Fisheries and Oceans Canada
Science

Pêches et Océans Canada
Sciences

C S A S

Canadian Science Advisory Secretariat

S C C S

Secrétariat canadien de consultation scientifique

Proceedings Series 2007/008

Séries des comptes rendus 2007/008

Proceedings of the Maritime Provinces Regional Advisory Process on Assessment and Management Strategy Framework for Banquereau Arctic Surfclam and Ocean Quahogs on Sable Bank and in St. Mary's Bay

Compte rendu des réunions du Processus consultatif régional des provinces Maritimes sur le cadre applicable à l'évaluation et à la stratégie de gestion de la mactre de Stimpson du Banquereau et du quahog nordique du banc de l'île de Sable et de la baie St. Mary's

17-18 January 2007
4-5 April 2007

Les 17 et 18 janvier 2007
Les 4 et 5 avril 2007

Paul Boudreau and Robert O'Boyle
Meeting Chairs

Paul Boudreau et Robert O'Boyle
Présidents de réunion

Bedford Institute of Oceanography
1 Challenger Drive, P.O. Box 1006
Dartmouth, Nova Scotia
B2Y 4A2

Institut océanographique de Bedford
1, promenade Challenger, C.P. 1006
Dartmouth (Nouvelle-Écosse)
B2Y 4A2

June 2007

juin 2007

Canadä

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings include research recommendations, uncertainties, and the rationale for decisions made by the meeting. Proceedings also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

Avant-propos

Le présent compte rendu a pour but de documenter les principales activités et discussions qui ont eu lieu au cours de la réunion. Il contient des recommandations sur les recherches à effectuer, traite des incertitudes et expose les motifs ayant mené à la prise de décisions pendant la réunion. En outre, il fait état de données, d'analyses ou d'interprétations passées en revue et rejetées pour des raisons scientifiques, en donnant la raison du rejet. Bien que les interprétations et les opinions contenus dans le présent rapport puissent être inexacts ou propres à induire en erreur, ils sont quand même reproduits aussi fidèlement que possible afin de refléter les échanges tenus au cours de la réunion. Ainsi, aucune partie de ce rapport ne doit être considéré en tant que reflet des conclusions de la réunion, à moins d'indication précise en ce sens. De plus, un examen ultérieur de la question pourrait entraîner des changements aux conclusions, notamment si l'information supplémentaire pertinente, non disponible au moment de la réunion, est fournie par la suite. Finalement, dans les rares cas où des opinions divergentes sont exprimées officiellement, celles-ci sont également consignées dans les annexes du compte rendu.

Proceedings of the Maritime Provinces Regional Advisory Process on Assessment and Management Strategy Framework for Banquereau Arctic Surfclam and Ocean Quahogs on Sable Bank and in St. Mary's Bay

17-18 January 2007
4-5 April 2007

Paul Boudreau and Robert O'Boyle
Meeting Chairs

Bedford Institute of Oceanography
1 Challenger Drive, P.O. Box 1006
Dartmouth, Nova Scotia
B2Y 4A2

June 2007

Compte rendu des réunions du Processus consultatif régional des provinces Maritimes sur le cadre applicable à l'évaluation et à la stratégie de gestion de la mactre de Stimpson du Banquereau et du quahog nordique du banc de l'île de Sable et de la baie St. Mary's

Les 17 et 18 janvier 2007
Les 4 et 5 avril 2007

Paul Boudreau et Robert O'Boyle
Présidents de réunion

Institut océanographique de Bedford
1, promenade Challenger, C.P. 1006
Dartmouth (Nouvelle-Écosse)
B2Y 4A2

juin 2007

ISSN 1701-1272 (Printed / Imprimé)

Published and available free from:
Une publication gratuite de :

Fisheries and Oceans Canada / Pêches et Océans Canada
Canadian Science Advisory Secretariat / Secrétariat canadien de consultation scientifique
200, rue Kent Street
Ottawa, Ontario
K1A 0E6

http://www.dfo-mpo.gc.ca/csas/

CSAS@DFO-MPO.GC.CA

Printed on recycled paper.
Imprimé sur papier recyclé.

Correct citation for this publication:
On doit citer cette publication comme suit :

DFO, 2007. Proceedings of the Maritime Provinces Regional Advisory Process on Assessment and Management Strategy Framework for Banquereau Arctic Surfclam and Ocean Quahogs on Sable Bank and in St. Mary's Bay; 17-18 January 2007 and 4-5 April 2007. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2007/008.

TABLE OF CONTENTS

SUMMARY

The Maritimes Regional Advisory Process (RAP) review of the assessment framework for the assessment and management strategy framework for Banquereau Arctic surfclam and ocean quahogs on Sable Bank and in St. Mary's Bay was undertaken in two meetings: data inputs (17-18 January 2007, Dartmouth, N.S.), and models for assessment and management strategy evaluation (4-5 April 2007, Dartmouth, N.S.). The framework was reviewed by Department of Fisheries and Oceans (DFO) and non-DFO scientists and input was received from members of the fishing industry, DFO managers, and provincial representatives. The framework is to be used, for the first time, to provide the assessment in support of the 2007/08 fishery.

SOMMAIRE

Le cadre applicable à l'évaluation et à la stratégie de gestion de la mactre de Stimpson du Banquereau et du quahog nordique du banc de l'île de Sable et de la baie St. Mary's a fait l'objet d'un examen, s'inscrivant dans le Processus consultatif des provinces Maritimes, lors de deux réunions. La première d'entre elle (les 17 et 18 janvier 2007, à Dartmouth [N.-É.]) portait sur les entrées de données et la seconde (les 4 et 5 avril 2007, à Dartmouth [N.-É.]) sur les modèles d'évaluation et l'analyse de la stratégie de gestion. À ces occasions, le cadre a été examiné par des scientifiques du ministère des Pêches et des Océans (MPO) et de l'extérieur du Ministère, et des membres de l'industrie de la pêche, des gestionnaires du MPO et des fonctionnaires ont pu donner leur avis à ce sujet. Ce cadre servira pour la première fois à l'évaluation effectuée à l'appui de la pêche pour 2007-2008.

INTRODUCTION

There has been a quota regulated fishery on Banquereau Bank Arctic surfclam since 1986, although there has not been an assessment framework developed; and advice has been provided by DFO Science to Fisheries and Aquaculture Management on an as-needed basis. A Total Allowable Catch (TAC) was established for Sable Bank ocean quahog in 2003, but this was not fished. There has been no fishery for St. Mary's Bay ocean quahog. An Expert Opinion (EO) on the habitat implications of a Clearwater/Deep Sea Clam Ocean Quahog development proposal was produced (EO 2002/03), as was an Expert Opinion on the rationale for ocean quahog harvest advice (EO 2005/04).

Recently, in collaboration with DFO, the fishing industry initiated a survey program for the Banquereau Arctic surfclam and Sable Bank ocean quahog resources. On an approximately five-year cycle, these banks, along with Grand Banks off Newfoundland, are planned to be surveyed. Sable Bank was surveyed in 2003, and Banquereau Bank in 2004. No survey was conducted in 2005, and the 2006 survey was conducted on the southern Grand Bank. The 2007 survey is tentatively planned for the northern Grand Bank. This initiative, and signs of a potential increase in effort in the fishery, is the stimulus for the current framework review.

This review examined not only the methodology used to assess these resources, but also undertook an evaluation of the management strategy. It was conducted over two meetings: the first (17–18 January 2007) to consider data inputs and the second (4-5 April 2007) to review the methodologies of the assessment and management strategy. The framework is intended to be applied in supporting the future management of these fisheries.

The objectives of the two meetings are provided in their terms of references (Appendix 1). The lists of participants and agendas are provided in Appendices 2 and 3, respectively. These proceedings were adopted by correspondence subsequent to each meeting.

DATA INPUTS
Futures Inn, Dartmouth, Nova Scotia
17-18 January 2007

The meeting commenced with the Chair, Paul R. Boudreau, welcoming the participants. He particularly noted the presence of Drs. James Boutilier, Jim Weinberg, and Stephen Smith, who were the invited external scientific reviewers for the meeting. The context and overall process of the framework review, as outlined in the terms of reference were then presented. Following this, there was a discussion on the objectives of this first meeting of the framework which focused on data inputs.

The Chair noted that all of the working papers were available at the back of the room along with a number of previously published papers relating to benthic habitat studies.

After thanking Tania Davignon-Burton, the meeting rapporteur, the presentation of the working papers commenced.

Life History Characteristics of Each Species Being Harvested

Roddick, D., K. Mombourquette, and R. Kilada. 2007. Science Advisory Process on Assessment and Management Strategy Framework for Banquereau Arctic Surfclam and Ocean Quahogs on Sable Bank and in St. Mary's Bay. RAP Working Paper 2007/10, Section 1.

Presentation Highlights

A general overview of the life history characteristics and biology of the following species was presented:

- Arctic surfclam (*Mactromeris polynyma)*;
- Ocean quahog (*Arctica islandica)*;
- Northern propeller calm (*Cyrtodaria siliqua)*; and
- Greenland smoothcockle (*Serripes groenlandicus*).

Arctic surfclams are a large bivalve, 75-125 mm, which occur on coarse sand bottoms in subtidal waters down to 110 m depth. They are slow growing and long-lived with significant numbers reaching 40 years of age. The oldest aged animal so far was 68 years old; the largest observed was 159 mm.

Little is known about the reproductive capacity of surfclams. They are sexually mature at sizes smaller than commercially harvested. On Banquereau Bank, there appears to have been some fluctuation in recruitment through time with two periods of higher recruitment about 11 years apart (1981 and 1992) with lower recruitment in between.

Natural mortality for the Banquereau Bank stock was estimated as 0.08.

Ocean quahogs are most abundant in fine to medium sand, burrowed within 12 mm of the surface. It is found in depths from 4 to 260 m, deeper in the southern part of its range, but 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, and on the offshore banks, especially Sable and Western Banks.

It is one of the slowest growing and longest lived commercial species. The harvested beds off the Mid-Atlantic States are dominated by animals 40 to 80 years old, with significant numbers over 100. The oldest aged specimen was over 221 years old. They reach the first marketable size, about 48 mm, at 11 to 14 years of age.

U.S. data show recruitment to be highly variable with infrequent strong year classes. Adult natural mortality ranges from 0.01 to 0.04. Predator mortality on newly settled and juvenile quahogs is thought to be high with crabs and groundfish being the main predators.

Northern propeller calms are large bivalves up to 100 mm. It completely buries itself in the sand to a depth of no greater than a few centimetres. It is thought to be an active burrower, but travels horizontally through the sediment rather than vertically. It occurs on fine sand bottoms usually between 50 and 150 m, but has been observed as shallow as 4 m and as deep as 500 m. It is often found in association with the sand dollar (*Echinarachnius parma)*. It avoids the coarse-sand bottom of the shallowest parts of banks because of the decrease in the amount of food available for buried molluscs.

The growth rate for this bivalve has not been determined. Preliminary work on samples from Banquereau Bank indicates that it is long lived, with large specimens reaching 70 years of age.

Natural mortality is not known. The propeller clam is a favourite food for cod, haddock, and yellowtail flounder.

The Greenland smoothcockle is a large bivalve, which can reach sizes of 13 cm. It is a subtidal organism, existing at depths up to 100 m. It is relatively fast growing, compared to the ocean quahog and even the Arctic surfclam. Maximum observed age is of 39 years at 93.3 mm in length. Not much is know about recruitment patterns and natural mortality. Although Greenland smoothcockle is the recommended common name, it is more often referred to simply as the Greenland cockle, or it's market name, the Cockle clam.

Discussion

Some information is being collected on condition factors in Arctic clams and there have been some anecdotal observations of “jelly clams” on the Grand Banks that had very low density flesh within the shell. There are no samples to confirm these sightings

The warmer waters in U.S. may be putting thermal stresses on clams. Changes in temperature may be causing changes in distribution of clam species so that they are more mixed in same bottom types.

Population Structure of the Species in the Management Units

Roddick, D., K. Mombourquette, and R. Kilada. 2007. Science Advisory Process on Assessment and Management Strategy Framework for Banquereau Arctic Surfclam and Ocean Quahogs on Sable Bank and in St. Mary’s Bay. RAP Working Paper 2007/10, Section 2.

Presentation Highlights

For Arctic surfclams, a study has shown small but non-significant genetic subdivision within the samples over wide geographic range. Most of the genetic variation was within cohorts rather than between them.

For ocean quahog, published scientific studies have examined the quantitative morphological traits between five different populations (four North Sea and one Canadian from Nova Scotia) and determined that all populations could be readily identified from their unique morphologies (shapes/growth patterns) derived from two factors resulting from a principal components analysis. Investigation, using random amplified polymorphic DNA (RAPD) analysis, into the genetics of the populations to indirectly assess whether the observed phenotypic differences could be related to potential differences in genotype, revealed that all populations were genetically distinct from each other even at a microscale (less than 25 km). It is concluded that although phenotypic differences can be used to distinguish between populations of *Arctica islandica*, it should not and cannot be used to infer genetic differences in the absence of further studies.

A second publication reported that it did not find significant differences between populations ranging from Maine (U.S.) to southern Virginia (U.S.).

General circulation over Banquereau Bank is typically a partial gyre with a strong offshore flow on its eastern side and an onshore flow on its western side with weak closed subgyres over the bank in spring and summer. On Sable Bank, there is a stronger broad anticyclonic gyre inside the 100 m isobath in all seasons, centered over the western side of Sable Island from spring to fall. This means that larvae produced on these banks have a means of being retained on the banks. The overall current structure also allows for some transport between stocks on Grand Bank, the Gulf of St. Lawrence, and Banquereau, but the circulation times in relation to the planktonic period of the larvae has not been investigated.

Discussion

It was clarified that the statement on page 10 of the RAP Working Paper 2007/10, re. “did not find significant differences between populations” does not adequately describe the feeling that there are more differences in waters north of Nova Scotia.

Fishery Catch and By-catch Estimates, Including Discard Mortality

Roddick, D., K. Mombourquette, and R. Kilada. 2007. Science Advisory Process on Assessment and Management Strategy Framework for Banquereau Arctic Surfclam and Ocean Quahogs on Sable Bank and in St. Mary’s Bay. RAP Working Paper 2007/10, Section 3.

Presentation Highlights

Areas and species of interest for this RAP:

	Arctic Surfclam	**Ocean Quahog**	**Propeller Clam**
Banquereau	Active fishery		By-catch in surfclam fishery
Sable Island Bank		Fishery licensed, but has not started	
St. Mary’s Bay		Licensed, but not recently active	

The fishery for the Arctic surfclam (*Mactromeris polynyma*) on the east coast of Canada started in 1986, and has developed into a multi-million dollar fishery. It focuses primarily on Banquereau Bank, in waters less than 100 m. Recent landings are on the order of 15,000 mt and the TAC has not been achieved. By-catch in the commercial fishery is very low; in the order of 5% of the catch. This by-catch is comprised mainly of sand dollars.

Some information is available on the catch per unit effort (CPUE) for this fishery, but it has a number of qualifications, in particular, the lack of resolution in the information on the specific area towed. CPUE estimates showed low CPUE in the early years of the fisheries, increasing during the late 1990's and then declining in recent years. This seems to be related to the increase in experience and knowledge in the early years. Recent declines are related to an ageing fleet and the diversion of some effort to the Grand Banks.

Incidental mortality for small clams that pass through the dredge is very low ranging from 6 to 15%. Some proportion of small clams is caught in the dredge and is discarded at the surface. It is expected that the mortality rate of these organisms is much higher.

Very limited information is available for the quahog fishery. The 2003 survey on Sable Island Bank showed that quahogs accounted for 31.3% of the catch by weight. Sand dollars were the second largest living component at 10.8%, followed by propeller clams and sea cucumbers at 0.9% each. The remainder of the items make up 3.4% of the catch.

The 2002 inshore survey in St. Mary's Bay showed that quahogs made up 44% of the catch by weight and other living species only made up 1.2% of the catch. No other single species made up more than 0.33% of the catch.

Discussion

There was some discussion on the interaction between the directed fisheries and populations of propeller clam in the area. Propeller clam are a preferred food for groundfish. Propeller clams are presently being caught in the fisheries and attempts are being made by the industry to develop a market for them.

Sand dollars have the same distribution as the ocean quahog on Sable Island Bank.

The Canadian 100 m contour forms a boundary with steep slopes and rocky bottom to deeper waters. It was agreed that this is a useful indicator of the geographical extent of the distribution of animals.

It was pointed out that it is important to have accurate report of all by-catch, even non-commercially significant species. There is current no industry work on technology to reduce by-catch.

It was pointed out that there has been a study in St. Mary's Bay, but no data was presented at the meeting.

Mobile species move out of the way of the dredge and catch is of sedentary species that would not avoid the dredge and would not anticipate any seasonality in by-catch.

Formerly groundfish trawlers would come in behind the clam vessels, indicating a concentration of groundfish feeding in the tracks. Underwater video of dredge tracks on Banquereau in 1996 showed food items available on the sediment surface, but a lack of scavengers.

There is a signal for serial depletion in the U.S. data from the commercial information. It is possible that CPUE might show the strongest signal of depletion and it may be necessary to look at the spatial distribution of the commercial catch to investigate the depletion.

The commercial catch directs to specific areas at specific times and this may affect some of the resultant statistics. Boats change their fishing location based on a number of factors including catch rates and desired size of the organisms harvested. This may impact on the use of CPUE as indices of abundance.

It may be useful to try to match length frequency of organism to specific trips. In most of the area, a mixture of sizes is observed. This may be useful in looking at the possibility of a manipulative management system.

Precision and Bias of Current Commercial Sampling Protocols, Construction of Catch Age/Size Including Grouping and Weighting of Samples and Catches

Roddick, D., K. Mombourquette, and R. Kilada. 2007. Protocols and Sampling Forms for On-board Sampling of the Catch of Mactromeris polynyma. RAP Working Paper 2007/09.

Roddick, D., K. Mombourquette, and R. Kilada. 2007. Science Advisory Process on Assessment and Management Strategy Framework for Banquereau Arctic Surfclam and Ocean Quahogs on Sable Bank and in St. Mary's Bay. RAP Working Paper 2007/10, Section 4.

Presentation Highlights

The commercial sampling on-board the vessels is done by the ships' personnel, usually the quality control personnel. There was some early observer coverage, but there has been none in recent years. The samplers are, therefore, not trained samplers and the sampling program is not the priority in their workload. When this is combined with the turnover of personnel, the sampling coverage and quality is sometimes erratic. There are a number of sampling programs carried out on board the vessels. From the hoppers, where the dredges are dumped, samples are taken for length frequencies and catch composition. Length frequencies are also taken from the sorted catch, i.e., after mechanical and hand sorting to remove other species/material; and from the discharge from this sorting process. On two of the vessels, samples for conversion factor estimates are run when the processing line is started back up after defrosting of the freezer tunnels and cleaning of the processing line. Frozen samples of clams are also retained and sent to DFO for morphometrics and ageing. The protocols for these sampling programs are in a separate document.

The length frequency sampling provides estimates of the size distribution of the catch. The sampling protocol calls for samples of approximately 100 clams, but for the discard samples this is often difficult to achieve as a lot of the clams are immeasurable; and if there are not a lot of clams being discarded it takes a long time to collect the sample. The standard error with increasing sample sizes for the processed clam samples was calculated from the existing length frequency data, both by taking the standard deviation of the entire data set divided by the square root of sample size, and by drawing 30 random samples of each size from the data and calculating the Standard Error. Increasing the sample size could decrease the error but the gain would be small. If time is available, it may be better to increase the number of samples being taken rather than increasing the sample size.

The conversion factor samples have been collected and used to define the present conversion factors used by statistics branch to convert round weight to processed weight.

The morphometrics samples have been taken and used for length-weight and other relationships.

During processing of the samples the gonads are assigned a visual maturity stage, and sub-samples of the shells are aged for growth studies. At present, the commercial landings are not converted to age structure, and it would take a lot of additional resources to institute an ageing program that could process enough shells to accurately do so.

Discussion

There was some discussion on the observed trends in catch per unit effort over time on Banquereau. It was suggested that the CPUE increases at the end of the time series due to the increased knowledge and experience of the fishermen in catching the organisms. It was pointed out in the discussion that the fisheries are able to accurately targeting clam concentrations through the application of bottom profiling RoxAnn technology in association with hydroacoustics.

The clam vessels have changed fishing areas over time and the gear is believed to be very efficient at capturing what is in its path. Although it is not thought that overfishing is occurring at this time, the pattern of constantly moving to new grounds while using a highly efficient gear means that sequential overfishing would not show up in trends of CPUE until the vessels started running out of grounds.

It was pointed out that the record of distance towed from the boat does not adequately capture the amount of bottom fished. Data was presented to indicate that there would be a large amount of overlap in the bottom fished by the individual tows.

Frequency and quality of the sampling of the commercial catch may have problems due to the use of available quality control personnel who are active on the boats to carry out a number of different tasks during the trip. There is also a high degree of turnover of industry staff between trips. This may be having an impact on the training and the quality of data collected through the year.

Canadian sampling on a sampling board is returning high numbers of clams in length bins that end in 0 or 5, suggesting a measurement bias in the length estimates. It was suggested that alternative methods of sampling length be used. It was suggested that the U.S. may have a technique that might be appropriate a hybrid method using PVC that might be usefully applied to measure large numbers of samples.

It is assumed that all sizes that are discarded at the surface have 100% mortality as a precautionary estimate. This is especially true for the larger clams as they get broken up. The survival of clams moving through the dredge on the bottom is estimated to be 15%.

It was agreed that, following the U.S. approach for assessment, long-lived species do not require annual assessments.

There appears to have been a recruitment pulse on the south side of the shoal waters 15 years after the original fishing effort. Graphs show pulses of age groups spaced by 10 years apart.

There appears to be a difference between the east and west portions of the Banquereau that may be resulting from increased retention of recruitment through oceanographic processes on the western end. The eastern end might be subject to eddies coming out of the Gulf that may be dispersing young stages. There is no evidence that clearing an area promotes recruitment.

One important question that will come up at the next workshop will be whether we have the data to investigate the implementation of area different management strategy, such as management on rotating geographic areas. Recruitment pulses have been observed in the U.S. quahog fisheries over long time periods and knowledge of the timing has helped to establish a level of sustainable exploitation.

A contractor will be doing modelling of fishing activities from available data. This will be done primarily from log book data. There may not be a sufficient level of geographic precision in the log books. Vessel Monitoring System (VMS) data is available for the boats for years starting 2001 for vessels landing in Nova Scotia. Vessels landing in Newfoundland will not be included in the VMS dataset. Positional information may be available from the RoxAnn technology.

Three licenses have been issued for St. Mary's Bay but there have been no fisheries carried out in recent years, and so data from the fisheries is very limited. Fisheries catch data for St. Mary's Bay was requested for next meeting to confirm the low level of fishing effort.

Precision and Bias of Ageing Protocols

Roddick, D. 2007. Banquereau Bank 2004 Survey for *Mactromeris polynyma.* RAP Working Paper 2007/08.

Roddick, D., K. Mombourquette, and R. Kilada. 2007. Survey for Ocean Quahogs (*Arctica islandica*) at the Mouth of St. Mary's Bay, Nova Scotia. RAP Working Paper 2007/07.

Roddick, D., K. Mombourquette, and R. Kilada. 2007. Protocols and Sampling Forms for On-board Sampling of the Catch of *Mactromeris polynyma*. RAP Working Paper 2007/09.

Roddick, D., K. Mombourquette, and R. Kilada. 2007. Science Advisory Process on Assessment and Management Strategy Framework for Banquereau Arctic Surfclam and Ocean Quahogs on Sable Bank and in St. Mary's Bay. RAP Working Paper 2007/10, Section 5.

Roddick, D., R. Kilada, and K. Mombourquette. 2007. Ocean Quahog (*Arctica islandica*) Survey and Yield Estimates for Sable Bank. RAP Working Paper 2007/11.

Presentation Highlights

Ageing error can be of two forms: error that affects precision, or the reproducibility of individual measurements on a given structure, and error that affects accuracy, or the proximity of the age estimate to the true value. Ageing precision should be assessed by comparing ageing between different readers and by comparing the ageing result of the same reader over time, which will ensure consistency. On the other hand, accuracy is achieved by validating the annual deposition of the growth bands so that their number would reflect the real age of the animal. A variety of methods exist through which age interpretations can be validated such as the bomb radiocarbon and Marginal Increment Analysis.

Ageing the Arctic surfclam is determined by counting the growth bands on the chondrophore area in a thin section. After cutting through the shell and bonding the section on a glass slide, a thin sectioning machine is used to produce a 0.3 mm-thick section. After grinding the section on the glass slide with sand paper of grit size 240, the section is checked using a Nikon microscope under transmitted light at 40x magnification.

With surfclams, the confidence of variation (CV) was found to be 3.7% for the same age reader over time and 7.1% for two readers with different level of experience.

For Arctic surfclams, samples for size and age at maturity were collected during the survey. The histogram of the length stratified sample has been fitted to a von Bertalanffy growth curve. This data was used to construct and age-length key to convert the survey length frequencies to age frequencies.

For ocean quahogs due to the old age, and as a consequence, the deposition of many growth bands on the shell, counting the bands is not possible on the external shell surface or in a cross section. Methods for ageing were presented.

There is lack of information about the general biology, in particular, the growth rate and age at sexual maturity for the Greenland smoothcockle. Because of the increase in interest in this species in the last few years, ageing became an important issue in its fisheries management. Steps used in cockle ageing are similar to that of the ocean quahog and are provided in the working papers.

This table presents a summary of the results for the different species.

	Precision/ Reproducibility	**Age Validation**
Arctic surfclam	High (CV < 5%)	
Ocean quahog		Bomb radio. Validated.
Greenland smoothcockle	High (CV < 5%)	MIR. Validated.
Propeller clam	Not yet	Not yet

Discussion

<u>Arctic Surfclam</u>

The U.S. are doing some work on refining ageing, and they are making progress with video imaging. Canadian studies may have done better at validation. A comparison of the two would be helpful.

Animals in captivity showed two rings a year with the tetracycline methodology. This study is consistent with U.S. studies that showed annual bands. It is good to revalidate this hypothesis in this area with these species.

Although there was a discussion of using tetracycline labelled organisms to validate ageing, recovery of offshore surfclams in deep water is not feasible.

Ocean Quahogs

The ageing of ocean quahogs is a very slow process. Whereas 300 scallops can be aged in one day, it takes up to six months to age 300 ocean quahogs.

Age validation has been done using bomb radiocarbon by looking at ^{14}C isotope from nuclear testing in the 1950's. This has validated that the quahogs do put down one ring per year and that rings can be used for ageing.

Reference collections of Arctic surfclams and ocean quahogs are being established.

Propeller clams and ocean quahogs have age bands in later life that are crowded, which increases the difficulty in ageing older individuals.

The ageing of Greenland smoothcockle cannot be validated using the bomb radiocarbon method because it does not live long enough to include the bomb radiocarbon spike in currently living cockles. Age validation is done by comparing the width of the last ring and the ring before last using samples throughout the year. Data does show that there is one cycle of band deposit and thus ring counting is a valid method.

Protocols to Estimate Growth and Size at Maturity

Kilada, R., D. Roddick, and K. Mombourquette. 2007. Banquereau Bank 2004 Survey for *Mactromeris polynyma*. RAP Working Paper 2007/08.

Roddick, D., K. Mombourquette, and R. Kilada. 2007. Science Advisory Process on Assessment and Management Strategy Framework for Banquereau Arctic Surfclam and Ocean Quahogs on Sable Bank and in St. Mary's Bay. RAP Working Paper 2007/10, Section 7.

Roddick, D., R. Kilada, and K. Mombourquette. 2007. Ocean Quahog (*Arctica islandica*) Survey and Yield Estimates for Sable Bank. RAP Working Paper 2007/11.

Presentation Highlights

A total of 178 surfclams, ranging in size from 22 to 79 mm, were processed for maturity and sex, of which 166 were aged. The resulting maturity data were fit with a logistic curve using maximum likelihood. The size at 50% maturity was 47.2 mm shell length, well below the size at 50% retention of the dredge, and the age of 50% maturity was 6.7 years old.

For ocean quahogs, samples for size and age at maturity were collected during the survey. A total of 335 quahogs were aged using the acetate peel technique, including those collected for the age/size at maturity study. The aged quahogs ranged between 2 and 210 years, and lengths of 8 to 118 mm. Growth rate was most rapid for quahogs less than 25 years old, declining to very low growth rates after 75 years of age. With such a wide range of ages, a sample size of 355 does not produce a smooth and full age frequency. There are still gaps in the distribution that would take a large increase in aged shells to fill.

The 50% maturity level in quahogs was reached at 30.96 mm and 8.2 years. This is well below the 50% selectivity size for the gear, and so the harvested quahogs should have approximately 20 years to reproduce before being vulnerable to the gear.

Precision and Bias of the Industry/DFO Science Research Survey*

Including:

- ***Survey design including survey area, sampling unit definition and allocation, and timing.***
- ***Protocols used to estimate post-survey relative indicators of abundance and biomass.***
- ***Estimation of survey abundance by size/age using sampling from the survey.***

Banquereau Bank Arctic Surfclam Survey

Kilada, R., D. Roddick, and K. Mombourquette. 2007. Banquereau Bank 2004 Survey for *Mactromeris polynyma*. RAP Working Paper 2007/08.

Kilada, R., D. Roddick, and K. Mombourquette. 2007. Protocols and Sampling Forms for On-board Sampling of Catch of *Mactromeris polynyma.* RAP Working Paper 2007/09.

Presentation Highlights

A survey was conducted on Banquereau Bank in 2004, for Arctic surfclams achieving 210 stations between the 40 m and 90 m contours. This provided coverage of one station per 41 km^2. The vessel, the Cape Keltic, was used to deploy a dredge at the selected stations with a navigation package to measure tow distance. A RoxAnn bottom discrimination system was deployed to check the bottom for suitability before each dredge.

Catch of major bivalves were based on a 25 bushel sample and catch of other components on a 5 bushel sample. Catch by weight were standardized to a tow area of 1,000 m^2 based on the estimated length of the tow form surface boat information and the width of the trawl. The best catches were obtained between 50 and 65 m depth.

Length distributions were estimated from a sample of at least 100 clams from each tow measured to the nearest mm. An artefact due to processor bias is evident in the length frequencies, with lengths in units of 5 and 10 mm having higher frequency than those in between.

For morphometrics and ageing, a sample of up to three clams from each 5 mm interval was collected during the length frequency measurements and frozen for later processing in a DFO laboratory. A length stratified sub-sample of 30 individuals per 5 mm shell length increment of the clams processed for morphometrics was taken for ageing.

Small clams were collected during the survey for size and age of maturity. They were processed for histology, and the gonad condition was visually classified into six maturity stages: fully spent, early active, late active, ripe, spawning, and immature. A total of 178 surfclams ranging in size from 22 to 79 mm were processed, of which 166 were aged. The size at 50% maturity was 47.2 mm which is well below the size at 50% retention of the dredge. The age at 50% maturity was 6.7 years old.

Dredge selectivity was studied using a covered-cage/codend method, where all organisms that passed through the grates of the dredge were captured within a loose cover made of 38 mm shrimp mesh. The size of 50% retention is 87.4 mm.

The mortality rate was estimated using two methods: catch curve method and by using the reverse cumulative numbers at age to fit a mortality curve. The rate of natural mortality is estimated at 0.08 for Arctic surfclams.

The biomass estimates were calculated using random sampling statistics and area expansion using inverse distance weighting with the ACON Data Visualization software package. Estimates ranged from 1.2×10^6 to 1.5×10^6 mt, with a 95% confidence interval in the order of $\pm$ 24×10^3 to 27×10^3 mt.

Discussion

There are two kinds of zeros – successful tows where there were no catch (such as in sandy bottom), but others where there were unsuccessful tow with no catch. This will cause model to be more complex.

Check to investigate changes in size frequency between surveys in 1996/97 and present day survey to see what impact the fisheries may have had in between.

There is no evidence to suggest that biomass estimates were smaller before fishing pressure applied.

The area has been fished for groundfish and this may have impacted on the population being sampled. There may not be a virgin biomass in this area.

Because of the preference for 0's and 5's, could we bin into larger size groups, or try zero mean random noise to smooth distribution as 5 mm of growth in the quahogs is a lot of years. This is not so important for the surfclam.

The cover on the selectivity studies may be affecting the catchability of the dredge, but this is not thought to be size selective. The liner is expected to only affect the results within the dredge. Towed at less than 2 knots with 1¾ mesh so a pressure wave would not be expected with the liner. There is only a 2 mm difference between the survey and the commercial gear - this might be a good indication that the liner is not having a significant effect.

There appear to be spatial patterns of growth. The assumption is that high density is indicative of good habitat and good growth. The U.S. has 30 years of experience and has seen growth rate changes over time periods of about 10 years. Data is available to look at changes in ring size related to environmental parameters.

It should be noted that there may be an impact of fishing activities (per area) on the calculation of present day mortality estimates. That is, it may be a wrong assumption to assume that this was a virgin population. There may be some compounding impacts from areas that have already been fished. Fishing may disturb juveniles, result in density dependent effects on growth and/or recruitment. There might be some biases introduced by selecting areas with the highest density.

In general, there is a high sampling density and this can be used in conjunction with the bottom characteristics as identified using the RoxAnn technology.

<u>Sable Island and St. Mary's Bay Surveys</u>

Roddick, D., K. Mombourquette, and R. Kilada. 2007. Survey for Ocean Quahogs (*Arctica islandica*) at the Mouth of St. Mary's Bay, Nova Scotia. RAP Working Paper 2007/07.

Roddick, D., R. Kilada, and K. Mombourquette. 2007. Ocean Quahog (*Arctica islandica*) Survey and Yield Estimates for Sable Bank. RAP Working Paper 2007/11.

Presentation Highlights

The Cape Keltic was used to carry out a Sable Island survey in 2003, which sampled 219 stations randomly assigned within the 100 m contour on Sable Bank. Tows were carried out with a minimum spacing of three km to ensure appropriate separation. Species in the catch changed dramatically from quahogs to Atlantic surfclams as the depth at the stations increased below 30 m. Sampling protocols were the same as used for the Banquereau survey and are documented in the working paper. Biomass estimates were calculated using three methods: random sampling statistics, areal expansion using inverse distance weighting with ACON, and spatial analysis using kriging after modelling the spatial relationship with a variogram using the Surfer software package. Estimates ranged from 1.2 x 10^6 to 1.4 x 10^6 mt, with the single estimate of 95% confidence interval in the order of $\pm$ 21 x 10^3. If the biomass estimate is adjusted for estimates of dredge efficiency, reported below, the efficiency corrected biomass estimate is 1.3 x 10^6 mt. From the gear selectivity studies, the mean length at first capture at which an individual clam has a 50% chance of being caught is 69.5 mm. As there is no fishery on Sable Island Bank, the mortality estimates will reflect only natural mortality. The analysis indicates that this is approximately 0.03.

A industry funded St. Mary's Bay survey was carried out in 2002. Stations were randomly assigned with the provision that the stations would be at least 1.5 km apart. The Midnight Dreamer was the vessel used. It was equipped with a cage type hydraulic dredge and a stern ramp. It used a MacSea 7.5 navigation package and a Questar-Tangent bottom discrimination system. Five-minute tows were used. A sample of five 0.0413 m^3 totes samples were taken from each catch and all ocean quahogs and other large clam species were separated out. A sub-sample of two totes were sorted and weighed. A random sample of 100 quahogs was measured for length, of which 30 quahogs selected to cover the full size range in the tow, were labeled and frozen for morphometric analysis in the laboratory. For the morphometric sample, organisms were measured for length, width, and height of shell, and the reproductive stage were described within the five stages. Biomass was estimated using estimated average catch/tow. Variograms were calculated using Surfer software package and a kriged grid was generated. The bed has an estimated biomass of 157 x 10^3 mt. The 95% confidence interval for biomass ranged from $\pm$ 95x10^3 to 201x10^3 mt. Total mortality estimated from the data ranges from 0.04 to 0.05.

Discussion

It was pointed out that here was no mensuration system on the dredge to ensure that it was adequately contacting bottom. Tow lengths are estimated from the surface navigation systems and the effective tow distance will vary. It was accepted that the tow distances have been over estimated and that this will ultimately result in a conservative biomass estimate.

This may be an issue with the data from the commercial fishing.

Studies from Iceland have reported quahogs burrowing into the bottom to a sufficient depth that they are unavailable to the dredge. There is no evidence that quahogs here are going sufficiently deep (more than 20 cm) to affect catchability.

Dredge Efficiency/Depletion Studies

Roddick, D., K. Mombourquette, and R. Kilada. 2007. Science Advisory Process on Assessment and Management Strategy Framework for Banquereau Arctic Surfclam and Ocean Quahogs on Sable Bank and in St. Mary's Bay. RAP Working Paper 2007/10, Section 6.

Presentation Highlights

Dredge efficiency is one of the biggest uncertainties in the U.S. survey and depletion studies have been carried out in an attempt to estimate this value. It may be related to depth, substrate, speed, tide, etc. This unknown will result in errors in the calculation of biomass estimates.

Depletion experiments have been carried out, two on Sable Island and two on Banquereau. There is less confidence in the depletion estimates from the Banquereau compared to the Sable Island study.

All linear regressions for the depletion experiments shown in Figure 6.4.6 of RAP Working Paper 2007/10, are inconsistent with the model. Suggestions were made to investigate the reason for this and to attempt to improve the fit.

The mean of the two ocean quahog efficiency estimates is 91.8%. For the Arctic surfclams, the mean of the two estimates is 78.4%. Additional work to investigate this variable was recommended for future surveys.

Discussion on All Three Research Surveys

- The various biomass estimates are as good as possible at the moment. There is not enough information to select one over another. There are a few small things that could be done try to improve the estimates of biomass.
- To investigate the impact on the variance estimate, analysis could be done with data only from areas where successful tows were made.
- For the depletion studies, it was suggested that gamma could be changed incrementally within models, while monitoring the impact of this on the residuals in an effort to get better fit.
- Establishing the efficiency of the dredge would give the biggest payoff. Relative efficiency may be available from commercial data.
- There are only 12 years of data to build the commercial catch time series.
- Alternative survey sampling strategies were discussed for future surveys. With sedentary long lived organisms, a simple statistical model may not be the best approach. There may be opportunities to more fully exploit a spatial model. Alternatives such as repeated stations, and/or a mixture of sampling strategies that include both repeated and random samples could be useful. Repeated sampling would be needed each year to establish small scale variability from interannual variability.
- Data may come from the commercial catch.
- CPUE in U.S. quahog always starts low, increases as crew gets experience, then a decline, before the boat moves to a new area. CPUE in area is very important.

- Are there decision rules for changing fishing areas? Typically there are few changes during the trip. Would the industry hand over the RoxAnn track data to get higher resolution of the location of the fishing effort? This would give the distribution of fishing effort on a fine geographic scale.

Previous Scientific Studies on the Impact of Clam Dredging on Benthic Habitat

Gilkinson, K.D., D.C. Gordon, Jr., K.G. MacIsaac, D.L. McKeown, E.L.R. Kenchington, C. Bourbonnais, and W.P. Vass. 2003. Immediate Impacts and Recovery Trajectories of Macrofaunal Communities Following Hydraulic Clam Dredging on Banquereau, Eastern Canada. ICES Journal of Marine Science. 62: 925-947.

Gilkinson, K.D., D.C. Gordon, Jr., D. McKeown, D. Roddick, E.L.R. Kenchington, K.G. MacIsaac, C. Bourbonnais, and W.P. Vass. 2003. Susceptibility of Soft Corals (Anthozoa: *Gersemia rubiformis*, Ehrenberg, 1834) to Capture by Hydraulic Clam Dredges off Eastern Canada: The Significance of Soft Coral-shell Associations. American Fisheries Society Symposium. 41:383-390.

Gilkinson, K.D., G.B.J. Fader, D.C. Gordon, Jr., R. Charron, D. McKeown, D. Roddick, E.L.R. Kenchington, K.G. MacIsaac, C. Bourbonnais, W.P. Vass, and Q. Liu. 2003. Immediate and Longer-term Impacts of Hydraulic Clam Dredging on an Offshore Sandy Seabed: Effects on Physical Habitat and Processes of Recovery. Continental Shelf Research. 23:1315-1336.

Presentation Highlights

The summary results of previous scientific studies on the impacts of hydraulic clam dredging on Banquereau Bank were presented. Visual evidence of activity was gone after one year, but sidescan evidence was still there at least three years after impact. The sidescan evidence may be a result of compaction from the operation of the dredge.

Over two years, there were no detectable changes in species composition of the benthic community. No large mollusc recovery has been seen yet. There were very few juveniles in the grab samples, indicating limited recruitment in the very short term.

Video grab was used to sample right after a commercial sample, and survivability of the juveniles that passed through the dredge was seen to be about 85%.

Discussion

It was noted that the experiment is considered to be still underway. There are plans to revisit the site in 2008, to see if there is any evidence of the original activity 10 years after the original dredging. It was agreed that this survey would be very valuable.

It was noted that in the previous studies, the plume from the dredge was fully settled out of the water column after only five minutes in shallow water depths. It was unclear if this is the same for deeper depths.

It was noted that after dredging activity, there are no obvious clam burrows in the path of the dredge. The organisms do not appear to be re-establishing themselves in the path of the dredge.

The dredge efficiency is seen to be very high, only one clam being observed in the track after dredging.

There might be some additional information on benthic impacts from a separate study, not reported here, that looked at fish habitat on Sable, Western, and Emerald Banks.

There was an update on the Canadian Centre for Science Advice process to review benthic impacts and their sensitivities to human activities. A national workshop has been held on the impacts of fishing gear on bottom habitat. The regional effort to identify Ecologically Significant Biological Areas (EBSA) is using national criteria.

It was noted that during the Sable Island Bank survey, out of 26 sampling sites that were surveyed with side scan sonar only six deep sites had evidence tow tracks one year later. This demonstrates a relatively quick return of the physical appearance of the sediments where they are actively worked by waves on this time scale.

Management Strategy Evaluation

Roddick, D., K. Mombourquette, and R. Kilada. 2007. Science Advisory Process on Assessment and Management Strategy Framework for Banquereau Arctic Surfclam and Ocean Quahogs on Sable Bank and in St. Mary’s Bay. RAP Working Paper 2007/10, Section 9.

Presentation Highlights

Robert O’Boyle and Tana Worcester provided an overview presentation summarizing the discussion at a recent Canada-Australian workshop on Management Strategy Evaluation (MSE). There is a need to put the biological system and fisheries management together in the broader context.

MSE is a simulation-based framework for evaluating Fisheries Management System as a whole including:

- Monitoring programs,
- Stock assessment methods,
- Harvest strategies, and
- Decision rules.

Discussion

If there is a report from the Canadian-Australian meeting, it should be presented at the next ”Models for Assessment and Management Strategy Evaluation” meeting.

One thing that is missing from the assessment is the footprint of the activity, such as on benthic habitat. The Fisheries Management System for this stock may have non-fisheries objectives.

The MSE should build on the present collaboration amongst science, management and industry.

Framework assessments under RAP are a good place to step back and see what should be provided to management. It helps to set priorities.

In the Australian situation, it was important to note that direction came down from high levels of management. Science was called in to assist in putting together and implement the MSE. The Australian fisheries management set the objectives. The offshore clam industry may be a good prototype to continue the development.

Additional work may be required to address non-fishing stakeholders in the MSE.

Concluding Remarks

The Chair reviewed the process to be followed for the remainder of the assessment framework review. The second meeting to deal with models for assessment and management strategy evaluation will be held on 4-5 April 2007 at the Bedford Institute of Oceanography. It was requested that the draft summary bullets from the meeting be sent to all participants for information.

The Chair thanked all the participants and closed the meeting.

MODELS FOR ASSESSMENT AND MANAGEMENT STRATEGY EVALUATION
Bedford Institute of Oceanography, Dartmouth, Nova Scotia
4-5 April 2007

The meeting commenced with the Chair, Robert O'Boyle welcoming the participants. He particularly noted the presence of Drs. J. Boutilier, J. Choi, L. Jacobson, and R. Mohn, who were the invited external scientific reviewers for the meeting. The context and overall process of the framework review, as outlined in the terms of reference were then presented. Following this, there was a discussion on the objectives of this second meeting of the framework which focused on models for assessment and management strategy evaluation. The Chair noted that in preparation for this meeting, DFO Science had conducted two planning sessions during which it was noted that work on habitat implications of the fishery should be considered in the review. For this reason, D. Fenton, P. Rodger, and T. Worcester were asked to provide thoughts on how these could be built into the assessment.

The Chair noted that all of the working papers and Expert Opinion documents were available at the back of the room.

After thanking Paul Boudreau, the meeting rapporteur, the presentation of the working papers commenced.

Methodology to Estimate the Current State of the Management Units and Robustness and Consequences of a Range of Management Strategies

Jonsen, I.D. 2007. Management Strategy Evaluation for Banquereau Arctic Surf Clam (*Mactromeris polynyma*). RAP Working Paper 2007/17.

Presentation Highlights

Two of the challenges in developing a management strategy framework for the Arctic surfclam fishery on Banquereau bank are the lack of a survey time-series and, consequently, a lack of quantitative information describing the recruitment process for Arctic surfclams. An attempt was made to fit biomass dynamic models, a Schaefer surplus production model and a delay-difference model, in state-space form to the only time-series data available, the commercial logbook data. The primary impediment to modelling these data was the observed lack of a coherent relationship between commercial CPUE and stock biomass. Analysis of the CPUE data indicated three distinct phases to the CPUE time-series that were related to spatio-temporal shifts in exploitation over Banquereau. Fits of the surplus production and delay-difference models suggested reasonable information in the data for parameter estimation, but the biomass estimates were poor and generally lower than that suggested by the 1996/97 and 2004 research surveys.

Due to the inadequacies of the commercial logbook data for time-series modelling, a series of simulation model scenarios were used to: (1) provide some insight into the role of recruitment in sustaining the stock; (2) to explore how proposed management reference points (MCY = 0.33 M B_o; MSY = 0.5 M B_o; F = M) would perform relative to one another and how the F = M reference point would perform under different time lags between research surveys. Biomass dynamics were simulated with a delay-difference model with growth and natural mortality parameterized from research survey data. The simulations suggested that under current exploitation rates a minimum constant recruitment rate of 0.043 would be required to maintain the stock. However, the research survey catch-at-age data suggests that recruitment may come primarily from episodic events. Further simulation suggests that when these events are large and frequent enough, a constant background recruitment rate is not required to maintain the stock. Finally, the simulation model suggested that the currently used management reference point F = M is less precautionary than either MCY or MSY over a 20 to 30 year time frame and this does not appear to change if the survey frequency increases from 2 to 4 to 10 years.

Discussion

CPUE Time Series

A key issue is whether or not Catch per Unit Effort (CPUE) is related to changes in population biomass. It is not possible to standardize the CPUE for area as the full area is not fished each year. It is most likely that the constancy of catch over time may be indicating that the fishery has not really reduced the overall biomass. The southeast shoal is showing some recruitment over the history of the fishery, but these individuals may have been in the area during the initial period of fishing and not recruited from standing stock since the start of the fishery. The clams seem to be “smaller than expected” in size, so there may be some density dependent processes underway. One would have to consider CPUE changes by smaller subareas on the bank. There is some evidence for serial harvesting or serial depletion is underway. From 2002, there is evidence that the central core area of the Bank was not fished very heavily. This infers that bank level CPUE can remain high while overall biomass might be declining, i.e., hyperstable relationship. The fishery is operating very efficiently with minimal regulatory influences and it is expected that the fishery is increasing in efficiency. In the U.S., catch rates have improved over time using improved technology, such as GPS, and with growing experience of fishermen in locating fishable densities of organisms. It was asked if there was any information in the RoxAnn data that could be used to understand the changes in CPUE.

A bigger issue with the CPUE data is the inability to match catch and effort data at a fine temporal and spatial scale. Until this is available, it will be difficult to use this dataset as an indicator of abundance.

In regards to available information on the impact and recovery from high fishing pressures, high catch rates are only now being seen south of the southeast of the shoal after 15 to 16 years since the last fishing effort. The timeline of events are:

- Early 1980’s - R/V Delaware survey identified an area with high density.
- 1987 to 1990 - Fisheries exerted high level of pressure in the area and declining catch rates.
- Early 1990’s - There was a settlement event.
- 2004 - The survey cruise found high densities of juveniles (see Figure 5, WP 2007/08).
- 2006 - The industry returned to fishing in the area and noted that the size is smaller than they expected.

It was agreed that the CPUE data does not currently provide a reliable time series of abundance. It may be possible to improve data collection through further collaboration with the industry.

Survey Indices

A number of surveys have been conducted: one during 1980-83 on the RV Delaware, two in 1996-97 and one in 2004. Tow distances were calculated by position of the boat when the winch was turned off. The start seems to be well estimated, but the end of the tow was not well estimated because the dredge may continue to fish before being lifted off of the bottom. Only the 2004 survey estimate of abundance was considered sufficiently representative to be of use in the assessment.

Survey estimate is not corrected for Q (catchability), but the gear is very efficient, possibly 100%. It was considered that this could be assumed in the management framework.

It is recommended that a follow-up survey be conducted on the Gordon sites in 2008 to see what the recovery rate is 10 years after fishing. One would have to correct from the 70 m depth of the experimental plots to depths more related the depths preferred by the Arctic clams.

Historical Reconstructions and Population Simulations

It was noted that the CPUE calibrated model produced biomass estimates that were considerably lower directly from the 2004 scientific survey (the highest biomass estimated). Overall though, catches appeared low compared to the overall biomass and management is estimated to be very conservative. The survey biomass index is about 1,200,000 mt while catch is fairly stable at 20,000 mt. At present, the fisheries is not catching all of the TAC.

M = 0.08 was used as input into the model and was considered appropriate.

There was discussion on the population's recruitment processes. There appeared to be pulses in recruitment every decade or so with low constant recruitment in between these events. There are many unknowns that make modeling of the recruitment process difficult. There may be density dependent spawning as there is a need for space for settlement. In the shoal area, the pulse of recruitment was not seen until a couple of years after the area was fished out. This may be evidence of density-dependence. It was noted that growth rates had declined in this area of the pulse recruitment but may be related to habitat or environmental impacts.

Overall, it was agreed that the absence of an historical time series of abundance did not permit modeling to determine stock trends and life history parameters. The management strategy would have to rely of the 2004 survey biomass estimate.

Control Rules

The discussion first focused on what would be an appropriate level of harvesting. One approach is to estimate B_0, take some small fraction of this, and then leave the fishery alone with perhaps infrequent monitoring. The alternate approach is to assess stock biomass at intervals and take some fixed fraction of this for the fishery between assessments. It was agreed that the latest estimate of biomass, rather than the estimate of virgin biomass, be used to calculate yield. Thus, the interval between assessments which provide the latest estimate of biomass, becomes important to the consideration of the appropriate level of harvesting. Less frequent surveys infer a more conservative harvest strategy. Regarding the appropriate harvest level, it was agreed that F = M is an upper bound. Other harvest levels were discussed that were a function of M (e.g., 0.5 * M). For instance, $F_{0.45}$ from a yield per recruit analysis has is a conservative estimate for long lived species. The current TAC of 24,000 t is approximately 0.6 * M * B_{RV}. The survey biomass index was 1,459,914 mt in 2004. It was noted that the survey measures fishable biomass as it is using commercial gear. It is agreed that a constant exploitation rate be used – not a constant catch, by using the B_{RV} as an estimate of the present population. The consequence of harvest rates from 0.2 to 1.0 * M = F should be evaluated.

The need for a limit reference point was discussed. For geoducks, there is a control rule if biomass reduces below 50% of virgin biomass. This is in line with the IUCN standards to get a species listed under SARA and the limit reference point that reflects having a species designated for SARA listing should be avoided. While this was felt useful, there was no agreement at this meeting for this limit reference point. However, it was noted that an excessive decline in biomass should be avoided.

Regarding survey timing and assessment, it was queried whether or not a survey could be done every three years as in the US. This has cost implications for the industry. The current plan is to do a survey every four years. Notwithstanding this, it was agreed that there would be an assessment whenever a survey is conducted. There was no need for an assessment in the interim. There was discussion on fishery indicators that might flag problems in the fishery and the need for a survey and assessment including length frequency distributional changes due to recruitment or fishing and the extent and distribution of areas of “less than commercial” densities. No specifics were felt required on these and it was felt that the assessment team and industry should interact to keep an eye out for ‘unusual’ events.

It was noted that propeller clams have twice the age at maturity than the targeted surfclams. How would this be included in the management strategy? While propeller clams are less resilient than Arctic clams, most of the propeller clams are outside of the distribution range of the Arctic clams.

<u>Management Approaches</u>

Given the information gaps, it was asked an experimental management approach could be used to gain knowledge on the response of the resource to harvesting. This raised a number of questions, e.g., what size of subarea, frequency and intensity of fishing and so on. Overall though, it was agreed that an experimental approach should be a key part of the research strategy of this fishery. During this discussion, the possibility of rotational harvesting was raised. While the industry already does this somewhat, extension of this might lead to loss of population subcomponents with undesirable genetic consequences.

Habitat Implications of Fishery

Fenton, D., T. Worcester, and P. Rodger. 2007. Re-visiting and Incorporating Benthic Habitat Evaluation into the Surf Clam/Quahog Assessment and Management Strategy Framework. (PowerPoint Presentation).

Presentation Highlights

This meeting has been focusing primarily on developing advice in regards to the management of the Arctic surfclam fisheries. In addition to having a responsibility for a particular species and the fisheries that exploits it, DFO has a number of additional responsibilities and mandate related to for the management of the oceans and its resources. These responsibilities include fish habitat, species at risk, biodiversity conservation, and oceans planning and management. Fisheries and Aquaculture Management need to consider the broader ecological situation for the fish and the fisheries as part of the decision making process. This would include addressing issues of benthic impacts, by-catch, and the role of the target species in the ecosystem.

The current Offshore Clams IFMP (2005-2009) has a number of objectives related to ecosystem considerations and protection of habitat. For example, “Diversity of Benthic Communities” is a stated consideration in the IFMP, with “*Maintain Disturbance within Identified Limits*” as a goal.

Nevertheless, work remains to accurately examine and define the acceptable “limits” under either the current fishery or future scenarios, as well as the on-going monitoring needs to ensure this goal is met.

There are a number of questions under the scope of the Oceans Act and Section 35 of the Fisheries Act that might be relevant to the fisheries management system generally. Habitat Protection and Sustainable Development, within the Oceans and Habitat Branch are responsible for Section 35 of the Fisheries Act that regulates the impact of activities on fish habitat in freshwater and marine environments. Recent policy has attempted to quantify specific pathways of effects (PoE) to link activities with their impacts within a risk management framework. To minimize impacts on fish habitat, efforts should be made to “break” the pathway of effects. An example was presented for marine finfish aquaculture as an attempt to demonstrate how these PoEs may be relevant to hydraulic dredging for Arctic clams, although this approach has not been applied yet to fisheries.

A couple of other assessment models were presented to structure the discussion around these issues with a focus on benthic habitat. An example of the driver pressure state impact response model was presented and then used in the context of the surfclam fishery. This model helps to make explicit the various components of an effective management system as it might apply to a marine fishery.

The area impacted by the fishery (the pressure) can be estimated using the “area swept” methodology used in the RAP working papers. The impacts can be estimated and potentially “scaled up” to a larger area using the Banquereau habitat impacts experiment conducted by DFO Science. This results in a relatively simple indicator of “% area with a fishery footprint”. The Banquereau area is in a multi-year recovery with different areas in different stages of habitat condition, e.g., recently impacted (less than 2 years), recovered, unimpacted to date. This indicator should be related to a unit of analysis and scale of habitat that is appropriate (the state). Several options were highlighted, including the recent work by Kostylev on benthic classification, or using the known surfclam community distribution on Banquereau.

Another useful indicator may be growth rate, which could be used to monitor the state of the environment over time. There may be other proxies worth developing. The aim is that a set of indicators could be used to direct a response from management (threshold is reached) and be used to consistently monitor the activity over time.

A number of next steps were proposed including:

- Regular analysis and feedback into management and assessment process.
- Development of list of indicators to select for the assessment phase and link with other components of Management Strategy Evaluation.
- Revisit of the experimental sites in 2008, to continue to understand the species and habitat recovery times (i.e., 10 year recovery state).

Discussion

It was noted that some work has been done to incorporate habitat considerations into the surfclam fisheries management plans, but this work may not fully incorporated DFO Oceans and Habitat concerns. The ultimate objective is to ensure that the clam harvesting does not irreversible damage the habitat. There was discussion on current efforts in DFO to better define reference points for impacts. As well, broad based industry consultation with all fishing sectors is required before implementation of measures to modify fishing plans to mitigate habitat impacts. It was noted that this is linked to efforts to define conservation objectives for an ecosystem approach to management through ESSIM and other such initiatives.

It was agreed that while these broader discussions are being conducted, it would be useful to define indicators of habitat impacts that could be monitored. It was noted that some of these are already available. For instance, area swept by year by depth range. An indicator of the frequency of disturbance was also mentioned. Further, it was noted that fishing activity requires a 0.9 kg/m^2 to be economical. This corresponds to just above the 50 kg per survey tow contour (Figure 5, WP 2007/08).

A suite of potential indicators was not agreed to at the meeting. It was recommended that Science and Oceans staff work closely together to develop this suite for future consideration.

Further Calculations on Management Strategy

Analyses that considered changes in Spawner per recruit at different harvest levels was conducted. The results of a calculation for $F_{45\%}$ were presented.

The model included the following assumptions:

Catchability:

- 0 for ages 1 to 4.
- 0.10 for ages 5 to 7.
- 1.0 for ages 8 and older.

It was assumed that 40% of age 5–7 clams that go through the grate die. It was recommended that this incidental mortality be included in estimation of the harvest strategy.

Age at maturity was assumed as 15.

Natural mortality was assumed as 0.08.

A number of harvest strategies were summarized. $F_{0.1}$ was estimated as 0.07 as opposed to 0.099 in WP 2007/08. $F_{45\%}$ (0.13), a proxy for MSY, is lower than F0.1 but still high compared to M.

There was considerable discussion during this session which is integrated into the following summary section.

Summary

Biological Model

There was agreement that the growth model and estimate of natural mortality (0.08) used were appropriate. It was noted that there is no information on potential changes in growth rates over time and how environment and fishing pressure might be influencing these.

A major source of uncertainty is the recruitment process (pulse versus constant). There is some evidence, from the age frequency information, of low constant recruitment with large pulses every 10 years or so. There is uncertainty on how recruitment distributes over the Banquereau Bank. Does it settle over the whole bank or only portions? It was noted that there may be consequent density dependent processes underway at smaller spatial scales, as hinted by observations from the southeast part of the bank.

These discussions highlighted the need to better understand the role of spatial processes in the population which then links to the role of habitat. It was asked if there is any connection between Banquereau and the Grand Banks. This raised the issue of population substructure. A study has shown that that there was some structure that might be reflecting inbreeding. There was a lack of heterozygotes on the level of self breeders. There may be small scale genetic source subpopulations that one has to be careful to conserve. It was pointed out that a rotational fishing strategy may not be appropriate, as it could result in local area depletion and thus lead to a reduction in genetic diversity.

Overall, there is considerable uncertainty of the population processes governing this resource. It was suggested that a spatially explicit population model be developed that would incorporate these uncertainties and allow exploration of the impact of these on management.

Observations

The issues with the commercial catch rates include the need for better spatial discrimination in the data, standardization of the time series to address changes in technology and experience and suspected lack of linearity and indeed hyperstability of CPUE with abundance. Regarding the quality of the CPUE data, it was recommended that DFO Science work with industry to improve the quality of the spatial information. It was noted that having the same vessel in the past engaged in harvesting has been some advantage, but the entry of a new boat will introduce another variable that will need to be considered in analysing CPUE index in the future. It was noted that the VMS and Roxann systems are available and could assist in this.

Regarding the research survey, the plan is to conduct a survey of each bank in a rotational manner approximately every five years. This was considered reasonable. As stated elsewhere at the meeting, the frequency of survey and thus assessment is linked to the harvest rate. Low frequency equals lower harvest rate and high frequency equals higher harvest rate. It was recognized that the surveys are a significant cost to industry. It appeared from the analyses presented that the survey sampling intensity could be significantly reduced without a significant reduction in variance. This reduced survey effort could be used to either increase survey frequency or address specific projects. This requires further discussion between DFO Science and industry.

Also on the survey, the assumed catchabiltiy of 1.0 was considered appropriate. This errs on the side of caution given the uncertainty.

Assessment

The meeting concluded that the assessments would occur at the same frequency as the survey and would not be needed between surveys. There was discussion on what would trigger an unplanned assessment. Rapidly changing CPUE in small areas was mentioned. However, it was agreed that rather than specify criteria for triggering an assessment, given that it is very uncertain what events might happen, that constant dialogue between DFO Science and industry be maintained to monitor events and if there is joint agreement on the need for an assessment, this would be planned.

Regarding assessment models, a number of future possibilities were mentioned at the meeting including Leslie depletion method and Catch Curves by subareas of the bank and perhaps a Delay difference model by subarea. No one method was recommended as further work on this is needed.

Regarding habitat indicators, maps, and times series of surfclam densities above 0.9 kg/m^2 were suggested as were indices of the percent of clam habitat fishing annually. It was recommended that profiles of species composition be developed by bank subarea. This could include a multivariate analysis of community types and maps of these. As well, an index of the frequency of disturbance is required. It was noted that consideration of recovery time from impact would need to be developed. These habitat indicators should be developed in conjunction with Oceans and Habitat Management Branch.

Harvest Strategy

It was recommended that the harvest rate should not be applied to the virgin biomass, B_0, but to the survey biomass, B_{rv}. This changes the strategy from a constant catch one to that of constant fishing mortality. This is preferred as it allows adjustment of catch every time a survey is conducted and is a more responsive strategy to changes in the population.

The recommended rule is then:

- $F = a * M$
- $TAC = F * B_{RV}$

The TAC advice would be held constant between assessment years.

It was agreed that the fishing mortality, F, should be a function, a, of the natural mortality, M. Agreement was not reached on a specific level of a. 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 at the low end. Other potential values were 0.33 (MCY approach) and 0.5 (MSY approach). The values of a associated with F0.1 (0.099) and $F_{45\%}$ (0.13) were 1.23 and 1.625 respectively which were considered too high. It was agreed that the assessments should consider the biological consequences of harvesting at rates ranging from F = 0.03 (38% of M) to F = 0.08 (100% of M) keeping in mind that the risk to the resource increases throughout this range and harvesting should be kept at the low rather than the high end of this range. As well, with the potential for serial depletion, it is best to be conservative.

As stated earlier, which level is chosen during each assessment is dependent upon the survey frequency.

It was also reiterated that COSEWIC considers that a species that undergone a 50% reduction in spawning numbers within three generations could be designated as threatened. Thus, lower harvest rates to avoid triggering this criterion would be prudent.

Implementation

It was noted that the industry already employs something akin to rotational harvesting in an effort to catch specific clam sizes for markets. This may be suboptimal regarding the biology of the resource. As well, as stated earlier, given the low level of information available, it was recommended to undertake an experimental plan that would examine the effects of different fishing mortalities in planned areas to better understand how the surfclam population responds to different levels of effort. This would include high, medium, and low fishing pressure reference areas. It could also include an area south of the shoal that has been heavily fished and in which density dependent growth appears to have occurred

It was recommended that an experimental plan be developed jointly with industry as part of the research initiative.

Overview

It was agreed that that the population's spatial processes are not well resolved and these need to be included in the population models and assessment. While the assessment meeting is to consider stock status, it was felt that the present fishery is likely harvesting the resource at a low rate. However, due to the limited time series of information available and the considerable uncertainty in the biology and the evolving fisheries, the model framework should be applied in a precautionary manner.

Applicability of Methodologies to Ocean Quahog and Other Species Impacted by the Fishery

It was agreed that the methodologies reviewed would be applicable to other similar species and fisheries. In particular, the methodologies should be used in establishing a management framework for Arctic surfclams on Georges Bank and Sable Island Bank, ocean quahog on Sable Island Bank, and propeller clams on Banquereau. It was noted that propeller clam is a by-catch to the surfclam fishery. No limits on this by-catch were agreed to, but it was recommended that harvest limits be developed for this and other by-catch species in a similar fashion as would be developed for surfclam. Certainly the consequences of surfclam harvesting on other species would need to be evaluated. In all these cases, it is important to ensure that the relevant biological parameters be incorporated into the specific assessments.

Research Recommendations

A number of recommendations were made throughout the meeting in relation to the various topics discussed. These are summarized below. In addition, subsequent to the meeting, D. Gordon, who could not attend the meeting, provided his own observations on these recommendations. These are provided in Appendix 4.

- CPUE
  - Need to better match catch and effort data on a fine temporal and spatial scale.
  - Need to determine the relationship between CPUE and resource abundance, e.g., investigate the degree of hyperstability in CPUE record; this may require considering fishing processes by subareas of the banks.
  - Explore the use of RoxAnn information to provide a more complete and high resolution record of fishing effort distribution.

- Survey
  - Undertake an examination of survey variance to evaluate an adequate level of sampling intensity; if there is nonessential sampling effort, this could be directed to other research activities.

- Population Processes
    - Undertake studies to better understand population structure, including:
        - Relationship between Banquereau and Grand banks.
        - Review of previous research on population genetic structure with intent to undertake further studies if deemed useful.
    - Undertake studies to understand recruitment processes; this would include:
        - Role of circulation in distributing spawn across the banks.
        - Role of habitat in recruitment survival, including environmental conditions
        - Role of predators in recruitment survival.
        - Role of density on recruitment survival; is there evidence for density dependent settlement?
    - Undertake studies on role of environment on growth:
        - Changes over time.
        - Changes by area.
        - Is there evidence for density dependent growth?

- Ecosystem processes
    - Conduct a follow-up survey on the 2008 Gordon sampling sites to evaluate the recovery rate after 10 years of fishing.
    - Undertake study to better understand the role of surfclam and ocean quahog in the ecosystem, and the effects of the fishery on ecosystem processes.
    - Investigate the relationship between surfclam and propeller clam on Banquereau and between quahog and other clam species on Sable Island Bank.
    - Develop methodologies to better evaluate the “footprint” of the fishery and undertake studies that would increase the accuracy of information on dredge tracks.
    - Develop suite of indicators that describe the impact of the fisheries on the habitat and benthic communities, including:
        - Indices of intensity of impact.
        - Indices of frequency of impact.
        - Indices of recovery rates for target and non-target species.

- Modeling and assessment
    - Develop a model that describes the key spatial and temporal processes of the clam populations to allow future examination of management strategies; this model would be enhanced as understanding of the biology grows.
    - Explore application of assessment techniques such as Delury at a subbank level.
    - In aid of defining reference points in the longer term, undertake a study of the response of clam populations to different levels of harvesting; this would involve fishing different parts of the banks at different levels, and monitoring the population’s response.

It was suggested that a workshop of relevant DFO, university, and stakeholder groups be convened in 2007/08 to review these recommendations, and prepare a research plan outlining the priorities and associated costs.

Concluding Remarks

It was agreed that the assessment meeting for Banquereau Bank surfclam and the other bivalue species would be held on 20 April 2007. The framework discussed at the current meeting would be applied to the existing information to develop advice for the 2007 and beyond fisheries.

The Chair confirmed that that the draft proceedings would be circulated for review and comment but could not guarantee this before the assessment meeting.

The Chair then thanked all the participants and closed the meeting.

REFERENCES

DFO, 2002. Expert Opinion On Clearwater / Deep Sea Clam Ocean Quahog Development Proposal. DFO Maritimes Region Expert Opinion 2002/03.

DFO, 2005. Expert Opinion on the Rationale for Harvest Advice on Ocean Quahogs (*Arctica islandica*). DFO Maritimes Region Expert Opinion 2005/04.

DFO, 2005. Offshore Clams Integrated Fishery Management Plan Maritimes and Newfoundland Regions 2005-2009. DFO Maritimes Region Integrated Fisheries Management Plans. 38 p.

Fenton, D., T. Worcester, P. Rodger, and. 2007. Re-visiting and Incorporating Benthic Habitat Evaluation into the Surf Clam/Quahog Assessment and Management Strategy Framework. (PowerPoint Presentation).

Gilkinson, K.D., D.C. Gordon, Jr., K.G. MacIsaac, D.L. McKeown, E.L.R. Kenchington, C. Bourbonnais, and W.P. Vass. 2005. Immediate Impacts and Recovery Trajectories of Macrofaunal Communities Following Hydraulic Clam Dredging on Banquereau, Eastern Canada. ICES Journal of Marine Science, 62: 925-947.

Gilkinson, K.D., D.C. Gordon, Jr., D. McKeown, D. Roddick, E.L.R. Kenchington, K.G. MacIsaac, C. Bourbonnais, and W.P. Vass. 2003. Susceptibility of Soft Corals (Anthozoa: *Gersemia rubiformis*, Ehrenberg, 1834) to Capture by Hydraulic Clam Dredges off Eastern Canada: The Significance of Soft Coral-shell Associations. American Fisheries Society Symposium. 41:383-390.

Gilkinson, K.D., G.B.J. Fader, D.C. Gordon, Jr., R. Charron, D. McKeown, D. Roddick, E.L.R. Kenchington, K.G. MacIsaac, C. Bourbonnais, W.P. Vass, and Q. Liu. 2003. Immediate and Longer-term Impacts of Hydraulic Clam Dredging on an Offshore Sandy Seabed: Effects on Physical Habitat and Processes of Recovery. Continental Shelf Research. 23:1315-1336.

Jonsen, I.D. 2007. Management Strategy Evaluation for Banquereau Arctic Surf Clam (*Mactromeris polynyma*). RAP Working Paper 2007/17.

Roddick, D. 2007. Banquereau Bank 2004 Survey for *Mactromeris polynyma.* RAP Working Paper 2007/08.

Roddick, D., K. Mombourquette, and R. Kilada. 2007. Survey for Ocean Quahogs (*Arctica islandica*) at the Mouth of St. Mary's Bay, Nova Scotia. RAP Working Paper 2007/07.

Roddick, D., K. Mombourquette, and R. Kilada. 2007. Protocols and Sampling Forms for On-board Sampling of the Catch of *Mactromeris polynyma*. RAP Working Paper 2007/09.

Roddick, D., K. Mombourquette, and R. Kilada. 2007. Science Advisory Process on Assessment and Management Strategy Framework for Banquereau Arctic Surfclam and Ocean Quahogs on Sable Bank and in St. Mary's Bay. RAP Working Paper 2007/10.

Roddick, D., R. Kilada, and K. Mombourquette. Ocean Quahog (*Arctica islandica*) Survey and Yield Estimates for Sable Bank. RAP Working Paper 2007/11.

APPENDICES

Appendix 1. Terms of Reference

**Science Advisory Process
on Assessment and Management Strategy Framework
for Banquereau Arctic Surfclam and
Ocean Quahogs on Sable Bank and in St. Mary's Bay**

17-18 January 2007
Future Inns Dartmouth
Dartmouth, Nova Scotia

and

3-4 April 2007
Bedford Institute of Oceanography
Dartmouth, Nova Scotia

TERMS OF REFERENCE

Context

There has been a quota regulated fishery on Banquereau Bank Arctic surfclam since 1986, although there has not been an assessment framework developed, and advice has been provided by Science to Fisheries and Aquaculture Management on an as-needed basis. A Total Allowable Catch (TAC) was established for Sable Bank ocean quahog in 2003, but this was not fished. There has been no fishery for St. Mary's Bay ocean quahog. An Expert Opinion (EO) on the habitat implications of a Clearwater/Deep Sea Clam Ocean Quahog development proposal was produced (EO 2002/03) as was an Expert Opinion on the rationale for ocean quahog harvest advice (EO 2005/04).

Recently, in collaboration with DFO, the fishing industry initiated a survey program for the Banquereau Arctic surfclam and Sable Bank ocean quahog resources. On a five-year cycle, these banks, along with Grand Banks off Newfoundland are to be surveyed. Sable Bank was surveyed in 2003, and Banquereau Bank in 2004. Due to financial issues in 2005, no survey was conducted and the 2006 survey was conducted on the southern Grand Bank. The 2007 survey is tentatively planned for the northern Grand Bank. This initiative and signs of a potential increase in effort in the fishery is the stimulus for the current framework review.

This review will examine not only the methodology used to assess these resources, but also undertake an evaluation of the management strategy. It is to be conducted over two meetings: the first (17-18 January 2007) to consider data inputs and the second (4-5 April 2007) to review the methodologies of the assessment and management strategy. The framework is intended to be applied in supporting the future management of these fisheries.

Objectives

Data Inputs (17-18 January 2007)

- Review the life history characteristics of each species being harvested.

- Document what is known on the population structure of the species in the management units.
- Review the fishery catch and by-catch estimates, including discard mortality.
- Review precision and bias of current commercial sampling protocols and construction of the catch age/size including grouping and weighting of samples and catches.
- Review precision and bias of ageing protocols.
- Review precision and bias of the industry/DFO Science research survey including:
    - Survey design including survey area, sampling unit definition and allocation, and timing.
    - Protocols used to estimate post-survey relative indicators of abundance and biomass.
    - Estimation of survey abundance by size/age using sampling from the survey.
- Review protocols to estimate growth and size at maturity.
- Present a summary of previous scientific studies on the impact of clam dredging on benthic habitat.
- Describe management strategy evaluation to provide context to surfclam and ocean quahog management activities.

Models for Assessment and Management Strategy Evaluation (4-5 April 2007)

- For surfclam, determine the methodology, exploring a range of models, to estimate the current state of the management units, including determination of biological indicators and the biological consequences of different levels of these.
- For surfclam, evaluate the robustness and consequences of a range of management strategies for use in decision making, including"
    - Methodology to provide short, medium and long-term yield forecasts.
    - How to respond if and when the fishery explores new areas.
- Discuss the applicability of the above methodologies to ocean quahog and other species impacted by the fishery.
- Provide guidance on the assessment procedure to be used during interim years, including
    - Recommended timing of subsequent reviews.
    - Procedures to verify the on-going efficacy of the framework.

Outputs

CSAS Science Advisory Report outlining the assessment framework and management strategy
CSAS Proceedings of the discussion of the two meetings
CSAS Research Documents

Participation

DFO Science Maritimes, Newfoundland, and other regions
DFO Maritimes and Newfoundland Fisheries and Aquaculture Management
Offshore Clam Advisory Committee
Inshore clam industry
Provincial representatives

Appendix 2. List of Participants

Science Advisory Process on Assessment and Management Strategy Framework for Banquereau Arctic Surfclam and Ocean Quahogs on Sable Bank and in St. Mary's Bay, Future Inns Dartmouth, Dartmouth, Nova Scotia, 17-18 January 2007.

Name	Affiliation	Fax	Notification Preference	Email Address
Boudreau, Paul R.	RAP Office/DFO	(902) 426-5435	Email	Boudreaupr@dfo-mpo.gc.ca
Boutilier, James	DFO	(250) 756-7053	Email	BoutillierJ@pac.dfo-mpo.gc.ca
Branton, Eric	DFO		Email	BrantonE@mar.dfo-mpo.gc.ca
Butler, Maureen	FAM/PED	(902) 426-9683	Email	butlerm@mar.dfo-mpo.gc.ca
Cassista, Manon	DFO		Email	CassistaM@mar.dfo-mpo.gc.ca
Clancey, Lewis	NS Dept. of Fisheries & Aquaculture	(902) 424-0336	Email	clancelh@gov.ns.ca
Claytor, Ross	DFO	(902) 426-1506	Email	claytorr@mar.dfo-mpo.gc.ca
Covey, Michele	DFO	(902) 426-7744	Email	CoveyM@mar.dfo-mpo.gc.ca
Davignon-Burton, Tania	DFO		Email	Davignon-BurtonT@mar.dfo-mpo.gc.ca
Gordon, Don	DFO		Email	GordonD@mar.dfo-mpo.gc.ca
Jones, Chris	FAM/PED	(902) 426-9683	Email	jonesc@mar.dfo-mpo.gc.ca
Jonsen, Ian	Dalhousie University, Biology Dept.	(902) 494-3910	Email	jonsen@mathstat.dal.ca
Kilada, Raouf	DFO		Email	KiladaR@mar.dfo-mpo.gc.ca
Mombourquette, Kathryn	DFO	(902) 426-1862	Email	MombourquetteK@mar.dfo-mpo.gc.ca
Mosher, Jim	Clearwater Fine Foods Inc.	(902) 634-8358	Email	jmosher@clearwater.ca
O'Boyle, Bob	RAP Office/DFO	(902) 426-5435	Email	oboyler@dfo-mpo-gc.ca
Penney, Christine	Clearwater Fine Foods Inc.	(902) 443-8443	Email	cpenney@clearwater.ca
Roddick, Dale	DFO		Email	RoddickD@mar.dfo-mpo.gc.ca
Rodger, Peter	DFO		Email	RodgerP@mar.dfo-mpo.gc.ca
Smith, Stephen	PED/DFO	(902) 426-1862	Email	smithsj@mar.dfo-mpo.gc.ca
Stansbury, Don	DFO	(709) 772-4105	Email	StansburyD@DFO-MPO.GC.CA
Weinberg, James	NOAA Fisheries, NEFSC	(508) 495-2230	Email	james.weinberg@noaa.gov
Worcester, Tana	RAP Office/DFO		Email	WorcesterT@mar.dfo-mpo.gc.ca

Science Advisory Process on Assessment and Management Strategy Framework for Banquereau Arctic Surfclam and Ocean Quahogs on Sable Bank and in St. Mary's Bay, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, 4-5 April 2007.

Name	Affiliation	Phone	Fax	Email Address
Boudreau, Paul	DFO, RAP			boudreaupr@mar.dfo-mpo.gc.ca
Boutilier, James	DFO, PAC	(250) 756-7048	(250) 756-7053	BoutillierJ@pac.dfo-mpo.gc.ca
Cassista, Manon	DFO	(902) 426-2665		CassistaM@mar.dfo-mpo.gc.ca
Choi, Jae	DFO	(902) 426-1616		choij@mar.dfo-mpo.gc.ca
Claytor, Ross	DFO, PED	(902) 426-4721	(902) 426-1506	claytorr@mar.dfo-mpo.gc.ca
Davignon-Burton, Tania	DFO	(902) 426-3318		Davignon-BurtonT@mar.dfo-mpo.gc.ca
Fenton, Derek	DFO			FentonD@mar.dfo-mpo.gc.ca
Fuller, Susanna	Dalhousie University	(902) 453-9228	(902) 405-3716	susannadfuller@gmail.com
Gibson, Jamie	DFO			gibsonajf@mar.dfo-mpo.gc.ca
Jacobson, Larry	NOAA			Larry.jacobson@noaa.gov
Jones, Chris	DFO, FAM	(902) 426-1782	(902) 426-9683	jonesc@mar.dfo-mpo.gc.ca
Jonsen, Ian	Dalhousie University, Biology		(902) 494-3910	jonsen@mathstat.dal.ca
Mohn, Bob	DFO, PED	(902) 426-4592	(902) 426-1506	mohnr@mar.dfo-mpo.gc.ca
Mombourquette, Kathryn	DFO	(902) 426-5715		MombourquetteK@mar.dfo-mpo.gc.ca
Mosher, Jim	Clearwater Fine Foods Inc.	(902) 529-2199		jmosher@clearwater.ca
O'Boyle (Chair), Bob	DFO, RAP	(902) 426-3526		OBoyleR@mar.dfo-mpo.gc.ca
Penney, Christine	Clearwater Fine Foods Inc.	(902) 443-0550	(902) 443-8443	cpenney@clearwater.ca
Roddick, Dale	DFO	(902) 426-6643		RoddickD@mar.dfo-mpo.gc.ca
Rodger, Peter	DFO, Habitat			rodgerp@mar.dfo-mpo.gc.ca
Winterbottom, Marina	Dalhousie University			mr308819@dal.ca
Worcester, Tana	DFO, RAP	(902) 426-9920		worcestert@mar.dfo-mpo.gc.ca

Appendix 3. Agendas

Science Advisory Process on Assessment and Management Strategy Framework for Banquereau Arctic Surfclam and Ocean Quahogs on Sable Bank and in St. Mary's Bay

Data Inputs: 17-18 January

Future Inns Dartmouth
20 Highfield Park Drive, Dartmouth, Nova Scotia

<u>17 January 2007 – Wednesday</u>

09:00 – 09:15	Welcome and Introduction (Chair)
09:15 – 10:00	Life History Characteristics of Each Species Being Harvested and Population Structure
10:00 – 10:15	Break
10:15 – 11:00	Fishery Catch and By-catch Estimates, Including Discard Mortality
11:00 – 12:00	Precision and Bias of Commercial Sampling Protocols and Construction of the Catch age/size Including Grouping and Weighting of Samples and Catches
12:00 – 13:00	Lunch
13:00 – 14:00	Precision and Bias of Current Ageing Protocols
14:00 – 15:15	Protocols to Estimate Growth and Size at Maturity
15:15 – 15:30	Break
15:30 – 17:00	Precision and Bias of the Industry/DFO Science Research Survey

<u>18 January 2007 - Thursday</u>

09:00 – 10:00	Precision and Bias of the Industry/DFO SCIENCE Research Survey (continued)
10:00 – 10:15	Break
10:15 – 11:15	Summary of Previous Scientific Studies on the Impact of Clam Dredging on Benthic Habitat
11:15 – 12:00	Discussion on Management Strategy Evaluation *(*MSE) to Provide Context to Surfclam and Ocean Quahog Management Activities
12:00 – 13:00	Lunch
13:00 – 15:00	Review of Meeting Conclusions
15:00	Adjournment

Science Advisory Process
on Assessment and Management Strategy Framework
for Banquereau Arctic Surfclam and
Ocean Quahogs on Sable Bank and in St. Mary's Bay

Models: 4 – 5 April 2007

George Needler Boardroom
Bedford Institute of Oceanography
1 Challenger Drive, Dartmouth, Nova Scotia

<u>4 April 2007 – Wednesday</u>

09:00 – 09:15	Welcome and Introduction (Chair)
09:15 – 12:00	Methodology to Estimate Current State of Management Units, Including Determination of Biological Indicators and Biological Consequences of Different Levels of These
12:00 – 13:00	Lunch
13:00 – 17:00	Robustness and Consequences of Range of Management Strategies for Use in Decision Making, Including: • Methodology to Provide Short, medium and Long-Term Yield Forecasts • How to Respond if and when the Fishery Explores New Areas

<u>5 April 2007 - Thursday</u>

09:00 – 12:00	Applicability of Surfclam Methodologies to Ocean Quahog and other Species Impacted by Fishery
12:00 – 13:00	Lunch
13:00 – 14:00	Guidance on Assessment Procedure to be Used During Interim Years, Including: • Recommended Timing of Subsequent Reviews • Procedures to Verify the On-going Efficacy of the Framework
14:00 – 16:00	Meeting Synopsis
16:00	Adjournment

Appendix 4. Comments from D. Gordon on Research Recommendations Received Subsequent to 4-5 April 2007 Meeting

A very high priority is to complete the joint DFO/industry experiment on the impacts of hydraulic clam dredging on benthic habitat and communities on Banquereau that was initiated in 1998. Full sampling in 1998 to 2000 documented the immediate impacts and the initial stages of recovery. Partial sampling in 2003 indicated that both habitat and communities have not yet completely recovered. It is recommended that full sampling (including Campod and Videograb) be repeated in 2008 on the tenth anniversary of the original disturbance and that the samples be processed to assess the stage of recovery. If recovery is not complete, sampling should be continued in future years until it is. Knowledge of the full recovery time, especially for the target species, is essential for proper long-term management.

It would be useful to set up a GIS project accessible to DFO scientists and managers plus industry with the following layers:

- Bathymetry
- Substrate
- Survey sampling sites
- Resource distribution
- Annual harvesting areas (in fine spatial detail)

This would provide every one with a good visual picture of the spatial and temporal distribution of the fishery and should allow easy calculation of the return period (the number of years between dredging disturbances).