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Science Advisory Report 2007/034

ASSESSMENT OF THE OCEAN QUAHOG (*ARCTICA ISLANDICA*) STOCKS ON SABLE BANK AND ST. MARY'S BAY, AND THE ARCTIC SURFCLAM (*MACTROMERIS POLYNYMA*) STOCK ON BANQUEREAU

Technographics BIO

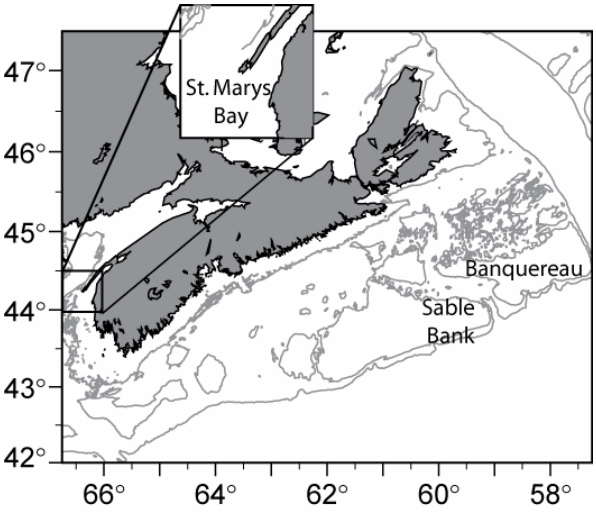

Figure 1: Map of the Scotian Shelf showing Banquereau, Sable Bank, and St. Mary's Bay.

Context:

The hardshell clam fisheries on the Scotian Shelf consist of separate inshore and offshore fisheries. The current fisheries started in the 1980's, although there had been a sporadic inshore fishery prior to that. The main species targeted are the Arctic surfclam (Mactromeris polynyma) and ocean quahog (Arctica islandica).

There are currently three inshore licences in South western Nova Scotia as well as exploratory licences in South western New Brunswick. The offshore fishery is pursued by three large freezer processors that fish on the Scotian Shelf and Grand Bank Newfoundland.

The management methods for the offshore fishery can be found in the Offshore Clams Integrated Fishery Management Plan, Maritimes and Newfoundland Regions. The main management tools for the offshore fishery are limited entry licences, a TAC (total allowable catch) divided into EA's (enterprise allocations), 100% dockside monitoring, mandatory logbooks and VMS (vessel monitoring systems). The inshore fishery has 20% dockside monitoring, 100% hailing, mandatory logbooks, and TAC's for individual areas. There is also an inshore fishing area from the Territorial Sea Geographical Baseline to 20 nm that does not have a TAC.

The TAC's for both the inshore and offshore are set for a multi-year period. Recently, there have been biomass surveys of the Sable Bank and St. Mary's Bay quahog stocks, and the Banquereau Arctic surfclam stock. This assessment provides advice on TACs using the framework developed for these stocks during Jan.- Apr. 2007, for the period until the next survey takes place.

SUMMARY

- The life histories of Arctic surfclams (*Mactromeris polynyma*) and ocean quahogs have implications for fisheries management, as both these species are long lived and slow growing.
- There has been an Arctic surfclam fishery on Banquereau since 1986. At present there is no fishery for ocean quahogs (*Arctica islandica*) in St. Mary's Bay or Sable Bank.
- Clam dredges have an immediate impact on the substrate and benthic organisms, and there continue to be uncertainties about the impact of dredges on overall benthic productivity.
- Given the current state of knowledge and our limited understanding of the spatial and temporal dynamics of the populations, particularly recruitment processes, it is recommended the TAC be set near the low end of the range of harvest strategies considered.
- Bycatch in the Arctic surfclam fishery is low.
- It is recommended that the TAC for Arctic surfclams on Banquereau should be at the low end of the range, between 38,599 and 116,968 t.
- It is recommended that the TAC for ocean quahogs on Sable Bank should be at the low end of the range, between 13,602 to 41,217 t.
- For the St. Mary's Bay area, there are no plans for a regular survey series. The expert opinion on inshore ocean quahog harvest levels recommended a constant harvest strategy based on MCY = $0.33MB_0$. as a sustainable harvest level. The resulting TAC is 2,344 t.

BACKGROUND

Species Biology

The **Arctic surfclam** (*Mactromeris polynyma*) is a large, long lived species found mainly in coarse sand bottoms. It is a strong, active burrower, capable of burrowing several inches below the sediment surface. A distinguishing feature is that most specimens have a purple color in the foot and mantle that turns red upon cooking, similar to lobster and shrimp.

In the western Atlantic, they occur from the Strait of Belle Isle to Rhode Island. In the Pacific they are found from the Juan de Fuca Strait to Point Barrow Alaska, and also from Sakhalin Island, Russia. All Atlantic populations are subtidal down to 110 m, but in Alaska there are intertidal populations as well.

Slow growing and long-lived, significant numbers of surfclams appear to reach forty years of age. On Banquereau, the oldest animal aged so far was 61 years old; the largest observed was 157 mm. The Alaskan population appears to be shorter lived with a maximum age of about 25 years. The inshore population in Scotia Fundy appears to be largely made up of smaller animals but there has been no extensive age sampling so far.

Natural mortality (M) for the Alaskan population was estimated as 0.13 - 0.25, and for the Banquereau stock, it was estimated as 0.08.

Based on life history and selectivity parameter estimates (Figure 2), the age of maximum biomass per recruit occurs close to the age of 50% selectivity. Therefore growth overfishing is unlikely to occur, and F_{MAX} is much larger than $F_{0.1}$. The age of 50% maturity is also below the age of 50% selectivity, indicating that individual surfclams will be able to spawn about 10 times before being recruited to the fishery. Although there have been no studies of the relative

fecundity of young versus older surfclams, this should help ensure that recruitment overfishing does not occur.

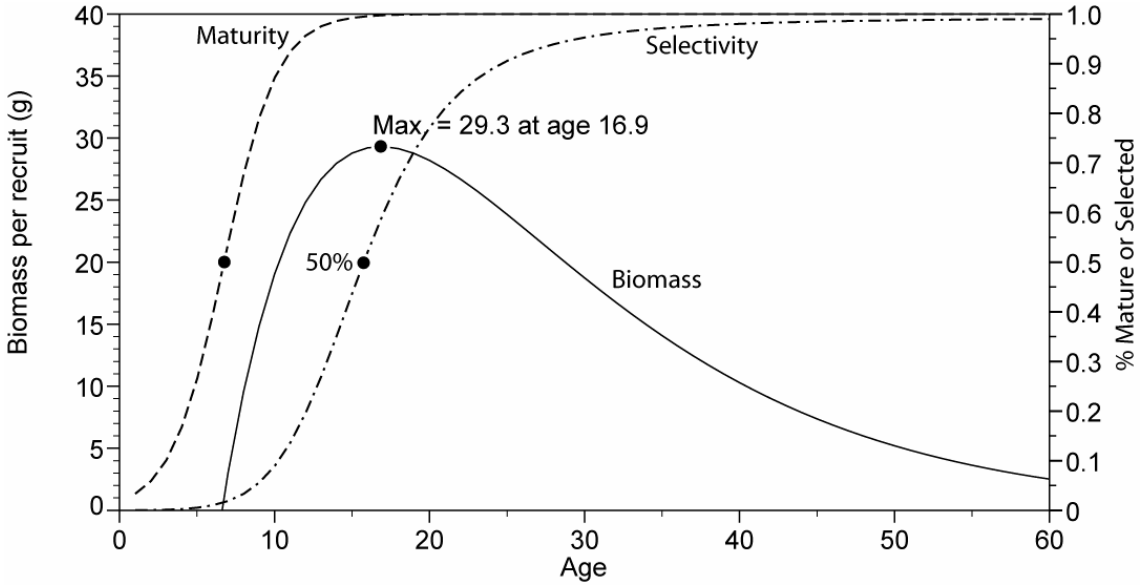

Figure 2. Estimated maturity and selectivity at age, and biomass per recruit with no fishing for the Banquereau Arctic surfclam population.

The **ocean quahog** (*Arctica islandica*) is one of the slowest growing and longest lived commercial species. The harvested beds off the Mid Atlantic States are dominated by animals 40 - 80 years old, with significant numbers over 100. The oldest aged specimen from the Scotian Shelf was 211, while the oldest aged anywhere was 225 years old from the eastern U.S.

Ocean quahogs occur in eastern North America from the Arctic to Cape Hatteras, N.C. and in Europe from the Arctic to the Bay of Cadiz, Spain. It also occurs in Iceland and the British and Faroes islands. It is most abundant in fine to medium sand bottoms in depths from 4 to 260 m, deeper in the southern part of its range, and has been dredged live from as deep as 482 m.

In the Scotia-Fundy Region of Nova Scotia, it is most abundant in the inshore harbours and bays of southwestern Nova Scotia, and the mouth of the Bay of Fundy. It is abundant on Sable and Western banks, and occurs in lower numbers in sandy areas throughout the region.

Based on U.S. observations, recruitment appears to be variable with infrequent strong year classes. When combined with their longevity, this has led to a U.S. management plan that uses a very low exploitation rate so the strong year classes can carry the fishery through the periods of low recruitment.

Estimates for adult natural mortality range from 0.01 to 0.04. Predator mortality on newly settled and juvenile quahogs is thought to be high, crabs and groundfish being the main predators. The inshore populations do not have the larger/older quahogs observed offshore, indicating a higher mortality rate. The current natural mortality estimates for Scotian Shelf quahogs are 0.03 offshore and 0.045 inshore.

The life history parameters (Figure 3) are from the 2002 St. Mary's Bay ocean quahog survey samples and from Rowell et al. 1990. Rowel et al. did not construct maturity curves but reported the range of ages in the intermediate maturity stage for both males and females.

There was no selectivity study done on the commercial inshore dredge used during the survey, but the size at 50% selectivity was estimated from the bar spacing in the dredge and a shell length-width relationship. The gear selectivity at age is slightly below the age of maximum biomass, indicating that growth overfishing may be a concern. Sexual maturity occurs over a broad size/age range, so some quahogs will have over a decade of spawning before being recruited to the gear; others are captured while still immature.

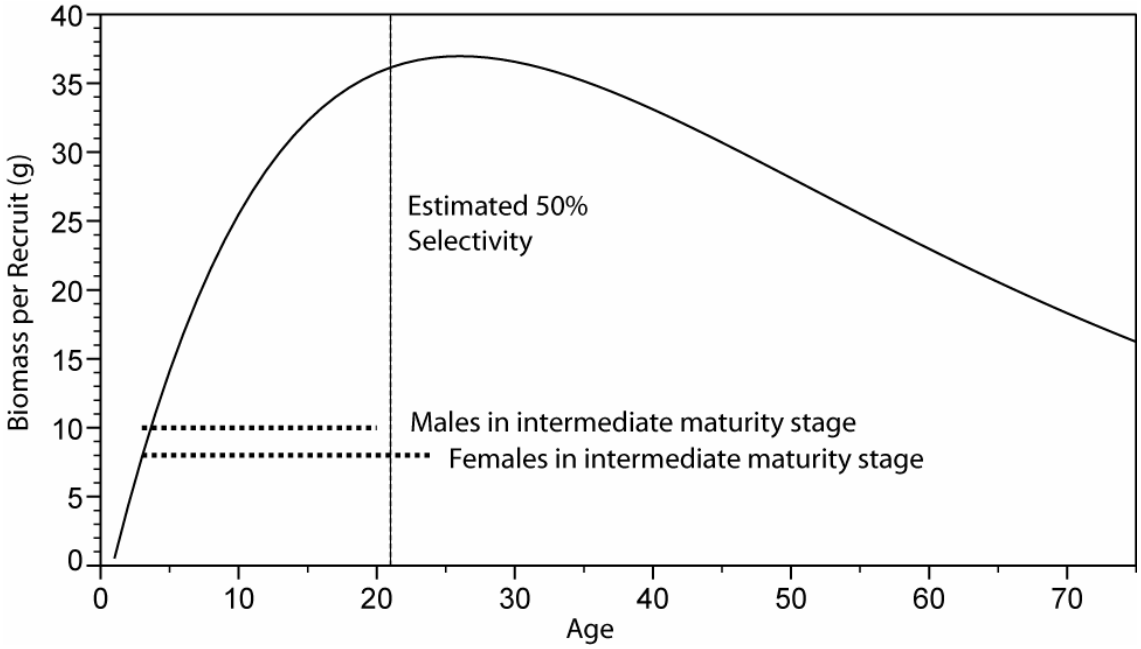

Figure 3. Biomass per recruit for St. Mary's Bay ocean quahogs. Also shown is the estimated 50% gear selectivity at age, and the range of ages of both male and female ocean quahogs in the intermediate maturity stage reported in Rowell et al. 1990.

The age at 50% selectivity of the gear used for the **Sable Bank** ocean quahog survey is higher than the age of maximum biomass and of maturity. There is no fishery on the Sable Bank population to date, so the commercial gear used when a fishery starts may have a different selectivity pattern than the survey gear.

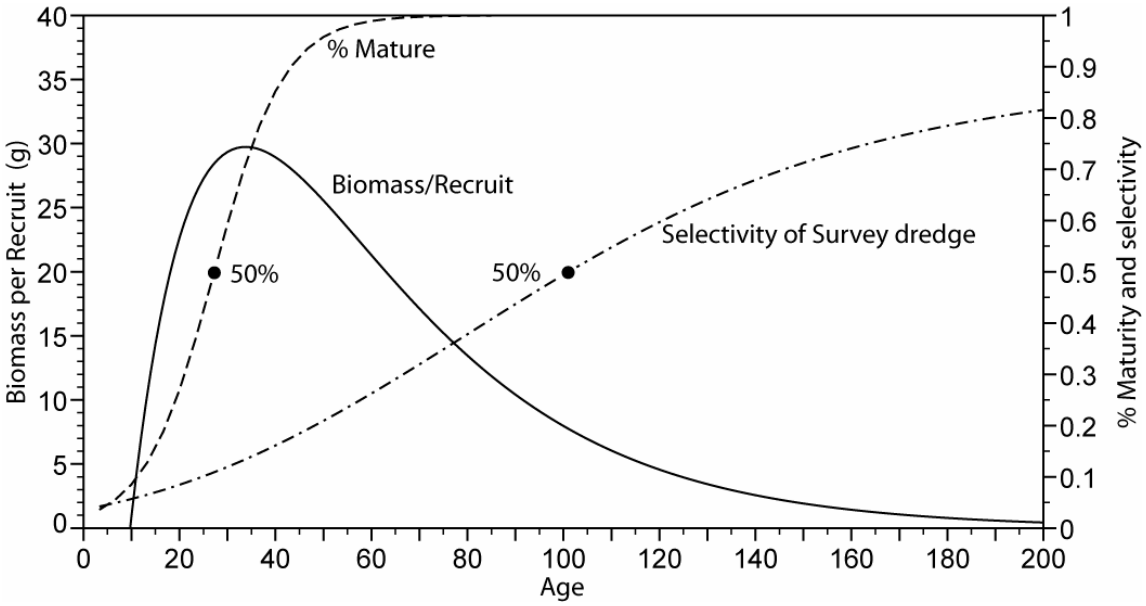

Figure 4. Biomass per recruit wit no fishing and percent maturity for ocean quahogs on Sable Bank. The size at 50% selectivity for the survey gear is also shown.

Fishery

There has been an Arctic surfclam fishery on Banquereau since 1986. It was initiated by a 1980 fishery development plan to determine the resource potential of the ocean quahog (*Arctica islandica*) and other underutilized clam species in the Scotia-Fundy Region. During these surveys, which took place from 1980 to 1983, commercial quantities of **Arctic surfclams** (*Mactromeris polynyma*) were found on Banquereau. Due to the exploratory nature of the surveys, other areas of the Scotian Shelf could not be precluded from containing commercial quantities of Arctic surfclams.

Following the survey and a three-month test fishery in 1986, an offshore surfclam fishery was developed. The TACs were set at 30,000 t for Banquereau and 15,000 t for the rest of the Scotian Shelf. There has been some exploration, but no sustained fishing, on the Scotian Shelf outside of Banquereau. Since early 1993, there have been 3 factory freezer-processors fishing year round, with catches up to 25,000 t (Figure 5). A 1996-1997 Industry-DFO survey of Banquereau resulted in a reduction of the TAC for Banquereau from 30,000 t to 24,000 t. The fishery has never caught the TAC due to low market demand.

The Offshore Industry has started a survey program that will survey the various banks involved in the fishery, rotating through them on approximately a 5 year cycle, so that each bank is surveyed once per cycle. Arctic surfclams on Banquereau were surveyed in 2004.

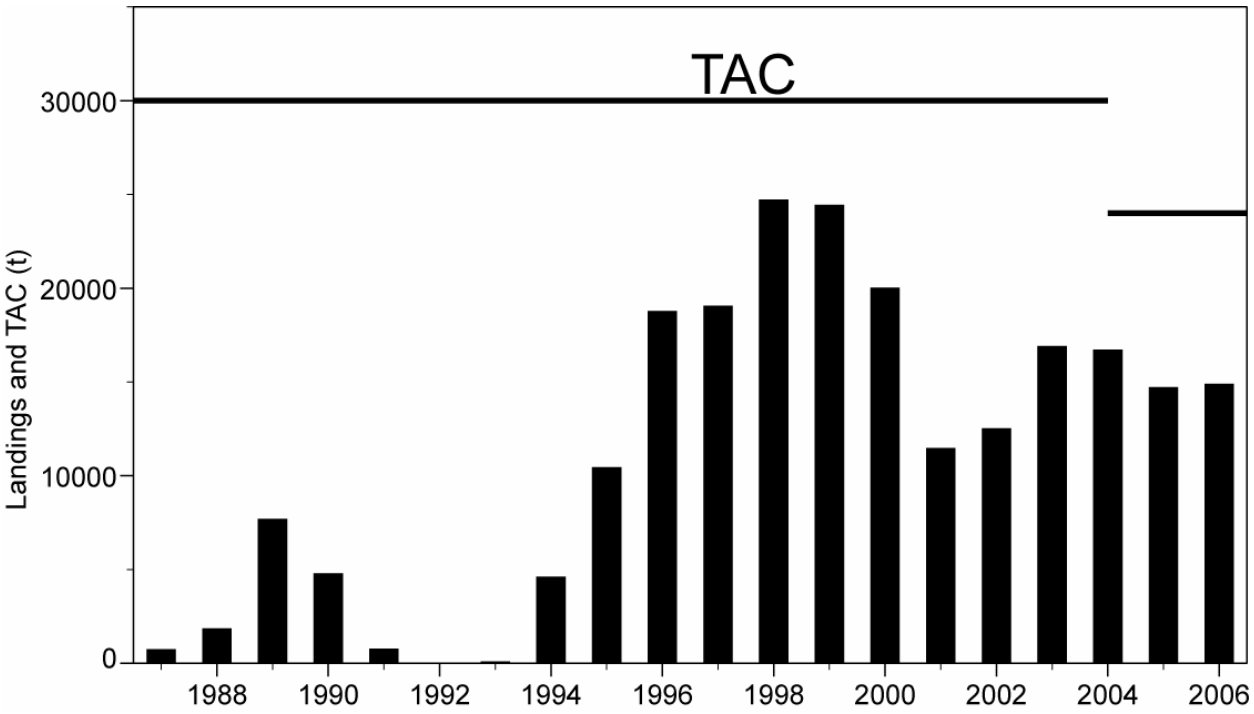

Figure 5. Arctic surfclam landings and TAC history for Banquereau.

Although there was no interest in developing an ocean quahog fishery following the 1980-1983 surveys, there has recently been renewed interest in **offshore ocean quahogs** (*Arctica islandica*). There has been one license issued, and an ocean quahog survey of Sable Bank was conducted in 2003 to provide a current biomass estimate. It is expected that a fishery will start in late 2007 or 2008.

The U.S. has had an offshore ocean quahog fishery since the 1940's and currently has a 27,000 t quota set as 2% of the standing stock biomass.

There has been sporadic interest in developing an **inshore ocean quahog** (*Arctica islandica*) fishery in Nova Scotia since the 1920's. There was a commercial fishery in 1970-71 in Southwest Nova Scotia, and since the early 1980s there has been a small fishery centered around Campobello Island, N.B. and Southwest Nova Scotia for small quahogs in the littleneck (less than 38 mm) to cherrystone (less than 50 mm) size for the live market, mainly in New England. Currently, there is no market for the large chowder size quahogs. Marketing of this size quahog would require a processing facility in the region. There is interest in establishing such a processing plant, but it would depend on the supply of large quahogs. St. Mary's Bay, N. S. is an area of interest, since a large bed of quahogs is known to exist. A survey conducted in 1997 did not cover the full extent of the bed. The 2002 industry funded survey covered a larger area.

ASSESSMENT

Stock Trends and Current Status

The **Artic surfclam** fishery has tended to operate on both Banquereau and Grand Bank. On Banquereau, the spatial distribution of fishing effort has changed through time, making catch per unit effort (CPUE) an unreliable index of biomass (Figure 6).

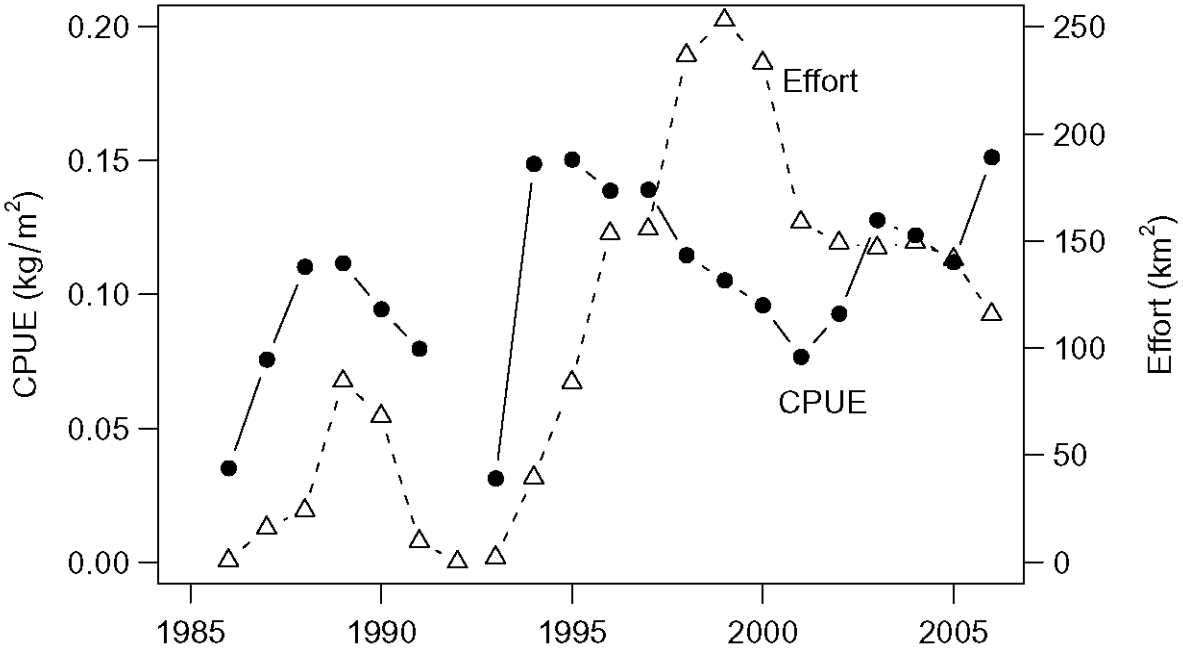

Figure 6. CPUE and effort history for the Banquereau Arctic surfclam fishery.

There has been no fishery for **ocean quahogs** in either St. Mary's Bay or on Sable Bank to provide an index of stock biomass. There have been previous research vessel (RV) surveys, but differences in the survey methodologies make it doubtful that differences in research vessel biomass (B_{RV}) reflect changes in population biomass. Assessment for these stocks is therefore based on the most recent B_{RV}.

Surveys have been conducted for ocean quahogs in St. Mary's Bay, Sable Bank and for Arctic surfclams on Banquereau and B_{RV} estimates produced (Table 1).

Table 1. B_{RV} estimates and confidence intervals for the three clam surveys assessed.

Survey	Year	Species	Biomass (t)	95% CI (t)
Banquereau	2004	Arctic surfclam	1,462,097	± 24,944
Sable Bank	2003	Ocean quahog	1,373,913	± 21,516
St. Mary's Bay	2002	Ocean quahog	157,843	± 53,212

Banquereau

In the 2004 Banquereau **Arctic surfclam** survey (Figure 7), the areas of high biomass generally coincided with those observed in previous surveys. These areas also corresponded to the areas where the fishery has concentrated its effort. The observation that the areas of greatest

effort are still the areas with the highest biomass indicates that serial depletion, a concern with fisheries for sedentary species, is not happening in this fishery.

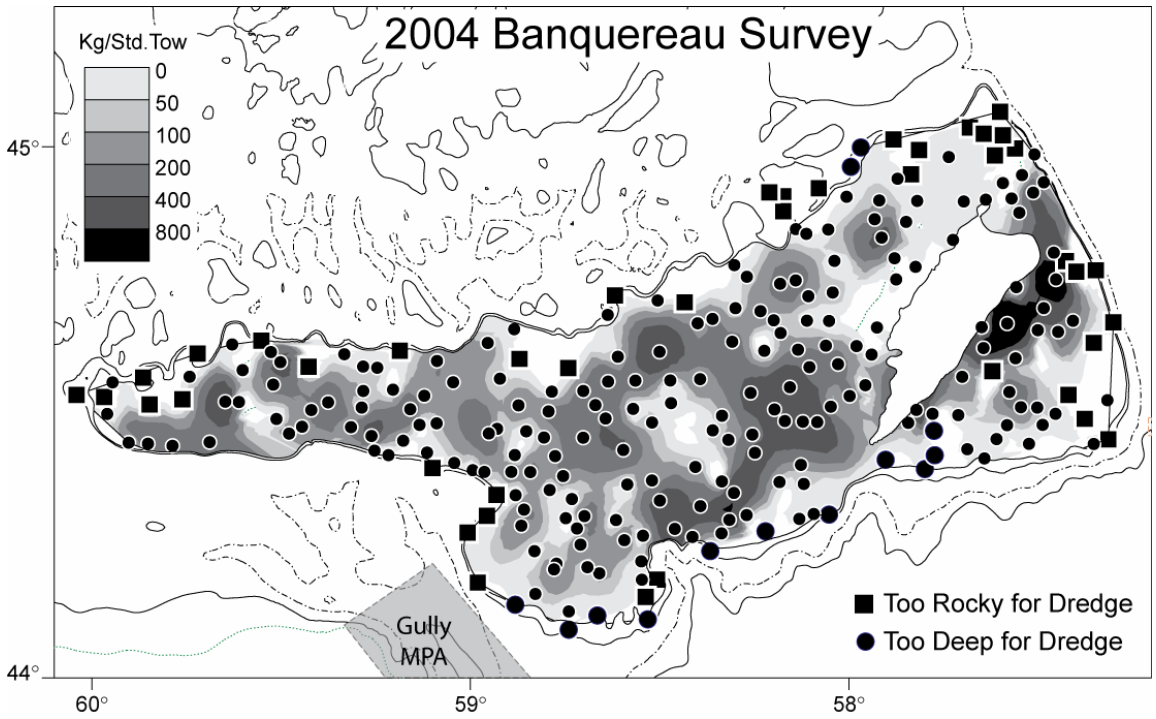

Figure 7. Contour map of the catch per standard (Std.) tow for the 2004 Banquereau Arctic surfclam survey.

A study of the incidental mortality of small clams that pass through the dredge was conducted on Banquereau, and estimated that 15% of the clams passing through the dredge suffer lethal damage. Yield per recruit analysis with and without a 15% incidental mortality (Figure 8) indicates that incidental mortality greatly reduces both the yield at high fishing mortality rates, and F_{MAX}. Spawning stock biomass (SSB) remains relatively high at fishing mortalities, around the $F_{0.1}$ level. When incidental mortality is included in the model, the $F_{0.1}$ estimate is within the upper range of fishing mortalities recommended by the framework.

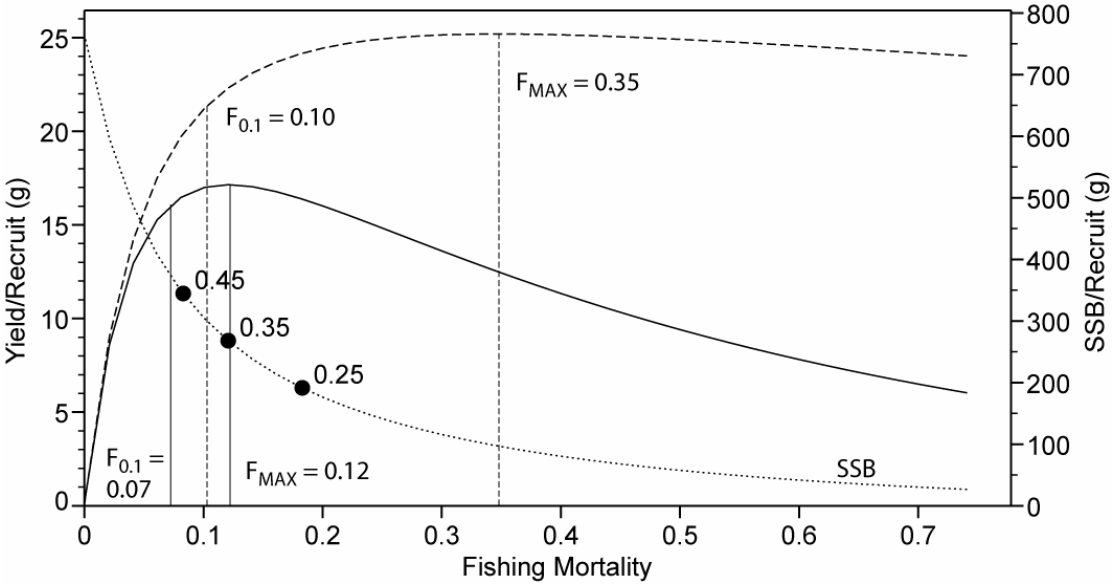

Figure 8. Yield and spawning stock biomass (SSB) per recruit for Banquereau Arctic surfclams. The top dashed yield per recruit curve is with no incidental mortality. The lower curve is with a 15% mortality of small clams that pass through the dredge.

Sable Bank

The areas of high biomass found in the 2003 Sable **ocean quahog** survey (Figure 9) are similar to those identified in the 1980's, although there are some differences (Roddick, Kilada and Mombourquette, 2007a). The maximum quahog catch during the survey was over 2 t, obtained during a 5 minute (666 m) tow with the 5 foot wide survey dredge. The quahog biomass is highest in the 30 to 50 m depth range around Sable Island. There is a distinct transition to Atlantic surfclams (*Spissula solidissima*) inside the 30 m depth contour. The oldest quahog aged from the survey samples was 211 years old, with approximately 20% of the aged sample over 75 years old.

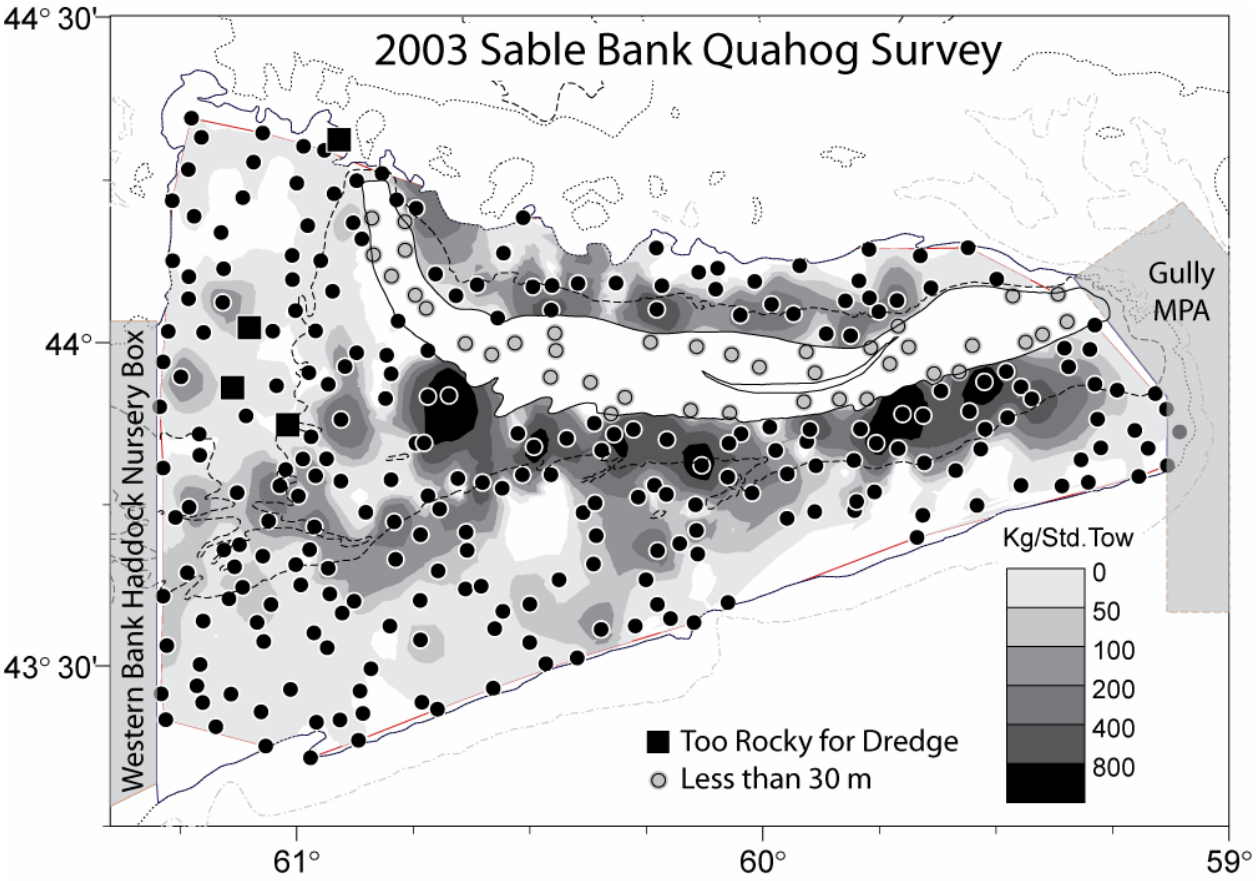

Figure 9. Contour map of the catch per standard (Std.) tow for the 2003 Sable Bank ocean quahog survey.

St. Mary's Bay

The area covered by the 2002 survey was much larger than that of the 1997 survey (Figure 10), and showed areas of high biomass further up the bay. The length frequency samples did not have any larger quahogs such as was observed on Sable Bank. The age data confirmed that this was not due to slower growth, as all quahogs were less than 75 years old. This results in a higher estimate of natural mortality for St. Mary's Bay ocean quahogs than for the Sable Bank population.

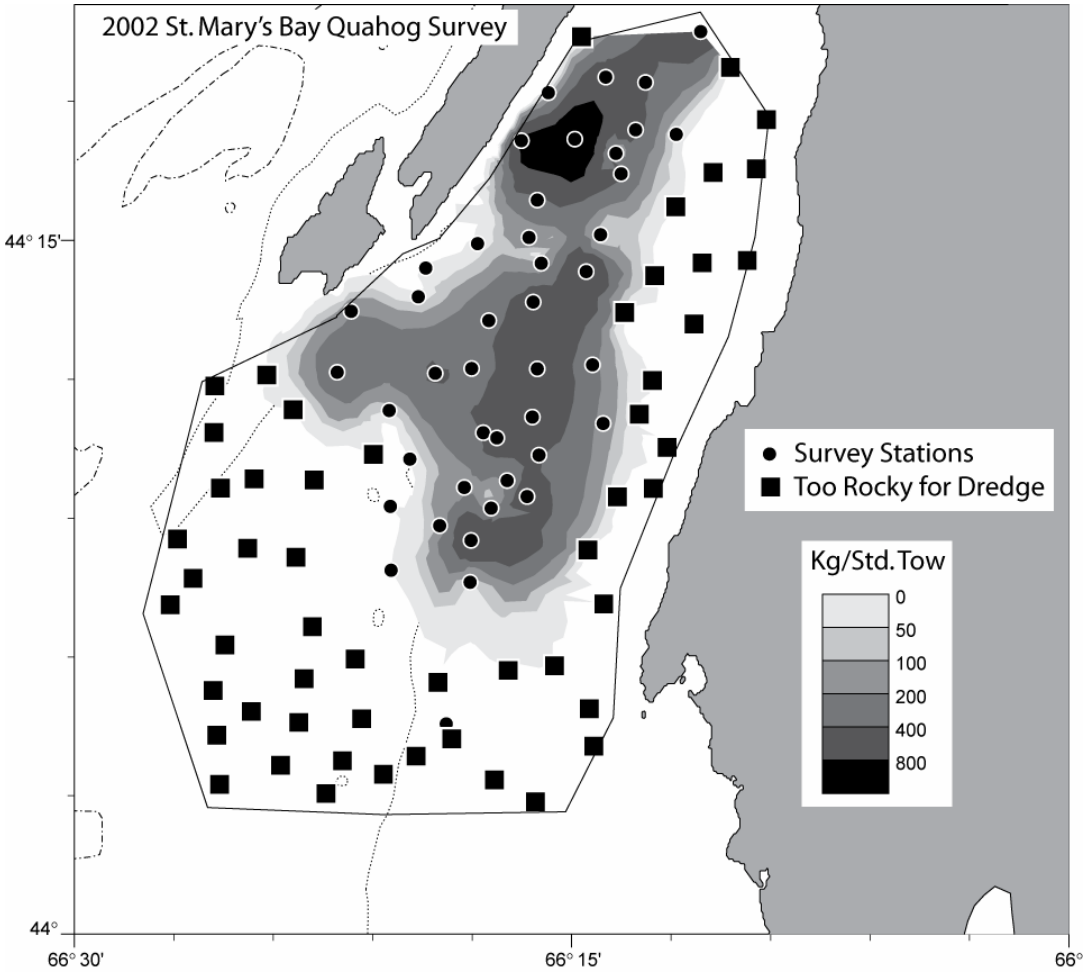

Figure 10. Contour map of the catch per standard (Std.) tow for the 2002 St. Mary's Bay ocean quahog survey.

The 2007 surfclam and quahog framework recommended that the harvest advice should be based on the most recent survey biomass, by applying a constant fishing mortality in the form TAC = FB_{RV}, where B_{RV} is the most recent survey biomass and F lies within the recomended range (Table 2). The TAC will be determined in consultation with Fisheries & Aquaculture Management and Industry.

Table 2. Fishing mortality and TAC options for Banquereau.

Harvest Strategy	F	TAC (t)	Comment
F = M	0.08	116,968	Considered to be an upper limit of F with the current state of knowledge in the fishery. Fishing at this level would involve a risk of detrimental effects in the long term, and warrant more frequent surveys than currently proposed.
F = 0.5M	0.04	58,484	Reasonable, would be applying a fishing mortality equal to half the natural mortality rate
F ~ MCY	0.026	38,599	Conservative, equivalent to an MCY estimate ($0.33MB_0$) assuming B_{RV} is currently at B_0
F current	0.0164	24,000	Equivalent to the current TAC of 24,000 t.

Ecosystem Considerations

Habitat

Clam dredges have an immediate impact on the substrate and benthic organisms as they liquefy the sediment down to at least 8 inches (20 cm), remove many large organisms and cause sedimentation adjacent to the track. On **Banquereau**, the impacts are being studied through an experiment at a site at 70 m depth. This is considered one of the most rigorous fishing gear impact studies done to date. There is a need to return to the study site in 2008 to understand recovery processes for the target mollusc species. There also continue to be uncertainties about the impacts on overall benthic productivity.

The experiment demonstrated immediate impacts on both habitat and non-target organisms within the first two years following dredging. In this timeframe, there was considerable recovery of the composition of non-target benthic species, such as echinoderms, with a shift in relative abundance of the species present. Visual evidence of dredge tracks disappeared after one year; however, sidescan sonar data showed evidence of dredge tracks at least three years after the activity. Hydraulic clam dredge fisheries occur on fairly mobile, well-sorted sand, which helps mitigate the overall impact on some elements of the benthic community. As expected with their long lifespan and slow recruitment rate, no recovery of large mollusc species has been seen to date. There were very few juveniles in the experimental grab samples, indicating limited recruitment in the very short term. The site should be revisited in 2008 to see if there is any evidence of the original activity, including the level of recovery of the target species in the 10 year period.

With only three vessels in each of the inshore and offshore fisheries, the area impacted (footprint) is relatively small compared to other fisheries and the spatial extent of the target species. On Banquereau, the footprint can be estimated using the “area swept” (km^2). Since the surf clam fishery began in 1986, 2,223 km^2 have been swept, with most of this activity in the post-1995 period. There is considerable spatial and temporal variation of area swept over the timeframe of the fishery, with areas of high clam biomass fished more frequently and intensely than other sections, and periods when the fishery concentrated on Grand Bank instead of Banquereau. The average annual area swept during the last five years of the fishery is approximately 140 km^2, with relatively stable effort in that period. In the last two years (2005 – 2006), 257 km^2 were swept (Figure 11), thus representing the area undergoing recovery by the non-target species as indicated by the experimental results. This represents roughly 3% of the known surf clam habitat on Banquereau.

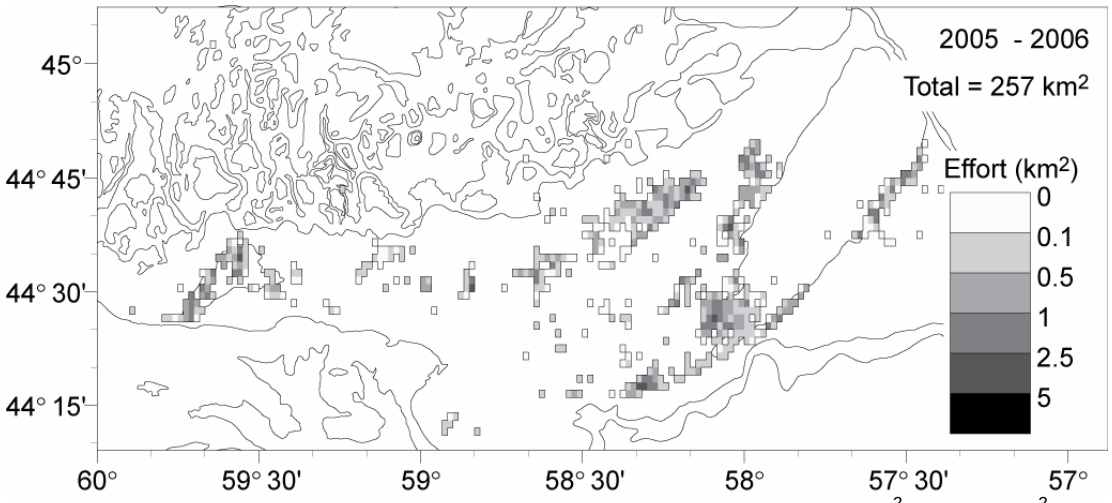

Figure 11. Spatial distribution of area swept for 2005 and 2006 (approx. 257 km^2). Total km^2 dredged is aggregated by one minute squares (not corrected for overlap of dredge tracks).

With no fishery in current operation, there has been no impact on the habitat of **Sable Bank** due to hydraulic dredge activity. The Banquereau experiment can give insight into the potential effects in this area; however, the benthic community in these two areas differ. It was noted that during the Sable Island Bank survey in 2003, out of 26 sampling sites that were surveyed with sidescan sonar one year later, only six deep sites still showed evidence of dredge tracks. This suggests water depth has a possible influence on track persistence, shallower areas having sediments that are more actively worked by waves and currents.

Bycatch

Bycatch in the Arctic surfclam fishery is low. In the 2005 fishery, surfclams made up 80% of the catch by weight, with shell and rocks accounting for another 8.5% (Table 3). Sand dollars and propellerclams were the only other species making up more than 0.5% of the catch.

In the 2004 survey, which sampled the entire bank, finfish made up 0.022% of the catch, and thorny skate, which is up for COSEWIC assessment, made up 0.026% of the catch.

Table 3. Catch composition from sampling of the unsorted catch from the 2005 Banquereau Offshore clam Fishery.

Scientific Name	Common Name	Weight (kg)	%	Cumm %
MACTROMERIS POLYNYMA	ARCTIC SURFCLAM	673.00	80.04	80.04
SHELL	SHELL	47.34	5.63	85.67
CLYPEASTEROIDA O.	SAND DOLLARS	45.80	5.45	91.12
CYRTODARIA SILIQUA	PROPELLERCLAM	33.50	3.98	95.10
STONES AND ROCKS	STONES AND ROCKS	24.05	2.86	97.97
HOLOTHUROIDEA C.	SEA CUCUMBERS	4.05	0.48	98.45
APHRODITA HASTATA	SEA MOUSE	2.79	0.33	98.78
STRONGYLOCENTROTUS SP.	SEA URCHINS	2.72	0.32	99.10
CRAB	CRAB	1.63	0.19	99.30
BUCCINUM SP.	WHELKS	1.56	0.19	99.48
SERRIPES GROENLANDICUS	GREENLAND COCKLE	1.20	0.14	99.62
NEPTUNEA DECEMCOSTATA	NEW ENGLAND NEPTUNE	0.97	0.12	99.74
ASTEROIDEA S.C.	STARFISH	0.66	0.08	99.82
COLUS SP.	SPINDLE SHELL	0.53	0.06	99.88
LIPARIS SP.	SEASNAIL	0.50	0.06	99.94
ARCTICA ISLANDICA	OCEAN QUAHOG	0.50	0.06	100.00

Sources of Uncertainty

The major source of uncertainty in this assessment is the lack of understanding of the temporal and spatial changes in the life history parameters of these species. For instance, while there is some evidence for a recruitment pulse on the order of 10-15 years for Banquereau, it is unclear whether this is a recurring process and how such pulses might supplement any smaller, ongoing recruitment to the population. There is insufficient information to judge such processes in the unfished Sable Bank and St. Mary's Bay areas.

There is some uncertainty in the survey biomass estimate. The estimates for the offshore surveys are very precise, but all three estimates are expected to be biased downwards, as there is no correction for dredge efficiency. Hydraulic clam dredges are known to be efficient gears, and research on the efficiency of the survey dredge is ongoing.

CONCLUSIONS AND ADVICE

The life history of these species has implications for management. Both of the species involved in this assessment are long lived and slow growing, especially ocean quahogs, the oldest aged from Sable Bank was 211. The productivity of slow growing species is low, so sustainable TACs must be a small fraction of the biomass. If overfishing occurs, it will take a long time before the stock recovers.

The framework assessment recommended that the fishing mortality, F, should be a function, a, of the natural mortality, M. A range of harvest levels could be considered. A value of a = 1.0 (F = M) was considered the upper limit, and the current harvest level (a = 0.25) was considered to be low. Other potential values were 0.33 (MCY approach) and 0.5 (MSY approach). The value of a associated with $F_{45\%}$ was above the recommended upper limit, while the estimate of $F_{0.1}$ is at the upper limit. The biological consequences of harvesting at rates ranging from F ~ MCY to F = M should be considered (Table 4). Given the current state of knowledge and our limited understanding of the spatial and temporal dynamics of the populations, particularly recruitment processes, it is recommended the TAC be set near the low end of the range of harvest strategies considered.

Table 4. Stock parameters and TACs for the range of Fishing mortalities considered.

Stock parameters				TAC (t)		
Stock	Species	Biomass (t)	M	F ~ MCY	F = 0.5M	F = M
Banquereau	Arctic surfclam	1,462,097	0.08	38,599	58,484	116,968
Sable Bank	Ocean quahog	1,373,913	0.03	13,602	20,609	41,217
St. Mary's Bay	Ocean quahog	157,8430	0.045	2,344	3,551	7,103

The present TAC of 24,000 t of surfclams for Banquereau corresponds to a fishing mortality of 0.0164, well below the recommended range, and can be increased. There are currently no quahog fisheries in St. Mary's Bay or Sable Bank.

For the St. Mary's Bay area, there are no plans for a regular survey series. The expert opinion on inshore ocean quahog harvest levels recommended a constant harvest strategy based on MCY = $0.33MB_0$ as a sustainable harvest level when there is no monitoring with regular surveys.

OTHER CONSIDERATIONS

There are perceived conflicts with other inshore fisheries, especially the lobster fishery.

Oil and gas exploration and production on Sable Bank has potential implication for the ocean quahog fishery. Drilling and production platforms remove areas from the fishery, and once abandoned, structures remaining on the bottom continue to make these areas unavailable to clam dredges. Mechanisms are in place for both the oil and gas and clam fishing industries to address these conflicts.

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