Proceedings of the US and Canada Scallop Science Summit: St. Andrews, New Brunswick, May 6–8, 2014

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Canadian Technical Report of Fisheries and Aquatic Sciences

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PROCEEDINGS OF THE US AND CANADA SCALLOP SCIENCE SUMMIT: ST. ANDREWS, NEW BRUNSWICK, MAY 6–8, 2014

by

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ABSTRACT

S.R. Bayer, T. Cheney, C. Guenther, and J.A. Sameoto. 2016. Proceedings of the US and Canada Scallop Science Summit: St. Andrews, New Brunswick, May 6–8, 2014. Can. Tech. Rep. Aquat. Sci. 3151: v + 48 p.

A council of stakeholders ranging from fishermen, to scientists, and fisheries managers from both Canada and the United States convened on May 6, 7, and 8, 2014 in St. Andrews, New Brunswick to review and discuss the most recent scientific information relevant to the sea scallop fisheries and aquaculture efforts in the US and Canada. The US and Canada Scallop Summit aimed to strengthen and broaden the knowledge base in the scallop fisheries, with a focus on the nearshore fisheries in the Gulf of Maine and Bay of Fundy, as well as aquaculture efforts, and develop research priorities that aim to assist in the goal of profitable, sustainable fisheries that support coastal communities.

More specifically, the overarching goals of this meeting were: i) to review and discuss the most recent scientific information relevant to the sea scallop fisheries and aquaculture efforts in the US and Canada among stakeholders – scientists, harvesters, and managers, ii) to bring together relevant groups – including scientists, harvesters, and managers, to increase coordination and collaboration on future scientific research opportunities, and iii) to provide an inclusive and participative forum to engage industry in scientific discussions and knowledge sharing.

The summit involved 41 participants (mainly from Atlantic Canada and New England) and 14 presentations over four theme sessions. These proceedings provide an overall summary of the meeting presentations, questions, and discussion sessions.

RÉSUME

S.R. Bayer, T. Cheney, C. Guenther, and J.A. Sameoto. 2016. Compte rendu du Sommet canado-américain des recherches scientifiques sur le pétoncle, tenu du 6 au 8 mai 2014 à Saint Andrews (Nouveau-Brunswick). Can. Tech. Rep. Aquat. Sci. 3151: v + 48 p.

Un conseil d’intervenants composé de pêcheurs, de scientifiques, et de gestionnaires des pêches du Canada et des États-Unis s’est réuni les 6, 7 et 8 mai 2014 à Saint Andrews, au Nouveau-Brunswick, afin d’examiner et de discuter les plus récents renseignements scientifiques sur la pêche du pétoncle géant et les efforts en matière d’aquaculture déployés aux États-Unis et au Canada. Le Sommet canado-américain des recherches scientifiques sur le pétoncle visait à consolider et à élargir la base de connaissances sur la pêche du pétoncle, en mettant l’accent sur les pêches semi-hauturières dans le golfe du Maine et la baie de Fundy, ainsi que sur les efforts en

matière d’aquaculture, et à établir les priorités de recherche dans le but d’aider à rendre les pêches durables et rentables pour les collectivités côtières.

Voici plus précisément les grands objectifs de cette réunion : i) examiner et discuter les plus récents renseignements scientifiques sur la pêche du pétoncle géant et les efforts en matière d’aquaculture déployés par les intervenants aux États-Unis et au Canada – scientifiques, pêcheurs et gestionnaires; ii) réunir les groupes concernés, dont les scientifiques, les pêcheurs et les gestionnaires, afin d’améliorer la coordination et la collaboration dans le cadre de futures possibilités de recherche scientifique; iii) offrir une tribune inclusive et participative permettant aux acteurs de l’industrie de prendre part aux discussions scientifiques et à l’échange de connaissances.

Le Sommet comptait 41 participants (principalement du Canada atlantique et de la Nouvelle-Angleterre), et 14 présentations ont été offertes dans le cadre de quatre séances thématiques. Ce compte rendu donne un aperçu général du contenu de la réunion, notamment les présentations, les questions et les séances de discussion.

PREFACE

The sea scallop (*Placopecten magellanicus*) fishery is one of the most important commercial species of shellfish in Canada and the United States of America (US). In the Maritimes Region, Canada, scallop landings (combined Inshore and Offshore) in 2012 were 48,593 (t, live weight) and valued at $103.7 million (CDN) while the US scallop landings in 2012 were 216,513 (t, live weight) valued at $559 million (USD). In the Canadian Maritimes Region, the sea scallop fishery has been separated into the Inshore and Offshore scallop fisheries since 1986. The major part of the inshore fishery occurs in the Bay of Fundy and Approaches while the largest part of the offshore fishery is on Georges Bank and Browns Bank. In the United States, the majority of the fishery is conducted on Georges Bank and in the Mid Atlantic; however, there are also fisheries in the federal Northern Gulf of Maine and nearshore waters of Maine's state three mile boundary.

Goals of the summit:

The overarching goals of this summit were:

i) To review and discuss the most recent scientific information relevant to the sea scallop fisheries and aquaculture efforts in the US and Canada among stakeholders – scientists, harvesters, and managers.
ii) Increase collaboration on potential future scientific research opportunities.
iii) Provide an inclusive and participative forum to engage industry in scientific discussions and knowledge sharing.

This would include identifying potential opportunities to strengthen and broaden the knowledge base in the sea scallop fisheries, with a focus on the nearshore fisheries in the Gulf of Maine and Bay of Fundy, as well as aquaculture efforts, and develop research priorities that aim to assist in the goal of profitable, sustainable fisheries that support coastal communities.

Summit Format:

The US and Canada Scallop Science Summit was held May 6–8, 2014, at the Algonquin Hotel in St. Andrews, New Brunswick, Canada with four consecutive sessions featuring contributions from academic and government scientists, resource managers, fishermen, and non-governmental organizations. The format of the summit was highly interactive for all participants and included addressing targeted questions, clarifying concepts, and discussion groups. Themes for the sessions were:

1. Large-scale temporal and spatial patterns and connectivity;
2. Fishery-dependent data;

3. Aquaculture, sea ranching and enhancement; and
4. Sustainable management of the sea scallop resource.

Organizers:

The summit's organizing committee was composed of:

- Trisha (Cheney) De Graaf (Co-lead), Maine Department of Marine Resources
- Stephen Smith (Co-lead), Fisheries and Oceans Canada, Bedford Institute of Oceanography
- Dr. Carla Guenther, Penobscot East Resource Center
- Leslie-Anne Davidson, Fisheries and Oceans Canada, Moncton
- Togue Brawn, Maine Dayboat Scallops
- Dr. Shawn Robinson, Fisheries and Oceans Canada, St. Andrews
- Dana Morse, Maine Sea Grant
- Alain d'Entremont, Full Bay Scallop Association

Funding:

Funding for the US and Canada Scallop Science Summit was primarily provided by the Maine Community Foundation's Broad Reach Fund to encourage *cross-border collaboration on issues that may increase the sustainability of Maine's scallop fishery*. Toward this end, the Broad Reach Fund provided an additional $20,000 to support collaborative research projects on scallops from research ideas that were generated from this workshop. Additional funding was provided by the Canadian Aquaculture Collaboration Development Research Program, Maine Sea Grant, and Penobscot East Resource Center. Finally, scallops for each of the evening receptions were donated by Togue Brawn of Maine Dayboat Scallops and Alain d'Entremont of O'Neil Fisheries Limited.

SUMMIT OPENING AND KEY NOTE TALKS

Opening Remarks:

Trish Cheney

Department of Marine Resources, State of Maine

The idea for this workshop came from a conversation between Trish Cheney and Stephen Smith in 2013 when both attended the Bay of Fundy scallop assessment at the Bedford Institute of Oceanography, Dartmouth, Nova Scotia. It had been a long time since stakeholders from both the US and Canada had come together to talk about scallops and both sides have lots to learn.

Whether meeting attendees are fishermen, scientists, managers, Canadian or American with a unique point of view, everyone attending the meeting has a common goal – which is the long-term biological and socioeconomic sustainability of this industry. The scallop industry is facing some very large challenges in a time of changing climate and environment, as well as increased competition for the use of marine space from other industrial sectors. At a United Kingdom scallop workshop in April 2014, the UK industry described large scale wind projects, marine protected areas and some of the worst weather on record that completely shut down almost all their fisheries for the winter months. The overall goal of this workshop was to promote future cooperation and collaboration between Canadian and American scallop fishing and aquaculture industries for their mutual benefit.

High-level aims of this workshop are:

1. To review and discuss the most recent sea scallop (*Placopecten magellanicus*) scientific information, and report on fisheries and aquaculture efforts in the US and Canada.
2. To bring together relevant groups - including scientists, harvesters, and managers to increase coordination and collaboration on future scientific research opportunities.
3. To provide an inclusive and participative forum to engage scientists and industry in discussions of scallop research and fishermen's direct observations. Specifically, we aim to strengthen and broaden our collective knowledge of inshore scallop fisheries in the Gulf of Maine and Bay of Fundy and aquaculture efforts toward developing research priorities that will support our goal of profitable, sustainable fisheries that support coastal communities.

Key Note: Atlantic Sea Scallop Fishery Overview

Canadian and US key note talks by Stephen Smith and Trish Cheney provided an overview of the North Atlantic sea scallop fishery, highlighting factors, trends, and management approaches.

<u>Stephen Smith</u> – Canadian North Atlantic Scallop Fishery Overview

Sea scallops are fished throughout the Atlantic Provinces of Canada with the majority of landings coming from Nova Scotia and southern New Brunswick (collectively referred to as the Maritimes region; Figure 1). In the Maritimes Region, the fishery is divided into inshore and offshore components for management purposes. The inshore fleets are limited to vessels < 19.8 m (65 ft) and minimum dredge ring size of 82 mm (3.23 inches) inside diameter while the offshore fleet is limited to vessels ≥ 19.8 m (65 ft) and meat count regulations are used instead of ring size restrictions. The majority of landings come from Georges Bank for the offshore areas and the Bay of Fundy for the inshore areas.

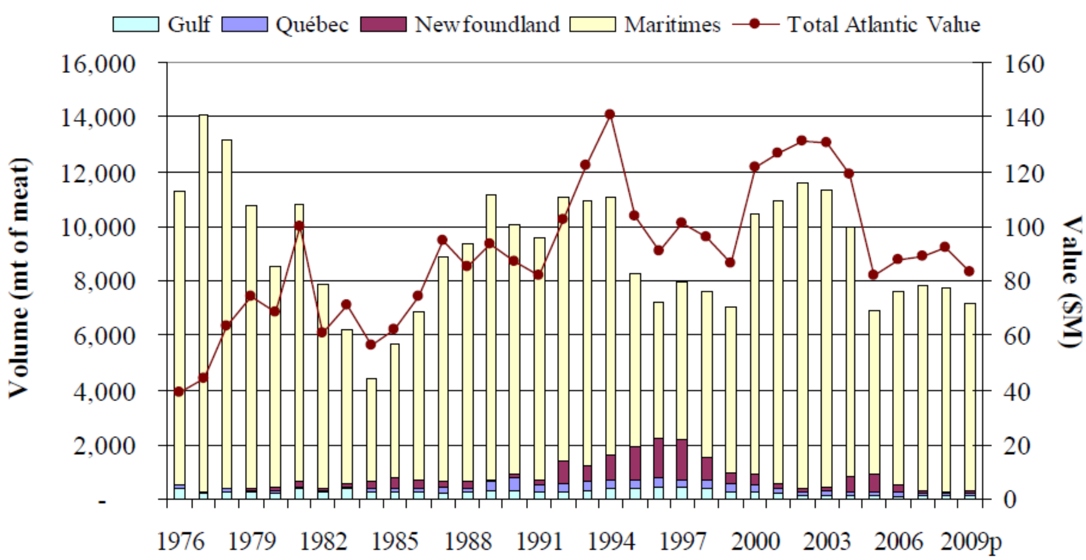


Figure 1. Atlantic Canada scallop landings in meat weight and value by Department of Fisheries and Oceans Canada (DFO) management areas from 1976-2009, preliminary data for 2009 (Source: Mallet 2010).

Management for both fisheries is based on provisions in the Fisheries Act (1985), The Atlantic Fishery Regulations (1985) and the Fishery Regulations Acts (1993). The fisheries use Integrated Fishery Management Plans (IFMPs), a sustainable fisheries framework and the precautionary approach (described in more detail in Session 4 talk by S. Smith). The stock status advice compares current stock biomass with limit and upper stock biomass reference points and compares the current exploitation rate with limit/target exploitation rates. Healthy stocks have current biomass greater than the upper reference point, stocks where current biomass is in between the lower reference point and the upper reference point are considered to be in the cautious zone, and stocks where current biomass is less than the lower reference point are considered to be in the critical zone.

All of the major scallop fisheries in the Maritimes Region are managed using Total Allowable Catches (TAC) that are set annually. Quotas are managed by Enterprise Allocations (percentage share of a TAC that is allocated to an enterprise) for the offshore fleets while two of the four inshore fleets have individual transferable quotas (ITQ) and the other two participate in competitive quotas. The inshore management measures include sharing arrangements between fleets in many areas. There are seasonal closures and voluntary or regulated closed areas in many areas and limited entry licensing. All fleets require satellite vessel monitoring systems (VMS) and mandatory logbook completion (required to be filled out daily for the Inshore fishery and every 6 hours for the Offshore fishery). Dockside monitoring is required in all areas with partial or full coverage depending upon fleet and fishery. On-board observer coverage is required in some of the areas. 100% hail in/hail out is also required for each fishing trip. Meat count restrictions are used in all fisheries.

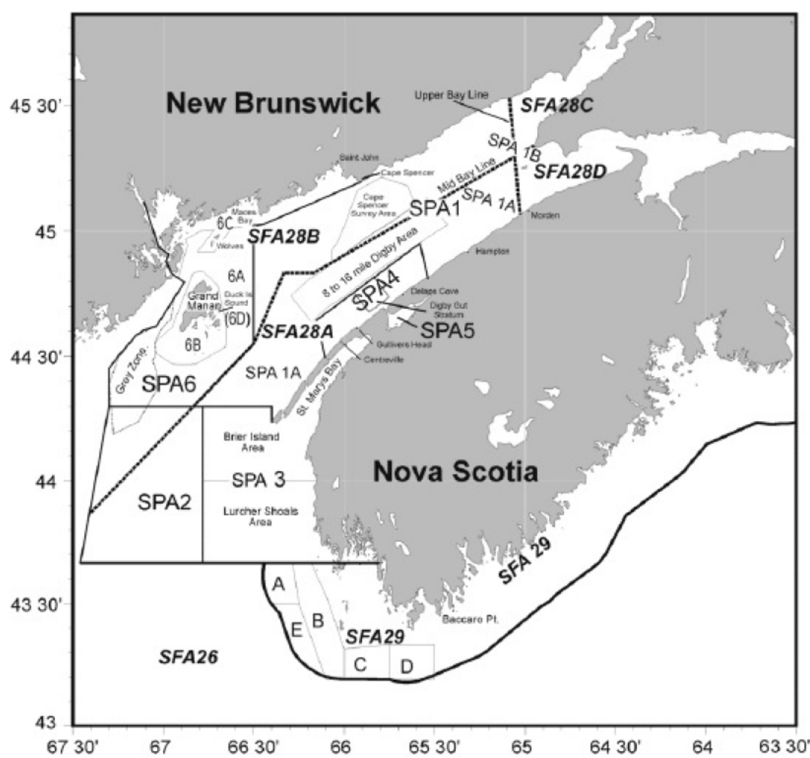


Figure 2. Canadian Maritimes Region inshore Scallop Production Areas (SPAs) and Scallop Fishing Areas (SFAs).

Annual fishery independent surveys have been conducted in parts of the Bay of Fundy since the early 1980s and the coverage expanded over time to include all fished areas in the Bay by the late 1990s. The stock assessment includes population models for Scallop Production Areas (SPA) SPA 1A, 1B, 3 and 4 (& 5) (Figure 2). Commercial catch rate indicators are used for SPA 6 and a new habitat-based population model is used for Scallop Fishing Area (SFA) 29 W. Assessments are conducted with peer-review meetings, with participants from industry, First Nations, management, science, and other stakeholders; and the resulting reports are publically available on the DFO Canadian Scientific Advisory Secretariat (CSAS) website. Stock status for each managed area is assessed with respect to biomass reference points as part of DFO's implementation of the precautionary approach to fisheries management. All stocks in the Bay of Fundy which have such reference points were assessed as being Healthy in 2013.

In the offshore fishery, fishery-independent surveys have been conducted since the early 1980s. The stock assessment has population models for Georges Bank and Browns Bank North and survey/commercial catch rate indicators are used for the other areas. Stock assessments are periodic with peer-review meetings (industry, management, and science participants) and annual updates occur in non-assessment years. Stock status for Georges Bank and Browns Bank North were assessed as being Healthy in 2013.

References:

Mallet, M. (2010) Commercial Scallop (*Placopecten magellanicus*) fishery profile in the Gulf Region. Statistical and Economic Analysis Series. No.1-5.

<u>Trisha Cheney</u> – United States/Maine (focus on Maine) Fishery Overview

Sea scallops are the most valuable single-species fishery in the United States (US), contributing $559 million (USD) in 2012 in revenue with the majority of the landings coming from the Mid-Atlantic and Georges Banks areas (Figure 3). There is also a small, primarily inshore fishery for sea scallops in the Gulf of Maine in the Northern Gulf of Maine (NGOM) Management Area managed under a total allowable catch (TAC) system (Figure 4). Management of the federal scallop fishery falls under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) with the National Marine Fisheries Service (NMFS), a division of the National Oceanic and Atmospheric Administration (NOAA), as the lead federal agency managing the fishery. The New England Fishery Management Council (NEFMC) is an intergovernmental agency that was established through the MSFCMA and is charged by the US Congress to recommend to NMFS management measures which ensure the long term sustainability of the scallop fishery.

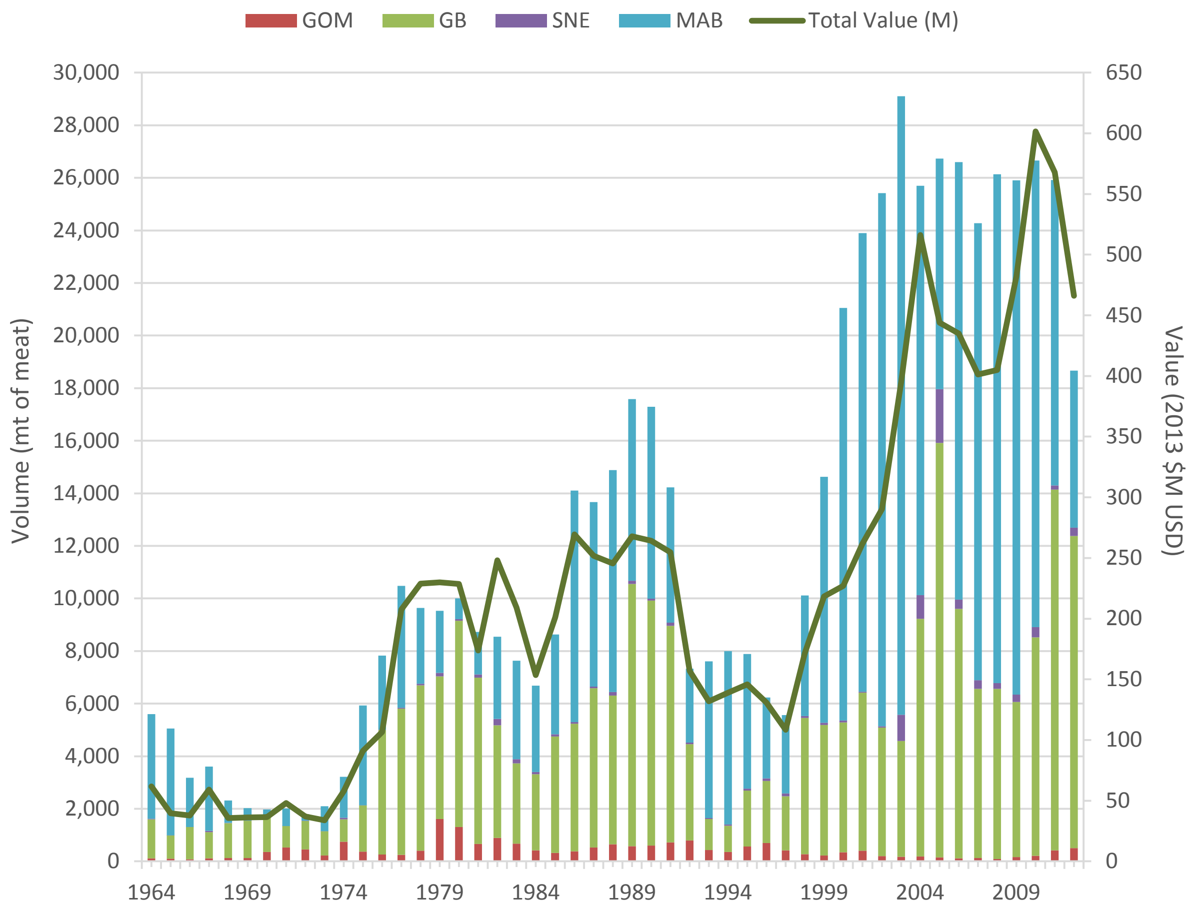


Figure 3. US scallop landings (metric tonnes of meats) by region (Gulf of Maine (GOM) includes Maine state landings; Georges Bank (GB), Southern New England (SNE), and Mid-Atlantic Bight (MAB)) and total value (Millions (M); Modified from NFSC 2015).

The State of Maine also has a small fishery within its territorial waters, which extends out to three miles from shore within the Gulf of Maine (Figure 5). It brings in significantly less than both the Mid-Atlantic and Georges Bank Federal fisheries. The Maine Sea Scallop Fishery is co-managed with an Advisory Council and has 438 active participants. The fishery is a December-March fishery and is typically comprised of 40-foot vessels. Harvesters often fish for lobster, sea urchin, clam, elver and halibut. The majority (> 90%) of landings are caught by dredge with some hand harvest by divers. In 2005, the landed catch was at a low of 33,141 meat pounds (15 metric tonnes).

The Federal offshore fishery implemented closures in 1996 through 2000 and had a 14-fold increase in scallop biomass. Not only were closures implemented, but there were also additional effort restrictions, and increases in ring size. Using these techniques, the size of a typical landed scallop meat (yield per recruit) doubled and the value of the market has gone from 12 million meat pounds ($76 million) in 1998 to 58 million meat pounds ($579 million) in 2011. It is the most valuable US single species fishery.

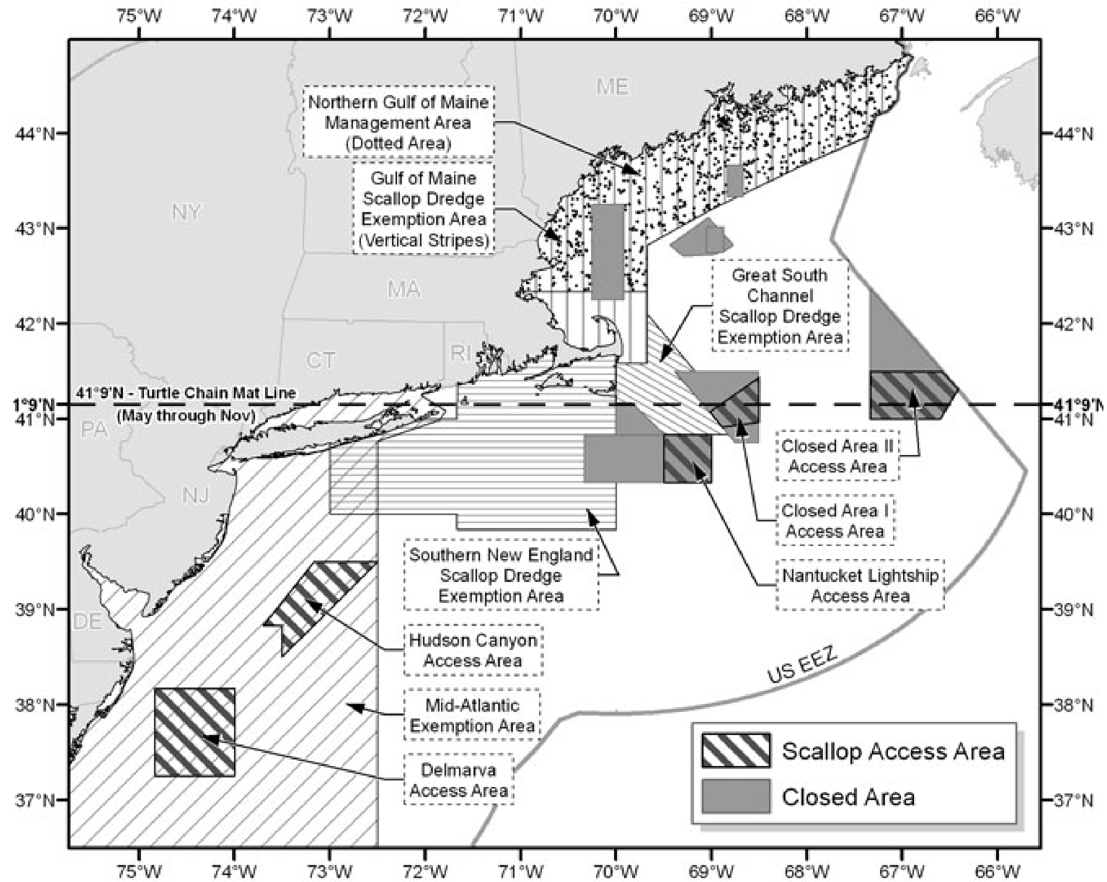


Figure 4. United States sea scallop fishing areas (NOAA 2014).

Encouraged by the success of the federal fishery, in 2009 Maine began to implement conservation measures aimed at rebuilding its scallop fishery. Prior to 2005, Maine had a 132 day season and a minimum of four inch shell and a 10 foot 6 inch drag size limit. In 2008 harvesters and dealers began reporting their catch and had a 200-pound daily limit. In 2009, entry to the fishery became limited, the season was reduced to 70 days, the minimum ring size increased to four inches, and 13 conservation closures encompassing 20% of coastal waters were created for the following three fishing seasons. In 2012, these closures were reopened as limited access areas, and three management zones were established to allow for different rebuilding tools to be utilized reflecting the diversity of the fleet and resources along the coast, with a 10-year rotation management plan established for Zone 2 (eastern Maine; Figure 5) as well as in-season targeted closures being implemented when areas were estimated to have exceeded sustainable fishing levels.

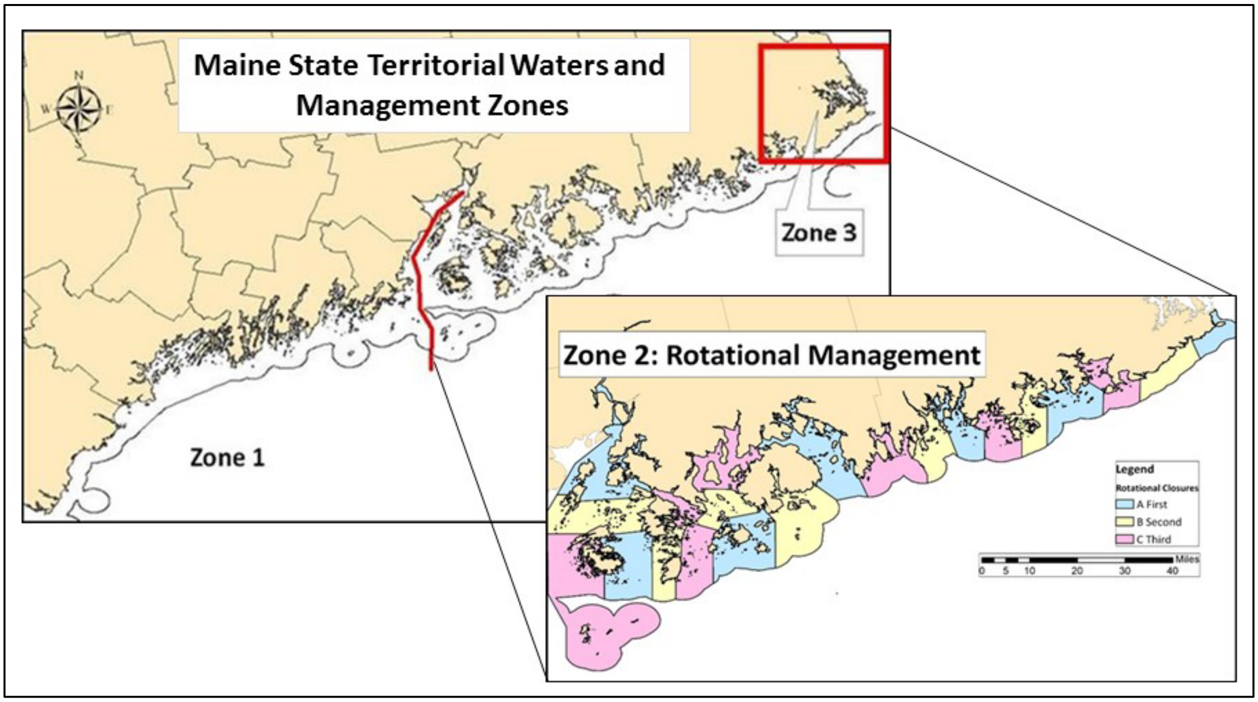


Figure 5. Maine's scallop management zones within three nautical miles. Insert: Zone 2's rotational management plan.

Targeted closures are either put in place pre-season through regular rulemaking or in-season via emergency rulemaking and are used to protect high concentrations of sublegal or seed scallops, depleted areas, and broodstock/spat production areas. The emergency in-season regulations are implemented through real time data surveys, port sampling observations, Marine Patrol (enforcement) reports, and direct input from industry members. The results were that the 2012–2013 season landings were the highest (nearly doubled) since mandatory reporting was implemented in the fishery in the 2008–2009 season. The 2013 landings were also the highest landings since 2000 and the highest value since 1998 when compared to historical data.

One of the greatest challenges to allowing a conservative fishery to occur whilst rebuilding the scallop resource has been the increase in fishing effort. There has been a high number of re-activated licenses over the past five years (631 commercial licenses were issued in 2013). It is driven by reopening of Closure/Limited Access Areas, the closure of the shrimp industry and the historically high price for scallops ($12.24/lbs in 2013). Some of the fleet is very mobile and is following a "roving bandits" model from the ecology literature. Enforcement is difficult to maintain as well, and not all illegal fishing activities can be documented or interrupted. The industry is currently undertaking discussions to help inform the development of a fishery management plan which will provide a vision for the future. The Fishery Management Plan is a document to guide long-term thinking about the fishery and it should be a living document that is not static and regularly updated. This will be developed with the Scallop Advisory Council and defines the vision for the fishery and potential triggers for action.

References:

NFSC, 2015. Stock assessment for Atlantic Sea Scallops in 2014, updated through 2013. 59th SAW Assessment Report. http://nefsc.noaa.gov/publications/crd/crd1409/partb.pdf (accessed 5 February, 2016).

NOAA, 2014. GARFO Sustainable Fisheries Atlantic Sea Scallop. http://www.greateratlantic.fisheries.noaa.gov/sustainable/species/scallop/ (accessed 5 February, 2016).

SESSION 1: TEMPORAL AND SPATIAL PATTERNS AND CONNECTIVITY

Moderator: Caitlin Cleaver, Hurricane Island Foundation

Targeted Questions:

i) What is the full story of temporal and spatial trends in recruitment, growth, and condition?
ii) Can we identify ways to undertake cross-border collaboration and exchange that may illuminate the underlying mechanism, and perhaps facilitate prediction?
iii) What challenges will sea scallop fisheries face in regards to ecological changes such as temperature, salinity, predator community, bottom scouring/dragging, ocean acidification, etc.?

Claudio DiBacco, Ian Bradbury and Mallory Van Wyngaarden – Investigating Sea Scallop Population Connectivity

Larval connectivity describes the rate of larval exchange between disjunct source-sink populations. These connections can vary dramatically; some populations are strongly connected, while others vary between weak to no connection interannually. Still others connections are effectively one way, while some populations in metapopulations are not directly connected but indirectly connected via intermediate populations. Estimating connectivity or isolation of populations can be measured at some level via a number of tools, including passive drifters, tagging (dyes, electronic tags, elemental and isotopic tags), genetic tools, and biophysical models.

Some examples of scallop population connectivity:

- Kenchington et al. (2006) used microsatellites to show significant genetic differentiation in Newfoundland, Gulf of St. Lawrence versus Gulf of Maine and

Scotian Shelf populations. There was evidence of local population connectivity supported by prominent currents.

- Owen and Rawson (2013) used Amplified Fragment Length Polymorphisms (AFLPs) to show small scale population structure in the Gulf of Maine. They showed both temporal (site-specific) and spatial (interannual) variation in local genetic structure.
- Bradbury, DiBacco and Van Wyngaarden used Restriction site Associated DNA markers and measured population connectivity in the same regions as Kenchington et al. (2006). They drilled down these results with Single Nucleotide Polymorphisms and targeted regions of interest. They found that populations sampled further north were more genetically distinct from those found further south (Figure 6).

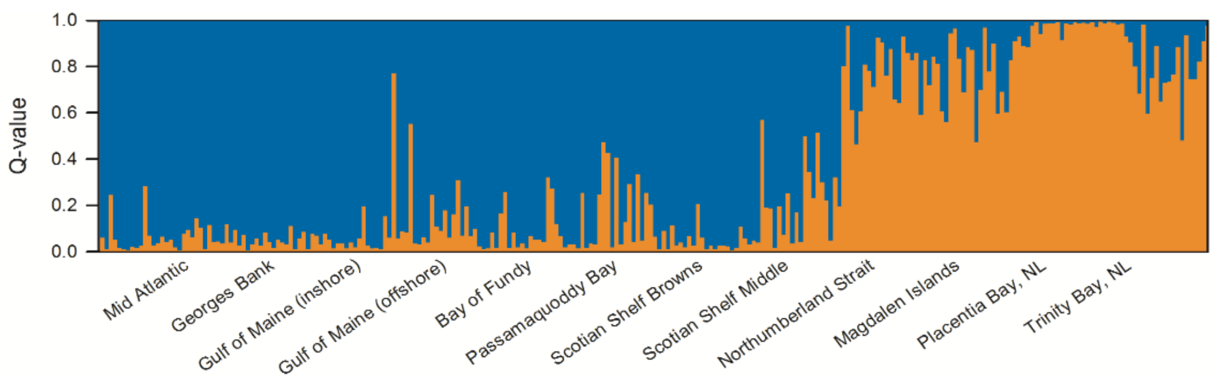


Figure 6. Bayesian clustering of samples of Placopecten magellanicus from eastern North America.

Bio-physical models show shorter ecological time scales relevant for many management issues. The key processes that need to be understood are production (reproductive timing, population size, individual size, relative abundance, distribution, and physiological state), dispersal (behavior, growth, mortality, and transport of larvae), settlement (habitat, larval behavior, settlement cues, mortality, and transport), and post-settlement survivorship (habitat, food, predation, and fishing). All of these processes vary in time and space. The focus for this talk is on reproductive timing and first-order mortality estimates.

We have been collaborating with colleagues on the relative importance of the bi-annual spawning cycle of sea scallops on Georges Bank (Canadian side). One of the overarching questions has been the relative importance of spring vs. fall spawning periods. The spring spawn was initially described more than 20 years ago yet it's never been considered significant because of lower fecundity, colder spring (meaning longer pelagic larval duration and higher natural mortality and predation). Further, FVCOM oceanography modeling has showed that 94% of settlement happens in the fall. However, when a temperature dependent mortality is included in this (in 23 taxa higher mortality is associated with higher temperatures), there is much more settlement from the spring spawn (Davies et al., 2014). Therefore, more empirical work is needed on mortality rates of larvae *in situ*. The lesson learned is that biology is just as important as the physics and may have management implications.

The questions that still remain are:

- Are there similar temporal and spatial patterns on the US side?
- Do these patterns reflect broad area environmental influences?
- Given the impact of changing condition on TACs, commercial catch rates and possibly on productivity, is it possible to model and predict these changes a year ahead?

References:

Davies, K.T.A., Gentleman, W.C., DiBacco, C., and Johnson, C. (2014) Seasonal and spatial variation in larval production and mortality affect modeled sea scallop (*Placopecten magellanicus*) settlement and connectivity on Georges Bank. Marine Ecology Progress Series 516: 209–227.

Kenchington, E.L., Patwary, M.U., Zouros, E., and Bird, C.J. (2006) Genetic differentiation in relation to marine landscape in a broadcast-spawning bivalve mollusc (*Placopecten magellanicus*). Molecular Ecology 15: 1781–1796.

Owen, E.F., Rawson, P.D. (2013) Small-scale spatial and temporal genetic structure of the Atlantic sea scallop (*Placopecten magellanicus*) in the inshore Gulf of Maine revealed using AFLPs. Marine Biology 160: 3015–3025.

<u>Jon Grabowski</u> – Using Genomics to Explore Large Scale Spatial Patterns and Connectivity of Sea Scallops

RAD-seq provides a genome-level resolution of a species. This has been used for the North Atlantic snail *Nucella lapillus*. This has been demonstrated in humans as well – indicating how similar genetic backgrounds are from different continents. This method helps identify the key source populations. Thanks to previous work, we have the opportunity to examine persistent aggregations of scallop on Georges Bank and elsewhere that may be larval sources. The goals of this project are:

- Determine persistent aggregations of scallops in the Gulf of Maine, Southern New England, and Mid Atlantic regions.
- Examine source-sink dynamics and the degree of connectivity among scallop populations located in each of the four regions of the U.S. Fishery.

The current sampling stations for this project are the closed areas of Georges Bank, Montauk, Great South Bay, Elephant Trunk, Platt's Bank, off the coast of Nova Scotia, near Prince Edward Island, and in coastal Maine (spanning from the Mid Atlantic Bight region to the Gulf of Maine and the maritime provinces of Canada).

The preliminary results from our genomic work suggest that scallop populations on Georges Bank exhibit some structure, mostly that Closed Areas I and II seem to cluster together away from Great South Channel and Nantucket Lightship, which is interesting because Closed Area I is closest to Great South Channel and Nantucket Lightship. We anticipate that samples from farther away will enhance our ability to detect population structure and examine source-sink dynamics on Georges Bank.

<u>Phil Yund</u> – Bivalve Population Connectivity in Eastern Maine: Lessons from Physical Oceanography and Mussels

Most work on connectivity of coastal invertebrate populations has focused on along-shelf larval transport. Understanding of across-shelf processes is not well integrated into connectivity studies but for populations in coastal habitats, the journey both begins and ends with an across-shelf journey. The Eastern Maine Coastal Current (EMCC) tends to bypass the Maine coast from Machias to Frenchman Bay. We can use mussel larvae as a tracer of across-shelf dispersal because *Mytilus trossulus* larvae can only enter the region via the EMCC (Rawson et al. 2007). If limited across-shelf mixing affects larval distributions then (1) *Mytilus trossulus* larvae will mainly be present on the offshore portions of across-shelf transects and (2) *Mytilus edulis* larvae will be present on both ends, but not homogenously distributed along the transects. Therefore, our results can help predict which areas of scallop grounds in the Gulf of Maine may be seeded from Canada (including the Bay of Fundy) and which grounds are self-seeding because of the retention of larvae inshore of the coastal current. Further support for applying these ideas to scallops comes from Owen and Rawson's (2013) paper, which showed that the Gouldsboro Bay scallop population (in the region bypassed by the EMCC) is genetically distinct from all other sampled populations throughout Maine.

References:

Rawson, P.D., Yund, P.O., Lindsay, S.M. (2007) Comment on "Divergent induced responses to an invasive predator in marine mussel populations". Science 316**,** 53. (doi:10.1126/science.1135099)

Owen, E.F., Rawson, P.D. (2013) Small-scale spatial and temporal genetic structure of the Atlantic sea scallop *Placopecten magellanicus* in the inshore Gulf of Maine revealed by using AFLPs. Mar. Biol*.* 160**,** 3015-3025. (doi:10.1007/s00227-013-2291-8)

SESSION 1: DISCUSSION

The following captures the discussion in relation to session 1 and opinions captured below are not necessarily indicative of consensus or suggestions made by the summit as a whole.

- This summit is a good first step to help foster collaboration and may have management implications in terms of regional efforts. The industry may have to support more science as government budgets get tightened and industry needs to meet the needs for data costs. This is because we need to have a better understanding of the potential threats and challenges to help prepare the industry for the future (e.g. potential changes in water temperatures, and increasing acidity).

- Taking the precautionary approach described by S. Smith provides stability that is important for members of the industry looking to gain what they invested in their ITQ license (Canada). The spatial and temporal data collected for this approach is good for telling one what *not* to do but not always what *to* do.

- The link between oceanography and population connectivity and temperature may create particular spatial patterns and it is important to understand the biology and oceanography that underlies the distribution of the resource. Then stakeholders can build businesses around that information. For example, the EMCC may not be contributing larvae or spat to a local area but may be contributing spat to others. If this is true, stakeholders would need to develop ways to ensure that their area has a sufficient supply of scallop larvae. Methods of doing this, however, depend on localized physical characteristics, and therefore local managers and possibly aquaculturists need to develop plans based on oceanographic data for a particular area. Some areas might have multiple sources of larvae and others might have high retention. This may indicate a need for identifying broodstock and protecting them. This also brings up the question of the carrying capacity of certain areas.

- While genetics have shown interesting connectivity patterns (for example Maine and western Georges Bank are highly connected) attendees are wondering what the implications of genetic diversity are on aquaculture seed sourcing and local wild populations. Larger connectivity questions need to be examined to see the connection between the Bay of Fundy, the Gulf of Maine, and Georges Bank. So far most of the studies have been focused on Georges Bank.

- Many fishermen learned that the spring spawn does exist and there may be implications for meats in terms of a) yield and b) condition. Should there be more investigation into the spring spawn in both the US and Canada?

- Canada seems to have more tools and data for biomass assessment versus Maine but Maine only started in 2006. One of the big questions is do you set regulations before the data are collected?

SESSION 2: FISHERY DEPENDENT DATA

Moderator: Carla Guenther, Penobscot East Resource Center

Targeted Questions:

i) What is the best way to determine the impact of a fishery on a population?
ii) How can this information be used to manage a fishery?
iii) How can we advance the use of fishery-dependent data in an environment of dwindling resources?
iv) How are different fishery-dependent data types (fishermen's observations, catch per unit effort, logbooks, landings, life history, etc.) utilized in real-time decision-making?
v) What are the most meaningful in-season data collection methods?
vi) How are fishermen's knowledge incorporated into survey design?
vii) Could in-season data be sufficient to manage a fishery (without pre-season estimates)?
viii) Is it more cost-effective to undertake in-season data collection vs. formal fishery-independent surveys?

<u>Diana Fillion (presented by Leslie-Anne Davidson)</u> – Commercial Scallop Fishery: Eastern New Brunswick, Canada, Scallop Fishing Area (SFA) 21A

For fishery management purposes, the east coast of Canada is divided into Maritimes, Gulf, Québec, and Newfoundland and Labrador Regions. Most of the southern Gulf of St. Lawrence is found in the Gulf Region where there are 6 Scallop Fishing Areas (SFAs) (Figure 7).

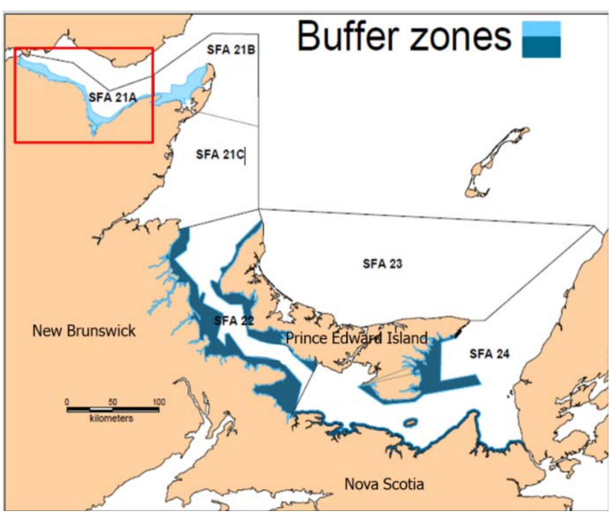


Figure 7. Gulf Region's Scallop Fishing Areas (SFAs): 21A, 21B, 21C, 22, 23 and 24.

Scallop fishery management plans vary from one SFA to another. In SFA 21A, there are 28 license holders. For conservation reasons, the scallop fishing industry requested that the fishery be closed for three years (2010–2012) in that fishing area. When the fishery re-opened, the SFA 21A fishermen accepted the most stringent management measurements in the Gulf Region. Mandatory Vessel Monitoring Systems (VMS) started in 2014. The fishing season is four weeks and in 2014 it was from July 7 to August 1. The meat count is a maximum of 37 scallop meats per 500 g. In 2015, the count was decreased to 35 scallop meats per 500 g. Mandatory logbooks must be mailed to Fisheries and Oceans Canada within two weeks of the end of the fishing season. The ring size of the buckets is 82.6 mm (3 ¼ inches) with the exception of the first row of the buckets where 76.2 mm (3 inches) may be used. A maximum of 2 steel washers may be used to join two bucket rings together. A rubber washer may also be used to join bucket rings; however, it can only be placed in the vertical position. The maximum width of the outside measurement of the drag is 6.09 m (20 feet). Scallops must be shucked prior to entering the port and only the adductor muscle can be landed. Water less than 18 m (60 feet) in depth is closed to scallop draggers to protect lobster fishing habitat. The catch per unit effort (CPUE) is evaluated at the end of each fishing season. The fishing season is only open the next year if the average CPUE for the entire SFA 21A is equal to or greater than 0.5 kg of scallop meat/hour/meter of drag.

<u>Trisha Cheney</u> – Using Fishery Dependent Data for Real Time Management

An integral part of Maine's rebuilding plan has been the use of in-season management measures implemented through a "trigger mechanism". The trigger mechanism is a clarification of the Department of Marine Resources (DMR) Commissioner's existing emergency authority allowing for an in-season action that will address "unusual damage" or "imminent depletion" of the resource. After three years of rebuilding using closed areas, the industry did not wish to immediately deplete the rebuilt resource within those areas, but preferred to have a more lasting benefit. Therefore, the closed areas were re-opened as Limited Access Areas governed by a trigger set to when 30–40% of the estimated harvestable resource was removed from the area, it was closed for the remainder of the season. This authority only allows the DMR to take away opportunities mid-season, not provide additional opportunity. Therefore, a season is set up through normal rulemaking that provides ample opportunity to the fleet up-front, and measures are taken in-season to address any areas experiencing overfishing. The DMR collects survey data before the season starts, and then utilizes data collected in real time through the port and sea sampling programs, as well as Marine Patrol observations to help make decisions. In addition, one of the most important pieces of data comes directly from industry members who voluntarily communicate observations and concerns to the DMR. By utilizing all these data sources, DMR has been able to effectively close down Limited Access Areas mid-season so as to allow the resource to not only replenish itself, but also continue to rebuild. This has been so effective that the DMR is considering expanding the trigger mechanism to the entire state scallop fishery for the following 2014–15 season.

Jessica Sameoto – Fishery Dependent Data: Experience from the Maritimes Region, Canada

The stock assessment is meant to assess the impact of a fishery on a population and provide fishery managers and industry with information to make decisions. To do this we need to determine the stock status (e.g. biomass, stock density) and the removal rate (e.g. exploitation). Assessments use available data to make the best estimates possible. The data types that are available can be defined as fishery dependent or fishery independent data. Fishery dependent data is derived from the fishing process whereas fishery independent data is derived from activities not associated with the commercial harvest. For stock assessment, fishery dependent and independent data complement each other. If we only have one data source, we may be missing part of the picture. The Maritimes Inshore scallop fishery has fishery dependent data from landings, logbooks, VMS, observers (SFA 29 West only), and fishermen's knowledge. The fishery independent data is from surveys (catch rate, condition, size/age composition), multibeam data (bathymetry, backscatter) and imagery data (video, digital stills).

The key findings from these data are:

- Spatial patterns in fishing effort aligns with scallop habitat.
- Survey catch rate and commercial catch rate can track population biomass.
- Annual commercial effort can be a good proxy for annual exploitation trends.

SFA 29 West is data rich in both fishery dependent and independent data (survey, logbooks, observers, VMS, multi-beam and benthic imagery). We developed a scallop habitat suitability map for this area using multi-beam bathymetry, backscatter, associated derived layers, and images of the seafloor. VMS data shows that effort is highest in areas that have the highest habitat suitability.

SPA 3 has no multi-beam or habitat data. The survey was initially stratified randomly in three strata. However there are spatial differences in scallop condition, abundance, and growth, which reflect habitat suitability. The spatial extent of the area fished decreased over time and there was concern whether the survey of the whole area was adequately detecting the impact when only part of the area was fished.

Scallop productivity is closely tied to habitat suitability. In the absence of habitat information, fishing effort can map habitat. We can use VMS in SPA 3 to delineate habitat. The suitable habitat area is significantly smaller than the survey area. We needed to redesign the survey to concentrate higher sampling effort in the more suitable habitat areas. We can then use the separate survey indices for inside and outside of the suitable habitat areas.

Survey estimates can line up with commercial catch rate estimates in the following year and we can track population biomass this way. In some areas, last year's survey can predict this year's average commercial catch rate. This gives confidence in the use of either catch rate index (commercial or survey) to track population changes. We can also estimate exploitation through population assessment models. However, models aren't always available. We have found that annual fishing effort shows a strong linear relationship with annual exploitation from our models. In the absence of a model, annual effort can be a good proxy for annual exploitation trends.

SESSION 2: QUESTIONS & DISCUSSION

The following captures the discussion from questions posed in relation to session 2 and opinions captured below are not necessarily indicative of consensus or suggestions made by the summit as a whole.

Q1. What are the summary points/take home messages from these presentations?

- Management advice can be obtained in the absence of models using adaptive methods and real-time fishery dependent data coupled with fishery independent surveys. Advice and strategies should be place-based and might not be universally appropriate across a fishery.
- Both fishery dependent and independent data are useful and it is ideal to have both. The Maine fishery has fishery dependent data and it is important compared to the fishery independent data. Stock assessments rely on landings data and accuracy in landings is important for assessments. Long-term data from fishermen's observations is important and gonad indices are helpful for determining the spawning season. However, there needs to be recognition of the limitations of different kinds of data and you have to know why you want to collect different kinds of data.
- It is important to take fishermen on board survey vessels and/or do side by side tows along survey vessels so that there is a better understanding of how to interpret survey data and what they represent, and to foster greater support and

trust in the estimations of harvestable biomass Maine is using to calculate an area's trigger. Furthermore, the more fishermen providing in-season fishery dependent catch data the better because the information will be more representative, which should more closely reflect what more fishermen in an area are experiencing and should therefore not only improve management decisions, but also increase industry support for in-season closures when they occur.

- Stocks are connected and a sustainable resource is the goal. Spatial management is necessary for scallops; however, this can require real-time information from fishery dependent data such as logbooks. These data (from logbooks) need to be available for use in a timely manner. Directing effort to less suitable habitat may lessen fishing impacts on biomass.

- Habitat suitability maps are useful, but are they useful for quota management? Habitat maps can be important in regards to meat quality and provide information on where "good" scallops are.

- Maine fishermen are impressed by the ability to predict commercial catch rates by survey indices (as shown in the Bay of Fundy). This could have implications for "triggers" in Limited Access Areas in Maine. These collaborative workshops are important for information sharing.

- Willingness to share data impacts the management system. The more industry is invested in the management system, the more willing they may be to share information.

- Scallops have been shown to grow faster and better in shallow water and slower in deeper colder water. Fishermen should start fishing deep and keep shallow areas closed longer to improve yield-per-recruit. This is important because condition (yield) does seem to matter for profit.

- Programs should be fit to the funds available and there needs to be new options for research funding like the research set aside (RSA) program in the US federal fishery.

Q2. What are some fisheries dependent data types, variables, and/or methods that you currently use in your fishery? How do you use them?

- For the inshore scallop fishery in the Maritimes Region, Canada, data available includes effort data from the number of tows per day and tow time, bottom type, gear size, license number, crew size, bycatch (only in SFA 29W), latitude and longitude, CPUE, catch (in logbooks), and VMS data. There is also dockside monitoring. Industry panel meetings for certain areas are also important for exchanging information on the fishery. All of these data (fishermen's observations, seed locations, habitat and meat/gonad condition) are used to help manage the fishery.

- Landings data available in Maine include port sampling, meat counts, number of tows to get the catch limit, time fished, latitude and longitude, real time phone surveys, and pounds landed.
- In the US Federal fishery at sea observations, meat weight, shell height, CPUE, bycatch, VMS, and log books are used to estimate biomass and implement management policies. The US has observer data as well.
- One take home message is that the Maine fishery needs reliable and timely landings data.

Q3. What are some of the challenges to using fisheries dependent data, generally, and in your fishery?

- There needs to be buy-in from the industry to improve the quality of data but there also needs to be an understanding of which questions the data will be used to address.
- Some of the challenges of fisheries dependent data include the issue with logbooks – positional data is not always accurately reported and it is not always possible to record the latitude and longitude.
- There are places where there is little to no fishing, thereby reducing the quality of fishermen dependent data.
- There is a lot of industry concern about data sharing because fishermen do not want to share their favorite fishing spots.
- There is a difference in collecting data versus actually being able to use it. Knowing what data are to be used for is helpful before collecting it. Data can also be lost or useless without complete records. There is also the issue of actually processing the data (gathering and interpreting data can be quite time consuming). These kinds of data can sometimes be very area specific and can't be applied to the whole stock.

- In Maine, there are technical issues with VMS reports with many reporting fishing in locations on land.
- Maine's system for logbook reporting is currently paper-based and could be more modernized or electronic so that there is more direct, and accurate, self-reporting.
- When interpreting fishery dependent data for use in Maine's trigger, other information that may be important to consider are the physical conditions and weather since these can influence fishing behavior and affect fishery data such as CPUE. Additionally, not all fishermen are created equal and their age, experience, vessel and motivation will also factor into changes in CPUE.
- In a rebuilding fishery, historical trends are important; however, what if something has changed? Having shifting baselines can be a real problem for interpreting how a stock is actually doing and determining what kind of baseline the fishery really should be aiming for.

Q4. How can the capacity for broader use of fisheries dependent data be built? Specifically, how could collaborative research contribute?

- In Maine, an association to build/raise funds would be ideal and there needs to be more coordinated volunteer efforts. Possibly differentiating a portion of Maine scallop funds to go to collaborative research would be ideal for developing cooperative research programs and increased fishery dependent data collection.
- Collaborative research should be the first step and should have scientists, managers, and fishermen do research together and broaden the use of fishery dependent data. Using collaborative research as a test-case of buy-in will help industries buy-in to management and the science. It helps if industry can see that more accurate data impacts catch advice.
- These potential programs should have regular meetings between science, industry and management to guide priorities. Using these kinds of programs we could develop standard operating procedures (SOPs) for data collection of report and logbook data. This kind of collaboration can improve fishermen's profitability and help meet management measures by defining a common goal with increased dialogue. This approach has to be collaborative with mutual benefits for all stakeholders. These programs should also have data gathered that is used and not discarded. Determining which data to collect can help develop better ways of collecting these data. These data must also be more accessible and be

valuable to fishermen without betraying confidentiality. These programs can determine things like the kind of capacity an area has, identifying sampling sites reliably, and determine meat conditions by area and season. These kinds of programs can develop trust among fishermen and between fishermen, managers, and scientists. There needs be more money to fund these projects.

SESSION 3: AQUACULTURE, SEA RANCHING and ENHANCEMENT

Moderator: Leslie-Anne Davidson, Fisheries and Oceans Canada

Targeted Questions:

i) What are the challenges facing better integration of aquaculture into the overall management?
ii) Could stock enhancement and sea ranching provide a natural connection that will help reduce potential skepticism and reluctance among wild fishery harvesters?
iii) Where is sea scallop aquaculture being conducted and what are the challenges?
iv) Could grow-out sites serve as potential broodstock sanctuaries?
v) Are there ways to use growth and other information to inform management?

<u>Leslie-Anne Davidson</u> – Scallop enhancement projects conducted in Canada and the need to integrate it with the scallop fishery management plan

In the Gulf region of Atlantic Canada, scallop fishermen and aquaculturists seem to operate as two separate entities. Both harvest sea scallops as a way to make their living but they appear to be doing so in a competitive manner rather than a collaborative one. Landings from the scallop fishery far exceed those of the aquaculture industry so aquaculturists seem to have made a conscious effort to avoid direct competition with the scallop fishing industry. It is my belief that both would benefit if they were more collaborative in the conduct of their activities.

In the late 1960s, the scallop fishery had nearly collapsed in Japan (Figure 8). After various studies, scallop aquaculture was initiated and by the mid 1970’s scallop aquaculturists and fishermen were able to work together. By 2000 the landings from the fishery were more than 10 times greater than the best historic landings and the harvest from aquaculture also had a 10 fold increase from its humble beginnings. As I see it, the partnership was the vehicle that contributed to this phenomenal increase. Enhancement and aquaculture allowed the scallop landings to reach levels that were greater than nature itself could have ever provided.

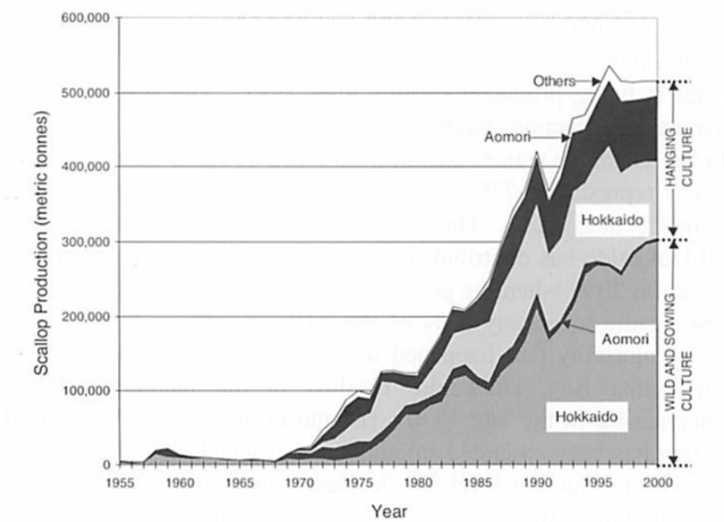
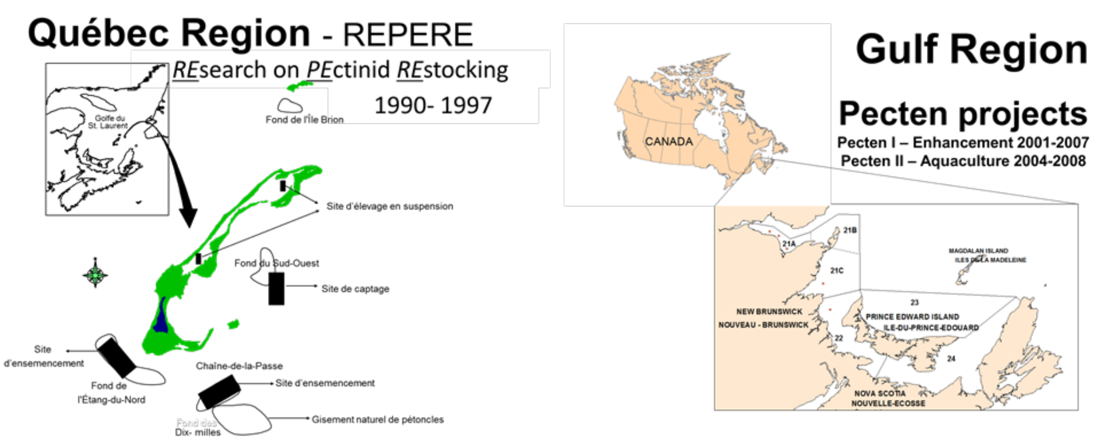


Figure 8. Japanese scallop, Patinopectten (Mizuhopecten) yessoensis Jay, landings in Japan, 1955-2000. (Source: Kosaka, Y. and Ito, H. 2006. Japan. <u>In</u> Scallops: Biology, Ecology and Aquacutlure S.E. Shumway and G. J. Parsons (Editors) 2006 Elsevier (original Source: Minister of Agriculture, Forestry and Fisheries, Government of Japan, "Annual report on statistics of fishery and aquaculture production")

Impressed by the Japanese success, various scallop enhancement/aquaculture projects were launched throughout the world. In Atlantic Canada, the <u>Re</u>search on <u>Pe</u>ctinid <u>Re</u>stocking (REPERE) project was conducted in the Québec Region from 1990 to 1997 (Figure 9a) and the Pecten I (2001–2007) and Pecten II (2004–2008) projects were piloted in the Gulf Region (Figure 9b).



a) b)

Figure 9 a) Québec Region project and b) Gulf Region projects (modified from Davidson and Mullen (2005) and Davidson and Légère (2007)).

The primary goal of our research was to establish if scallop aquaculture and enhancement could be done in our waters. The biological and technical aspects of the Japanese technology were successfully transferred to Canada. However, we did not effectively integrate this technology within an appropriate management scheme. Restocking and stock enhancement of the coastal fisheries has been attempted for many species in many different parts of the world. Upon review of the potential, the problems, and the progress of these activities, Bell *et al.* (2006) informs us that one of the essential steps to ensure their success is to integrate the activities within an appropriate management plan. The Maritime Fishermen Union (MFU) had conducted the Pecten I and Pecten II project and Martin Mallet from the MFU had suggested a management approach (Figure 10). Mr Mallet agreed to share his concept for discussion purposes; however, the management strategy was not implemented.

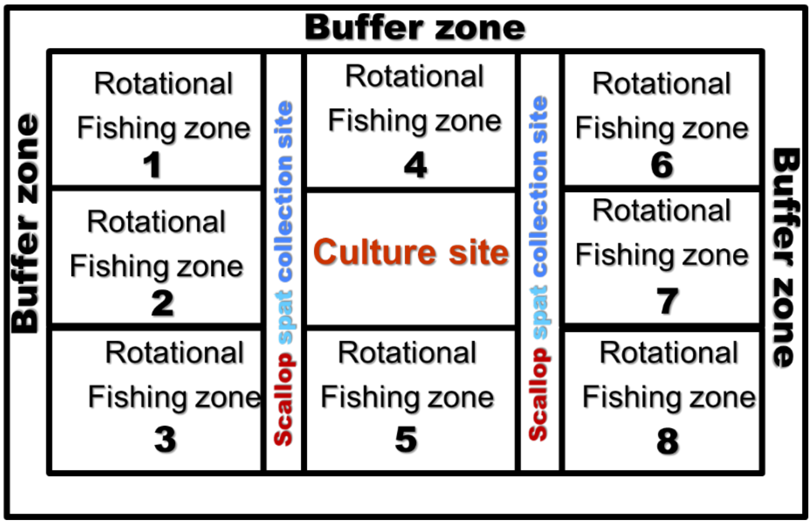


Figure 10. Proposed management strategy for integrating scallop aquaculture and fishery (Martin Mallet).

References:

Bell, J.D., Bartley, D.M., Lorenzen, K. and Loneragan, N.R. (2006) Restocking and stock enhancement of coastal fisheries: Potential, problems and progress. Fish. Res. 80, 1-8.

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Davidson, L.A., and Mullen, J. (2005) Proceedings of the Scallop Aquaculture Workshop: Halifax, Nova Scotia, January 24, 2004. Can. Tech. Rep. Fish. Aquat. Sci 2610: iv + 37p.

<u>Dana Morse</u> – The 50-Second Dash: Six Observations about scallop aquaculture and enhancements in Maine. In Five Minutes.

Maine has benefited from knowledge, expertise and willingness to share by Canadian colleagues including Leslie-Anne Davidson, Shawn Robinson, Melanie Bourgeois, Steve Backman, Blair Cooper, Duncan Bates, Cyr Couturier, Madeleine Nadeau, Mike Dadswell, Monique Niles, Sylvain Vigneau, Caroline Durand, Ron Boudreau, Rodney

Fougere, Julien Gaudet, Michelle Theirault, Charles Purdy, Jay Parsons, Andre Mallet, Claire Carver, Peter Darnell, Andrew Bagnall, and Paul-Aime Joncas.

Spat bags are an incredibly important tool to help develop useful research questions and collaboration. Spat bags have changed the way Maine fishermen and researchers think about scallops. Some questions spat bags can help address include:

- Where are the parents?
- Where do the larvae go?
- What are impacts of predators/where/how bad?
- What are the influences of large/small scale currents, tides, etc.?
- How do we ensure a good larval supply?

Maine has demonstrated excellent capability in spat collection with catches mostly between 1,000-3,000 individuals/bag, sometimes 4,000-5,000 individuals/bag. The success in re-seeding is much less obvious. We need to intensify our observation on re-seeded bottoms at 24 h, 48 h, 1 week, 2 week, and 4 week intervals. Following movements and predation in the short term may shed light on post-settlement processes.

There are a lot of opportunities for aquaculture, both for its own use and overlapping with the fishery and wild resources. Several important discoveries from spat bags and examining adult scallops include:

- Very strong growth – up to 0.19 mm/day, first market size within 6-10 months.
- Roe is present much of the year in several sites.
- State support in the regulatory aspects, strong regime for minimizing public health risks from biotoxins. Present help is toward sales of live/roe-on.
- Product development and diversification.
- Passive collectors could assist with re-seeding wild beds.
- Oceanography could benefit larval retention.
- Diversification for fishermen is possible – won't be for everyone, but many positive qualities exist for fishermen who also act as farmers.
- In 2014, there were some sales of live product and of seed (and concurrently the testing and MOU-signing that had to precede those live sales).

The risks and needs are: public health and safety, integration of fishing and farming will be imperfect, US market development, allocation of waters into private use through leasing, biosecurity (pests and disease), it will be awhile before competition with wild production occurs (but bears attention), and profitability is suspected but unproven yet.

Nate Perry – Maine SeaGrant/Commercial trials for Sea Scallop grow-out in Southern Maine

I primarily work on oysters at my aquaculture site, but would like to diversify the farm and my income. In 2014, I got involved with the aforementioned scallop project and here are two things that I am currently experimenting with:

1) Growing all scallop stages in containers and balancing this with gear. From a labor standpoint, there is more gear to work with, but there is less labor per piece of gear than labor required for container care. For commercial profitability, details and data must be compiled by site to better determine a sequence of phasing between bag culture, cage/stack culture, and ear-hanging. In addition to best operational and successful growing methods, this will help provide a template for determining what variety products (e.g. seed, whole, roe-on, meat, etc.) will help diversify profit and for that matter, risk.

2) Seeding or enhancement with container grown scallops is an area of interest for me – particularly seeding around the area of my aquaculture lease. We agree there needs to be a way to measure the retention rate of seeding and that the site (on relatively small scale) may significantly influence retention rates.

Michelle Thériault – Sea Scallop Aquaculture in Nova Scotia

Seed collection for growing spat is predominantly in Chedabucto Bay (northeast Atlantic coast of Nova Scotia). There are existing growers in Lunenburg and potential new growers in Shelburne, all along the Atlantic coast of Nova Scotia. Seed supply has been collected by Université Sainte-Anne starting in 2012. The goal is to provide a stable and consistent supply of high quality seed for the scallop aquaculture industry. The collection site is in cold, deep waters and has consistently produced good yields, high quality seed.

Mechanical sorting and grading is used to harvest the seed. This sorting technique helps sort out good, large seed from mostly other organisms. The maintenance and preparation of spat bag gear is labor intensive and benefits from partnerships with industry and the Nova Scotia government to assist with labor. Culture methods of the collected spat include large arrays of hanging lantern nets. The interest in scallop aquaculture is growing of both a mix of new and existing growers. Scallop culture provides good options for diversifying incomes on existing farms or areas affected by invasive tunicate species. The University will continue to work to support the development of the industry through seed supply.

Pierre Poitevin – Research and Development to develop Scallop Aquaculture and Sea Ranching in Saint-Pierre and Miquelon Archipelago

Miquelon and Saint-Pierre are two French islands off the southeastern coast of Newfoundland, with an area totalling 242 km² and a population of 6,200. The annual average temperature is 5.5°C with an oceanic climate showing pronounced seasonality and a strong seasonal thermocline.

A joint research and development (R&D) effort has been developed since 2007 by a private company (Exploitation des Coquilles (E.D.C.)) and a scientific research team (Association de Recherche et de Développement pour l'Aquaculture (ARDA) and the Institut Français de Recherche pour l'Exploitation de la Mer (Ifremer)) to enhance giant sea scallop, *Placopecten magellanicus,* breeding techniques and assess its environmental requirements. The R&D strategic plan is based upon a 3 year project also taking into account the E.D.C. requirements.

The global strategy is based either on a local spat settlement supply or spat imports from the Canadian Maritimes. Spat collectors are deployed for 9 months to maximize spat settlement in areas selected from a hydrodynamic model simulation. The pre-growing stage lasts 9 months until a size of 35 mm shell diameter. Scallops are then deployed in lantern nets using the "longline aquaculture" grow-out technique for three years or seeded directly on the seafloor for five years, also known as "sea ranching". The site selection process has been developed using geomatics and a hydrodynamic model.

Additional aspects of this project include genetic characterization of the spat collection and potential effect of spat imports on local population, modelling the hydrodynamic structure and thermocline patterns, multi-site monitoring of natural spawning and spat collection, habitat mapping for site selection, evaluating various husbandry methods (considering by way of example optimal scallop densities), studying dredge efficiency and bottom impacts and developing the annual *in situ* video monitoring for stock assessment and quantifying fishing effort. Meanwhile, environmental conditions and carrying capacity is assessed through *in-situ* continuous monitoring using multi-parameter probes and phytoplankton samples (quantitative and qualitative surveys).

SESSION 3: QUESTIONS & DISCUSSION

The following captures the discussion from questions posed in relation to session 3 and options captured below are not necessarily indicative of consensus or suggestions made by the summit as a whole.

Q1. What are the threats that aquaculture presents to the wild fishery?

- The threats that aquaculture poses to wild fisheries include genetic monocultures that make local stocks more vulnerable to disease and the potential cross contamination (disease/parasite) from high-density stocks. The use of chemicals in aquaculture may have an influence on genetics, disease, and production. Spat collection could also negatively affect recruitment to wild scallop beds.

- There could also be competition for bottom habitat and food between wild and cultured stocks. Culturing could bring forth space and gear conflicts with the wild fishery resulting in the loss of fishing grounds and brings the potential to introduce more predators and threats of invasive species. There could be a shift in fishing seasons and timing of spat collection. If only one portion of the fishery (aquaculture and wild) invests in seeding, how would they ensure that they benefit from it?

- There is also competition for markets between aquaculture and the wild fishery and this may result in changes to the value of product in wild versus aquaculture raised scallops. There could be competition for labor and a conflict between mindsets and approaches. There could also be a shift in markets due to the consumer perception of aquaculture versus wild caught scallops. All of this could result in shifts of local political power, and potential changes to the character of the waterfront.

Q2. What are the opportunities between scallop aquaculture and fishing?

- The opportunities presented between these two industries are resource enhancement, product stability, data sharing and collaboration, reduced conflict between aquaculture and fishing, global market presence, economic stability, increased awareness, tourism and education, increased waterfront infrastructure, income diversification, youth employment, community support, and the potential to reduce the stress on wild populations and the environment by reducing dredge activity.

Q3. What are the weaknesses of integrating aquaculture and enhancement in wild fishery management plan?

- The weaknesses of integrating aquaculture and enhancement in wild fishery management includes the lack of buy in from both industry and management, confusing multiple management authorities, differences between enhancement and aquaculture, potential conflict and competition for space, potential competition for the same markets and preferential treatment, seeding methods are still in the development stage, propriety/ownership conflict, potential genetic issues, quantifying impact of enhancement, a history of mistrust between the two groups, the lack of understanding of impacts on wild resources, potential negative social impact, and increasing the complexity of an already complex fishery.

Q4. What are strengths of integrating scallop fishing and aquaculture?

- Some of the strengths of integrating scallop fishing and aquaculture include developing a stronger market (and control over that market), rounding out the scallop supply and increasing product. This will stabilize income; increase job opportunities and diversify the industry. This could lead to overall resilience of coastal communities and decrease the conflicts of combining wild and aquaculture sectors. This could also lead to simplifying management and integration across aquaculture and wild fisheries and potentially strengthen fishery management overall.
- Integration may increase participation in research from both sectors. Knowledge sharing will increase. This collaboration will increase the ownership and responsibility of fishermen of the resource and may help to maximize their profit by increasing catch rates and decreasing costs. The value of your enterprise could increase along with increases in the available resource.
- Cultured stock can increase the natural stock (broodstock and seed) by capturing larval stages where natural settlement would not occur. These raised larvae that are seeded into natural beds may help bring back those populations again. This could help maximize the resource yield in those areas.

SESSION 4: SUSTAINABLE MANAGEMENT OF THE SEA SCALLOP RESOURCE

Moderator: Alain d'Entremont, Full Bay Scallop Association

Targeted Questions:

i) What are the components of a well-managed fishery?
ii) What is each sea scallop fishery's approach to defining reference points?
iii) How do you define reference points (or should you even try) when a fishery does not have a formal assessment?
iv) What broader indicators can be used in a data poor situation (biological, economic, management)?
v) How do you pragmatically scale management to match resources?
vi) What does sustainability mean in the context of a drag and dive based fishery?
vii) How is sustainability defined?
viii) What are each fishery's goals (maximizing the number of participants or yield)?
ix) How is success defined?

Stephen Smith – Sustainable Management of the Sea Scallop Resource in Canada

The Precautionary Approach (PA) means being cautious when scientific information is uncertain, unreliable or inadequate and not using the absence of adequate scientific information as a reason to postpone or fail to take action to avoid serious harm to the resource. In 2001, the United Nations Agreement on Straddling and High Migratory Fish Stocks (UNFA) committed Canada to use the PA approach. In 2004 the Atlantic Fisheries Policy Review (AFPR) led by DFO called for a comprehensive risk management framework for decision-making, which incorporated the PA.

Elements of Sustainability:

1. Stock Status: The stock is at a level which maintains high productivity and has a low probability of recruitment over-fishing
2. Reference Points: Limit and target reference points that are appropriate for the stock
3. Stock Rebuilding: Where the stock is depleted, there is evidence of stock rebuilding
4. Harvest Strategy: There is a robust and precautionary harvest strategy in place
5. Harvest control rules and tools: There are well defined and effective harvest control rules in place
6. Information / monitoring: Relevant information is collected to support the harvest strategy

7. Assessment of stock status: There is an adequate assessment of the stock status

<u>Two Conditions of Sustainability:</u>

Surplus production = growth + recruitment – mortality

1. At any level of biomass, catch is less than surplus production
2. There is a level of biomass where the stock is most productive and provides the maximum sustainable catch

DFO developed reference points and decision rules to maintain the stock biomass near maximum productivity. The limit reference point (LRP) represents the stock status below which serious harm in terms of reproductive capacity is occurring to the stock. This can be a very difficult point to determine accurately and guidance from published case studies suggest 40% of biomass at maximum sustainable yield (B_{MSY}) as a proxy. In Canada, the LRP is set at 30% B_{MSY} for the offshore scallop populations and at the lowest biomass in the time series from which a sustained recovery occurred for inshore populations. The upper stock reference (USR) point is the threshold below which removals are reduced to promote recovery and is usually set at 80% B_{MSY} for Canadian fisheries. In Canada this 80% is applied to the mean biomass over a set period of years for offshore scallop populations while the USR is defined as the B_{MSY} for inshore populations calculated from the population model used for stock assessments. The exploitation target in Canada is the average exploitation rate for offshore populations (1981 to 2009) and the exploitation rate resulting in B_{MSY} for inshore populations. The removal reference is the maximum acceptable removal rate for the stock. The decision rules have to do with the state of the stock. If a stock is above the USR it is designated as being in the healthy zone (e.g., Figure 11). Fishing plans for healthy stocks can be quite flexible as long as there is a low probability of the stock dropping below the USR. Once a stock drops below the USR, it is in the cautious zone and exploitation is reduced to promote biomass growth so that the biomass is greater than the USR over a set period of years. More restrictive management actions such as minimal or no fishing may be warranted when the stock drops below the LRP and is considered to be in the critical zone.

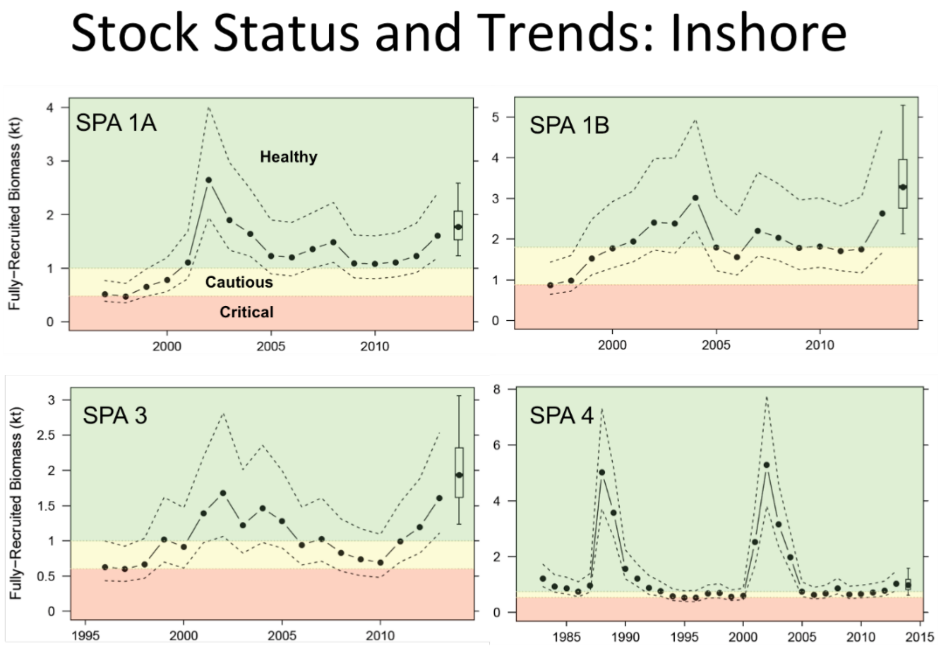

Figure 11. Biomass estimates for fully-recruited scallops (kt) from the assessment model fit to the survey and commercial data for scallop fisheries in the Bay of Fundy and approaches. Dashed lines are the upper and lower 95% credible limits on the estimates. The predicted biomass for 2014 in each area, assuming the 2013/2014 initial TAC, are displayed as a box plot with median, 50% credible limits (box) and 80% credible limits (whiskers). Green-shaded area represents the healthy zone (based on a Upper Stock Reference (USR) point, yellow area represents the cautious zone (based on Lower Reference Point (LRP)) and red is the critical zone (< LRP).

Spatial patterns are important for measuring and evaluating sustainability of scallop fisheries. Stock productivity is a function of habitat and density as opposed to the traditional MSY used for fish stocks, which depends only on biomass and assumes a constant exploitation rate over the whole population. The stock-recruitment relationship is not obvious for scallops and recruitment is to specific areas. Density dependence is important at settlement and later on in life. Fishing mortality of scallops should only be applied to fished areas and not to the entire population. Habitat suitability has been assessed extensively by DFO in Canada, and is the basis for new models being developed for scallop fisheries off of southwest Nova Scotia where there has been extensive multi-beam sonar coverage (Figure 12). Biomass trends, density trends, and catch trends indicate that habitat significantly impacts density and therefore catch rates.

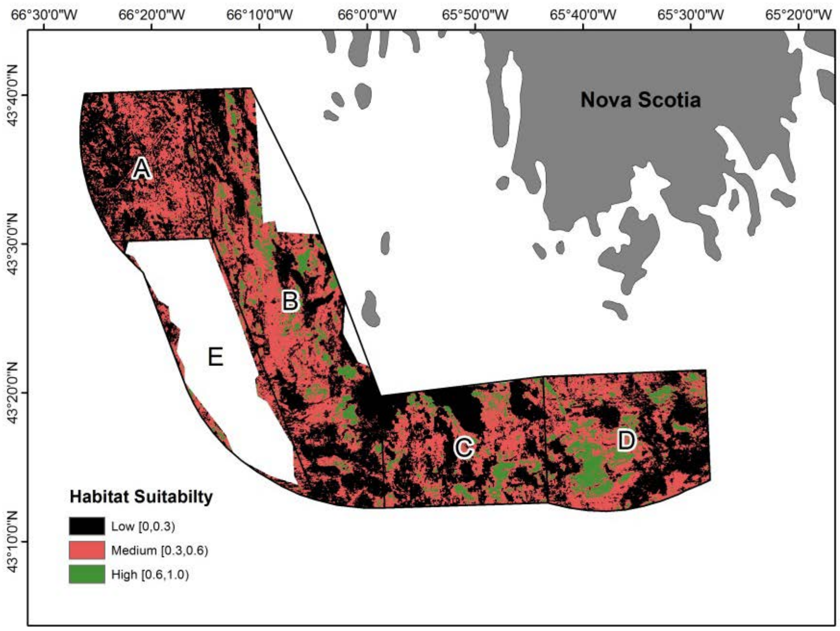

Figure 12. Scallop habitat suitability map from the Maxent Species Distribution Model (Brown et al., 2012) binned by Low [0, 0.3), Medium [0.3, 0.6) and High [0.6, 1.0) categories of habitat suitability probabilities for SFA 29 West.

References:

Brown, C., Sameoto, J. A., and Smith, S. J. (2012). Multiple methods, maps, and management applications: purpose made seafloor maps in support of ocean management. J. Sea Res., 72: 1–13.

<u>Deirdre Boelke</u> – Sustainable Management of the US Sea Scallop Resource

In 1976 the Magnuson-Stevens Fishery Conservation and Management Act was established and NOAA established a 200-mile EEZ and created regional councils to monitor fish stocks. Decisions made are based on input from the industry, scientists, and regional managers. Councils forward proposals to NOAA's National Marine Fisheries Service (NMFS). The New England Fishery Management Council (NEFMC) monitors multi-species (groundfish), herring, red crab, sea scallop, skate, monkfish, dogfish, Atlantic Salmon, and Halibut.

For the sea scallop, the US fishery started in the mid-1900s and had sporadic booms and busts. The Scallop Fishery Management Plan (FMP) was established in 1982 and at first was managed by minimum shell sizes and meat count limits. In 1994 there were major changes implemented including a limit on the number of boats, maximum number of days, and crew and gear limits.

In 1994 three large areas were closed to fishing on Georges Bank to help reduce mortality on groundfish. In the 1990s there was a sharp decline in the scallop fishery. In 1999, the scallop fishery was granted limited access in part of one of the closures on Georges Bank and following the success of that access the Council developed a large-scale area rotation program. The current program surveys the resource annually and beds of small scallops are closed for 2-3 years. Vessels are then allocated controlled access in reopened areas to reduce bycatch and mortality.

The way that the US fishery has updated guidelines and definitions for the scallop plan is that Optimal Yield (OY) is defined as the amount of fish that will provide greatest benefit to the Nation based on social, economic, and ecological factors. The Annual Catch Limit (ACL) is the optimal yield instead of the maximum sustainable yield (MSY; old management model).

The scallop assessment is a very data rich assessment. The overall biomass and recruitment information are based on results from several surveys. First, the Northeast Fisheries Science Center (NEFSC) has had a dedicated dredge survey since 1977 that has sampled the resource using a stratified random design. More recently, the NEFSC scallop survey has evolved into a combined dredge and optical survey. Dredge tows are still completed in each stratum, and a digital camera (Habcam Version 4 or “Seahorse”) is towed behind the survey vessel on all three legs of the survey. In addition, the University of Massachusetts School for Marine Science and Technology (SMAST) completes a video survey with a drop camera in all or portions of the scallop resource area depending on funding. The Virginia Institute of Marine Science (VIMS) conducts an intensive grid design survey towing two dredges in several areas that vary year to year based on funding. Finally, Habcam Group, an scallop industry based organization, has completed very intensive optical surveys of discrete areas that also change each year using a towed camera similar to the one used by NEFSC (Habcam Version 2). Staff from Woods Hole Oceanographic Institute have been involved in many of the towed camera surveys with both Habcam Group and NEFSC. The Scallop Plan Development Team (PDT), the technical body advising the Council, combines the results from all available surveys to estimate sea scallop biomass and recruitment on an annual basis.

Summary on sustainable management:

- Goals of program need to drive the system
- High quality survey data – broad-brush index may not be enough – dedicated Research Set-aside (RSA) program developed to provide funding for more detailed surveys of the resource
- Strong effort controls – so target catch can be closer to catch limit
- Ability to adjust measures quickly if needed
- Direct measures to address bycatch and other environmental issues - to help keep OY closer to MSY

SUMMARY

This summit has offered the opportunity for scientists, fisheries managers, industry, and environmental organizations to come together, learn and exchange information in a collaborative setting. These opportunities are relatively uncommon but welcomed. Increasing these opportunities for scientists, managers, and stakeholders to get together can only benefit the industry and its future because the relationships between harvesters, science, and management are an important component to a successful industry.

Discussions included breaking down the science discussion, especially what connectivity really means and what the overall implications of population connectivity are to scallop stocks. If we can take what we have learned, get the money, the industry buy-in, then we can be successful in achieving our collaborative research goals. It was noted that the managers and the fishermen in Canada have a lot of confidence in their survey system.

Many of the conference attendees found that the new information discussed at this meeting was informative but might take a while to integrate. For example, connectivity between populations is an interesting issue, but there is no management structure in place to use it yet, and it may be difficult as connectivity of populations crosses both county and country lines. In terms of scallops, there are a lot of gaps in our pre- and post-settlement knowledge of processes affecting their lifecycle. But all attendees agreed that good data leads to good management of a resource.

Maine fishermen were impressed with how Canada's fishery is doing, however it can take years for a change to an ITQ system to settle out. There is an upfront social cost to transition to ITQ that takes commitment. Changing to limited entry programs (e.g., ITQ) may be difficult but may need to happen to maintain stocks long-term. This relates back to a concern about whether or not there will be 200 struggling businesses in the scallop industry versus 20 successful ones. Choices will need to be made in the industry based on multiple factors.

The idea of sustainability came up as something that needs to be defined by the cultural, conservation, economic, and social goals.

In regards to the industry, a number of issues are similar across countries, governments, and locations. Challenges the Maine fishery faces include dealing with effort and capacity of the fishery. In the end, it was agreed that without knowing for whom you are saving the resource for, it will be difficult to promote sustainability. It was agreed that there needs to be long-term management plans to maintain the resource that takes into account the ecology of the species and our changing climate.

Questions expressed at the end of the summit included:

- How can we apply this new information about connectivity to the Maine inshore fishery?
- What does sustainability really mean?
- Should collaborative research be a condition of access?
- What are the professional opportunities?
- How can the US and Canada improve their stock assessments?

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Appendix 1. Letter of Invitation

Hello Mr/Ms,

On behalf of its steering committee, I would like to invite you to participate in the *US/Canada Scallop Science Summit* that will take place from May 6-8 at the Algonquin Resort in Saint Andrews, New Brunswick.

The goal of this workshop is to increase collaboration and knowledge sharing between scallop fishermen, researchers, managers and aquaculturists in the United States and Canada. We are limiting the workshop to 40 attendees to facilitate active contributions from all participants.

This workshop was funded by the Maine Community Foundation with a specific goal in mind, which is *to enable cross-border collaboration on issues that may increase the sustainability of Maine's scallop fishery*. As a result, discussions at this workshop will focus on inshore scallop fisheries in the Gulf of Maine (including the Bay of Fundy). Discussions will be divided into four general topics: large scale temporal changes and connectivity; strategies for fishery-dependent data collection; aquaculture, sea ranching and enhancement; and long-term sustainability of the Sea Scallop resource. In addition, funding is also being sought through the Canadian Aquaculture Collaboration Development Research Program to support this workshop.

We expect to have roughly equal participation from US and Canadian scientists, fishermen, aquaculturists and managers. On the US side, industry participation will be limited to those who fish Maine state waters or in the Federal General Category fishery in keeping with the inshore focus of the workshop.

We have identified you as someone with knowledge and experience that will enhance discussions and contribute to meaningful results. We also feel that your ability to share those results with stakeholders in your field will help increase the impact of this workshop. A copy of the latest version of the summit outline is attached for your consideration. We hope you are able to attend, and would be grateful for a prompt reply regarding your availability as soon as possible so we may extend the invitation to someone else in your field if you are unavailable.

If you have any questions regarding the summit please don't hesitate to contact me. To RSVP, contact Lynn Wardwell at wardwell@maine.edu. Hotel reservations at the Algonquin resort must be made by April 14, 2014; reference the "Scallop Summit" to get the discounted room rate.

We look forward to seeing you in May!

Regards, Trish

Fisheries and Oceans Canada Pêches et Océans Canada

Canada

Appendix 2. Workshop Agenda

 US & Canada Scallop Science Summit Agenda 

May 6-8, 2014 – The Algonquin Resort, St. Andrews, New Brunswick, Canada

High level aims of the workshop

1. To review and discuss the most recent scientific information relevant to the Sea scallop (*Placopecten magellanicus*) fisheries and aquaculture efforts in the US and Canada.

2. To bring together relevant groups - including scientist, harvesters, and managers to increase coordination and collaboration on potential future scientific research opportunities.

3. To provide an inclusive and participative forum to engage industry in scientific discussions and knowledge sharing. This would include identifying potential opportunities to strengthen and broaden the knowledge base in the scallop fisheries in the Gulf of Maine and Bay of Fundy, as well as aquaculture efforts, and develop research priorities that aim to assist in the goal of profitable, sustainable fisheries that support coastal communities.

This workshop was funded by the Maine Community Foundation with a specific goal in mind, which is to *enable cross-border collaboration on issues that may increase the sustainability of Maine's scallop fishery*. As a result, discussions at this workshop will focus on inshore scallop fisheries in the Gulf of Maine, including the Bay of Fundy and well as aquaculture efforts in the region. Discussions will be divided into four general topics:

- large scale temporal changes and connectivity;
- strategies for fishery-dependent data collection;
- aquaculture, sea ranching and enhancement; and
- long-term sustainability of the Sea Scallop resource.

In addition, funding has also been secured from the Canadian Aquaculture Collaboration Development Research Program to support this workshop.

Day One: Tuesday, May 6, 2014

5:00 – 7:00 Welcome Reception

Day Two: Wednesday, May 7, 2014

8:00 – 9:00 Breakfast & Registration

9:00 – 9:30 Welcome, Introductions of Participants, and Review of Workshop Goals

- *Trisha (Cheney) De Graaf, Maine Department of Marine Resources*

9:30 – 10:15 Atlantic Sea Scallop Fishery Overview

- Stephen Smith – Canadian Key Note
- Trisha (Cheney) De Graaf – US Key Note

An overview of the North Atlantic sea scallop fishery, highlighting factors, trends, and management approaches.

10:15 – 10:30 Coffee Break

SESSION 1: Large-scale Temporal and Spatial Patterns and Connectivity

10:30 – 12:30

MODERATOR: Caitlin Cleaver, Hurricane Island Foundation

PANELISTS:

- Claudio DiBacco 12 minute presentation
- Jon Grabowski 12 minute presentation
- Phil Yund 12 minute presentation
- 20 minute discussion
- 45 minute breakout discussion
- 15 minute session summary

Answering the questions:

What is the full story of temporal and spatial trends in recruitment, growth, and condition? Can we identify ways to undertake cross-border collaboration and exchange that may illuminate the underlying mechanism, and perhaps facilitate prediction? How would we go about assessing both the level of connectivity between inshore and offshore as well as Canadian and US populations and the potential fishery impact? How do we assess where the broodstock are contributing to the fishery - basically, where are the larvae coming from and where are they going? Are broodstock sanctuaries effective? What challenges will sea scallop fisheries face in regards to ecological changes such as temperature, salinity, predator community, bottom scouring/dragging, ocean acidification, etc.?

12:30 – 1:30 Lunch

SESSION 2: Fishery-Dependent Data

1:30 – 3:30

MODERATOR: Carla Guenther, Penobscot East Resource Center

PANELISTS:

- Leslie-Anne Davidson 6 minute presentation
- Trisha (Cheney) De Graaf 6 minute presentation
- Jessica Sameoto 24 minute presentation
- 20 minute discussion
- 45 minute breakout discussion
- 15 minute session summary

Answering the questions:

What is the best way to determine the impact of a fishery on a population? How can this information be used to manage a fishery? How can we advance the use of fishery-dependent data in an environment of dwindling resources? How are different fishery-dependent data types (fishermen's observations, Catch Per Unit Effort, logbooks, landings, life history, etc.) utilized in real-time decision making? What are the most meaningful in-season data collection methods? How are fishermen's knowledge incorporated into survey design? Could in-season data be sufficient to manage a fishery (without pre-season estimates)? Is it more cost-effective to undertake in-season data collection vs. formal fishery-independent surveys?

3:30 –3:45 Coffee Break

3:45 – 4:45 Clarifying Concepts

Small group break-out session:

Large-scale temporal and spatial patterns and connectivity

Fishery-Dependent Data

What questions do you still have? What is still not clear? What would you like more information on? What are the next steps?

4:45 – 5:00 Report Back from Small Groups

6:00 – 8:00 Evening Dinner Reception

Day Three: Thursday, May 8, 2014

8:00 - 9:00 Breakfast

9:00 – 9:20 Synthesis of First Day's Discussions

Trisha (Cheney) De Graaf, Maine Department of Marine Resources

SESSION 3: Aquaculture, Sea Ranching & Enhancement

9:20 – 10:30

MODERATOR: Leslie-Anne Davidson, Fisheries & Oceans Canada

PANELISTS:

- Dana Morse 5 minute presentation
- Nate Perry 5 minute presentation
- Michelle Theriault 5 minute presentation
- Pierre Poitevin 12 minute presentation

20 minute discussion (Step 1)

10:50 – 11:00 Coffee Break

11:00 - 12:00 Aquaculture, Sea Ranching & Enhancement (continued)

45 minute Interview matrix (Step 2 – Appendix 3)

15 minute session summary (Step 3)

Answering the questions:

What are the challenges facing better integration of aquaculture into the overall management? Could stock enhancement and sea ranching provide a natural connection that will help reduce potential skepticism and reluctance among wild fishery harvesters? Where is sea scallop aquaculture being conducted and what are the challenges? Could grow-out sites serve as potential broodstock sanctuaries? Are there ways to use growth and other information to inform management?

12:00 – 1:00 Lunch

Working lunch to bring together all suggestions on research questions and group into themes.

SESSION 4: Sustainable Management of the Sea Scallop Resource

1:00 – 2:45

MODERATOR: Alain d'Entremont

PANELISTS:

- Stephen Smith 12 minute presentation
- Deirdre Boelke 12 minute presentation
- 20 minute discussion
- 45 minute breakout discussion
- 15 minute session summary

Answering the questions:

What are the components of a well-managed fishery? What is each sea scallop fisheries approach to defining reference points? How do you define reference points (or should you even try) when a fishery does not have a formal assessment? What broader indicators can be used in a data poor situation (biological, economic, management)? How do you pragmatically scale management to match resources? What does sustainability mean in the context of a drag and dive based fishery? How is sustainability defined? What are each fisheries goals (maximizing the number of participants or yield)? How is success defined?

2:45 - 3:00 Coffee Break

3:00 - 4:00 Clarifying Concepts

MODERATOR: Carla Guenther, Penobscot East Resource Center

Small group break-out session with themes that evolve at the workshop. What questions do you still have? What is still not clear? What would you like more information on? What are the next steps?

4:00 - 4:20 Report Back from Small Groups

4:20 - 4:50 Open Discussion Identifying Next Steps

- *Carla Guenther, Penobscot East Resource Center*

Discussion regarding identifying potential research collaborations and priorities.

4:50 - 5:00 Concluding Remarks

- *Trisha (Cheney) De Graaf, Maine Department of Marine Resources*

Appendix 3. Attendee List

Canadian Attendees:
Stephen Smith, Fisheries and Oceans Canada, Bedford Institute of Oceanography
Dr. Shawn Robinson, Fisheries and Oceans Canada, St. Andrews
Leslie-Anne Davidson, Fisheries and Oceans Canada, Moncton
Alain d'Entremont, Full Bay Scallop Association
Jessica Sameoto, Fisheries and Oceans Canada, Bedford Institute of Oceanography
Pierre Poitevin, St. Pierre and Miquelon Aquaculturist
Maureen Butler, Fisheries and Oceans Canada, Dartmouth
Mallory Van Wyngaarden, Memorial University of Newfoundland
Doug Bertram, Aquaculture Association of Nova Scotia
Carmen Burnie, Full Bay Scallop Association Fisherman
Melanie Sonnenberg, Grand Manan Fishermen's Association
Tom Robarts, Upper Bay Scallop Association Fisherman
Vance Hazelton, Full Bay Scallop Association Fisherman
Greg Thompson, Fundy North Fishermen's Association Fisherman
Harvey Matthews, Fundy North Fishermen's Association Fisherman
Robert Hines, East of Bacarro Fisherman
Dr. Andrew Cooper, Fisheries and Oceans Canada, St. Andrews
Dr. Michelle Thériault, Université Sainte-Anne
Dr. Vicki Swan, Aquaculture Association of Nova Scotia
*Dr. Claudio DiBacco, Fisheries and Oceans Canada, Bedford Institute of Oceanography (*May 7 only)
*Monique Niles, Fisheries and Oceans Canada, Moncton (*May 8 only)

American Attendees:
Trisha (Cheney) De Graaf, Maine Department of Marine Resources
Dr. Carla Guenther, Penobscot East Resource Center
Dana Morse, Maine Sea Grant
Togue Brawn, Maine Dayboat Scallops
Kevin Kelly, Maine Department of Marine Resources
Dr. Kevin Stokesbury, School of Marine Science and Technology, University of Massachusetts Dartmouth
Deidre Boelke, New England Fishery Management Council
Dr. Phil Yund, Downeast Institute
Alex Todd, Maine State Scallop Drag and US Federal Scallop Fisherman (NGOM)
Mike Murphy II, Maine State Scallop Drag Fisherman
Paul Cox, Maine State Scallop Dive Fisherman
Tad Miller, Maine State Scallop Drag and US Federal Scallop Fisherman (NGOM)
Curtis Haycock, Maine State Scallop Drag Fisherman
Dr. Dvora Hart, New England Fisheries Science Center
Nate Perry, Pine Point Oysters
Dr. Rick Wahle, University of Maine
Dr. Jon Grabowski, Northeastern University

Caitlin Cleaver, Hurricane Island Foundation
Bob Keese, Federal General Category IFQ Scallop Fishermen
Kristan Porter, Maine State Scallop Drag and US Federal Scallop Fisherman (NGOM)

Workshop Support Staff:
Skylar Bayer, University of Maine PhD Student [Rapporteur]
Lynn Wardell, Maine Sea Grant [Workshop Support]

Appendix 4. Updates since May 2014

(1) Mallory Van Wyngaarden; Paul V.R. Snelgrove; Lorraine C. Hamilton; Naiara Rodríguez-Ezpeleta; **Claudio DiBacco**; Ian R. Bradbury

Population structure in the sea scallop, *Placopecten magellanicus*, determined using RADseq

Since May 2014

Following quality control on the previously identified SNP loci we selected 7163 SNPs for further analysis, including identifying loci potentially under selection. Examination of adaptive markers such as SNPs for signatures of selection can provide more detailed and fine-scale information about population structure and differentiation than markers from neutral regions of the genome (i.e., non-coding regions and those not under selection). Loci identified as potentially under selection can also elucidate possible drivers of selection by comparing variation in environmental parameters and genetic differentiation between sample sites.

Using a Bayesian method implemented in the program BayeScan (Foll and Gaggiotti, 2008), we identified 112 loci as potentially under selection (outlier loci). Population structure analysis was completed using three datasets (all 7163 loci, 112 outlier loci, and 7051 neutral loci (non-outlier)) whereas environmental correlations were examined using only the outlier loci.

We used several methods to identify population differentiation and structure among all samples[1]. Analyses revealed a major split between the 4 northern-most (Newfoundland and the Gulf of St. Lawrence) and the 8 southern-most populations, however this split was much more pronounced in outlier loci than in neutral loci. Further analysis of the 4 northern-most populations that examined the outlier and neutral datasets showed different patterns of population structure, indicating that different processes may influence levels of population structuring within the region.

Preliminary results indicate a significant relationship between genetic variation in the outlier loci and environmental variation between sample sites (revealed through principal components analysis on both environmental and genetic variation), and that

[1] Population differentiation was determined using isolation-by-distance (comparison of pairwise geographic and genetic distances) and measures of G_{ST} and F_{ST}. Bayesian clustering using the program Structure (Pritchard et al., 2000), k-means clustering using Principal Components Analysis implemented in the R package *adegenet* (Jombart, 2008), neighbour joining trees based on the Cavalli-Sforza and Edwards chord distance calculated in the program Populations (Langella, 1999), and analysis of molecular variance (AMOVA) were all used to detect population structure.

ocean productivity and temperature may influence genetic variation (revealed through redundancy analysis that contrasted 66 environmental variables with genetic variability).

References:

Foll, M., & Gaggiotti, O. (2008) A Genome-Scan Method to Identify Selected Loci Appropriate for Both Dominant and Codominant Markers: A Bayesian Perspective. Genetics, 180(2), 977-993. doi: 10.1534/genetics.108.092221

Jombart, T. (2008) Adegenet: a R package for the multivariate analysis of genetic markers. [Article]. Bioinformatics (Oxford), 24(11), 1403-1405. doi: 10.1093/bioinformatics/btn129

Langella, O. (1999) Populations 1.2. 30. CNRS UPR9034.

Pritchard, J. K., Stephens, M., and Donnelly, P. (2000) Inference of population structure using multilocus genotype data. Genetics, 155(2), 945-959.

(2) Pierre Poitevin

Research and Development to develop Scallop Aquaculture and Sea Ranching in Saint-Pierre and Miquelon Archipelago

Since May 2014

Scientific actions have been implemented to optimize scallop spat settlement. Moreover, one of the R & D priorities has focused on the characterization of the phytoplanktonic community by species and relative abundance. Regular fluorimetric profiles (within the full water column) and phytoplankton samples have been conducted between June and October, when the water is most stratified. Those measurements will provide additional information to assess carrying capacity in areas nearest to scallop culture sites as well as scallops' diet to establish relationship with overall growth. Upgrading of the video monitoring system was initiated in 2014 aiming to convert to a fully digital system. Further environmental (using sclerochronology and sclerochimistry tools) and behavioral research on areas seeded with scallops are likely to be developed over the next few years.