Alternative and Emerging Species Workshop Proceedings

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Prepared for the Prince Edward Island Aquaculture Alliance

Acknowledgements

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Contents

Introduction

The Alternative and Emerging Species Workshop was hosted by the Prince Edward Island Aquaculture Alliance (PEIAA) and funded by PEIDAF, PEI Atlantic Shrimp Corporation, ACRDP and NRC-IRAP with industry sponsors PEI Aqua Farms and Bouctouche Bay Industries Ltd.

The main goal of the workshop was to inform aquaculturists of opportunities that may exist in the culture of emerging species or in the alternative use of production products or by-products from aquaculture production. Speakers included aquaculturists, product developers, researchers, service providers and potential project funders. Attendees were encouraged to participate and share ideas and experiences. This was accomplished by opening up the floor to questions after each talk and by a scheduled discussion on each of the days facilitated by Peter Warris, R&D Coordinator for the PEIAA. Speakers and participants were actively involved in the question and answer periods as well as the discussion sessions. These proceedings provide a summary of the presentations and discussions.

The workshop explored the opportunities that emerging and alternative species and processes may present to aquaculturists, indicated possible paths forward for new developments and identified challenges that have been or may be faced with their application.

Presenter Biographies

Kyle Pepperman is from Williamsburg, Pennsylvania and graduated from the University of Maine in 2009 with a B.Sc. in Marine Biology. He is currently working at the Down East Institute to raise soft-shell clams for research, outreach, and stock enhancement purposes. In addition, he is responsible for the hatchery work on blue mussel broodstock conditioning, larval-rearing, and post-larval production associated with a project funded through the National Science Foundation and the University of Maine System.

Steve Backman is President of Magellan Aqua Farms, based in St Stephen, NB. A family farm producing giant scallops and Sugar Kelp since 2003, their motto is: "Your Natural Choice for Sustainable Seafood". He is also an Aquaculture Veterinarian with Skretting North America and has worked for them under several different titles since 1988. A licensed Veterinarian, he studied at Nova Scotia Agricultural College and at the University of Guelph, in Ontario where he earned his DVM and where he subsequently completed his internship in Anatomical Pathology. In his spare time, he is involved in a number of community organizations and has been the President of the Charlotte County Hospital Foundation board of Trustees for the past 11 years.

Peter Warris has been the R&D Coordinator with the PEIAA since 2006. Peter has an M. Sc. in Shellfish Biology, Fisheries & Aquaculture, University of Wales, School of Ocean Sciences and a B. Sc. (Hons) Biological Sciences, University of Plymouth. In his role as R&D Coordinator, he is responsible for the coordination of all R&D related activities within the association, including communication of industry priorities, project development, project management, workshops and missions.

Patrice Dionne joined innoVactiv in 2004 as Director of Business Development, before becoming its Chief Executive Officer in 2007. His passion at innoVactiv is to provide clients of the dietary supplement and cosmetic industries, science-based specialty ingredients that will make their products stand out from the competition and make a difference in improving and maintaining people's wellbeing. He holds a Bachelor degree in Economics and a Master degree in Agricultural Economics, both from Laval University.

Patrick Gagnon is an Associate Professor of marine biology and ecology at the Department of Ocean Sciences of Memorial University of Newfoundland where he runs the Cold Ocean Benthic Ecology Lab. His current research is on the kelp and rhodolith beds in Newfoundland

and Labrador. He has over 20 years of experience researching various aspects of the biology and ecology of the green sea urchin across eastern Canada. Over the last two years, he has created research partnerships with international, national, and provincial industry members to examine various approaches to consistent urchin roe production that could help establish the foundation of an urchin farming industry in Newfoundland and Labrador.

Chris Mills, is currently Acting Chief of the Aquaculture Leasing Division at the PEI office in Charlottetown, has been involved in aquaculture in some respect since 1990. He received a BSc in Marine Biology from Dalhousie in 1993 and a Masters in Aquaculture from Simon Fraser University in 1995. For 7 years he worked in the industry growing trout in Idaho and salmon in New Brunswick. Then 9 years with the province of PEI aquaculture division doing industry development related work. For the past 6 years he has been with DFO in various roles.

Mike Randall is the Executive Director of Lennox Island Development Corporation and Director of Economic Development for Lennox Island First Nation. The aquaculture portfolio of the Development Corp consist of the Bideford Shellfish Hatchery and Bideford River Biological Centre.

André Mallet has been working in shellfish aquaculture for the past 35 years. In 1982, he completed his PhD in Marine Biology with a specialty in the quantitative genetics of the Eastern oyster. With more than 50 publications in the primary literature, he has remained very active in the scientific field. Since 1996, he has been the president of the shellfish company L'Etang Ruisseau Bar Ltd located in northern New Brunswick which produces hatchery seed and market-sized Eastern oysters and bay scallops.

Dr. Gerry Johnson is the Director of Science at Halibut PEI and is integrally involved in all aspects the daily operations of their facility in Victoria and responsible for the design and coordination of new research and development projects. Dr. Johnson is a Veterinary Pathologist and Professor Emeritus at the University of Prince Edward Island. He has three decades of experience specializing in farmed fish health and production problem solving.

Lea Murphy retired from DFO eleven years ago where he was involved in several areas; aquaculture development, environmental Risk Assessments, Watershed Planning, and leadership in community based Planning Initiatives. Following retirement, he has continued to be involved

in the mussel culture and processing industry working with Prince Edward Aqua Farms and Coles Mussel Farms on several projects.

Anke Krutof received her B.Sc. in process engineering and her M.Sc. in chemical engineering from Mannheim University of Applied Sciences, Germany. After visiting Memorial University at the end of her master's thesis, Anke came back to St. John's to continue her education in the field of renewable fuels. She is now in her third year doing a PhD in Process Engineering. Her research is focused on the production and optimization of liquid fuel from wood. As well as her studies she is engaged with Women in Science and Engineering (WISE NL GSS) and the graduate student's union financial committee.

Allan Dale is a retired Naval Officer who served in the Royal Canadian Navy for three decades. On retirement from service, he worked in the Defence/ Engineering Industry and now at the School of Sustainable Design Engineering connecting industry partners to the School's innovative program.

Joy Shinn has spent her career supporting the food sector providing technical resources and strategic management. Currently she is a Food Scientist & Business Development Manager at BioFoodTech. Joy has previously worked with the Food Centre (SK), PEI Food Trust, PEI Preserve Company and her own artisan vinegar business. From this, she has gained extensive knowledge of innovation with much hands-on success commercializing value-added products. Joy has also held key leadership roles with food organizations including FOODTECH Canada, the PEI Food & Beverage Processors Association and the PEI Healthy Eating Alliance.

As Executive Director of Canada's Smartest Kitchen, **Peter Crooks**, brings his extensive entrepreneurial, business and product development experience to the team that has been put together to support three key pillars of CSK's innovation platform - culinary arts, food science and market insight. Prior to joining CSK in 2012, Peter worked for the National Research Council's Institute for Nutrisciences and Health where he was responsible for business development and commercialization of natural health products and functional ingredients.

Shane MacDougall is the Director of Business Development and Innovation with Innovation PEI. Innovation PEI is the lead provincial economic development arm of the provincial government and works to develop a more prosperous and vibrant economy through new business

start-ups, innovation and expanded export markets. Prior to coming to Innovation PEI 4 years ago, Shane was the General Manager of Central Development Corporation, a Regional Economic Development Organization based in the central region of PEI. In his current role Shane oversees the implementation of IPEIs Innovation programming.

Aaron Ramsay has been a Shellfish Biologist with the PEI Aquaculture Division since 2009. He completed his BSc in Environmental Science at Mount Allison University in 2003 and received a MSc in Shellfish Health from the Atlantic Veterinary College in 2008. The focus of his MSc was vase tunicate reproduction and mitigation strategies on mussel farms. In the last few years Aaron's work has been closely associated with mussel production and productivity. He is also responsible for the Aquaculture Technology Program.

Denise Lang started at DFO last September as manager for the delivery of the newly launched Atlantic Fisheries Fund (AFF) for the Provinces of NB and PEI. Denise has 16 years of experience with ACOA where she occupied varies positions in the direct delivery of programs to commercial and community organizations. Before that, Denise worked in the banking sector for number of years. Denise is based out of the DFO Gulf Region office in Moncton. The first and newest addition to her team is Stephen Lewis, who will be located in the DFO area office in Charlottetown to work with AFF clients in PEI. Stephen also has several years of experience in program delivery with the provincial PEI government.

Heath Coles is a Deputy Director with the Atlantic Regional Office of Agriculture and Agri-Food Canada, based in Charlottetown. One of the roles of the Atlantic Regional Office is to provide export market development services to the agriculture and food sector, including aquaculture, fish and seafood. He has worked with Agriculture and Agri-Food Canada in a variety of roles since 1992. Prior to that he worked with the PEI Department of Agriculture for five years with the West Prince and Charlottetown District Offices.

Tom O'Rourke has been an Industrial Technology Advisor with National Research Council stretching back to the early days of mussel culture on PEI, and has assisted companies technology development in aquaculture for the past 31 years. He is a graduate of the University of Prince Edward Island in Marine Biology and specializes in food (fish) processing, aquaculture development and natural product development. He is located at the BioFoodTech where he assists biotechnology, food, agriculture, and aquaculture producers develop appropriate technologies.

Presentation Summaries

Soft-shell clam culture in Eastern Maine, USA

Kyle Pepperman, Brian Beal, Justin Lewis, Ben Ellis, Cody Joudet

Presented by: Kyle Pepperman, Aquaculture Production and Research Assistant, Down East Institute
(kyle.pepperman@maine.edu)

The Down East Institute is located in Washington County in far eastern Maine, USA. It is the most eastern based research station and is associated with the University of Maine at Machias. It is a non-profit organization with the goal "to improve the quality of life for the people of down east and coastal Maine through marine research marine science education, and innovations in wild and cultured fisheries". Workshop participants are invited to visit the facilities. These are under development as the facilities expand to three times their current size. The new facilities are expected to open in 2018. As well as other additions, the expansion will allow a doubling of the algae production capacity with the addition of LED lighting and bioreactors to increase capacity to 800 gallons per day.

Some of the work that we have conducted at our facility includes a broodstock selection program that has been underway for softshell clams for the past 17 years. This program has used mass selection: picking the fastest growing clams for breeding. We saw immediate results with this selection program and are now on the third generation (F_3) which is showing 12% faster growth than the wild population. This is slightly suppressed from the F_2 generation which showed 18% faster growth than the wild population. We are now switching to family paired selection.

Hatchery grown clams are easy to identify in the wild because they carry a distinct mark on their shell that represents their growth in the hatchery. This mark can be seen for their entire lives.

The clam production process begins with a 30 to 40 day thermal conditioning period in February when the clams are fed cultured algae. In mid-March the clams can be induced to spawn. 24 hours after fertilization, trocophore larvae can be observed. These develop into D-veliger larvae at 48 hours and carry on with growth and development. At one month, the clams are ready to settle and are exposed to PET screening upon which they settle. They are then moved to the ocean in floating nursery trays.

Our location is too cold for the use of upwellers at the nursery phase since the ocean water temperature does not get above 15 °C. However, the trays will create a microclimate which will get above 24°C. (In Freeport the clams were kept in upwellers at 25°C for the nursery phase. In this system, they achieved a size of 25mm by the end of July.)

It takes minimal work to maintain the trays and the clams will grow to an average size of 14mm by November. At this time, they are moved on land for over-wintering. If this is not done, ice scouring will kill the small clams. For over-wintering the clams are stored below 8°C so that they go dormant.

The main predator of the clams is the green crab. These become less of a problem when the clams achieve a size of 25mm. Another predator is the milky worm. These prey on the clams after 25mm in size and there is no defense against them. Moon snails also prey on the clams. There are two species present in Maine. Their presence in an area is evidenced by their egg casts so that areas with these should be avoided for clam seeding.

Predator exclusion netting is effective against green crabs. This netting is a 4.2 mm mesh size and is kept off the bottom with five spacers placed in a pattern like the dots on a die. The sites for using this netting have to be chosen carefully to ensure that the nets will not be prone to fouling. Crabs may still get under the nets but these may be removed manually.

We have been working on stock enhancement with several communities, including the communities of Addison and Pembroke. At these sites, we have demonstration plots that are 4m X 4m square. Each of the plots was seeded with 5000 clams. One in five of the plots had no predator exclusion netting to demonstrate the effectiveness of this netting.

Plots were assembled and seeded in May and were sampled in November using a handmade coffee can sampler that extracted a consistent core of mud. We used 5 cores per sample and took 25 samples in un-netted plots and 25 samples in netted plots. Survival in netted plots proved to be 94% at the Pembroke site (unusually high), and 54% at the Addison site, while survival in the un-netted plots was virtually nil, clearly demonstrating the effectiveness of the netting on improving survival. Growth was very good at both sites with the clams achieving a final mean length of 36.6mm and 33.5mm at the Addison and Pembroke sites, respectively. There was also recruitment of natural set at both sites with Pembroke natural set densities reaching 99.8 clams/ft^2 in the netted plots. The netting was also effective at enhancing natural recruitment.

Clams are worth more the larger they get. A quick review of the economics of clam culture suggests that the prime size for harvest is 65mm where even at low survival, a good return is yielded. The actual time to harvest is something that needs to be determined on a site specific basis to ensure best return for investment.

Best growing areas can be identified by using a simple sentinel pot technique. To do this, pots are filled with mud and 12 hatchery clams are added to each pot and sunk into the mud. They are then left from April to November when they can be sampled for growth and survival. This technique has been trialed and has been able to demonstrate site differences in survival and growth as well as natural recruitment. Similar work can be done for assessing the potential for enhancement of other species of clams and quahogs.

Question and Answer:

André Mallet: What is the price of the seed? And is that fall or spring (overwintered) price?
Kyle Pepperman: Spring price is $2.50 for 1000 of >8mm (average 14mm) juvenile clams. Generally the smaller the seed, the cheaper the price.

Johnny Flynn: Have you seen any problems with neoplasia?
Kyle Pepperman: There is some indication of lower incidence in hatchery reared clams but this is an ongoing study.
Johnny Flynn: Does neoplasia pass through the water?
Kyle Pepperman: We think it is a result of stress.

Unknown: How much movement have you seen of the green crab north?
Kyle Pepperman: We are seeing very fast movement north and a great increase in population growth over the past 60 years. There is another invasion coming south and the southern and northern populations are crossing to create a "super crab". These hybrids are less susceptible to cold weather.

Peter Warris: Why have you started doing the enhancement work?
Kyle Pepperman: In 1984, we saw a dramatic decrease in landings. We are currently at only 25% of what we were. This is partly due to green crabs. We are seeing low stock numbers but very high market prices (up to $4/lb – previously was $0.75/lb).

Magellan Aqua Farms

Steve Backman, President, Magellan Aqua Farms
(sbackman@nb.aibn.com)

Magellan Aqua Farms has been farming scallops since 2003 and began trialing sea vegetables and an IMTA addition over the past three years. It is interesting to point out that both scallops and seaweeds have been touted as having great potential for aquaculture for more than 30 years. And yet we have not come very far with them.

Magellan Aqua Farms is a family farm located on the north end of Passamaquaoddy Bay. This area experiences extremely high tides and this affects how we manage our gear. An advantage is that we have no ice to deal with. Our most significant concerns are fouling, predators (including starfish, polydores, and people), labor (high level of physical labor which is not appealing for the younger generations) and a general lack of support. Our industry is dominated by salmon aquaculture and there is little support for other species. We are one of only two scallop farmers in the Bay of Fundy.

The farm is licensed for several species including scallops, mussels, sea urchins, and kelp. Kelp species include *Palmaria sp., Saccharina sp.,* and *Alaria sp.*

The first question to ask is why we chose scallops? The culture techniques are undeveloped and there is a vibrant wild harvest. This is the opposite of where you would normally go in choosing a species to culture. However, if you look at the landings of scallops over the past decades they fluctuate a lot. Buyers, retailers, and consumers don't like this lack of consistency in the market place and farming scallops can flatten out these curves. This creates new market opportunities. In addition, price trends show a steady increase over the past 15 years with prices in 2016 reaching CDN $20/lb. Our production model in 2003 was based on a price of $7/lb.

Scallops spawn naturally in late summer when food sources are typically high for the seed. We put our collectors out in late August. For the past 10 years we had good numbers; however in 2015 spat settlement decreased sharply and has been zero for the past two years. This demonstrated how much the security of spat supply is a risk. We are not sure why this occurred –it may be due to climate change or a temporary issue. It does highlight the fact that for an industry to develop there needs to be a consistent supply of juveniles so we need to develop a hatchery. One option with a fledgling industry would be to develop a regional shellfish hatchery to supply multiple species of shellfish and maintain broodstock programs for trait enhancement.

In year 1, the scallops are placed in 9mm lantern nets. This is the only size net that is available and may be too small for optimum culture. We stock at 30 to 40 per net layer. At this stage we expect 20% mortality. This can be due to fouling, tunicates and predation by starfish. A lot of time is spent removing starfish from the nets as they are very adaptive to finding ways in. The spat is sorted using a homemade sorting table since there is no commercially available equipment for this. The ten level lanterns are deployed in May/June when the scallops are 30 to 40 mm in size. They are submerged about 5m below the surface. The intent is to minimize any movement caused by wave action as scallops are very susceptible to stress. To maintain tension, and therefore minimize movement with the 9m tidal range, it is important the mooring lines are provided a lot of scope. Maintaining submerged long lines also has the advantage of making them harder to steal.

In year 2, the scallops are cleaned and graded and the density is decreased to 15 to 20 per layer. We use 9 or 18mm mesh circular lantern nets. The 18mm nets are less prone to fouling but are hard to source. We keep densities low to reduce handling and to reduce the chance that the scallops will move and scissor one another. We can harvest these as a small grade for use in chowders in Canada. But this size cannot be sold in the US since they are undersized.

In this second year, we expect additional 10-15% mortality and the scallops are more at risk from poachers. Fouling with tunicates and mussels is an issue. Starfish and Polydora can also be a problem. We have used urchins to eliminate the Polydora, and they are effective against some of the fouling as well.

In the final year, we harvest the medium grade scallops and direct market to restaurants and farmers markets. Some may be on-grown for a third year to get a large grade. The shells are cleaned at harvest. Shells are also returned to the area after harvest as an attempt to buffer possible ocean acidification.

The biggest expense in scallop culture is the annual maintenance. The tides require the tightening of lines and other maintenance.

We have completed a number of in house R&D projects. In particular, we have looked at bag/cage innovations and IMTA. Some of our cage innovation attempts have resulted in some pretty complicated and heavy equipment which is difficult to manage. One of our cage designs used a discarded salmon cage bird net stand as a frame. This was used as a large cage. We found that this fouled less than the smaller lantern and round nets we were using, and urchins kept the mesh quite clean, Also we found predation by starfish to be less of a problem and we think it was because the scallops had space to swim away from the starfish. Cost of production in the large cage was about half of our cost of production in the lantern nets, at $0.67/piece versus $1.19/piece respectively.

Main constraints to scallop aquaculture have been site access, access to technical support, achieving a critical mass for the industry to have credibility, availability of equipment and consistency of spat supply.

Question and Answer:

Patrick Gagnon: You mentioned the decline in recruitment of spat. Is the population in the area being monitored to see if its levels are affecting spatfall?

Steve Backman: No. Collection has been high for the past 10 years so we have not looked at it. Not sure if this is extending to wild stocks. Shawn Robinson at the Biological Station is looking at his information on this too and thinks he also sees les recruitment, We don't know if this is temporary or not. We have seen high temperatures (22°C) which may be affecting spatfall.

Jimmy A'Hearn: What type of collectors are you using?
Steve Backman: Onion bags with Netron inside.

Andre Mallet: You mentioned you are harvesting seed at 28mm. How old is this?
Steve Backman: This is seed that has been in the collector for one year.
Andre Mallet: Can you clarify the cycle then?
Steve: One year in collector, plus two years to reach small to medium grade, plus one year to large grade (6" to 7" shell diameter).

Starfish: a new opportunity for mussel growers and a new source of innovative marine bioactive molecules

Patrice Dionne, Chief Executive officer, innoVactiv inc.
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Starfish is a well-known predator of mussels for aquaculture operations so there are many efforts towards trying to control them. Some of these have included a starfish mop, dredge, various traps, fences, use of brine dips and liming. Most of these have been found to be inefficient or have undesirable environmental impacts.

At innoVactiv, we are hoping to turn a problem into an opportunity. Since 2004, we have developed many specialty ingredients from the marine environment for use in the cosmetic and dietary supplement industries. We got interested in starfish mainly due to its well-known regeneration ability (re-growth of lost limbs). This suggested a possible use in the cosmetic industry for anti-aging products.

The early phases of our work included sampling of various starfish species and the finding of in vitro activity in the coelomic fluid of *Asteria vulgaris*. But could this ability be made into a cost effective and viable cosmetic ingredient?

Signs of aging in the skin are associated with a reduction in Type III and Type IV collagens in the skin layers. Retinol is the cosmetic industry gold standard to reducing such aging effects. It has been demonstrated to reduce the signs of intrinsic aging and allow repair of photo-damaged skin. However, there are also recognized negative side effects with its use including peeling, dryness, erythema and irritation of the skin. The question was could starfish coelomic fluid replace and/or outperform Retinol with no adverse side effects?

The fluid was stabilized and formed into a product called Juventide which was then tested on skin explants. Results were very positive with improved epidermis thickness and increased presence of Type III and Type IV collagen. Human trials using Juventide showed similar positive results. Wrinkle depth, volume and width were reduced with its application. Skin firmness, elasticity were improved and hydration was improved with its application.

We analyzed Juventide to try to determine its active components but found that once fractionated, the positive effects disappeared. The components of the coelomic fluid seem to work together.

In order to produce a premium quality ingredient for the cosmetic industry, your product must have several attributes:

- Be supported by research,
- Have a strong safety profile,
- Be produced using Good Manufacturing Practices,

- Have a secure, documented and traceable chain of custody, and
- Have good supply reliability.

This last point was the biggest question for the supply of the starfish coelomic fluid – ensuring reliable sourcing. There is no commercial starfish fishery in Canada so we thought it may be necessary to go where their prey is which means going where the mussels are, i.e. PEI.

A preliminary supply chain was established in 2008/9 through partnerships with Stephen Stewart for the sourcing of starfish and the Nova Scotia Agricultural College for the development of an extraction line. The ramp up was slower than expected. This was mainly because starfish are considered "animals", and it was necessary to ensure the extraction was not harmful to the animals, and they could be returned to the ocean.

There has been a commercial breakthrough in Asia (China) where a strong demand for growth is increasing the need for coelomic fluid.

The process for collection is simple, gentle on the animals and respects the marine ecosystem. It includes the harvesting of the starfish, their transportation to the extraction site, coelomic fluid collection then reintroduction of the starfish to the environment. A high traceability of the supply process is necessary as well as assurance of high quality methods. This is assured through a QA/QC process.

At the farm level, we form partnerships with mussel growers for starfish harvesting. Only starfish >5" in size are collected from the mussel lines and put in saltwater tanks on the collection vessel. They are then transported to shore where a proprietary portable and mobile coelomic fluid extraction line has been set up. Fluid is collected into a trough as it drips out of the starfish. It is then frozen for storage until use. The starfish are returned to the ocean.

The most recent starfish harvest collected over 5000 at a price of $0.65 a piece paid to the mussel growers. The next harvests are planned for spring and fall of 2018. Eventually we hope to achieve a harvest scale of 100,000 pieces to fulfill short term needs. There is potential for this need to increase if we look at the demand for comparable ingredients (e.g. snail slime).

For the future, we see this as being a win/win partnership with the shellfish industry. It can be implemented easily by producers and presents the opportunity to generate revenue from a pest species. Harvesting will require adherence to strict SOPS and the assurance that the animals are returned alive to the ocean.

Question & Answer:

Isabelle Tremblay: How many starfish would be required to make harvest worth a visit by the mobile fluid collector?

Stephen Stewart: We can process 3000/day. The starfish should be stocked in the harvest tanks at 500/mussel (X-actic) tote. For us to go to Nova Scotia, we'd want to have 3 day's supply to make it worthwhile. We collect about 10ml of coelomic fluid per starfish.

Patrick Gagnon: Do you know what the active molecules are?
Patrice Dionne: There are actually a number of active families of molecules (saponins) which have not been fully characterized. What we know for sure is when we tried to fractionate the coelomic fluid, we lost the biological activity.

Patrick Gagnon: If you cannot characterize it, will there be regulatory issues
Patrice Dionne: Not in the cosmetics industry.

Unknown: Will more coelomic fluid or more effective coelomic fluid be produced if the animal is injured?
Patrice Dionne: We do not think so. We collect quickly so that there is probably not enough time to elicit new metabolites in the fluid.

Kyle Pepperman: Is it up to the farmer to return the starfish? Can they return them somewhere away from their site?
Patrice Dionne: Yes, but as long as the starfish are returned to their natural habitat.

Green sea urchin farming in eastern Canada: creating opportunity with advanced feed technology

Patrick Gagnon, Associate Professor, Memorial University
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In Newfoundland, the green sea urchin fishery was slow to develop. Although it started in the 60's, it did not really begin to advance until the 1990's when the cod moratorium came into place. At this time it grew substantially, reaching a peak in 2003 of 1.9 million pounds. After that date, catches decreased until 2009 when catches began to rise again. Part of the reason for the rebound of the fishery was new regulation to standardize the price for the gonad.

There are challenges to the harvesting of wild sea urchins which include the harsh environmental conditions in the areas and seasons for fishing (for best product quality), the non-traditional harvesting methods that are necessary, and the difficult logistics of ensuring that the product makes it to the market (Japan) from rural Newfoundland in a very short time frame to preserve the quality.

Most product goes to Japanese markets where the desired gonad index (GI = gonad wet weight divided by the whole body weight expressed as a percent) is 10 to 15%. This is where you typically get the best texture, taste, and colour of the gonad, all of which determines the value of

the product. Typically if the GI is higher, the gonad suffers from texture issues. If the GI is lower, it typically suffers from taste issues. The ideal texture is firm with two distinct gonads. The ideal colour is bright yellow to orange and the ideal taste is sweet. Previous trials using formulated diets have resulted in taste issues while those using natural diets have resulted in low GI and borderline colour acceptability.

Nofima has developed a formulated feed that has attempted to overcome the roe quality issues that typically result from feeding urchins a formulated diet. The feed has been in development for more than 15 years, has been tested in Norway, New Zealand Australia, USA and Japan and has been used commercially in Japan for more than 10 years. Mitsubishi is a collaborator on the feed development. In Canada, the feed is being tested on the local sea urchin (green sea urchin) with a private company: Urchinomics.

The commercial partner for the feed testing conducted at Memorial University is Green Seafoods where trials are being conducted under an NSERC Engage grant. This project's goal is "to assess the performance of the formulated feed at contrasting stages of gonad production and its relationship with the thermal environment for land-based production of green sea urchin roe at Green Seafoods Ltd".

Within this project, four and eight week trials were conducted using urchins pre and post spawning at three different temperatures. Ten tanks were run at three different temperatures: ambient (ca. 1°C), 3°C, and 6°C) for each of two experiments: one using pre-spawn, the other using post spawn urchins. Twenty urchins of 45 to 55 mm diameter collected from the barrens (with a known low GI) were stocked per tank. These were fed ad libitum. Feed consumption, fecal production, roe yield and quality were monitored. For all experiments, feed consumption and fecal production increased with temperature.

Feed consumption and fecal production were particularly high for the post spawning urchins during weeks 5 to 8 of the experiments suggesting that a few weeks adjustment period was necessary for the urchins to reach steady state. Fecal production was correlated with feed production rate. More efficient feed processing (less feces/food fed) occurred in post spawning urchins suggesting a better food conversion for these animals.

Optimum GI was achieved at 4 weeks at 6°C. GI was higher than optimum (>15%) at 8 weeks. This suggested that you only need 4-6 weeks at 6°C to get the optimum GI. Control urchins that were left in the field, by contrast, had a GI of around 5% or less.

Roe quality was assessed using a taste test by 24 volunteers who rated the roe on preference and flavor. The urchins collected from the field rated highest for preference and flavor relative to the urchins grown using the formulated diet - with the urchins grown at 6°C rated the lowest. Colour of the roe was variable in the field collected urchins, and those from the experiments kept at ambient temperature. Urchins kept at 3°C had better colour and those kept at 6°C had the best colour and lowest variation in colour.

Several key outcomes from the experiment were that:

- It takes 4 to 5 weeks to "bulk up" the roe to the optimum level in a holding system (at 6°C).
- It takes 2-3 weeks for the urchins to adapt to the holding system.
- The colour and taste of the roe using this system and this diet still need some work.

Next steps include keeping urchins in a new raceway style holding system and trialing three new feed formulations. It is also necessary to see if we can achieve similar results in the field, assess handling and transportation stress on the urchins and complete a feasibility study to determine if techniques used to enhance urchin roe are a good fit for rural Newfoundland.

Question & Answer:

Steve Backman: Do you know what the FCR is so that you can assess the cost?
Patrick Gagnon: No but we have the data to do it. First we want to optimize the feed.

Jimmy A'Hearn: Will the urchins survive on sea lettuce?
Patrick Gagnon: Likely, but that diet may not sustain gonad production. Urchins are generally not found associated with sea lettuce.

Cultivating sea vegetables. Are we there yet?

Steve Backman, President, Magellan Aqua Farms
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Globally there is a lot of interest in producing kelp. No land and fresh water are required and the vegan industry looking for plant based protein sources is growing. Carrageenan, an alginate naturally occurring in kelp, has received a lot of attention lately with some groups concerned about its presence in food products. This concern has grown to the extent that many top vegan brands of milk remove it. The validity of the health concerns regarding carrageenan is questionable.

For Magellan Aqua Farms, it is our third year producing kelp. It is produced on the infrastructure used for scallops so that there is minimal increase in cost. We grow two species: *Saccharina latissimi* and *Alaria esculanta.* To produce these species, the gametes are fertilized in the lab and allowed to settle on braided polyester twine wrapped around a PVC core. In the field, a 3/8 inch rope is passed through the center of the core and the free end of the seeded twine is tied to the rope. As the rope is pulled through the core the seeded line wraps around the rope which is then attached to the tension buoy lines of the scallop long line backbone. The optimum depth of the line is close enough to the surface to be within the photosynthetic zone but below any fresh water surface influences. Depths of 3m to 10 m have been attempted but growth was reduced below 5m. Optimum depth is likely site dependent.

The market for the products is developing. Our aquaculture industry is currently geared toward one species, one process, one product. We need to change our perspective and move towards multiple species and processes with many product streams.

Brown seaweeds have recognized value for nutrition. They have been deemed a "super –food" and their use has been associated with a variety of positive health attributes. Some founded, some unfounded. They do have a substantially higher nutrient content compared to many land vegetables.

Seaweed is prepared in many different dishes internationally. A range of products occurs in the artisanal market (inclusion in chocolates, shakes, oils, dips, spices, etc.) but we would like to get it into mainstream. Seaweeds are recognized for their potential for human consumption, cosmetics, fishmeal substitution, and for their contribution to eco-certified foods. (E.g. sea weed production can be certified organic and can be used as biochar for aquaponics.) Magellan Farms partners with local companies for its product distribution but sees tremendous potential for expansion.

Constraints to the seaweed industry include a poor understanding of the market, a lack of distribution channels, no road map to market access, a lack of supply channels, a sluggish regulatory framework, and restrictions due to the seasonality of the product (product must be harvested within a month or it will lose its quality as it becomes reproductively active).

For thirty years, the potential for seaweeds have been recognized but it has never been realized. Seaweeds need to be recognized as a safe, nutritious food for Canadians. For that to happen there needs to be regulatory support.

Question & Answer:

Isabelle Tremblay: You want to expand, why not deploy more lines and increase efficiencies?
Steve Backman: We can use existing infrastructure so it is easy to ramp up production. The hatchery phase may be a question – who will produce the spools of seeded line. The harvesting is easy too but the constraint is what happens after harvest. There are currently processing constraints. We are trying a modified tobacco kiln to develop a process.

Unknown: Can the spools be re-used?
Steve Backman: The PVC Spools are reusable. The polyester twine is not, however the ropes are. The species of sea vegetable we grow does not grow back after harvest.

Unknown: Will the line get really fouled if it is re-used?
Steve Backman: After harvest, the ropes are cleaned and dried before re-use. If we put the ropes out too late or too early, we will get overgrowth with biofouling. We've tried different times for deployment and there is an optimum.

Unknown: What is the yield per acre?

Steve Backman: Hard to estimate by surface area but for *Saccharina,* average about 20 Kg per running meter of line and for *Alaria,* about 10 Kg

Unknown: What depth is required?
Steve Backman: I wouldn't go below 3m. You need light for growth. But you also have to be beneath the fresh water. If you have fresh water around, you want to avoid the surface and make sure you are below the fresh water lens, again very site specific.

André Mallet: Is seaweed culture possible for PEI with its ice cover?
Steve Backman: You could sink your lines below the ice. You may get sufficient light through the ice.
Isabelle Tremblay: It is grown under ice in Québec.
Steve Backman: It depends on the clarity of the water. You can go deeper in clearer water.

Facilitated Discussion 1: Emerging species

Question to the audience: Within the presentations heard from so far, what questions do you have, what has interested you the most and what potential do you see? What are some barriers to development of emerging species aquaculture? Are there constraints that can be addressed through research or other initiatives?

(Audience given 10 minutes to come up with 1 to 2 questions to help move these topics forward.)

Table 1 (Producers):

- Clams are of interest. We get good clams but they die around August. Will this reduce if we put screening over sand?
    - It seems that location is very important to determine if enhancement will be effective. Use of pilot surveys was described earlier (by Kyle Pepperman). These pilot surveys may be used to assess suitability of location for other species as well.
- Starfish potential is interesting.
- Kelp is also interesting but we may need more water depth.
    - This may be dependent on the species. If there is no fresh water, the kelp can be grown at the surface. You want to be above 28ppt.

Table 2 (PEIDAF)

- We are examining what barriers exist to development.
- Testing soft shell clam potential is interesting. Interested to look into predator exclusion netting and the cost for this.
- For sea scallops, we are concerned about hatchery seed, ice and fouling.

- For urchins, how would they do on just kelp? What are the optimum temperatures?
- For seaweed: It is interesting that we could make use of existing infrastructure. How will ice cover affect production? There are marketing issues.
- (Added later) The bar clam is also a species of interest. There used to be problems in the hatchery in getting from larvae to the set stage. This may still be an obstacle or may have been resolved since we were in the hatchery business. Once set they are nearly indestructible and grow to "butter clam" stage quickly and are a wonderful product.

Table 3:

- Access to seed is a concern, including for seaweed.
- Clams showed the most promise but there is no hatchery for them. Have people tried this before?

Table 4:

- Licensing and regulations are the biggest questions.
- Seed supply for clams is a constraint. We need an active, reliable hatchery and funding for such ventures. A lot of potential here.

Leasing Policy and Regulatory Considerations for New Species

Chris Mills, Acting Chief of Aquaculture Leasing Division, DFO
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There are three main areas where regulatory regimes administered by DFO come into play for new species. These are:

- Introduction and transfer licence,
- Fish health considerations, and
- Leasing authority.

DFO is the authority within the introductions and transfers (I&T) process under Part VIII Fisheries (General) Regulations pertaining to release of live fish into fish habitat and transfer of live fish to a fish rearing facility. Under Section 56 of these regulations, DFO has three areas of interest that are: the proper management and control of fisheries, fish health, and genetics. DFO's national I&T policy was renewed in 2013 to accommodate changes in fish health management responsibilities. The Policy outlines how each provincial I&T committee will operate, what they must consider and the framework of how to consider it. The new policy also provides a decision making framework for I&T requests and includes a risk assessment process that would be required for the introduction of a non-native or exotic species. This assessment

would determine the risks associated with the establishment of the introduced species on native species. The risk level would be assessed according to probability and consequence. Each of these would be rated high, medium or low. The certainty of risk is reflective of the level of demonstrated knowledge (i.e. research and common knowledge). It would be rated very uncertain, relatively uncertain, relatively certain or very certain. The final risk level attributed to the request would be the highest risk level combined with the lowest certainty rating. An acceptable risk for applications would be low but there could be mitigatable actions that could reduce a risk assessed at medium to be reduced to low and therefore be acceptable.

Fish health considerations have met with change in management at the national level. CFIA has become the new lead national agency on fish health under this program and has created a domestic and import program under the National Aquatic Animal Health Program that is independent of the I&T program. While there is some coordination regarding licence issuance between the I&T and NAAHP, the NAAHP is independent of the I&T process. They have their own lists of reportable and notifiable diseases and zones for disease presence. In addition (for finfish only currently) a new Atlantic Provinces Program linked to the I&T programs requires an Atlantic Fish Health Certificate of Transfer. This was developed by the Atlantic Provinces to manage production diseases for commercial aquaculture facilities. The program has been incorporated into the National I&T Code and is used by the Atlantic I&T committees as part or all of the fish health portion of the program. DFO uses the COHFT as the fish health "check off" for finfish transfers.

In terms of leasing authority, PEI has a unique regulatory environment. There is a Federal/Provincial MOU where the province has delegated authority to DFO for the issuance of leases for provincial land. The province has no aquaculture specific act or regulations and aspects that would normally be covered under such frameworks in other jurisdictions are covered by lease contracts. These can include such things as fees, site maintenance requirements, site utilization, requirement to comply with the Fisheries Act, Navigation Protection Act, etc.. The PEI Shellfish Aquaculture Leasing Policy provides operational guidance. This policy allows multiple species on one lease. An application must include a site development plan (spatial development plan) as well as a production plan. It is evident that for seaweed culture, some flexibility will be required for the spatial development plan if existing shellfish infrastructure will be use to provide the lines for seaweed growth (i.e. a specific section of the lease would not be designated for the culture of seaweed, the space would overlap with other species).
With regards to land-based operations, DFO has no authority to issues licences or other authorizations.

Question & Answer:
Unknown: What about new species?

Chris Mills: The disease profile of the species would have to be reviewed to see if it could impact natural species. Risks to fish habitat impacts would also have to be assessed. It would be the same process regardless of species introduced.

Unknown: If DFO has no authority over land-based operations, what are the regulating authorities?
Kim Gill (NSDAF): The Province is looking into this aspect.

Bideford Shellfish Hatchery

Mike Randall, Lennox Island Development Corporation
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The Bideford Shellfish Hatchery is located in the Bideford River Marine Center located in western PEI. This facility has had many uses in past years. It is currently a multi-tenant facility with the shellfish hatchery located in the middle section of the building.

In 2015, the concept of developing a shellfish hatchery came about and a pilot project was developed to do so. The goal of the facility was to "provide the aquaculture industry with an Island-based supply of hatchery seed, which will allow for increased production within the industry, and the protection of Island shellfish stock from threatening diseases. In being the only facility of its kind on Prince Edward Island, and through its operation as a not-for-profit facility, the hatchery will be able to provide the industry with a competitively-priced supply of shellfish seed." Indirect and direct economic benefits were projected from the hatchery as well as overall benefits to the industry.

Our first season for 2017 has ended. It was a busy season with retrofits underway during production. We met our benchmark for the year and learned a lot. A post mortem revealed that we have to grow with demand; and we have plans to do so. Spawning for the next season is this week and we plan to double production for 2018.

We are growing into the facility and hope to expand into the entire facility. We have exceeded our direct employment numbers with up to five employees now. And we aim to expand to other species such as soft shell clams.

Most recent expansions have included increased upweller and algae production capacity. (The pictures in the slides presented are old.) And we have a FLUPSY system where the small oysters are naturally provided with feed. In the FLUPSY system, growth was fast with a weekly doubling in size.

Our original production plan included expanding oysters from Year 1 to 2, and adding other species (Bay scallops, quahogs, soft shell clams) in Year 2. Candidates for future species include the razor clam and bar clam.

Our success is largely attributed to our excellent R&D team who provided expertise and training.

We have to thank our supporters including Lennox Island First Nation, Ulnooweg, PEIDAF, Mi'kmaq Confederacy of PEI, ACOA, AACI and Eskasoni Fish and Wildlife.

Question & Answer:

Peter Warris: You mentioned oysters and soft shelled clams as well as quahogs. Are all of these available from the hatchery?
Mike Randall: Our oyster seed is currently the bread and butter of the business. We see potential with quahogs and other species as well but we cannot stray too far from oyster because it has to make business sense.

Unknown: If a grower is interested in razor clam seed, what is the roadmap from interest to seed production?
Mike Randall: This is more of a question for our hatchery manager and board. There needs to be an opportunity for Bideford. We recognize the need for diversity but staff has little free time. It can be done but it has to make sense for the business.

Jimmy A'Hearn: On one of the slides, it indicated that you were working on MSX resistance at Lennox Island. Would that require activities that could expose the industry to MSX?
Mike Randall: This is a project possibility. We are aware of the biosecurity risks and that our work cannot affect or expose the industry to risk.

Unknown: If someone was interested in quahogs, which species would be available as seed?
Mike Randall: It would be best to call the hatchery and ask Steve Palmer or Randy Angus.

Shellfish Hatchery Seed Supply: Alternate and Emerging Species

André Mallet, L'Etang Ruisseau Bar Ltée
www.malletoyster.com

As a brief history of our company, we began in 1972 with a dream of growing oysters but the seed supply was an issue. We started using scallop shells, egg crates, and veneer rings as a means to collect seed but the cost and inefficiency led my father to France to explore what they were using. He came back with the Chinese hat collector which is still widely used in the industry to collect oyster spat although this collector is not being manufactured anymore.

However, the question remained as to how to over-winter the spat on the collectors so my father bought the land around a coastal pond, obtained the water rights, and built a flood gate to control water height which allowed him to suspend the collectors on rafts below the ice.

I started my hatchery work at Bideford in 1978 and worked at and built several other hatcheries after that. In 2009, we finally opened our own hatchery in Shippagan, New Brunswick and completed in 2017 our land-based nursery system which consists of 360 18" upweller units with the flow capacity of 10,000L water per minute. This should support the growth of about 40 million seed and take them to a 10mm size. At this point they can be sold to producers to be transferred to 4mm bags or they can be transferred to our leases and grown to be sold subsequently at a larger size to the industry.

At present, the company is composed of three shareholders – my two sons and myself. Each of us has a unique role to play. We are currently setting up a breeding program which will attempt to maintain genetic diversity while improving production. One goal is to maintain high genetic diversity such that the stock can respond to inevitable future changes to the growing conditions.

Alternate or emerging species have to be viewed realistically, with the recognition that it is a long and expensive process with no guarantee of commercial success. However, if success is achieved the ROI will make it worthwhile. We have seen two examples of once emerging species that have become commercial species. These include the mussel which took about 10 to 12 years to commercialize and oysters which took about 40 to 50 years to commercialize. (It is only in the past 10 years that we have moved into the commercial realm.)

Constraints to emerging species include:

- seed supply (reliable sources, wild versus hatchery supply),
- production strategy (require high recovery of seed at a marketable size as well as a planned production scenario with low production costs and predictable outputs), and
- market demand (if there are no significant sales, it is a "no go" and the species will remain "emerging").

These constraint aspects can be examined for emerging species of interest as described in the table below:

Species	Availability of seed	Production strategy worked out?	Market demand there?
Mussels	Wild supply	Yes	Yes
American oyster	Hatchery & wild supply	Yes	Yes
European oyster	None	Yes	Yes
Bay scallop	Hatchery supply	Yes	Small market
Sea scallop	Hatchery & wild supply	Site specific	Probably, still emerging

Soft shell clams	Hatchery & wild supply	To be completed	Yes – good demand
Quahogs	Hatchery & wild supply	Not clear	Yes-good demand
Bar clams	Hatchery & wild supply	Not clear	Niche market which may expand
Razor clams	Not sure, untried	Unknown	Unknown

A reality check of the history of shellfish hatcheries in Atlantic Canada is also required. Out of a total of 24 hatcheries that have been developed in recent history – some of which were large investments, only four are known to be operational today (2 commercial + 2 research) and two with unknown status.

Possible explanations for hatchery failures include disease agents, water quality issues, and a lack of knowledge-based business expertise. In particular, hatchery operations are complex and need a dedicated staff, efficient design and effective husbandry. This complexity is aggravated by the fact that in Canada, we have to produce seed in a short season because our winters are long and hard on small seed stock.

The economics of hatchery production must balance the high costs with revenues. There are three examples of failures at a large scale: Novostrea (France) (good wild set dropped prices below minimum), FRDL (Nova Scotia) (hatchery successful but remaining production cycle was too expensive), and Mountain Island Hatchery (Nova Scotia) (hatchery and field production issues encountered).

Shellfish hatchery operations are feasible but they must have well defined goals – research vs. commercial vs. restoration. The integration of a hatchery operation with a grow-out operation is more likely to be successful since the grow out can initially finance the initial investment phases. You need good R&D staff to address production problems.

Hatcheries for emerging species require long term financial support, and the right partnership is required to ensure best systems and strategies.

Conclusions for emerging species include:

- Diversification is desirable but capital intensive,
- High valued product without significant commercial fishery should be preferred,
- Wild collected seed is a good place to start to help with production strategy development,
- Commercial hatcheries have little R&D space,
- Research hatcheries need to be funded for the long term (at least 10 years), and
- Success is feasible but financial risks are very high.

Question & Answer:

Unknown: What temperature range is best for Bay scallops?

Answer: They can tolerate down to 0.5°C and will continue to filter feed as low as 3 to 4°C but they are not growing at this temperature. They will grow well in August at 5-7mm per week but you have to make sure you reduce your densities at the correct time. Temperatures from 26 to 28°C are tolerable, wet holding is possible at 2°C; but they will die over a short time period if held at less than 0°C. Wet storage can be done but it adds cost to the operation.

Potential use of mussels as feed supplements

Gerald Johnson, Director of Science, Halibut PEI
(gjohnson@halibutpei.com)

Halibut PEI started raising halibut in low salinity water in 2008. In 2013, the company added an expansion in the form of a recirculating aquaculture system to increase halibut grow out capacity to 75 tons. The original building was the Polar facility used for live storage of lobster.

In 2010, we received a Discovery and Development Grant from Innovation PEI for which using cull mussels as a protein source was part of the initiative. In 2012, we received funding support from PEI Atlantic Shrimp Corp. to develop a mussel meal for use in fish feed. It is clear that fish meal is under high demand so there is appeal in converting or substituting with another type of meal.

Mussel meal is the refinement of a high value waste protein stream. Cull mussels are a cost to producers for disposal even though the meats are a known commodity with a good protein balance and nutritional profile and the meats and shells are easily separated. But we wanted to make a stable meal that would be acceptable for use as an animal feed. We thought that since a lot of information is known about PEI mussels, it should be easier to get approval for its use. (This was not the case.)

In 2013, an extraction procedure was developed with BioFoodTech. It was a simple way to process the cull meats and dehydrate them to make a stable powder. We put some of this through an extruder with Steve Backman at Skretting and it also proved to have good milling characteristics.

In 2014, the process was scaled up at BioFoodTech and 200kg of high quality meal was produced. Skretting sent the meal to Europe for testing at its facilities in Norway and Italy. The product was tested on two different species.

A great deal of shrinkage occurred in the process with only ~15% of wet volume remaining as a meal. This means that a lot of wet volume is required to make a relatively small amount of meal. We estimated from this that we would have had to have millions of tons of cull mussels to have enough meal to run the feed mill for only 1 to 1.5 days. That is, the cull mussel meal would be a relatively small amount relative to the use of other meals unless a higher volume of mussels was available.

The mussel meal proved to be different than conventional fish meal in a number of ways. Mussels are fresh and are consistent and high quality. It is treated like a human food product in the meal production process. It has low bacteria levels, with no bacteria of concern and a good shelf life once packaged. Fish meal by contrast often varies in freshness and resulting quality. The process used to render fish meal involves high temperatures and a range of cook times so that the product is graded for value due to its variability, and it is usually sold in bulk.

Chemical analysis of the mussel meal demonstrated a good profile with fat levels having some variability with an average of 7.5% fat but reaching a high of 10% fat. It was preferable to leave fats and oils in the meal as there was no need to extract them considering the intended end use of the product (fish feed).

Experimental feeds were produced with mussel meal providing 20% or 40% of the protein requirement. Salmon in seawater and trout in fresh water were used for the testing of the feed. Digestibility of the feed, its acceptance and the fatty acid balance were all very good. The fatty acid balance again supported leaving the fatty acids/oil in the meal rather than extracting them.

Conclusions from our work included the finding that mussel meal makes a great replacement for fish meal and can be easily prepared for that purpose; however there were insufficient quantities of the cull mussels in PEI to generate a business at that time.

We stopped pursuing the use of mussel meal for Halibut PEI because the registration process for feed ingredients for experimental use requires that the end product is destroyed and does not enter the food chain. The registration for a feedstuff in Canada is laborious requiring a minimum of 2 years. And successful approval would mean anyone could buy and use the meal in any species so that we would have to compete with other industries for its access. In other words, the company would incur substantial expense without seeing benefit. So, the project was shelved in 2014.

Question & Answer:

Peter Warris: What was the amount of cull mussels you estimated to be available at the time you did the trials?

Gerry Johnson: We estimated we could get our hands on about 2 to 4 million pounds. This was calculated based on personal communication and estimation. It could be possible to expand mussel production activity to produce mussel meal. This may be a future avenue as fish meal prices continue to rise.

Alternative product development utilizing mussel processing by-products

Lea Murphy, Prince Edward Aqua Farms
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PEI Aqua Farms is one of the three largest mussel processing plants in North America. It is active in the R&D realm and has conducted research projects in the areas of mussel process waste, mussel shell products, mussel holding and oxygenation systems, as well as value added investigations for undersized and broken processed meats.

One of the major initiatives was to add the mussel shell to Schedule IV of the Feeds Act. This would be necessary if we wanted to sell mussel shells for use in commercial animal feeds (e.g. for laying hens). Oyster shells have been on this Schedule for a long time. Janice MacIsaac and Derek Anderson spent 1.5 years researching this topic and found that mussel shells contained similar calcium content as oyster shells.

The approval process was extremely difficult. After a long time, the process was completed and it is now on the list of approved ingredients and available for use as a feed component. However, there is still a volume problem and we have to do something with the meats as well. The small total volume available may allow an opportunity in local, organic markets since the mussel products are organic. But for this to be an industry, the mussel meats must be removed.

We also found that mussel shell was an excellent source of calcium and had a liming effect over a long period when added to crop lands. Also mussel shell sourced from solid waste or a shell source blended with a carbon source could be composted locally and used in garden centers. East Coast Composting of Maine market such a product as a grub and slug deterrent. It is sold as such throughout the Northeast US down to Georgia and west to Michigan. There is no science to support the grub and slug deterrent claim but it is being effectively marketed.

The liquid fraction of mussel waste is also available. This is a by-product of having to isolate the mussel processing wash water for aquatic invasive species control. The NPK (nitrogen, phosphorous, potassium) level of this liquid is quite low, averaging 1.28, 0.14 and 0.26% with a pH of 7.2 and a C:N ratio of 8.3. Although this could serve as a good nutrient source for land crops, the cost of transportation is very high due to its low dry matter content (mostly water) and the cost to dehydrate the liquid would be high.

The solid waste fraction includes shells and biofouling and is separated from the product during the de-clumping process and pick off table. It does not amount to a large amount but tends to be difficult to get rid of since it is very unstable with an intensive odour and it can leach into the ground possibly into the water table. Currently this waste is collected by a dairy farmer who combines it with their other waste for use as a crop fertilizer. Ideally this waste could be stabilized in some way so that it would be storable until its use as a fertilizer (e.g. around May) would be possible. The composted product has 10X less NPK ratio than the raw product so that stabilization for a short time period would be best.

The main issues encountered when dealing with waste from the mussel processing operation include the following:

- The waste is generated year round, and not only when it has an immediate application.
- There is not enough waste from one plant to develop a business. There needs to be some cooperative or combination with other plants and other processes to make it viable.
- We need research on market opportunities, transportation, packaging, and other issues.

- Waste products need to be stabilized so that the nutrients are maintained in the product until they can be applied to the land.
- There may be a need to develop new products, such as pet food for example.

Co-processing of fishery and forestry residues – extracting value from residues

Anke Krutof, Memorial University
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My research focus is to look at available by-products from forestry, fishery and agricultural wastes then think of all the products that be produced from them. In Newfoundland, we have unique challenges to this since locations are often remote with limited infrastructure and these aspects must be considered.

The first step is to examine all waste that would be available from an industry and recognize the differences in terms of timing of availability of the waste products as well as their volumes.

The research approach at MUN is to examine several different paths for products, including on-site by-product processing or storage and shipment to a central processing facility where it can be combined with other waste streams. Questions regarding existing infrastructure, distance to market, product value, stability and regional interests are issues that play a role in determining the pathway that is feasible.

Current projects in bio-refining are examining shellfish, finfish, and mining residues and combining them with forestry residues. Pyrolysis of the products yields char, pyrolysis oil, and non-condensable gas with each product having unique uses.

One of the processes examined includes using a pilot plant reactor to be able to transform sawmill residues (sawdust, shavings, and bark) to pyrolysis oil increasing its energy density. The resulting pyrolysis oil shows high water, oxygen, and acid content resulting in instability of the oil and evidence of other difficulties for its application as a fuel (e.g. corrosivity). These quality problems can be expensive to correct. For example the oil may be processed again to increase the content of hydrocarbon components but it would require an expensive process using catalysts and added processing steps. Another option would be to co-process, or process the forest residue feedstock with another waste type so that a more usable product would be attained. Some of the other potential residue streams for the co-pyrolysis could be red mud (waste product from mining), mussel shells or shrimp shells.

Detailed studies investigating the potential of mussel shells as an additive included experiments co-pyrolysing softwood with mussel shells while varying four parameters: temperature, nitrogen flow, operational mode and softwood-to-mussel additive ratio. An analysis of the oil and char that resulted from these studies demonstrated that under the right conditions co-pyrolysis of

softwood with waste mussel shell can improve the quality of the oil. Using mussel shell as an additive decreased acidity and increased the water content while there was little change in the heating value of the oil. However further analyses are needed to further define the process and model and design a scaled up system for the process.

Question & Answer:
Unknown: Is the sawdust oil in its current form used anywhere?
Anke Krutof: There is some pilot scale use of it as a heating oil but it is not suitable for use in vehicles.

Unknown: Have you tried using lobster shells?
Anke Krutof: No but the shrimp shell did not look promising as an additive since it increased the nitrogen in the products.

School of Sustainable Design Engineering

Alan Dale, Director of Industry Partnerships

The School of Sustainable Design Engineering is the newest engineering school. Previously, students at UPEI were only offered the initial two years of an engineering program then went elsewhere to finish their degree. The intent of the school was to be the most innovative engineering school in the world. It was very import to the school to be very technically focused. Our goal is to develop graduates with broader attributes than typical engineering training, including skills in communication, teamwork, lifelong learning, CSR and other soft skills. A combination of technical and soft skills would produce a graduate who is industry ready.

Our program focuses on clinic projects where we find a client with a real life problem. These could be local clients or from around the globe. We source out about 75 projects per year and assign five students per project so they are set up like a small engineering firm. For that year, the group works directly with the client. Students get a different project each year. A visit to the client is often the first step to understand the project. The students are then assigned to a clinic bay where they work together. 30% of their time is spent in this clinic so that the majority of their time is project based learning. During this time, the students are mentored by staff. If students need help beyond their staff mentor, they have access to other faculty members who are experts in the appropriate field. Our standards for our staff are very high. They must have industry experience, PhD, and have displayed teaching excellence.

The students start working as an engineering company from Day 1 of the program.

Junior level projects are free of charge to clients and take the solution to a TRL (technical readiness level where 9=full commercialization) of 2 or 3. This is a conceptual or pilot scale level.

Senior level projects are currently at a cost of $10,000 to $15,000 for a client and take the solution to a TRL of 6 or 7. The industry owns the IP that results so that it is available for commercialization.

Students build from the get-go with lots of real life, hands-on experience.

The three main themes are renewable energy, megatronics and bio-resources. We intend to add biomedicine in the future. The school has five Centers of Excellence including renewable energy, bio-resources, megatronics, sensors/options/imaging, and advanced manufacturing (both additive and subtractive). Faculty members are experts in these topics.

We are open for business with room for new client projects and invite projects from the aquaculture industry.

Question & Answer:
Lea Murphy: One class has graduated already. What is the feedback on these students?
Alan Dale: Out of our seven graduates, four have formed their own engineering company, three are in industry positions with positive feedback from industry. We expect the students will go into one of three streams: 1/3 will have their own company, 1/3 will continue their studies, and 1/3 will go into industry.

Jason Simpson: Does the $15,000 cover prototype costs?
Alan Dale: The $15,000 provides access to students. Prototype costs are borne by the company.

Unknown: Does industry get to feed into the process since they have money invested?
Alan Dale: We want students to use their creativity but we also want the product to be usable so that the dialogue between the students and the customers is vital. The clients can also reach out to the industry liaisons of the school. With money invested, we want the outcomes to be applicable.

Facilitated Discussion 2: Secondary products from waste or by-product development

Question to the audience: Based on what we have heard today, identify the barriers to develop waste and by-product utilization projects. What questions do you have or what opportunities do you see?

Table 1:

- Something that was never considered before was the idea of returning shells to the water to combat ocean acidification.

- What about sock waste plastic – can it be re-used so that we can remove it from the waste stream?
    - The socks are washed. 65 to 75% of the waste weight is sediment and biofouling – a tumbler can remove these, so that when socks go to landfill, it is only plastic.
- If the plastic is fairly clean, it may facilitate recycling.

Table 2 (PEIDAF):

- A key barrier to use of by-products is that there is not enough volume, some form of partnership between players would be key to having required volumes.

Table 3:

- We should have a discussion on R&D funding programming. What we have seen at PEIAquaFarms is that if we have an issue, we apply for funding but as the process evolves and we want to change course, we cannot access funding to change course. For example the oyster grader evolved as a piece of equipment that took over a year but funding was only available for a single year.
- We see that we need automation in mussel socking.
- If an industry partner pays for the innovation, it may not get into the rest of the industry. We need to have public funding or another means for development for the greater good of industry.

Opportunities for product development

Joy Shinn, BioFoodtech
(jmshinn@biofoodtech.ca)

BioFoodTech has been operating for 29 years. Our main goal is to provide technical support for the food industry. For resources, we have 20 + highly qualified staff in a variety of disciplines (food scientist, engineers, bioscientists, etc.), pilot, processing facilities (4) and registrations necessary for food production. Our model is to turn concepts to pilot to marketable products. It is possible to manufacture within our plant and sell to various markets.

We have three integrated divisions: food technology, lab services and bioscience. Lab Services is the largest unit in terms of revenue from lab testing services to industry.

The Food Technology division includes all steps in the innovation sequence from concept through to commercialization, such as new product development, shelf-life, quality, scale up, etc. We recognize this is not necessarily a linear path and projects do not have to go through the sequence. Our food technology support can help at any step. Another key service includes Ideation brainstorming, where we bring in our technical resources with varied experiences and

knowledge and we connect with others in the industry and organizations to work with companies to firm up concepts and determine how to achieve outcomes.

Our Lab support offers accredited analysis along with food safety, HACCP based training, and in-plant troubleshooting.

Our Bioscience support includes pilot scale equipment, pilot scale processing, process optimization, and analytical services. This can include use of pilot equipment by start-ups to get into test markets and large companies to undertake development work.

Results from our support include many impacts from short to long term. We recognize that there may be limited technical resources within companies so that our contract services can be more economical for a company and provide a greater breadth and depth of knowledge.

We have worked with hundreds of companies over the years, and average about 60 projects in the food tech group and 25 to 30 in the bioscience group per year. Most of the companies that we have worked with are in the Atlantic provinces but there have been others across the country and internationally based.

We have a huge variety of food processing equipment at varying scales. Much is typical food processing equipment, including cooking, drying, chilling, packaging, homogenizers etc. and some specialized equipment. We also have a variety of bioscience processing equipment including fermentation, spray drying, extraction/filtration and more.

In terms of value add opportunities for the aquaculture industry, it is important to recognize that many innovations are incremental. Some of the value add ideas include packaging to steam heat, or easy to heat food with flavours and sauces. With shellfish a key is the recognition of the high value of meat once it is extracted so that combining it with low value ingredients is one way to make it cost effective. Other NPD ideas are changing formats (i.e. from canned to frozen), smaller sizes and making these products “everyday” vs. “occasions”.

There are also sometimes higher value opportunities. Examples are nutraceutical markets. It is necessary to determine optimal factors, such as costs, supply of raw ingredients, etc. to justify development. Other opportunities beyond the human food supply have been recognized, like pet food, other feed, fertilizers, etc..

We partner with many organizations such as Canada’s Smartest Kitchen and have other resources to tap into such as other food centers, associations, including the PEIAA, and others. Sometimes we simply make the connection to the best partner.

Feedback from clients is key to us.

Canada's Smartest Kitchen

Peter Crooks, Executive Director
(rpcrooks@hollandcollege.com)

Who is Canada's Smartest Kitchen?

We are located at the culinary institute in Charlottetown and are a food product development center that is globally recognized. This came about through a pathway from conception to realization to foundation to growth to global outlooks.

Conception: The conception came from the recognition that industry was often trying to access chefs at Holland College to help with product development. In 2007 CSK was born.

Realization: When I began, I noticed that the ideas had been developed but we needed to round out the skill set to ensure that the ideas got to markets. We needed more than chefs to get products onto shelves.

Foundation: So our foundation was the combination of a range of personalities and backgrounds that included chefs to ensure the food tastes good, scientists to ensure that the food is safe, and business people to ensure we had an understanding of the market.

Growth: Our new process promoted both local, regional and national uptake, and our growth has been demonstrated by the fact that we started out with 4 people and have grown to 15 and are running out of infrastructure to support more.

Global: There is now international interest in this innovation model and we intend to establish global partnerships

Our culinary arts team is our biggest strength but they cannot work alone and we need the input from our food science team and our business team to ensure we are successful.

CSK can act as an extension of your organization to provide consumer and trend insight through international travel of our team; and we have a broad network of industry professionals to tap into. We also have global market access. All of these factors combine to allow risk mitigation. Food product development is risky so this is important.

The services we offer include product development, sensory and consumer science, market research, food styling and photography, and corporate chef services.

CSK operates in a food innovation ecosystem. We forge relationships and partnerships so that if CSK cannot solve the problem, we can access others who will. This food innovation ecosystem includes:

- Partnerships, including in foreign markets;
- Market access which is international;

- Supplier access due to our established relationships with ingredient suppliers and personal relationships that provide technical help when needed;
- Infrastructure and expertise, including NRC, BioFoodTech, Perennia; and
- Funding partners: provincial and federal.

Our market focus has paid off in performance. To date we have influenced over 2000 food innovations, the most significant of these being the new SKUs on the marketplace.

We implement a SMART process:
S=Strategic Business Review- first step is to understand your business;
M=Market assessment- we gather data and look at trends and current offerings in the marketplace;
A=Accelerated concept ideation –this involves a strategic ideation session and assesses regulatory and practical aspects of development;
R=research & development- iterative process that ends when the client is satisfied;
T=technical scale up.

Our facilities include a demonstration kitchen, science lab, sensory lab, and photo studio.

"Canada's Smartest Kitchen's multidisciplinary team delivers market-validated solutions to food companies of all sizes."

Question & Answer:
Unknown: Can anyone off the street come in and ask a question?
Peter Crooks: Yes, anyone is free to stop by to develop ideas or ask questions.

Innovation PEI Supports

Shane MacDougall, Director Business Development and Innovation, Innovation PEI (shanemacdougall@gov.pe.ca)

The main mandate of Innovation PEI is to grow the economy of PEI. We are into business development, growing exports, and creating innovations.

Aquaculture is one of the key sectors that we support. PEI is a "Food Island" so that is a key priority.

The tool that is likely most relevant to you is our Product Development Fund. This is aimed at the food & biotech sector. It supports both the BioFoodTech and Canada's Smartest Kitchen but you can also outsource the services you need. The product must have export potential. With this fund, we will support 50% of project costs as a grant, to a maximum of $50,000.

The Innovation Funds may also be applicable. These are competition based funds. We issue a call for proposals and the best of the best are selected. The Ignition Fund is a start-up grant and

is not necessarily for product development but can be for any typical start up as long as it is innovative and will be incremental to the Province. The grant is for $25,000 with no matching funds required. The Pilot and Discovery Fund supports early proof of concept projects. It will support 50% of project costs up to $25,000. The Development and Commercialization Fund supports project that are past the prototype/pilot stage into commercial scale production. This requires an extensive application process and will support 50% of project costs as a grant to a maximum of $80,000.

We have other funding supports as well. These include close to 30 programs that try to support and accommodate business growth. Included in these are funding assistance for capital acquisition, rental incentives, human resources, information technology, productivity and quality improvement, through to marketing support and web presence.

The key elements of all of these programs are that they:

- Support a strategic sector,
- Promote development of an export, import replacement or represent first of kind,
- Are value added products or processes,
- Are innovative,
- Provide incremental growth for the provincial economy,
- Promote quality employment,
- Are scalable.

To apply for these supports contact an IPEI Business Development Officer. The applications are also on-line.

Question & Answer:
Lea Murphy: When is the call for proposals usually?
Shane MacDougall: Ignition is usually launched in June, D&C in March/April. The website will announce the dates.

Aquaculture Technology Program

Aaron Ramsay, PEI DAF
apramsay@gov.pe.ca

The Aquaculture Technology Program has been around almost 15 years. Its intent is to develop or adopt new techniques and technologies that will expand aquaculture production, reduce production costs or maximize efficiencies. It could be used to assess new species or increase the environmental acceptability of aquaculture.

For eligibility, you must be a person or incorporated company involved in aquaculture in PEI or an organization or institution recognized in the PEI aquaculture industry.

The program supports 60% of eligible expenditures to a maximum of $10,000. Eligible expenditures could include equipment or modifications to equipment, materials and supplies, seedstocks, or design and engineering costs. The program will not cover real estate, vehicles or salaries and wages.

The project should involve a new or innovative approach to production techniques, equipment or culture stocks. The proposal must detail technical, operational and biological aspects of the project and demonstrate a benefit to the industry. The project must be completed by March 31. The program is renewed annually.

Some past examples of support for shellfish aquaculture have included mussel socking and grading equipment, oyster harvesting and grading equipment, fouling & predator control, and farm management systems. For finfish it has included paddlewheel aeration for ponds, UV systems, containment systems, pH control, biofilters, and the development of a cryopreservation process.

There are still funds available for this year. We usually support about 5 to 8 projects in a year

Question & Answer:
Jimmy A'Hearn: Will new species qualify for this program?
Aaron Ramsey: New species like algae – yes.

Jimmy A'Hearn: What about quahogs which are not currently farmed?
Aaron Ramsey: We'd look at the production system. The application goes through a review committee.

Jimmy A'Hearn: Would it pay a hatchery to produce quahogs?
Aaron Ramsey: There would be potential there for proof of concept.

Jimmy A'Hearn: Who do we talk to?
Aaron Ramsey: We have applications available here.

Atlantic Fisheries Fund

Denise Lang, Manager of AFF for NB & PEI, Fisheries & Oceans, Canada
Denise.lang@dfo-mpo.gc.ca

I am located in the Moncton Office and will be dealing with New Brunswick and PEI. Steven Lewis will be located in Charlottetown.

We began accepting application for this program August 31, 2017. It is a federal/provincial program with a 70/30 funding split.

The intent of the program is to help Atlantic Canada's seafood sector meet the market demand for high quality, high value, sustainably sourced seafood products. It is a $400 million dollar fund which will be invested over 7 years.

It is a fund for industry (with collaborators). Industry includes harvesters, processors and aquaculturists. Non-commercial organizations such as indigenous groups or organizations, industry association and research and academic institutions may also apply.

The main three elements are:

- Innovation –led by industry with support from academia or other technical support.
- Infrastructure-to adopt new technologies, processes or equipment, e.g. to reduce the labour shortage. This would be direct investment in private companies.
- Science partnerships – work to be done by academics and institutions.

For commercial applicants, contributions of less than $100,000 are not repayable, while contributions over $100,000 are conditionally repayable. The repayment will be tied to commercial and technical success of the project. For companies with <20 employees, funding is up to 80%, for 20-99 employees, it is up to 75% , and for >99 employees, it is up to 50%.

For non-commercial organizations, non-repayable contribution are 80% maximum (i.e. all government sources) and the actual % contribution will be based on need.

The AFF is not intended to replace other funders.

Contact information follows:

- Website: atlanticfisheriesfund.ca
  - E-mail: RegionalAFF-FPARegional@dfo-mpo.gc.ca
  - Toll Free: 1-844-795-9718
- Denise Lang, Manager of AFF for NB and PEI
  - E-mail: Denise.Lang@dfo-mpo.gc.ca
  - Tel: (506) 866-5378
- Provincial Partners

Programs and Services for the Fish and Seafood Sector (AAFC)

Heath Coles, Agriculture and Agri-Food Canada
(Heath.Coles@AGR.GC.CA)

Agriculture and Agri-Food Canada (AAFC) is responsible for international market development of the Canadian fish and seafood industry. To do this, we bring together the Seafood Value Chain Roundtable (SVCRT) and have an AgriMarketing Program, Agri-Food trade service, trade event support, and the Canada Brand.

The SVCRT brings together provincial/federal/territorial policy makers with industry leaders throughout the value chain with an industry co-chair and government co-chair. The key objectives are to improve sector competitiveness, maintain and increase access to international markets and address labour challenges.

The AgriMarketing Program ends in March 2018. It is designed to develop export markets. It has two streams: Market Development and Assurance Systems. The Market Development Stream has assisted associations to do broad based market work as well as individual company activities. The Assurance Systems Stream provides support to make credible and verifiable claims to buyers and markets about the safety, production methods used or characteristics of their food products. One project that has been funded is the development of an online seafood traceability system. As of April 1, 2018, there will be a new 5 year program: the Canadian Agricultural Partnership. This will include marketing funding.

Agri-Food Trade Services are available to help the Canadian food industry reach international markets. It provides information reports on a marketplace, statistics, consumer preferences and produces a monthly publication that is available. It also provides trade show support including its flagship shows which feature a Canadian Pavilion.

The Canada Brand Program helps companies gain a marketing advantage by linking Canada's positive image with products.

Industrial Research Assistance Program

Tom O'Rourke, National Research Council
Tom.orourke@nrc-cnrc.gc.ca

IRAP is a Canada-wide organization with 255 Industry Technical Advisors located across the country.

IRAP was established in 1947, shortly after WWII when factories making war equipment needed to shift their focus to making other products. We now serve over 13,000 clients in all sectors that have a desire to innovate. An ITA can provide advisory services and may provide technical and business advice, referrals to other programs and services and linkages with needed resources.

Our current funding programs include:

- IRAP Core – to assist small and medium enterprises with R&D projects with the intention to grow the business.
- Youth Employment Program (YEP) – helps SME's hire post-secondary graduates.
- Youth Employment Green – Helps SMEs increase their green innovation capacity by hiring youth.
- Concierge – helps a client navigate innovation and support programs.

The core IRAP funding helps small companies grow through innovation. It is intended to encourage investment in R&D activities that have clear commercialization goals. IRAP is looking for a 10:1 return. The intellectual property developed through an IRAP-funded project remains the property of the company. The fiscal year is April 1 to March 31 and all the funds for the IRAP core funding have been allocated for this fiscal year but funding will be available again after April 1. IRAP also funds organizations like CATC and PEIAA, etc. that provide services at early stage development, diagnostics, and investigation of new concepts to incorporated companies. BioFoodTech and Canada's Smartest Kitchen are also funded on the same basis to support individual projects.

The Youth Employment Program (YEP) supports a 6 to 12 month internship of a post-secondary graduate up to a maximum of $20,000 with 100% being non-repayable.

The Youth Employment Green supports a 3 to 6 month internship of a youth (15 to 30 years old) up to $10,000 maximum with 100% being non-repayable.