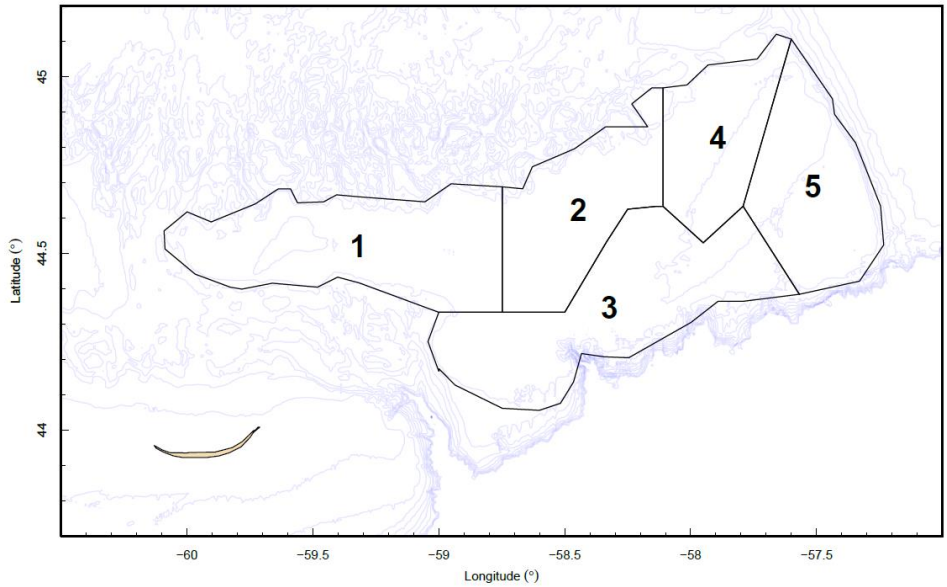

Figure 3. Five spatial assessment areas on Banquereau used in the assessment.

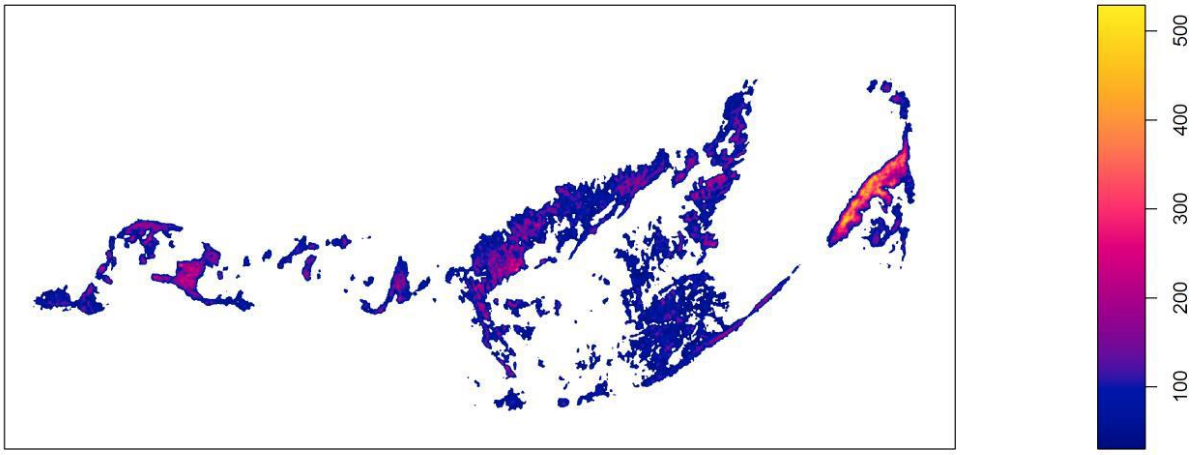

Figure 4. Vessel Monitoring System (VMS) density on Banquereau estimated from a kernel smoothed intensity function with a standard deviation of 0.2 on a 100 m^2 resolution. The scale bar shows VMS intensity expressed as the number of transmissions (pings) per km^2 for 2004–2016. The colored region shows 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 2018, catch rates increased in all areas. The largest increase was in area 4, where catch rates increased from 89.5 t/km^2 in 2017 to 120.2 t/km^2 in 2018. Catch rates in area 5 were the highest in 2018 at 152.2 t/km^2.

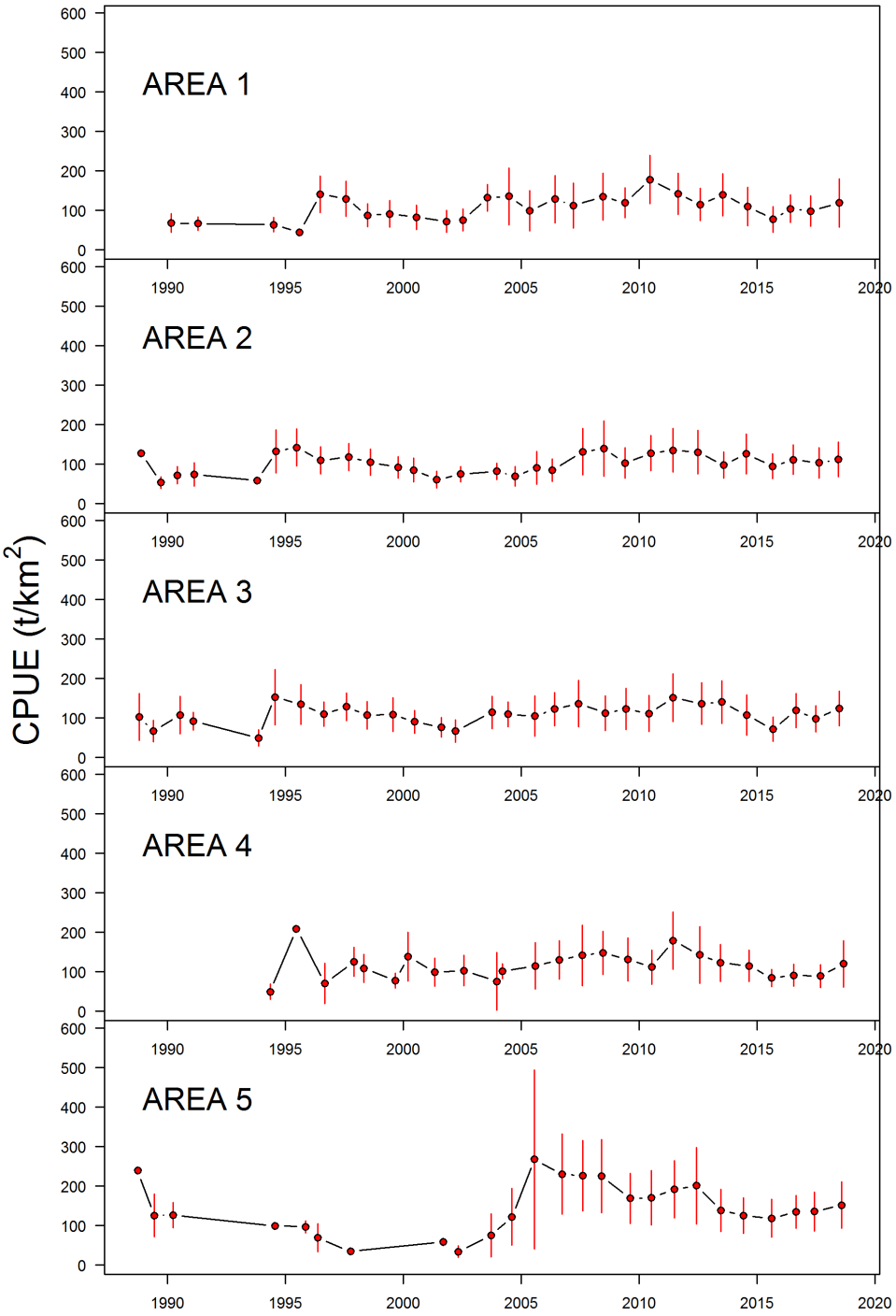

Figure 5. Banquereau Catch Per Unit Effort (CPUE; tonnes per km^2) by spatial assessment area (1 to 5) showing the annual mean values (red points) ± 1 standard error (red lines).

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, and they do not typically occur in multiple areas in the same year. In 2018, exploitation rates increased in areas 1 and 3, and decreased in the

other areas. Exploitation rate in area 5 was the highest overall at 0.07. Exploitation rates in the other areas ranged from 0.02 to 0.04.

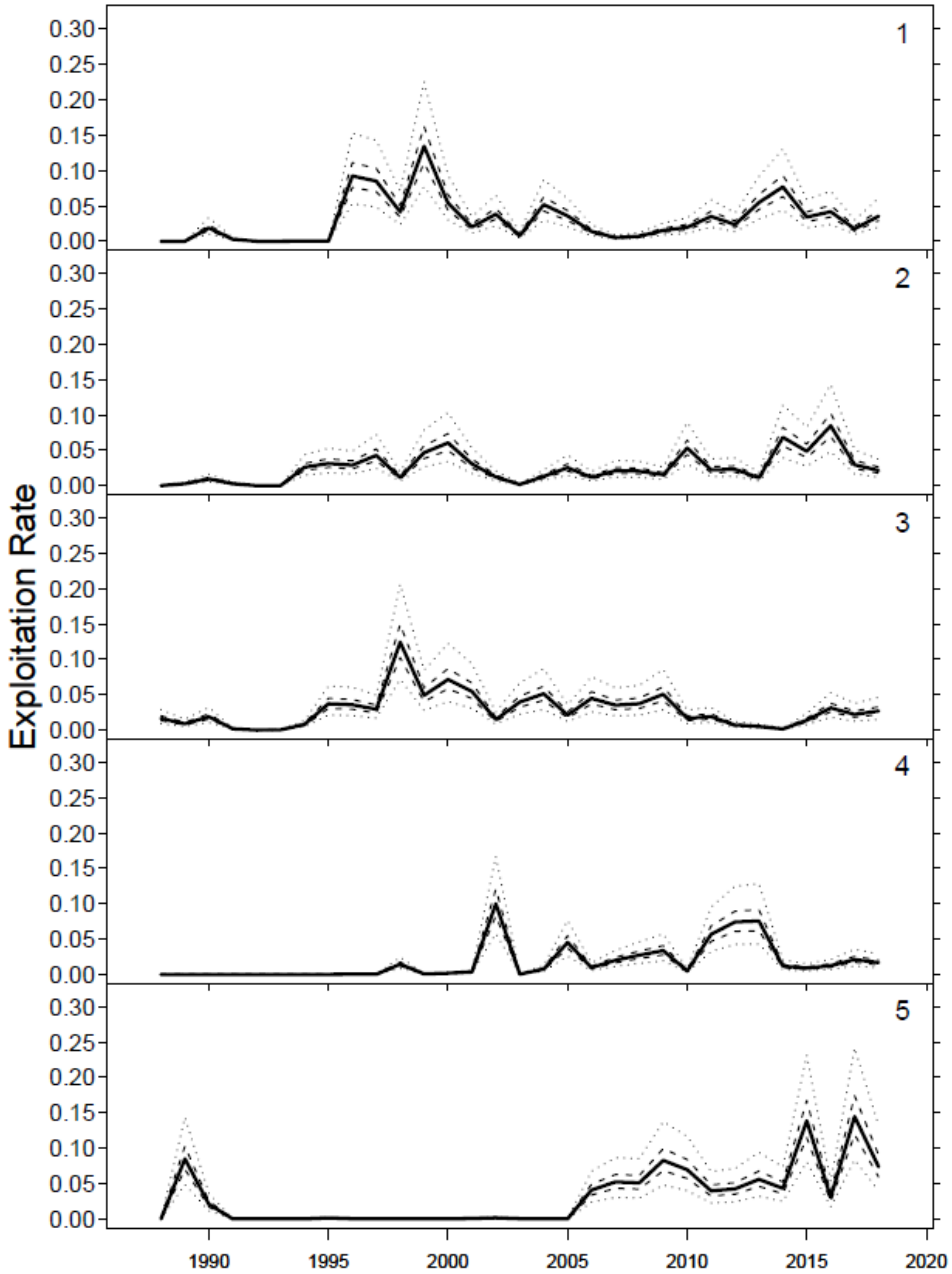

Figure 6. Estimates of exploitation rate on Banquereau for 1988–2018 from the spatial production model by assessment area. Lines denote the median (solid), 50% credible interval (dashed), and 95% credible interval (dotted).

Median areal biomass estimates from the model in 2018 indicate all areas are within 10% of the biomass estimates in the previous year (Figure 7). The largest biomass estimates were in areas 2 and 3, which are the two largest assessment areas (436 and 442 km^2, respectively).

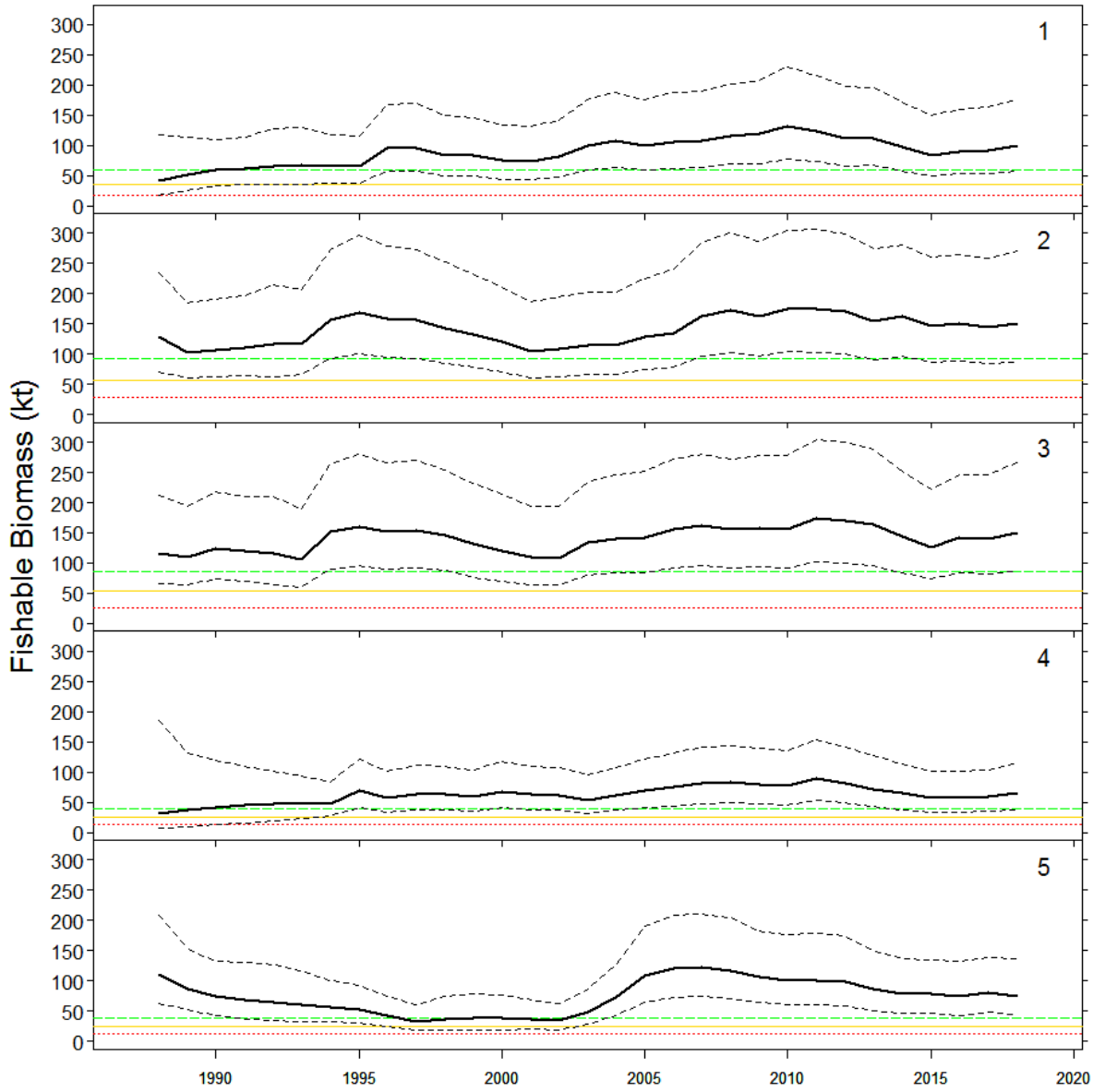

Figure 7. Estimates of fishable biomass (kilotonnes) on Banquereau from the spatial production model by assessment area. Black lines denote the median estimate (solid) and 95% credible interval (dotted). The horizontal lines represent (from top to bottom): $CPUE_{70}$ reference (green), upper stock reference (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 provided annually to DFO. 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 2018 (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 2018 (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 2018 (Table 1), although Banquereau was near the threshold for the first time since 2005. An examination of the shell length frequencies collected from onboard sampling show that the size range of the catch was similar between 2017 (51 – 148 mm) and 2018 (51 – 142 mm), with the difference in percentage of clams >120 mm being driven by the amounts of large clams being caught as opposed to a shift to catching smaller sizes (Figure 8).

Table 1. 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.

	Grand Bank		Banquereau	
Year	%>105 mm	n	%>120 mm	n
2009	-	-	3.87	17940
2010	1.34	224	3.64	16683
2011	0	251	7.31	10841
2012	-	-	4.5	12129
2013	6.67	180	2.76	21290
2014	-	-	1.57	14127
2015	19.17	600	1.55	13741
2016	16.65	8600	2.31	18967
2017	15.61	7298	2.31	16695
2018	11.35	8000	1.07	16395

– no data available

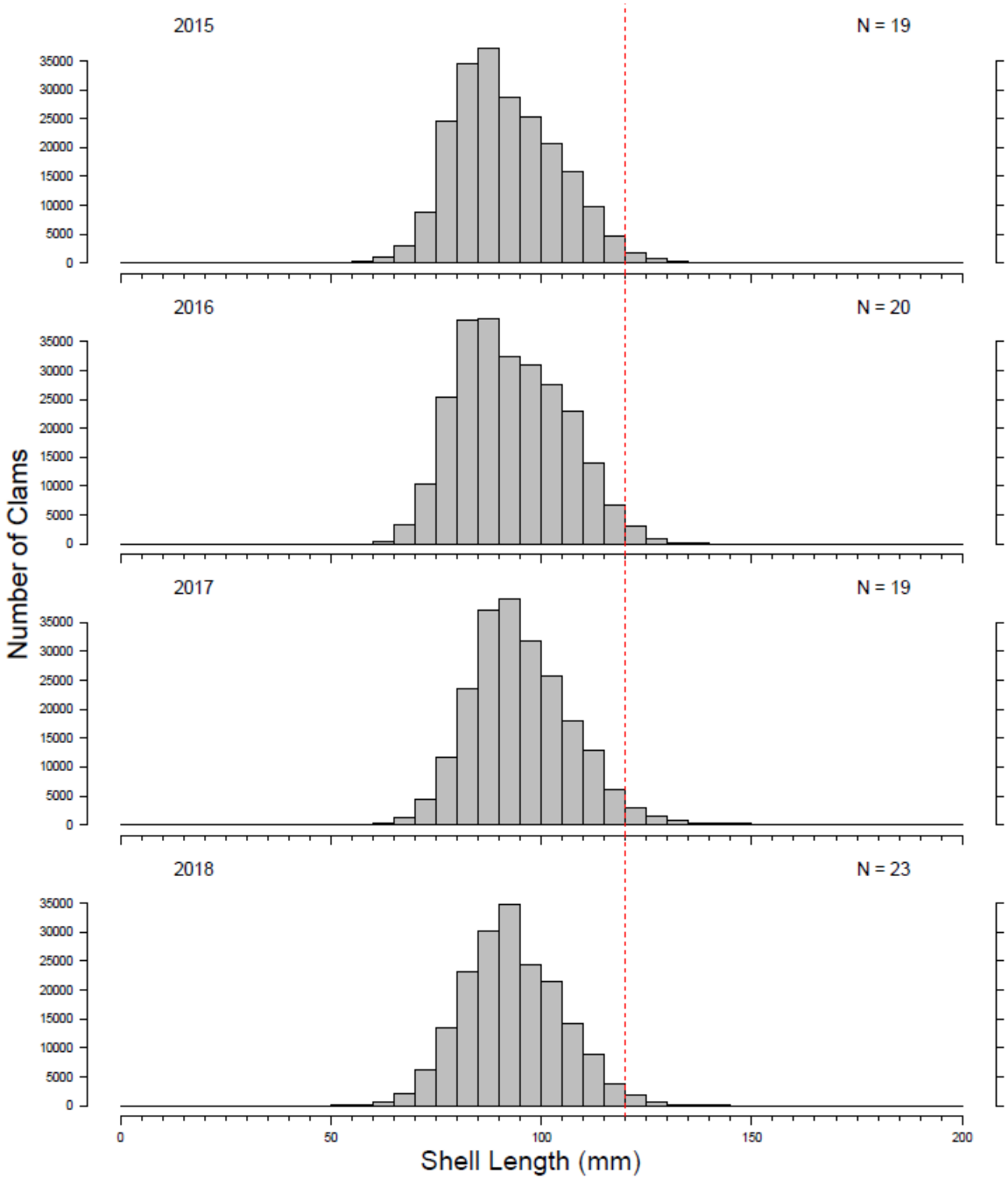

Figure 8. Shell length (mm) frequencies for Arctic Surfclam on Banquereau from the onboard sampling program for 2015 – 2018. Vertical line indicates 120 mm.

Biomass based reference points have been presented for Banquereau (Hubley et al. 2018) 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 2018, the probability that the biomass estimate was above the USR and the $CPUE_{70}$ reference line was >0.99 for all areas (Table 2).

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 9). In 2018, the estimated median total biomass in the fished areas was 539,096 t (95% CI: 311,851 – 965,744 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 2).

Table 2. 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	>0.99
4	>0.99	>0.99	>0.99
5	>0.99	>0.99	>0.99
Total	>0.99	>0.99	>0.99

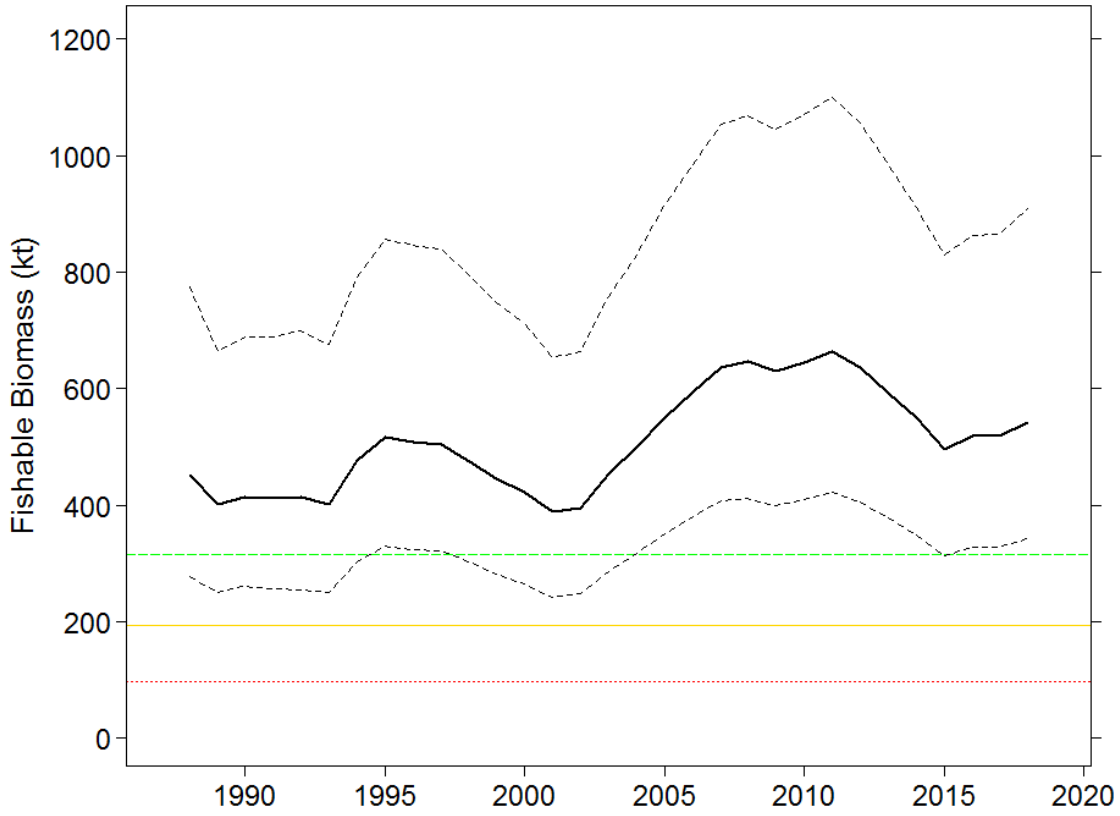

Figure 9. Estimate of fishable biomass (kilotonnes) on Banquereau from 1988 to 2018 from the spatial production model for the total fished area. Black lines denote the median estimate (solid) and 95% credible interval (dotted). The horizontal lines represent (from top to bottom): $CPUE_{70}$ reference (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 Propeller Clam (*Cyrtodaria silique*) or Greenland Cockle (*Serripes groenlandicus*). Northern Propeller Clam is caught more frequently on Banquereau, where landings increased annually from 2010 to 2014. Since 2014, landings on Banquereau have fluctuated but remain high relative to earlier years. Greenland Cockle is more often caught on Grand Bank, and landings tend to have large fluctuations. Greenland Cockle landings on Grand Bank increased substantially from 2017 (774 t) to 2018 (2613 t). Ocean Quahog (*Arctica islandica*) 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 2018, the TAC was not exceeded for Ocean Quahog on either bank (Figure 10).

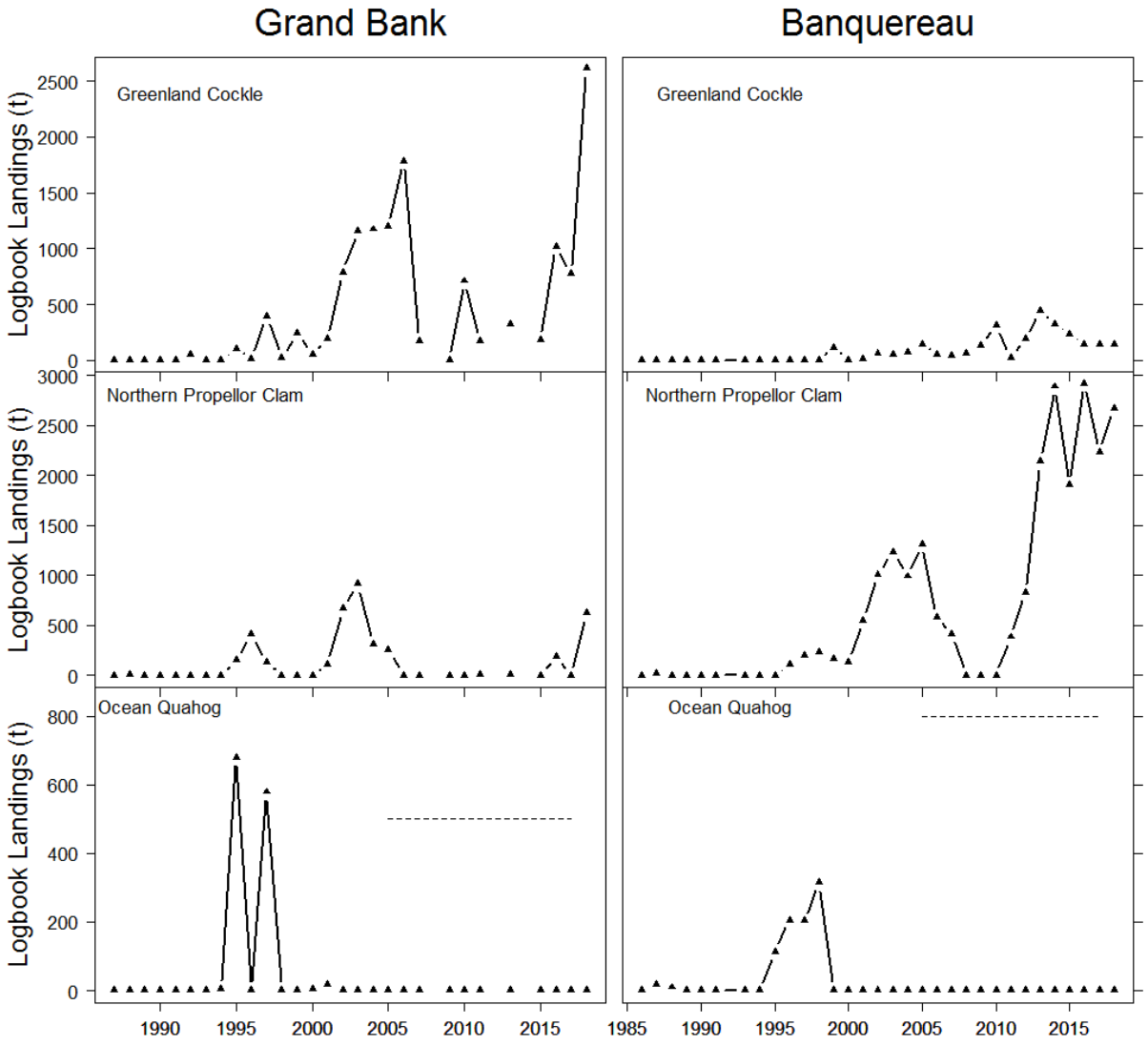

Figure 10. Landings from the fishery logbooks for three other clam species on Grand Bank (left column) and Banquereau (right column) from 1987 to 2018. Dashed horizontal line is maximum limit for Grand Bank and total allowable catch for Banquereau. Note different axes.

Sources of Uncertainty

As fishing becomes more efficient, catchability is likely increasing over time leading to a bias in CPUE based indicators. Changes in efficiency and catchability could mask actual biomass trends. 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 2018 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 2018 biomass estimates from the spatial production model. A removal level of 0.5 F_{MSY} would result in a TAC (23,753 t) that is greater than the 2019 TAC for Banquereau (20,943 t). A removal level of 0.33 M, where M is the natural mortality rate of 0.08 (Heaslip and Hubley 2018), would result in a much lower TAC when applied to the fished area biomass (Table 3). 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 3. Areal removals in tonnes for removal reference levels (F) for assessment areas (1 – 5) on Banquereau calculated using the 2018 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)	4375	6648	6572	2876	3281	23753
0.33 M (0.026)	2552	3877	3833	1677	1914	13853

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Sources of information

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