Presented by Canadian agencies and organizations currently undertaking aquaculture research in Canada

CANADIAN AQUACULTURE R&D REVIEW

Includes 150 summaries of recent research projects on salmon, trout, charr, oysters, mussels, marine species plus special full length features on completed projects across the country.

CANADIAN AQUACULTURE **R&D REVIEW**

Bridging research, development and commercialisation

Improving awareness of aquaculture R&D activities in Canada and increasing transfer of knowledge and technology to the aquaculture sector has been the goal of the aquaculture R&D review since its inception in 2004. It grew out of efforts by the federal and provincial governments to improve aquaculture R&D coordination and communication in Canada.

This third bi-annual edition continues to build on the success of the first two editions. It summarises about 150 R&D projects that have been underway since spring of 2007 until now that have received funding from governments. It is available in both English and French, in print as well as in various electronic formats on several web sites (Aquaculture Association of Canada, AquaPort.ca, Fisheries and Oceans Canada). This has enabled the summaries to reach and inform many interested people. The current edition captures the breadth of aquaculture R&D activities across the country, including marine and freshwater finfish, salmonids, shellfish, seaweeds, wild-cultured interactions, integrated multi-trophic aquaculture, and fish health. It reflects an impressive diversity and depth of research expertise across the country.

Over the past two years, the landscape has changed significantly with respect to how and where aquaculture R&D is funded and takes place. The funding mandate of two significant organizations was completed: AquaNet (a Network Centre of Excellence in Aquaculture) and the Pacific Salmon Forum (PSF). In part, the AquaNet experience highlighted the importance of a multi- and inter-disciplinary approach in fostering innovation across the country. The PSF was successful in developing collaborative approaches to addressing key issues of wild Pacific salmon and aquaculture interactions on the west coast of Canada.

In Budget 2008, there were two important initiatives for aquaculture R&D. Within Fisheries and Oceans Canada (DFO), there were new resources for an aquaculture regulatory science program and funds for the Aquaculture Innovation and Market Access Program (AIMAP). The regulatory research program aims to increase the availability and accessibility of research to support aquaculture siting and environmental management. Two key components are a new internal DFO Program for Regulatory Research (PARR) and core funding for the Centre for Integrated Aquaculture Science, a DFO virtual Centre of Expertise based in St. Andrews, NB that focuses on ecosystem-based approaches. The objective of AIMAP is to improve the competitiveness of the Canadian aquaculture industry by encouraging an aquaculture sector that continuously develops and adopts innovative technologies and management techniques to enhance its global competitiveness and environmental performance. As well, the Natural Sciences and Engineering Research Council (NSERC) received new funds for a special initiative on natural resources including fisheries and aquaculture. This has allowed NSERC to issue a special call for Strategic Grants and Networks. Both of these initiatives in DFO and NSERC further enable collaborative approaches to conducting R&D and further addresses a way to narrow the R-D-C gap in ensuring that a complete innovation cycle is achieved for the aquaculture sector in Canada.

The production of this issue was again a coordinated effort among Dr. Tim DeJager, DFO – Aquaculture Science Branch, and Peter Chettleburgh (Capamara Communications Inc.). Tim was responsible for overall coordination and external communications, Tricia Gheorghe (DFO) was responsible for coordinating all DFO submissions and arranging for translation of all the project descriptions and Peter was responsible for production. A special thank you is extended to these three, as well as Corina Busby (DFO) and Ingrid Burgetz (DFO) who assisted with reviewing the publication and James Lewis for design. Funding for this edition was provided by the DFO Aquaculture Collaborative R&D Program (ACRDP) and the British Columbia Aquaculture Research and Development Committee of the BC Innovation Council.

Jay Parsons, PhD, Aquaculture Science Branch, Fisheries and Oceans Canada

Al Castledine, PhD, BC Ministry of Agriculture and Lands

Tim DeJager, PhD, co3 consulting

CONTENTS

The Canadian Aquaculture Research and Development Review has been published with support and funding provided by Fisheries and Oceans Canada – Aquaculture Collaborative Research and Development Program (ACRDP) and British Columbia Innovation Council – British Columbia Aquaculture Research and Development Committee (BCARDC).

Submitted materials may have been edited for length and writing style. Projects not included in this edition should submit material in time for the 2011 edition.

Project Coordinator
Tim DeJager, Ph.D.
co3 Consulting

Produced and Distributed By
Capamara Communications Inc.
4623 William Head Road, Victoria, BC, V9C 3Y7

Design by James Lewis
Capamara Communications Inc.

Researchers quantify nutrient fluxes from fish farms in fresh water

Perceived risk of altering the trophic status of lakes is currently limiting the development of Canadian freshwater aquaculture. This perception persists despite the operation of fish farms and extensive environmental monitoring by farms in the North Channel for more than 20 years. They have yet to document detectable increases in nutrient concentrations. At the same time there is a lack of sound scientific knowledge regarding aquaculture's potential effects on receiving waters and sediments.

Organic loading from fish cage farms increases the total nutrient content of the sediments and it can also increase the concentration of soluble forms that can be released into the overlying water. However, the fate of those nutrients (burial or release back to the water column) and the factors regulating that fate in sediments affected by aquaculture wastes are poorly understood. Researchers are conducting investigations to quantify the effects of sediment chemistry and water temperature on the nutrient release rates from the sediments affected by fish wastes.

Duration: Mar '07 – Mar '08

Funded by: DFO-ACRDP Co-funded by: Aqua-cage Fisheries Ltd.

Project team: Paula Azevedo (DFO), Cheryl Podemski (DFO), M. Robin Anderson (DFO), Gord Cole (Aqua-cage Fisheries Ltd.)

For information contact: Paula Azevedo (Paula.Azevedo@dfo-mpo.gc.ca)

In situ N and P fluxes measurement

Summer 2008 field season in the North Channel (Photo: K. Boulton)

Ontario team investigates what happens to rainbow trout that escape net pens

In the North Channel of Lake Huron farmed rainbow trout are being marked and released to emulate both small- and large-scale 'escape events'. Through the release of small numbers of farmed rainbow trout outfitted with telemetry transmitters, scientists hope to determine the spatial extent of escapee movements and their potential for interaction with native fish species based on habitat selection.

In the summer of 2008, the team implanted farmed rainbow trout with telemetry transmitters and released equal numbers of fish (20) at two farms. Preliminary results show that many of the escaped fish remained in close proximity to the farms, and also that these fish were susceptible to predation and angling.

In the 2009 field season, researchers plan to extend the telemetry research and conduct large-scale releases of farmed rainbow trout (1000 at each farm). Recapture data are expected to provide survival and growth rates for escaped fish, which are critical to understanding the potential impacts on native fisheries and food webs.

Duration: Jul '08 – Mar '11

Funded by: DFO-ACRDP Co-funded by: Meeker's Aquaculture Canada Inc., North Wind Fisheries Ltd.

Project team: Paul Blanchfield (DFO), Doug Geiling (DFO), Tom Johnston (Laurentian U/OMNR), Kristen Patterson (MSc student, U of Manitoba), Lori Tate (DFO), Chris Wilson (Trent U/OMNR), Dan Glofcheskie (North Wind Fisheries Ltd.), Mike Meeker (Meeker's Aquaculture Canada Inc.)

For information contact: Paul Blanchfield (paul.blanchfield@dfo-mpo.gc.ca)

Research advances the fight against coldwater disease on Ontario trout farms

Bacterial coldwater disease is caused by *Flavobacterium psychrophilum* and is the primary disease of concern for raceway operations that use groundwater. Researchers are preparing to conduct autogenous vaccine trials for coldwater disease. But in order for this strategy to be effective, more research is needed.

The strains of *F. psychrophilum* specific to Ontario must be identified. The growth conditions required for optimum expression of virulence and immunogenic proteins must be characterized and effective production monitoring systems developed to ensure that improved performance can be evaluated.

The research team has been using two-dimensional polyacrylamide gel electrophoresis for comparison of culture conditions that influence protein expression of *F. psychrophilum*. They have identified several proteins that are strong candidates and are screening larger numbers of strains.

An additional objective of this work is to raise antisera to these proteins of interest. The project also involves a treatment trial to determine the efficacy of florfenicol as a therapeutic measure to blunt the impact of coldwater disease. Florfenicol is used to treat outbreaks of coldwater disease and appears to be effective in the short term. What is not known is if treatment in early stages (<1 g) can produce long-term improvements in fish health and farm productivity.

Duration: Aug '07 – Mar '09

Funded by: DFO-ACRDP Co-funded by: AquaCage Fisheries Ltd., Lyndon Fish Hatcheries, University of Guelph

Project team: John S. Lumsden (U Guelph), Arman Yazdanpanah (U Guelph), Shohreh Hesami (U Guelph), Paul Huber (U Guelph), Doug Geiling (DFO), Gord Cole (AquaCage Fisheries Ltd.), Sean Pressey (Lyndon Fish Hatcheries)

For information contact: John Lumsden (jsl@uoguelph.ca)

Project investigates effectiveness of constructed wetlands for treating aquaculture waste

Source water protection has emerged as a priority science area in Ontario. Aquatic systems are experiencing increased loading of nutrients, pathogens, and emerging contaminants such as pharmaceuticals. Consequently, land-based fish farms are faced with increasingly stringent regulations on the discharge of effluent.

Conventional wastewater treatment systems currently used to treat aquaculture effluent are ecologically and economically expensive to build, operate, and maintain and they treat parameters within a relatively narrow range. Constructed wetlands have been shown to be effective at removing or reducing the concentrations of nitrogen and phosphorous, pathogens and emerging contaminants such as pharmaceuticals and personal care products in wastewater effluent. However, much of the research on treatment wetlands has been done in warmer or more moderate climates such as the equatorial areas and warmer regions of the United States and Europe.

Researchers believe that properly designed wetlands can perform well in colder climates too. Hence this project is a step towards the research needed to validate applications of constructed wetlands which would then be subject to regulation by the Ontario Ministry of the Environment, the Ontario Ministry of Agriculture, Food, and Rural Affairs, and/or the Ministry of Municipal Affairs and Housing through the Ontario Building Code.

Duration: May '07 – Mar '10

Funded by: DFO-ACRDP Co-funded by: Ontario Trillium Foundation, Haliburton County Development Corporation

Project team: Brent Wootton (FC), Chris Metcalfe (Trent U), Robin Slawson (WLU), Tom Pratt (DFO), Mark Williamson (FC), Stephen Thompson (FC), Scott Miles (FC), Kyla Greenham (Haliburton Hatchery), Karl Dickob (Fisheries and Aquaculture Enhancement Association)

For information contact: Brent Wootton (bwootton@flemingc.on.ca)

Installing a current meter in Lake Diefenbaker, SK. (Photo: Heather Zanzerl)

Predictive modeling tools assist freshwater site licensing decisions

Governmental agencies charged with the responsibility of licensing and regulating the aquaculture industry need objective tools to assist in their decision-making processes. The development of such tools would benefit industry, since the main factor limiting the expansion of the freshwater industry is access to new sites. The lack of tools to estimate ecological consequences of new sites has resulted in a very precautionary atmosphere, a complex and expensive application process and, ultimately, limited development of the industry.

Aquaculture has the potential to have far-ranging impacts on the lake ecosystem. Increased nutrient inputs can affect overall ecosystem productivity and excessive nutrient inputs can lead to eutrophication. This can have undesirable consequences such as nuisance algal blooms, oxygen deficiency and loss of biodiversity. The deposition of sold wastes under farms contributes to increased sediment oxygen demand as well as the potential to significantly alter the quality of benthic habitat and the composition of benthic communities beneath and surrounding farms.

There are five components to the strategy to develop objective tools. These include evaluating DEPOMOD, developing a dispersion model, developing a benthic impacts model, testing particle dispersion and benthic impacts models, and modeling ecological effects.

Duration: Jul '08 – Mar '12

Funded by: DFO-ACRDP Co-funded by: Wild West Steelhead, SE, U Sask

Project team: Cheryl Podemski (DFO), Paula Azevedo (DFO), Dominique Bureau (U Guelph), Rob Tkach (DFO), Adam McFee (DFO), Doug Watkinson (DFO), David Ross (DFO), Peter Ashcroft (SE), John Geisey (U Sask), Dean Foss (Wild West Steelhead)

For information contact: Cheryl Podemski (Cheryl.Podemski@dfo-mpo.gc.ca)

Researchers scale up phase-feeding in rainbow trout to reduce phosphorous discharges

In fish farming operations, phosphorous, which is an essential nutrient for skeletal development and growth, is obtained almost entirely from dietary sources. Discharges of phosphorous into the environment from fish farms come largely from feed that is not ingested by the fish or from ingested phosphorous that exceeds the organism's physiological requirements. Intensive aquaculture can generate environmental phosphorous loadings that contribute to eutrophication of sensitive receiving water bodies.

These phosphorous discharges can be reduced by directly modifying the bioavailability of this element and the composition of the fish feed. The first objective of the research team is to optimize the formulation of a phosphorous-deficient diet. The second objective is to determine the alternating sequence of phosphorous-sufficient and phosphorus-deficient diets to maximize growth of rainbow trout and minimize phosphorous discharges.

The results of this project will contribute directly to the sustainable development of the Canadian aquaculture industry. This type of dietary regime could be a useful tool to help aquaculture producers achieve the objectives of Quebec's freshwater aquaculture development strategy (STRADDAQ).

Duration: Sep '08 – Mar '11

Funded by: DFO-ACRDP Co-funded by: SORDAC, FQRNT, RAQ, NRC-IRAP

Project team: Grant Vandenberg (U Laval), Johanie Fournier (U Laval), Eric Boucher (IPSFAD), Emilie Proulx (U Laval), Joël de la Noüe (U Laval), Daniel Proulx (U Laval), Rémy Lambert (U Laval)

For information contact: Grant Vandenberg (grant.vandenberg@fsaa.ulaval.ca)

Laboratoire règional des sciences aquatiques (LARSA) (Photo: E. Boucher, D. Proulx)

Laboratoire règional des sciences aquatiques (LARSA) (Photo: E. Boucher, D. Proulx)

Cinnamon oil compound tested to control fungus infection in trout

The common fungus *Saprolegnia parasitica* is a "water mold" that infects dead fish eggs and spreads to healthy eggs. It also infects the yolk sac and digestive tract of fry that are just starting to feed. With the banning of malachite green, the salmon farming industry urgently needs new effective and inexpensive treatments for this mold which have no negative effects on fish, humans, or the environment.

Some natural antifungal agents appear to have the desired qualities, and cinnamaldehyde, derived from the oil in the bark of cinnamon trees, is being investigated. The effectiveness of cinnamaldehyde on the fungus, in vitro as well as on the eggs and fry of brook trout *(S. fontinalis)* and rainbow trout *(O. mykiss)*, is being tested and compared to malachite green, formaldehyde and bronopol.

The researchers are also measuring the impact of the treatment (bath or in feed, depending on the test) on the egg hatching rate as well as on fry malformation and survival rates. The treatment is also being validated for aquaculture purposes.

Duration: Apr '06 – Mar '09

Funded by: DFO-ACRDP Co-funded by: SORDAC, U Montreal, Pisciculture des Alleghanys Inc., Pisciculture de la Jacques-Cartier Inc.

Project team: Grant Vandenberg (U Laval), Pierre Belhumeur (U Montreal), Arianne Faille (U Montreal), Éric Boucher (IPSFAD), Émilie Proulx (U Laval), Daniel Proulx (U Laval), Richard Le Boucher (U Laval), Gabrielle Fortin, Marie-Ève Gervais, Amélie Potvin

For information contact: Grant Vandenberg (Grant.Vandenberg@fsaa.ulaval.ca)

Saprolegnia spores (Photo: E. Proulx, A. Faille)
Inset: Alevin infected by *Saprolegnia* (Photo: É. Boucher, É. Proulx)

Model Farm in Denmark (Photo: G. Vandenberg)

Canadian model aqua-farm initiative begins in Manitoba

Rainbow trout market (Photo: IPSFAD)

The Canadian Model Aqua-Farm Initiative involves developing and constructing a state-of-the-art commercial land-based freshwater aquaculture production system intended to be the basis for a standardized approach to freshwater aquaculture production. In addition, this first model farm will be heavily monitored to document the economic and environmental performance of the model design. The anticipated outcome is a model for a 'turn-key' freshwater aquaculture operation that will catalyze the development of a sustainable freshwater aquaculture industry in Canada.

Expansion within the freshwater aquaculture sector is dependent upon development and implementation of a strategic approach to generate the knowledge, technologies and practices necessary to resolve challenges. Development of a land-based 'model farm' program is a priority initiative in the 3rd Industrial Action Plan of the Interprovincial Partnership for Sustainable Freshwater Aquaculture Development (IPSFAD).

In March 2007, IPSFAD assembled a group of recognized national and international authorities on the design, operation, management and regulation of land-based aquaculture systems to develop the Canadian Model Aqua-Farm concept.

The 'Canadian Model Aqua-Farm' will be a production unit that effectively integrates the most current technologies in terms of nutrition and feeding strategy, fish health management, design of infrastructure and equipment, water conservation and utility, manure processing and management, production management, and operational practices and standards. All of these factors combine to optimize both financial and environmental performance. The model farm is expected to establish norms and baseline standards pertaining to the biological, technological, financial and environmental sustainability of aquaculture.

The first beta site for development of the Canadian Model Aqua-Farm is in Manitoba. It is anticipated that two additional beta sites will be developed – one in Saskatchewan and another in Alberta or British Columbia.

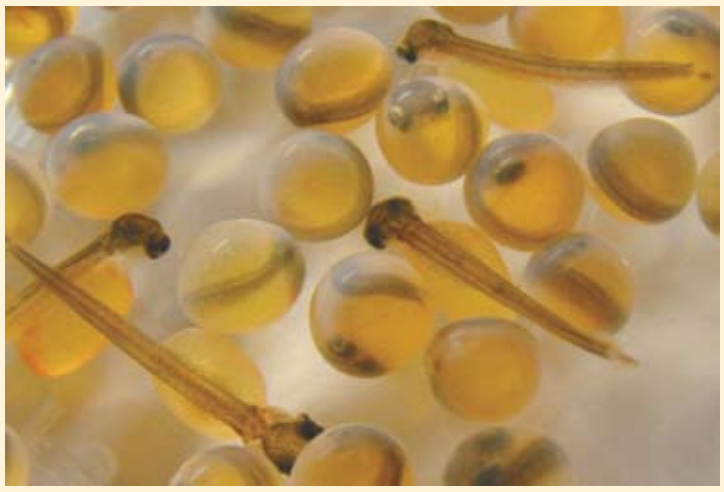
Duration: Jul '08 – Dec '11

Funded by: DFO-AIMAP Co-funded by: MAFRI, IPSFAD, DFO-ACRDP, NRC-IRAP, Riddell's Roasters Inc.

Project team: Daniel Stechey (Canadian Aquaculture Systems), Grant Vandenberg (U Laval), Jeff Eastman (MAFRI), Eric Boucher (IPSFAD), Bill Robertson (Huntsman Marine Science Centre), Rudy and Leslie Reimer

For information contact: Daniel Stechey (stechey@cogeco.ca)

Workshop participants take first step to investigating development of a national broodstock program for rainbow trout

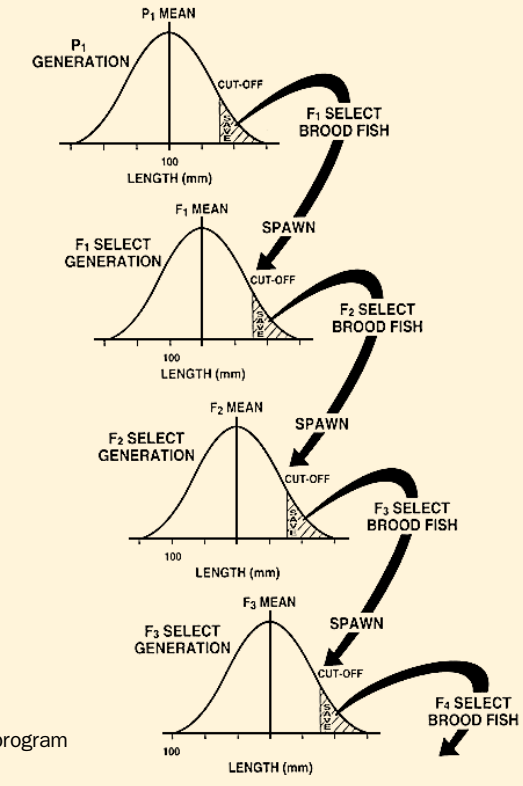


Trout eggs and alevins (Photo: E. Proulx)

If the freshwater aquaculture industry is to realize its potential, the 'unofficial' moratorium it faces must be addressed in a rational manner. Sustainable development must progress by means of research, development, and technology transfer activities in priority areas that are currently limiting its expansion.

One of those priorities is the establishment of a national broodstock program to enhance performance in rainbow trout, specifically targeting improved fillet yield, enhanced growth rate and greater tolerance to warm-water conditions.

As a first step in this process, the Interprovincial Partnership for the Sustainable Freshwater Aquaculture Development (IPSFAD) held a workshop on creating a selection and breeding program for rainbow trout aquaculture in Canada. This event, held in February 2009, drew together various Canadian stakeholders of the rainbow trout aquaculture industry and Canadian and international specialists in the genetic field to establish priorities. It also brought old and new players together to establish new partnerships for the benefit of the future national broodstock program.



Genetic selection program (Photo: E. Proulx)

Duration: Jan '09 – Mar '09

Funded by: NSERC - Strategic Workshops Program Co-funded by: DFO-NASAPI, DFO-ACRDP, NOAA, NRC-IRAP

Project team: Rich Moccia (U Guelph), Grant Vandenberg (U Laval), Eric Boucher (IPSFAD), Karen Tracey (NOAA), Steve Naylor (OMAF), David Bevan (U Guelph), Michael Burke (U Guelph)

For information contact: Rich Moccia (rmoccia@uoguelph.ca)

Composted fish waste (Photo: NOAA)

Analysis of composted fish waste enables farm to meet regulatory guidelines in Ontario

Increased restrictions and costs of rendering animal products, a partial response to outbreaks of bovine spongiform encephalopathy (BSE) in North America, have resulted in changes to the Dead Animal Disposal Act and stimulated the review of composting techniques for carcass disposal. Furthermore, there is the opportunity to produce a value-added product from waste that incurs ever increasing disposal costs.

A private fish farmer in Northern Ontario has developed a composting system for fish waste. The system utilizes fish processing waste and dead stock along with locally available waste sawdust in an aerobic digester to produce compost. While further refinement of the production process is ongoing, sampling procedures and analysis requirements have been finalized and the operation could produce over 2,000 tonnes of compost per year. The compost from this process is now analysed.

The Ontario Ministry of the Environment (OMOE) has regulatory guidelines for the production and use of aerobic compost in Ontario. These guidelines include site construction, operational methods and quality analysis. To comply with OMOE guidelines for the sale of commercial compost, selected metals and organic chemicals must not exceed stated levels and minimum concentrations of certain plant nutrients (e.g., N, P, K), organic matter, and carbon:nitrogen ratio are desirable. The required chemical analysis and compilation of the ensuing results were the focus of the project.

Duration: Jul '06 – Jul '08

Funded by: EC Co-funded by: DFO-ACRDP

Project team: Richard D. Moccia (U Guelph), David Bevan (U Guelph), Mike Meeker (Meeker's Aquaculture Canada Inc.), Doug Geiling (DFO)

For information contact: Richard D. Moccia (rmoccia@uoguelph.ca)

Website: http://www.aps.uoguelph.ca/~aquacentre

Researchers begin developing predictive models and nutrient trigger limits for cage culture in lakes

In Ontario, the Great Lakes provide a potential opportunity for growth in the fresh water sector. But perceived environmental impacts are presently restricting the growth of this industry. The need for sustainable environmental management of cage-aquaculture farms is of the utmost importance to preserve the ecological integrity of the Great Lakes. The environmental concerns include, but are not limited to, the impact of farming activities on water quality, benthic communities (excess feed and feces), and native fisheries. Industry, regulators, as well as academic and other government agencies are striving to create a sustainable ecosystem approach that would include a sustainable aquaculture industry.

This work is a component of a larger project to develop predictive models and nutrient trigger limits for a lake with cage aquaculture. The goal of this work is to organize, plan and implement the necessary means to collect the appropriate physical and chemical data essential to address current "science gaps" and provide sound data for use in development of predictive models and trigger limits. The components include developing a study plan to collect relevant physical and chemical data, reviewing existing physical and chemical data, consulting with owner/operators of fish farms to collect relevant information, generating detailed maps and illustrations of sampling locations, and developing a model of assimilative capacity and estimating nutrient loading from farms.

Sediment core sampling (Photo: B. Lalonde)

This work will increase the understanding of water movement, fluctuations, and the nutrient regimes of a freshwater lake with caged-aquaculture. This output will be used by Ontario regulators to make more informed science-based decisions to enable development of a sustainable freshwater aquaculture industry.

Duration: Jan '08 – Jan '09

Funded by: EC

Project team: Richard D. Moccia (U Guelph), Jacqui Milne (U Guelph)

For information contact: Richard D. Moccia (rmoccia@uoguelph.ca)

Website: http://www.aps.uoguelph.ca/~aquacentre

Computer tool supports regulator decision-making for site applications in Ontario

A computerized Decision Support Tool (DST) is being developed to provide a consistent formula to regulators in the review of aquaculture license applications. It is tied to a four-stage process. Any persons seeking to obtain an aquaculture license to culture fish in cages in open water must submit to OMNR detailed information on the site, location, water chemistry, surrounding ecosystem, public and aboriginal concerns and the proposed operational plan, as well as a risk analysis. This information will be entered into the DST by the applicant and submitted to OMNR. The DST becomes the application package, and supports regulators in deciding whether an application should be approved or denied, or identifies the need for further information or consideration.

The DST has ten worksheets which contain the decision criteria and document decision points which lead to a rating of risk pertaining to the 10 categories - Fish Habitat, Fish Health, Fish Communities, Species at Risk, Operational Practices, Water Quality, Sediment, Consultation, Navigable Waters, and Crown Land Tenure.

DST decision points result in a colour rating (green, yellow, orange or red) for each of the ten categories reflecting the level of risk. The "Recommendation Tab" assigns an overall rating to the final application based on the number of green, yellow, orange and red ratings for the ten categories and provides a final recommendation.

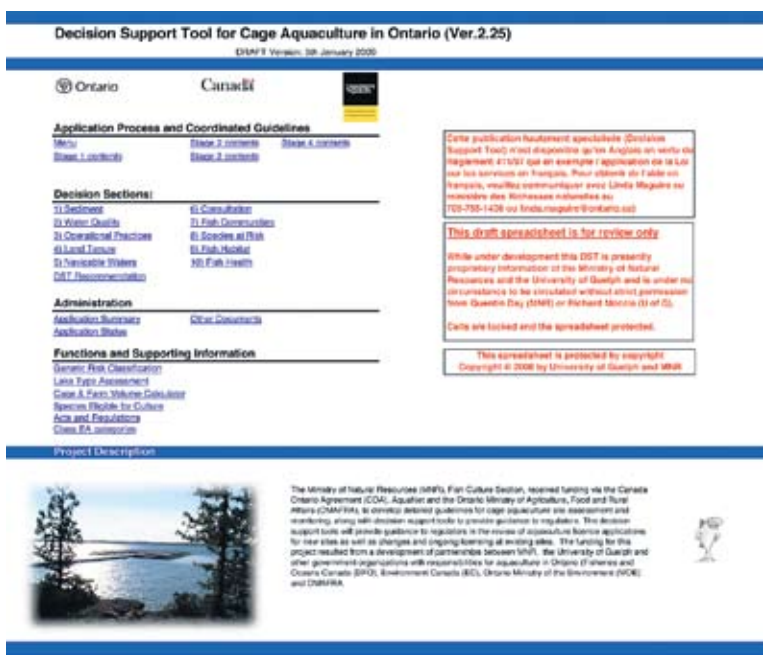
Duration: 2005 – 2009

Funded by: COA Co-funded by: AquaNet, OMAFRA

Project team: Richard D. Moccia (U Guelph), Quentin Day (OMNR), Lisa-Miller Dodd (OMNR), Laura Blease (OMOE), Amy Pogue (OMOE), Dave Ross (DFO), Wayne Hyatt (DFO), Nardia Ali (EC), Steve Naylor (OMAFRA), David Bevan (U Guelph), Gregor Reid (UNB)

For information contact: Richard D. Moccia (rmoccia@uoguelph.ca)

Website: http://www.aps.uoguelph.ca/~aquacentre



Decision Support Tool for cage aquaculture in Ontario

Newer feed formulations require updating of fish waste composition for Ontario regulations

Recently, there has been evidence that elevated levels of certain trace metals might accumulate under fish cages, which may warrant additional environmental concern. More recently, there has been discussion by the Ontario Ministry of the Environment, regarding the use of toxicity testing of benthic deposits (primarily fecal and feed wastes) below cage farms, as a possible means of assessing environmental impacts. All land-based fish farms in Ontario that require 'Certificates of Approval' for the collection and handling of effluent, need acceptable 'Standard Operating Procedures' (SOP's) for the disposal of materials collected in the licensed sewage treatment works.

A detailed chemical analysis of fish feces from Ontario aquaculture farms has been previously reported. However, the formulations and ingredients used in commercial fish feed in Ontario have changed significantly over the last 15 years. Notably, there has been an increase towards higher energy diets, total phosphorus concentrations have been reduced, fish-meal and plant meal types have changed, and there has been a reduction of the non-digestible materials (mainly carbohydrates and fibre) to create 'nutrient-dense' diets.

Therefore, research on the composition of rainbow trout feces warrants updating of this previously published material in order to reflect present day feed standards and management practices. This investigation provides an updated chemical analysis of feces collected from Ontario rainbow trout fed contemporary commercial feeds and addresses the implications of these findings to the Ontario Nutrient Management Act and its regulatory compliance.

Duration: Jun '06 – Jun '07

Funded by: EC Co-funded by: OMAFRA

Project team: Richard D. Moccia (U Guelph), David Bevan (U Guelph), Gregor Reid (DFO)

For information contact: Richard D. Moccia (rmoccia@uoguelph.ca)

Website: http://www.aps.uoguelph.ca/~aquacentre

Vertical temperature profiles aim to improve farm management at lake sites

Year-round vertical temperature profiles at different cage site environments are being investigated in order to understand temperature fluctuations to which fish are exposed and to learn how this may affect aquaculture management. Correlating these temperature profiles to farm productivity and health of the fish can assist decision making by farmers on topics such as feeding, health maintenance and waste management.

Reporting covers all of the plots of the different temperature profiles and relevant site-specific data tables. Suggestions are being made on how farmers can use this information to streamline their operational procedures for more effective management.

The goal is to make the aquaculture industry as environmentally dynamic as possible by incorporating all relevant monitoring parameters into adaptive management strategies which may be useful in minimizing the impacts of farms on the environment, and improving the health and quality of the fish produced.

Duration: May '07 – Dec '08

Funded by: EC

Project team: Richard D. Moccia (U Guelph), Kris Osuchowski (U Guelph)

For information contact: Richard D. Moccia (rmoccia@uoguelph.ca)

Website: http://www.aps.uoguelph.ca/~aquacentre

Feed company evaluates alternative fat sources in feed formulations for rainbow trout

Hand-feeding rainbow trout (Photo: D. Bevan)

The cost of feed is the single most significant factor in the economics of rainbow trout production. Fish oil sources in trout diets are expensive and because availability is expected to decline while demand continues to increase, feed prices are expected to increase, contributing to higher costs of fish production.

Fats and lipids are essential nutrients for fish. They are an important energy source, they allow absorption of fat-soluble nutrients, they play a role in membrane structure and they are components of hormones. There are several alternative sources of fats suitable for commercial trout diets. These sources can be used to manufacture a variety of diets, containing different protein:energy ratios, that may result in different growth responses.

The test diets in this trial are manufactured with commercially available products approved under the Canadian Feeds Act. The feed manufacturer desires to know if these substitutes are suitable in rainbow trout diet formulation such that they maintain nutrient quality in a cost efficient manner.

Growth performance, feed efficiency, morbidity, mortality, feeding behaviour and carcass yield are being used to assess the performance of the test diets, allowing comparison to existing commercial diets.

The anticipated benefit will be the ability to evaluate the effects of formulation on growth efficiency and overall profitability for both the trout producer and on carcass yield for the fish processor.

Duration: Mar '07 – Nov '07

Funded by: Martin Mills Inc. Co-funded by: OMAFRA

Project team: Richard D. Moccia (U Guelph), Michael Burke (U Guelph), Mark Wagner (Martin Mills Inc.)

For information contact: Richard D. Moccia (rmoccia@uoguelph.ca)

Website: http://www.aps.uoguelph.ca/~aquacentre

Monitoring flow of water on land-based fish farms enables better management of Ontario water resources

MagFlow Water Meter Assembly (Photo: D. Bevan)

The management of surface and ground water in Ontario is legislated by the Ontario Water resources Act (OWRA) and accompanying regulations. The Water Taking and Transfer Regulation (O.Reg 387/04) Section 9 requires all permit holders to collect and record data on the actual volume of water taken daily and to report this data to the Ontario Ministry of the Environment (MOE) annually. The volume of water taken must be measured by a flow meter or calculated using a ministry approved method. Several publications are available to assist permit holders comply with these regulations and an online data reporting system has been developed.

Knowledge of the actual water taking data, as opposed to the maximum permitted amount, will allow better management of Ontario's water resources through the development of water budgets and watershed-based planning and development strategies.

Most land-based aquaculture facilities hold a Permit to Take Water (PTTW) with a variety of conditions attached. This project reviews potential methods available for water flow monitoring at land-based aquaculture farms, outlines the criteria used for selection of an appropriate measurement device and provides a detailed evaluation on the use of electronic "Magnetic flow meters" recently installed at the Alma Aquaculture Research Station of the University of Guelph.

Duration: Jul '06 – Apr '08

Funded by: EC Co-funded by: OMAFRA

Project team: Richard D. Moccia (U Guelph), David Bevan (U Guelph)

For information contact: Richard D. Moccia (rmoccia@uoguelph.ca)

Website: http://www.aps.uoguelph.ca/~aquacentre

Investigating radiation bystander effects in fish

X-ray irradiation of trout eggs (Photo: D. Bevan)

In radiation biology, the accepted principle of exposure is that the effect of radiation is directly related to the dose which is received (i.e., an increase in the dose results in a directly proportional increase in the cellular or genetic level effect). However, at very low radiation doses the effects begin to deviate from what would be the classical predicted model of exposure effects.

This deviation is thought to be a result of the so-called 'Bystander Effect'. The bystander effect has been demonstrated in cultured cells and occurs when cells which have not been irradiated but are in the proximity of a radiated cell, begin to exhibit some or all, of the effects of direct irradiation (e.g., DNA damage, apoptosis or necrosis).

This project addresses potential concerns about heated waste water from nuclear power plants. The presence of a bystander effect could have important consequences for the safe use of heated effluent water for increasing aquaculture production, as well as its potential impact upon the reproductive success of fish, including the wild fisheries.

Additionally, the project may also support a new paradigm in our understanding of the effects of exposure to low levels of radiation and synergistic responses. The notion of a "bystander effect" has important implications in epidemiology and resource management, because this work is demonstrating that there may be unexpected responses to low level effects of radiation exposure, and these may have both detrimental as well as advantageous effects on the genetics and/or physiology of impacted fish species.

Duration: Nov '06 – May '10

Funded by: NSERC Co-funded by: OMAFRA

Project team: Colin B. Seymour (McMaster U), Carmel E. Mothersill (McMaster U), Richard W. Smith (McMaster U), Richard D. Moccia (U Guelph)

For information contact: Colin Seymour (seymouc@mcmaster.ca)

Website: http://www.aps.uoguelph.ca/~aquacentre

Ontario advances coordinated process for cage aquaculture sites

The Ontario Ministry of Natural Resources (OMNR), Fish Culture Section, received funding through the Canada Ontario Agreement (COA), for 2004-09, to develop detailed guidelines for cage aquaculture site assessment and monitoring, along with a decision support tool to provide guidance to regulators. The guidelines, when completed, will set out the specific data collection requirements for an applicant, including collection methodology and rationale, and also identify any ongoing monitoring requirements.

The decision support tool will provide guidance to regulators in the review of aquaculture license applications for new sites as well as changes and ongoing licensing at existing sites. The funding for this project is contingent on the development of a partnership with academic partners, University of Guelph, and other government organizations with responsibilities for aquaculture in Ontario.

This project is consistent with the mandate of the Aquaculture Task Group (ATG) of the Canadian Council of Fisheries and Aquaculture Ministers (CCFAM) to address site access issues and to focus on improving and harmonizing the site application and review processes. It also assists Ontario in continuing to regulate the aquaculture industry in a manner providing for ecologically sustainable growth. By working together, the guidelines and decision support tool we develop will help to minimize the ecological risks associated with aquaculture and will support the harmonization process.

Ontario aquaculture cage farm (Photo: D. Bevan)

Duration: Jan '04 – Dec '09

Funded by: COA Co-funded by: U Guelph, OMAFRA, OMOE, DFO, EC

Project team: Quentin Day (OMNR), Lisa-Miller Dodd (OMNR), Laura Blease (OMOE), Amy Pogue (OMOE), Dave Ross (DFO), Wayne Hyatt (DFO), Nardia Ali (EC), Steve Naylor (OMAFRA), Richard Moccia (U Guelph), David Bevan (U Guelph)

For information contact: Quentin Day (Quentin.day@ontario.ca)

New Brunswick Institute conducts genetics program to improve Arctic char

In recent years, the Coastal Zone Research Institute (CZRI) has been working with the New Brunswick, Nova Scotia and Quebec fish farming industry to genetically improve Arctic char in order to develop leading-edge solutions to ensure the production of high-quality eggs with known genealogy.

CZRI is breeding this species in captivity to select the highest-performing individuals in each generation for intensive production. Researchers are currently at the fourth generation, which means these are higher-performing fish. CZRI is the only organization in the world that is rearing a Fraser strain broodstock with a known pedigree.

This research project is also intended to create several high-performing families of Arctic char. This is essential for maintaining the genetic diversity of the stock, which will make it possible to rear a fifth generation and all-female lots that perform as well as the preceding generations.

The program also includes scientific studies on the evaluation of growth, salinity tolerance, flesh pigmentation, late maturation, effects of triploidy, and the continuous improvement of rearing techniques.

Duration: 2004 – 2010

Funded by: ACOA-AIF Co-funded by: NBIF, NB DAA-Total Development Fund, NSERC

Project team: Claude S. Pelletier (CZRI), Michel Poitras (CZRI), Gilles David (CZRI), Joël Cormier (CZRI), Guelph University, Merlin Fish Farm, NB DAA, CJL Pisciculture, Aquaculture Nord'est

For information contact: Claude S. Pelletier (Claude.S.Pelletier@irzc.umcs.ca)

Study to investigate protective effect of UV on fin abrasion

Now in its third year, a DFO co-funded study on the effects of ultra-violet radiation (UVR) on salmon fin abrasion is getting down to brass tacks. After two years of work with three strains of Pacific salmon, Dr. Max Bothwell of Environment Canada and Dr. Blair Holtby of DFO, will be narrowing their focus to one strain this year, and trying to determine the effect of stocking densities on a previously-demonstrated "protective" effect of UVR exposure in young salmonids.

The current work is being co-funded by DFO's Aquaculture Collaborative Research and Development Program (ACRDP) and Creative Salmon Company Ltd., a BC firm interested in improving the appearance and quality of chinook salmon for the high-end Japanese gourmet market.

A UVR paradox

UVR is a short- wavelength, high-energy component of natural sunlight that has long been demonstrated to have a variety of negative effects on living organisms. The current investigations began in 2007 when Max Bothwell decided to follow up on previous anecdotal observations of juvenile coho. Young fish reared indoors or under cover developed badly abraded fins, while those reared in open tanks outdoors or in shallow "free-run" flumes consistently did not. This went against conventional wisdom about the damaging effects of UV, a nagging paradox that could have important repercussions for hatchery operations. Preliminary work in flumes and Capilano troughs with populations of coho fry confirmed the protective effects of UV radiation and ruled out the involvement of pathogens.

The project began with Bothwell and his BC team performing UVR exposure trials on Big Qualicum chinook pre-smolts. They were astonished to find no measurable difference between exposed and sheltered populations, an indication that the previously noted "protective" effect of UVR on coho fins might be species- or strain-specific, dependent on timing, or due to unknown factors.

In 2008 the team ran expanded trials at the Sea Spring Hatchery in Chemainus, BC, using three different strains of salmon: Big Qualicum chinook, Big Qualicum coho and Yukon chinook. Tanks were covered with either UV-transparent or UV-opaque Plexiglass, and

Tank set-up at Sea Spring Hatchery. *(Photo: Max Bothwell)*

image analysis software was used to quantify fin damage. Both the Big Qualicum coho and the Yukon chinook showed significantly higher fin-fraying without UVR exposure. The Big Qualicum chinook continued to appear unaffected, regardless of exposure. With lower stocking densities in these trials, the effects were somewhat less pronounced than previous observations, but remained significant.

In this final year of the current ACRDP funding, work is underway at Sea Spring's hatchery to investigate in more detail the effects of stocking densities and UV radiation with Yukon chinook, the strain that Creative Salmon is interested in developing for their Japanese markets. Bothwell also wants to study hormone responses mediated by the pineal glands of fish under different conditions, seeking a possible mechanism for the apparent protective effect of UVR on fin health.

Future studies would allow the team to relate protective response to gradients of UVR intensity, timing and duration, both indoors and outdoors, and identify the exact physiological mechanisms responsible for the protection from fin abrasion in UVR-exposed fish. This could translate into direct health benefits for hatcheries and improved product quality across the industry.

Duration: Jan '08 – Oct '09

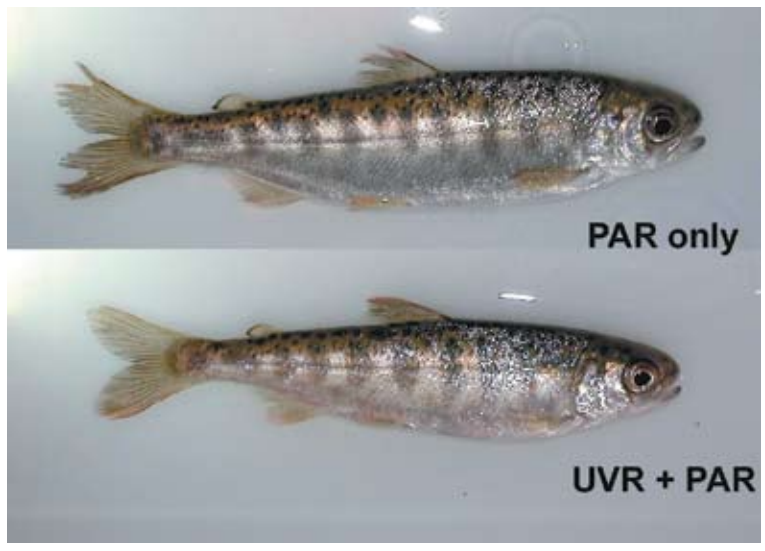
Funded by: DFO-ACRDP Co-funded by: Creative Salmon Co. Ltd.

Project team: Blair Holtby (DFO), Max Bothwell (EC), D. Groves (Sea Spring Salmon Farm Ltd.), Jake Etzkorn (DFO)

For information, contact: Blair Holtby (Blair.Holtby@dfo-mpo.gc.ca)

Juvenile Big Qualicum Chinook. *(Photo: Max Bothwell)*

Downloading radiation exposure data in the field. *(Photo: Max Bothwell)*



Yukon chinook exposed to photoactive radiation (PAR) alone and to both PAR and ultraviolet radiation (UVR) show visible differences after five months. *(Photo: Max Bothwell)*

Mature red and white Chinook salmon (Photo: R. Devlin)

Molecular genetic capabilities to improve strains of Chinook salmon in BC

Chinook salmon farming in British Columbia has been underway for more than 20 years and remains an important industry that provides significant commercial and social benefit to the Province. The future success of salmon farming, as with all agricultural activities, depends upon continual application of science. In particular, application of emerging genomic methodologies has significant potential to facilitate the development and improvement of salmon strains in BC.

For example, developing a molecular genetic map for Chinook salmon will allow the identification of genes involved in commercially important traits which can facilitate marker-assisted breeding programs. Similarly, application of microarray technology (large-scale gene expression analysis) has large potential for its ability to detect important genetic differences between strains of salmon with different phenotypic traits.

Molecular mapping and gene microarray technology are being utilized in this project to enhance molecular genetic capabilities for Chinook salmon. Investigation is focused on carotenoid pigment deposition in flesh as a major trait system, but also monitoring growth rate, survival, and age of maturation within these experiments.

Duration: Jul '08 – Jul '12

Funded by: DFO-ACRDP Co-funded by: Yellow Island Aquaculture Ltd.

Project team: Robert Devlin (DFO), Wendy Tymchuk (DFO), Ann and John Heath (YIAL), Dan Heath (U Windsor), Willie Davidson (SFU), Dag Inge Vage (CiGene, Norway)

For information contact: Robert Devlin (Robert.Devlin@dfo-mpo.gc.ca)

Efficacy of the APEX vaccine is tested under severe conditions

Efficacy of the APEX vaccine in Atlantic salmon subjected to an IHNV exposure simulating natural and/or elevated field challenges

Infectious hematopoietic necrosis virus (IHNV is an aquatic rhabdovirus that has had a devastating effect on the BC salmon aquaculture industry. In particular, Atlantic salmon are highly susceptible to this endemic pathogen at all life stages.

To minimize the effects of IHNV, Novartis Animal Health Canada Inc. has developed a highly efficacious IHNV plasmid vaccine (APEX-IHN®) that is commercially available. Laboratory tests of the vaccine have revealed the vaccine to provide significant protection against lethal virus challenge. The efficacy observed in the laboratory setting has warranted the use of the vaccine in the field, however due to the lack of a natural field challenge it remains unclear as to the efficacy of the vaccine in an environmental outbreak.

This project will evaluate the effectiveness of the APEX vaccine under conditions that are equal to, or more severe than, a natural field challenge. This work is necessary for salmon farmers to better evaluate husbandry and disease management strategies.

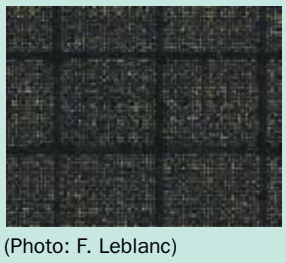
Duration: Apr '07 – Oct '07

Funded by: DFO-ACRDP Co-funded by: Marine Harvest, Novartis Animal Health Canada Inc.

Project team: Kyle Garver (DFO), Laura Hawley (DFO), Diane Morrison (Marine Harvest Canada Inc.), Todd Cook (Novartis Animal Health Canada Inc.), Allison MacKinnon (Novartis Animal Health Canada Inc.)

For information contact: Kyle Garver (Kyle.Garver@dfo-mpo.gc.ca)

Researchers identify genetic markers of the immune response to ISA



(Photo: F. Leblanc)

Infectious diseases present a significant economic burden to finfish aquaculture industries and there is concern that diseases may also negatively impact wild fish populations. Increasingly, genomic tools are being used to investigate diseases of fish and their causative agents and are beginning to provide scientists, clinicians and regulators with management options. Despite this, very little is known about the diseases and pathogens affecting Canadian finfish culture industries or adjacent wild populations.

Infectious salmon anemia virus (ISAV) is an important virus pathogen of salmonids and causes mass mortalities. It remains a recurrent problem in Eastern Canada and Maine since the initial epizootics of 1996.

This study is taking a genomic approach to the disease using DNA microchips to better understand the short and long term immune response of Atlantic salmon to ISAV and to identify genetic markers of this response. Validation of these genetic markers in vivo will provide tools to study disease and recovery from disease, resistance to clinical disease, or response to vaccination.

Duration: Jul '07 – Mar '09

Funded by: DFO-ACRDP Co-funded by: New Brunswick Salmon Growers Association, DFO-GRDI

Project team: Nellie Gagné (DFO), Mark Laflamme (DFO), Francis Leblanc (DFO), Kira Salonius (DFO), Nathalie Simard (DFO)

For information contact: Nellie Gagné (Nellie.Gagne@dfo-mpo.gc.ca)

Novel recombinant vaccine models against Infectious Salmon Anemia Virus (ISA)

Infectious salmon anemia virus (ISAV) is an important virus pathogen of salmonids and causes mass mortalities. It remains a recurrent problem in Eastern Canada and Maine since the initial epizootics of 1996.

Recombinant vaccines are based on the expression of synthetic DNA constructs encoding proteins from specific pathogens. Heat Shock Proteins (HSPs) are involved in protein conformation, chaperoning, shuffling, etc. Whenever a cell is stressed, HSPs are produced. When cells rupture, such as during viral infections, HSP-peptide complexes are released, and detected by specialized cells that present the antigenic peptide at their surface, thus activating the cytotoxic T cell response, as part of an effective immune response.

Researchers are taking a novel approach using recombinant ISAV protein subunits combined in vivo to fish HSPs. Various studies have demonstrated that antigenic recombinant peptides are more effective when combined with HSPs. In this approach, we will transfect fish cell lines with recombinant expression vectors. Once recombinant ISAV proteins are produced in these cells, necrosis (unplanned cell death) will be induced. Necrosis conditions will be selected such as to obtain the highest level of HSPs production before cell burst, and release of recombinant ISAV proteins associated with HSPs.

Mélanie Roy (M.Sc candidate) preparing fish cells for plasmid transfection (Photo: N. Gagné)

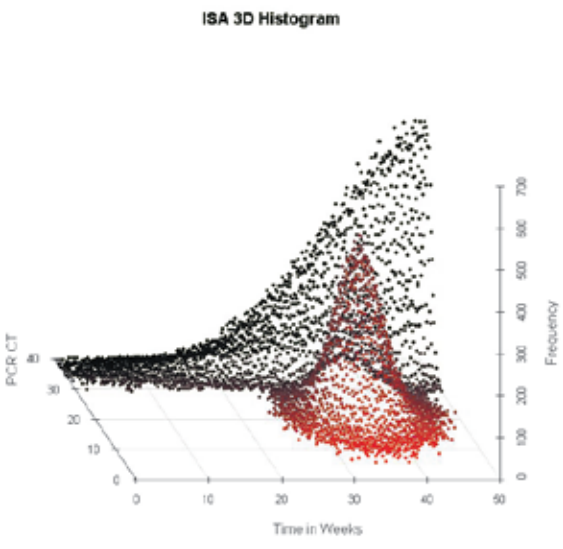
Duration: Jul '07 – Mar '09

Funded by: DFO-ACRDP Co-funded by: NBSGA, DFO-GRDI

Project team: Nellie Gagné (DFO), Mark Laflamme (DFO), Mélanie Roy (MSc Student, U Moncton), Kira Salonius (DFO), Nathalie Simard (DFO)

For information contact: Nellie Gagné (Nellie.Gagne@dfo-mpo.gc.ca)

ISA prevalence and sampling strategy in relation to outbreak stage and vaccination status



Hypothesized 3D Histogram of an ISAV outbreak. The frequency of infection is represented over time in function of the virus load (low values of PCR CT refer to high virus load, in red, when low values of PCR CT values refer to low virus load, in black). High infected fish (in red) are assumed to match with clinical mortality, and low infected fish are assumed to be apparently healthy fish.

In 2005, a series of salmon cages were initiated in the New Brunswick aquaculture industry to explore vaccine efficacy in a randomized clinical field trial. In 2006, one of the study cages experienced a severe ISAV episode caused by the HPR4 virulent strain.

Preliminary results from these samples revealed that infected salmon are either highly or lowly infected with very few intermediate stages detected. This unexpected observation led to a hypothetical three dimensional model of the disease dynamic during the outbreak. This project is investigating the phenomena further.

Firstly, the model is being refined by further viral quantitative testing of this population. This is expected to provide a better comprehension of the disease dynamic which in turn will lead to an optimized surveillance program.

Secondly, the outbreak cage contained 7 different groups of Atlantic salmon vaccinated against different fish diseases including 3 groups vaccinated against ISAV and 4 groups not vaccinated against ISAV. Utilizing survival analysis statistical techniques is allowing for the simultaneous analysis of the prevalence and virus load distribution controlling for the vaccine group as well as other confounding factors. This kind of efficacy assessment, and the deeper understanding of the protective effect of the ISAV vaccine, will directly benefit the salmon culture industry.

Duration: Feb '08 – Mar '09.

Funded by: DFO-ACRDP Co-funded by: Cooke Aquaculture Inc.

Project team: Nellie Gagné (DFO), Charles Caraguel (UPEI-AVC), Larry Hammell (UPEI-AVC), Carol McClure (UPEI-AVC), Mike Beattie (NB Department of Agriculture and Aquaculture), Larry Ingalls (Ocean Horizons Canada), Mike Szemerda (Cooke Aquaculture Inc.)

For information contact: Nellie Gagné (Nellie.Gagne@dfo-mpo.gc.ca)

Loading the qRT-PCR machine to begin a run

Efficacy of the APEX vaccine in Atlantic salmon subjected to an IHNV exposure simulating natural and/or elevated field challenges

The source of the infectious hematopoietic necrosis virus (IHNV) introduction to farmed salmon is unknown, but epidemiological investigations have identified sockeye salmon and herring as likely sources. Due to the potential devastating effect of IHNV on the economic sustainability of the BC salmon aquaculture industry, companies have developed biosecurity action plans for viral containment in the event of another outbreak. However, effectiveness of any containment plan depends on rapid diagnosis of the index case. Therefore, rapid and accurate diagnosis of IHNV is essential. The traditional method of diagnosing IHNV was through recognizing necrosis of cells grown in tissue culture – a technique requiring between 5 and 21 days for confirmation of virus.

Quantitative polymerase chain reaction (QPCR) is rapidly replacing more traditional methodologies as a diagnostic test. QPCR offers many advantages over other diagnostic techniques including a fast turn-around time as well as reduced frequency of false positives, increased sensitivity, low requirements for tissue and high sample through-put. This technology can also be employed in the detection of IHNV but must include an additional step owing to the fact that the genome of IHNV is composed of single-stranded, negative-sense RNA. Therefore, a reverse transcription step is required to convert genomic and messenger RNA (mRNA) to complementary DNA (cDNA). The research team is working on developing this type of assay for the detection of IHNV – a quantitative reverse transcription - qRT-PCR assay.

Duration: Apr '07 – Mar '09

Funded by: DFO-ACRDP Co-funded by: BCSFA, BC CAHS

Project team: Kyle Garver (DFO), Valerie Funk (DFO), Zina Richmond (BC CAHS), Laura Hawley (DFO)

For information contact: Kyle Garver (Kyle.Garver@dfo-mpo.gc.ca)

Sampling salmon cage with controlled photoperiod

Melatonin assay improves photoperiod regimes to reduce grilsification

Photoperiod plays a significant role in the development and maturation of salmon. Alterations in the natural photoperiod can accelerate or decelerate smoltification or reproductive maturation. By appropriately manipulating photoperiod, spawning times can be controlled to allow for the production of out-of-season smolts, and grilse rates can be reduced during grow out allowing enhanced growth and greater insurance of quality marketable product.

The way in which photoperiod is perceived by salmon and how signals are relayed to systems which control sexual maturation is not clearly understood. But evidence suggests that melatonin, produced by the pineal gland, may be a significant mediator of the photoperiod effects. In salmon, melatonin levels rise during dark hours and drop during light hours. Since melatonin levels appear to help communicate day/night lengths to salmon, monitoring its levels would be an effective way to measure the efficiency and accuracy of artificial lighting systems in lengthening light hours in a 24 hour day.

The project team is investigating the levels of melatonin observed in salmon under natural lighting photoperiods in the Bay of Fundy region and under manipulated photoperiods through the use of artificial lighting. Melatonin levels are correlated with grilse rates, fish weight, water temperatures, family/stock origin and light intensity measurements. The data from these investigations should indicate the effectiveness of the lighting regimes being used in reducing melatonin levels and give insight on how grilse rates might be further reduced.

Duration: Jul '07 – Mar '09

Funded by: DFO-ACRDP Co-funded by: Cooke Aquaculture Inc.

Project team: Brian Glebe (DFO), Keng Pee Ang (Cooke Aquaculture Inc.)

For information contact: Brian Glebe (Brian.Glebe@dfo-mpo.gc.ca)

How do different strains of ISAV affect fish in the field?

Different strains of Infectious salmon anemia virus (ISAV) are associated with different pathogenicity in the field and in the laboratory. The apparent, but poorly elucidated disparity in virulence of ISAV strains confounds management decisions relating to infected fish. Laboratory studies show differences in mortality rates and onset, with some ISAV strains such as the HPR0 apparently posing little threat to the health of the fish, and strains such as the HPR4 posing considerable threat to infected fish.

While laboratory studies provide useful information, they are rarely an accurate representation of how the strains affect fish in the field. However field studies are often hampered by incomplete data sets, and confounding factors such as variables between sites and factors that can influence observed disease outside of the pathogen strain itself.

In the present study, the industry is making available detailed mortality data for ISAV infected and uninfected fish for two year classes of fish. Analysis of this data and other confounding factors will allow elucidation of the impact of different ISAV strains on fish in the field, helping inform fish health decisions regarding depopulation or eradication and disease control, and leading to intelligent and economical disease management.

Duration: Feb '08 – May '08

Funded by: DFO-ACRDP Co-funded by: Cooke Aquaculture Inc.

Project team: Nellie Gagné (DFO), Rachael Ritchie (RPC).

For information contact: Nellie Gagné (Nellie.Gagne@dfo-mpo.gc.ca)

Salmon cages- Spyglass II

Monitoring in Fortune Bay assesses the risk of hypoxia in Atlantic salmon

Aquaculture is expanding rapidly in Fortune Bay and specific sites have experienced low dissolved oxygen in the past. Real time biological and environmental monitoring of the area is vitally important. Water currents, oxygen, temperature, and salinity are being monitored at sites where low dissolved oxygen has been observed as well as sites that have not seen such events.

In addition, Newfoundland weather produces significant environmental effects impacting fish. Determining stress levels and immune responses of cultured fish are essential tools for improving productivity and fish health. *In vitro* and *in vivo* experiments will be conducted on salmon to investigate health status of farmed fish under environmental stressors such as hypoxia through evaluation of fish immunity and physiology using flow cytometry and real-time PCR. Laboratory trials are being conducted at the Northwest Atlantic Fisheries Centre. Field sampling of fish is being conducted in collaboration with the industry partner to examine any physiological and/or immunological changes in fish during episodes of hypoxia.

Duration: Apr '08 – Mar '10.

Funded by: DFO-ACRDP Co-funded by: Northern Harvest Sea Farms.

Project team: Dounia Hamoutene (DFO), Gehan Mabrouk (DFO), Dwight Drover (DFO), Lynn Lush (DFO), Fred Page (DFO), Doug and Jennifer Caines (Northern Harvest Sea Farms)

For information contact: Dounia Hamoutene (Dounia.Hamoutene@dfo-mpo.gc.ca)

Use of genetic markers indicates family-level differences in coho growth performance

Family selection methods are powerful approaches for improving the performance of agricultural species. Modern methods of analysis now enable tracking parents and offspring to families using microsatellite and other molecular genetic marker based systems. Development of a suite of variable genetic markers therefore can significantly enhance breeding programs. This project is developing and applying these genetic markers to cultured coho salmon.

Some of these variable markers have been mapped to chromosomal regions associated with loci (quantitative trait loci QTLs) controlling traits of interest which enhance performance in other species. Analysis of the genetic basis of growth in coho salmon and rainbow trout show that this trait is largely controlled by additive genetic variance, making it likely that controls of growth rate will be found in these two species using family analyses of phenotypic variation and molecular genetics.

Recent research has shown that QTL marker loci identified in one salmonid species are often associated with control of the same trait in other salmonids. The team is developing markers associated with QTLs originally developed *de novo* in rainbow trout, Arctic char and Atlantic salmon, and applying them to coho salmon production populations to assess whether family-level differences in performance exist, and to assess whether specific markers are associated with growth performance.

Aquaculture broodstock can become bottlenecked due to a lack of novel genetic material being introduced over a period of several generations. Researchers in this project have introduced new genetic variation from wild strains into a domesticated coho salmon stock, and are currently assessing the effects on growth performance under aquaculture conditions. Genetic marker-based determination of families within this production population is being used for this analysis.

Duration: Nov '07 – Sep '10.

Funded by: DFO-ACRDP Co-funded by: Tri-Gen Fish Improvement Ltd.

Project team: Ruth Withler (DFO), Tri-Gen Fish Improvement Ltd.

For information contact: Ruth Withler (Ruth.Withler@dfo-mpo.gc.ca)

Eggs subdivided for fertilization in breeding program

Coho in polyculture with wasabi

Coho in rearing tank

Coho fillets

Flesh quality of farmed salmon enhanced through diet formulation modelling

A multidisciplinary team of researchers with expertise in nutrition, contaminants, health and aquaculture science is developing a model to predict contaminant burden and fatty acid content in farmed salmon based on the composition of contaminants and lipid profiles in the corresponding fish diets.

Farmed salmon are fed alternate diets and contaminant bioaccumulation is examined as a function of fish size, feeding practices and growth characteristics. The levels of the target contaminants (PCDDs, PCDFs, PCBs, PBDEs, and 20 Organochlorine [OC] pesticides) are measured in the flesh of a wide range of farmed Atlantic salmon of all sizes fed three different composition diets.

Concurrently, the research team is examining the impact of the alternate feeds on the profiles of the omega-3 unsaturated fatty acids in the flesh of the target species. The bioaccumulation behaviour of the target contaminants and the profiles of the fatty acids are then modeled. The model is calibrated according to the findings of this study. The intent is to use the model developed from this study to predict contaminant burden and fatty acid content in farmed salmon based on the composition of contaminants and lipid profiles in the corresponding fish diets.

Duration: Jul '08 – Mar '10.

Funded by: DFO-ACRDP Co-funded by: Cooke Aquaculture Inc., NRC.

Project team: Michael G. Ikonomou (DFO), Keng Pee Ang (Cooke Aquaculture Inc.), Santosh P. Lall (NRC IMB).

For information contact: Michael Ikonomou (michael.ikonomou@dfo-mpo.gc.ca)

New Brunswick team developing novel vaccine technologies

A research group in New Brunswick is working on a truly novel form of vaccine for salmonids. Farmed Atlantic salmon are susceptible to a variety of pathogens from bacterial or viral origins. To date, only a few commercial vaccines are available, and of these, many have less than the desired efficacies. Many of these vaccines are based on attenuated or killed pathogens. More modern vaccines are based on recombinant DNA technologies. Such vaccines "pre-expose" the fish to non-virulent versions of the pathogen, with the goal of boosting the immune response if an actual infection should occur.

This team, however, is developing a novel form of vaccine based on the RNA interference (RNAi) mechanism. The mechanism works by transfecting fish cells with small RNA molecules. These molecules act as guides that target and destroy pathogenic mRNAs by using the fish's RNAi system. The fish RNAi system is active in natural populations of fish, where it functions to regulate gene expression, and protect fish from certain infectious diseases.

Work in this project is focused on manipulating this system to specifically protect fish from pathogens that are problematic to the salmon aquaculture industry. The project is initially developing a vaccine against the Infectious Salmon Anemia Virus, but the researchers believe this system can be easily adaptable to many other pathogens.

Duration: Sep '08 – Apr '09

Funded by: DFO. Co-funded by: U Moncton.

Project team: Mark Laflamme (DFO), Nellie Gagné (DFO), Chanel Losier (Undergraduate student, U Moncton)

For information contact: Mark Laflamme (Mark.Laflamme@dfo-mpo.gc.ca)

Airlift feed collector reduces feed loss and environmental impact of salmon farming in Newfoundland

Feed wastage from Atlantic salmon cage sites on the south cost of Newfoundland can be costly and it is important to evaluate and reduce the economic and environmental impact. Investigators in this project are determining the amount of actual feed wasted at different feeding times and the pattern of such wastage during each meal. They are also examining the nutritional losses of the wasted pellets and their disintegration pattern.

A trial to evaluate the efficacy of using an airlift feed collector to collect and re-suspend the uneaten pellets back to the cages is being conducted. The effect of this technique on fish performance and feed conversion ratios is also being investigated. In addition, the team is conducting an evaluation of the environmental effects of the reduced feed wastage on the sea bed under the cages.

Duration: Jun '07 – Mar '09

Funded by: DFO-ACRDP Co-funded by: Natures Sea Farms Inc.

Project team: Atef A.H. Mansour (DFO), Gehan Mabrouk (DFO), Elizabeth Barlow (NL DFA)

For information contact: Atef Mansour (Atef.Mansour@dfo-mpo.gc.ca)

Researchers use DNA chips to uncover immune response to ISAV isolates

Infectious salmon anemia virus (ISAV) affects salmon in Atlantic Canada. In earlier research by the team, controlled challenges were conducted using an ISAV HPR2 (non-virulent) isolate and low levels of fish mortality were observed. The team hypothesized that the surviving fish had developed immunity against ISAV and would resist exposure to virulent ISAV isolates. This hypothesis was supported by a high survival rate of these fish following a re-challenge with an ISAV HPR4 isolate (virulent type). Further work with various rearing conditions and exposure regiments is being done in this project to confirm these results.

Although a variety of factors may be implicated, it seems the apparent variability in virulence between the various ISAV isolates is linked to the HPR type. The viral mechanisms leading either to fish death or survival and resistance are not well understood at the immune or molecular levels. In order to gain further understanding of these mechanisms, the research team is using salmon DNA chips to study the immune response and global gene expression patterns in fish following exposure to either HPR2- or HPR4-type isolates of ISAV.

The results of this project are expected be useful in many areas of fish health such as novel vaccine development, the evaluation of isolate virulence, fish selection for resistance to disease, and others.

Duration: Apr '08 – Mar '11

Funded by: DFO-GRDI.

Project team: Nellie Gagné (DFO), Mark Laflamme (DFO), Brian Glebe (DFO)

For information contact: Nellie Gagné (Nellie.gagne@dfo-mpo.gc.ca)

Aquaculture Engineering Group establishes Nova Scotia operation to demonstrate eco-friendly solutions

Aquaculture Engineering Group Inc. (AEG) is establishing a small finfish aquaculture operation in St. Mary's Bay, Nova Scotia to demonstrate sustainable technologies for salmon farming. The company plans to raise Atlantic salmon on the site through the early smolt stage of a grow-out cycle (60-300 g).

AEG is developing and demonstrating a number of its advanced solutions through this project. The *AEG Feeder* provides stock with pulse feeding capability compared with the meal feeding approach that is now standard in the industry. The AquaSonar technology and the onboard *AEG Feeder* integrate the fish sizing program to allow daily fish size updates from permanently mounted AquaSonar units. The AEG site management software application *Neptune* is being applied to evaluate daily smolt size data for superior feed management and market planning.

A submersible HDPE collar is being developed for use with the innovative *AEG Containment System*. Logistics mitigation strategies, possible only while using integrated *AEG Solutions* to enhance overall farm management and productivity, are being refined.

Aquaculture Engineering Group Inc. was incorporated in November 2002 to develop equipment and management solutions that address current industry technology shortcomings.

Duration: Aug '08 – Dec '10

Funded by: DFO-AIMAP Co-funded by: NS DFA, ACOA, NRC-IRAP, Skretting Canada, Marine Systems International.

Project team: Chris Bridger (AEG), Phillip Dobson (AEG), Wade Landry (AEG), Dave Hoar (Motion Design), Skretting Canada, Motion Design, Marine Systems International, Future Nets & Supplies, Aquatic Sensing Technologies Limited, Huntsman Marine Science Centre.

For information contact: Chris Bridger (chris.bridger@aeg-solutions.com)

Website: http://www.aeg-solutions.com

Oceanographic study supports salmon production management in Newfoundland

The province of Newfoundland is experiencing a significant influx of investment in salmonid farming. The increasing biomass, the growing number of companies, the diversity of production strategies, and the concentration of farm sites, particularly in outer Bay d'Espoir, are challenging the management of biosecurity and sustainability of salmon farming on the south coast of Newfoundland.

The lack of data and full understanding of the oceanography of the outer Bay d'Espoir area precludes establishment of scientifically validated production and management areas to guide site licensing, production planning, and sustainable management of the industry. The problem is particularly acute in this area because company production plans will result in overlapping year-classes in the area in 2009.

This project is establishing the infrastructure and the foundation for Newfoundland to be able to carry out an oceanography program to collect and model the physical environmental data - currents, dissolved oxygen, temperature, and salinity – and map the environmental parameters and potential zones of influence that will be used to establish production management areas.

Duration: Sep '08 – Mar '09

Funded by: DFO-PARR

Project team: Gehan Mabrouk (DFO), Geoff Perry (DFO), Dave Senciall (DFO), Fred Page (DFO), Peter J. Cranford (DFO), Dwight Drover (DFO), Randy Losier (DFO), Thomas Puestow (MUN C-CORE), Darrell Green (NAIA)

For information contact: Gehan Mabrouk (Gehan.Mabrouk@dfo-mpo.gc.ca)

Rapid IHN detection technique piloted in BC project

Lab technician, Kristin Mulholland, pipetting with precision (photo by BC CAHS)

In British Columbia, infectious hematopoietic necrosis virus (IHNV) is the most economically significant viral pathogen of salmonids. Since the introduction of Atlantic salmon to the BC coast in the mid 1980's, there have been two serious outbreaks of IHN in farmed Atlantic salmon. The estimated economic loss resulting from both combined outbreaks was $40 million in inventory representing $200 million in lost sales. Due to the potential devastating effect of IHNV on the economic sustainability of the BC salmon aquaculture industry, companies have developed biosecurity action plans in the event of another outbreak. However, the effectiveness of any such plan depends on rapid diagnosis.

The traditional method of diagnosing IHNV was through recognizing necrosis of cells grown in tissue culture – a technique requiring between 5 and 21 days for confirmation of virus. Quantitative PCR (QPCR) is rapidly replacing more traditional methodologies as a diagnostic test. QPCR offers many advantages over other diagnostic techniques including a fast turn-around time, increased sensitivity, and high sample through-put. The BC Centre for Aquatic Health Sciences (BC CAHS) is piloting the application of the rapid detection for salmon farms in BC.

Located in Campbell River, BC CAHS operates as a fourth pillar organization bringing together industry, academics and government researchers to drive innovation.

Duration: Jul '08 – Jan '09

Funded by: DFO-AIMAP Co-funded by: BC Salmon Farming Industry.

Project team: Linda Sams (BC CAHS), Sonja Saksida (BC CAHS), Valerie Funk (BC CAHS), Kevin G. Butterworth (UBC-CAER)

For information contact: Linda Sams (Linda.sams@cahs-bc.ca)

Mike Anderson of New Zealand King Salmon looking into the microscope for activity of sperm after the milt was brought out of the cryopreserved state. (Photo: BC CAHS)

BC project implements new cryopreservation technology for aquaculture

Cryopreservation of milt or sperm from fish is a new technology in the aquaculture industry. This is in contrast to cattle breeding where artificial insemination (AI) with frozen semen has been essential for breeding progress since 1965. Today advances in technology have reached a level where cryopreservation can be exploited commercially. Cryopreservation of milt can increase the number of offspring from genetically superior males, and speed up the breeding process. For production of commercial eggs, frozen milt increases the possibilities of varied production techniques and increased operational efficiencies.

The BC Centre for Aquatic Health Sciences (BC CAHS) is coordinating a project to import expertise in cryopreservation techniques from New Zealand King Salmon and transfer those techniques through staff and technician training and through pilot, commercial application. With a focus on sustainable farming practices, New Zealand King Salmon has built a reputation for one of the finest salmon stock breeding programs in the world and uniquely avoids the use of chemicals or vaccines in supporting the pristine advantages of its grow-out environment in the Marlborough Sounds.

This project brings together BC salmon farming companies working through their membership with the BC Salmon Farmers Association (BCSFA).

Duration: Sep '08 – Nov '08

Funded by: DFO-AIMAP Co-funded by: BCSFA and Member companies, New Zealand King Salmon, BC CAHS.

Project team: Linda Sams (BC CAHS), BCSFA, Michael David Anderson (New Zealand King Salmon), Karl James French (New Zealand King Salmon).

For information contact: Linda Sams (linda.sams@cahs-bc.ca)

Hard seabed monitoring project progresses to support new waste control regulations in BC

In British Columbia many finfish aquaculture operations are sited over hard seabed substrates, where conventional soft seabed sampling techniques (sediment grabs and cores) cannot be used to sample benthic communities. Most of these sites have higher currents and little accumulation of natural sediments. Hard seabed biological communities differ from soft seabed communities as they are dominated by attached or mobile epibenthic organisms rather than infaunal organisms.

For hard seabeds the current Finfish Aquaculture Waste Control Regulation (FAWCR) lacks standard protocols for field survey data interpretation and analysis. In addition, performance standards (e.g., the level and type of community change deemed to be unacceptable) have not been defined. A three-phase project, beginning in 2003, has now concluded its third phase.

In Phase 1 video imagery was recommended as the most effective tool for operational monitoring. Phase 2 reviewed marine environmental video monitoring methods and monitoring parameters, developed video data interpretation and classification protocols, and conducted ROV field survey and classification trials. Phase 3 of this project involved working with stakeholders and regulators to amend the regulations.

Duration: Jan '04 – Oct '08

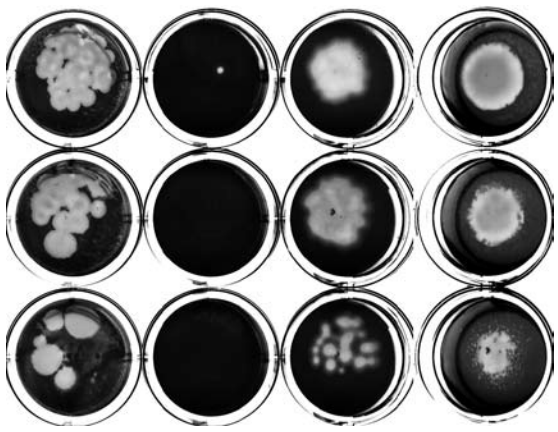
Funded by: BCARDC-AE Co-funded by: BCMoE, BCMAL, DFO

Project team: Brian Emmett (Archipelago Marine Research), Pam Thuringer (Archipelago Marine Research), Sarah Cook (Archipelago Marine Research), Jon Chamberlain (DFO), Jason Dunham (DFO), Barb Cannon (Creative Salmon Ltd.), Dave Stirling (Mainstream Canada), Sharon Dedominicis (Marine Harvest Canada), Mia Parker (Grieg Seafood BC Ltd), Norm Penton (BCSFA), Bill Harrower (BCMAL), March Klaver (DFO), Kerra Hoyseth (DFO) Bernie Taekema (BCMoE)

For information contact: Brian Emmett (briane@archipelago.ca)

Researchers use amoebae to study furunculosis

Furunculosis is an infectious disease occurring particularly in farmed trout and salmon. The disease is caused by the *Aeromonas salmonicida* bacteria. A growing number of strains of *A. salmonicida* are resistant to multiple antibiotics. This compromises the ability to overcome future infections caused by this bacterium.



The amoeba is used in evaluation of the bacteria's virulence. Each of the wells contains a different strain of bacteria (black). Strains in which the amoeba cannot grow (no white areas) are virulent. (Photo: Laboratoire Charette)

One solution to this problem involves the creation of compounds to complement the antibiotics and thus decrease the infectious nature of the bacteria. Development of these anti-infection agents requires, as a first step, better understanding the virulent behaviour of the bacteria and thus finding molecular targets suitable for developing these anti-infection agents. Repeated confrontations between bacteria and host are necessary for this kind of study.

For ethical, economic and practical reasons, it is difficult to do this while using the living fish as the host. Here, the research team is studying the virulence of *A. salmonicida* using a substitute host, the amoeba *Dictyostelium discoideum*. The objective is to define the infectious nature of *A. salmonicida* and propose new approaches to treat infections caused by this bacterium.

Duration: Mar '08 – ongoing

Funded by: U Laval. Co-funded by: RAQ, AUCC

Project team: Steve Charette (U Laval), Rana Daher (M.Sc. Student, U Laval), Geneviève Filion (U Laval), Michael Reith (NRC-IMB)

For information contact: Steve Charette (Steve.charette@bcm.ulaval.ca)

Website: www.amibe.org

Researchers prepare a seine net along the shores of Discovery Passage (Photo: BC CAHS)

Juvenile coho monitoring project

A collaborative research partnership is monitoring phytoplankton and zooplankton levels in the Northern Georgia Strait to determine optimal release dates for the improved survival of juvenile, enhanced coho. The collaboration is being facilitated by the BC Centre for Aquatic Health Sciences (BC CAHS) in partnership with the BC Ministry of Environment (BC MOE) – Marine Division, DFO Quinsam Hatchery, A-Tlegay Fisheries, Ritchie Foundation, Campbell River Foundation, Campbell River Lodge, and the City of Campbell River.

At the Quinsam Hatchery, as well as other hatcheries on the BC coast, survival of enhanced coho has dropped from highs of 8-10% in the 1980's to less than 1% today. Many factors are contributing to this decline including changes in magnitude and timing of ocean productivity (i.e., plankton blooms) likely related to global climate change.

Researchers are analyzing plankton levels in the stomach contents of captured coho. They will use this data to adapt the timing of release such that the juvenile fish enter seawater when food is at maximum availability. The development of this project will lead to a long-term monitoring program that will help guide the release time of enhanced coho in this area. The full report is available on the BC CAHS website

Duration: Jan '07 – Oct '07

Funded by and Project team: BC CAHS, BC MOE – Marine Division, DFO Quinsam Hatchery, A-Tlegay Fisheries, Ritchie Foundation, Campbell River Foundation, Campbell River Lodge, City of Campbell River

For information contact: Linda Sams (linda.sams@cahs-bc.ca)

Website: http://www.cahs-bc.ca

Halibut study pilots off-season grow-out in PEI lobster holding facility

Some of the halibut were transferred into one of the large existing lobster-holding tanks on the island, while other smaller fish were put into fibreglass tanks (bottom) specially installed for the purpose.

An eight-month initiative is looking to fast-track a new halibut production industry on PEI. Through a joint effort between DFO-AIMAP, PEI's Department of Fisheries, Aquaculture and Rural Development (PEIDFARD) and several private firms, Halibut PEI aims to determine the feasibility of using off-season lobster-holding facilities for grow-out of Atlantic Halibut fingerlings.

Currently, several PEI lobster holding facilities with access to salt water wells stand unused for up to nine months of the year. Proponents of the initiative believe that land-based grow-out of the valuable fish could comprise a new and profitable way to keep existing infrastructure in full use and staff employed throughout the year. Stable water conditions and minimal renovation expense mean that a new industry could be underway without delay, once it has been demonstrated that the facilities can produce high-quality, market-sized fish in one 8-month growing season.

The study is currently underway at MorningStar Fisheries, a lobster holding facility in Victoria, PEI owned by Ocean Choice International Ltd. Fingerlings were provided by Scotian Halibut from their Clark's Harbour Hatchery in Nova Scotia. The research team includes Project Manager Jim Dunphy of J. Dunphy Inc., fisheries and aquaculture consultant Bob Johnston, and Dr. Gerald Johnson of the UPEI Atlantic Veterinary College in Charlottetown. Jim Dunphy is confident that a new industry is on the horizon: "We are committed to sharing the results of our project with other investors who may be interested in establishing halibut grow-out operations in their facilities. This could create a new aquaculture industry in PEI as well as creating full time jobs in plants where employment has been seasonal up to this time."

The research grant of $160,000 from DFO's Aquaculture Innovation and Market Access Program (AIMAP) was part of DFO's overall $23.5 million commitment to industry R&D over the next five years. The DFO funding was augmented by $40,600 from the PEI Department of Fisheries, Aquaculture and Rural Development and a total of $127, 000 from the participating firms that also included Waterline Ltd. and Viodiaq Inc.

Duration: July '08 – Apr '09

Funded by: DFO-AIMAP Co-funded by: Halibut PEI, Scotian Halibut, Ocean Choice International, Waterline Ltd, Viodiaq Inc., UPEI-AVC, J Dunphy Inc., Robert Johnston Consulting, PEI DFARD

Project team: Jim Dunphy (J Dunphy Inc.), Bob Johnston (Robert Johnston Consulting), Gerald Johnson (UPEI-AVC), Brian Blanchard (Scotian Halibut), Melissa Rommens (Scotian Halibut), Wayne Van Toever (Waterline Ltd.), David Speare (UPEI-AVC), Ocean Choice International

For information contact: Jim Dunphy (902-892-0953)

Above: Implanting rockfish with visible implant tags (Northwest Technologies) to identify and monitor individual growth performance during study. (Photo: S. Balfry)

Left: Juvenile rockfish in tanks at the Centre for Aquaculture and Environmental Research for growth performance study. (Photo: S.Balfry)

Research begins on culturing juvenile copper rockfish in BC

Identifying, in a controlled and scientific manner, the impact of selected factors such as temperature, size, and sex, on the growth performance of cultured copper rockfish *(Sebastes caurinus)* is underway at the DFO - University of British Columbia's Centre for Aquaculture and Environmental Research. This initial research is providing the information on the biology of cultured copper rockfish so that it can be readily transferred to industry wanting to develop this new species for aquaculture in British Columbia.

In addition to gaining an understanding of these factors, information on health and welfare parameters on this new species will be provided to assist in the development of health management plans to facilitate in the regulation of this new aquaculture industry.

Duration: Jan '08 – Oct '09

Funded by: DFO-ACRDP Co-funded by: Ko-Un Fish Company

Project team: Shannon Balfry (UBC), Steve Macdonald (DFO), Jeff Marliave (Vancouver Aquarium), Scott McKinley (UBC), Phil Konken (Ko-Un Fish Company).

For information contact: Shannon Balfry (balfry@interchange.ubc.ca)

(Photo: M. Rise)

Project improves broodstock and creates genomics tools for an Atlantic cod industry

The $18.1 million Atlantic Cod Genomics and Broodstock Development Project (CGP) aims to develop a breeding program and a set of fundamental genomics tools that will be used to supply the developing Atlantic cod aquaculture industry in Canada with improved broodstock. Family-based breeding programs have been initiated in Newfoundland, Labrador, New Brunswick and New Hampshire ensuring that local stocks can be used for the benefit of industry partners. CGP data suggest that the breeding programs will be highly successful at improving growth rates of cod for aquaculture.

CGP has dramatically improved the availability of genomic resources for this species. At present, 85.8% of publicly available DNA sequence information for cod was contributed by the CGP. Thousands of cod genomic markers have been identified, and a microarray or "cod chip" is in production. Other characteristics including tolerance to stress and disease are also being assessed in juvenile cod. A cod genetic map is in development, and will be used to identify quantitative trait loci (QTL) and to develop markers applicable in Marker Assisted Selection (MAS). MAS will enable rapid enhancement of cod broodstock.

Finally, the Genomics-Related Ethical, Economic, Environmental, Legal and Social issues (GE^3LS) team is developing solution-oriented legal and policy options regarding: ownership of commercially valuable research results, the status of elite cod broodstock under Canadian environmental law and Canada's international obligations, and options regarding benefit sharing and improved methods of consultation with the affected publics.

Duration: Jan '06 – Dec '09

Co-funded by: TAGC, Genome Canada, Hunstman Marine Science Centre, ACOA-AIF, NLDFA, DFO-ACRDP, DFO (SABS, NAFC), NRC-IMB, NB Innovation Foundation, the Provinces of NB, NL, and NS, MUN-OSC, UBC, U Guelph, UNB, Cooke Aquaculture Inc., GreatBay Aquaculture, Newfoundland Cod Broodstock Company, NAIA, Northern Cod Ventures, RPC

Project team: Sharen Bowman (Genome Atlantic), Ed Trippel (DFO), Keith Culver (DFO), A. Kurt Gamperl (MUN-OSC), Stewart Johnson (DFO), Matthew L. Rise (MUN-OSC), Andy Robinson

For information contact: Sharen Bowman (sbowman@genomeatlantic.ca) or Ed Trippel (Edward.Trippel@dfo-mpo.gc.ca)

Website: www.codgene.ca

Juvenile cod in respirometer (Photo: D. Chabot)

Juvenile Atlantic cod diets improved by using herring fishery by-product

Canadian researchers have already developed initial feed formulations for juvenile and broodstock marine fish, but further research is still needed to optimize growth and health of cultured juvenile marine fish in general, and of Atlantic cod (*Gadus morhua*) in particular. Furthermore, recent work suggested that including tissue from gonads of male herring in feed was of interest for two reasons: it can increase growth and performance of the immune system and it solves the problem of disposing of this fishery by-product in an environmentally sound manner.

The research team at the DFO Institut Maurice-Lamontagne are further improving existing feed formulations by testing the impact of three levels of male herring gonad contents and three levels arachidonic acid (ARA) supplementations on growth rate of juvenile cod. Fish are grown on a selection of these diets and respiratory capacity is measured to relate differences in growth to metabolic costs and assimilation.

Furthermore, tolerance to hypoxia is being measured for cod fed the same diets. In addition to checking for the impact of diet on hypoxia tolerance, this work provides precious information to predict how long cod can survive when oxygen is not supplied to a tank, according to the number and size of fish and the tank volume.

Duration: Jan '07 – May '09

Funded by: DFO-ACRDP Co-funded by: Cooke Aquaculture Inc.

Project team: Denis Chabot (DFO), Sébastien Plante (DFO).

For information contact: Denis.Chabot@dfo-mpo.gc.ca

Long term project continues development and optimization of larviculture techniques

The marine fish research and development team was formed in 1994 to develop a viable alternative to salmon aquaculture in the Bay of Fundy. Haddock (*Melanogrammus aeglefinus*) was the first species targeted. Connors Brothers Ltd. joined the project in 1996, leading to the transfer of the first fish to sea in 1997. The first phase of research and development focused on the development of rearing techniques and feeding strategies.

In 2003, industry interest shifted from haddock to Atlantic cod. To support the viable development of an alternative species, the team transferred its field of research to this new species and, at the same time, entered the second phase of research and development, which involved optimizing the techniques and reducing operating costs to achieve viability.

The Coastal Zones Research Institute (CZRI) is currently working with Cooke Aquaculture Inc. on automating and optimizing live feed production and on the various steps of Atlantic cod larviculture. The team recently completed testing on a high-density rotifer production system applicable to Atlantic cod farming. The use of such a system is a world first for marine fish farming.

Duration: 1994 – Ongoing

Funded by: NBDAA

Project team: Rémy Haché (CZRI), Yves Hébert (CZRI), Claude Landry (CZRI), Caroline Roussel (CZRI), Cooke Aquaculture, NBDAA, U Moncton Shippigan Campus

For information contact: Rémy Haché (Remy.hache@umcs.ca)

Cod broodstock research in Newfoundland takes critical step toward formulated feeds

Knowledge of broodstock nutrition for Altantic cod is greatly limited due to factors such as difficulty accessing proper broodstock and lack of sufficient tank space. Previous work on cod broodstock in Atlantic Canada has been performed, utilizing a diet of baitfish (herring, mackerel, squid) and vitamin supplementation, with good success. However, a wild baitfish diet has numerous drawbacks including inconsistent supply and quality of product, as well as potential introduction of diseases.

Preliminary studies in Newfoundland in 2004 using formulated experimental diets did not lead to positive results. However, as broodstock development moves towards using F1-generated captive broodfish and away from wild-caught fish, the need for the use of a formulated manufactured diet is paramount. F1-broodfish are never fed a baitfish diet and are reared on formulated feeds from weaning.

Gadid broodstock diets have recently been developed by feed companies world wide. So far, comprehensive comparisons between current standard feeding practices and newly available diets have not been performed. This project is investigating the effect of these diets on fish condition, gamete quality, egg fertilization, larval performance, post-spawning condition and the ability of fish to recrudesce properly.

Duration: Apr '08 – Mar '11

Funded by: DFO-ACRDP Co-funded by: Northern Cod Ventures, Genome Canada.

Project team: Dounia Hamoutene (DFO), Lynn Lush (DFO), Jonathan Moir (Northern Cod Ventures Ltd.), Danny Boyce (MUN)

For information contact: Dounia Hamoutene (Dounia.Hamoutene@dfo-mpo.gc.ca)

Cod broodstock held at the Ocean Sciences Centre

Cod stripping

Research reveals how photoperiod affects growth and sexual maturation in juvenile cod

Light control in aquaculture has been used to increase growth and influence sexual maturation. However, long light periods advance maturation at the cost of muscle production. In addition, growth of significantly fattier livers in fish under extended photoperiods significantly reduces commercial productivity. To improve growth and to be able to efficiently control environmental interactions, it is necessary to understand the mechanisms through which these processes operate and how storage of energy sources (i.e., fats) may be affected.

This project, underway at the DFO St. Andrews Biological Station, is examining how differences in light period change patterns of protein production (i.e., muscle growth) as well as lipid metabolism, energy storage, and sexual maturation.

Research already completed has focused on growth and the protein content of tissues. Twenty-four hour light produced significant increases in growth (i.e., length, body and liver mass) and protein content that lasted throughout the experiment. Protein found in the blood did not vary between different light periods although it did increase with fish size. Increased muscle protein content under 24-h light may indicate changes in the controls for protein manufacture.

Follow-up work continues on the mechanisms responsible for the decline in protein per unit muscle produced.

Duration: Dec '06 – Dec '09

Funded by: DFO

Project team: D. John Martell (DFO), Les Burridge (DFO), Steve Leadbeater (DFO), Tammy Blair (DFO)

For information contact: John Martell (D.John.Martell@dfo-mpo.gc.ca)

International workshop probes cod gyrodactylosis

An international workshop on cod gyrodactylosis was held September 21-23, 2008 in St. Andrews, NB, at the Huntsman Marine Science Centre and the DFO biological station. Experts from Norway, Denmark, Iceland, Scotland, and Canada discussed the emergence of this disease in captive cod in the North Atlantic and an application for a strategic grant (to NSERC) was developed and submitted.

The project involves four main components. The first is the identification of the species involved (7 known to date) using both morphometric and molecular data. The second is the determination of the transmission dynamics of each species to allow development of prophylactic measures. Third is the development of environmentally-friendly treatments (e.g., avoiding the use of formalin baths which are not only toxic to the environment, but also render the fish more susceptible to further infection). The fourth component involves identification of those captive stocks which show increased resistance to infection and hence would be more useful to the aquaculture industry.

Proceedings of the Workshop are now in press and copies can be obtained from mburt@unb.ca.

Duration: May '09 – Apr '12

Funded by: NSERC

Project team: M.D.B.Burt (UNB), Scott R. Gilmore (DFO), Russell H. Easy (Dalhousie U), Stanley K. King (SMU), Tor-Atle Mo (NVI Norway), Kjetil Olstad (NVI Norway), Haakon Hansen (NVI Norway), Willy Hemmingsen (U Tromso, Norway),Ken MacKenzie (U Aberdeen, Scotland), Catherine Collins (Fisheries Research Services, Scotland), Kurt Buchmann (U Copenhagen, Denmark), Matthias Eydal (U Iceland).

For information contact: David Cone (David.Cone@smu.ca)

Integrated aquaculture systems to be tested on commercial scale at BC site

Is it possible to rear commercial quantities of several marketable seafoods on fish waste and sunshine within a full-scale finfish net pen operation? If the "devil is in the details", work now underway in BC is answering some of the crucial questions around commercial scale development of Integrated Multi-Trophic Aquaculture (IMTA) systems, or what team leader Dr. Steve Cross of Kyuquot SEAFoods Ltd. calls Sustainable Ecological Aquaculture (SEA).

Over the past two years a study funded by DFO's Aquaculture Collaborative Research and Development Program (ACRDP) has been investigating the feasibility of a full-scale sablefish/ sea cucumber/ sea urchin/ shellfish/ kelp operation, with a focus on three seminal questions: 1) Can sea cucumbers effectively use the settled waste below net pens, via an infrastructure that is functionally independent from the finfish operation? 2) Can modifications be made to steel cages to accommodate more range of depth for shellfish than is possible with traditional wooden rafts? 3) Can kelp seed be set throughout the year to ensure consistent, adequate interception of dissolved nutrients and continuous, commercially viable production? Answers from these lines of investigation, according to Cross, will determine critical details of the system's design and operation, and allow SEA systems to be more adaptable.

With a grant from DFO-ACRDP, and co-funding from Kyuquot Seafoods Ltd. of Courtney, BC, Dr. Steve Cross, and Drs. Chris Pearce and Lucy Hannah of DFO are concluding preliminary studies on sea cucumbers. They have engineered and built a prototype movable tramway system to service shellfish lines suspended within fish cage superstructures, and designed and tested submergible culture trays that can be positioned beneath net pens, and operated without interfering with the pens.

According to Cross, preliminary results strongly indicate that sea cucumbers will utilize waste deposits below fish pens as a food source, and do not appear to accumulate heavy metals or other trace contaminants. Sea cage modifications developed during the study will facilitate simultaneous culture of more than one type of shellfish (e.g., mussels near the surface, scallops at depths up to 15 m.). Timing of kelp seedling development can be controlled to allow year-round seeding and harvest.

A site in Kyuquot Sound, on the West Coast of Vancouver Island, will be the proving ground for both equipment and grow-out protocols based in part on the results of this work, and will act as an ongoing test site for future research and development. It is the first multi-trophic SEA site to be approved in BC. Other IMTA sites exist in New Brunswick on the East Coast.

Duration: Apr '07 – Jun '09

Funded by DFO-ACRDP Co-funded by: Kyuquot SEAFoods Ltd.

Project team: Steven Cross (Kyuquot SEAFoods Ltd. and U Vic), Chris Pearce (DFO), Lucy Hannah (U Vic), Nathan Blasco (U Vic).

For information contact: Steve Cross (sfcross@office.geog.uvic.ca).

IMTA project investigates adding polychaete worms as additional biofilter

The Canadian aquaculture industry is striving to become more sustainable and environmentally benign. The underlying principle behind the Integrated Multi-Trophic Aquaculture (IMTA) concept is one of re-cycling nutrients for more profitability and sustainability. In essence, the IMTA practice combines, in the right proportions, the cultivation of fed aquaculture species (e.g., finfish) with organic extractive aquaculture species (e.g., filter feeders, deposit feeders) and inorganic extractive aquaculture species (e.g., seaweed).

Particulate engineer, Darren Cleaves, working on some of the flow characteristics of organic particles in the lab and how they may be possibly captured by a cage for polychaete worms.

While recent research shows that mussels are effectively filtering the fine organic particulates coming from the salmon site, the majority of the organic loads settling to the bottom are too large for mussels to physically handle. Therefore, the waste energy coming from the salmon faeces needs to be recycled through detritivores or decomposers before it reaches the sea bottom; preferably one that also has a commercial value. One group of organisms that would fit the detritivore criteria for finfish aquaculture is the polychaetes.

The sand worm, *Nereis virens*, in a white plastic dish in the lab. The species is being examined as one of potential organic biofilters from the detritivore trophic level.

This study evaluated the feasibility of using polychaete worms (*Nereis virens*) in an IMTA operation with salmon. Lab study showed that the worms could be grown successfully on a diet composed of salmon food/feces. However, field trials indicated that production was lower than expected. Prototype culture containers were developed during the project.

Duration: Jul '07 – Mar '09

Funded by: DFO-ACRDP Co-funded by: Cooke Aquaculture Inc.

Project team: Shawn Robinson (DFO), Rachel Shaw (DFO), Fernando Salazar (DFO), Craig Smith (DFO), Jim Martin (DFO), Terralynn Lander (DFO), Cooke Aquaculture Inc.

For information contact: Shawn Robinson (Shawn.Robinson@dfo-mpo.gc.ca)

IMTA study finds salmon farm by-product particulates affect biophysical properties of mussel faeces

Mussels cultured under Integrated Multi-Trophic Aquaculture (IMTA) techniques are supplemented with pulses of salmon farm particulate nutrients. The effect of these particles on the biophysical properties of mussel biodeposits is unknown and is essential information for modelling nutrient dynamics of IMTA systems.

Researchers in this project are characterizing the effect of various diets (mix algal paste, diatoms paste, salmon feed 'fines' and salmon faeces) on the biophysical properties (faecal morphometrics, organic content and density) of mussel faeces produced.

All diets in the experiments were fed to three mussel size classes (small: 30 – 35 mm, medium: 50 – 55 mm, and large 70 – 75 mm). The team found that differences in faecal deposit characteristics are minimal within small mussel sizes, but become more significant as mussel lengths increase (50 mm to 75 mm). Absorption efficiencies of mix algal, diatom, salmon feed and salmon faces, were 87, 81, 90, and 86% (all significantly different, $p < 0.05$), respectively. Regardless of diet, small mussels produced biodeposits that dispersed over larger areas than those produced by larger mussels as a function of sinking velocity: small 0.18 cm sec^{-1}, medium 0.29 cm sec^{-1} and large 0.54 cm sec^{-1} (sinking velocity of 50 % of particles).

Duration: Oct '07 – Feb '09

Funded by: ACOA-AIF Co-funded by: DFO

Project team: Matthew Liutkus (DFO), Shawn Robinson (DFO), Bruce MacDonald (DFO), Gregor Reid (DFO), Cooke Aquaculture Inc.

For information contact: Matthew Liutkus (Mathew.Liutkus@dfo-mpo.gc.ca)

Experimental exposure trials at Memorial University (Ocean Sciences Centre) (Photo: A. Both)

Newfoundland project investigates mussels to mitigate some impacts of cod aquaculture

Newfoundland researchers are investigating the feasibility of culturing mussels, *Mytilus edulis*, as a component in a cod Integrated Multi-Trophic Aquaculture (IMTA) system. They are evaluating the effluent leaving an onshore Atlantic cod aquaculture site as a food source for mussels.

Experiments are being undertaken to measure changes in the biochemical composition of mussels fed effluent in comparison with starved mussels and mussels fed algae over a ten week period. The growth of mussels fed cod effluent is also being measured over a six month period and compared to that of starved mussels and algae fed mussels. Some smaller experiments on individuals will be undertaken to determine the ability and extent to which *M. edulis* can filter cod effluent out of surrounding waters.

Some preliminary analyses are revealing that the bulk of the effluent leaving cod tanks (96%) is of a size larger then 500 µm which is too large for mussels to ingest, with a small portion (1.8%) being smaller then 70 µm and of a size suitable for mussel ingestion. Preliminary settlement rate experiments are showing that although the smaller particles comprise a small portion of the effluent they are the particles with the greatest capacity to spread over large areas.

Duration: Feb '08 – Feb '10

Funded by: NSERC Co-funded by: DFO

Project team: Chris Parrish (MUN), Adrianus Both (MUN), Randy Penney (DFO), Ray Thompson (MUN)

For information contact: Chris Parrish (cparrish@mun.ca)

Study to shed light on effects of organic enrichment by salmon in IMTA systems

The flow of nutrients from salmon farms and their effects on the growth and reproductive physiology of species within the localized farm ecosystem is not clearly understood. This project aims to better understand these pathways and effects within Integrated Multi-Trophic Aquaculture (IMTA) farms in Southeast New Brunswick.

Mytilus edulis, *Strongylocentrotus droebachiensis* and *Caprella mutica* - representing filter feeding molluscs, scavenging echinoderms and opportunistic crustaceans, respectively - have been selected to investigate the contributions to the pathways of effects.

The assimilation of salmon farm waste by these species is being investigated over a one year period using stable isotope and fatty acid tracers. The effect of this diet on growth and reproduction is then measured by calculating differences in growth and reproductive output of animals held within and outside of the nutrient plume of three salmon farms.

These species, representing different functional groups and trophic levels within the organic extractive niche of the IMTA farm, provide insight into the effects of organic enrichment on secondary production and trophic energy transfer efficiencies. Such research is essential for calculating the nutrient recovery potential of IMTA candidate species. Ultimately this research improves our understanding of energy flow and effects within IMTA sites and coastal ecosystems.

Duration: May '07 – May '10

Funded by: ACOA-AIF

Project team: Jason Mullen (DFO), Shawn Robinson (DFO), Bruce MacDonald (DFO), Gregor Reid (DFO), Cooke Aquaculture Inc.

For information contact: Jason Mullen (Jason.Mullen@dfo-mpo.gc.ca)

Researchers incorporate sea urchins into IMTA system

Integrated Multi-Trophic Aquaculture (IMTA) is proving to be successful in the Bay of Fundy with salmon, mussels, and kelp as the initial bio-extractive components. Currently, several detritivores species are being considered for incorporation into the IMTA system in order to further improve the level of nutrient recycling in an open marine environment for finfish aquaculture.

The green sea urchin appears to be a promising candidate because of its relatively high economic value and ability to ingest larger organic particles descending from finfish cages. They are often found around salmon aquaculture sites.

This project is evaluating the potential relative growth performance of sea urchins from aquaculture sites compared to nearby reference areas. A relationship between the test diameter and the length of the rotules found in Aristotle's lantern, the chewing organ of the sea urchin, has been observed.

Using the growth rings found in the rotules, researchers are comparing animals from different sites to evaluate the hypothesis that sea urchins around the aquaculture sites experience higher growth rates than conspecifics in nearby natural areas. This project is part of a larger initiative looking at the degree to which aquaculture sites impact the relative growth rates of organisms away from the site.

Duration: Dec '08 – Mar '09

Funded by: DFO

Project team: Shawn Robinson (DFO), Andrew Cooper (DFO), Janelle Arsenault (DFO), Carissa Graydon (DFO), Jacquelyn Ferris (DFO), Jim Martin (DFO), Terralynn Lander(DFO), Craig Smith (DFO)

For information contact: Shawn Robinson (Shawn.Robinson@dfo-mpo.gc.ca)

IMTA group examines recycling of aquaculture nets for the collection of mussel seed

In order to successfully implement mussels as a full commercial crop in the Integrated Multi-Trophic Aquaculture (IMTA) system, a consistent collection source for juveniles ('spat' or 'seed') must be identified. Researchers have been examining the potential for reusing old salmon nets previously treated with cuprous oxide for mussel spat collection in the Bay of Fundy.

The settlement density and shell length of blue mussels was measured on newly treated (NT), previously treated (PT) and untreated (UT) collector panels, made from commercial salmon nets, to assess how mussel spat collection efficiency was affected by commercial cuprous oxide treatment.

Significant differences were found between treatments for mean spat density (MSD) after a 5 months. Reduced settlement on NT and PT panels was attributed to the inhibitory effects of cuprous oxide on mussel settlement. Although PT panels collected fewer spat than UT panels, the numbers were still adequate for commercial spat collection. Mean shell length (MSL) was not significantly different between treatments.

Based on these results, the research team believes there is potential for recycling used salmon nets for mussel collection as PT panels continued to collect large numbers of mussel spat while inhibiting unwanted foulers with lingering anti-foulant properties.

Duration: Jun '07 – Dec '07

Funded by: DFO

Project team: Shawn Robinson (DFO), Rachel Shaw (DFO), Terralynn Lander (DFO), Jim Martin (DFO), Cooke Aquaculture Inc.

For information contact: Shawn Robinson (Shawn.Robinson@dfo-mpo.gc.ca)

Juvenile mussels that have settled on used salmon nets that will be shortly harvested and re-deployed in socks hung on IMTA mussel rafts (Photo by S. Robinson)

Research suggests new benefit of IMTA in pathogen depletion by mussels

One of the methods currently being considered in the evolution of aquaculture in Canada is a practice known as Integrated Multi-Trophic Aquaculture (IMTA). When different organisms are combined, either intentionally or unintentionally, the possibility exists for biological interactions to occur.

In commercial aquaculture situations, negative interactions could be expressed in the form of disease transfer or parasites and this has been the concern of several countries in adoption of IMTA principles.

However, studies are beginning to emerge that suggest mussels may have the ability to destroy the ISA virus. IMTA researchers are determining the ability of mussels to affect the occurrence and titre levels of various fish pathogens in their environment.

The results from this experiment suggest that mussels are effective at depleting the ISAV and the IPNV viral types. However, they are not as effective on Nodavirus suggesting different mechanisms are involved.

Mussels do not seem to deplete BKD or furunculosis bacteria in the water column in the same fashion as viruses. Although there are trace amounts of bacteria remaining, it is not clear whether these are able to be released back into the environment. More work is going to be done on these mechanisms.

Duration: Aug '07 – Mar '08

Funded by: DFO-ACRDP Co-funded by: Cooke Aquaculture Inc., RPC

Project team: Shawn Robinson (DFO), Rachael Ritchie (RPC), Ben Forward (RPC), Brian Glebe (DFO), Terralynn Lander (DFO), Wilfred Young-Lai (DFO)

For information contact: Shawn Robinson (Shawn.Robinson@dfo-mpo.gc.ca)

Above: Mussels in white plastic bucket with viral titer added in the quarantine facility at the St. Andrews Biological Station

Right: Titers of virus to be placed in the experimental tanks with mussels to determine the ability of the shellfish to remove virus from the water column

Might sea lice be a vector for other pathogens?

The potential role of sea lice in a vector-pathogen association affecting farmed salmon has not been explored. Using standard OIE bacteriological screening protocols, a Vancouver Island University researcher and his students sampled the external carapace and internal stomach contents of motile sea lice (*Lepeophtheirus salmonis*, *Caligus clemensi*) collected from farmed Atlantic salmon from May 2007 to April 2008 in British Columbia.

The results of this pilot study include the first isolation of three potentially pathogenic bacteria (*Tenacibaculum maritimum*, *Pseudomonas fluorescens* and *Vibrio* spp.) from sea lice and their corresponding healthy salmon hosts. Spatiotemporal variation among prevalence of bacteria was evident from external (58-100%) and internal (12.5-100%) sea lice samples. There was also an increase in prevalence of bacteria cultured from lice collected from higher seawater temperatures and age of lice (90-100% among adult lice compared to < 40% among pre-adult).

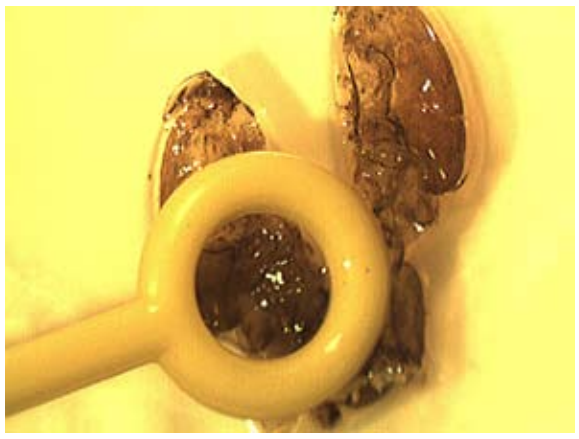
These preliminary results have lead to an NSERC proposal to conduct a comprehensive, long-term study in which this team intends to explore, within an ecological context, the role of sea lice as vectors of pathogens to salmon. Where (geographically) and when (seasonally), could sea lice carry important pathogens of salmon? A further question to explore is can sea lice be used as indicators of pathogens in an environment?

Duration: May '07 – May '08

Funded by: VIU. Co-funded by: Marine Harvest Canada, BCMAL.

Project team: Duane Barker (VIU), Laura Braden (VIU), Mark Sheppard (BCMAL), Maria Coombs (BCMAL), Brad Boyce (Marine Harvest Canada)

For information contact: Duane Barker (Duane.Barker@viu.ca)



Sea lice bisected for bacterial sampling (photo: D. Barker)

Above: Duane Barker & Laura Braden in bacteriology lab

Bacteria colonies isolated from lice (photo: D. Barker)

Catching smolt: Crew spread purse seine net.

Adding smolt to water column.

BC Pacific Salmon Forum:

Summary of Interim Research Results

The BC Pacific Salmon Forum (BCPSF) is an independent citizen body using science and stakeholder dialogue to advance sustainable governance of BC Pacific salmon. Three objectives were identified for a two year research program focused primarily in the Broughton Archipelago: 1) To determine whether salmon farms in the Broughton impact sea lice loads on wild salmon and if so how; 2) To determine whether the survival of individual wild fish is compromised due to increased lice loads; and 3) To determine if any reduced survival of individual salmon has consequences on salmon populations, and if so, are there management techniques that can be put in place to mitigate any risk to wild salmon?

In 2008 the Forum provided funding to 15 collaborative research projects that involved more than 35 scientists. A wealth of new knowledge was gained in areas ranging from fish health and physiology, to oceanography, host-parasite interactions and the biology of sea lice. While the research focused predominantly on the Broughton Archipelago region, projects were also undertaken in other regions along the BC coast, some still ongoing. The findings from the 2008 research period built upon those from earlier seasons and will assist scientists in reaching a clearer understanding of ecosystem interactions in the Broughton and potentially beyond. The following provides a brief overview of the preliminary findings from the 2008 field season.

MODELING MOVEMENTS

Aquatic organisms are in intimate contact with the ecosystems in which they reside and scientists are only just beginning to scratch the surface of the complex interactions between fish, parasites and pathogens, and the environments they coexist in. The environment plays a defining factor in the outcomes of those interactions and a clearer understanding of the mechanisms of transport and exchange within the aquatic environment is vital to understanding to dynamics of salmon populations in our waters.

Oceanographic circulation and sea lice dispersion models have been developed for the Broughton Archipelago and have been utilized to simulate oceanographic conditions and lice concentrations for defined collection periods. Ocean currents, salinities and temperatures in the model simulations were found to agree relatively well with data collected from the field leading to the expectation that these models may prove to be useful tools for investigating wild/farmed salmon interactions with sea lice and examining farm management strategies in the future.

STOCK ORIGINS

One of the difficulties in understanding salmon dynamics is a lack of knowledge regarding the exact origins of a fish. Understanding the origins of each sample assists scientists in determining migration patterns and in identifying potential significant differences in infection patterns of different stocks. It is well known that different stocks of organisms do not share identical genetic makeup, some stocks may possess greater or poorer resistance to pathogens and this knowledge is useful in identifying stocks that may be at greater risk of impact from infection.

Micro-chemical analyses demonstrated that it is possible to discriminate the natal origins of pink and chum salmon sampled in the Broughton Archipelago based on otolith composition. Juvenile salmon rearing in different stream systems are subjected to variations in water chemistry and these can be traced by micro-analysis. Salmon of known origin were correctly identified approximately 85% of the time suggesting that this research could provide a useful analytical tool in the ongoing efforts to better understand salmon migration pathways in the Broughton Archipelago.

MARINE MONITORING

There has been a great deal of debate surrounding the dynamics of juvenile salmon and associated sea lice. While the answers still remain somewhat elusive, certain patterns are merging. Extensive sampling programs by several different research groups, over 5 or more years, has demonstrated that there are significant shifts in both salmon and lice populations, although these do not always appear to share a positive correlation. Total catches of juvenile wild pink and chum were high in 2003, but declined substantially for both species in 2004. Although total catches and catch-per-unit-effort (CPUE) remained relatively constant for both species from 2004 to

Mike Sackville studies specimens under a microscope.

2008, the number of fish captured each year varied widely between sampling locations and between years.

In 2008, a total of 622 sets were completed using beach seine and purse seine fishing gear with sampling occurring over 8-10 days each month, near the end of March, April, May and June. In 2008 a total of 22,995 juvenile pink salmon and 9,394 juvenile wild chum salmon were captured, very similar to the number captured in 2007.

It is generally considered that smaller fish are more susceptible to infestation by sea lice. In 2008, a large number of juvenile salmon were examined for sea lice. There were large variations in both incidence and severity of infection by *L. salmonis* on juvenile pink and chum salmon between years, and also between different locations within any particular year.

The prevalence and abundance of *L. salmonis* on juvenile pink and chum salmon has continuously declined since 2004 although the explanations for this decline are not fully understood. The percent of lethally-infected pink salmon declined from approximately 1% in 2005 to zero in 2008. Lab studies have demonstrated that once fry reach approximately 0.7 g they are highly resistant to the effects of lice.

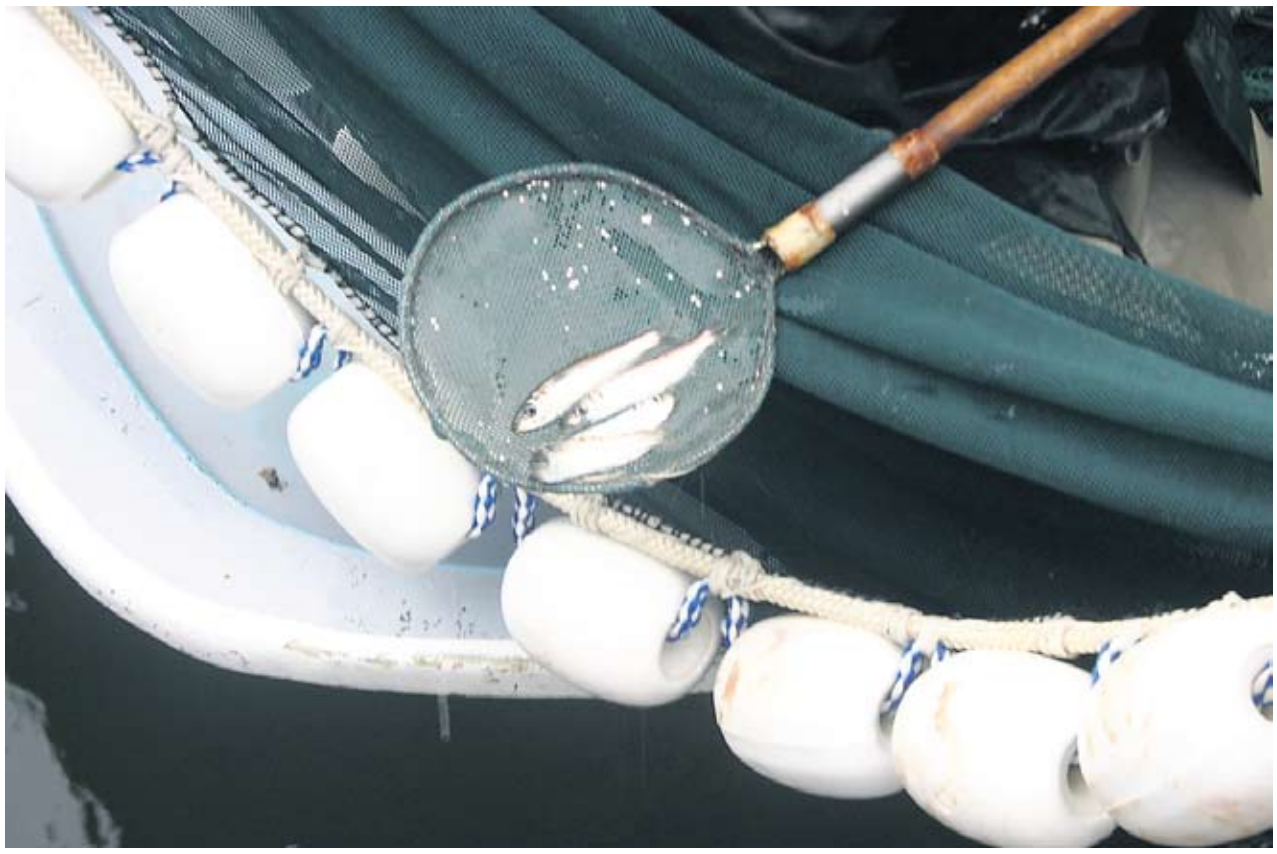
A question that has yet to be clearly answered is where do the lice come from. Farmed salmon are not infected when they enter the saltwater pens therefore, logically, the lice are of a natural source in the environment. Yet we have yet to clearly identify that reservoir.

Water column raised for inspection.

SEA LICE MANAGEMENT

It is accepted that there exists a relationship between sea lice on wild salmon and salmon farms, although that relationship is, as yet, incompletely defined. Regardless, prudence demands that a cautionary approach be taken to managing the interactions. Mathematical modeling has been used to connect data from farms with that from wild salmon sampling. SLICE® has been shown to reduce lice on farms and therefore transmission to wild juvenile salmon. Reduced sea lice transmission implies improved wild salmon survival but it remains unknown if SLICE® is sufficient to conserve and restore wild salmon.

Studies in the Broughton indicate that infections begin in the winter. In the winter of 2008, salmon farms at the Knight Inlet/Tribune Channel region were treated with SLICE and thus were virtually free of sea lice. In the winter of 2007/2008 sticklebacks



This catch: mostly herring, few smolt.

around these farms were heavily (~70%) infected with chalimus stages of *C. clemensi*, an infection that occurred throughout the winter and continued after SLICE® was administered. The prevalence and intensity of the infection before and after treatment indicated that *C. clemensi* was being continually produced from a source other than the salmon farms.

An important component of management is an understanding of the range and density of lice in the environment. In an attempt to quantify the abundance and map the distribution of larval lice in the region, bi-weekly plankton tows were conducted throughout the Broughton in 2007-2008. The abundances of naupliar and copepodid stages of both *Lepeophtheirus salmonis* and *Caligus clemensi* were low. *L. salmonis* were found to be most abundant near recently active fish farms while *C. clemensi* showed little or no spatial association with fish farms, but may have been associated with herring aggregations.

HOST-PARASITE INTERACTIONS

That sea lice migrate towards the surface at night and move deeper during the daylight hours has long been accepted. However, recent research suggests that this may be less clear than previously thought. When *L. salmonis* nauplii and copepodids were held in a 10 m column suspended in the ocean there did not appear to be a preference for any particular depth and there was no apparent effect of daytime period on their vertical distribution. In the absence of lice, juvenile pink salmon distribution changed slightly from day to night, fish less than 3 weeks post-saltwater entry (up to ~0.5 g) were typically found to occupy the top 3 m of the water column.

When lice and fish were held together in the column, salmon dispersed more during the day, but their pattern of distribution did not change at night. No difference in the proportion of infected vs. uninfected fish was observed relative to the vertical distribution of the fish, suggesting that infective pressure is independent of daylight and depth. There have been suggestions that juvenile salmon prey on the eggs of lice and/or the lice themselves. It is unknown whether the copepodids were following the fish as potential hosts or the fish were following the copepodids as a potential food source, only that their vertical distributions were correlated within the column when they were free to interact.

PHYSIOLOGICAL IMPLICATIONS

While much of the focus in recent years has been on population effects of lice loads, there is very little available data on the effects infection on individual fish. Experiments in 2008 involved over 10,000 juvenile pink salmon, some as small as 0.2 g, and examined, in a field setting, the effects of *L. salmonis* on ionic balance and swimming performance of the fish at sea lice densities of 1 to 3 lice per fish. Sub-lethal effects of 1 louse per fish on ionic balance and swimming performance were dependent on the size of the fish but significant effects occurred only on fish with a body mass of <0.5 g. A higher density of lice (2 or 3 lice per fish) was required to trigger sub-lethal effects on ionic balance and swimming performance in larger fish (0.5 – 3.7 g). In all cases, sub-lethal effects were only detected when the life stage of the louse was at least chalimus 3-4. Compared with the sub-lethal changes observed for <0.5 g fish with 1 louse per fish, increasing lice density up to 3 lice per fish did not have an additive sub-lethal effect for fish of any size.

Interestingly, naturally infected fish appeared to be less sensitive to lice loads than did those fish that were artificially infected under lab conditions. Regardless, in all physiological studies mortality was minimal (<2%) among fish infected with sea lice during tests that lasted up to 28 days. Additionally, there is evidence from more than one study, that juvenile salmon may possess effective mechanisms for shedding lice.

FISH HEALTH

Fish health is a complicated field and involves a great deal more than a simple host parasite interaction. Fitness is impacted by early rearing, natural feed supplies, genetics, environmental conditions etc. Many factors lead to the state we call disease, and a pathogen is merely one factor in a complicated equation. Merely finding a parasite or pathogen on or in any organism is not to be confused with a state of disease. If a fish is in a healthy state it will be quite capable of combating any number of challenges. When that same animal is compromised by some factor, biotic or abiotic, the scenario can play out quite differently. For this reason it is important that we gain knowledge regarding the overall health of a population of fish. Juvenile pink salmon out-migrating through the Broughton Archipelago in 2008 were evaluated for physiologic condition, sea lice, other parasites, bacteria, viruses, and microscopic lesions.

Histopathology found microscopic lesions that are considered to have developed in the saltwater environment, yet were not attributable to sea lice. This suggests that there are other, as yet unidentified, factors that are impacting juvenile salmon in the Broughton. In nature, parasites are a normal and natural occurrence but the question remains, are salmon unhealthy because they are infested with lice, or are they infested with lice because they are unhealthy.

SALMON POPULATION DYNAMICS

It is important to highlight the fact that salmon populations have shown significant declines all

along the BC coastline. The population depressions are not limited to the Broughton. However, the research funded by the Forum focused on this region and found that pink salmon production out of the Glendale Channel was approximately half of that of 2007 and this is likely attributed to low adult escapement in 2007 relative to higher numbers observed in 2006.

Installation of a resistivity counter on the Glendale spawning channel will allow accurate egg to fry survival numbers to be acquired over the coming years to assess survival trends over time. Preliminary estimates of escapement derived via over-flight assessments indicate replacement of brood in some systems and much reduced returns relative to brood in other systems. The overall trend in escapement indicates a significant decrease in overall numbers between 2006 and 2008 with the Glendale at 91% fewer numbers of returning adults than in 2006. The trends are similar to those observed in other systems outside of the Mainland Inlets (i.e. Central and North Coast) and do not appear to be a localized event as was encountered in 2002 and 2003.

SALMON/SEA LICE DYNAMICS IN REGIONS OUTSIDE THE BROUGHTON ARCHIPELAGO

While the overall focus of the Forum funded research was the Broughton Archipelago, there were research projects underway in other regions that were fully or partially funded by the BCPSF. Juvenile salmon in the Bella Bella region, an area that lacks salmon farms, were found to host low levels of sea lice (3.5%), which are considered to be natural background levels for the region. In regions where there are fish farms, significantly more juvenile salmon were found to host sea lice in areas near to farms compared to areas farther from farms. Elevated levels of lice nearer to farms included significantly greater proportions of *L. salmonis*, a salmon-specific species, than *C. clemensi*, which is more of a generalist (found on numerous fish species).

The Kitasoo Fisheries Program undertook a monitoring program and collected juvenile salmon in areas around and away from salmon farms between 2004 and 2008 and assessed them for sea lice. Both *C. clemensi* and *L. salmonis* were observed on fish in all areas sampled. In 2008, lice levels were the lowest of all years data were collected. Prevalence and intensity of *L salmonis* was low in all areas sampled and in all years examined for both chum and pink salmon. *L. salmonis* abundance levels were higher on pink salmon caught around farms in 2005 and 2006 but not in 2007 or 2008 when data were compared to the reference area.

The Gulf Islands area in the Strait of Georgia is a major rearing area for all species of juvenile Pacific salmon. As part of another study in 2008, researchers were able to measure sea lice levels on these juvenile salmon. The levels of infection were approximately 70% and were mostly *C. clemensi*. There were no salmon farms in the area, indicating that large, natural infections of sea lice can occur.

CONCLUSIONS

The purpose of the Broughton research strategy was to attempt to clarify some of the interactions between farmed and wild fish in the marine ecosystem with a primary focus on wild pink and chum salmon populations in all facets of their life cycle. The research considered what factors in the ecosystem may impact these wild fish populations, the incremental risk, if any, associated with salmon farming, and how any potential risks could be mitigated. While many questions remain unanswered and new questions have arisen as a result of a rigorous collection of scientific investigations, the research findings expand our existing knowledge and will continue to provide a foundation for future studies that will shed more light on the inter-relationships among all factors.

Note: This article is based on individual research summaries provided to the BCPSF and the information has not been subjected to a formal peer review process. The full summaries of the research projects highlighted within the above may be found at the BC Pacific Salmon Forum's website at http://www.pacificsalmonforum.ca/

A list of researchers involved in the BCPSF funded projects is available at the Forum website: www.pacificsalmonforum.ca

Measuring the overall health of out-migrating juvenile pink salmon

There is considerable discrepancy in the interpretation of findings between lab-based and field sea lice studies conducted in British Columbia. Moreover, little information is available on the effects of other parasites and lesions on wild pink salmon at the individual and population levels.

In order to resolve this situation, researchers have been investigating the overall health of juvenile pink salmon during their out-migration in the Broughton Archipelago in 2007 and 2008. The fish were evaluated for physiologic condition, sea lice, other parasites, bacteria, viruses, and microscopic lesions.

This investigation yielded a number of interesting results. Juvenile pink salmon collected directly from the Glendale River in March 2008 had no sea lice or microscopic lesions suggesting that all lesions in fish sampled from salt water developed after saltwater entry. In 2008, the highest prevalence of motile sea lice occurred in June. Condition factor was not significantly associated with sea lice. Maximum prevalence of fish with acutely damaged liver cells (hepatocellular hydropic degeneration) was greater in 2007 (32%) than in 2008 (12%). Sea lice were negatively associated with liver glycogen stores in 2008. Parasites belonging to several taxonomic groups infested the Juvenile pink salmon, in many cases at higher prevalence levels than sea lice.

Duration: Mar '07 – Nov '08

Funded by: BC Pacific Salmon Forum

Project team: Sonja Saksida (BC CAHS), Gary Marty (BCMAL), Simon Jones (DFO), Sophie St-Hilaire (Idaho State U)

For information contact: Sonja Saksida (sonja.saksida@cahs-bc.ca)

Monitoring reveals decline in sea lice prevalence and abundance on wild salmon juveniles

In the Broughton Archipelago the prevalence and abundance of *L. salmonis* on wild juvenile pink and chum salmon has continuously declined since 2004. The reasons for this decline are not yet fully understood. DFO has conducted surveillance for sea lice since 2003.

In a controlled laboratory experiment, approximately 35% pink salmon weighing less than 0.3 g died following exposure to *L. salmonis* copepodids. But by the time these juvenile pink salmon grow to about 0.7 g, they are highly resistant to the lethal effects of *L. salmonis*. From this research the threshold of lethal infection was calculated to be of 7.5 lice/g for pink salmon weighing less than 0.7 grams.

The monitoring in the Broughton Archipelago has shown that in all years, virtually all wild pink salmon (> 98.9%) sampled in late March and early April had a mass of less than 0.7 g. But by June, in all the years surveyed, less than 1% of wild pink salmon juveniles are still under 0.7 g. The monitoring also revealed that the percentage of wild pink salmon weighing less than 0.7 grams with infections greater than 7.5 lice per gram was 4.5% in 2005, 0.8% in 2006, 0.4% in 2007 and zero in 2008.

Duration: Mar '03 – Nov '08

Funded by: BC Pacific Salmon Forum, DFO-ACRDP Co-funded by: Marine Harvest Canada, DFO.

Project team: Simon Jones (DFO), Brent Hargreaves (DFO)

For information contact: Simon Jones (simon.jones@dfo-mpo.gc.ca)

Multi-disciplinary team investigates genomics in sea lice and salmon

A new multidisciplinary research team in British Columbia initiated a project called Genomics in Lice and Salmon (GiLS). This 3-year project involving collaboration between three universities, industry partners and provincial and federal governments is aimed at achieving four key objectives.

First, researchers expect to elucidate Pacific and Atlantic salmon genetic responses following laboratory exposures to the sea lice *Lepeophtheirus salmonis* using salmon microarray technology. This knowledge should enable them to predict defense responses in both susceptible and refractory host species.

Second, the team is working to uncover the parasite genetic responses in order to develop effective parasite treatment targets. They plan to do this by obtaining a comprehensive list of the genes of *L. salmonis* and *Caligus* spp. and building a gene chip to examine gene expression patterns following exposure to environmental or biological effects.

Third, the team intends to confirm and define the newly identified Pacific population of *L. salmonis*. They are using existing and novel microsatellite markers and single nucleotide polymorphisms (SNPs) to examine the amount of genetic variation and its distribution in Pacific populations of sea lice.

In the fourth component of the project, researchers will analyze the potential for effective use of science in understanding, and ultimately moving towards the resolution of the sea lice/salmon controversy.

The full journal article of this project's results can be viewed at: http://springerlink.com/content/u63k14u857p40387/

Duration: Nov '08 – Oct '11

Funded by: Genome BC Co-funded by: U Vic, DFO, SFU, VIU, Marine Harvest Canada, Mainstream Canada, Grieg Seafoods, Microtech Research and Development Ltd., BCMAL

Project team: Ben Koop (U Vic), Simon Jones (DFO), Willie Davidson (SFU), Grant Murray (VIU)

For information contact: Ben Koop (bkoop@uvic.ca)

Can SLICE® have an impact on non-target organisms?

Sea lice infestations at marine cage finfish farms in British Columbia are often treated by the anti-parasitic chemotherapeutant SLICE®. Concerns have been raised by various stakeholder groups regarding the potential effect of the active compound in this treatment, Emamectin benzoate (EB), on non-target organisms.

To address this concern, researchers are investigating the fate of EB and its desmethyl metabolite following the application of SLICE® at selected finfish farm sites in the surrounding environment. They are measuring concentrations in localized sediments and the water column in order to provide an assessment of the potential effect on ecosystem functioning. The team is also looking at the uptake of EB and its desmethyl metabolite by the Pacific Spot Prawn, *Pandalus platyceros*, under both laboratory and field conditions.

This dual approach is providing a standardized framework for toxicity assessment and evaluation of 'real world' environmental conditions against which the toxicity measures can be compared. The outcomes of the laboratory study are providing a framework within which field derived measurements can be assessed. In addition, the measured environmental EB concentrations are being used to test, calibrate and implement the DEPOMOD model so it can be used to predict the behavior of EB in relevant aquatic ecosystems. These findings are proving to be useful in developing policy towards the regulation of SLICE®.

Duration: Sep '08 – Aug '09

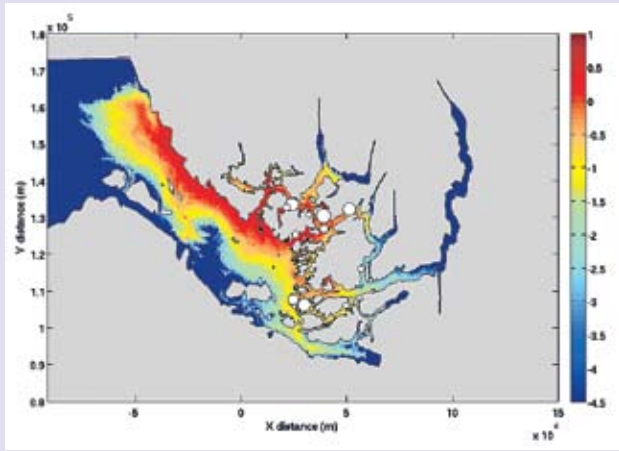
Funded by: BC Pacific Salmon Forum Co-funded by: DFO-PARR, BCMoE

Project team: Michael G. Ikonomou (DFO), Jon Chamberlain (DFO), Graham van Aggelen (EC), Caren Helbing (U Vic), Eric McGreer (BCMoE), Chris Sporer (Pacific Prawn Fishers Association)

For information contact: Michael G. Ikonomou (Michael.Ikonomou@dfo-mpo.gc.ca)

Modeling supports coordinated area management production in the Broughton

The Broughton aquaculture industry has recently proposed a Coordinated Area Management Production (CAMP) plan in which a combination of SLICE® treatments and fallowing are used to minimize potential lice infections on wild juvenile salmon migrating seaward past fish farms.



Concentration of infective sea lice (Log_{10}[copepods/m^3]) arising from farm sources. White circles show farm locations and size of the circles represents strength of the source

As part of a BC Pacific Salmon Forum project, researchers Dario Stucchi and Mike Foreman have developed two computer models for the Broughton Archipelago. One is a three-dimensional numerical circulation model that, with appropriate forcing for specific time periods, is capable of simulating velocity, salinity and temperature fields throughout the region. The second is a model of sea lice dispersal, development, and behaviour. This model applies the 3D circulation model of currents to predict dispersal of the planktonic larvae and model the temperature and salinity fields which control sea lice development and mortality.

As a guide to the future implementation of CAMP and in consultation with industry, the two models are being used to investigate how the 2008 infective pressures would have changed under different treatment/fallowing scenarios.

Duration: Sep '08 – Mar '09

Funded by: DFO PARR Co-funded by: BC Pacific Salmon Forum

Project team: Dario Stucchi (DFO), Mike Foreman (DFO), Ming Guo (DFO), Piotr Czajko (U Vic), Gabe Wiebe (U Vic), Brent Hargreaves (DFO), Simon Jones (DFO), Marine Harvest Canada, Mainstream Canada, Grieg Seafood BC Ltd.

For information contact: Dario Stucchi (Dario.Stucchi@dfo-mpo.gc.ca)

Researchers test light traps to monitor and control planktonic-stage sea lice

Investigators at Simon Fraser University and DFO are looking at novel ways to monitor and control sea lice using light traps. Sea lice are parasitic copepods that attach to and feed on fin fish. Aquaculture operations are striving to minimize sea lice infection within fish farms and prevent transfer between cultured and wild fish. Infection of both wild and cultured fish occurs when they encounter larval sea lice during their brief free-living planktonic stage of the life cycle.

Present control strategies minimize production of planktonic lice by limiting the density of their parasitic parent population. Presently this is done by adding the pesticide SLICE® to the fish feed when parasites on the penned fish exceed a triggering threshold abundance. However, the treatment is expensive, and cannot be administered close to harvest date.

A supplementary control could involve elimination of the planktonic stage lice. Both adult and planktonic sea-lice are positively phototactic: they swim toward a point source of light. This behavior can be exploited to physically trap the lice. Light traps are being deployed within and near fish pens in the Broughton Archipelago. By comparing trap capture rates with ambient densities of planktonic lice, sampled by pump, an estimate of the mortality or removal rate per trap can be made.

The team is also making a limited number of net tows in a region where planktonic lice were relatively abundant in 2007 and 2008, to learn if enhanced SLICE® treatment and fallowing in 2009 is having the desired effect.

Duration: Sep '08 – Mar '09

Funded by: DFO-PARR

Project team: David Mackas (DFO), Moira Galbraith (DFO), Brian Riddell (DFO), Iñigo Novales Flamarique (SFU), Christina Gulbranson (SFU)

For information contact: David Mackas (Dave.Mackas@dfo-mpo.gc.ca)

Will Scottish sentinel cage technology work in the Broughton Archipelago?

Health management of cultured salmon in British Columbia includes scheduled monitoring of parasitic sea lice, including *Lepeophtheirus salmonis*. Farmed stock is treated if sea lice infestations exceed the threshold defined in the Provincial Sea Lice Action Plan. Although infestations of farmed Atlantic salmon persist, associated disease has been virtually absent in BC and the parasite is considered a nuisance.

The extent to which local environmental (e.g., salinity, temperature, currents) and biological (e.g., abundance, distribution and diversity of wild hosts) processes not associated with salmon farming regulate levels of sea lice risk within the Broughton Archipelago is poorly understood. There is very little information on the abundance and distribution of wild salmonid hosts in the Broughton Archipelago particularly in the winter months. Consequently, farmed Atlantic salmon continue to be implicated as the most abundant hosts.

A method for quantifying the abundance of planktonic sea lice larvae (copepodids) during the winter months is needed, particularly during the weeks and months prior to the outmigration of juvenile pink and chum salmon. The objective of the proposed research in this pilot study is to determine the feasibility of using proven Scottish sentinel cage technology to better characterize the distribution of infective sea lice stages in the Broughton Archipelago.

Duration: Dec '07 – Sep '09

Funded by: DFO-ACRDP Co-funded by: Marine Harvest Canada

Project team: Simon Jones (DFO), Sonja Saksida (BC CAHS)

For information contact: Simon Jones (Simon.Jones@dfo-mpo.gc.ca)

Juvenile pink salmon must reach critical weight to withstand sea lice

Controlled laboratory exposures to *L. salmonis* were used to assess the effect of host size and parasite dose on the susceptibility and survival of wild- and hatchery-spawned pink salmon. The researchers conducted three trials in which juvenile pink salmon had starting weights of approximately 0.3, 0.7, and 2.4 g. In each trial, the fish were exposed to 0, 25 (only for 0.3 g), 50, or 100 copepodids per fish.

The results revealed that regardless of the pink salmon stock, approximately 37% of the 0.3 g fish died following exposures to 50 or 100 copepodids. The mean days to death was 16.1 and more than 80% of the lice on the dead fish were in the chalimus stages. Mortality was significantly lower when the larger fish were exposed to the sea lice. The researchers surmise that the skin of the 0.3 g pink salmon is histologically poorly developed and lacks scales compared with skin of 0.7 g and 2.4 g pink salmon.

The results indicate that an elevated risk associated with *L. salmonis* infection may occur among migrating post-emergent pink salmon during a relatively brief period before the fish reach 0.7 g.

The full journal article of this project's results can be viewed at: http://www3.interscience.wiley.com/journal/120751387/issue

Duration: Apr '07 – Jun '08

Funded by: DFO-ACRDP Co-funded by: Marine Harvest Canada

Project team: Simon Jones (DFO), Eliah Kim (DFO), William Bennett (DFO)

For information contact: Simon Jones (Simon.Jones@dfo-mpo.gc.ca)

Stress effects in shellfish investigated three ways

Responding to an industry-wide need for more efficient ways to evaluate and monitor health states in shellfish, three research teams across Canada have been looking at different aspects of the problem.

Seedstock differences in Newfoundland

DFO's Randy Penney, based in St. John's, Newfoundland, is interested in the reported variability in performance of different mussel seedstocks, some of which comprise two species (*Mytilus edulis* and *Mytilus trossulus*), when confronted with stresses related to temperature and salinity. At DFO, Randy Penney, Dr. Dounia Hamoutene and their team are comparing physiological stress responses (primarily "heat shock protein" Hsp) of several indigenous seedstocks from the Notre Dame Bay area. The team is currently working out some standardized testing protocols for Hsp and other stress proteins in the hopes of developing a quantitative way to identify "hardy" strains that can be used for inter-site transfers, and which may be expected to perform favourably compared to local mixed-species stocks. They hope to provide recommendations to the industry regarding the most desirable stocks for commercial development, and to begin comparative work on stress response in scallops (*Placopecten magellanicus*).

Behavioural indicators in Quebec

Mussels were also involved in a recently-completed study at the University of Quebec at Rimouski. Noting the difficulties in determining the state of health of individual shellfish outside obvious indicators such as very slow closing of the valves in already-moribund animals, Dr. Rejean Tremblay, Rachel Picard and Dr. Bruno Myrand have been seeking a simple, behavioural indicator that could be quantified for intermediate levels of stress between robust health and deep morbidity. They tested the time required for softshell clams (*Mya arenaria*) to bury themselves, and assessed the strength of attachment and number of byssus threads produced by mussels (*Mytilus edulis*), after removal from the water for more than three days at 100% humidity. The researchers reported that the behavioural indicators selected were not able to discern various levels of stress in test animals.

A Genome-based model in BC

A research program (*Myt*-OME) on the West Coast funded by Genome British Columbia and the BC Innovation Council has taken a different approach to the challenge of quantifying stress responses in shellfish. Led by Dr. Helen Gurney-Smith of Vancouver Island University's Centre for Shellfish Research and Dr. Stewart Johnson of the DFO Pacific Biological Station, a team of international collaborators is attempting to identify the genes involved in the expression of stress responses.

According to Dr. Gurney-Smith, "Most people have heard the expression 'happy as a clam', but the truth is we do not have any tools to determine if a clam is happy (healthy). Genomic science can provide the necessary tools".

In 2008 an investment of more than $400,000 by the Government of Canada through Western Economic Diversification Canada helped to establish a Shellfish Genomics Laboratory at Vancouver Island University in Nanaimo, BC, where research tools will be developed to diagnose various factors related to transportation, pollution and environment in hatchery-reared larvae and adult shellfish.

In recognition of the many possible overlapping sources of stress arising through environmental conditions, human activities and biological influences such as disease, Dr. Gurney-Smith and her team have launched a major program to develop a genomics tool for use with mussels (*Mytilus* spp.), a known ecosystem bio-indicator genus. They hope to devise an accurate way to measure the activity of specific genes that are up- and down- regulated in response to a variety of stressors. Once they can measure accurately the genomic biomarkers that respond to multiple-stressing conditions in the marine environment, they will be able to correlate levels of stress with environmental conditions, and to understand what ultimately determines a fatal response. With a sensitive genomics tool applied to a number of "keystone species", scientists should be able to perform far more accurate and timely health assessments of individual shellfish. This would facilitate assessments of ecosystems in various coastal zones and stocks in aquaculture operations, as well as monitoring of environmental changes and their effects.

Dr. Helen Gurney-Smith

Newfoundland study:

Duration: Nov '08 - Ongoing

Funded by: DFO

Project team: Randy Penney (DFO), Dounia Hamoutene (DFO), Juan Perez Casanova (DFO), Sean Macneill (DFO), Marsha Clarke (DFO).

For information contact: Randy Penney (Randy.Penney@dfo-mpo.gc.ca)

Quebec study:

Duration: 2005 – 2008

Funded by: MAPAQ

Project team: Rejean Tremblay (ISMER-UQAR), Rachel Picard (ISMER-UQAR), Bruno Myrand (CEMIM-MAPAQ).

For information contact: Rejean Tremblay (Rejean_tremblay@uqar.qc.ca)

British Columbia study:

Duration: Jan '09 – Mar '10

Funded by: Genome British Columbia.

Project team: Helen Gurney-Smith (CSR-VIU), Stewart Johnson (DFO), Ben Koop (UVIC), Antonio Figueras (CSIS-IIM, Spanish Ref. Lab. For Mollusc Diseases, Spain), Crain Newton (ATG Genetics).

For information contact: Helen Gurney-Smith (Gurneysmh@viu.ca)

(Photo: S. Gauthier-Clerc)

Quebec team investigates the metabolic basis for mussel gaping

The phenomenon of gaping observed in cultivated mussels in Quebec is a major obstacle to the development of the mussel aquaculture industry as consumers are very reluctant to buy open mussels. Mussels from Prince Edward Island, Quebec's main competition in this market, are reported to have a significantly lower incidence of gaping. It is therefore critical for the Quebec mussel aquaculture industry to gain an understanding of this phenomenon in order to be able to address it.

The research team is investigating whether the propensity of mussels for gaping is voluntary and occurs when they are exposed to air, resulting from a lack of sufficient oxygen to meet their metabolic needs, or whether it is caused by a decrease in tone of the adductor muscle, which controls valve movement. The appearance of gaping so soon after harvesting suggests that priority should be given to examining this phenomenon.

Several questions are being asked. Does temperature influence the intensity of metabolic activity in mussels and therefore their propensity for gaping? Does icing the mussels with large quantities of ice immediately after they are removed from the water help reduce their metabolic activity, increase their stress tolerance, and decrease their propensity for gaping?

Duration: Jun '07 – May '10

Funded by: DFO-ACRDP Co-funded by: SODIM, RAQ

Project team: Marcel Fréchette (DFO), Sophie Gauthier-Clerc (ISMER-MAPAQ), Réjean Tremblay (UQAR-ISMER), Francis Coulombe (CTPA-MAPAQ), Sonia Belvin (ISMER-MAPAQ), Marie-Élise Carbonneau (CTPA-MAPAQ), Réjean Allard (Pêcheries R. Allard Inc.), Marie-Gil Fortin (MAPAQ) Nicolas Bouchard (DFO), Linda Girard (DFO)

For information contact: Marcel Fréchette (Marcel.Frechette@dfo-mpo.gc.ca)

Finding the causal agent of malpeque disease in Nova Scotia oysters

The oyster industry has been plagued on several occasions by a highly infectious Malpeque disease. Initially, the disease appeared in 1915 in Malpeque Bay, PEI, and again in the 1950's and 60's, with losses of up to 90% of affected stocks. Disease tolerance developed over time followed by recovery of most stocks. In 2007, new outbreaks were observed in the Bras D'Or Lakes and St Ann's Harbour, Cape Breton.

Malpeque disease is believed to be caused by a pathogen, although all attempts to identify the cause of this abnormal condition have been inconclusive. The disease is diagnosed on various gross and histological observations, e.g., mantle regression, gaping, nodules in the mantle, accumulation of ceroid-containing cells, haemocyte infiltration and focal haemocyte accumulations.

Researchers are working on a two part investigation leading to the development of molecular-based tools for the diagnosis of Malpeque disease. The first is to confirm the presence of a pathogen in infected oyster tissues by isolating small parts of its genetic material. Using these data, the second part of the project is the development of a PCR-based test to determine the presence or absence of the pathogen from animal tissues.

Duration: May '08 – Mar '10

Funded by: DFO-ACRDP Co-funding: AANS.

Project team: Nellie Gagné (DFO), Mark Laflamme (DFO), Roland Cusack (NS DFA)

For information contact: Nellie Gagné (NellieGagne@dfo-mpo.gc.ca)

Mechanical harvester

Does mechanical clam harvesting in BC pose any environmental risk?

BC shellfish farmers are finding it challenging to compete in the international shellfish marketplace. To increase their competitiveness, the industry must find ways to increase productivity while at the same time reducing harvesting costs. For certain species, the use of a mechanical harvester holds significant promise to increase efficiency and lower costs.

In 2002, Chuckanut Shellfish Inc. modified a mechanical tulip bulb harvester, designed for greenhouse harvest, to successfully harvest Manila clams (*Venerupis philippinarum)* in Samish Bay, Washington. This machine effectively reduced harvest labour costs to 3-5% of the farm gate value.

Approximately 1,600 metric tonnes of Manila clams are harvested annually from farms in BC, and the traditional method of harvesting Manila clams is by hand, using rakes. Even though this is the accepted method in BC, an environmental assessment of hand harvesting has not been conducted. Literature on the environmental effects of mechanical harvesting does exist, though much of it is focused on different techniques and species in other areas of the world.

The research team in this project is determining the potential near and far field effects of mechanical and hand harvesting. In particular, they are considering the potential risks to valued habitat productivity, providing the scientific information necessary for the development of appropriate regulatory approval criteria for such activities.

Clam harvesting

Hand harvesters

Duration: Jul '08 – Jun '10

Funded by: DFO-ACRDP Co-funded by: BCSGA.

Project team: Kerra Hoyseth (DFO), Ryan Sherman (DFO), Steven Cross (U Vic), David McCallum (BCSGA), Tom Broadley (BCSGA), Gordy McLellan (Macs oysters), Richard Hardy (Pentlatch Seafood), Bill Taylor (Taylor Shellfish), Chris Pearce (DFO), Bill Heath (BCMAL).

For information contact: Kerra Hoyseth (Kerra.Hoyseth@dfo-mpo.gc.ca)

Project website: http://bcsga.ca/?p=444

Submersible deep-water mussel system to begin commercial trials

Mussel growers in Atlantic Canada, Quebec and British Columbia have to contend with challenges presented by rough seas, ice and diving ducks, all of which can compromise the consistency and economic viability of production. However, if socks or lines could be suspended in deep water, at least for part of the year, most of these perils could be avoided without removing or relocating the entire farm. For some areas, where mussel farming is now marginal, a way to mitigate these challenges could ensure sustainability and help local mussel growers consolidate their position in the spectrum of local aquaculture businesses.

A research program funded by DFO-AIMAP and the Government of Newfoundland and Labrador has been investigating the feasibility of submerging long lines in deeper water during the winter. During Phase I of the current project, a reeving device was created by Farewell Mussel Farms of Newfoundland, then modified for use in deep water, and deployed by Norlantic Processors, Ltd. Other Phase I stakeholders included the National Research Council of Canada, and Go Deep International of New Brunswick. During this trial, the lines were lowered and raised over two consecutive seasons, and performed well through periods of rough weather, shore-fast ice and pack ice movement. Although the aim is to protect equipment by sinking it out of harm's way, the mussels no doubt benefited from less handling and more stable growing conditions at a time when conditions can be extreme.

With good results over the last two growing seasons, the project will be moving into Phase II this summer. A deep water site has been selected for early commercialization trials, and if the concept proves economically viable, mussel farmers on both coasts will have a way to protect their gear and their stocks, and may look forward to all-season production with far fewer headaches.

Duration: Aug '08 – Jul '09

Funded by: DFO-AIMAP Co-funded by: NRC, NL DFA, Go Deep International, Farewell Mussel Farms.

Project team: Terry Mills (Norlantic Processors), Shawn Paul (Norlantic Processors), Greg Brake (Norlantic Processors).

For information contact: Terry Mills (terrymills@nf.aibn.com)

(Photo: T. Landry)

Evaluating and optimizing mussel seed quality in Nova Scotia

One of the strengths of the mussel aquaculture industry in Atlantic Canada is the access to an affordable and reliable seed supply. However, this has also generated some concerns over the quality of mussel seed, particularly in relation to the presence of the two *Mytilus* species; *M. edulis* and *M. trossulus*.

Poor seed quality has resulted in crop losses due to high mortality rates, processing difficulties and low market values. Recent work on the seed quality issue is providing mussel farmers with a better knowledge on geographical variability in seed quality in terms of species composition as well as physiological fitness.

Work in this project is focused on the temporal variability of mussel seed. Specifically, researchers are investigating the ratio of *M. trossulus* and *M. edulis* and their respective physiological fitness throughout their growth cycle in the natural population and aquaculture sites in Nova Scotia.

Researchers are developing cost-effective and practical approaches to evaluate and optimize seed quality by reducing the percentage of *M. trossulus* while improving the quality of seed in terms of the physiological fitness. Apart from the clear economical benefits of developing these approaches, there are equally important ecological benefits associated with optimizing seed quality. Improving the efficiency of mussel farms will help optimize the critical ecological services provided by mussels and other filtering animals in aquaculture environment.

Duration: Mar '07 – Jun '09

Funded by: DFO-ACRDP Co-funded by: Darren Porter, NS DFA

Project team: Thomas Landry (DFO)

For information contact: Thomas Landry (Thomas.Landry@dfo-mpo.gc.ca)

Can manipulation of culture depth reduce summer mortalities in Pacific oysters?

Oyster growers in British Columbia normally lose approximately 10% of their stock in raft-based operations during the summer. Transient periods of very high temperature and the occurrence of harmful algal blooms can cause a massive increase in the mortalities, decimating oyster stock by as much as 50 to 100%.

Researchers are proposing a management option to mitigate the impact of these two environmental factors. It involves lowering oyster culture trays to a depth where the temperature is lower and harmful algae are less concentrated. This is to be done as soon as the temperature and seawater transparency reach certain critical values. The caveat of this method is that normal phytoplankton are also concentrated close to the water surface, and lowering the oysters would take them out of reach of their food source, thus reducing their growth.

In order to find the optimum balance between oyster mortality and growth, it is necessary to find the optimum depth to which the oysters should be lowered in conjunction with the temperature shift that should be triggered by the change of depth. This investigation is geared to study this problem with scientific methods applied to farm conditions throughout the Strait of Georgia. The results of this research will allow oyster growers to make management decisions to reduce the mortalities in their stock based on simple environmental monitoring and tray movement.

Duration: Jun '08 – Jul '09

Funded by: DFO-ACRDP Co-funded by: BCSGA, Mac's Oysters Ltd., Taylor Shellfish Canada.

Project team: Maite Maldonado (UBC), Chris Pearce (DFO), David Cassis (UBC)

For information contact: Chris Pearce (Chris.Pearce@dfo-mpo.gc.ca)

Gulf of St. Lawrence navigation buoys may serve as mussel spat monitoring tools

Choosing a good mussel culture site is complicated by the lack of prior knowledge of recruitment and growth of spat under farmed conditions. Once established, mussel culture operations also need annually updated information about spat performance. In addition, the approaches generally used in this field are often plagued by problems inherent in monitoring the spatial and temporal variability in the marine environment.

These constraints impose choices that limit the geographic scope of conventional monitoring programs. Without sound data, the industry's ability to plan its research and development needs is compromised. It is therefore essential to develop effective and economical strategies for studying geographic variations in the recruitment and growth of mussel spat.

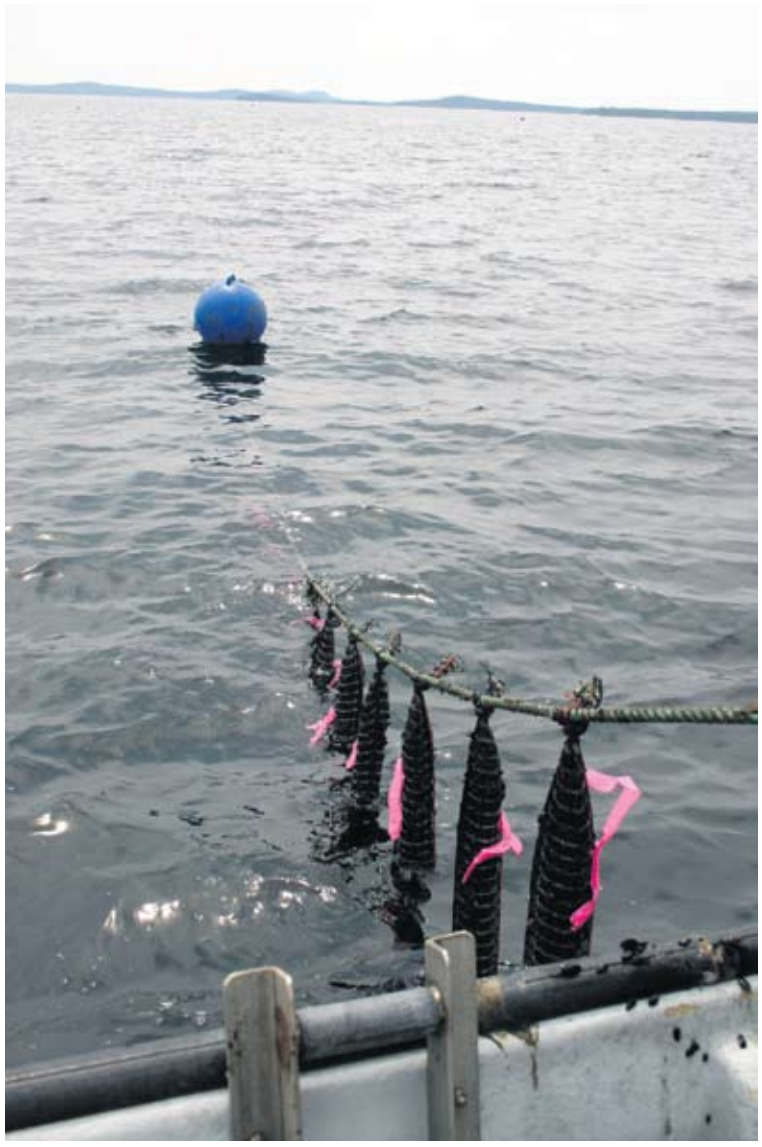
This project aims to develop a simple, effective and low-cost method for monitoring recruitment and growth of mussel spat. The team is comparing spat populations from conventional collectors with spat found on navigation buoys at various sites in the Gulf of St. Lawrence. The spat from collectors can be considered to be representative of the aquaculture situation and will serve as a control. The investigation is focusing on the potential usefulness of the navigation bouys for aquaculture monitoring.

Duration: Dec '06 – Mar '10

Funded by: DFO-ACRDP Co-funded by: SODIM, RAQ

Project team: Marcel Fréchette (DFO), Martin Guay (CACN), Yannick Goaziou (CACN), François Bourque (MAPAQ), Benoît Thomas (MAPAQ), Ihsène Ben Salah (UQAR-ISMER), Jocelyne Pellerin (UQAR-ISMER), Linda Girard (DFO), Myriam Lachance-Bernard (DFO)

For information contact: Marcel Fréchette (Marcel.Frechette@dfo-mpo.gc.ca)



An experimental mussel transfer in Green Bay, NL (Photo: DFO)

Improved mussel seed supply results from Newfoundland project

Mixed *M. edulis* and *M. trossulus* stock from NL (Photo: DFO)

Newfoundland is a zone of hybridization between two mussel species, *Mytilus edulis* and *M. trossulus* and growers currently use seedstocks of mixtures of both species and their hybrids. Low production rates and poor quality product have been associated with stocks of high proportions of *M. trossulus*. Evidence has shown that culture of monospecific *M. edulis* stocks has potential to improve industry-wide production and product quality.

The use of transferred monospecific *M. edulis* stocks by industry has been recommended to replace the current practice of collecting seed on sites with high ratios of *M. trossulus*. However, monospecific *M. edulis* stocks have not always consistently outperformed indigenous mixed-species stocks when such seedstocks have been transferred to other growout sites.

There is speculation as to the reasons for this, but genetic variation within the *M. edulis* genotype is highly suspected. Sources of monospecific or high-ratio *M. edulis* stocks need to be identified and their performance needs to be tested on recipient sites to determine their true potential as donor seedstock sites.

The research team is searching for and assessing new potential seedstock sources. In addition, they are closely assessing seedstock in relation to existing aquaculture leases to determine their potential for development as future donor sources of high quality seed.

Duration: Apr '08 – Mar '10

Funded by: DFO-ACRDP Co-funded by: NRC-IRAP; MI, CCFI.

Project team: Randy Penney (DFO), Sean Macneill (DFO), Sharon Kenny (DFO), Marsha Clarke (DFO/NAIA), Kim Hobbs (NAIA), Christopher Dawe (MI), Darryl Green (NAIA), Tom Brown (MI), Chris Brown (NRC), David Innes (MUN), Marc Kielley (CCFI).

For information contact: Randy Penney (Randy.Penney@dfo-mpo.gc.ca)

Female skeleton shrimp: Mature female skeleton shrimp (*Caprella mutica* about 12 mm total length excluding antennules) showing well developed brood pouch.
(Photo: T. Gosselin)

Research aims to control epibionts on mussel spat collectors

Epibionts can have a significant effect on mussel spat collection and growth. Researchers are examining interactions between skeleton shrimp, hydrozoans and mussels at mussel culture sites in Cascapédia and Gaspé bays. Improving the basic knowledge about these epibionts is helping to verify the effectiveness of an epibiont control protocol and is leading to the development of criteria for determining whether "treatment" is worthwhile, based on a cost/benefit analysis over time periods representative of mussel spat collection and socking operations.

During the course of this project, the research team is documenting the biology, ecology and spatial and temporal variability of the establishment of undesirable epibiont communities. They are testing the hypothesis of a negative effect of skeleton shrimp and hydrozoans on mussel spat collection and growth in the short term (intra-season) and in the long term (spat collection and socking) and quantify the impact.

They are also exploring the trophic dynamics of epibiont communities on spat collectors and, the case arising, determining the mechanism by which skeleton shrimp impact spat collection and growth (predation and/or competition for food). Finally, they are verifying the effectiveness of early bringing in for controlling epibionts and propose decision-making rules based on the impact and costs for various "infestation" thresholds.

Mussel spat collectors with heavy set of mussel spat completely covered by a dense population of skeleton shrimp. (Photo: C. Turcotte)

Duration: Apr '07 – May '10

Funded by: DFO-ACRDP Co-funded by: DFO-AIS.

Project team: Bernard Sainte-Marie (DFO), Christian Turcotte (UQAR), Réjean Tremblay (UQAR), Fabrice Pernet (IFREMER, Sètes)

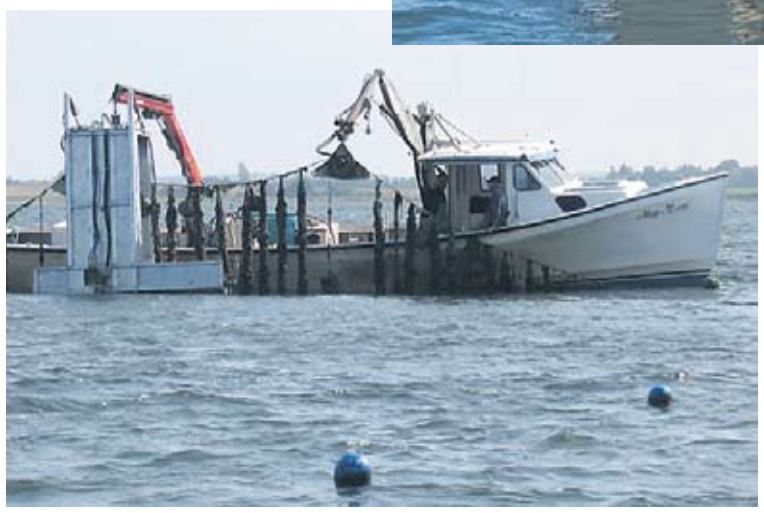
For information contact: Bernard Sainte-Marie (Bernard.Sainte-Marie@dfo-mpo.gc.ca)

Projects begin to yield results in managing invasive tunicates in PEI

A multi-project initiative is yielding innovative equipment and approaches in managing and processing tunicate infested mussel crops in PEI. Over twenty individual projects are currently being conducted to reduce the impact of invasive tunicates on mussel crops and to improve the productivity in infested waters. Technologies to reduce the biomass of tunicates on mussel socks are being transferred, modified and tested.

The industry is focusing its main efforts on two technologies in order to optimize their use in relation to timing and frequency of application, within a sound environmental context. These projects are providing critical information on the effects of these treatment regimes in different geographical areas with varying levels of infestation.

Complementary scientific investigations are providing valuable information on the biology of the invasive tunicate to assist in developing optimal management strategies that will ensure the sustainability of the mussel industry in PEI, as well as other aquaculture industries in Canada affected by aquatic invasive species.



Above: Lime treatment system used to treat the clubbed tunicate in Malpeque Bay, recovers the lime in the horizontal part of the mechanism for re-use. This system belongs to Martin MacDonald.

Left: High-pressure washer used to treat mussel socks for *Ciona*. The machine uses two rows of 8 high pressure oscillating water nozzles to clean *Ciona* off the mussel socks as they pass through the vertical chamber suspended from the side of the boat. This picture was taken in Cardigan Bay. The pressure washer belongs to Wayne Chaisson and has proved very effective at cleaning *Ciona* off mussel gear.

Duration: Jul '07 – Mar '08

Funded by: DFO-ACRDP Co-funded by: PEI DFAE, ACOA, PEIAA

For information contact: Thomas Landry (Thomas.Landry@dfo-mpo.gc.ca)

Project investigates sources of impacts to clam gardens in the Broughton Archipelago

Concern has been raised by Broughton Archipelago First Nations ('Namgis and Kwicksutaineuk-Ah'kwak'ah'mish First Nations) about changes to the productivity of a number of clam beaches and culturally modified clam terraces within their Traditional Territories.

The concern centers on the possibility of impacts to clam populations from commercial salmon farms in the Broughton Archipelago. In addition to salmon farming, the range of possible human disturbances in this region includes forestry impacts, such as watershed logging and sediment deposition, log handling and storage activities, and woody debris buildup in the marine environment.

Desired outcomes of this project are to understand the forces that shape and impact the populations of bivalves in the study area with special reference to the potential effects of salmon farms. Of equal importance is the development of a hierarchical ranking of factors that influence intertidal clam populations. In addition, future considerations for long-term monitoring or mitigative procedures to suspend or reverse further loss of clam productivity and quality standards will be outlined.

Duration: Nov '07 – Sep '10

Funded by: DFO-ACRDP Co-funded by: Marine Harvest Canada Inc.

Project team: Terri Sutherland (DFO), Sharon Dedominicis (Marine Harvest Canada Inc.), Clare Backman (Marine Harvest Canada Inc.), Marty Weinstein (M.S. Weinstein Consulting Services), Doug Aberley ('Namgis Nation Representative), Jason Dunham (DFO), Curtis Roegner (NOAA Fisheries Service), John Harper (Coastal and Ocean Resources Inc.), Barry Hargrave, Shawn Robinson (DFO), Kevin Butterworth (BC CAHS), Eric McGreer (BC MoE).

For information contact: Terri Sutherland (Terri.Sutherland@dfo-mpo.gc.ca)

Developing strategies to optimize shell growth performance and quality of near market size oysters

In this 18-month study, researchers explored the efficacy of different grow-out methods, anti-fouling techniques and grading strategies for the purpose of augmenting the production of market-size oysters grown in suspended culture in Baie St-Simon in northern New Brunswick.

They are documenting the annual shell growth of various size classes using individually-labeled oysters deployed in various systems including floating bags, oyster tables, OysterGro cages and Dark Sea trays.

In addition, the team is evaluating the effectiveness of brine dipping and/or air exposure for eliminating various fouling organisms including oyster spat, barnacles, mussels and boring sponge.

Work is also being done to evaluate three grading strategies for oysters larger than 50-mm. The three methods are mechanical grading in spring (mid-June 2008), mechanical grading in fall (mid-September 2007), and no grading where oysters were left in bags and fouling organisms were eliminated via bag flipping/brine dipping.

Duration: Apr '07 – Mar '09

Funded by: DFO-ACRDP Co-funded by: L'Étang Ruisseau Bar Ltd.

Project team: Marie-Hélène Thériault (DFO), André Mallet (L'Étang Ruisseau Bar Ltd.)

For information contact: Marie-Hélène Thériault (Marie-Helene.Theriault@dfo-mpo.gc.ca)

American Oyster growth

OysterGro cages temporarily upside-down for eliminating fouling organisms

Do New Brunswick biofouling control methods impact oyster productivity?

In New Brunswick, the farming of eastern oysters (*Crassostrea virginica*) is mainly carried out using floating Vexar® bags. This technique allows for easy access to stocks, reduces predation, and promotes growth by maintaining the oysters in relatively warm and phytoplankton-rich surface waters.

Nonetheless, floating bags are vulnerable to fouling organisms and researchers in this project are investigating whether biofouling control methods such as desiccation and heat exposure significantly impact oyster productivity.

Bags provide a good recruitment substrate for wild mussel larvae (*Mytilus edulis*). They are also susceptible to other fouling organisms, such as barnacles (*Semibalanus balanoides*, *Balanus balanus*, *Balanus crenatus*), wrinkled rock borers (*Hiatella arctica*), and wild oysters. Fouling organisms grow rapidly during summer, compete for the same food resources as oysters, and ultimately obstruct water flow.

Growers mitigate the biofouling problem by exposing bags to air for three days, a desiccation approach that is quite labor-intensive. Another mitigation measure presently being developed by the industry consists of briefly exposing fouled bags (containing oysters) to heat (50 - 80°C).

Duration: Jun '08 – Aug '10

Funded by: DFO-ACRDP Co-funded by: NBPSGA

Project team: Luc Comeau (DFO), Elise Mayrand (U Moncton), Tina Rousselle (DFO), Léon Lanteigne, Maurice Daigle (Aquaculture Acadienne Ltee.).

For information contact: Luc Comeau (Luc.Comeau@dfo-mpo.gc.ca)

Oyster bag fouled with mussels

Hot water bath for control of biofouling organisms. Conveyor belt drives Vexar® bags in hot water.

Floating oyster bags in New Brunswick

Can culture density be increased for oysters in New Brunswick?

In New Brunswick, oysters are primarily grown in floating Vexar® bags attached to longlines. A recent aerial survey indicated that growers deploy bags at an average density of 2,000 bags per hectare. This density is strikingly low compared to other oyster farming areas, such as in France where average stocking density is reportedly 5,000 bags per hectare.

The rationale for conducting the present investigation is based on a proactive strategy for shellfish management in NB, considering that the NB oyster industry is still developing, and that control sites are readily available to carry out impact studies using robust designs such as BACI (Before-After-Control-Impact).

This project is evaluating the effects of increasing stocking densities on oyster productivity (e.g., shell growth) and the environment (e.g., biodeposition). In these trials, stocking densities are being increased well beyond current levels in NB and the effects are being monitored over a three-year period.

Oyster tables in Marennes-Oléron (France)

Duration: Jun '08 – Mar '12

Funded by: DFO-ACRDP Co-funded by: NBPSGA

Project team: Luc Comeau (DFO), André Mallet (Mallet Research Services Ltd.), Claire Carver, Sylvio Doiron (NB DAA)

For information contact: Luc Comeau (Luc.Comeau@dfo-mpo.gc.ca)

Cockle (Photo: CSR)

BC project works out cockle hatchery production techniques

There is significant interest in the commercial cultivation of the basket cockle (*Clinocardium nuttalli*) within British Columbia. This is due to several factors, including its relatively fast growth rate, its ability to utilize various substrata, its adaptation to grow and survive in the cold waters of the coast of BC and Alaska, and its importance as a preferred First Nations' food group.

This targeted project is designed to investigate the optimal hatchery rearing conditions for this species, building on previously established work on broodstock conditioning and the early embryogenesis phases.

Research is underway into the optimal species composition and ration of microalgal cells for growth and survival of both larvae and post-larvae (up to 2 mm in length). In addition, work is being done on optimal rearing densities and rearing temperatures for both larvae and post-larvae of this species.

Duration: April '07 – Jun '09

Funded by: DFO-ACRDP Co-funded by: CSR-VIU

Project team: Helen Gurney-Smith (CSR-VIU), Chris Pearce (DFO), Wenshan Liu (CSR-VIU), Don Tillapaugh (CSR-VIU), Andrew Dryden (Evening Cove Oysters).

For information contact: Helen Gurney-Smith (Helen.Gurney-Smith@viu.ca)

BC project investigates conditions for optimal on-growing of the basket cockle

The basket cockle, *Clinocardium nuttallii*, occurs on the Pacific coast of North America from San Diego to the Bering Sea. In British Columbia there is significant commercial interest in basket cockles as an aquaculture species as a result of their relatively fast growth rate, ability to utilize different substrata, adaptation to the cold waters of BC, and importance as a preferred First Nations' food group.

Researchers are investigating the optimal on-growing conditions for this species, building on previously established work on broodstock conditioning, embryogenesis, and hatchery development.

The project combines laboratory and field-based studies on optimal on-growing conditions. Laboratory research is investigating the optimal seed rearing techniques for maximized production in the hatchery, the growth and survival of cockle seed in different substrata, and the post-settlement movement of these motile bivalves. Field studies are determining the optimal seed size, densities, season, and site for transplantation. In addition, the team is looking at optimal on-growing aquaculture husbandry methods (intertidal or off-bottom suspension culture).

This project is yielding valuable recommendations for the management and sustainable production of basket cockles through the responsible development of a new native aquaculture species of cultural significance.

Duration: Aug '08 – Oct '09

Funded by: DFO-ACRDP Co-funded by: CSR-VIU

Project team: Helen Gurney-Smith (CSR-VIU), Chris Pearce (DFO), Anya Epelbaum (CSR-VIU), Don Tillapaugh (CSR-VIU), Andrew Dryden (Evening Cove Oysters)

For information contact: Helen Gurney-Smith (Helen.Gurney-Smith@viu.ca)

Research team assesses impacts of geoduck harvesting

Geoduck harvest impacts (Photo: DFO)

There has been widespread interest in the culture of the Pacific geoduck clam (*Panopea abrupta*) within British Columbia for a number of years. However, the commercial-scale development of this species has been hindered by a lack of governmental policy/legislation and concerns around how geoduck culture and harvest will impact the environment.

These concerns are generally focused on the harvesting process, as high-pressure water hoses ("stingers") are used to liquefy the substratum around the clams in order to extract them. This technique is used by aquaculturists as well as the wild fishery.

Researchers are assessing the effects of geoduck clam harvest on the benthic sedimentary environment, nearby eelgrass beds, and the suspended sediment concentration. In addition, they are examining how these effects vary spatially and temporally at both intertidal and subtidal study sites.

The outcomes are anticipated to enable government agencies to make informed decisions about the potential expansion of geoduck aquaculture in BC in both intertidal and subtidal sites.

Duration: Sep '08 – Dec '10

Funded by: DFO-ACRDP Co-funded by: BCMAL, West Coast Geoduck Research Corp., Abrupt Shellfish Inc.

Project team: Chris Pearce (DFO), Wenshan Liu (CSR-VIU), Miriam O (DFO), Grant Dovey (Resource Consulting Inc.), Bruce Clapp (West Coast Geoduck Research Corp.), Michelle James (West Coast Geoduck Research Corp.), Sean Williams (Abrupt Shellfish Inc.)

For information contact: Chris Pearce (Chris.Pearce@dfo-mpo.gc.ca)

Bay of Fundy project aims to enable over-wintering of juvenile soft-shell clams

Researchers are seeking to determine the optimal over-wintering techniques for juvenile soft-shell clams in the Passamaquoddy Region. A key outcome of the project is to establish and maintain a reliable hatchery source and transport of juvenile clams for the clam industry in Southwest New Brunswick.

The team is investigating techniques that yield the highest survival rates. They are transplanting over-wintered hatchery spat to the Lepreau Harbour lease site (MS 1113) and monitoring post-seeding survivorship through seasonal sampling. Pending the success of this technique, the project aims to develop this technology on a larger scale that can support the industrial demand.

Over-wintering soft-shell clams in the Bay of Fundy can yield reasonably high survival levels (~80%) with an anchored, submerged floating cage system. Keeping the cages anchored from the bottom and floating at a depth of at least 15 meters from the surface at mean low water would provide the most stable environment and highest survival of soft-shell clams. Over two years, mortality results from clams sampled in Lepreau Harbour lease averaged ~18.5% each year. The result of this initial work is now leading to work in other areas of the Bay of Fundy.

Biologist from Eastern Charlotte Waterways examining experimental clam plots for survival of the over-wintering clam seed.

Photo of the experimental clam plot in Lepreau Basin, Bay of Fundy, showing the netting covering the area to exclude predators from the newly planted juveniles. Notice the boot mark for scale.

Duration: Dec '06 – Mar '09

Funded by: DFO-ACRDP Co-funded by: Eastern Charlotte Waterways Inc..

Project team: Shawn Robinson (DFO), Benny Travis (Eastern Charlotte Waterways Inc.), Karl Whelan, Jeremy Matheson, Dan McGrattan, Laura Barrett, Eastern Charlotte Waterways Inc.

For information contact: Shawn Robinson (Shawn.Robinson@dfo-mpo.gc.ca)

Estimating fall-off of mussels cultured on self-operating collectors

In Carleton (Chaleur Bay, Quebec), some mussel farmers are using the self-operating collector method, which consists of culturing mussels on collectors without adjusting the density. This results in a decrease in population density due to a self-thinning process. Differences in the number and size of mussels that fall to the bottom depend on whether socks or self-operating collectors are used.

Mussel fall-off with self-operating collectors can be calculated based on the principle of self-thinning. The necessary data are currently available in a publication in preparation by Lachance-Bernard *et al.*. However, there are at present two possible approaches to calculation.

The goal of this project is to determine the best approach and to provide a preliminary estimate of the fall-off process. The requisite samples are obtained by divers in order to minimize mussel fall-off during sampling. This work is a preparatory stage for comparison of the ecosystem effects of conventional suspension culture and mussel culture using self-operating collectors.

Duration: Sep '08 – Mar '09

Funded by: DFO-PARR

Project team: Marcel Fréchette (DFO), Linda Girard (DFO) Myriam Lachance-Bernard (DFO), Marine de Roumefort, Éric Bujold (Ferme maricole du Grand Large, Carleton)

For information contact: Marcel Fréchette (Marcel.Frechette@dfo-mpo.gc.ca)

Team studies impact of cultured mussels and exotic tunicates on plankton communities in PEI

Ecological principles suggest that suspended mussel culture will have a direct influence on planktonic communities via predation and grazing by the mussels. A number of cascading effects may also influence this. One recent suggestion is that mussels will influence the size structure of the plankton. This, in turn, may influence the ability of exotic tunicates to establish and out-compete the farmed mussels as the tunicates may feed on smaller sized organisms/particles.

In this study, researchers are assessing the influence of mussels and/or associated tunicates on plankton community size structure. They are placing purpose-built small mussel socks in mesocosms for 1 hour periods and comparing the abundance and size-structure of the communities before and after the socks are introduced into the mesocosms and among treatments.

Trials consist of mussels only, inert controls, inert controls with tunicates, and mussels with tunicates. Both of the species *Ciona intestinalis* and *Styela clava* are used independently for a total of 8 treatments.

This work is helping to better understand the interactions between farmed mussels and invasive tunicates as well as their impact on planktonic communities.

Duration: Apri '08 – Mar '09

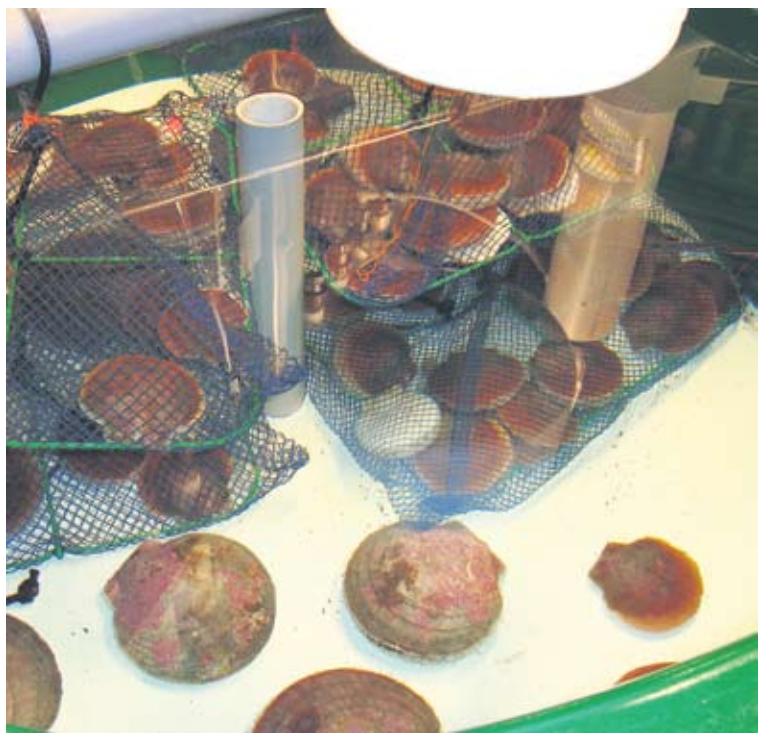
Funded by: CAISN Co-funded by: DFO

Project team: Chris McKindsey (DFO), Mayi Lecuona (DFO), Mathieu Huot (DFO)

For information contact: Chris McKindsey (Chris.McKindsey@dfo-mpo.gc.ca)

Mussel socks in mesocosms were used to evaluate the influence of mussels and associated exotic tunicates on plankton communities, PEI (Photo: M. Lecuona)

Moncton team develops rapid identification technique for larval scallops



Two species of scallop, *Placopecten magellanicus* and *Chlamys islandica*, are commercially exploited in eastern Canada. *P. magellanicus* is found on the Atlantic coast of North America from North Carolina to Newfoundland. *C. islandica* has a more northern distribution ranging from Greenland to Massachusetts.

Juvenile recruitment with spat collectors is used for stocking natural beds and for aquaculture ventures. Collecting sites may yield very different proportions of *P. magellanicus* and *C. islandica* individuals. A method for the rapid and specific quantification of each species from a sample of larvae would help to prevent the use of collectors where the recruitment of the preferred species is not optimal. This method would also replace the time-consuming process of visually identifying and counting larvae under a microscope.

With the use of fluorescent probes, a real-time PCR is being developed for the purpose of specifically identifying the ratio of each species in a mixed sample. The assay is being tested and validated using samples collected in various areas of eastern Canada.

Duration: Sep '08 – Mar '09

Funded by: DFO Co-funded by: University of Moncton

Project team: Nellie Gagné (DFO), Mark Laflamme (DFO), Monique Niles (DFO), Kynan Philippe (Undergraduate student, U Moncton)

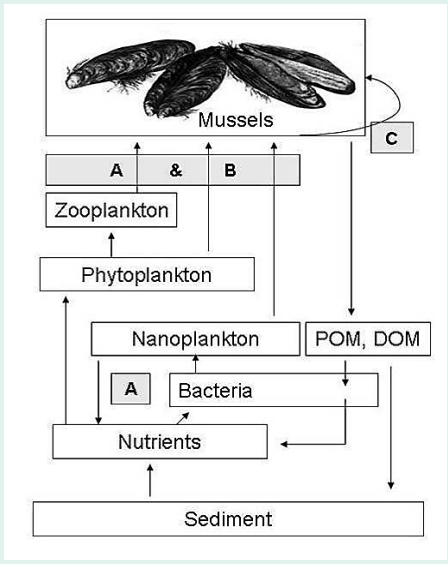
For information contact: Nellie Gagné (Nellie.Gagne@dfo-mpo.gc.ca)

Quebec project applies novel approach to understand nutrients and mussel culture

The future of aquaculture is dependent upon research that leads the way to economically efficient yet environmentally sustainable methods of production. One approach to achieving this goal lies in understanding and managing aquaculture facilities as a food-web that is embedded in the natural, spatially extended, marine ecosystem.

In cooperation with the mussel aquaculture industry on the Magdalen Islands, the team is conducting experimental research that applies the principles of food web and ecosystem ecology. The investigation is exploring how the flows of matter and energy across the food web can be managed in a way that results in an increased production of high-quality, harvestable shellfish. This approach is novel in that it goes beyond examining these processes at the scale of the individual mussel. Rather, it attempts to understand the process of shellfish production in an ecosystem context.

Specifically, the team is looking at the links between cultured mussels and planktonic communities, impacted directly through grazing and indirectly through altering nutrient fluxes. In addition, they are investigating how these nutrient fluxes in turn influence planktonic communities which then influence the mussels. This research is expected to have a strong influence on government policy and eventually translate into novel production methods for Canadian shellfish aquaculture. The team describes their project as AQUAMAN: AQUAculture of Mussels And Nutrients.



Simplified web of trophic relationships in mussel aquaculture. Grey boxes refer to research sub-projects (Credit: G. Fussman)

Duration: Sep '08 – Jun '11

Funded by: NSERC Co-funded by: DFO, SODIM, Moules de culture des Iles

Project team: Gregor Fussmann (McGill U), Philippe Archambault (UQAR-ISMER), Connie Lovejoy (U Laval), Bruno Myrand (MAPAQ), Chris McKindsey (DFO), Stéphane Plourde (DFO), Réjean Tremblay (UQAR-ISMER), Michel Fournier (Moules de culture des Iles)

For information contact: Gregor Fussmann (gregor.fussmann@mcgill.ca)

Team develops indicators to monitor phytoplankton depletion by mussels

Filter-feeding by mussels naturally results in some local reduction (depletion) of their phytoplankton food supply. If the spatial scale of phytoplankton depletion includes a significant fraction of the coastal inlet, this effect on the base of the marine food web raises concerns about the ecological costs to other components of the ecosystem. These costs can be used to define the "ecological carrying capacity" of the site.

Phytoplankton depletion was documented at mussel aquaculture farms in Canada and Norway using a computer controlled, towed undulating vehicle (BIO-Acrobat) that permitted rapid 3-D mapping of phytoplankton variations over farm to coastal ecosystem scales. Intensive mussel culture activities not only significantly affected phytoplankton concentration at the coastal ecosystem scale under some conditions, but also markedly altered the size of the phytoplankton.

Six PEI embayments were surveyed in August 2008. Researchers found that the bays that are at the highest risk of significant bay-wide particle depletion from mussel culture were dominated by small species (picophytoplankton; 0.2 – 2.0 µm cell diameter). These results indicate a significant destabilization of the basis of the marine food-web that can be monitored using identified indicators and ecosystem persistence targets.

Duration: Jan '07 – Dec '09

Funded by: DFO Co-funded by: NNRC (Norway)

Project team: Peter Cranford (DFO), William Li (DFO), Øivind Strand (IMR Norway), Tore Strohmeier (IMR Norway)

For information contact: Peter Cranford (Peter.Cranford@dfo-mpo.gc.ca)

Researchers attempt to get ahead of invasive tunicates in BC

There are at least four species of tunicates in British Columbia which are non-native and potentially invasive: the solitary tunicate *Styela clava* (club tunicate) and the colonial tunicates *Botrylloides violaceus* (violet tunicate), *Botryllus schlosseri* (golden star tunicate), and *Didemnum* sp. Recent monitoring surveys have detected some of these tunicate species at a variety of shellfish culture leases and marinas around British Columbia.

However, it appears that they have not had the same impact on this coast as they have in Prince Edward Island and Nova Scotia. This raises questions about the factors controlling invasion success and establishment. Research of basic tunicate biology and ecology is being aimed at resolving these questions.

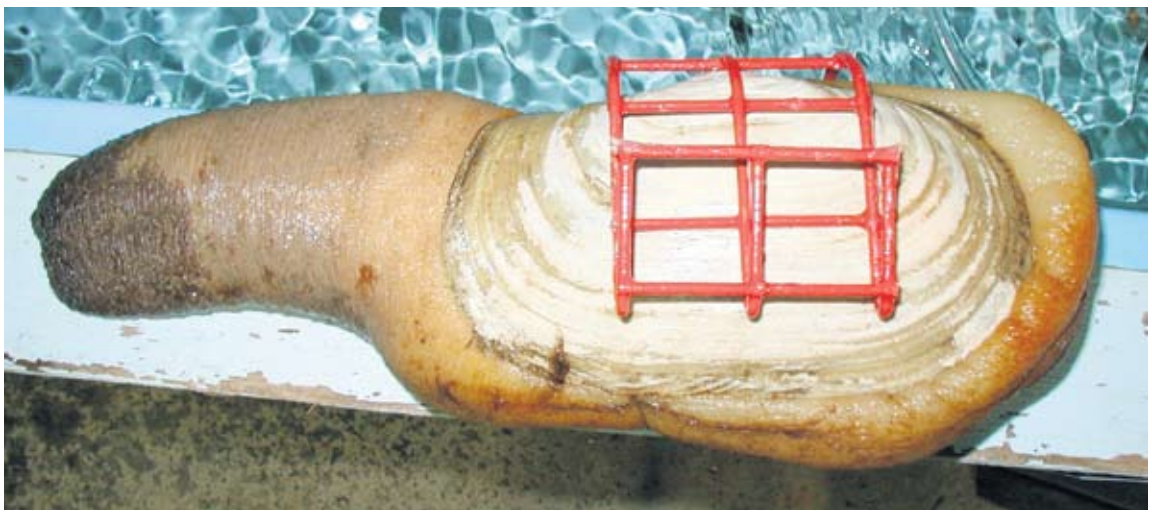
Researchers in this project are examining how survivorship, growth, and reproduction of tunicates are affected by predation intensity and changes in environmental conditions, such as temperature and salinity. Results from these experiments should allow the team to assess the ability of these tunicates to invade new habitats and the threat that they may pose to other benthic invertebrates within the ecosystem. The research should also enable development of mitigation strategies to prevent further spread of these non-indigenous species and the potential economic impact they may have on the shellfish culture industry of British Columbia.

Duration: Aug '06 – Mar '09

Funded by: DFO-AIS

Project team: Chris Pearce (DFO), Tom Therriault (DFO), Anya Epelbaum (CSR-VIU), BCSGA

For information contact: Chris Pearce (Chris.Pearce@dfo-mpo.gc.ca)



(Photo: DFO)

BC group looks for ways to improve geoduck broodstock performance

Researchers are aiming to find which factors promote maximum fecundity and egg quality in a hatchery setting for broodstock geoduck clams, (*Panopea abrupta)*. They are looking at the effects of various temperature, salinity and nutritional regimes on gonad development. The ranges of temperature and salinity are selected to reflect those typical of an estuarine environment in British Columbia (7 to 19˚C and 17 to 30 ppt, respectively).

Quality of nutrition is being manipulated by presenting live algal feeds that vary in levels of essential fatty acids, namely docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA). Various rations are also being administered to the broodstock to manipulate caloric intake.

To quantify the effects of the various treatments on gonad development, several indicators are being examined for use. These include histological examination, oocyte diameters, gamete occupation indices, gonadosomatic indices, oocyte per follicle counts, and biochemical composition of gonad tissue.

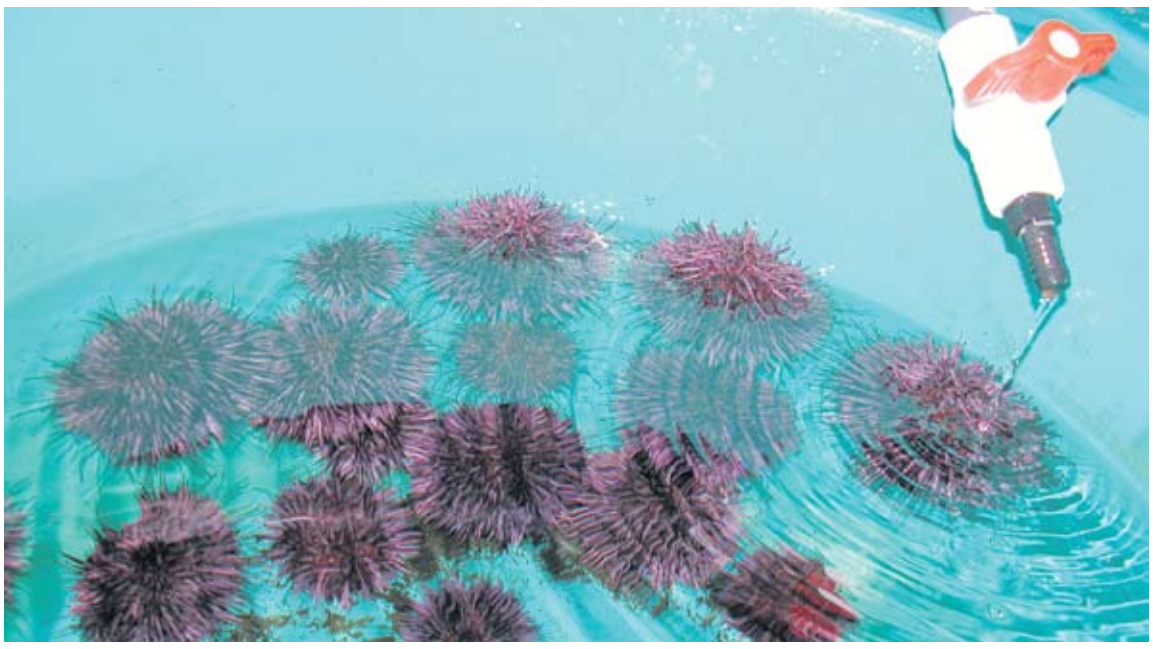
Duration: Jan '06 – Mar '10

Funded by: NSERC Discovery Grant. Co-funded by: DFO

Project team: Chris Pearce (DFO), Scott McKinley (UBC), Rob Marshall (UBC)

For information contact: Chris Pearce (Chris.Pearce@dfo-mpo.gc.ca)

Research uncovers potential for purple sea urchin culture in BC



Purple Sea Urchin (Photo: DFO)

In the development of aquaculture of any new species for culture, one of the major obstacles to overcome is the production of healthy juveniles. Although information about the reproduction cycle and spawning of potential commercial species of sea urchins is readily available, information about larval culture and juvenile grow out are still scarce, especially for the purple sea urchin (*Strongylocentrotus purpuratus*).

As a first step to developing the purple urchin as a potential new candidate for aquaculture in British Columbia, this project is focusing on broodstock conditioning and larval/juvenile rearing.

The project is investigating four key questions: What are the effects of various feeds (kelps and prepared diets) and temperature on gonad production? What are the effects of different natural feeds, feed rations, densities, and temperatures on growth and survival of larvae? What are the effects of various natural and artificial substrata on larval settlement and metamorphosis? What are the effects of various feeds and temperature on growth and survival of juveniles and adults?

Duration: Sep '06 – Mar '10

Funded by: OSAP Co-funded by: DFO

Project team: Chris Pearce (DFO); Scott McKinley (UBC), Kalam Azad (UBC)

For information contact: Chris Pearce (Chris.Pearce@dfo-mpo.gc.ca)

Mussel site in Nova Scotia to validate environmental assessment and monitoring

The largest single mussel aquaculture application in the Maritimes was approved in 2003 for St. Anns Harbour, NS after an extensive assessment of environmental risks and the implementation of a rigorous environmental monitoring program.

Now that the mussel leases are developed, an extensive environmental sampling program is being conducted to test both the environmental impact assessment predictions and the effectiveness of the environmental monitoring program design. The data collected will help to advance regulatory science and improve regulatory certainty among stakeholders. Major stakeholders are jointly coordinating this large project.

Duration: Sep '08 – Mar '09

Funded by: DFO-PARR

Project team: Peter Cranford (DFO), William Li (DFO), Brent Law (DFO), Joe Crocker (DFO), Dawn Sephton (DFO), Barry Hargrave (DFO), Toby Balch (NS DFA), Robin Stewart (Bounty Bay Shellfish Inc), Jon Grant (Dalhousie U)

For information contact: Peter Cranford (Peter.Cranford@dfo-mpo.gc.ca)

Development of genomic tools enable little neck clams to be ecosystem bioindicators

Often referred to as keystone species, bivalves are major components of coastal and estuarine ecosystems and play a prominent role in the development of ecosystem health indices and values, which can then be applied to ecosystems in general.

It is well documented that stressful environmental conditions (natural or man-made) affect aquatic animal physiological performance (e.g., growth and fecundity), health and survival. Unlike finfish, for which sensitive biochemical assays, genomic tools and visual indicators of stress are available, there are few informative and reliable tools for bivalves.

Researchers in this BC project are developing genomic tools to aid in the study of native little neck clam responses to environmental and anthropogenic stress factors. These tools will facilitate the use of this species as a bio-indicator in the assessment of ecosystem health and resilience in the presence of aquaculture operations.

Duration: Sep '08 – Mar '09

Funded by: DFO-PARR

Project team: Stewart Johnson (DFO), Terri Sutherland (DFO), Helen Gurney-Smith (CSR-VIU)

For information contact: Stewart Johnson (Stewart.Johnson@dfo-mpo.gc.ca)

Quebec project re-visits research on dredge harvesting of soft-shell clams

One of the upcoming aquaculture activities in Quebec (and elsewhere) is the development of soft-shell clam (and related) farming in intertidal or shallow subtidal areas. The impacts of this type of work are likely to be associated with harvesting when this is done by hydraulic rake, as is often done in Quebec.

However, the work to date on the impacts of harvesting by hydraulic rakes has been done in more dynamic systems such as environments with strong currents and coarse sediments and/or studies have only been done over very short time scales. To address this gap, a study was done in Quebec in 2003 to evaluate the impact of harvesting clams by hydraulic rakes on benthic communities in local conditions (sandy sediments in low energy systems) as well as the recovery of the communities. The study was done at 2 different times of the year to evaluate temporal differences in impacts and recovery.

This new project is analysing and publishing the results of this research, which is increasingly important for understanding potential impacts and possible ways to mitigate them.

Duration: Sep '08 – Mar '09

Funded by: DFO-PARR Co-funded by: DFO-ACRDP, SODIM, DFO.

Project team: Chris McKindsey (DFO), Lizon Provencher (DFO), Mathieu Huot (DFO)

For information contact: Chris McKindsey (Chris.McKindsey@dfo-mpo.gc.ca)

New raft designs in the works for BC shellfish industry

The goal of this project is to develop new high quality shellfish aquaculture raft designs for the BC shellfish farming industry using state-of-the-art materials and techniques to enhance economic profitability and environmental sustainability. Vancouver Island University's Centre for Shellfish Research and the BC Shellfish Growers Association, together with industry members, are working with Dynamic Systems Analysis (DSA) to develop these new designs.

Through computer simulations, Ryan Nicoll of DSA is able to anticipate problems and identify successes with different raft design components and materials. Once suitable designs have been selected, the CSR will fabricate and test prototypes at the Deep Bay Field Station. A final report will be prepared including construction plans for the industry.

Work has been done on the preliminary stages in the simulations. Information has been provided by industry on the current most typical raft designs. The mass and drag of a typical oyster tray stack has been used to develop a computer-generated simulation of how it performs in the natural environment.

Once the simulation is constructed, DSA can change stresses (waves, currents, etc.), loadings and construction materials to see how the raft performs. Optimal designs will then be developed and different construction materials will be tested to determine an optimum cost benefit ratio.

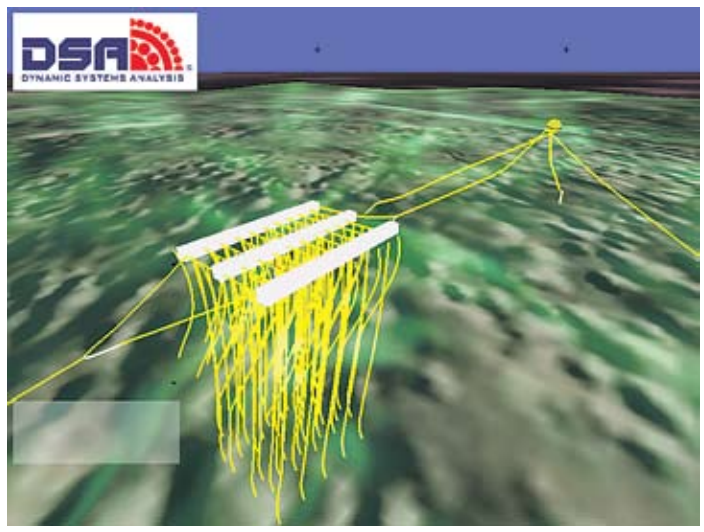
Duration: Aug '08 – Mar '09

Funded by: DFO-AIMAP Co-funded by: CSR-VIU, experts, and stakeholders.

Project team: Brian Kingzett (CSR-VIU), David McCallum (BCSGA), Stellar Bay Shellfish, Barr Plastics, Seaco Marine, CSR-VIU, UVic Innovation and Development Corporation

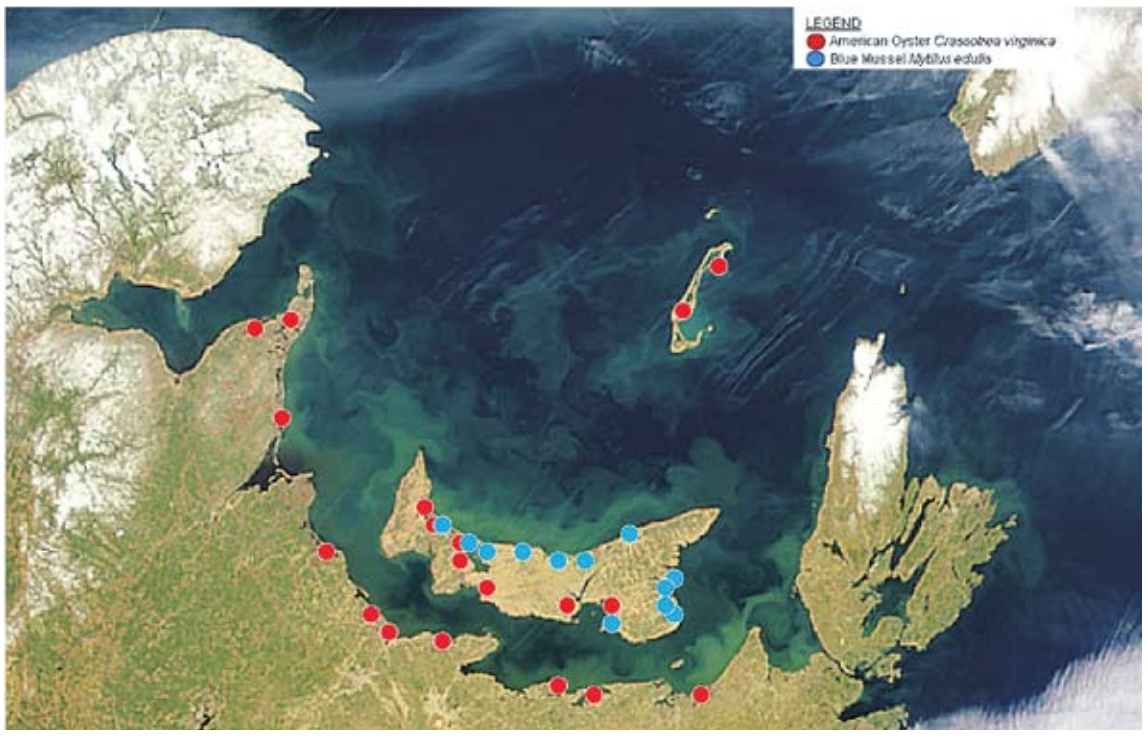
For information contact: Brian Kingzett (Brian.Kingzett@viu.ca)

Website: PbWiki site, contact Joy.Wade@viu.ca for access



Preliminary simulations. Each string represents the mass and drag of a typical oyster tray stack.

DFO team updates southern gulf of St. Lawrence region shellfish monitoring network



SMN Coverage

The shellfish aquaculture industry has grown significantly over the last decades and has become an important part of the economy in eastern Canada. Concurrently, the Habitat Protection and Sustainable Development (HPSD) section is required, under the Fisheries Act and the Canadian Environmental Assessment Act (CEAA), to conduct environmental risk assessments of these activities on the marine habitat. They need scientific advice that will provide them with efficient tools and indicators that will enable them to respond adequately to these requirements.

One concern is in the potential effect of increasing the shellfish biomass on the carrying capacity of estuaries. A proposed tool to address this issue is the Shellfish Monitoring Network (SMN) which is based on a standardized method that measures the productivity of a sentinel species, such as the American oyster, as an ecosystem indicator. This method of examining the spatial and temporal variations in shellfish productivity has been conducted in the southern Gulf of St. Lawrence region on an experimental level since 1995.

This project is focused on the consolidation of the data collected through the SMN. The strengths and weaknesses of this tool are being analysed in the context of the current HPSD requirements. On the basis of this analysis, the requirements for a long-term and sustainable SMN are being designed.

Duration: Sep '08 – Mar '09

Funded by: DFO-PARR

Project team: Marc Ouellette (DFO), Luc Comeau (DFO), Guy Robichaud (DFO)

For information contact: Marc Ouellette (Marc.Ouellette@dfo-mpo.gc.ca)

www.glf.dfo-mpo.gc.ca/os/smn-rmm/index-e.php


Oyster Condo Fouling

Productivity improvement through mechanization and automation of mariculture operations

Quebec mussel growers have observed that significant mussel losses can occur during harvesting of commercial-sized mussels, especially during summer. SODIM's mariculture engineer and the Halieutec Inc. team are investigating a harvesting system developed in the Netherlands that uses the venturi effect. A technology transfer mission was therefore organized to Ireland, where some mussel growers have adopted this system.

A venturi system was acquired and modifications begun, including replacing the original 8-inch diameter harvesting pipe with a 10-inch one, which was necessary because of the size of the socks used in Quebec mussel farms. Halieutec then determined the extent of the reduction in losses due to mussel fall-off as well as the time saved in harvesting mussel spat and commercial-sized mussels.

The results obtained during sea trials conducted in the summer of 2008 are encouraging. Harvesting can be carried out 3.5 times faster compared to the conveyor system, though further trials are necessary to validate these results.

Concurrent with these trials, another project conducted by MAPAQ's Centre Technologique des Produits Aquatiques (CTPA) is measuring the impact of harvesting using this system on the commercial characteristics of marketed mussels – the incidence of gaping, broken shells, product uniformity, and shelf life.

Other related parts of this major project are also underway. These include development of a cleaner for floating line buoys. Another product of the project is a system to avoid tangling of the cords of submerged lines in order to avoid work stoppages during water operations. Scallop farms in Quebec are also now testing scallop production using the ear-hanging technique. Finally, a hydraulic rake is being developed to reduce manpower costs and increase the efficiency of harvesting soft-shell clams.

Duration: Jul '08 – Mar '10

Funded by: EPAQ Co-funded by: DFO-AIMAP, Québec shellfish producers

Project team: Sylvain Lafrance (SODIM), Robert Vaillancourt (SODIM), Marie-Joëlle Leblanc (Halieutec Inc.)

For information contact: Sylvain Lafrance (sylvain.lafrance@sodim.org)

Website: http://www.sodim.org/

Quebec mussel growers see development of farm management software on the horizon

At present, shellfish farmers have no effective computer tools to manage their mariculture equipment and mollusc stocks. This project is designing software to manage the shellfish farming equipment and operations (long lines and mussel socks) used in mussel culture, whether in continuous or traditional socks or on long lines.

The software is designed to be user-friendly and operational on a Windows PC or Mac OS. The mussel farmers' requirements for this software include entry of the data necessary to support software functions and consideration of the type of paper reports generated that can be used by workers at sea for guidance in their work. The programming is object-oriented so that it is possible to add additional modules.

The software package, accompanied by training for shellfish farmers, is being delivered to the industry in March 2009 for use in the coming production season. In addition a team consisting of a statistician and a shellfish culture expert plan to establish a reliable protocol for sampling shellfish farms in order to evaluate the biomass in production. The results of this sampling will be processed using a computer tool compatible with the shellfish equipment management software in order to incorporate the results.

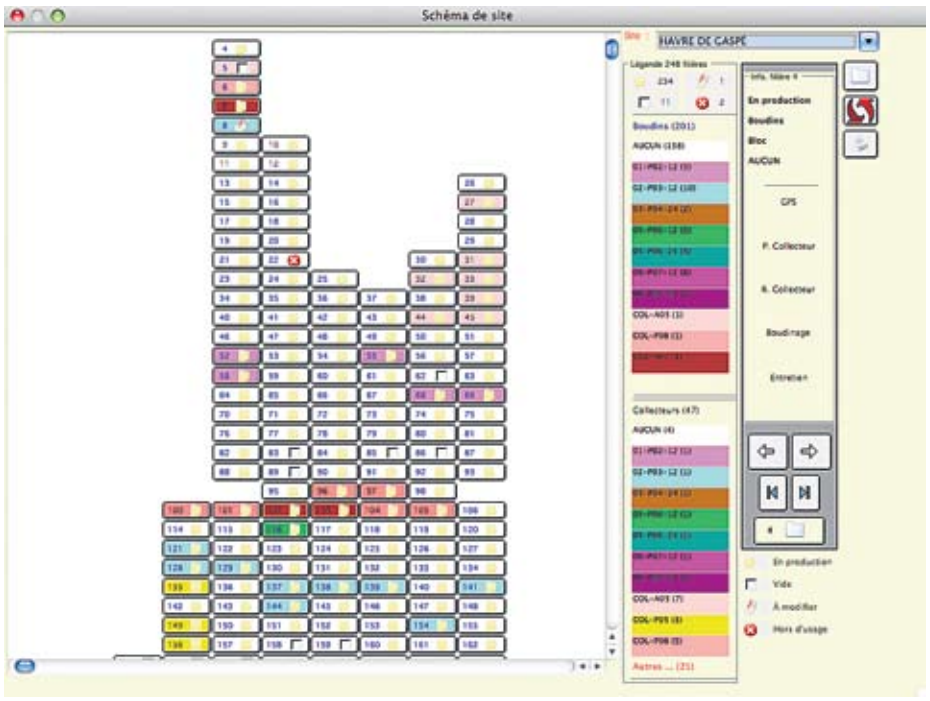
Duration: Jun '08 – Mar '09

Funded by: DFO-AIMAP Co-funded by: MAPAQ, SODIM, Moules Forillon

Project team: Sylvain Lafrance (SODIM), Stéphane Morissette (Moules Forillon), Nathalie Méthot (Gescode), Robert Vaillancourt (SODIM)

For information contact: Sylvain Lafrance (sylvain.lafrance@sodim.org)

Website: http://www.sodim.org/



Production of oyster spat in a natural environment, Phase 1: tests of cup-collectors

The project tested an adaptation of the French technique, cups, for the collection and production of oyster spat. It is being adapted to the circumstances in New Brunswick in order to mechanize the operation and reduce production costs.

Collection tests were carried out in Bouctouche, NB and Caraquet, NB to evaluate the performance of the new collector. The tests confirmed that the technique improves the productivity of collection and the mechanization of operations. In addition it is making it possible to address key constraints for establishing a sorting strategy that would select the individuals most likely to grow successfully.

Duration: Jul '08 – Feb '09

Funded by: DFO-AIMAP

Project team: Léon Lanteigne, Alain Landry, Emmanuel Mallet, Onile Lanteigne, Jules Lanteigne, (all from 638131 NB Inc.), Maurice Daigle (Aquaculture Acadienne Ltée)

For information contact: Léon Lanteigne (Naomie@nbnet.nb.ca)

Algal photo-bioreactor boosts productivity of shellfish hatchery in New Brunswick

The New Brunswick shellfish company, L'Étang Ruisseau Bar Ltd, has selected the northern bay scallop (*Argopecten irradians irradians*) as a means of diversifying its product base. Research between 2001 and 2005 focusing on improving field production performance led to a protocol that yielded market-size scallops (>52 mm) within one growing season.

The company is currently developing a hatchery-nursery and a wet holding facility in Shippagan, New Brunswick in order to produce bay scallop seed and hold product for the winter sales. This hatchery facility will also be used to implement a genetic improvement program for the American oyster (*Crassostrea virginica*).

Integrating the Brite-Box, an algal photo-bioreactor, into this facility is key to achieving the desired reliability and economic viability essential to the operation of a commercial hatchery. This development will allow the company to augment their annual revenues by 10-20% and promote the diversification of the New Brunswick shellfish industry.

Duration: Oct '08 – Aug '09

Funded by: DFO-AIMAP Co-funded by: ACOA, NB DFA, NRC-IRAP, SRD

Project team: André Mallet (L'Étang Ruisseau Bar Ltd), Claire Carver (Carver Marin Consulting), Sylvie Gauvin (L'Étang Ruisseau Bar Ltd.)

For information contact: André Mallet (amallet@ns.sympatico.ca)

Eel Lake Oyster Farm's anti-fouling device

Eel Lake Oyster Farm, under the direction of Nolan D'Eon (owner/operator), is developing an environmentally-friendly machine to eradicate invasive species in the oyster industry. Currently, there is a problem that needs to be addressed due to the increasing invasive species in the waters of Eel Lake, Yarmouth county, Nova Scotia.

The project is exploring using the current water table and a heating method to control invasive species without the use of pesticides or toxins.

Duration: Sep '08 – Mar '09

Funded by: DFO-AIMAP Co-funded by: Eel Lake Oyster Farm

Project team: Nolan D'Eon, Colton D'Eon, Clark D'Eon (all from Eel Lake Oyster Farm)

For information contact: Nolan D'Eon (nolandeon@eastlink.ca)

New Brunswick maturation facility for shellfish to be the first of its kind in North America

A multifunctional, closed-loop storage facility for shellfish is in development in New Brunswick, the first of its kind in North America. Taking advantage of new technology developed in France, the project sponsors are building the infrastructure to store shellfish while making it possible to decontaminate the product and maintain the health of coastal areas.

This approach ensures that market supplies are maintained during critical periods in order to take advantage of the globalized market for BeauSoleil oysters. In addition, this project is expected to enable fish regulations to be more flexible while certification ensures the health of the product.

Duration: Aug '08 – Mar '10

Funded by: DFO-AIMAP Co-funded by: ACOA, Province of NB, BNB

Project team: Amédée Savoie (Maison Beausoleil), Léon Lanteigne (Maison Beausoleil), Armand Lejeune (EMYG Aquaculture), Brian Blanchard

For information contact: Amédée Savoie (Amedee@maisonbeausoleil.ca)

Improved hydraulic system helps to automate mussel operations in Newfoundland

Blue mussel seed collection, stripping, grading, and socking operations are the most costly and labour intensive activities on mussel farms in Newfoundland and Labrador. Seeds are handled multiple times and are stored on working platforms for extended periods of time while individual pieces of equipment are installed and removed.

Typically, each piece of equipment has its own hydraulics package to power the equipment. A more efficient new hydraulics system would have the oil capacity to operate multiple hydraulic motors at any given time. This would enable automation of the seeds collection to seeds socking operation and significantly reduce the cost of production for mussel farmers.

Duration: Jul '08 – Oct '08

Funded by: DFO-AIMAP

Project team: Gilbert Simms (LBA Enterprises Ltd), John Pelly Jr. (Western Hydraulics), Scott Simms (LBA Enterprises Ltd.)

For information contact: Gilbert Simms (Phone: (709) 267-5121, Fax: (709) 267-5121)

New Brunswick oyster operation improves biofouling control

Based on the strong results from the first phase in 2007, which evaluated the biological feasibility of using scalding in a boiling water bath to control biofouling, Vienneau Aquaculture sought to establish a procedure to integrate this operation into its oyster-culture activities.

The project was also designed to perfect a scalding system in order to improve the effectiveness of this new approach to controlling biofouling. The results were conclusive but revealed some production constraints related to the silting or deposition of oysters within the culture structures which are currently being addressed.

Duration: Jul '08 – Mar '09

Funded by: DFO-AIMAP Co-funded by: NBDAA, BNB

Project team: Paul Vienneau (Vienneau Aquaculture Inc.), Léon Lanteigne (638131 NB Inc.), Alain Landry (638131 NB Inc.)

For information contact: Paul Vienneau (Tourlou@nb.sympatico.ca

Researchers find best algal diet to yield optimum essential fatty acid profile in European oysters

Algal EPA (eicosapentaenoic acid), DHA (docosahexaenoic acid) and ARA (arachidonic acid) are essential in the diet of aquaculture organisms. This project is investigating the type of algal diet that yields the optimum fatty acid profile in European oysters.

Ostrea edulis juveniles were fed with combinations of microalgal diets to determine the effect on growth, survival and fatty acid profiles of these oysters. Juvenile oysters from a shellfish hatchery were laboratory-reared in 15-L static tanks with three replicates for each treatment.

The algal combinations tested were: *Chaetoceros muelleri* and *Isochrysis galbana* (CHGRA+T. ISO), *Tetraselmis striata* and *Thalassiosira weissfloggii* (TETRA+ACTIN), and *Nannochloropsis oculata* and *Pavlova lutheri* (NANNO+PAV).

The microalgae were grown in optimum conditions. Fatty acid profiles of algae and juvenile oysters were analyzed. A very highly significant difference ($P<0.0001$) was found in the growth rate of the oysters. The best growth rate was observed in the NAN+PAV treatment group. The treatment group with lowest growth rate was TETRA+ACTIN. Survival rate was 100% for all treatment groups. EPA, DHA and ARA values were significantly higher in the NANNO+PAV treatment group and lowest in the TETRA+ACTIN treatment group ($P<0.001$).

Therefore, the best algal diet in culturing European oysters is a mixture of *Nannochloropsis oculata* and *Pavlova lutheri*, creating a better growth rate and a higher level of polyunsaturated fatty acids for consumers.

Duration: Sep '07 – Sep '08

Funded by: NSAC.

Project team: Jesse Ronquillo (NSAC), Jamie Fraser (NSAC), Audrie-Jo McConkey (NSAC)

For information contact: Jesse Ronquillo (jronquillo@nsac.ca)

Newfoundland project makes progress on oyster nursery culture

The Canadian Center for Fisheries Innovation and Badger Bay Mussel Farms are continuing efforts to develop the potential for oyster culture in Newfoundland.

Previous projects have been successful with respect to conditioning and spawning of the oyster broodstock. Fertilization was also successful, although fertilization rates were low and larval survival was poor. During the past projects, protocols have been established for most stages of oyster aquaculture and success has been proven. All these protocols have been developed in stages.

Oysters are a non-native species and are considered incapable of spawning in Newfoundland due to colder water temperatures so seed must be obtained from a hatchery supplier.

In May 2008, 160,000 spat were transferred from the Shippagan Hatchery to the Marine Institute, followed by another shipment of 200,000 spat. The spat were graded and added to upwellers where they were fed until they reached 3 - 5 mm in size.

The goal was to deploy the spat in Placentia Bay for the nursery phase of the project in the late fall. However due to unexpected delays the deployment will now take place in the spring of 2009.

Duration: 2008 – 2009

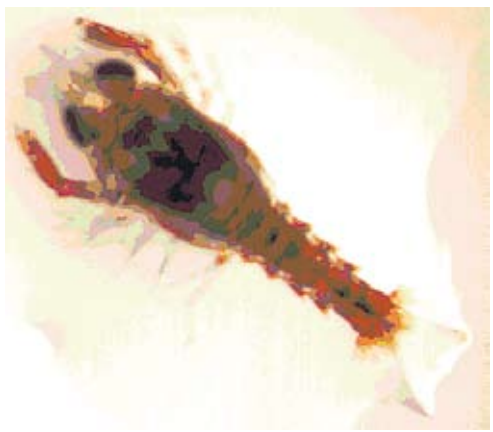
Funded by: CCFI

Project team: Chris Dawe (MI), Chris Brown (NRC), Marc Kielley (CCFI)

For information contact: Marc Kielley (marc.kielley@mi.mun.ca)

Website: http://www.ccfi.ca/

Natural zooplankton-based diet to increase survival rates of lobster larvae



Lobster larva (Photo: M.L. Beaudin)

Enriching lobster larvae with polyunsaturated fatty acids obtained from a diet of natural zooplankton could improve their survival, and enhance their cryptic behaviour and their flight behaviour when faced with predators' odours.

Researchers are finding that feed based on natural zooplankton produces a higher accumulation of polyunsaturated fatty acids in the lipid membranes of the larvae. They suggest that this enrichment of the cellular membranes encourages an increased activity of the ionic enzymes that lead to the establishment of osmoregulation.

The osmoregulation process in lobster larvae is established during the transition from the pelagic phase to the benthic phase and can bring about a more rapid installation of the larva on sea bottom, which can lead to improved cryptic behaviour and better chances of surviving predators. To test their hypothesis, the establishment of osmoregulation in larvae fed different diets is being related to various behavioural measurements.

Duration: 2007 – 2009

Funded by: MAPAQ. Co-funded by: RAQ

Project team: Rejean Tremblay (ISMER-UQAR), Simona Motnikar (CAMGR-MAPAQ), Louise Gendron (DFO), Marie-Lou Beaudin (ISMER-UQAR), Sonia Belvin (MAPAQ-UQAR), Fabrice Pernet (IFREMER-Sète)

For information contact: Rejean Tremblay (Rejean_tremblay@uqar.qc.ca)

Aaron Ramsay (Researcher) completing environmental monitoring. (Photo: AVC & PEIAA)

Major PEI project develops techniques and strategies to manage invasive tunicates

Sustainable and efficient methods of managing invasive tunicate species are needed in the PEI Aquaculture Industry. Invasive tunicates are solitary (*Styela clava* and *Ciona intestinalis*) and colonial (*Botrylloides violaceus* and *Botryllus schlosseri*).

The PEI Aquaculture Alliance has been collaborating with the University of Prince Edward Island on a four-year Atlantic Innovation Fund project to address the tunicates at three different levels: detection, prevention and treatment.

Monitoring and detection are essential to the management of aquatic invasive species. The detection work proposes to develop a diagnostic kit using tunicate genetic material to identify different tunicate life stages in sea water samples.

The goal of the prevention work is to develop an environmentally sound and sustainable anti-fouling agent derived from marine natural products. Researchers have been analyzing marine samples that do not show any fouling because they may contain a natural product that deters the settlement of tunicate larvae.

The work on different tunicate treatments involves field work and direct collaboration with PEI mussel growers. The efforts include the development of new treatments for the mitigation of tunicates, the delivery of mitigation agents to mussel socks, and the development of lease and bay level mitigation strategies.

Duration: Jun '07 – Jun '11

Funded by: ACOA-AIF Co-funded by: PEIAA, UPEI, PEI Atlantic Shrimp Co. Inc., AFRI, PEI-DFARD, DFO

Project team: PEIAA, Russ Kerr (UPEI), Jeff Davidson (UPEI), Ahmed Siah (UPEI)

For information contact: Linda Duncan (ed@aquaculturepei.com)

Quebec project finds means to reduce mussel depuration costs in Gaspe Bay

Gaspe Bay, an ideal mussel growing area, is subject to periodic contamination, especially after heavy rains. The result is that mussels have to go through a costly depuration process.

Experiments conducted in 2002 showed that using seawater can account for as much as 26% of the total depuration cost at a rate of 50 L/min for 225 kg of bulk mussels, which translates into $0.81 per net kilo. The Canadian Food Inspection Agency currently accepts 40 L/min. Reducing the flow rate could lower these costs.

Trials were conducted in systems supplied with continuously circulating seawater where temperatures varied from 5°C to 8°C in compliance with the Canadian Shellfish Sanitation Program (CSSP) standards governing treatment water quality.

One working hypothesis was that oxygen is more soluble in cold water. Consequently, using a slower water flow rate at these temperatures should not create an oxygen deficit. Two trials were conducted in water at 8°C flowing at 20 L/min and two trials were conducted in water at 5°C (20 and 30 L/min).

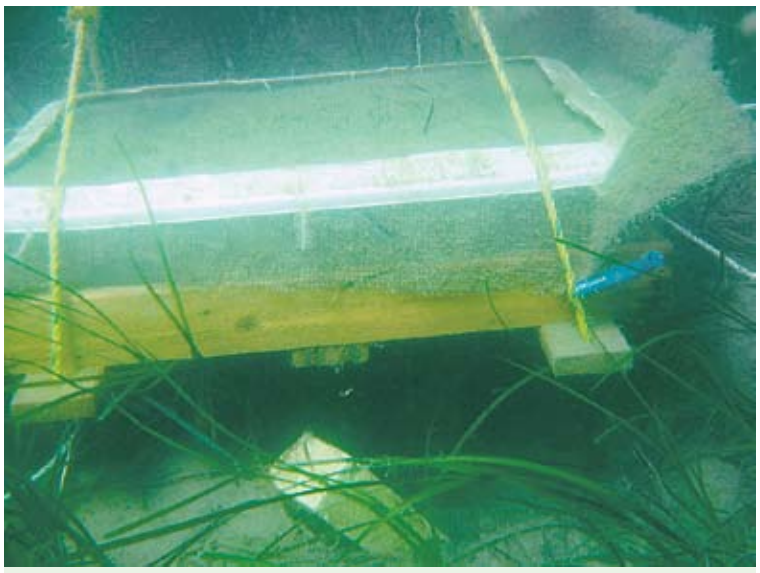
Results showed that a flow rate of 20 L/min at temperatures around 8°C in the fall was unacceptable. The CSSP minimum standard for percentage of dissolved oxygen in treatment water could not be met in the water exiting any of these tanks. A flow rate of 30 L/min would be acceptable in 5°C water where dissolved oxygen in those tanks was often higher than 60%.

Duration: Apr '06 – Mar '09

Funded by: DIT-MAPAQ

Project team: Francis Coulombe (CTPA-MAPAQ), Nathalie Moisan (CAMGR-MAPAQ), Michel Girard (CAMGR-MAPAQ), Marcel Roussy (CAMGR-MAPAQ), Cathy Cauvier (CAMGR-MAPAQ)

For information contact: Francis Coulombe (francis.coulombe@mapaq.gouv.qc.ca)



Suspended sand-filled box used for softshell clam pre-grow-out on the Magdalen Islands (Photo: M. Déraspe)

Sand boxes prove to be ideal for nursery boosting of juvenile clams in Magdalen Islands

Experience acquired on the Magdalen Islands shows that clams must measure at least 25 mm when seeded to obtain the best results. Collected clams measure 8 to 9 mm on average when gathered in the fall. Although they grow somewhat while over-wintering, they still measure only 9 to 10 mm the following spring.

Moreover, a significant percentage of wild clams harvested for transfer to seeding beds are smaller than 25 mm. Consequently, juvenile clam supply strategies call for a pre-grow-out phase prior to seeding.

The MIM program and the aquaculture site 'Élevage de myes PGS Noël' have investigated a number of approaches to solve this problem. The most promising is a sand-filled box suspended in the water column in which clams grew twice as fast as clams in the other systems investigated: a FLUPSY and floating bags.

The clams grew as much as 1.04 mm on average per week in the sand-filled boxes, reaching an average size of 25 mm by fall. In addition, 85% to 90% of the young clams were recovered at the end of the growing season.

There are a number of advantages to this approach. The young clams, fossorial bivalves, are placed in optimal growing conditions. Furthermore, the boxes suspended in the water column never emerge from the water so the clams can feed without interruption. Finally, they are sheltered from endo- and epi-benthic predators. All that now remains to be done is to develop this pre-grow-out system for commercial-scale use.

Duration: Apr '07 – Mar '09.

Funded by: DIT-MAPAQ Co-funded by: CED, MDEIE, SODIM, CLD-Îles-de-la-Madeleine.

Project team: Bruno Myrand (CeMIM-MAPAQ), Lise Chevarie (ISMER-UQAR), Réjean Tremblay (ISMER-UQAR)

For information contact: Bruno Myrand (bruno.myrand@mapaq.gouv.qc.ca)

New blanching technique yields high benefits for Newfoundland IQF mussel products

A Newfoundland project is determining the market acceptance and commercial opportunity of a new blanching technique for whole in shell ready to eat IQF mussels. A pilot scale production line is being set up with Golden Shell Fisheries at their Portugal Cove processing plant.

There are expected to be significant and immediate benefits of this innovative system over the existing vacuum packing system. This technique is reducing production costs while requiring less packaging. It promises greater versatility for producing ready-prepared marketable products such as mussels glazed in beer, wine or natural juices. In addition, there is no restriction on pack sizes for retail or food service and the cooking and freezing container is designed for repeated use.

Duration: Aug '08 – Nov '08

Funded by: DFO-AIMAP Co-funded by: Newfoundland Organic Seafoods

Project team: David Walsh, Tom Stephens, Bob Hardy, Pat O'Neill, Eric Coombs

For information contact: David Walsh (Walsheslogybay@nl.rogers.com)

Magdalen Islands open-water mussel rearing proves successful

A study conducted from 2002 to 2007 to determine the parameters for open water mussel production on the Magdalen Islands (Gulf of St. Lawrence) led the way to the establishment of a commercial mussel production. The chosen site, where the water is 19 m deep, lies 7 km from a fishing harbour.

Deployment of collectors by La moule du large inc. (Photo: F. Bourque)

The results of this study are very encouraging. There were no conflicts between users. No rearing structures were lost throughout the lifespan of the study. Spat collection was abundant and recurrent. Mussels reached commercial size in one year after being socked. Commercial yield exceeded 6 kg/m. Cooked meat yield was greater than 40% even after spawning. Mussels withstood post-harvest treatment well despite having shells about 35% lighter than mussels reared in sheltered environments such as lagoons.

These encouraging results led to the establishment of a new company and since 2007, La moule du large Inc. has been operating a 183-hectare site located next to the experimental site. The first commercially produced mussels are expected to be marketed in 2009.

Duration: Jun '02 – Mar '08

Funded by: DIT-MAPAQ Co-funded by: MAPAQ, SODIM, CED

Project team: François Bourque (MAPAQ), Bruno Myrand (CeMIM-MAPAQ)

For information contact: François Bourque (Francois.bourque@mapaq.gouv.qc.ca)

Research tool is adapted to measure scallop vitality

Maintaining animals in conditions conducive to maximum production and ensuring their survival and growth is essential to success in aquaculture. But the industry lacks simple, quick and affordable operational stress indicators to assess health. So MAPAQ researchers joined forces with their counterparts at Réseau Aquaculture Québec and French Research Institute for Exploration of the Sea (IFREMER) of France to identify simple methods, based on behavioural indicators, which can be used to assess the vitality of sea scallops.

Their work led to the development of a tool that effectively measures scallop vitality. Held in an aquarium supplied with recirculating seawater, a dynamometer measures the muscular strength and reactions of a scallop when it is exposed to a starfish. This technique is used primarily in research projects, and needs to be adapted for use in commercial operations.

MAPAQ and Université Laval researchers are working together to address this need, and ensure the device not only meets the needs of scallop producers but also provides reliable and reproducible data. The main adaptation is the use of a plastic rod to replicate the effect of the star fish on the scallop.

The vitality data has been continuously recorded since 2004 and is identifying the variables to be considered when conducting a simplified analysis. The threshold limit values of these variables for healthy individuals are also being determined. A modified haemostatic clamp is being used to measure the vitality of scallops as small as 10 cm.

Duration: 2004 – 2009

Funded by: DIT-MAPAQ

Project team: Madeleine Nadeau (CeMIM-MAPAQ), Xavier Jansoone (UL), Helga Guderley, (UL)

For information contact: Madeleine Nadeau (Madeleine.Nadeau@mapaq.gouv.qc.ca)

Quebec research assesses ecological risk of spat transfers

The risk of transfer of undesirable species potentially associated with transferred spat is currently the main reason for DFO's refusal to allow transfers in Quebec. However, security of the spat supply continues to be a critical factor for Quebec mariculture operations and sometimes depends directly on the approval of transfer requests.

Better knowledge of the ecological risk associated with these transfers and field protocols designed to minimize the risk of introduction of undesirable species from spat supply sites would help minimize the risk posed by these transfers. It is therefore critical that the industry have as much information as possible on this subject in order to develop field protocols that would be considered satisfactory in the context of the DFO risk assessment process in the event that undesirable species are present at a supply site chosen by the industry.

The objective of this study is to identify and more effectively assess the ecological health risks associated with transfers of wild spat from mussels, sea scallops and clams and to propose methods for mitigating this risk.

Duration: Apr '07 – Mar '08

Funded by: DFO-ACRDP Co-funded by: SODIM, UQAR-ISMER,

Project team: Chris McKindsey (DFO)

For information contact: Chris McKindsey (Chris.McKindsey@dfo-mpo.gc.ca)

Finding optimum temperature extends holding time for lobsters in the market

What is the best temperature for maintaining live lobster for an extended period while ensuring that meat quality would be acceptable for consumers? Temperature plays an important role in the biological condition of lobsters held for prolonged periods and its effect can be determined by assessing total blood protein levels, and physiological processes like moulting, egg extrusion in females and mortality.

In summer 2007, 157 male and female lobsters were held for an extended period in tanks supplied with seawater. Tanks holding water at 5°C, 10°C and ambient, uncooled temperatures (varying from 11°C to 17°C) were used for the study.

The results confirmed that the health of lobsters is connected to the environmental conditions in which they are held. It is difficult to keep physiological conditions stable at temperatures varying from 11.2°C to 17.4°C. To maintain meat quality, it is advantageous to slow the natural changes that result from prolonged holding.

The optimum temperature seems to be 10°C since relatively high protein levels, which are an indicator of good health in lobster, can be maintained. Little variation is observed in protein concentration, which indicates that physiological processes and stress are fairly well controlled. It also appears that males are the best candidates for prolonged holding since they are not as affected by temperature variations as females. In addition, water taken from the sea at 17°C to 10°C is less costly than cooling it to 5°C.

Duration: May '07 – Mar '09

Funded by: MAPAQ Co-funded by: RPPGR

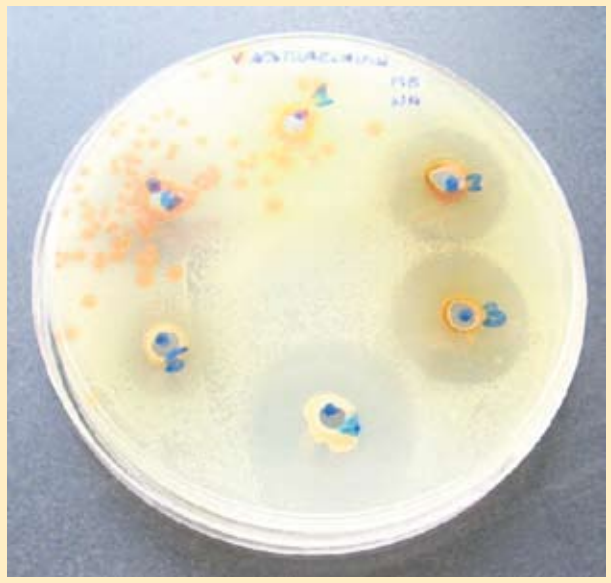
Project team: Nathalie Moisan (MAPAQ), Cathy Cauvier (MAPAQ), Francis Coulombe (CTPA-MAPAQ), Simona Motnikar (CAMGR-MAPAQ), Johanie Cauvier (CAMGR-MAPAQ), Dorothée Mitchell (DFO), Jean Lavallée (UPEI-AVC), Sophie Gauthier-Clerc (ISMER-UQAR)

For information contact: Nathalie Moisan (Nathalie.moisan@mapaq.gouv.qc.ca)

Quebec project shows probiotics improve scallop larval culture

Scallops are cultivated in hatcheries on a commercial scale, but development of the industry has been slowed by massive larval mortality. Researchers have established that opportunistic bacteria in the water are the primary cause of the observed larval mortality. Four genera of bacteria, *Pseudomonas*, *Alteromonas*, *Aeromonas* and *Vibrio*, are considered to be responsible for this phenomenon with *Vibrio* being the most frequently observed.

Solving these problems may lead to the establishment of a more viable commercial industry. The use of antibiotics in larval ponds might improve the situation. However, their use is restricted because of the risks to human health, the emergence of resistant bacteria, and transfers of resistant genes to bacteria that have never been in contact with the antibiotic.



An antibiogram, testing the effect of potential probiotic bacteria on the pathogenic bacteria, *Vibrio aestuarianus*. (Photo: M.L. Beaudin)

The use of probiotics, defined as a microbial additive with a beneficial effect on the host, could make it possible to prevent diseases in mollusc hatcheries. After testing more than a dozen possible probiotic bacteria, one has been identified to be particularly effective in acting on the four strains of pathogenic bacteria.

Duration: 2007 – 2010

Funded by: MDEIE Co-funded by: RAQ

Project team: Rejean Tremblay (ISMER-UQAR), Ismail Fliss (UL), Marie-Lou Beaudin (ISMER-UQAR), Bertrand Génard (ISMER-UQAR), Jean-Louis Nicolas (IFREMER-Brest)

For information contact: Rejean Tremblay (Rejean_tremblay@uqar.qc.ca)

Mussels spat supply may be influenced by plankton fluctuations in the Magdalen Islands

Work carried out in the lagoons of the Îles-de-la-Madeleine shows some stability in the quantity of organic material present in the water during the larval cycle of the mussels. But recent investigations reveal that the primary diet comes from microzooplankton (small ciliate-type organisms less than 20 µm). Microalgae, on the other hand, only dominate the mussel's diet on a few occasions over the summer.

Yet, these microalgae are essential for the ontogenic development of the larvae. The microalgae are rich in long-chain polyunsaturated fatty acids while the microzooplankton contain weak-chain monosaturated fatty acids.

Therefore, an overabundance of microzooplankton might be one cause of the slow ontogenic development of mussel larvae. This dietary deficiency in essential elements appears to result in a low rate of successful metamorphosis into juveniles. Thus, poor synchronization of microalgae blooms and mussel larva development might be one cause of the geographic and temporal variations in the harvest success rate.

Pediveliger larva of mussels (*Mytilus edulis*) (Photo: N. Toupoint)

Researchers in this project are attempting to verify whether variations in mussel harvests in these lagoons may be caused by a mismatch between the larval requirements and the quality of nutrients available.

Duration: 2007 – 2010

Funded by: MAPAQ Co-funded by: RAQ

Project team: Rejean Tremblay (ISMER-UQAR), Nicolas Toupoint (ISMER-MAPAQ), Bruno Myrand (CeMIM-MAPAQ), Frédéric Olivier (CRESCO), Fabrice Pernet (IFREMER-Sète)

For information contact: Rejean Tremblay (Rejean_tremblay@uqar.qc.ca)

Hydrodynamic modeling of longlines in Quebec leads to new software program for industry

In 2001, the Regroupement des mariculteurs du Québec (RMQ) commissioned the consulting firm Biorex Inc. to identify possible improvements to the subsurface longlines used to rear shellfish in Quebec and to determine the design criteria for an optimal longline. As part of this contract, a simulation software program was developed to help industry improve the configuration of their subsurface longlines based on rearing site characteristics.

However, it became evident that the main limitation of this software was the lack of accurate data for a number of the parameters used in the model. In addition, this software did not take into consideration the shape of the continuous socks or how sock configuration changes due to current effects.

The accuracy of the simulation results could be significantly improved if more accurate data were available on the environmental characteristics of the rearing sites (particularly current velocity), the submerged mass of the rearing media and the mechanical properties of the various components (drag coefficient due to fouling, tensile strength of the anchors and elasticity of the ropes).

A second contract was therefore awarded to Biorex Inc. with the general objective of conducting new numerical simulations using more accurate data for the modelling parameters. Several surveys were carried out by the team of consultants to characterize in detail the longlines, currents and waves as well as the hydrodynamics at the main mariculture sites, the strength of the various types of anchors and, finally, the strength of the ropes used. A separate characterization report was prepared for each of these parameters.

The requirements also included developing a new software program, in collaboration with the National Research Council of Canada (NRC). The final version of this software was delivered to SODIM in June 2008. A copy of the NRC software program is available in each of the three mariculture regions in Quebec through frontline technical support officers.

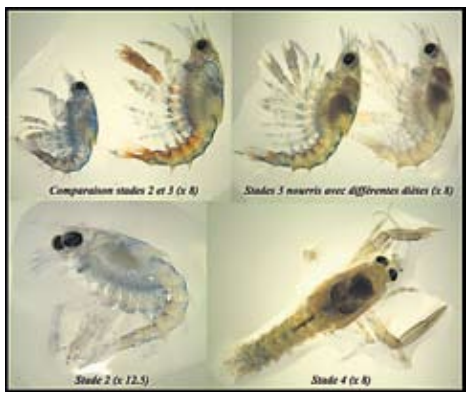
Duration: Sep '05 – Aug '08

Funded by: SODIM Co-funded by: MAPAQ MDEIE

Project team: Robert Vaillancourt (SODIM), Pierre Bergeron (Biorex Inc.)

For information contact: Robert Vaillancourt (Robert.vaillancourt@sodim.org)

Researchers work to improve quality of hatchery-reared lobster larvae



The decline of lobster (*Homarus americanus*) landings in the southwestern Gulf of St. Lawrence (swGSL) has led some fishers' groups to develop larval or juvenile lobster release programs to complement existing conservation measures. However, there is no point in producing Stage IV lobster larvae if they cannot survive in the natural environment after being released.

To address this problem and achieve its Stage IV lobster production objectives, Homarus Inc. (a branch of the Maritime Fishermen's Union) established a research partnership with the Coastal Zones Research Institute (CZRI) in April 2002.

While the zootechnical aspects have now been mastered, the nutritional aspect remains problematic. The primary objective is to find an appropriate alternative to live feed production, which entails very high labour costs. Larval lobster production relies heavily on the use of live feed (brine shrimp). However, live feed production can account for up to 50% of hatchery operating costs during the first few months of production. This factor limits the commercial production of many marine species, including lobster.

Stage IV is a critical stage for lobster, because the larva is transitioning from a pelagic to benthic lifestyle. Good physiological conditions, combined with appropriate lipid reserves, will give the larva a certain advantage for adapting to its new lifestyle. These indices have never been developed in larval *H. americanus* and are key to the advancement of research into the production of high-quality larvae with a good chance of successful release into the natural environment.

Duration: 2004 – 2010

Funded by: Homarus Inc., NRC-IRAP Co-funded by: NBIF, NB DAA –Total Development Fund

Project team: Dounia Daoud (CZRI)*, Rémy Haché (CZRI), Yves Hébert (CZRI), Claude Landry (CZRI), Caroline Roussel (CZRI), Steven Mallet (CZRI), Rémy Benoit, Martin Mallet (Homarus Inc.), Michel Comeau (DFO), Sébastien Plante* (UMonctonSC)*, Gilles Miron (U Moncton)*

For information contact: Dounia Daoud (Dounia.daoud@irzc.umcs.ca)

Website www.irzc.umcs.ca

Project seeks alternatives to live algae for American oyster larvae production

Larval production techniques in American oyster (*Crassostrea virginica*) hatcheries have now been mastered. Rates of survival, growth, metamorphosis and particularly larval attachment vary depending on the quality of the diet. An appropriate diet therefore allows larvae to better tolerate production conditions and to build up sufficient energy reserves to undergo the critical stage of metamorphosis, during which the larvae attach to a substrate.

Hatcheries currently produce their own live algae. Algae production is costly, particularly in terms of labour. This project is focused on completely or partially replacing live algae produced in hatcheries with commercial alternatives: dried algae powder and algae concentrates. Since American oyster is a highly selective feeder, the challenge in this project is to find a high-quality alternative food that is adapted to this species.

After much testing, our preliminary results are encouraging. They indicate that it will be possible to reduce algae production in hatcheries by at least 50% over the medium term.

The overall objective of this project is first to reduce production costs in order to increase the economic viability of the hatcheries while maintaining the quality of the product. The second aim is to promote the development of oyster hatcheries in eastern Canada.

Duration: 2008 – 2009

Funded by: CZRI

Project team: Florent Garnerot (CZRI), Chantal Gionet (CZRI)

For information contact: Florent Garnerot (florent.garnerot@umcs.ca)

PEI project delves into invasive tunicate biology to improve management

Since the establishment of invasive tunicate species in Prince Edward Island (PEI) waters, *Styela clava* and *Ciona intestinalis* have had devastating effects on mussel culture. Mussel productivity has been adversely affected by these infestations and this is posing challenges for farm husbandry.

This project is exploring some aspects of tunicate biology which could be exploited to minimize tunicate abundance in aquaculture sites through passive approaches. The first objective is to investigate the reproductive biology of *C. intestinalis* in PEI waters with the aim of determining the optimal time and effort of active treatment. The second objective is to evaluate environmental tolerances of tunicate early-life stages in order to determine their level of vulnerability to natural and/or treatment conditions. The third objective is to document the effects of water flow on the recruitment ability of *C. intestinalis*.

Duration: Apr '08 – Mar '11

Funded by: DFO-ACRDP Co-funded by: PEIAA, PEI DFAE

Project team: Daniel Bourque (DFO)

For information contact: Daniel Bourque (Daniel.Bourque@dfo-mpo.gc.ca)

BioCage to control fish farm escapees through genetically-engineered nutritional requirement

A unique study (BioCage) taking place at Laval University in Quebec is looking at a novel way to prevent long-term survival of escaped cultured fish. This would effectively prevent interactions with wild populations of the same or related species, and establishment of feral populations in areas where they are not native. While there has been relatively little demonstrated problem to date with escaped salmon, concerns will inevitably grow as more alien species are added to the aquaculture repertoire. Global warming is also likely to increase the risk of warm-water fish surviving and breeding unchecked in northern areas where they formerly would not have survived.

A team from Laval University, led by Dr. Grant Vandenberg, is developing a line of transgenic Atlantic salmon with an increased requirement for a specific nutrient that cannot be supplied by foods in the natural environment, but could be incorporated into fish feed formulations. Penned fish would remain healthy, but without the extra nutrient in their prepared feed, escaped fish would be unable to reproduce and would soon die due to lack of the missing nutrient.

Specifically, the project is a three-year investigation designed to: 1) evaluate several genetic constructs that would have the effect of increasing the specific requirement for a particular nutrient, 2) use a model species to verify appropriate expression of the modified or introduced genes, and 3) validate the ability of special feed formulations to maintain good growth and health in the modified fish.

Funded through grants from NSERC, the Atlantic Salmon Federation, FQRNT-RAQ and Laval University, the BioCage program is now in its second year.

Duration: Nov '07 – Oct '10

Funded by: NSERC Co-funded by: Atlantic Salmon Federation, FQRNT, RAQ, U Laval

Project team: Grant Vandenberg (U Laval), Mark Ekker (U Ottawa), Garth Fletcher (MUN), Lyne Létourneau (U Laval), Francois Pothier (U Laval), Rodrigue Yossa-Nouaga, Pallab-Kumer Sarker.

For information contact: Grant Vandenberg (Grant.Vandenberg@fsaa.ulaval.ca)

Studies seek methods to track aquaculture wastes in the environment

All animal-rearing operations have the potential to affect local environments through inputs of feed formulations, feces, chemicals and therapeutants, and through biological or mechanical effects, such as disease transmission, shading or physical displacement. In aquaculture, however, one of the most difficult things to assess is the movement of nutrients from aquaculture wastes as they are degraded, metabolized and assimilated into local environments. As components of waste materials are transported between trophic levels by organic decomposition, plant uptake, grazing, predation and/or deposition the percentages of stable isotopes of key elements may not remain constant, and therefore would be difficult to use for tracking this waste in the environment.

Much of the current work has been focused on identifying a reliable and precise method of tracking the fate of aquaculture wastes by quantifying these changes. Recent studies in Vancouver, BC, St. Andrews, NB and Guelph, ON have looked at stable isotopes, trace elements (copper and zinc), pigments, pesticides, antibiotics and secondary effects on wild populations.

Secondary effects studied in New Brunswick

On the East Coast, Dr. Andrew Cooper and Dr. Shawn Robinson have been conducting investigations of secondary effects of finfish culture, both near- and far-field, through changes in wild species distributions, abundance, growth, reproduction and disease. Because aquaculture activities are subject to extremely varied local conditions and occur among different biological communities, assessment of secondary effects can be problematic. To systematically sample and determine true cause and effect of secondary impacts in a cost-effective manner will require some prior understanding of the spatial and temporal scale of changes in food webs that can arise from aquaculture inputs. The aim of this research, being conducted out of the St. Andrews Biological Station with grants from PARR and ACOA, is to establish a reliable methodology to detect exposure to aquaculture feed and the extent to which this occurs in key wild species.

Ontario study seeks stable isotope technique

Prof. Richard Moccia and his team at the University of Guelph are investigating how isotopes ratios are affected in the field as freshwater finfish wastes move into surrounding ecosystems. Previous work has shown that isotopic signatures unique to certain fish feeds are distinct from those of other materials commonly found in freshwater sites, when rainbow trout were raised in laboratory conditions.

However, studies on a farm site in Lake Wolsey, Manitoulin Island failed to show any consistent relation between sediments near cages and the isotopic signature of the feed used.

Previous evidence has indicated that microbial or chemical degradation could be a mechanism for this observed fractionation of isotopes. The current study will attempt to determine whether microbial action may be responsible for changes in the isotopic signature of fish feces to the extent that they can no longer be identified in the natural environment.

This project, funded primarily by Environment Canada, is part of a series of investigations intended to develop a method for tracking the fate of aquaculture wastes by comparing isotope signatures in the environment with those of feeds or fresh wastes. The researchers aim to quantify the isotopic changes in rainbow trout fecal matter through a period of microbial degradation and establish whether these changes form a consistent fractionation pattern that could be used to describe or even predict the final signature. The three-year study is now in its second year.

West Coast researchers focus on trace metals

There currently exist only a limited number of sensitive detection tools that might be applied to the tracking of aquaculture wastes in the environment, notably sediment-free sulfides (S/Eh) and trace metals. Trace elements such as zinc and copper, along with carotenoid pigments (from fish feeds), pesticides, antibiotics and the fatty acid profiles from certain lipids used in fish feeds have all been proposed as candidates that could help scientists track the movement of waste nutrients through the ecosystem, and to monitor the impacts over time.

A study now nearing completion at the DFO West Vancouver Lab has identified the trace metals zinc and copper as providing a possible suite of tracers that could track waste transport pathways linking waste-loading sources with far-field deposition sites. According to team leader Dr. Terri Sutherland, this should lead to a future method that can complement the currently recommended S/Eh system in quantifying potential impacts associated with aquaculture operations.

New Brunswick study:

Duration: Sep '08 – Mar '09

Funded by: DFO-PARR

Project team: J. Andrew Cooper (DFO), Shawn Robinson (DFO), Randy Losier (DFO), Blythe Chang (DFO), John C. Reid (DFO), Paul McCurdy (DFO), Kats Haya (DFO), Les Burridge (DFO), Bruce MacDonald (UNBSJ), Thierry Chopin (UNBSJ).

For information contact: J. Andrew Cooper (Andrew.Cooper@dfo-mpo.gc.ca) or Shawn Robinson (Shawn.Robinson@dfo-mpo.gc.ca)

Ontario study:

Duration: Feb '07 – Feb '10

Funded by: Environment Canada.

Project team: Richard D. Moccia (U Guelph), Kris Osuchowski (U Guelph)

For information contact: Richard D. Moccia (rmoccia@uoguelph.ca)

BC study:

Duration: Sep '08 – Mar '09

Funded by: DFO-CIAS

Project team: Terri Sutherland (DFO), Phil Yeats (DFO), Tim Milligan (DFO), Kats Haya (DFO), Dave Higgs (DFO), Cheryl Podemski (DFO).

For information contact: Terri Sutherland (Terri.Sutherland@dfo-mpo.gc.ca)

DFO project maps sea bed of southern Gulf of St. Lawrence

A good understanding of the physical, chemical and biological characteristics of the seabed is a key element in habitat characterisation needed in assessing development of off-shore aquaculture. This benthic assemblage has proven to be challenging to evaluate on a large scale.

However, there are some tools presently available that will enable the collection of baseline information. A Wide Angle Sonar Seabed Profiler (WASSP) multi-beam sonar and an OLEX system is being installed aboard the Gulf Region research vessel "Opilio" to gather marine bottom information during every research mission. Olex AS is the developer and manufacturer of the electronic chart systems OLEX.

The real-time 3D seafloor profiler can provide 2D bathymetric contour mapping. Off-shore data from this system on the "Opilio" will be combined with the near-shore data already obtained by the Gulf Region lobster group to complete comprehensive marine bottom maps.

Duration: Sep '08 – Mar '09

Funded by: DFO-PARR

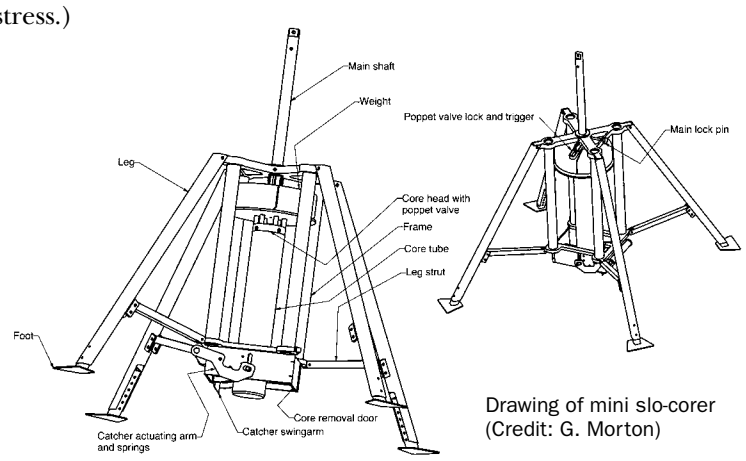
Project team: Leslie-Anne Davidson (DFO), Monique Niles (DFO), Michel Comeau (DFO), Gilles Paulin (DFO), Marc Ouellette (DFO), Mark Newcombe (CMC Electronics), Darryl Landry (DFO-CG), Joanne Kane (DFO-CG), Nigel Hawksworth (DFO-CG)

For information contact: Leslie-Anne Davidson (Leslie-Anne.Davidson@dfo-mpo.gc.ca)

New tools in development to assess resuspension and transport of aquaculture wastes

The project team is developing new tools for parameterizing the erodibility of aquaculture wastes and their associated contaminants for use in predictive models and as far field indicators.

A new mini slo-corer capable of preserving the sediment-water interface during sampling is being designed, constructed and tested. Bottom sediment cores collected with this corer are coupled to an in-situ erosion device to quantify resuspension dynamics (i.e., mass eroded, grain size, organic carbon concentrations and trace metal concentrations as a function of shear stress.)



Drawing of mini slo-corer (Credit: G. Morton)

Modeling programs like DEPOMOD deal primarily with the initial deposition of aquaculture wastes but fail to predict their subsequent resuspension and dispersal due to an inability to parameterize erosion shear stress and the grain size of the eroded material.

The development of predictive models for transport of aquaculture wastes that could be used to assess the potential for far-field impacts requires both concentration and the size of the resuspended material, which this project addresses.

Duration: Sep '08 – Mar '09

Funded by: DFO-PARR

Project team: Brent Law (DFO), Tim Milligan (DFO), Gary Bugden (DFO), Glen Morton (DFO), Fred Page (DFO), Randy Losier (DFO)

For information contact: Brent Law (Brent.Law@dfo-mpo.gc.ca)

Jeannette Arseneault, Molecular biology technician at the Gulf Fisheries Center, DFO, doing a DNA extraction from oyster tissue. (Photo: A. Veniot)

Moncton lab validates assay for the detection of ISA and MSX

The National Aquatic Animal Health Program (NAAHP) of Fisheries and Oceans Canada (DFO) comprises a network of laboratories, where fish and shellfish diseases are diagnosed. Many assays are developed in-house. The laboratories are currently implementing ISO 17025, and validating assays on their scope.

Two assays are validated with no gold standard and latent class models at the Aquatic Animal Health Unit of Moncton: the detection of infectious salmon anemia virus (ISAV), which is a pathogen found primarily in salmonids, and *Haplosporidium nelsoni* (MSX), a pathogen affecting oysters in Canada. Assays for ISAV and MSX include a regular RT-PCR and a real-time RT-PCR assay. For MSX, histopathological detection is validated, and for ISAV, a viral assay is part of the validation.

Assay characteristics such as repeatability (within laboratory) and reproducibility (between laboratory), specificity and sensitivity are determined following the processing of hundreds of carefully selected samples archived or collected for this purpose, and statistical analysis done by epidemiologists at the Atlantic Veterinary College of University of PEI. The assays are used for surveillance, surveys, trade purposes, diagnostics, research, etc. Validation to ISO 17025 standards provides a level of assurance internationally recognized.

Duration: Sep '07 – Sep '09

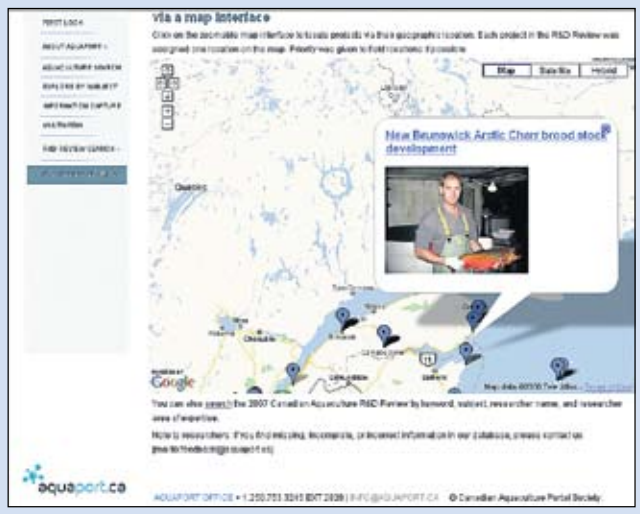
Funded by: DFO

Project team: Nellie Gagné (DFO), Anne Veniot (DFO), Charles Caraguel (UPEI), Carol McClure (UPEI), Mélanie Robichaud-Haché (DFO), Michèle Maillet (DFO), Crystal Collette (DFO)

For information contact: Nellie Gagné (Nellie.Gagne@dfo-mpo.gc.ca)

AquaPort creates "First Look" site for future web portal

The effort to develop a web-based knowledge mobilization platform for aquaculture in Canada took a step forward with the development of a demonstration site called "First Look". A talented group of students at Vancouver Island University contributed to its development. Four components have been built in this early stage of development – search, taxonomy, web alerts using tagging and RSS, and an R&D database.



The AquaPort Search Portal was developed using "Google" custom search and deploys full-text / keyword search technology to provide access to the more-than 7,000 full-text aquaculture resources that were sourced by students working on the earlier AquaNet-funded portion of the project. The search index that has been built for AquaPort consists of "url patterns" exclusively for aquaculture resources and is thus ideal for building a "vertical" search engine that specializes in only one sector.

The team also developed a custom taxonomy (at this point, a simple hierarchy or "enumerative" taxonomy) for use during Stage 1 of the search portal. The AquaPort taxonomy is an aquaculture-based hierarchy of subjects which means all aquaculture subjects can be placed in and accessed, via browsing, from one place.

AquaPort wanted to demonstrate the potential of tagging, RSS alerts, and RSS aggregation to facilitate rapid and targeted information transfer and knowledge mobilization for the Canadian aquaculture sector. The team created a demonstration of how tagging and RSS feeds could be implemented in a specific program or area of interest in to Canadian aquaculture. Aquatic animal health was chosen as a topic area.

The content of the 2007 Aquaculture R&D Review has been separated into its constituent parts (text and images), and together with relevant metadata, stored in a custom-developed MySQL database. A map-based access has also been developed by "mashing" the location data from the database with the Google Map API (Application Programmer Interface). Users will therefore be able to locate projects by geographical area, and zoom in on the location to view the full project information.

Duration: Jan '08 – Apr '08

Funded by: DFO-ACRDP Co-funded by: BCARDC

Project team: Tim DeJager (co3), Barbara Thomas (VIU), Linda Hiemstra (Mel Mor Science), VIU Students: Omar Beltran, Ye Zhou, SiJie Guo, Jas Randhawa, Laura Braden

For information contact: dejagert@co3.ca

Atlantic project develops models for drum filters and large diameter tanks

This project is the continuation of recent work on solids removal in recirculation aquaculture systems. It seeks to reduce the production cost of land-based aquaculture systems by focusing on the development of improved design methodologies for rotary drum filters and the scale-up of triple-drain tanks beyond the current maximum size of 11 m.

Rotary drum filters are widely used for removing suspended solids in recirculation systems but their design has hereto been performed using rules of thumb. This project is improving the mathematical model developed in the recent work so that it can be used to accurately size drum filters for a variety of applications. The screen coverage per unit mass of solids entering the drum filter, a key input parameter of the model, is being measured in the field using an image analysis technique that will be developed for this purpose.

The team is also developing a computational fluid dynamics (CFD) model for the hydraulic behaviour of large triple-drain fish tanks. As the aquaculture industry strives to reduce cost, there is a growing trend toward large diameter fish tanks but no information is available on the impact of increasing tank size on tank hydraulics and self-cleaning.

The CFD model fills this gap by guiding the development and scale-up of large diameter triple-drain tanks. The drum filter and CFD models are being validated by comparing their predictions with performance data from equipment operating at salmon-smolt farms.

Duration: 2008 – Ongoing

Funded by: CCFI

Project team: Michel Couturier (UNB), Adrian Desbarats (Atlantech), Jake Elliott (Cooke Aquaculture Ltd.), Charlane Hatt (NB DAA), Andy Chapman (CCFI)

For information contact: Marc Keilley (marc.kielley@mi.mun.ca)

New Brunswick project upgrades habitat data for aquaculture site assessments

Between the early 1990's and early 2000's a series of regional projects were undertaken that sought to identify and map sensitive fishery areas within Southwest New Brunswick in relation to aquaculture development.

Many results still exist in the form of specific project reports and advisory documentation. From the mid-late 1990's, comprehensive approaches to marine habitat mapping (MHM) have emerged globally, primarily applied to date at regional-scale applications.

This project is reviewing existing regional reports and completing two draft technical reports on approaches to aquaculture site monitoring in relation to habitat suitability and sensitivity for invertebrate fisheries resources. All reports identify promising technical approaches from MHM theory and practise that may be applied in developing new integrated aquaculture assessments.

Duration: Sep '08 – Mar '09

Funded by: DFO-PARR

Project team: Peter Lawton (DFO), Fred Page (DFO), Blythe Chang (DFO)

For information contact: Peter Lawton (Peter.Lawton@dfo-mpo.gc.ca)

The K'ómoks First Nation welcome attendees of the Aboriginal Youth and Sciences Professional Development Workshop (Photo: BC CAHS)

BC project builds aquatic science capacity in aboriginal communities

Three model institutions are collaborating on a project called "Towards Building Aquatic Science Capacity in Aboriginal Communities" funded by the BC Ministry of Advanced Education.

On September 27, 2007, the BC Centre for Aquatic Health Sciences (BC CAHS), North Island College (NIC) and New Zealand's National Institute of Water and Atmospheric Research (NIWA) signed a Memorandum of Understanding for the purposes of establishing and furthering academic exchange opportunities, capacity building, and cooperation in the field of aquatic sciences.

The collaborative project aims to develop institutional bases for cooperation and academic exchange and to provide for the exchange of students annually. In addition, the project provides opportunities for the transfer of Aboriginal/Maori educational models. It supports the exchange of aquatic science methodologies and assists in the transfer of aquatic industry expertise. The project is designed to be sustainable beyond the initial funding period.

The partnership is preparing to build on NIC's successful "learning circle" model by forming a group of young aboriginal scientists who will tour BC First Nation Coastal communities acting as role models for success in the area of mathematics and sciences.

Duration: Sep '08 –Ongoing

Funded by: BC Ministry of Advanced Education

For information contact: Linda Sams (Linda.Sams@cahs-bc.ca)

Website: http://www.cahs-bc.ca/

Newfoundland information initiative helps manage threat of invasive species

The introduction of invasive alien species (AIS) into Newfoundland and Labrador waters represents a significant potential threat to the Newfoundland shellfish aquaculture industry. Although economically-harmful invasive species have not been found on any aquaculture site in the province, finding invasive tunicate and crab species in NL waters illustrates that the threat to our industry is real.

The current NAIA initiative, funded through the Government of Canada's Invasive Alien Species Partnership Program (IASPP), has been very valuable in providing an extra level of security for industry by proactively dealing with AIS before they become a problem.

The driving force for this NAIA initiative is the continuation of the Newfoundland AIS Advisory Committee, co-chaired with DFO, NL region. The Committee has been essential as a conduit of information between the various groups in Newfoundland that have an interest in the issues surrounding AIS establishment and spread.

Another important and extremely productive part of the project has been the organization of Invasive Species Workshops in 2007 and 2008. These workshops were successful in engaging people from a wide range of backgrounds and interests, and in examining impacts of AIS and current management approaches used here in NL and elsewhere.

Duration: Apr '08 – Mar '10

Funded by: IASPP Co-funded by: DFO, NL DFA, MI, MUN-OSC, EC, CFIA

Project team: Darrell Green (NAIA), Cynthia McKenzie (DFO), Derek Mouland (NL DFA)

For information contact: Darrell Green (dgreen@naia.ca)

Marine bacteria may be source of marine anti-foulant treatment

A New Brunswick team is exploring the potential of developing an antifouling treatment derived from local marine bacteria for use in aquaculture as an alternative to existing antifouling treatments. The approach is based on the identification of marine bacteria which inhibit the early colonization of surfaces by bacteria which promote or permit the settlement of macroscopic fouling organisms.

The project has four objectives. The first is the isolation, identification and cultivation of early bacterial colonizers from selected marine surfaces. The second is to apply in vitro high throughput screening assays for the selection of bacteria from a library of marine bacteria which produce substances that actively inhibit the early colonizers identified in objective1. The third is to formulate extracts from antifouling strains identified in objective 2 into experimental coatings for testing. The fourth is to test the experimental coatings on selected surfaces in vivo and compare with current industry standard products.

Piece of experimental netting hung in the water to capture various forms of fouling organisms.

Panels of nets were deployed during the early fall which have been subsequently retrieved. Bacterial colonies are now being isolated and identified from these surfaces at RPC in Fredericton.

Duration: Jul '08 – Mar '10

Funded by: DFO-ACRDP Co-funded by: NBSGA

Project team: Shawn Robinson (DFO), Ben Forward (RPC), Caroline Graham (NBSGA), Clarence Blanchard (Future Nets and Supplies Limited)

For information contact: Shawn Robinson (Shawn.Robinson@dfo-mpo.gc.ca)

BC group links fish health management with goals for sustainable aquaculture

Dr. Preeni Abeynayke in Sri Lanka

Sorting fresh water ornamental fish in Sri Lanka

The Centre for Coastal Health, based at Vancouver Island University, has 3 projects on fish health policies and practices and sustainable aquaculture.

In the first project, the team reviewed attitudes and policies in British Columbia salmon farming. They found four main obstacles to sustainability-based health management.

First, salmon farming faces the same challenges as other industries when trying to establish a working definition of sustainability that captures stakeholders' interests. Second, no program is responsible for comprehensively integrating regulations and monitoring efforts to develop a comprehensive view of sustainability. Third, there is inadequate research and social consensus on the criteria to be used to track health for sustainability purposes. Fourth, the regulatory and management paradigm has focused on diseases and pathogens as opposed to embracing a more inclusive health promotion model. A paper is being published in the journal Ecohealth and includes recommendations for steps forward.

The next two projects are ongoing and are taking place in Sri Lanka. One is examining the policy framework for sustainable development of the ornamental fish farming industry while the other is examining needs and opportunities to implement best management practices in ornamental fish and shrimp farming with respect to the avoidance of antimicrobial resistance.

Duration: Apr '07 – Dec '09

Funded by: TCGHF Co-funded by: PHAC

Project team: Craig Stephen (CCH), Jennifer Dawson Coates (CCH), Nalaka Munasinghe (U Peradeniya, Sri Lanka), Preeni Abeynayake (U Peradeniya, Sri Lanka)

For information contact: Craig Stephen (cch@viu.ca)

Website: www.centreforcoastalhealth.ca

Fatty acid enrichment of microalgae

Microalgae are widely used as nutrients in aquaculture. They are the essential nutrients for mollusc culture and are used to nourish zooplankton (rotifers, artemia and copepods) on which the larvae of fish and crustaceans feed, in turn.

Many studies have shown the importance of nutritional quality in successful culture of mollusc larvae, and particularly the essential polyunsaturated fatty acid (PUFAs) levels of microalgae. The general objective of this study is to determine the optimal production and stabilization conditions for concentrates of live PUFA-enriched microalgae.

The fat content of various microalgae concentrates (*Nannochloropsis*, *Isochrysis galbana* and *Pavlova lutherii*) were evaluated, as well as a mixture of the three species. The concentrates retained essentially the same nutritional properties after 8 weeks in storage at 4°C. Overall, more than 80% of fatty acids were retained in all species.

Live algae concentrate (left) vs fresh algae culture (right) (Photo: D. Diouf)

In addition, fatty acid enrichment of microalgae was carried out in diatom cultures (*Chaetoceros gracilis* and *Thalassiosira pseudonana*) where the PUFA content quadrupled, doubled and tripled (EPA, DHA and AA), respectively.

Duration: 2007 – 2008

Funded by: NSERC Co-funded by: RAQ

Project team: Réjean Tremblay (ISMER-UQAR), Diadié Diouf (ISMER-UQAR), Réal Fournier (ISMER-UQAR), Fabrice Pernet (IFREMER)

For information contact: Réjean Tremblay (Rejean_tremblay@uqar.qc.ca)

BC aquaculture and environment capacity-building initiative continues growth

In 2006, four British Columbia aquaculture scientists were selected to receive BC Aquaculture & Environment Innovation Awards. The goal of these awards is to catalyze the formation of long-term collaborative research that will lead to environmental sustainability solutions for BC aquaculture. These 5-year funding awards are enabling the 4 researchers and their institutions to build critically needed research programs by leveraging funding for numerous research projects.

These programs are being developed in four centres that are growing into important research hubs. Dr. Helen Gurney-Smith, at Vancouver Island University's Centre for Shellfish Research, is focusing on shellfish health and husbandry. Among her numerous projects is a genomics project to develop a health assessment tool for mussel culture.

Dr. Stephen Cross, based at the University of Victoria, is advancing the research needed to develop multi-trophic aquaculture in BC. He is leading a team in the development of the SEA (Sustainable Ecological Aquaculture) system at a site in Kyuquot sound.

Dr. Shannon Balfry, at the UBC-DFO Centre for Aquaculture and Environmental Research, specializes in host and pathogen interactions and is leading projects working on a variety of cultured and wild species of fish.

The BC Centre for Aquatic Health Sciences is set to welcome Dr. Luis Afonso to continue the research program that was being developed by Dr. Val Funk to address fish health issues through improved understanding of host-pathogen interactions and host immune mechanisms responsible for preventing disease.

Duration: Apr '06 – Mar '11

Funded by: BCARDC-AE

Project team: Helen Gurney Smith (VIU-CSR), Stephen Cross (UVic), Shannon Balfry (UBC-CAER), Luis Afonso (BC-CAHS)

For information contact: Tim DeJager (dejagert@co3.ca)

Websites: CSR http://www.viu.ca/csr/ Pacific SEA Lab: http://www.pacificsea-lab.com/ BC-CAHS: http://www.cahs-bc.ca/

Acronyms used in the 2009 Canadian Aquaculture R&D Review

AANS – Aquaculture Association of Nova Scotia
AARS – Alma Aquaculture Research Station - University of Guelph
ACOA – Atlantic Canada Opportunity Agency
ACOA-AIF – Atlantic Canada Opportunity Agency - Atlantic Innovation Fund
AEG - Aquaculture Engineering Group Inc.
AFRI - Aquaculture and Fisheries Research Initiative Inc (PEI)
ASF – Atlantic Salmon Federation
AUCC – Association of Universities and Colleges Canada
BC CAHS – British Columbia Centre for Aquatic Health Sciences
BC MoE – British Columbia Ministry of Environment
BCARDC – BC Aquaculture Research and Development Committee (BC Innovation Council)
BCARDC-AE – BCARDC Aquaculture and Environment Research Fund
BCIC – British Columbia Innovation Council
BCMAL – British Columbia Ministry of Agriculture and Lands
BCSFA – British Columbia Salmon Farmers Association
BCSGA – British Columbia Shellfish Grower's Association
BNB – Business New Brunswick
CACN – Centre aquacole de la Côte-Nord,
CAISN – Canadian Aquatic Invasive Species Network (CAISN)
CAMGR-MAPAQ – Centre aquacole marin de Grande-Rivière
CCFAM ATG – Canadian Council of Fisheries and Aquaculture Ministers – Aquaculture Task Group
CCFI – Canada Center for Fisheries Innovation
CED – Canada Economic Development for Quebec Regions
CeMIM-MAPAQ – Centre maricole des Îles-de-la-Madeleine
CFIA – Canadian Food Inspection Agency
CGP – Atlantic Cod Genomics and Broodstock Development Project
COA – Canada Ontario Agreement Respecting the Great Lakes Basin Ecosystem
CRESCO - Centre de Recherche et d'Enseignement sur les Systèmes Côtiers (France)
CSR-VIU – Centre for Shellfish Research, Vancouver Island University
CTPA-MAPAQ – Centre technologique des produits aquatiques
CZRI – Coastal Zones Research Institute Inc. (U Moncton Shippegan Campus)
Dalhousie U - Dalhousie University
DFO – Fisheries and Oceans Canada
DFO-ACRDP – DFO Aquaculture Collaborative Research and Development Program
DFO-AIMAP – DFO Aquaculture Innovation and Market Access Program
DFO-AIS – DFO Aquatic Invasive Species
DFO-CG – DFO Coast Guard
DFO-GRDI – DFO Genomics Research and Development Initiative
DFO-NASAPI – DFO National Aquaculture Strategic Action Plan Initiative
DFO-PARR – Program for Aquaculture Regulatory Research
DIT-MAPAQ – Direction de l'innovation et des technologies (MAPAQ)
EC – Environment Canada
EPAQ - École des pêches et de l'aquaculture du Québec
FC – Fleming College
FQRNT – Fonds québécois de la recherche sur la nature et les technologies
IASPP – Invasive Alien Species Partnership Program (Environment Canada)
Idaho State U – Idaho State University
IFREMER – French Research Institute for Exploitation of the Sea
IML – Institut Maurice-Lamontagne
IMR Norway – Institute of Marine Research, Bergen, Norway
IPSFAD – Interprovincial Partnership for Sustainable Freshwater Aquaculture Development Inc.
MAFRI – Manitoba Agriculture, Food and Rural Initiatives
MAPAQ – Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec
McMaster U – McMaster University
MDEIE – Ministère du Développement économique, Innovation et de l'Exportation (Québec)
MI – Marine Institute of Memorial University of Newfoundland
MUN – Memorial University of Newfoundland
MUN OSC – Memorial University of Newfoundland - Ocean Sciences Centre
NAIA – Newfoundland Aquaculture Industry Association
NB DAA – New Brunswick Department of Agriculture and Aquaculture
NB DAA–TDF – NB DAA - Total Development Fund
NBIF – New Brunswick Innovation Fund
NBPSGA – New Brunswick Professional Shellfish Growers Association
NBSGA – New Brunswick Salmon Growers Association
NL DFA – Newfoundland and Labrador Department of Fisheries and Aquaculture
NNRC – Norway National Research Council
NOAA – Northern Ontario Aquaculture Association
NOAA Fisheries Service – National Oceanic and Atmospheric Administration National Marine Fisheries Service
NRC – National Research Council Canada
NRC-IMB – National Research Council Canada – Institute for Marine Biosciences
NRC-IRAP – National Research Council Canada – Industrial Research Assistance Program
NS DFA – Nova Scotia Department of Fisheries and Aquaculture
NSAC – Nova Scotia Agricultural College
NSERC – Natural Sciences and Engineering Research Council of Canada
NVI Norway – National Veterinary Institute of Norway
OMAFRA – Ontario Ministry of Agriculture, Food, and Rural Affairs
OMNR – Ontario Ministry of Natural Resources
OMOE – Ontario Ministry of Environment
OSAP – Ontario Student Assistance Program
PEIAA – PEI Aquaculture Alliance
PEI-DFARD – Prince Edward Island Department of Fisheries, Aquaculture and Rural Development
PHAC – Public Health Agency of Canada
PSF – Pacific Salmon Foundation
RAQ – Réseau Aquaculture Québec
RPC – Research and Productivity Council
RPPGR – Regroupement des pêcheurs professionnels de Grande-Rivière
SABS – St. Andrews Biological Station
SE – Saskatchewan Environment
SFU – Simon Fraser University
SMU – St. Mary's University
SODIM – Société de Développement de l'Industrie Maricole
SORDAC – Société de recherche et de développement en aquaculture continentale
SRD – Government of Alberta Sustainable Resource Development
TAGC – The Atlantic Genome Centre
TCGHF – Teasdale-Corti Global Health Fund (International Development Research Centre)
Trent U – Trent University
U Aberdeen – University of Aberdeen
U Copenhagen – University of Copenhagen
U Guelph – University of Guleph
U Iceland – University of Iceland
U Laval – Université Laval
U Moncton – Université de Moncton
U Montreal – Université de Montréal
U Ottawa – University of Ottawa
U Sask – University of Saskatchewan
U Tromsø – University of Tromsø
U Vic – University of Victoria
U Windsor – University of Windsor
UBC – University of British Columbia
UBC-CAER – UBC and DFO Centre for Aquaculture and Environmental Research
UNB – University of New Brunswick
UPEI – University of Prince Edward Island
UPEI-AVC – UPEI Atlantic Veterinary College
UQAR-ISMER –, Université du Québec à Rimouski - Institut des Sciences de la Mer
VIU – Vancouver Island University
WLU – Wilfred Laurier University

Organizations Supporting Projects in this Publication

Canadian Centre for Fisheries Innovation

The Canadian Centre for Fisheries Innovation (CCFI) is in the business of solving problems and creating opportunities for the aquaculture industry and fishery through science and technology. Since its opening in 1989, over 200 leading Canadian companies in the aquaculture, processing, harvesting, biotechnology and related sectors have come to CCFI for help developing new products, new technologies and techniques, and solving virtually every type of technical problem that the industry faces.

What makes CCFI stand apart is the unique working relationships it has established with fourteen universities and colleges in Atlantic Canada. With these arrangements, the hundreds of scientists, engineers and technologists in those institutions provide their expertise and facilities to CCFI clients. Many are world leaders in their fields, and have made it possible for the Centre to carry out 670 industrial projects worth $80 million over 17 years.

The Centre offers its clients a comprehensive service. Industrial Liaison Officers analyze the client's problem or opportunity, draft a research plan and budget, identify and secure the services of scientific or engineering specialists to carry out the work, and if needed, enlist other organizations in getting involved. The Centre also helps fund the initiative. CCFI shepherds the client company through the maze of activities in the research, so that it can continue to concentrate on its business needs. In aquaculture the Centre's scientific and technological services run the entire gamut from early feeding trials for new developing species to offshore cage development.

For more information contact: Marc Kielley (marc.kielley@mi.mun.ca)
Website: http://www.ccfi.ca/

Natural Sciences and Engineering Research Council of Canada (NSERC)

NSERC's role is to make investments in people, discovery and innovation for the benefit of all Canadians. The organization invests in people by supporting more than 26,500 university students and postdoctoral fellows in their advanced studies. NSERC also promotes discovery by funding more than 10,000 university professors every year and it helps make innovation happen by encouraging more than 500 Canadian companies to invest in university research.

Website: www.nserc-crsng.gc.ca/

Genome Atlantic

Genome Atlantic is a not-for-profit corporation with Board members from all four Atlantic provinces, dedicated to the promotion of fundamental and applied research in genomics for the furtherance of scientific understanding and for the development of the knowledge-based economy in the region.

Genome Atlantic invests in and manages large scale genomics research projects and technology infrastructure throughout the Atlantic Region, with over $50 million in committed financing to date from Genome Canada, the Atlantic Canada Opportunities Agency (ACOA), Federal and Atlantic Provincial governments, and other funding organizations.

This investment is ensuring that our best scientific minds stay in the region, while attracting talent from around the world and creating high quality training and employment opportunities for our local graduates.

For information contact: Dr. Steve Armstrong, President and CEO
(sarmstrong@genomeatlantic.ca)
Website: http://www.genomeatlantic.ca/

Genome British Columbia

Genome British Columbia is a research organization that invests in and manages large-scale genomics and proteomics research projects and science and technology platforms focused on areas of strategic importance such as human health, forestry, fisheries, ethics, agriculture and the environment. By working collaboratively with all levels of government, universities and industry,

Genome BC is the catalyst for a vibrant, genomics-driven life sciences cluster with far reaching social and economic benefits for the province and Canada.

Genome BC's major investors are Genome Canada and the Province of British Columbia. This funding is complemented by other private and public investments. Genome British Columbia is investing over $380 million in 60 projects and technology platforms.
Established in 2000, Genome BC is one of six Genome Canada centres across the country.

For more information: http://www.genomebc.ca/

Innovation and Technologies Directorate (MAPAQ)

Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec fosters sustainable development and competitiveness in the fisheries and aquaculture sector in Québec.

Its Innovation and Technologies Directorate (Direction de l'innovation et des technologies – DIT) supports programs involving scientific research and technical support for the industry at its three R&D centres: the Magdalen Islands Mariculture Centre (CeMIM), the Grande-Rivière Marine Aquaculture Centre (CAMGR); and the Aquatic Products Technology Centre in Gaspé (CTPA). These centres generate knowledge that is of use to the industry and coordinate the technical aid provided to aquaculture businesses via a network of contributors posted throughout Québec.

MAPAQ is responsible for the development and implementation of strategies and programs designed to foster innovation. It provides funding for intelligence watch, R&D, technology transfer and information dissemination projects and encourages collaboration between the industry, institutions, and organisations involved in R&D.

Finally, mandated by the Government of Québec, MAPAQ oversees two research funds managed by the mariculture industry development corporation (Société de développement de l'industrie maricole – SODIM) and the inland aquaculture research and development corporation (Société de recherche et de développement en aquaculture continentale inc. – SORDAC), and provides funding to R&D organisations like the North Shore Aquaculture Centre (Centre aquacole de la Côte-Nord) the Salmonid Selection and Transfer Centre (Centre de transfert et de sélection des salmonidés) and the Marine Biotechnology Research Centre (Centre de recherche sur les biotechnologies marines).

Pacific Salmon Forum

The BC Pacific Salmon Forum completed its mandate to the Province of British Columbia with the delivery of a final report and recommendations in January, 2009. It has operated since April 2005 as an independent citizen body using science and stakeholder dialogue to advance the sustainable governance of BC Pacific salmon. Since 2006 it has funded a variety of research initiatives and technical reports.

Before ending operations, the Forum funded several initiatives to be carried out in spring and summer 2009, including:

- oceanographic data collection to support the refinement of the dynamic finite volume coastal ocean model tracking the movement of sea lice and other particles in the Broughton Archipelago;
- marine monitoring and analysis of wild juvenile pink and chum salmon in the Broughton Archipelago during the out-migration period of March through June; and
- lab and field study of the biological effects of SLICE®, (emamectin benzoate), a widely used anti-parasitic agent used on salmon farms to control sea lice, on the marine environment.

In addition, an independent peer review of the Forum's interim research findings from the two-year Broughton Research Program will be conducted.

Forum members are also urging the Province to appoint an independent science secretariat to assume responsibility for future research to support an ecosystem-based management approach. This research is necessary to evaluate all development activities in BC watersheds and nearshore marine systems, improving public confidence that urban and industrial activity is being undertaken based on the best science available.

For more information: A copy of the Forum's Final Report and Recommendations along with research results and other contracted reports can be found at www.pacificsalmonforum.ca/research/index.php. This website will remain active for at least one year.

Société de développement de l'industrie maricole (SODIM)

Société de développement de l'industrie maricole (SODIM) inc. was founded in 1997 for the purpose of providing firms interested in marine aquaculture with flexible financial assistance tailored to their needs. SODIM is a not-for-profit corporation and its mission is to contribute to the creation and development of profitable, competitive marine aquaculture enterprises.

To achieve its mission, SODIM has set the following goals to promote the development of a viable marine aquaculture industry within its territory, namely in the Gaspé Peninsula, Magdalen Islands, Lower St. Lawrence and North Shore, specifically by:

- Providing financial assistance for the start-up, diversification and expansion of marine aquaculture enterprises;
- Offering technical assistance and advisory services to marine aquaculture enterprises; and
- Promoting research and development and technology transfer in aquaculture.

SODIM has two important tools with which to achieve its mission - an investment fund and a R&D fund. The general purpose of the R&D fund is to stimulate research and technology transfer and promote the development of freshwater and marine aquaculture enterprises in the maritime regions of Quebec. The fund is designed to support pre-competitive research activities, i.e., activities of a very practical nature. With the fund, SODIM seeks to promote innovation in the aquaculture industry in these regions. With the collaboration of its partners, SODIM is responsible for identifying research priorities and developing and overseeing the implementation of a science action plan.

Website: www.sodim.org/

The British Columbia Aquaculture Research and Development Committee (BCARDC) – Aquaculture and Environment Fund

BCARDC was formed to enhance aquaculture research and development capacity and organization on the Pacific coast. Operating under the umbrella of the BC Innovation Council, BCARDC:

- Identifies and sets regional aquaculture R&D priorities;
- Provides strategic direction and advice regarding aquaculture-related R&D expenditures;
- Enables communication and improves coordination amongst entities involved in R&D and extension services related to aquaculture in British Columbia; and
- Provides reliable information on aquaculture, its activities and its sustainable management.

The BC Aquaculture Research & Development Committee encourages independent research to foster a fully sustainable aquaculture industry in British Columbia in conjunction with the stewardship of aquatic resources. The Committee exists to define research priorities, fund and coordinate research projects and communicate research results to the broader community. With industry representatives in the finfish and shellfish aquaculture sector as well as federal and provincial government agencies and university research institutions, the Committee has worked to significantly develop research capacity in British Columbia. The Aquaculture and Environment Fund was provided by the BC Ministry of Agriculture and Lands.

Website: http://www.bcic.ca/research-institutions/research-development/aqua-e-fund

Organizations Supporting Projects in this Publication

The Réseau Aquaculture Québec

The Réseau Aquaculture Québec (RAQ) is a network of researchers (academic, provincial and federal government researchers, CEGEP professors) involved in aquaculture research in Québec. The network has been supported by Valorisation Recherche Québec (VRQ) and the Société de développement de l'industrie maricole (SODIM) from 2001 to 2006. From 2006 to 2012, the network will be supported through the "Réseaux stratégiques" program of the Fonds québécois de la recherche sur la nature et les technologies (FQRNT).

RAQ has succeeded in bringing together all Québec researchers with an interest in finfish and shellfish aquaculture, in both the fresh and marine environments, and to provide them with a forum for comparing and combining their research results and expertise.

RAQ has always had very close contact with the aquaculture industry in Québec, especially to its close association with SODIM and the Société de recherché et de développement en aquaculture continentale (SORDAC), partners who play an active role in the elaboration of the RAQ's scientific program.

For more information contact Céline Audet, Ph.D. Scientific Director, celine_audet@uqar.qc.ca or visit http://raq.uqar.ca/

Fisheries and Oceans Canada (DFO)

DFO delivers programs and services that support the sustainable use and development of Canada's waterways and aquatic resources. On behalf of the Government of Canada, DFO is responsible for developing and implementing policies and programs in support of Canada's scientific, ecological, social and economic interests in oceans and fresh waters. It is DFO's mission to deliver to Canadians the following outcomes:

- Safe and Accessible Waterways;
- Healthy and Productive Aquatic Ecosystems; and
- Sustainable Fisheries and Aquaculture.

In working toward these outcomes, the Department is guided by the principles of sound scientific knowledge and effective management.

DFO is the lead federal department for the sustainable management of fisheries and aquaculture. Responsibility for aquaculture management and development (governance) is shared between the federal, provincial and territorial governments. We work together, with many other partners, to ensure that the legislative and regulatory framework for aquaculture is responsive to the public's and industry's needs.

DFO's aquaculture research aims to address regulatory knowledge gaps, and collaborative research and development with the aquaculture industry. Collaborative research facilitates the transfer of the latest technologies to the aquaculture industry. Research on the environmental effects of aquaculture also provides a solid scientific foundation for the conservation and protection of fish and fish habitat in marine or freshwater ecosystems. On-going research contributes to scientific certainty with respect to aquaculture operations and how they interact with the aquatic environment.

In recent years, DFO's research effort has been directed at understanding environmental effects of aquaculture on freshwater and marine habitat and ecosystems. We also invest in aquatic animal health research to understand how best to prevent, mitigate and treat disease. As species diversification is often seen as a means of increasing Canada's global market share, DFO scientists also play a key role in innovative research.

DFO enables research pertaining to aquaculture in Canada through the implementation of research funding programs. These programs vary in their mandates, resulting in a comprehensive strategy for funding scientific research, development or pre-commercialization, whether the research team be made up of researchers internal or external to the department, as well as differences in their funding envelopes and project timeframes.

The following five DFO programs are currently funding Canadian aquaculture research:

Aquaculture Collaborative Research and Development Program (ACRDP)

The Aquaculture Collaborative Research and Development Program (ACRDP) is a DFO initiative to increase the level of collaborative research and development activity between the aquaculture industry and the department, and in some instances with other funding partners. The ACRDP is an industry-driven program that teams industry with DFO researchers. Projects are conducted at DFO Research facilities or possibly industry partner facilities. The program allocates ACRDP funds to collaborative research projects that are proposed and jointly funded by aquaculture producer partners. The ACRDP funding is approximately $4.275 million per year and is subdivided regionally.

The key goals of the program are to improve the competitiveness of the Canadian aquaculture industry, increase collaboration between the department and industry to enhance aquaculture in Canada, facilitate and accelerate the process of technology transfer and research commercialization, and increase scientific capacity for essential aquaculture research and development in the aquaculture sector.

The broad research and development objectives, under which National and Regional priorities have been established, are threefold:

- Best performance in fish production
- Optimal fish health
- Industry environmental performance

Since the program's inception in 2001, over 253 projects have been approved and funded. In total, over $59.2M in research has been funded through the ACRDP, consisting of $27.3M in ACRDP funds, $13.1M in industry contributions, $5.3M leveraged from other project partners, and $13.5M that DFO has contributed on top of the yearly ACRDP allocation.

For more information, please visit the ACRDP website at: http://www.dfo-mpo.gc.ca/science/enviro/aquaculture/acrdp-pcrda/index-eng.htm

Centre for Integrated Aquaculture Science (CIAS)

As part of the DFO Science Renewal, DFO Science has created Centres of Expertise (COEs) in key areas to promote innovation, effectiveness and efficiency in the delivery of science. One of these COEs is the virtual Centre for Integrated Aquaculture Science (CIAS), with its Secretariat located at the St. Andrews Biological Station (SABS), New Brunswick.

The mandate of the CIAS is to lead, facilitate, coordinate, and implement an inter-regional and nationally integrated DFO ecosystem-based, longer-term aquaculture regulatory research program that supports the Department's aquaculture development and management mandate.

In order to deliver this mandate, the objectives of the CIAS are to:

- Identify, implement, and coordinate national and inter-regional longer-term research approaches, programs and projects focused on ecosystem-based aquaculture regulatory research that address the relevant departmental aquaculture needs and priorities;
- Help identify new capacities and expertise required to address existing and emerging ecosystem-based aquaculture regulatory science issues;
- Help facilitate inter- and cross-laboratory partnerships as required to address inter-regional and pan-Canadian DFO ecosystem-based aquaculture regulatory science priorities in an effective and efficient manner, and within a nationally integrated research framework;
- Help develop an awareness within the DFO Science community of the aquaculture related objectives and priorities of the Department, including emerging issues that require a science response;
- Help communicate within DFO Science and to its clients (i) the priority needs for national and inter-regional DFO ecosystem-based aquaculture regulatory science, (ii) the science activities being conducted to meet those needs, and (iii) the results of those activities.

For more information, contact: Fred Page (Fred.Page@dfo-mpo.gc.ca), or visit http://www.mar.dfo-mpo.gc.ca/sabs/CIAS-CSIA/CIAS-eng.html

Program for Aquaculture Regulatory Research (PARR)

The Program for Aquaculture Regulatory Research (PARR) is an internal DFO research program that supports research projects focused on increasing the relevant science knowledge base that supports and advises informed DFO ecosystem-based environmental regulation and decision making of the aquaculture sector.

This program was created in 2008 as part of the New Aquaculture Program initiative, and the knowledge and information produced as a result of the funded research will support the Federal, Provincial and Territorial activities to develop a Canadian Framework for Aquaculture Environmental Risk Management.

Research priorities for PARR include understanding aquaculture-environment interactions, science to support fish health management, and genetic interactions between wild and cultured organisms.

For more information, contact: Ingrid Burgetz (Ingrid.Burgetz@dfo-mpo.gc.ca), or visit http://www.dfo-mpo.gc.ca/aquaculture

Aquaculture Innovation and Market Access Program (AIMAP)

In 2008 the Department of Fisheries and Oceans announced a new grants and contributions program to bolster the development, early commercialization and/or early adoption of innovative techniques for the Canadian aquaculture sector. Over the next five years $23.5 million will be made available for innovation and market access projects.

The goal of this new program is to catalyze private sector and other investment in the aquaculture sector that will:

- Improve the competitiveness of the Canadian aquaculture industry by encouraging an aquaculture sector that continuously develops and adopts innovative technologies and management techniques to enhance its global competitiveness and environmental performance; and
- Position Canadian aquaculture products as having high value in the market place based on their environmental performance, traceability and other considerations.

Since June 2008 AIMAP has contributed approximately $4.5 million towards 26 projects totalling $37 million in value. These projects are contributing towards the program goals of sustainable development, species diversification or the development of green technology.

For more information, please visit the AIMAP website at: http://www.dfo-mpo.gc.ca/aquaculture/sustainable-durable/innovation-eng.htm

Genomics Research & Development Initiative (GRDI)

Fisheries and Oceans Canada (DFO) uses genomics for the aquaculture industry and in the management of the wild fishery. These tools lead to better disease identification and control, development of techniques to accurately determine the population structure of wild marine fish and to identify endangered species and minimize illegal or inadvertent harvesting. As an enabling technology, genomics provides powerful tools and precise information to support operational mandates and upon which policy and regulatory decisions can be based.

The Genomics R&D Initiative was established for the purpose of building and maintaining capacity inside government departments to do genomics research. Through targeted investments the Initiative has enabled the establishment of critical mass in genomics research that supports innovation in key Canadian sectors, and ensures that federal departments can mobilize their support for the overall, national genomics effort (e.g., projects funded by Genome Canada, CIHR). Programs funded under the genomics R&D initiative are also used to augment human resources and help create partnerships with other government departments, universities, and industry (where applicable) through the sharing of technology platforms and by collaborating in research areas that cut across traditional departmental sectors.

For information, contact: Dan McPhee (Dan.Mcphee@dfo-mpo.gc.ca), or visit http://www.dfo-mpo.gc.ca/Science/biotech/abgrds-srdbfa/index-eng.htm

Further information on priorities, plans, programs and projects can be found on the DFO web site: http://www.dfo-mpo.gc.ca