acffa Atlantic Canada Fish Farmers Association

ACFFA Annual Technical Workshop
And
Research Review 2012

FINAL REPORT

November 14 and 15, 2012

Huntsman Marine Science Center

St. Andrews, NB

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Introduction

The Atlantic Canada Fish Farmers Association hosted its annual technical workshop and research review on November 14th and 15th, 2012. This annual workshop is designed to support review and discussion of R&D results, identification of new technologies and begin the development of multi-disciplinary, collaborator research projects to address knowledge gaps. The 2012 workshop also provided a venue for federal and provincial regulators and other national associations to present overviews of their activities, and other information important to the Canadian aquaculture industry. Attendance at the workshop included representatives from the aquaculture industry from across Canada, researchers (local, national and international), pharmaceutical companies, regulators and other stakeholders including fishery and conservation interests.

Sea lice and alternative control methods / management tools to support a fully operational intengrated pest management (IPMP) continues to be a primary focus of research for the salmon aquaculture industry in Atlantic Canada. The complexity of sea lice dynamics and the marine environment of the Bay of Fundy mean these research initiatives require many years of study and some projects presented require multiple years of study to support meaningful results. The research presented from other countries facing the challenge of sea lice continues to be important in informing the Canadian industry including that of new technology that may be evaluated for use in local conditions.

Other regional and global fish health issues were also discussed. This included both Infectious Salmon Anemia (ISA) and Amoebic Gill Disease. A review of National Aquatic Animal Health Program (NAAHP) program under CFIA and a review of the new requirements for farming companies where ISA may occur was a timely discussion.

Other R&D project results presented continue to increase environmental knowledge, enhance farm management practices, and support conservation / enhancement projects. The Recovery of Endangered Inner Bay of Fundy Atlantic Salmon Project involving ACFFA, Fundy National Park and many others provided data which can be used to inform future recovery strategies in the Park and potential new collaborations.

The 2012 agenda allowed time for a facilitated discussion of continuing knowledge gaps and potential research projects for 2013. This discussion was focused on the themed research areas of: sea lice, general fish health, and environmental priorities.

A research connector event for industry and university researchers was a new addition to the 2012 program. The connector event was intended to bring together researchers from universities / academia and industry representatives to share and discuss research interest areas and potential collaborations.

Over 130 individuals attended the technical workshop on November 14th and 15th.

Acknowledgements

The ACFFA wishes to acknowledge the support of:

Aquaculture Collaborative Research and Development Program (ACRDP), DFO

NSERC

NRC-IRAP

Fish Vet Group

PHARMAQ AS

Skretting

Solvay Chemicals

Aqua Pharma

Future Nets

Novartis Animal Health

Mitchell McConnell Insurance Ltd

Northeast Nutrition

Sweeney International Management Corp

RDI Strategies Inc.

Silk Stevens Limited

In addition, the participation of all of the speakers at this session is greatly appreciated by the ACFFA.

Agenda

acffa Atlantic Canada Fish Farmers Association

Annual Workshop and Research Review 2012

November 14th and 15th, 2012
Huntsman Marine Science Center, St. Andrews, NB

WEDNESDAY, NOVEMBER 14, 2012

8:00 **Registration and Coffee**

8:30 Welcome and Introduction – Pamela Parker, ACFFA
8:35 Fisheries and Oceans Canada - Investing in Science and Aquaculture Research – Jay Parsons, DFO
9:00 Pan-Atlantic Initiative – Kathy Brewer-Dalton, NB DAAF
9:25 Canada – Seizing the Opportunity – Ruth Salmon, CAIA
9:50 AAC Operations and Research – Gail Ryan, AAC

10:15 **Refreshment Break**

10:30 NAAHP and ISA Management – Emery Leger, CFIA
11:15 Amoebic Gill Disease – James Hoare, Fish Vet Group
11:25 iBoF Salmon Recovery Project – Bronwyn Pavey /Dan Mazerolle, Fundy National Park

12:00 **Lunch**

1:15 **Sea Lice R&D 2012**
- 1:15 Are 'lousy' fish more susceptible to ISAV? - Sarah Barker, U of Maine
- 1:40 Sea lice effects on ISA infection: Host strain differences – Jennifer Covello, AVC
- 2:05 Mussels and mechanical traps for sea lice - Shawn Robinson, DFO-SABS
- 2:30 There's something about lumpsuckers – knowledge from initial trials in Norway - Nils Fredrik Vestvik, Aqua kompetanse
- 2:55 Egg viability work & future R&D on Paramove 50 in Europe – Ian Armstrong, Aqua Pharma

3:20 **Refreshment Break**

3:35 **Sea Lice R&D 2012 continued**
- 3:35 AlphaMax & Salmosan Denaturing – Leo Cheung, RPC
- 4:00 Sea Lice: Update on NB Industry Trends & Comparisons - Larry Hammell, AVC

4:30 **Adjournment**

6:30 Holiday Reception and Dinner
New Brunswick Community College, 99 Augustus Street, St. Andrews

THURSDAY, NOVEMBER 15, 2012

8:00 **Coffee and Mixer**

8:30 **General presentations**

- 8:30 Canadian Aquaculture Organic Standard – Ruth Salmon / Justin Henry, Pacific Organic Seafood Association
- 9:00 Noise control on aquaculture sites – Randy Griffin, Cooke Aquaculture
- 9:30 Aquaculture Real-Time Integrated Environmental System – Tom McKeever, Marine Institute

10:00 **Refreshment Break**

10:30 **Moving the Research Agenda Forward - *A facilitated discussion on identifying research priorities for 2013***

12:00 Lunch

1:30 **Research Connector Event for Industry / University Researchers**

1:40 Academic presentations

Brian Wilson, Acadia	Hart Devitt, UNB-SJ
Cyr Couturier, MUN	Kurt Gamperl, MUN
Michel Couturier, UNB	Peter King, MUN
Shelley King, Genome Atlantic	Suzanne Dufour, MUN
Thierry Chopin, UNB	Nathan Crowell, NSCC

4:00 Coffee and networking

Thanks to our sponsors!!

Many thanks also to collaborators on this event: ACRDP (DFO), NSERC, and NRC-IRAP

Presentation Synopses and Speaker Biographies

The following synopses were completed by the speakers or prepared by ACFFA and approved by the speakers.

Wednesday, November 14, 2012

INVESTING IN SCIENCE AND AQUACULTURE RESEARCH

– Dr. Jay Parsons, Director, Aquaculture Science Branch, Fisheries and Oceans Canada (DFO) Ottawa

Dr. Parsons began his presentation providing the context on the transformation of the government and the Department, while assuring the audience that science will continue to provide the decision making foundation for sustainable aquaculture development. He also reviewed issues and opportunities for the aquaculture industry, in light of the increasing global demand for seafood, the Cohen Commission and end of the current funding under the Sustainable Aquaculture Program.

The funding programs related to aquaculture science within DFO were described with backgrounds on program intent, priority focus, amounts invested and examples of projects funded. Between 2008 and 2012 DFO invested over $24 million directly into aquaculture research under the Program for Aquaculture Regulatory Research (PARR) and the Aquaculture Collaborative Research Development Program (ACRDP) with $7 M and $17M, respectively. An additional $15 M was invested in other regulatory science and capacity activities.

PARR is an internal DFO research program; its potential renewal will see priority areas that will remain generally the same, although there may be a change in emphasis, such as more focus on wild fish / farm interactions as an example. To inform decision making and address the increasing demand for robust peer-reviewed science, DFO Management has been seeking advice through the DFO Canadian Science Advisory Secretariat (CSAS). Five CSAS peer-review processes have been completed in 2012 with three scheduled for early 2013. The Aquaculture Science Branch is also developing a Risk Assessment Framework for Aquaculture to provide science advice within the context of a risk-based approach.

The ACRDP has moved to a single nationally coordinated model, with steering and technical committees consisting of representatives from DFO Science and Management, academia, other related federal and provincial government departments and industry. Research priorities are set annually, based on two focused areas: Optimal Fish Health and Industry Environmental Performance. Projects / workshops must address these areas and fit within the yearly priorities. With $2 million in funding, the 2012 – 2013 allotment was fully committed to 25 ongoing, 11 new projects and 5 workshops.

DFO is also committed to communicating science from the PARR and ACRDP research programs and CSAS reviews. This is primarily achieved through fact sheets, primary publications, workshops, conferences and web sites.

For the future, a list of DFO commitments includes continued investment in collaborative science to support sustainable aquaculture development, the development of renewal options for the aquaculture regulatory research program and increased efforts to communicate research activities and results to the public.

See Attached Presentation

<u>Jay Parsons</u>
Dr. Jay Parsons has been involved in the aquaculture sector for 30 years and has extensive experience in aquaculture research and management. Since 2003, Dr. Parsons has been with the Aquaculture Science Branch of Fisheries and Oceans Canada in Ottawa where he is Branch Director responsible for DFO's national aquaculture science programs and aquaculture research coordination and advice. From 1995-2003 he was a researcher and faculty member at Memorial University (St. John's, Newfoundland,

Canada) where he taught graduate courses in shellfish aquaculture and directed several graduate students involved in projects on culture, feeding and reproduction in scallops, oysters, mussels, sea urchins and shrimp. He is also a past president of the World Aquaculture Society (WAS) and has served on the WAS Board since 2001. He was also President of the National Shellfisheries Association (NSA) and twice President of the Aquaculture Association of Canada (AAC). And he still maintains an active involvement in these professional societies through the promotion and dissemination of aquaculture science nationally and internationally.

PAN-ATLANTIC COLLABORATIVE FISH HEALTH INITIATIVE

- Kathy Brewer-Dalton, NB Department of Agriculture, Aquaculture and Fisheries

As a representative of the provincial government's Pan-Atlantic group, Brewer-Dalton began by explaining how science-based decision making can achieve the goal of a sustainable and productive aquaculture industry in the Atlantic Province. Scientific research will support decision making processes, policy development, smart regulations and a mutual understanding and respect of each party's role in the development of public policy.

The vision for the group is to: *"Produce harmonized, validated Atlantic Province fish health programs, policies and regulations in support of sustainable aquaculture growth leading to prosperity for the citizens of our provinces".* The industry and government already collaborate in many areas including fish health management, aquaculture development, research projects and policy / program development. The Pan-Atlantic initiative would see these examples broadened to include all of Atlantic Canada in these collaborations with activities like the movement of fish between the provinces an example of an area of focus.

The reasons a Pan-Atlantic Collaborative Fish Health Initiative was conceived and believed to be of benefit include:

- Increasing production and similar client base and needs
- Fish health and biosecurity key to sustainability (eg. Infectious Salmon Anemia, Sea Lice, Infectious Hematopoietic Necrosis)
- The supporting elements are of mutual interest to the Atlantic Provinces
- Public confidence and community acceptance
- Significant efficiencies in collaborating with other provinces and stakeholders

Even with the provinces agreement on these benefits, Kathy emphasized that this will be a complicated process, requiring the roles and responsibilities of many agencies to be determined including federal departments of Environment, Health, and the Canadian Food Inspection Agency. This has been an area of focus in 2012 and an MOU is under development. Other areas that the group has been involved with include the development of the Aquaculture Activities Regulations and MOU and the management of recent ISA cases in Atlantic region under CFIA's new role (NAAHP).

<u>Kathy Brewer-Dalton</u>
Kathy is a Fish Health Specialist with the Resource Management and Fish Health Branch of NB DAAF. She has been working with the Department since 2005, and focuses on fish health and disease management, research, policy, program and regulatory development and wild and farmed fish interactions. Kathy Brewer-Dalton has an honours degree in Marine Biology from the University of New Brunswick in Saint John, NB. She has been working in and around the aquaculture industry for approximately the last 17 years on both the East and West coasts of Canada.

CANADA – SEIZING THE OPPORTUNITY

- Ruth Salmon, Canadian Aquaculture Industry Alliance

Ruth Salmon provided an overview of the role of the global aquaculture industry in meeting the world's rapidly growing demand for food and the potential for and Canada's aquaculture sector to become a major supplier of quality farmed seafood and fulfill her potential in the world marketplace.

World population is anticipated to grow to 9 billion in 2050 with the global demand for protein raising by 2 ½ times its current level. The combined factors of increasing population, rising incomes, and decreasing poverty in developing countries are identified as the basis for the large increase in food demand. Global production of protein will have to increase significantly to meet this demand and though historically this has been achieved though intensive livestock production, the limits of our freshwater resources to meet the needs of the agriculture industry will require an alternative food production method - aquaculture.

In the shorter term, as seafood demand continues to increase 7% to 9% per year, the United Nations suggests an additional 40 million tonnes of seafood will be needed by 2030.

The many benefits and need for increased seafood through aquaculture has been discussed under the two broad headings of environmental sustainability and health benefits to consumers. For the 2.1 billion dollar Canadian aquaculture industry, the large economic benefits realized within the individual province of origin has impacts realized across the country. However, in contrast to the ongoing increases in global production, Canadian aquaculture production has stalled over the past 12 years. Despite Canada's natural advantages for aquaculture production, our industry has been constrained by an antiquated and confusing regulatory framework, resulting in reduced competitiveness and limited growth.

The need for a national strategy for aquaculture development in Canada was emphasized along with a continued movement toward a science-based regulatory framework that supports industry growth.

See Attached Presentation with Speaking Notes

Ruth Salmon

Ruth Salmon brings more than a decade of aquaculture experience to the Canadian Aquaculture Industry Alliance, having served five years as Executive Director of the BC Shellfish Growers Association and seven years as a private consultant. She has held senior positions with the Canadian agri-food industry – as General Manager of the Alberta Milk Producers Association and Advertising Manager with the Dairy Bureau of Canada. Having worked at both the provincial and national levels, Ruth takes a special interest in the promotion and expansion of the aquaculture industry across Canada.

AQUACUTURE ASSOCIATION OF CANADA (AAC)

–Gail Ryan, Executive Director

The Aquaculture Association of Canada was incorporated in 1984 and today has 565 members including academics, researchers and scientists. It is lead by a Board of Directors whose members come from across the country.

Ryan provided an overview of the AAC mission and their new strategic plan to meet the mission goals. With its foundation in sustainability and stability, the plan focuses on five pillars:

- PILLAR 1: MEMBERSHIP VALUE AND ENGAGEMENT
- PILLAR 2: PROGRAMS AND SERVICES
- PILLAR 3: COMMUNICATIONS AND MARKETING
- PILLAR 4: PEOPLE POWER – STAFF AND VOLUNTEERS
- PILLAR 5: FINANCIAL, OPERATIONS AND ADMINISTRATION

In Pillar 1, membership value and engagement the new Ambassadors Team initiative was highlighted as a way to increase broad industry engagement from the regions and sectors. This Team can also act as a sounding board for the AAC. Within Pillar 2 - programs and services – the AAC plans to establish science panels to address specific interest topics , develop white papers and / or hold workshops. Ryan also provided Aquaculture Canada's upcoming conference in Guelph, Ontario June 2- 5th, 2013 with the theme: Farming our Waters: Agrifood Innovations.

In providing further information on the Science Panel program, objectives were reviewed; including the intent that the panel groups be proactive in presenting balanced, science-based information on issues which presently and/or potentially impact the aquaculture industry and provide more clarity on issues to help inform the broader discussion. Science Panels would also help to identify knowledge gaps and develop plans to address these gaps. The format of the program would include the development a draft white paper on a key issue with the assistance of the chosen experts, followed by a panel workshop to peer review the compiled information leading to the preparation of a summary document. A spokesperson(s) would be chosen from each panel of experts to be available to respond to media and other inquiries. The AAC plans to develop a database of experts available and able to respond publicly when relevant issues are in the media. Proceedings would be published for panels as a series, white papers would be submitted to scientific journals, and results communicated in language that can be understood by all (non-scientists).

Following a survey of stakeholders Disease Outbreak Management and Response/Pre-emptive Management and Integrated Pest Management was identified as the first issue to be addressed in this series. The scope of the panel will include bio security, communications, environmental impacts and treatments for disease management, pest control, etc., and will be held in January/February 2013.

PS - The Panel was postponed and will be held on June 1st, 2013 immediately preceding Aquaculture Canada OM in Guelph. **Panel Topic: A Review of Disease Interactions Among Wild and Farmed Aquatic Organisms**

See Attached Presentation

Gail Ryan

Gail Ryan is the President of Gail Ryan Consulting and has over 20 years experience working in the private sector in various industries, including public relations, life sciences and natural resources. She spent 13 years with the St. John's Board of Trade, one of the largest Chambers of Commerce in Atlantic Canada, and was General Manager from 2003 to 2008. Prior to starting her consulting company in 2009, Gail was the Chief Financial Officer for Newlab Life Sciences, a clinical research, genomics and proteomics laboratory and pharmaceutical development company. Gail has most recently been working with companies in the biotechnology, telecommunications and health and wellness industries. She has secured funding, developed business, strategic and operational plans, conducted functional audits and human resource reviews and implemented policy.

ISAV SUSPICION ON MY SITE …. WHAT NOW?

– Emery Leger, Canadian Food Inspection Agency

CFIA officers responsible for National Aquatic Animal Health Programs (NAAHP) in Atlantic Canada participated in an Annual Workshop and Research Review of Atlantic Canada Fish Farmers Association on Nov.15th, 2012 in St. Andrew, New Brunswick. Six CFIA personnel attended the Workshop:

Atlantic Animal Health & Meat Hygiene Program Manager – Dr. Emery Leger
Telephone: (506) 851 3648 Emery.leger@inspection.gc.ca

Atlantic Area Program Specialist - Dr. Wole Oguntona
Telephone: (506) 851-3213 Samson.Oguntona@inspection.gc.ca

New Brunswick Regional NAAHP Veterinarian –Dr. Michael Trenholm
Telephone: (506) 851-7654 Michael.Trenholm@inspection.gc.ca

Newfoundland and Labrador Regional NAAHP Veterinarian - Dr Karla K Furey
Telephone: (709) 772-4714 karla.furey@inspection.gc.ca

Nova Scotia Regional NAAHP Veterinarian - Dr Shane Hood
Telephone: (902) 679-5586 Shane.Hood@inspection.gc.ca

Prince Edward Island Regional NAAHP Veterinarian - Dr. Tim McQuaid
Telephone: (902) 566-7290 (2025) timothy.mcquaid@inspection.gc.ca

During the workshop a presentation entitled "ISAV on my site...............what next?" was presented to the workshop participants. A hypothetical case scenario was used to illustrate the CFIA expectations and time lines associated with CFIA disease control activities on a suspect site.

The presentation reviewed CFIA expectations from industry and the provinces during an ISAV event as well as the importance of movement controls, quarantines, enhanced bio-security, tracing documentation and CFIA sampling requirements. CFIA also discussed lessons learned from the previous outbreaks.

CFIA expectations from industry highlighted the importance of Industry Standard Operating Procedures (SOP). These documents describe the various industry activities which may include but not limited to the following:

- Harvest / destruction
- Transfer to ground transport
- Ground transport
- Transfer to processing \ disposal
- Processing\ disposal
- Clean & Disinfect (C&D) (personnel, vessels, gear, equipment, nets and pens)
- Mortality removal
- Bio-security

It is hoped that similar presentations will be delivered at various industry meetings in the four Atlantic Provinces.

<u>Emery Leger</u>
Born, raised and currently living in Shediac NB. Attended the NSAC where he was granted a BSc in Agriculture in 1988. Graduated from the Atlantic Veterinary College in 1994 and practised as a large animal practitioner in the Moncton Area for 5 years. Emery returned to the Atlantic Veterinary College in 1999 and completed an MSc in Epidemiology in 2002. For the past 11 years Emery has worked for CFIA. During this time period he has been involved with various aspects of emergency preparedness and provided assistance with the 2099 Avian Influenza response in Abbotsford BC. Emery is currently employed as the Atlantic Area Meat Hygiene and Animal Health Program Manager.

AMOEBIC GILL DISEASE IN FARMED SALMON

***-**James Hoare, Fish Vet Group (FVG)*

Amoebic Gill Disease (AGD) was first recognized as a significant problem for marine-farmed salmonids in Tasmania in the 1980s. AGD continues to be an issue there, and adds approximately 14% to annual production costs. Atlantic salmon is particularly susceptible to this disease. The first reported case in North America was in Coho salmon in 1985 in Washington State. Outbreaks observed in Pacific salmon tend to be minor and sporadic suggesting possible inherent resistant. The first cases reported in Europe were in the mid-nineties at sites in Ireland, France and Spain. Norway reported 4 cases in autumn 2006 and Chile had its first reported case in 2007. In the last 12 to 15 months there have been more significant outbreaks in Ireland and Scotland.

AGD affects farm operations in two major ways – impact to fish health and, consequently economic impact. Given the right conditions AGD can cause significant fish mortality. Australia reported 10% stock loss per week when farms were left untreated; in Scotland one farm recently experienced close to 70% mortality. A relatively low pathogen burden will compromise the fish by a general drop in appetite and lost growth. With severe AGD, large numbers of fish will collect at the surface with obvious respiratory distress and no interest in feeding. These fish are also more susceptible to handling stress, as well as secondary infections and other diseases complicating treatment decisions. Economic impacts

include lost productivity and the costs associated with treatments (i.e. treatment compounds, equipment, well boat etc.). There is also the cost of mortality removal and disposal.
Gill disease in salmonids often involves a series of events or combination of factors to cause a gill disease complex. These factors may include harmful algal blooms, harmful zooplankton spores, other parasites or pathogens, and toxins or other irritants. Biofouling, poor smolt quality, and other infected sites in the area have also been implicated. Salinity (> 32ppt) is regarded as one of the most important environmental factors in AGD. Although amoebae can be found on salmon gills at temperatures below 10°C, clinical disease is most commonly reported between temperatures of 12–20°C.

For some time *Neoparamoeba pemaquidensis* was considered the aetiological agent for AGD but subsequent work revealed that AGD lesions were consistently related to a new species called *Neoparamoeba perurans,* which was confirmed as true agent of AGD in 2007. This free living and parasitic amoeba survives in sediment, net pens and gills of dead fish. It can spread in seawater over 1km and survives in seawater for at least 14 days. The parasite can be observed on fresh gills smears and histopathology. A PCR test is also available to diagnose AGD.

A freshwater bath is the current treatment of choice but is logistically very difficult to organize, due to the huge volumes of water required and sourcing the freshwater supply. While most 2 to 3 hour treatments were reported as very effective, re-infection was observed in some sites. Hydrogen peroxide is currently used in the majority of treatments in Scotland. These treatments have been relatively effective at reducing amoeba numbers at 48 hours, with improvements in appetite and lower mortality reported post treatment; however, new lesions tend to establish 7-10 days later and there are occasionally treatment related losses.

Potential in-feed treatment products have been identified but are not licensed for use as yet. Alternative oral therapies are worthy of further investigation. Early-stage trials on the development of a vaccine are continuing in Australia. Genetic selection of fish for resistance to AGD also holds great potential and research being focused in this area should be a priority.

See Attached Presentation

<u>James Hoare</u>
Dr. Hoare graduated from the Royal Veterinary College, London & subsequently completed a master's degree in Aquatic Veterinary Studies at the University of Stirling. Since 2007, James has been working at the Fish Vet Group in Scotland providing veterinary support to the UK aquaculture industry. In May 2012, James moved to Portland, Maine to become Operations Director for FVG Inc.

FUNDY NATIONAL PARK'S INNER BAY OF FUNDY ATLANTIC SALMON RECOVERY PROGRAM - CEO AWARD-WINNING COLLABORATION RESULTS IN 20 YEAR HIGH IN SALMON RETURNS TO FUNDY NATIONAL PARK.

– Bronwyn Pavey for Dan Mazerolle and Corey Clarke, Fundy National Park

A collaborative *Species at Risk* conservation project is yielding high numbers returning salmon. Recent surveys to count returning adult salmon to Fundy National Park rivers detected 41 Endangered Inner Bay of Fundy (IBoF) Atlantic Salmon in the Upper Salmon River. It has been over 20 years since this many fish have been observed in a park river.

Fish are collected from the wild in Fundy National Park as smolt (juvenile salmon migrating from river to ocean) and reared for 18 months (a typical marine migration period) either in a hatchery or customized sea-cage in the Bay of Fundy.

More recently, Parks Canada-led monitoring and research data has highlighted the importance of natural exposure, particularly during early life stages. With these findings in mind, a collaboration between Parks Canada, Fisheries and Oceans Canada, and the Atlantic Canada Fish Farmers Association began in 2009. A pilot project began where wild, juvenile IBoF salmon are reared in outdoor sea cages (similar to those used in commercial aquaculture) in the Bay of Fundy. So far, it seems the sea-cage

reared fish are better able to survive in the Bay of Fundy, retuning nine months later to their natal rivers to spawn. The majority of this year's returning adults are from the sea cage – reared group.
In 2010, this project was recognized nationally when collaborators received an award from the CEO of Parks Canada for excellence in partnership engagement.

See Attached Presentation

Bronwyn Pavey
Bronwyn is the Partnering, Engagement and Communications Officer for the New Brunswick South Field Unit in Parks Canada. Fluently bilingual, Ms. Pavey earned a master's degree in water sciences (hydrological statistics) from l'Université du Québec in 2007. She successfully nominated the Inner Bay of Fundy Salmon Recovery partnership between Fundy National Park and ACFFA for the Parks Canada CEO Award of Excellence in 2010. Prior to joining Parks Canada, Ms. Pavey worked as an environmental scientist for Stantec Consulting Ltd., where she developed skills in environmental planning and permitting, science communication, public consultation and project management.

Dan Mazerolle
Dan Mazerolle is the park ecologist for Fundy National Park. He has a B.Sc. from the University of New Brunswick and a M.Sc. and Ph.D. from the University of Saskatchewan. Prior to his current position, he worked as a postdoctoral fellow in the Department of Renewal Resources at the University of Alberta. Dan has been working as an ecologist for Fundy National Park since 2007.

Corey Clarke
Corey Clarke (BSc) (MSc candidate), a Resource Management Officer for Parks Canada has been employed in Fundy National Park for 11 years. He is currently an MSc graduate student at the Memorial University of Newfoundland in the Environmental Science program. Mr. Clarke holds a Bachelor's Degree in Environmental Management from the University of New Brunswick as well as a diploma in forest technology from the Maritime Ranger School in Fredericton NB. He has worked on all aspects of Fundy's Inner Bay of Fundy Atlantic Salmon recovery program since 2002 and has coordinated program operations since 2006 reporting to the park Ecologist. Since its beginning in 2009, Mr. Clarke has coordinated an innovative new collaborative project rearing smolts captured from the Park's rivers in sea cages to compare with standard hatchery practices currently practiced for conservation. In this role, he works closely with representatives from many organizations critical to the project's success including AFFCA members Admiral Fish Farms and Cooke Aquaculture, The Department of Fisheries and Oceans, The Atlantic Salmon Federation, Memorial University and Concordia University. Much of the data collected from this project will contribute to Mr. Clarkes MSc program co-supervised by Dr. Craig Purchase and Dr. Dylan Fraser. Field work for this 3-year project is currently ramping down with focus now turning to data compilation, analyses and reporting.

ARE "LOUSY" FISH MORE SUSCEPTIBLE TO ISAV?
- Sarah Barker, University of Maine

Research to date indicates that sea lice can carry various bacteria and viruses, and in the lab, sea lice have been found to transmit IHN virus to the host fish. However, the question of whether the sea louse is a carrier or vector of ISA virus still needs to be answered; since a vector is not only required for part of the pathogen's life cycle, but also transmits the pathogen directly to the host. In either instance, another question posed is: does the presence of sea lice on salmon result in those fish being more susceptible to ISA virus? If so, is this a result of 1) the host's immune system being suppressed by the lice, 2) mechanical damage of the salmon's skin, which is one of the first defense barriers against pathogen entry, or 3) a combination of the two. This is the basis of the work to be presented with the specific questions: Are salmon pre-infected with *Lepeophtheirus salmonis* (the salmon louse) more susceptible to ISAV infection? What are the effect(s) of prior lice infection on the immune response to ISAV infection? Do *L. salmonis* feeding upon ISAV-infected salmon carry viable virus, and if so, are they capable of transmitting ISAV to a naïve host when they host switch?

In order to answer these research questions, three treatment groups of 130g Atlantic salmon smolts were sampled over a time series. The three treatment groups comprised: 1) uninfected controls *i.e.*

sham lice and sham ISAV challenge, 2) sham lice challenge followed by ISAV challenge, and 3) Lice challenge followed by ISAV challenge. All salmon were housed in 3 identical saltwater recirculation systems at UMaine, Orono campus. Each system possessed duplicate tanks per treatment, resulting in 6 replicate tanks per treatment group in total. The salmon were presented with a true or mock sea lice challenge via a bath exposure to the infective copepodid stage. Fish were subsequently challenged with a mock or true ISAV challenge via a cohabitation exposure. Fish from each treatment were sampled prior to ISAV challenge and then 3, 16, and 37 days post-ISAV exposure (n = 24 fish per treatment group per time point (6/tank). Two tanks per treatment group were monitored for mortality and carrier status at 51days post ISAV exposure.

The results of this experiment indicate that salmon pre-infected with a high intensity of *L. salmonis* appear to be more susceptible to subsequent ISAV infection. This conclusion is based on the fact that: 1) a higher proportion of the salmon infected with sea lice prior to ISAV exposure were positive for viable ISA virus than those exposed only to ISAV, 2) viable virus was detected earlier in dual infected fish, and 3) salmon infected with sea lice prior to ISAV exposure possessed a significantly lower survival than those exposed only to ISAV.

The results outlined above led us to ask whether the intensity of prior sea lice infection affected the host's susceptibility to the ISA virus. To this end salmon were sham infected or infected with a low or medium sea lice intensity followed by either sham or true ISAV cohabitation exposure challenge. The results corroborated the first challenge indicating that prior sea lice infection increased susceptibility to the ISA virus. However, there was not a significant difference in the mortality of the salmon due to ISAV infection between the salmon groups with a low lice intensity and those with a medium lice intensity. This indicates that there is an increased risk of ISAV infection even when low levels of sea lice are present on the Atlantic salmon. However, the role mechanical damage by the sea lice, and the systemic and localized immuno-modulation by the lice in the salmon plays in increased susceptibility to ISAV are still being determined. This project is a collaboration between Dr Sarah Barker, Dr Ian Bricknell and Deborah Bouchard at UMaine, and Dr Mark Fast and Dr Jennifer Covello at UPEI who are determining the immune response of the salmon to single and dual infection by performing quantitative RT-PCR on head kidney samples taken from both the trials described above.

Salmon lice were found to be positive for viable ISAV when sampled from ISAV positive salmon in both trials i.e. the salmon louse can carry viable ISAV. The following questions are currently being examined at UMaine: 1) do sea lice carry the viable ISA virus on the exoskeleton or internally, 2) what is the time frame that viable ISA virus is associated with sea lice, and 3) do sea lice feeding on ISAV positive salmon pose a risk of ISAV transmission to naïve fish when they host switch. These are potentially important questions for disease management on salmon farms.

Sarah Barker

Sarah received her BSc (Hons) Zoology at the University of Manchester, U.K., and masters in research (M.Res) at the University of Aberdeen where she began to carry out research at the Fisheries Research Services laboratory in Aberdeen, Scotland on the host-parasite interactions between sea lice and their salmonid hosts. Sarah then went on to a PhD in aquatic veterinary sciences at the Institute of Aquaculture, University of Stirling. In early 2010, Sarah came to Maine, USA and started working in the University of Maine Animal Health Laboratory before transitioned to a post-doctorate research fellow working with Dr Ian Bricknell and Deborah Bouchard, where she was involved in several projects, such as, studying the interactions of sea lice and ISAV and their host Atlantic salmon, feasibility of selective breeding for resistance to sea lice. Sarah is now a research scientist within the ARI involved in several commercial driven projects as well as a NOAA-Seagrant project investigating the role of wild and farmed fish in modulating the infectious pressure of *Lepeophtheirus salmonis*.

EFFECTS OF SEA LICE INFECTION AND ISAV ON ATLANTIC SALMON: HOST STRAIN DIFFERENCES

– Jennifer Covello, UPEI

Previous research has shown that sea lice infections can have immuno-suppressive effects on Atlantic salmon possibly leaving them more susceptible to secondary infections. Additionally, the mechanical damage the sea lice inflict on the protective layers of mucous and skin breach the primary barrier against infection, thus leaving the salmon more exposed to secondary pathogens. Working with Sarah Barker and others, and using the same study design, this work was conducted to compare the responses of two strains of Atlantic salmon – Saint John River and Penobscot – to infection with sea lice and/or ISAv.

Three treatment groups of 130g Atlantic salmon smolts were sampled over a time series. The three treatment groups comprised: 1) uninfected controls *i.e.* sham lice and sham ISAV challenge, 2) sham lice challenge followed by ISAV challenge, and 3) lice challenge followed by ISAV challenge. All salmon were housed in 3 identical saltwater recirculation systems at UMaine, Orono campus. Each system possessed duplicate tanks per treatment, resulting in 6 replicate tanks per treatment group in total. The salmon were presented with a true or mock sea lice challenge via a bath exposure to the infective copepodid stage. Fish were subsequently challenged with a mock or true ISAV challenge via a cohabitation exposure. Fish from each treatment (~12 per strain) were sampled prior to ISAV challenge and then 3, 16, and 37 days post-ISAV exposure (n = 24 fish per treatment group per time point (6/tank).

Head kidney was sampled from each of the salmon and quantitative Polymerase Chain Reaction (qPCR) was used to analyze the cDNA for differences in the level of gene expression in four specific genes – two related to the immune response to sea lice (IL-1β and MMP 9) and two related to the response to ISAv (MX 1 and MHC-1). Based on qPCR results for the sea lice related genes, the Penobscot strain appeared to have a slight advantage over the Saint John River strain in that the Penobscot fish had a more rapid and pronounced increase in inflammatory markers and also a more pronounced wound healing response. The qPRC results were mixed for the genes related to the immune response to ISAv, with the Saint John River stain showing increased MX 1 expression, and no stock-specific difference for MHC-1 expression. It is unclear whether the increase in MX 1 expression in the St John River stock offers any type of protection against ISAv. Previous work has shown that MX 1 is not indicative of ISAv protection. It may be that the St John River salmon are having their immune response shunted down an inappropriate viral response pathway, thus leaving them more susceptible to ISAv. Further work is being conducted to determine whether or not strain differences occur with respect to appropriate ISAv responses.

<u>Jennifer Covello</u>
Jennifer began her post-doc in the Hoplite lab in May of 2010 with her main area of interest is host-parasite interactions, with current research focusing on Atlantic salmon (*Salmo salar*) and sea lice (*Lepeophtheirus salmonis*). Prior to joining the Hoplite lab, she earned her PhD from the University of Tasmania, Australia in 2010, MSc from the University of Stirling, Scotland in 2002, and BSc Hon from Dalhousie University. Her honours research involved looking at the host response to sea lice, particularly the differences between Coho and Atlantic salmon. Her work recently, concentrating on the use of in-feed immune stimulants to boost the response of Atlantic salmon to sea lice, in an effort to reduce the number of lice that successfully settle.

MUSSELS AND MECHANICAL TRAPS FOR SEA LICE - REPORT YEAR 3
– Shawn Robinson, DFO - SABS

Terrestrial farmers use a number of predators and parasites as alternatives to pesticides for plant and animal crops. In many situations these alternatives use a combination of mechanical and biological controls for the organism of concern. Biological controls include the use of lady bugs, a mite predator, and wasps. Examples of mechanical controls are lures (light and/or pheromones) and various traps that may be purchased for pests such as slugs and mosquitoes. To aid fish farmers in controlling sea lice, a parasite of salmon, similar approaches based on the same principles are being evaluated by DFO and industry partners.

As a biological control, mussels and other shellfish are being evaluated as predators of sea lice larval stages since shellfish can naturally occur on the farm or they can be intentionally placed on a site as a component of an integrated multi-trophic aquaculture operation. Lab trials have shown that several shellfish species including mussels and scallops can eat sea lice larvae but further work will have to be done to assess effectiveness in the field.

There have been some projects that have looked at light traps to attract sea lice larvae. Typically the traps used white light which attracted many other pelagic species including sea lice. The trap, if not regularly cleaned, eventually become overwhelmed with the organisms they attracted. Preliminary work done to refine this type of trap has tried to identify the specific part of the light spectrum that would attract sea lice and minimally other zooplankton. Prototype traps deployed at cages sites have survived well under the normal weather conditions of summer and winter. Samples are still being analyzed, but it is obvious the traps need to be made more selective.

To assess the number of sea lice larvae in the area, a field survey of 51 samples were taken over 6 sites around the Bay of Fundy to attempt to quantify the number found on salmon farms compared to reference stations. While no sea lice larvae were found at any of the reference sites, active farms sites surveyed had an average of 0.0061 larvae per liter of water filtered. This is a very low density in comparison to the other so plankton present.

We are also looking at the early life history ecology of the species in order to try and understand the natural infection model for sea lice. It is possible the natural traits that have evolved in sea lice to increase their success of reproduction with natural salmon populations are acting to create the outbreaks on salmon farms. By understanding these early life history dynamics, it may be possible to break the cycle at some point. Early observations are indicating that egg strings can hatch on benthic sediments with or without the female and that the swimming abilities of the early larvae are quite impressive. Swimming trials indicate that with a light attractant, sea lice larvae can swim about 1.8mm/second. This would mean it would take 2-3 hours to swim 20m. Information like this will help develop infection models.

Shawn Robinson
Dr. Shawn Robinson has been working for the last 18 years as a research scientist with the Dept. Fisheries and Oceans at the Biological Station in St. Andrews, New Brunswick. He is also an adjunct professor at the University of New Brunswick and the Nova Scotia Agricultural College and is actively engaged in applied ecological research on marine shellfish species such as blue mussels, sea scallops, sea urchins and soft-shell clams. His research team is studying the natural processes by which these animals interact and utilise their environment so that better and more sustainable culture techniques can be developed. One example of this research is the study of an integrated multi-trophic aquaculture (IMTA) project (sometimes known as polyculture) where shellfish are grown in conjunction with other species to produce a more sustainable and productive system. Much of this work involves collaborative projects with industry and academic partners and takes a more holistic view of the aquaculture system combining biology, physics, economics, sociology, and government policy.

THERE'S SOMETHING ABOUT LUMPSUCKERS – KNOWLEDGE FROM INITIAL TRIALS IN NORWAY

- Nils Fredrik Vestvik, Aqua Kompetanse

As wrasse have been the cleaner fish of choice to date in countries like Norway to reduce sea lice treatments, the presentation began with a discussion of advantages of using lumpsuckers (lumpfish) as cleaner fish. The advantages can include faster growth, greater temperature range tolerance – especially low water temperature, and natural occurrence / growth in salmon cages. Currently only broodfish are caught for lumpsucker production which supports sustainability, although there is still a question around the ability to domesticate this fish.

Data presented showed that lumpsuckers of 5-6 cm could be produced within 4 to 5 months and placed into smolt cages, whereas it takes 1.5 years to produce a wrasse of appropriate size. The need to produce multiple species / sizes of wrasse to be used with various sizes of salmon adds to the advantage of using lumpsuckers as biological control agents. The challenge of rearing lumpsuckers; however, includes the need for strict hygiene, proper tank area / design / dynamics, and need for shelters. While larval mortality is generally very low (3-5%), vibriosis can be a problem. Trials are being conducted using a trout vaccine as a possible solution; the first group of vaccinated fish was put in the sea this November.

Controlled lab trials have shown that lumpsuckers do eat sea lice from salmon. At a ratio of two lumpsucker per salmon, and an initial lice count of ten lice per salmon, there was a 70%-90% reduction in lice within 24 hours. It was acknowledged that this ratio of lumpsuckers to salmon would not be used in the field and therefore reduction in lice numbers would need to be evaluated in the field setting. The video presented can be seen at - http://www.namdalakvasenter.no/?side=97&nyhet=269

Initial filed trial results from three marine sites have not shown any difference in lice numbers between pens using lumpsuckers and pens with wrasse. While dissections have indicated that only a few of the lumpsuckers had actually eaten sea lice (2 of 10) in some cases, some individuals had eaten approximately 150 lice. It was noted that sea lice decompose in the digestive track of the lumpsucker within a couple of hours; therefore, the number of fish actually eating sea lice could be underestimated. Lice have been found in the stomach of lumpsuckers both in summer and winter. Challenges with recovering / recording mortality of the very small lumpsuckers and maintaining the required ratio can be a challenge so ensuring appropriate net mesh size is used and that nets, shelters and ropes are free of biofouling organisms are important.

Going forward better control at the hatcheries for the factors indicated previously should lead to increased survival and more predictable production, ensuring there are enough lumpsuckers available for effective use of as a cleaner fish. Fieldwork work continues to determine percentage of cleaner fish required and prove effectiveness. A national survey of cause of death, infection studies and investigation into new vaccine candidates is also being planned.

See Attached Presentation

Nils Fredrik Vestvik
Nils completed a Master of Science in Aquatic Medicine from the University of Bergen in 2011, working on the immune system of cod. He is currently working as a trainee for the companies, Aqua kompetanse, Bjørøya fiskeoppdrett, Marine Harvest and Salmar in Flatanger, Norway. His main responsibility is the combat against sea lice, and especially concerning biological measures. Since October 2011 Nils has been working with lumpsucker as an alternative for traditionally used wrasses. He works mainly in the field, but in close relations to the land rearing facilities and research institutes. He has participated on an article likely to be published late October on the unspecific immune system of lumpsucker.

PARAMOVE® IN EUROPE: EGG VIABILITY RESEARCH & FUTURE RESEARCH & DEVELOPMENT

- Ian Armstrong, Aqua Pharma

In displaying a picture of salmon in a well during an Interox Paramove treatment the questions were asked – why are there some lice still on the fish and what is happening to those lice that have come off? To begin answering the second question the results of in field work on eggstring viability post treatment with PARAMOVE® were discussed.

In 2011 Aqua Pharma and Solvay worked with Norwegian School of Veterinary Science, VESO Vikan (Aquamedical contract research facility), and the Marine Lab Solbergstrand on a pilot study to ensure compliance with GCP standards. A cage with Atlantic salmon (1.2 kg) was treated with 1500 mg/l PARAMOVE® in for 30 minutes including dose time. Salmon lice were collected post treatment with a net during flushing, egg strings carefully removed and transferred to a transport flask with clean sea water from the site. Control egg strings were collected from anesthetized fish from the same cage immediately before treatment but difficulties were encountered in obtaining sufficient controls to comply with the GCP protocol. In the control group, all egg strings hatched and the nauplii developed to copepodids with an average 57 copepodids produced per egg string. In the PARAMOVE® treated group the unpigmented egg strings did not hatch. The pigmented egg strings hatched to some degree, with an average number of 8 nauplii per egg string. None of these nauplii developed into copepodites. It was noted that these results are in line with earlier laboratory studies by McAndrew et al. 1998.

A larger study was conducted during the strategic Spring treatment in April 2012 and followed the same basic research design. This study confirmed the findings of the pilot study , but was supported by a better data set, this time with the control group robust enough to meet the required GCP standards. Publication of the study results by Stian M. Aaen of the Norwegian School of Veterinary Science in Oslo will be available in early 2013 in a peer reviewed scientific publication.

As part of Armstrong's review of future work planned, a project with lice filtration on well boats was described. An Ocea Aquafilter Optimise will be fitted on a Norwegian well boat working in Scotland. This two stage lice filter is designed to remove all particles through a 150 micron filter in the first stage followed by a 90 micron filter in the second stage. A price tag of $700k including pipe work installation was quoted for this system and initial results will be available in Spring 2013. Development work has also begun on a new tarpaulin system design to enable farmers to treat more cages per day than is possible using wellboats.

<u>Ian Armstrong</u>
Ian has worked in the Atlantic salmon farming industry since 1982 since graduating from the University of Edinburgh, and for the first 12 years he held various farming management positions with Marine Harvest in Scotland & in Chile. He then became Processing Manager for Marine Harvest & Scottish Sea Farms (SSF) for the next 8 years, before becoming an independent consultant in 2002 and helping to successfully develop the Closed Valve Harvesting concept along with Sølvtrans. Aqua Pharma Inc, a company which was formed in June 2010 to help deliver specialist solutions to our North American salmon farming clients. It is an Aquatic Group company, Aquatic being a leading Norwegian specialist service provider to various parts of the food industry.

DENATURATION OF SALMON SEA LICE THERAPEUTANTS FROM WELL BOAT TREATED SEAWATER

- Leo Cheung, Research and Productivity Council (RPC)

Chemical treatment of wastewaters to remove pesticides from agriculture and industrial processes, and for drinking water has been done for many years. It was based on this history that RPC research has focused on investigating the possibility of using this same process to denature the active ingredients in topical sea lice treatment products. Initial work on this project was completed with the Department of Agriculture, Aquaculture and Fisheries (DAAF) and the Department of Fisheries and Oceans (DFO) evaluating the potential of ozone, hydrogen peroxide, and Fenton's Reagent for use in this process. Though ozone (O3) was an effective denaturing agent above 2ppm, fish are sensitive to O3 level above 0.005ppm and so further work was discontinued.

General bench scale procedures and initial results were presented for each of the compounds evaluated to denature Alpha Max (deltamethrin) and Salmosan (azamethiphos). The work to denature deltamethrin with hydrogen peroxide indicated a 72% reduction using a dosage of 1500ppm, while the various Fenton's Reagents tested provided between and 57% and 78% reduction in deltamethrin. When ferrous sulfate was used as the iron compound of the Fenton's Reagent, an insoluble iron oxide precipitate was formed which absorbed an additional 21% of the deltamethrin, resulting in a total removal of 96% of the deltamethrin. This was followed by a degradation test in which ten times the prescribed concentration of deltamethrin (20ppb) was denatured with Fenton's Reagent (1000ppm H_2O_2/10ppm Fe^{2+}) for 30 minutes, and the resulting seawater was sampled over 14 days to measurement degradation of deltamethrin. Results showed that 92.0% of the deltamethrin was denatured, 5.7% was absorbed by the iron oxide precipitate for a total of 97.7% deltamethrin denatured / removed. During the fourteen day monitoring of the post-denaturing seawater, one per cent of the deltamethrin was released within one day and the remaining 20% of deltamethrin adsorbed by the precipitate was degraded in 7 – 10 days. Deltamethrin remained bound to the iron oxide by-product and did not release back into the seawater. A dioxin analysis was performed using high resolution mass spectrometry and provided no evidence for production of dioxin by the destructive oxidation of deltamethrin in sea water. Gas Chromatography/Mass Selective Detection (GCMS) was also used for denatured product characterization and results indicate that no harmful denature by-products are created by the process.

Similar tests have been performed to denature azamethiphos and characterize the by-products. Hydrogen peroxide alone (1500ppm) denatured 78% of the azamethiphos; various Fenton's Reagents did not improve removal, even with absorption included. GCMS testing of the treated sea water (150ppb Azamethiphos, 1500ppm H2O2) indicate no harmful by-products were created in the denaturing process.

Work continues to assess other options and to complete the final lab work required to support potential field trials.

See Attached Presentation

Leo Cheung

Leo Cheung is the manger of the Process Engineering group of the Process Environmental Technology department at RPC. He has over 22 years of experience on numerous process and development projects serving clients in the food, oil, pulp and paper, chemical and mining sectors on a worldwide basis. Project experience and expertise over the years has involved the successful development and commercialization of a number of process technologies. He holds a B.Sc. Degree in Chemical Engineering from the University of New Brunswick. He is a registered professional engineer and a member of the Association of Professional Engineers and Geoscientists of New Brunswick.

SEA LICE: UPDATE ON NB INDUSTRY TRENDS AND COMPARISONS

-Larry Hammell, Atlantic Veterinary College (AVC)

Hammell's presentation was based on data within the Decision Support System (DSS). This system contains sea ice monitoring and treatment information reported by industry and evaluated for precision by experienced third-party counters (AVC personnel). Data presented indicated the number of sites reporting each week affected by submission of data and fluctuations based on harvesting, stocking and seasonal changes in active sites. Since its inception in late 2009, use of the DSS has improved which now supports more thorough comparative analyses. In addition, improved sea lice monitoring reflects the sea lice training program for site counters. To date 138 individuals have attended the sea lice training and certification program provided by AVC. Counting of adult female, and pre-adult (male and female) and adult male lice by site personnel was on par with AVC counts, although there may be inconsistencies (under-estimation by sites) in counting of chalimus. Data also indicates that sea lice patterns have changed over the last three years. Although likely not important to the salmon due to the generally low numbers, an interesting difference in 2012 was the substantially higher number of *Caligus* per fish reported through the summer. In a yearly comparison, the average number of the chalimus life stage per fish in 2012 was higher than in 2011, but both years were lower than 2010. Within the 2012 data, it is apparent those sea lice counts differ by bay management area (BMA) likely reflecting different control success and the location of market sized fish. Average number of pre-adult / adult males (PA/AM) per fish over the last three years also fluctuates with the highest numbers in 2010 and lowest in 2011. Sea lice abundance was also discussed in relation to the water temperatures recorded in the DSS over the last three years. In each year the highest temperatures were generally recorded around September 1st, with 2012 identified as the warmest.

In 2010 (year with most Salmosan treatments), there was approximately a 50% chance of a successful treatment (defined as >70% reduction of chalimus and PA/AM) with Salmosan, while in the few treatments in 2011 this probability increased to 100% for PA/AM. For Interox Paramove treatments since 2011, the probability of greater than 70% reduction in chalimus was 24%, 61% for PA/AM, and 74% for AF lice. It was noted that the timing of post treatment counts affects the interpretation of percentage reduction calculations since increased efficacy was observed for post counts occurring within the first seven days.

See Attached Presentation

Larry Hammell

Larry Hammell, DVM, MSc (Epidemiology), is Director of the AVC Centre for Aquatic Health Sciences and Professor in the Department of Health Management, Atlantic Veterinary College, UPEI. Dr. Hammell has been a faculty member in the Department of Health Management at AVC since 1992 and was Coordinator of Fish Health at AVC from 1996 to 2002. As a specialist in finfish health management, Dr. Hammell has a particular interest in applying epidemiology research tools to evidence-based management of aquaculture health issues, and has taught and worked with veterinarians and farmers in many parts of the world, including both coasts of Canada, Chile, Australia, Thailand, and the United States. As an epidemiologist, Dr. Hammell carries out both applied and clinical research in aquatic food production settings, including risk factor studies, clinical field trials, and the development and evaluation of surveillance programs.

Thursday, November 15, 2012

CANADIAN AQUACULTURE ORGANIC STANDARD

– Ruth Salmon for Justin Henry, Target Marine Hatcheries Ltd., Northern Divine Caviar

Currently the North American marketplace has not had organic seafood because to date there has not been an agreed-upon national organic standard. Key factors in the development of organic standards for aquaculture were the need to meet growing demand for organic food, to compliment other organic standards, facilitate trade and overcome trade barriers, and manage importation from other jurisdictions. Information presented from the Canadian Organic Trade Association (2012) showed that the Canadian organic consumer market increased by 160% from 2006 – 2010, Canada is now the 5th largest organic market worldwide, and that US and EU organic equivalency agreements give Canada access to 96% of the global organic market ($59 billion), making this market an opportunity for our seafood growers.

Since 2002 a variety of groups have been involved in the development of standards, but standards either were never certified or did not include aquaculture. In October 2010 a 40 member Canadian General Standards Board Committee (CGSB) was struck to develop an aquaculture standard and by April 2011 a draft was made available for second public comment.

In October 2011 the CGSB committee voted to approve the standard and following changes in January 2012, the standard was released in April 2012. The Canadian Organic Aquaculture Standard was developed for equivalency with the Canadian Agriculture and EU Aquaculture standards, with the exception that the EU standard does not allow the use of recirculation systems. The same general principles for organic certification - protecting the environment, maintaining long term biological stability, recycling materials and resources, providing attentive care to the animals, and maintaining the organic integrity of the products are all covered within the aquaculture standard.

The scope of the Canadian Organic Aquaculture Standard includes the production of the animals / plants, the feed used in their production, the processed products for use as human or animal food, and prohibited substances, methods, and ingredients. The section on animal aquaculture covers topics such as water quality and environment, animal species and origin, antifouling measures and cleaning, reproduction, and health and welfare. The seaweeds and aquatic plant aquaculture section covers topics such as sustainable harvesting, cultivation conditions, and the cleaning of equipment and facilities. The standard also requires the grower to have a detailed “organic plan” with all management practices described, documentation required, and how traceability and parallel production / buffer zones are to be addressed.

Although there are no seafood products currently organically certified in Canada, applications have been submitted, and certifying bodies are in the process of obtaining clarification from CGSB.

See Attached Presentation

Justin Henry

Justin Henry began studying aquaculture at UBC and furthered his studies in aquaculture biotechnology at Aalborg University in Denmark. He is currently the general manager of Target Marine Hatcheries, an aquaculture company in British Columbia producing coho salmon broodstock and white sturgeon caviar. Justin chaired the Canadian General Standards Board committee to develop the Canadian Organic Aquaculture Standard which was released in the spring of 2012. Justin also chairs the Land Based Aquaculture Association of Western Canada.

FEED BLOWER NOISE REDUCTION

– Randy Griffin, Cooke Aquaculture

A noise reduction project by initiated by Cooke Aquaculture had three objectives: the reduction of noise levels generated by feed blowers, improve health and safety for farm personnel, and reduce environmental impact for neighbors. Since the aquaculture industry moved from feeding salmon with shovels to using blowers, noise has been a concern for industry and some upland property owners. While feed blowers have evolved over time with reduced RPMs and therefore reduced noise, the level of noise from blowers can be above acceptable ranges.

Working with existing blowers the first effort to reduce noise resulted in the relocation of the blower unit under the boat deck and the installation of an eight foot inlet silencer. With these changes the recorded noise on the vessel level dropped from 75 dB to 61 dB, and 500 feet away from 62 dB to 48 dB. While this drop in recorded noise level was significant logistical issues with the length of the silencer and the space required in the location made these changes impractical for normal operations and/or for many vessels.

A second trial resulted in the inclusion of a muffler system on the blower with inlet and outlet silencer having a much smaller footprint. This new prototype was tested at a marine cage site in Campobello where there are a number upland neighbors located close by. The overall noise level recoded (ambient+ boat +blower) was reduced by 10%, with a 23% reduction in noise from the blowers specifically. Feedback from local land-owners has been positive.

See Attached Presentation

Randy Griffin

Randy Griffin is Cooke Aquaculture's Manager, New Brunswick Saltwater Operations. He grew up on Grand Manan, NB and spent most of his working career in the marine environment, both in the fishery and the aquaculture industry. He has served many different roles in Cooke Aquaculture's Saltwater Division and now manages Cooke's New Brunswick Saltwater Farming side of the business. Randy's hands-on, practical experience as well his leadership in the development of new and improved technologies has led to many innovations in the company.

ARIES - AQUACULTURE REAL-TIME ENVIRONMENTAL SYSTEM

– Tom McKeever, Marine Institute

The SmartBay Project in Placentia Bay, Newfoundland (www.smartbay.ca) is an ocean observation system designed and implemented for shipboard users (transport, fishing) to improve vessel safety and situational awareness in the bay. Buoys deployed as part of SmartBay provide meteorological and oceanographic data – water temperature, wind speed / direction, wave height etc. Special options to generate general weather synopsis (4 times per day), high resolution forecasts for areas of interest , and predictions of conditions such as wind, waves, air, sea temperature, precipitation, icing potential are also included.

The aquaculture industry has many of the same basic information requirements, which lead to the development of the Aquaculture Real-time Integrated Environmental System (ARIES) demonstration project in 2012, a partnership of the Newfoundland Aquaculture Industry Association and the Marine

Institute of Memorial University. Industry requirements were defined; equipment was selected and purchased with testing and deployment beginning in September 2012. Three salmon farming companies are participating in the project, with site data collected continuously and transmitted automatically every 15 minutes (adjustable) to the ARIES server at the Marine Institute. Company personnel access site information through a restricted webpage (www.ariesaqua.com). Here they can access real-time water data including dissolved oxygen, salinity and temperature at 3 site specific depths and meteorological data - wind speed / direction, air temperature, air pressure in various formats. Farmers can also set parameter alarm levels within the program and receive an email when level is exceeded.

The ARIES Sensor String, currently comprised of optical oxygen sensors (Optodes), conductivity sensors and temperature probes at three depths is deployed within a cage or off a barge. The cage collar or barge is where the cell antennas, data logger, wireless communications module, meteorological module, batteries and solar panels are installed.

After several months of operation there seems to be agreement that ARIES data is accessible, accurate and reliable; it has already provided some interesting data to the growers. Challenges with weak cell communications at one site required additional investigation into other options that resulted in the installation of a satellite communication system at this site.

Funding from the Newfoundland and Labrador Department of Innovation, Business and Rural Development (IBRD) and ACOA was secured to initiate the project, and additional funds are being sought to allow the ARIES systems and web portal to be maintained for one year. Depending on the level of additional funding secured, the project partners also plan to pursue the addition of still image capture (surface and cage), and other sensors such as acoustic doppler current profilers, and tide gauge and/or current meters with all equipment to be integrated with existing ARIES equipment and web portal.

Future proposed developments include the design of a custom data-logger for aquaculture, integration of additional sensors and expansion to additional sites in the Coast of Bays. In the future SmartBay buoys and weather forecasting for the Coast of Bays' aquaculture industry, and possible applications of vessel Automated Identification System (AIS), may also be developed for safety, detailed weather forecasting and biosecurity management.

See Attached Presentation

Tom McKeever

Thomas McKeever, an Instructor/ Researcher with the Centre for Aquaculture and Seafood Development (CASD), possesses over 24 years of experience in applied research & development, industrial assistance, technical project management, business development and advanced education delivery in the aquaculture, fisheries and ocean/offshore technology sectors. His specialties include team management, finfish aquaculture operations, sensor product design & development, field operations/logistics management, health and safety management, offshore operations, and international development, marketing/sales. Thomas is a graduate of Memorial University and the Marine Institute of Memorial University where he completed a Bachelor of Science in 1986, an Advanced Diploma in Aquaculture in 1989, a Master of Science (with distinction – Fellow of Graduate Studies for outstanding research) in Aquaculture in 1998, and a Masters Certificate in Project Management in 2011.

MOVING THE RESEARCH AGENDA FORWARD; IDENTIFYING 2013 RESEARCH PRIORITIES

A facilitated review ongoing knowledge gaps and discussion of potential research projects for 2013 was conducted. Several areas of focus emerged and included:

- Sea Lice Research – this area included discussion on ongoing work in the area of novel treatments such as lice traps, cleaner fish, other potential biological controls, broodstock programs, etc.
- Support for Canadian registrations / licensing of new fish health medicines – this would include the development of Minor Use Minor Species (MUMS) program to assist pharmaceutical companies in registering products for aquaculture in Canada and the authorization for new feed ingredients to support anti-attachment products, immunostimulants, etc. for functional feed development
- Evaluation of new technologies to improve sea lice bath treatments and /or reduce potential environmental impact
- Environmental research to better understand marine and sea lice dynamics,
- Emergency preparedness SOPs to support viral management
- Ongoing review and enhancement of current best management practices for on-farm operations

RESEARCH CONNECTOR EVENT FOR INDUSTRY AND UNIVERSITY RESEARCHERS

This program was intended to connect the aquaculture industry with researchers from the university / academic to support improved research collaborations. This event was made possible through NSCERC. In the past, federal and provincial regulators (DFO and NB Department of Agriculture, Aquaculture and Fisheries) have been primary collaborators in aquaculture research. However, both industry and academia can benefit from increased collaborations in addition to increasing R&D capacity.

Presentations made by a representatives from a variety of universities and faculties provided an overview of the range of research capacity, priorities and existing research projects that could be beneficial to salmon farming industry to help build research capacity. This session also enabled academic researchers to understand the various priorities of the industry.

Summary information is provided below and presentations are attached to this document, if permitted.

University: Acadia University
Researcher: Anthony Tong, PhD
anthony.tong@acadiau.ca
Area of research: Wastewater treatment and reuse using membrane bioreactor

Summary: Dr. Tong is actively pursuing advancements and applications of this technology. Areas of hatchery and processing wastewater, nutrient removal (nitrate, phosphate, ammonium, etc.), organic and blood removal, and water quality analysis and customized design were identified.

University: Acadia University
Researcher: Brian C. Wilson PhD, Weston Animal Care Centre, Dept. Of Biology
brian.wilson@acadiau.ca
Area of research: Interests in connecting stress pheromonal research with industrial applications; assessing fish behavioural and physiological changes to stress.

University: Marine Institute of Memorial University
Researcher: Cyr Couturier / Center for Aquaculture and Seafood Development
Cyr.Couturier@mi.mun.ca

Area of research: Site & performance evaluation, fish/shellfish culture, water recirculation / treatment, fish health & nutrition, diet development & feed formulation, design and development of live holding systems, Waste utilization and value addition, Fisheries – aquaculture interactions

Summary: The Aquaculture Research Facility includes: fresh and salt water recirculation systems, histopathology, bacteriology and necropsy labs, and flow through fresh water quarantine facility.
The Marine Institute also has a federally registered seafood processing pilot plant, the Fisheries and Aquaculture Marine Bioprocessing Facility, and Dr. Joe Brown Aquatic Research Building (Ocean Sciences Center). Recent research projects are presented.

University: University of New Brunswick
Researcher: Chris Martyniuk, Science Director of the Environmental Toxicogenomics Facility
cmartyn@unb.ca
Area of research: Research focus on the molecular and physiological impacts of endocrine disrupting chemicals found in aquatic environments; gene expression profiling (microarrays) and environmental proteomics used to assess impact on fish populations

Summary: Key words for Molecular Reproductive Toxicology lab are genomics, environmental impacts, fish, reproductive physiology, water protection, aquatic toxicology, protein biotechnology, bioinformatics, toxicity testing, bioassays

University: Memorial University
Researcher: Kurt Gamperl, Dept. of Ocean Sciences
kgamperl@mun.ca
Area of research: Fish health evaluations / toxicology, improving fish health treatment efficacy, biological control of sea lice, immunostimulant evaluation, feed development / testing, new technology (diagnostic tools) to support fish health / farm management

Summary: A list of ongoing projects at the Ocean Sciences Centre was provided as well as a description of the capabilities and infrastructure at the OSC and Dr. Joe Brown Aquatic Research Building (JBARB). Members of the aquaculture research team were identified along with their areas of research. Other areas of specialization identified were: environmental interactions / sustainability, optimization of culture conditions / determination of limits, product quality / nutritional value, and broodstock development / family rearing programs.

University: University of New Brunswick
Researcher: Michel Couturier, PhD, P.Eng., Dept. of Chemical Engineering
cout@unb.ca
Area of research: design engineering – recirculating aquaculture system components (RAS), effluent treatment systems, rearing tanks

Summary: Dr. Couturier, as NSERC Chair in Design Engineering and NSERC-UNB Chair for Collaborative Engineering Design Education, presented a list of previous projects and the opportunity for aquaculture industry to become involved with students in a design project which would provide two innovative solutions to the identified problem and the opportunity to evaluate future graduate engineers.

University: Nova Scotia Community College
Researcher: Nathan Crowe, Applied Geomatics Research Group
nathan.crowell@nscc.ca or Timothy.webster@nscc.ca
Area of research: Integrated water quality modelling using surface and environmental models

Summary: The surface model provides a topographical model of the bathymetry and land cover within an area and the environmental model captures weather information. Case studies identified how these models can be used in areas such as site selection for land based and marine sites, hydrodynamics in watersheds and estuaries, and transport modeling for particles / nutrients.

University: Memorial University
Researcher: Peter King
peter.king@mun.ca
Area of research: An Autonomous Underwater Vehicle developed specifically to meet needs and challenges of the aquaculture industry

Summary: The benefits of an AUV for efficient repeated data collection and safety etc were presented along with the potential to access the MERLIN lab. Partners from the aquaculture industry would be involved in commercialization of technology, support in-field demonstration, and have design input to ensure industry needs are met.

Group: Genome Atlantic
Researcher: Shelley King, VP Research & Business Development
sking@genomeatlantic.ca
Area of research: Genomics, bioinformatics

Summary: The aim of Genome Atlantic, collaborations and impacts to date and the plan for perusing future research work were discussed.

University: Memorial University
Researcher: Suzanne Dufour, Biology Department
sdufour@mun.ca
Area of research: Enriched sedimentary habitats

Summary: The two projects of main interest were described: organisms living in organically enriched sediments, i.e. near aquaculture sites; and novel approaches for studying how organisms modify sediments (CT scanning). There would be no financial contribution required for an industry partner for the pilot study but access to sites, background data, facilitation and access to specimens (grabs, divers) would be needed.

University: University of New Brunswick
Researcher: Thierry Chopin, Canadian Integrated Multi-Trophic Aquaculture Network (CIMTAN)
tchopin@unb.ca
Area of research: Integrated multi-trophic aquaculture (IMTA)

Summary: After working for many years on IMTA in the marine environment, Dr. Chopin is hoping to extend the IMTA concept to land-based, freshwater hatcheries (FIMTA). Both flow-through and recirculating facilities are being assessed to design the most appropriate FIMTA systems, based on water quality and flow, nutrient concentrations and bioavailability, temperature, light, space availability, plant candidates and economic viability.

Participants

November 14th and 15th Workshop

First Name	Last Name	Company
Matthew	Abbott	Fundy Baykeeper
Keng Pee	Ang	Cooke Aquaculture Inc
Ian	Armstrong	Aqua Pharma Inc
Steve	Backman	Skretting
Bev	Bacon	RDI Strategies Inc
Sarah	Barker	Aquaculture Research Institute
Jeff	Beardsall	Acadia University
Michael	Beattie	Dept of Agriculture, Aquaculture and Fisheries
Aaron	Bennett	Dept. Of Environment & Local Gov
Mairi	Best	Consultant
Clarence	Blanchard	Future Nets & Supplies
Brian	Bosien	Snow Island
Christy	Bourque	Mitchell McConnell
Peter	Bourque	Mitchell McConnell
Tim	Bowden	Aquaculture Research Institute
Kathy	Brewer-Dalton	Dept of Agriculture, Aquaculture and Fisheries
Bill	Brown	Admiral Fish Farms
Chuck	Brown	Cooke Aquaculture Inc
Glen	Brown	Admiral Fish Farms
Elvin	Bugge	Aqua Pharma Inc
Amy	Canan	Cooke Aquaculture Inc
Rod	Carney	NB Community College - Instructor
Leo	Cheung	Research and Productivity Council
Thierry	Chopin	University of New Brunswick, CIMTAN
Kathy	Cleghorn	Dept of Agriculture, Aquaculture and Fisheries
Jeff	Cline	Fisheries and Oceans Canada
Jason	Collins	Fish Vet Group
Dave	Cook	SimCorp
Sarah	Cook	Skretting
Karen	Coombs	Dept of Agriculture, Aquaculture and Fisheries
Cyr	Couturier	Marine Institute of Memorial University
Michel	Couturier	University of New Brunswick
Jennifer	Covello	Atlantic Veterinary College, UPEI
Nathan	Crowell	NSCC - Applied Geomatics Research Group

Paula	Currie	Cooke Aquaculture Inc
Hart	Devitt	University of New Brunswick
Tom	Dick	Northern Harvest Sea Farms
Alan	Donkin	Northeast Nutrition Inc
Terry	Drost	Four Links Marketing
Suzanne	Dufour	Memorial University
Stacy	Fielding	Cooke Aquaculture Inc
Kathleen	Frish	Mainstream Canada
Karla	Furey	Canadian Food Inspection Agency
Kurt	Gamperl	Memorial University
Amber	Garber	Huntsman Marine Science Centre
Sheldon	George	Cooke Aquaculture Inc
Brian	Glebe	Fisheries and Oceans Canada
Danielle	Goodfellow	Aquaculture Association of NS
Caroline	Graham	NB Community College - Instructor
Randy	Griffin	Cooke Aquaculture Inc
Nell	Halse	Cooke Aquaculture Inc
Larry	Hammell	Atlantic Veterinary College, UPEI
Jim	Hanley	ACFFA
Chris	Hendry	DFO Newfoundland
Murray	Hill	ACFFA
James	Hoare	Fish Vet Group
Jason	Holmes	Northeast Nutrition Inc
Shane	Hood	Canadian Food Inspection Agency
Betty	House	ACFFA
Lynn	Hutchin	Dept of Agriculture, Aquaculture and Fisheries
Tim	Jackson	NRC-IRAP
Travers	Jones	NB Community College - Student
Kathy	Kaufield	ACFFA
Mark	Kesselring	Northern Harvest Sea Farms
Peter	King	Memorial University
Shelley	King	Memorial University
Ted	Kuchnicki	Health Canada PMRA
Christena	LaBillois	NB Community College - Student
Johannes	Larsen	NRC-IRAP
Cory	Leavitt	Dept of Agriculture, Aquaculture and Fisheries
Emery	Leger	Canadian Food Inspection Agency
Andreas	Lindhom	Norsk Oppdrett Service

Rob	Little	Northern Harvest Sea Farm
Joe	Lund	Atlantic Veterinary College, UPEI
Troy	Lyons	Dept of Environment & Local Government
Linda	MacDonald	Atlantic Canada Opportunities Agency
Allison	MacKinnon	Novartis Animal Health
JR	McCarthy	NB Community College - Student
Doni	McGee	ACFFA
Jason	McGrattan	Novartis Animal Health
Stan	McGrattan	Cooke Aquaculture Inc
Thomas	McKeever	Marine Institute of Memorial University
Alastair	McNeillie	Solvay Chemicals
Tim	McQuaid	Canadian Food Inspection Agency
Selcuk	Metin	NB Community College - Student
Pat	Mowatt	Dept of Agriculture, Aquaculture and Fisheries
Stephanie	Nauss	NB Community College - Student
Matthew	Ness	Research and Productivity Council
Jeff	Nickerson	Cooke Aquaculture Inc
Thomas	Ogilvie	Dept of Agriculture, Aquaculture and Fisheries
Wole	Oguntona	Canadian Food Inspection Agency
John	O'Halloran	Aqua Vet Services
Rodney	O'Neil	Cooke Aquaculture Inc
Pamela	Parker	ACFFA
Jay	Parsons	Fisheries and Oceans Canada
Bronwyn	Pavey	Parks Canada
Hernan	Pizarro	Fish Vet Group
Joanne	Power	Fisheries and Oceans Canada
Danielle	Quinn	Acadia University
Ken	Robertson	DSM Dyneema
Lori	Robinson	Atlantic Canada Opportunities Agency
Shawn	Robinson	Fisheries and Oceans Canada
Allie	Rose	NB Community College - Student
Michael	Rouse	Enterprise Charlotte
Gail	Ryan	Aquaculture Association of Canada
Fernando	Salazar	Atlantic Policy Congress of First Nations Chiefs
Ruth	Salmon	Canadian Aquaculture Industry Alliance
Kehar	Singh	Atlantic Veterinary College, UPEI
Amanda	Smith	SimCorp
Arianna	Smith	NB Community College - Student

Jamie	Smith	Fisheries and Oceans Canada
Sybil	Smith	ACFFA
Trevor	Stanley	Skretting
Nils	Steine	Pharmaq
Don	Stevens	University of Prince Edward Island
Roy	Strom	Aqua Pharma Inc
Bob	Sweeney	SimCorp
Michael	Szemerda	Cooke Aquaculture Inc
Stephanie	Taylor	Admiral Fish Farms
Tom	Taylor	Northeast Nutrition Inc
Bruce	Thorpe	Dept of Agriculture, Aquaculture and Fisheries
Anthony	Tong	Acadia University
Michael	Trenholm	Canadian Food Inspection Agency
Edward	Trippel	Fisheries and Oceans Canada
Nils Fredrik	Vestvik	Aqua Kompetanse
Scott	Walker	Atlantic Canada Opportunities Agency
Kimberly	Watson	Dept of Agriculture, Aquaculture and Fisheries
Jessica	Whitehead	SimCorp
Brian	Wilson	Acadia University
Laurie	Wright	Dept of Agriculture, Aquaculture and Fisheries

Fisheries and Oceans Canada / Pêches et Océans Canada

Fisheries and Oceans Canada (DFO)

Investing in Science and Aquaculture Research

Dr. Jay Parsons, Director, Aquaculture Science Branch

ACFFA Annual Meeting

13th November 2012

Canada

Overview

- Objectives
- Context
- Issues and Opportunities
- Investing in Aquaculture Research
- DFO Aquaculture Research Programs and Priorities
- Communications and Knowledge Mobilization

Objectives

- Provide context on Government of Canada transformation
- Offer an update on DFO's investment in aquaculture science
- Outline aquaculture research plans and priorities
- Encourage industry participation in collaborative research activities
- Discuss knowledge mobilization
  - Getting relevant science into the hands of those who can use it

Context

- Government of Canada Transformation
  - Responding to new fiscal realities and challenges
  - Re-alignment across federal departments/agencies
  - Introducing changes and efficiencies to better support core mandate
  - Improving services to Canadians
- Departmental Transformation
  - Improving how we operate, deploy resources, and manage our science and regulatory duties
- Science is the 'backbone' of the department
  - Foundation for decision-making
- Sustainable Aquaculture Development is an ongoing priority

Issues and Opportunities

- Aquaculture can help meet increasing global need for protein/food
  - Considerable growth potential for this industry in Canada
  - Improved regulatory efficiencies based on sound science can contribute to the sustainable development of aquaculture in Canada
- Cohen Commission
  - Government of Canada is reviewing the findings and recommendations carefully
  - DFO will continue to work with stakeholders and partners to identify and manage issues of concern related to the sustainability of aquaculture development in Canada
  - Clear role for science to help address some recommendations
- Sustainable Aquaculture Program (SAP)
  - Sunsetting program in March 2013

Aquaculture Science at Fisheries and Oceans Canada (DFO)

- Program for Sustainable Aquaculture (2000)
  - Aquaculture Collaborative Research and Development Program (ACRDP)
- Regulatory Science Program (2008)
  - Program for Aquaculture Regulatory Research (PARR)
- Other activities and initiatives
  - Peer Review and Advice (CSAS)
  - Workshops (PARR & ACRDP)
  - CIMTAN (NSERC-DFO Network on IMTA)
  - Environmental Risk Assessment Framework
  - International Science
    - Collaborations (e.g., Chile, Spain, Norway)
    - Organizations (e.g., PICES, ICES)
  - University Partnerships (e.g., ARCP)
  - Program Evaluations

Investing in Aquaculture Science

- Over the past 5 years (2008-2012), DFO has **invested over $24 Million** directly into aquaculture research under its two key research programs:
  - **PARR**
    - Research investment of **$7 M** in over 50 research projects
      - Additional $15 M invested in other regulatory science activities and capacity
  - **ACRDP**
    - Investment of **$17 M**
      - DFO in-kind, industry funds and in-kind collaborator investments are in addition to the $17 M

Program for Aquaculture Regulatory Research (PARR)

- *Internal* DFO research program
- Prioritized research to address regulatory knowledge gaps and management needs
  - supports ecosystem-based aquaculture regulation and decision-making
- Program users:
  - DFO: Aquaculture Regulators – Aquaculture Management Directorate, Aquaculture Operations, Habitat Management;
  - Other Departments and Agencies: *e.g.*, Health Canada's Pest Management Regulatory Agency; Environment Canada
  - Provinces
- PARR priorities are identified and reviewed annually in consultation with the program users

PARR Research Priorities

- Priority Research areas 2008-2012
  - Release of Organic Matter
  - Fish Pest and Pathogen Treatments and Management
  - Fish Health / Bay Management
  - Wild-Farmed Interactions
  - Carrying Capacity / Ecosystem Impacts
  - Habitat Impacts
  - Introductions and Transfers / Release of Fish

PARR Funded Research

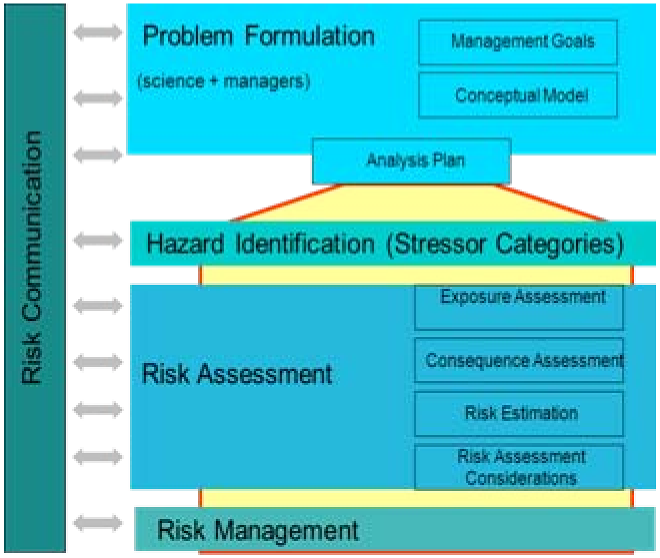
- Examples of PARR funded research
  - Oceanographic study of the south coast of Newfoundland
  - Zone of impact modeling for Lake Huron cage farms (freshwater research)
  - Carrying capacity for suspended shellfish culture (BC; Gulf)
  - Biological effects of anti-louse pesticides on non-target organisms (Maritimes, Pacific)
  - Transport and dispersal of sea lice chemical therapeutants in southwest New Brunswick (Maritimes)
  - Relationship between aquaculture and eelgrass coverage on a bay-wide scale (Gulf)

Science Advice

- Increasing demand for robust peer-reviewed science to inform decision making
- Formal advice is provided through the Canadian Science Advisory Secretariat (CSAS)
  - The ensuing advice is communicated through:
    - Science Advisory Reports (SARs) and Proceedings
    - Research Documents (Res. Docs.)
- Recent and ongoing CSAS processes:
  - Environmental impacts of SLICE (October 2011, Regional, Pacific)
  - Sea lice therapeutants (bath) in Bay of Fundy , Part 1 (November 2011, National, Internal)
  - By-catch (March 2012, National)
  - Sea lice monitoring (September 2012, National)
  - IMTA (October 2012, Regional St. Andrews, NB)
  - Salmon aquaculture effects on hard bottom (January 2013, Regional, NL)
  - Sea lice therapeutants , Part 2 (February 2013, National)
  - Effects of imports of European strain Atlantic salmon to NL (March 2013, National)

Aquaculture Risk Management Framework

- Increasing demand to provide science advice within the context of a risk-based approach
- Risk-specific advice ensures that management decisions and regulations are made in accordance with the associated level of risk. This will allow
  - Prioritization of effort and resources on highest risk rather than low risk activities
  - Establishment of appropriate mitigation measures for activities
- To develop risk analyses and provide advice in this format, Aquaculture Science has developed a Risk Assessment Framework for Aquaculture.



Canada

Aquaculture Collaborative Research and Development Program (ACRDP)

- Collaborative Research between DFO scientists, Industry, and other partners
- Funding - approximately $2 million/yr
- Focus of R&D:
  - Optimal Fish Health
  - Industry Environmental Performance

ACRDP – Successes in 2012

- National Coordination model
- National Steering Committee
- Technical Review Committee
- 14 new projects and 5 workshops funded
- 2012-13 ACRDP research funds fully committed
- Positive Program Evaluation (2012)

Industry participation in the ACRDP

Submitting research proposals:

- proposals to fund research projects and/or workshops must meet the broad research objectives of *optimal fish health* and *environmental performance* and also align with yearly research priorities
- annual call for proposals deadline is February 1
- workshop proposals are welcome at any time

Who can apply?

- any marine licensed aquaculture producer in Canada or group of producers, including industry associations
- other organizations (academia, feed producers) may partner with a producer on a project

Communicating Science

- DFO remains committed to providing access to publicly-funded science
- Some pro-active communications include:
  - DFO's Canadian Science Advisory Secretariat (CSAS) Reports
    - over 1,600 peer-reviewed science reports published over past five years.
  - Science Journal Publications
    - scientists working at DFO published more than 1,000 articles in science journals over the past five years
  - **Online Science Feature articles** for a general audience:
    - Regular features, with an archive of over 200 DFO science stories is online
- **Online subscription service** to automatically alert subscribers to the publication of our peer-reviewed science, the feature articles and other science reports.
- DFO contributes key content to the federal Science Portal: www.science.gc.ca
- Media Requests:
  - DFO responds to over 300 science-based media requests per year (e.g., 421 between Oct 2011 and Oct 2012).
  - All media inquiries handled with attention to detail and complexity but in a timely manner

Aquaculture Science Communications and Knowledge Mobilization

- ACRDP and PARR Research fact sheets
- Canadian Aquaculture R&D Review
- Primary Science Publications
- CSAS reports
- Aquaculture Websites
- Featured articles (Science outreach)
  - Regular articles in industry publications (ex. Aquaculture North America)
  - Online science feature stories
- Multimedia (videos, podcasts, etc.)

Communicating the science that supports decision-making and policy development

Looking to the Future

- Continued investment in science for sustainable aquaculture
- Maintain focus on sustainable aquaculture development
- Continued collaboration with industry
- Actively developing options for renewal of our aquaculture regulatory research program
- Increased efforts to communicate research activities and results

Thank you.
Questions?

Canadian Aquaculture: Seizing the Opportunities

Presentation to:
ACFFA
November 14, 2012

CANADIAN AQUACULTURE INDUSTRY ALLIANCE | ALLIANCE DE L'INDUSTRIE CANADIENNE DE L'AQUACULTURE

Farming Canadian Waters with Care

Who is CAIA?

World's Growing Population & Need for Protein

Over next 50 years:

- ✓ Population ↑ from 7-9 Billion
- ✓ Rising Incomes; Decreasing Poverty
- ✓ Explosion of Food Demand

Food Shortages

Increase in Protein over last decade

What Role Can the Oceans Play?

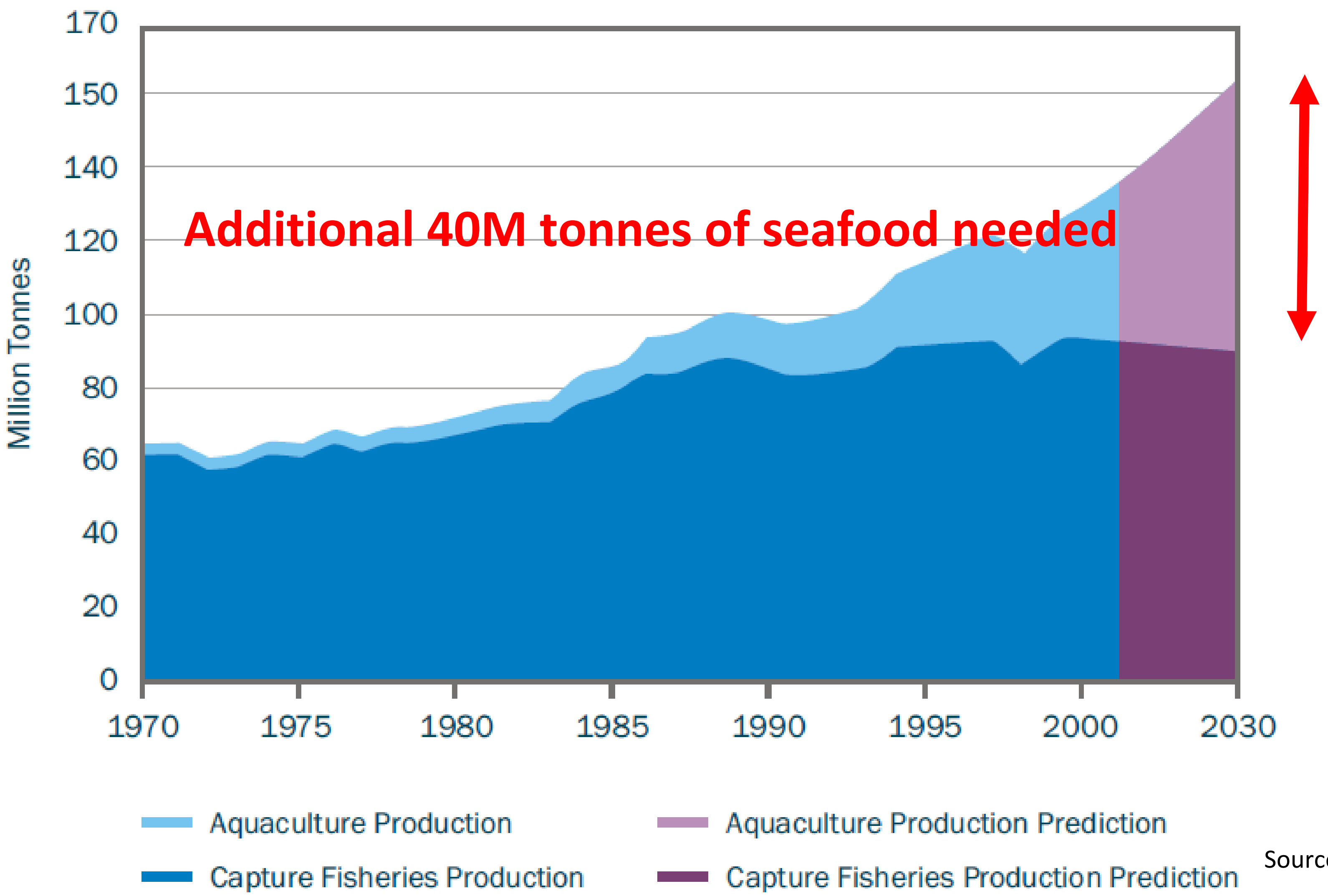
Global Demand for Seafood

doubled since 1973

Consumption Growth driven by:

- ✓ Population Growth: 1 in 5 depend on fish for protein
- ✓ Growth in per capita consumption

WORLD FISH PRODUCTION



Source:FAO

Farm the Seas to feed the people

Reduce pressure on Wild Stocks

Reduce pressure on freshwater resources

Environmental Impact

Aquaculture has a low carbon footprint compared to other animal food producing methods

Feed Conversion Efficiencies

8 Kg Feed

6 Kg Feed

2 Kg Feed

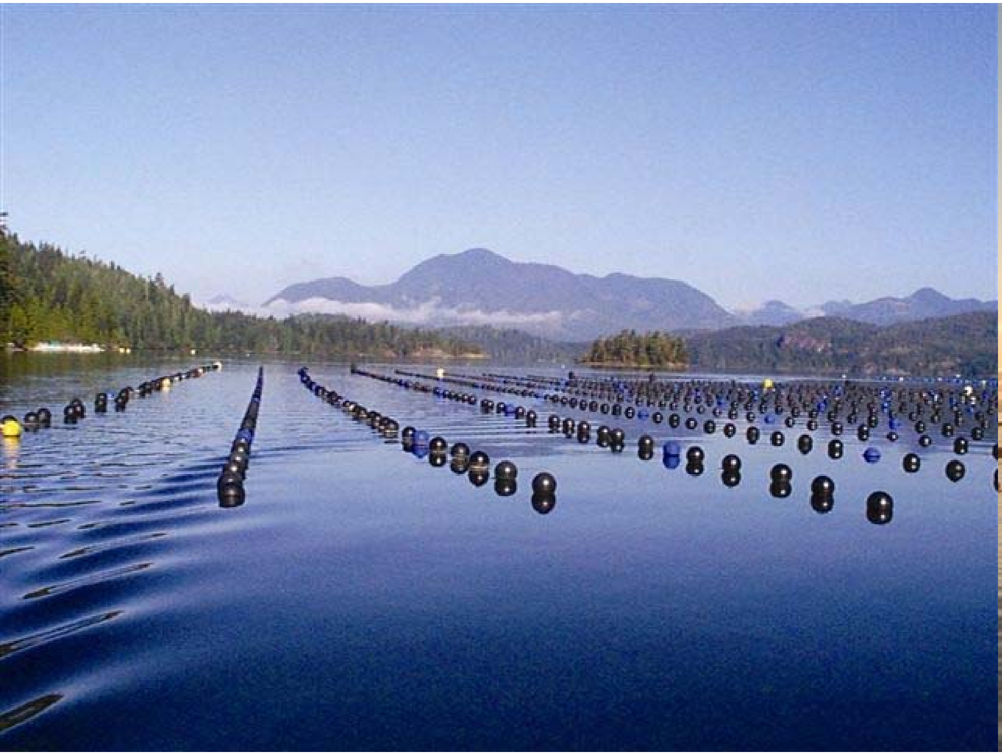
1.2 Kg Feed

Health Benefits

- ✓ High in Omega 3's
- ✓ Low in Saturated Fats
- ✓ Heart and Brain Health

Global Aquaculture Production

Canadian Aquaculture



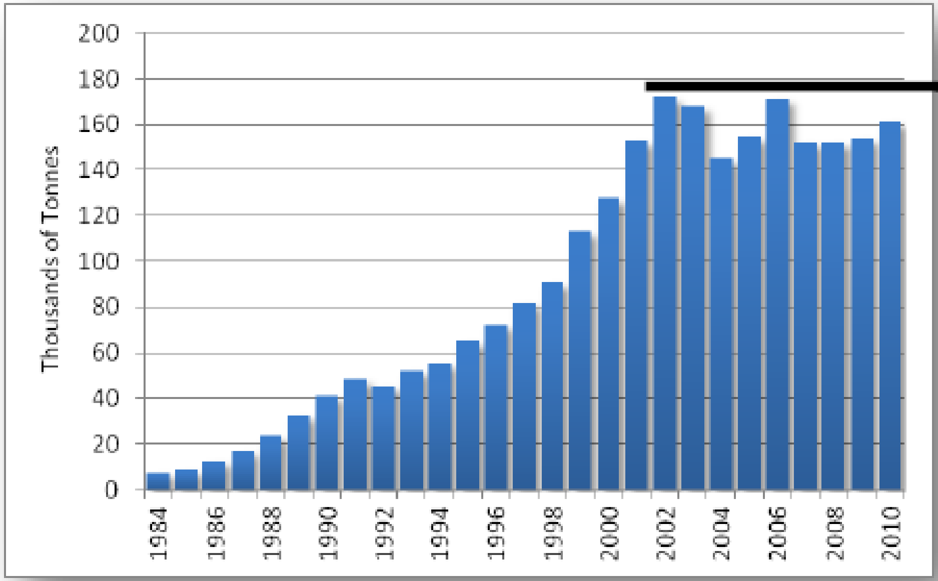
Aquaculture occurs in all provinces & the Yukon

Canadian Aquaculture Industry

- $2.1 Billion
- 15,000 Jobs
- 1/3 value of Fisheries production

12 years of stagnated growth

Aquaculture Production in Canada (1984 to 2010)



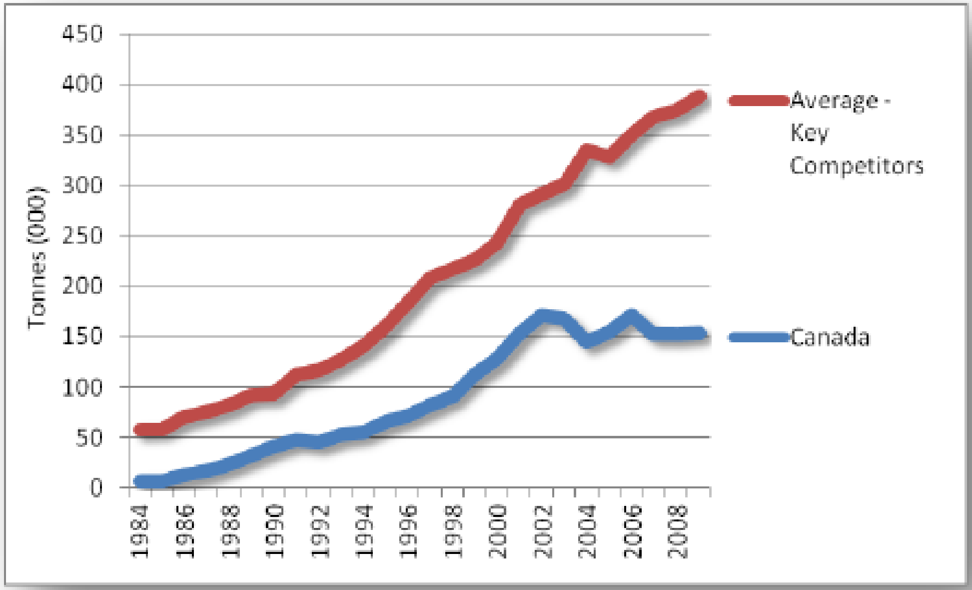
Aquaculture production has stagnated in Canada over the past 10 years.

Source: FAO Statistics

- **Longest coastline, largest freshwater system, largest tidal range**
- **Abundance of highly skilled workers**
- **World class scientists & research facilities**
- **World-renowned sustainability practices**
- **Reputation for high quality products**
- **Access to major seafood markets in US, Europe and Asia**

Falling behind key competitors

Aquaculture Production – Canada vs. Key Competitors (1984-2009)



Source: FAO Statistics

Key competitors = U.S., Australia, Norway, Chile, New Zealand, Scotland, Ireland

Why have we flat lined?

1. Regulatory system is complex, uncertain and confusing
2. Fisheries Act never meant for aquaculture
3. Patchwork quilt of statutes

Potential Jobs and Growth

1. According to DFO, Canadian aquaculture output could increase by approximately 8% to approximately 214,000 tonnes within 5 years. Generating new farm-gate revenues of approximately $1.1 billion.

2. By 2020, sector output could exceed 308,000 tonnes and generate total farmgate revenues in excess of $1.5 billion = 7,000 jobs

CAIA is committed to work with government & stakeholders to help build a responsible, sustainable industry in Canada

CAIA Presentation: ACFFA November 14, 2012

World's Growing Population & the Need for Protein

Aquaculture is all about producing nutritious, affordable food to feed the people. According to the UN, the world population is projected to grow from 7 billion now to 9 billion in 2050. The combination of increasing population, rising incomes, and decreasing poverty in developing countries - has resulted in an explosion of food demand. As result, the global demand for protein will rise to 2 ½ times its current level.

The big increase in animal protein demand over the last few decades has largely been met by the worldwide growth in **intensive** livestock production, particularly poultry and pigs. But it is very unlikely that these sources will be able to continue to grow to accommodate our ever expanding need for protein due to limited freshwater resources.

Up to 70 % of the water taken from rivers and groundwater goes into irrigation that supports agriculture. Clearly the world's growing need for protein can't come solely from terrestrial agriculture.

Global Demand for Seafood

Seafood is already making a significant contribution to the world's demand for protein. This growth in consumption is driven by several factors:

- Population growth. Each year, there are 75 million more people to feed around the world and 1 out of 5 of these people depend on fish for their primary source of protein, so as the population increases, the demand for seafood increases

- Growth in per capita consumption. In 1970, each person ate – on average - 11.5kg of seafood per year. By 2008, consumption had risen to17.0 kg per year. The demand for fish has increased at twice the rate of population growth over the last 50 years

Currently demand is increasing by 7% to 9% per year so according to the United Nations, an additional **40 million tonnes of seafood** will be needed by 2030. Most traditional capture fisheries are either **over-exploited or in decline** and can meet less than half this demand.

An increased reliance upon aquaculture to meet the world's protein needs - makes sense in some very important ways:

<u>Greater Environmental Sustainability</u>

Increased aquaculture production would actually make a positive contribution to the sustainability of the environment:

- It would reduce the reliance upon wild stocks to meet increasing protein demand…and thereby support the sustainability of wild populations

- It would reduce the pressure on finite freshwater resources needed to grow protein on land

- Expansion of aquaculture production would help to reduce the carbon footprint of animal protein production.

  Studies have shown that farmed seafood has a smaller carbon footprint than producing pork, poultry, beef, or fish harvesting with large ocean trawlers. The production of shellfish such as mussels or oysters has a very low carbon footprint, partly because of the reliance on natural food particles in the water, but also because these animals take up carbon in the formation of their shells. In other words, aquaculture production has a low environmental impact compared to other animal food producing methods.

- Aquaculture also supports environmental sustainability due to the capacity of farmed fish to efficiently convert the food they eat into high quality animal protein.

  While farmed salmon require only 1.2 kilograms of feed to produce1 kilogram of flesh – poultry require 2kg of feed. Pork needs 6kg of feed. And beef requires about 8kg.

Health Benefits to Consumer

Aquaculture produces protein that's **high in omega-3 fatty acids**, **low in saturated fat**, and positively impacts **heart and brain health**.

A joint report published by the Food and Agriculture Organization of the United Nations and the World Health Organization clearly points out that **not eating enough seafood** can have significant negative implications on heart and brain health. It also stresses that eating fish lowers the risk of death from heart disease – and that eating fish during pregnancy and breastfeeding lowers the risk of poor brain development in babies.

Another study by the Public Library of Science ranked low seafood intake as the **second-largest cause of diet-related deaths** in North America, just behind the high consumption of salt.

Global Aquaculture Production

From a production of less than 1 million tonnes per year in the early 1950s, production is now over 50 million tonnes with a value of more than 79Billion. Aquaculture now produces half of the fish consumed by the human population worldwide.

Canada:

Production

As part of this global expansion, Canadian aquaculture grew rapidly from the early 80's to the end of the 90's. Aquaculture now occurs in all provinces – as well as in the Yukon. The largest aquaculture producing provinces are: British Columbia, New Brunswick, Prince Edward Island and Newfoundland. Farmed salmon is BC's largest agricultural export product - and the largest crop in the New Brunswick agri-food sector.

Impact

Today, aquaculture generates $2.1 billion for our national economy and accounts for 14% of total Canadian seafood production and 35% of its value.

Aquaculture in one province **triggers economic activity in every other province**, providing opportunities for all Canadians. This is because of aquaculture's spin-off benefits, such as equipment and feed suppliers, processors, marketers and other services. For example, BC triggers an economic value of **$1.2 billion** across the rest of Canada and New Brunswick triggers approximately **$590 million** across the country.

Our industry employs **15,000 people**. Over 90% of these jobs are located in rural and coastal communities. The majority of workers in our industry are below the age of 35 – so this industry is providing leadership and training opportunities for young people - so they can work and raise families in their home communities. Given the decline of resource-based industries, this employment has proven to be a **revitalizing social and economic force for a number of small coastal communities** - from Newfoundland to the west coast of Vancouver Island.

And several First Nation communities have been among those experiencing this revitalization. First Nations in several provinces already have aquaculture businesses operating within their traditional territories.

Industry Stagnating

Canadian aquaculture grew rapidly from the early 80's to the end of the 90's. But since that time, industry growth has basically been stagnant. Few nations can match Canada's wealth of natural advantages when it comes to competing globally yet - during the past 12 years - production has effectively "flat-lined. Canada's share of the world's farmed fish market has fallen by 40% during the past decade. Canada now accounts for only 0.2% of global aquaculture production.

Why is it stagnating?

The principal challenge confronting Canada's aquaculture sector is the complicated set of regulations that restrict growth and limit investment.

Our industry is regulated by the *Fisheries Act* - a wildlife management act that was never intended for an innovative, food production sector. This is a piece of legislation that dates back to Confederation when commercial aquaculture in Canada did not exist.

In addition, rapid development of the sector in the 80's and 90's resulted in a myriad of federal, provincial and local regulations - many of them implemented before commercial scale aquaculture was even a significant activity. As a result of this patchwork approach, many of these policies and regulations are reactive and inefficient. And together, they create an overarching policy framework that retards competitiveness, obscures certainty and stalls growth.

Government Recognizes Aquaculture's Potential

Governments are recognizing that a strong aquaculture sector offers a rare opportunity in these challenging economic times to create new jobs and strong, ongoing growth. According to DFO's own estimates "with immediate strategic action, Canadian aquaculture output could increase by approximately 8% within 5 years. By 2020, sector output could exceed 308,000 tonnes and generate total farmgate revenues in excess of $1.5 billion."

Aquaculture Association of Canada
Association Aquacole du Canada

Aquaculture Association of Canada

Presentation to the Atlantic Canada Fish Farmers Association

November 14th , 2012

AAC at a Glance

- Incorporated in 1984
- 565 members (today)
- Home office in St. Andrews, NB
- 2 full time employees and one part time employee
- Members 50% individual, 25% corporate, 25% student, retired and library
- 10 Board members from across the country

Mission

- To be the preeminent, independent science and technology based organization in Canada for the aquaculture industry
- The source for leading research for the aquaculture community
- Facilitate timely and widespread information sharing and dissemination from the research community
- Contribute to the development of the industry through the support of R&D and education

Strategic Plan Foundation

- The Foundation of the Plan is Sustainability and Stability
- This plan is focused on membership growth and added value, along with building a sustainable financial model
- Committed to the challenge of knowing, understanding and meeting the needs of a wider and deeper market – member segmentation

Strategic Plan Foundation Continued…

- Create a deep culture of member inclusion and participation through new programs and services based on "knowing our member"
- This Strategic Plan will be a living document that will be reviewed and augmented regularly based on continuous member feedback and goal measurement.

Plan Pillars

- The new plan focuses on strengthening the organization's core
- PILLAR 1: MEMBERSHIP VALUE AND ENGAGEMENT
- PILLAR 2: PROGRAMS AND SERVICES
- PILLAR 3: COMMUNICATIONS AND MARKETING
- PILLAR 4: PEOPLE POWER – STAFF AND VOLUNTEERS
- PILLAR 5: FINANCIAL, OPERATIONS AND ADMINISTRATION

Pillar 1: Membership Value and Engagement – New Initiatives

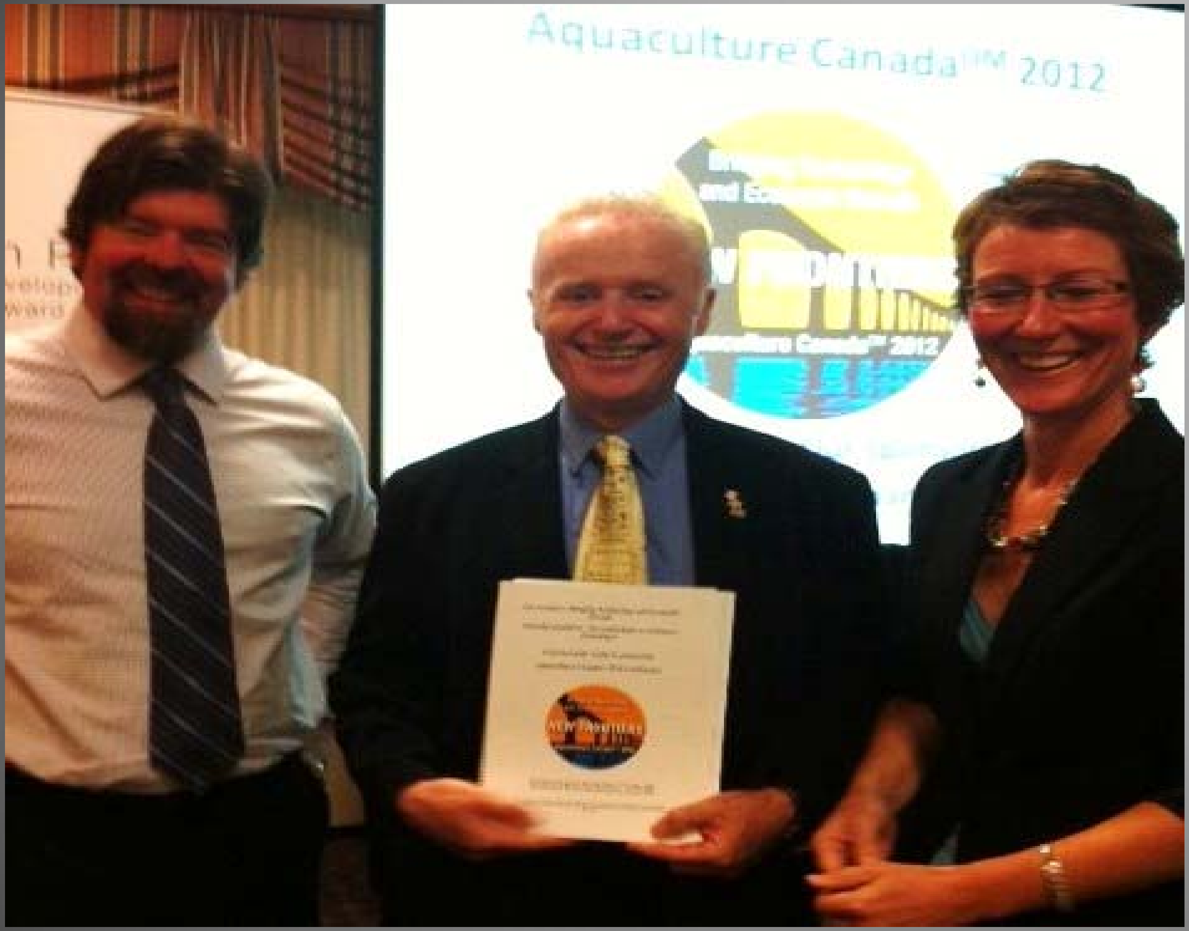
- Annual recruitment and retention plans
- Ambassadors Team
- Membership Category Specific Service Plan
- Membership Surveys
- Member Recognition Program

Pillar 2: Programs and Services – New Initiatives

- 2012 R&D Review in partnership with DFO
- Hosting Salmon Aquaculture Research Database on site
- Science Panel Program
- Membership Directory
- Planning In School Program – Workshops and Presentations on Aquaculture as a Career Choice
- Members Profiles in Watermark

Aquaculture Canada^{OM}

- Aquaculture Canada^{OM} – 2013 in Guelph, Ontario June 2– 5th, 2013: Farming our Waters: Agrifood Innovations
  - Over 150 talks with three days of concurrent talks and expert presentations
  - Keynotes and Plenary speakers
  - 300+ attendees
  - Present Annual Awards
  - Student Paper and Poster Competitions
  - Fund student travel through Endowment Fund



Dr. Brian Lee Crowley, Keynote Speaker

(l-r) Tim Jackson, AAC Past President; Dr. Brian Lee Crowley, MacDonald Laurier Institute; Ann Worth, Executive Director PEI Aquaculture Association

Dr. Chris Frantsi, 2012 Lifetime Achievement Award Recipient

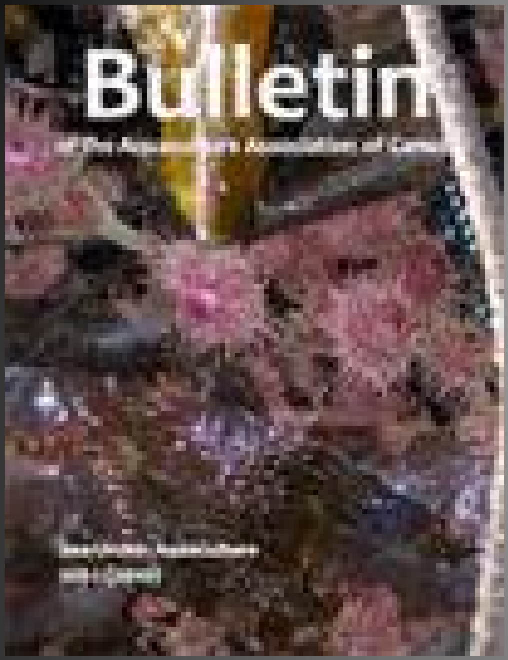
(l-r) Caroline Graham, AAC Board Member; Dr. Chris Frantsi

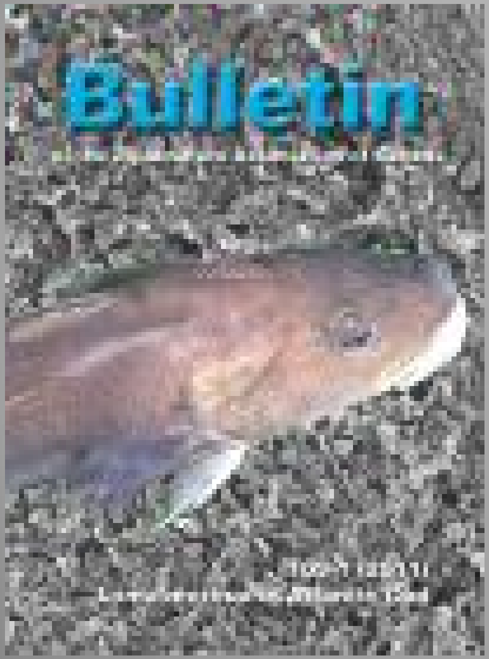
Dr. Joe Brown BBQ

Students conducting games raising money for the Student Endowment Fund

Pillar 3: Communications and Marketing

- Re-designed Bulletin and improving publication schedule
- Annual Conference Proceedings–up to date
- Various Partnership Publication Initiatives
- Updated website
- Watermark newsletter re-formatted and published quarterly
- Regular issue specific member surveys





AAC Bulletin

Science Panel Program Objectives

- National Scope
- Be proactive in presenting balanced, science-based information on issues which presently and/or potentially impact the aquaculture industry
- Provide more clarity and certainty on certain issues to help inform the broader debate
- Through the Science Panel process, determine where knowledge gaps exist and develop a plan to address those gaps

Science Panel Format

- Location – will depend on location of experts and travel availability – across country
- A white paper on key issue will be drafted prior to the workshop with the assistance of the experts chosen
- The panel workshop will include a plenary and breakouts with a reconvening of all experts for a summary
- A spokesperson or persons will be chosen from each panel of experts who will be available to respond to media and other inquiries

Key Issue Survey Results

- Membership and stakeholder survey completed in September
- The top three priority areas as chosen by members are:
  - Social License/Public Awareness
  - Regulatory
  - Fish Health – Disease Management
  - Environment
- Surveyed and researched R&D Activities being carried out by partners and other associations in Canada to ensure no conflict or duplication of effort

First Key Issue and Timeline

- **Disease Outbreak Management and Response/Pre-emptive Management and Integrated Pest Management**
- The scope will include bio security, communications, environmental impacts and treatments for disease management, pest control, etc.
- First panel will be held in January/February 2013

Science Panel Deliverables

- Publish proceedings of panels as a series and write papers for scientific journals
- AAC will publish findings and information
- Communication in language that can be understood and interpreted by all (non-scientists)
- Develop a database of experts available and able to respond publicly when relevant issues are in the media

Future Issues and Collaboration

- The Science Panel Program will be a continuing series – survey results identified several key issues
- Future issues to be chosen through additional collaboration and consultation

Thank You

Amoebic Gill Disease in Farmed Salmon

James Hoare, FVG Inc.
ACFFA Annual Fall Workshop

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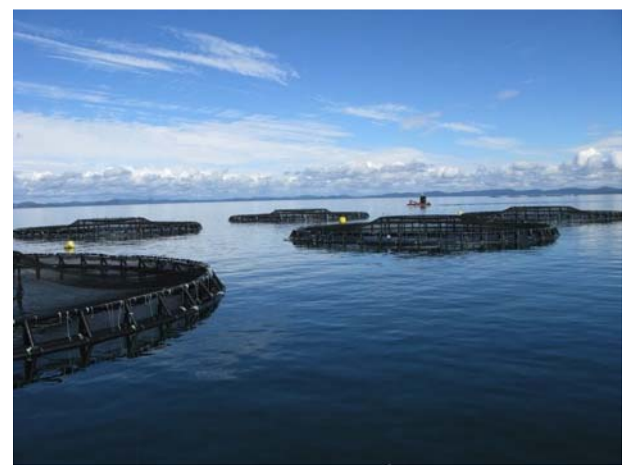
Objective

- General Overview

- Recent Scottish Experience



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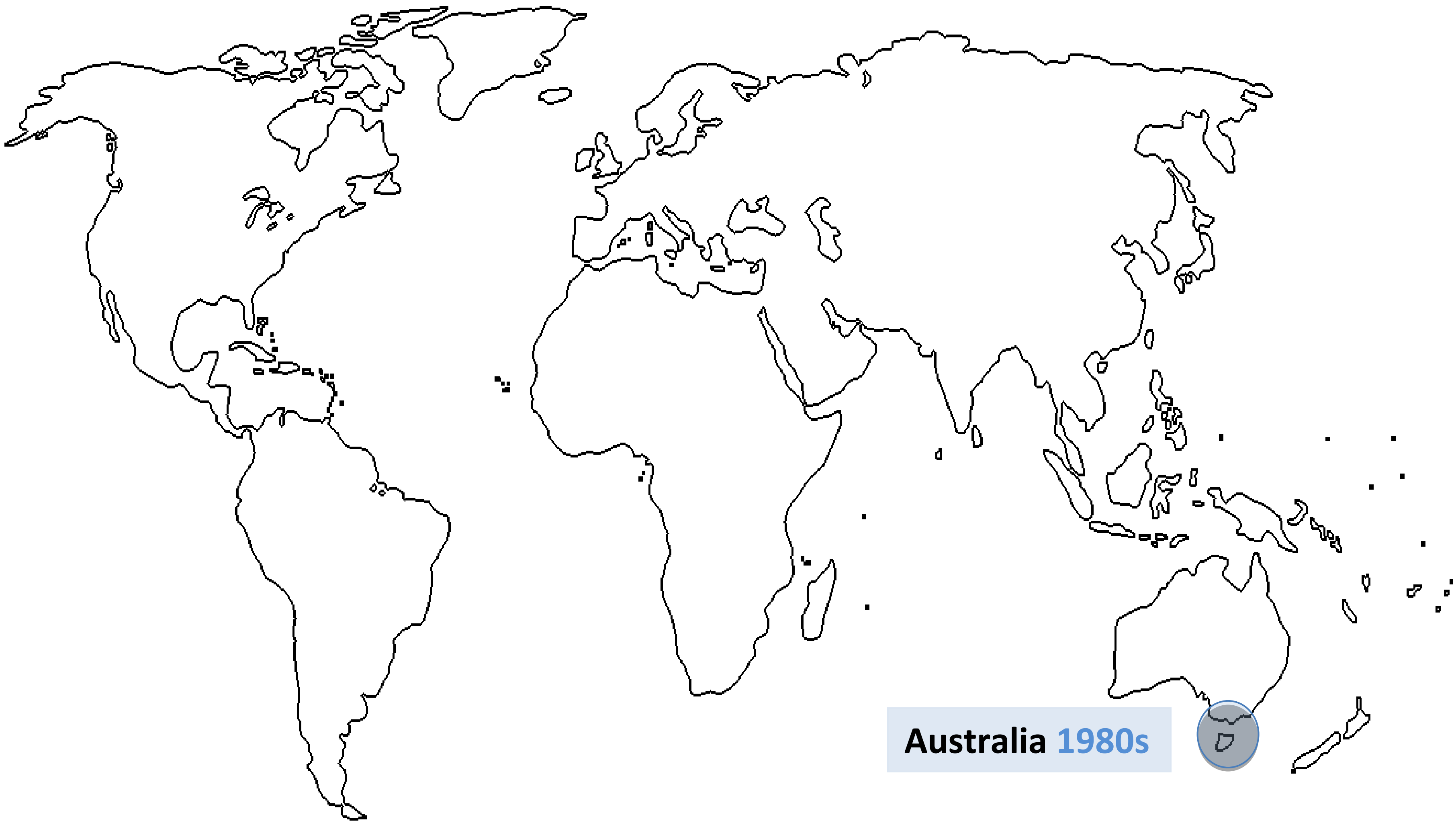
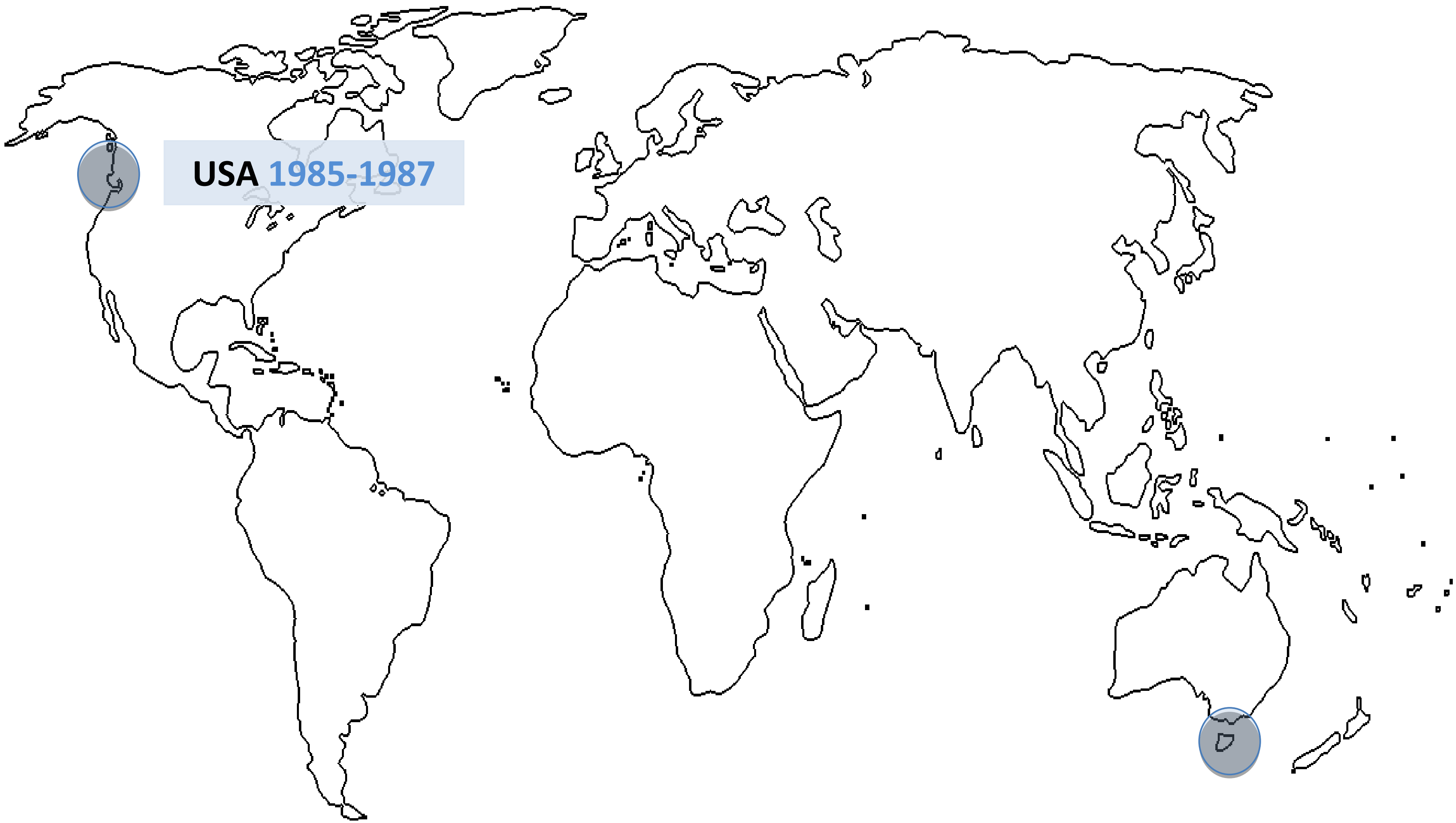
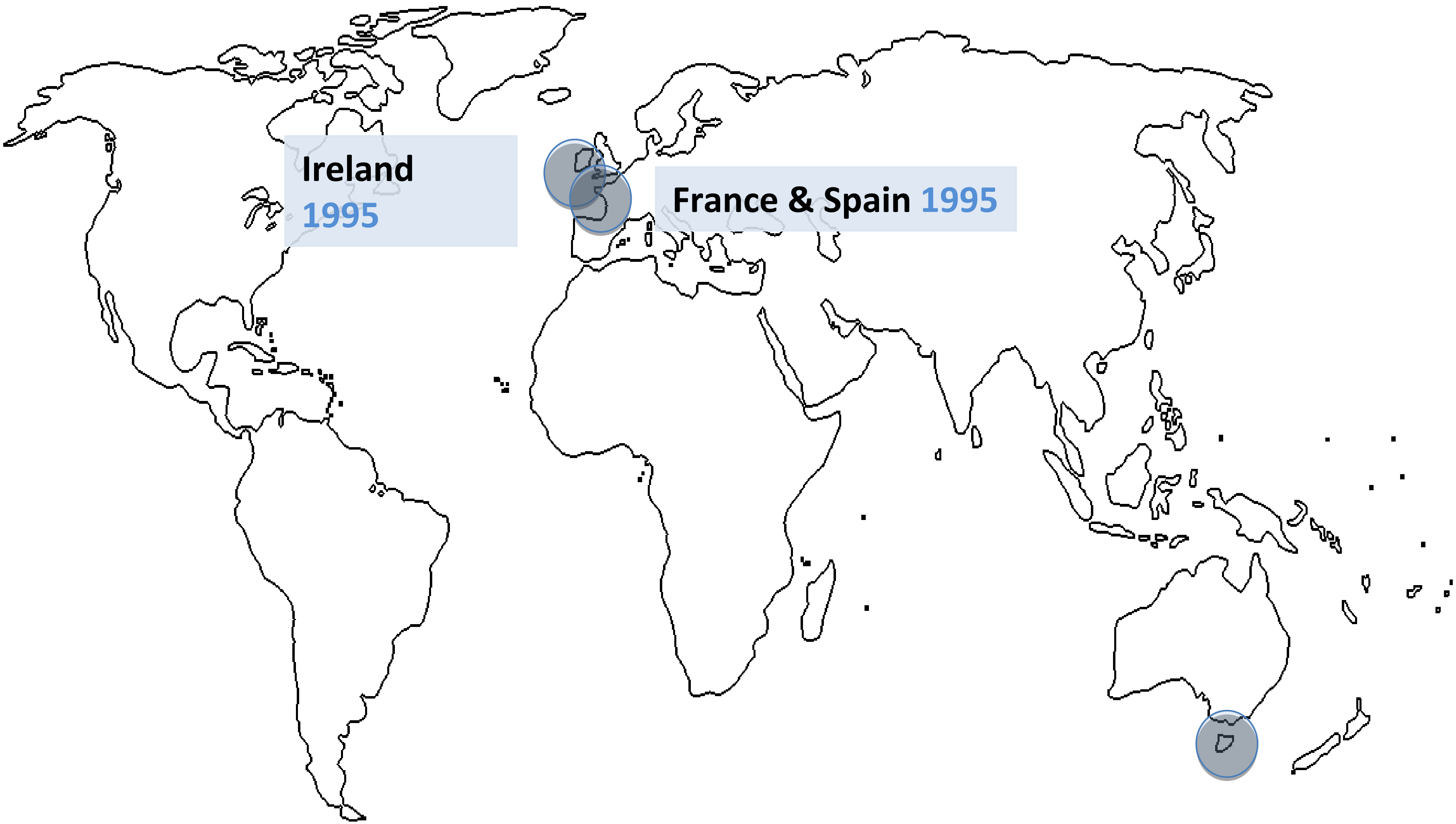
Brief History



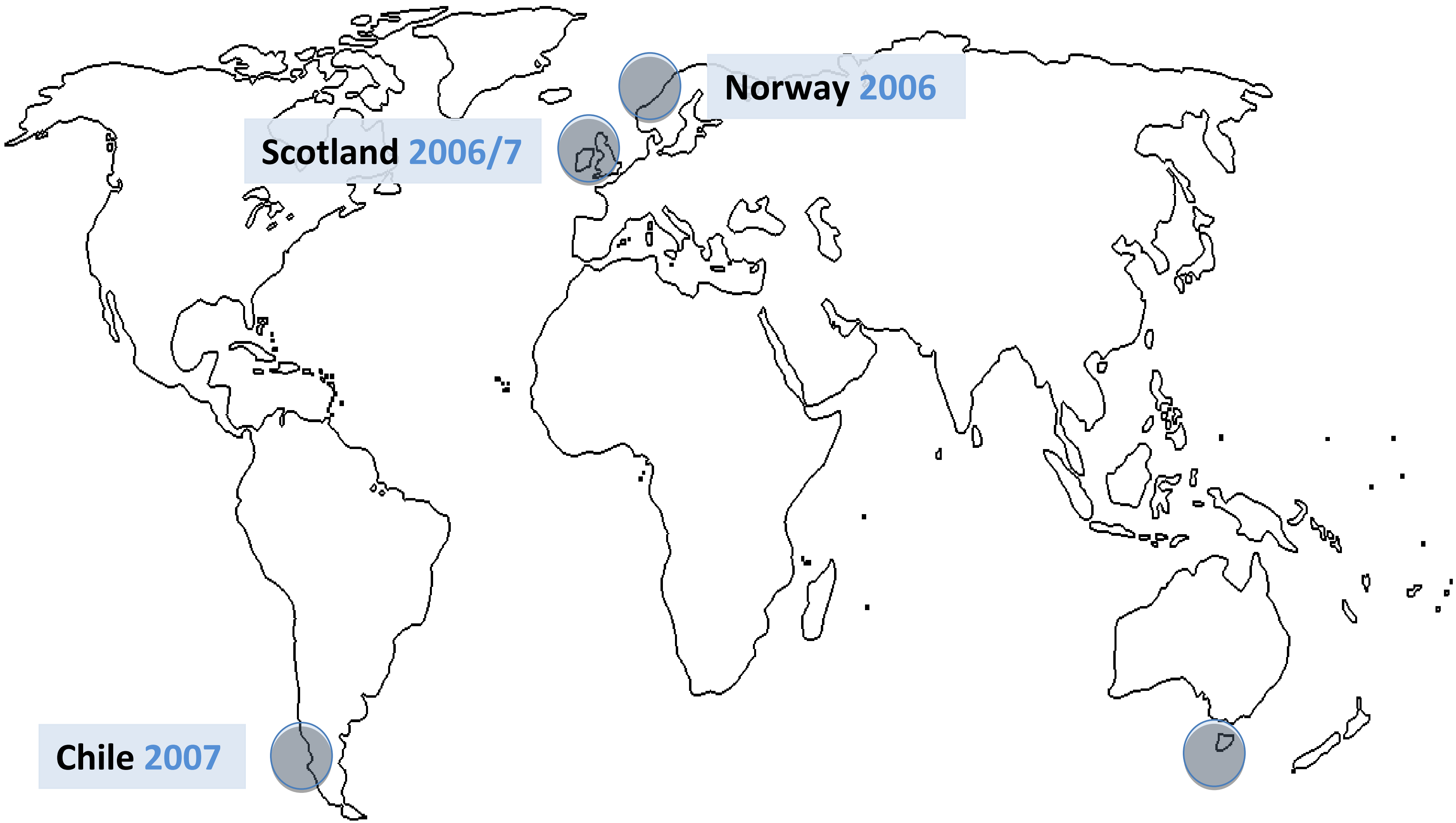
Brief History



Brief History



Brief History



Brief History

Global Issue

Impact

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Impact – Fish Health

- Direct Mortalities

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Impact – Fish Health

- Direct Mortalities

- Lost Growth

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Impact – Fish Health

- Direct Mortalities

- Lost Growth
- Secondary Disease

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Economic Impact

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Economic Impact

- Lost Productivity

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Economic Impact

- Lost Productivity
- Cost of Treatments

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Economic Impact

- Lost Production
- Cost of Treatments
- Cost of Mortality Removal & Disposal

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Causes of Gill Disorders in the Marine Environment

- Harmful algal blooms
- Harmful zooplankton spores
- Amoebic Gill Disease & other parasites
- Bacteria
- Viruses
- Toxins, other irritants

Most commonly a combination of the above

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Amoebic Gill Disease (AGD)

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Aetiology

Neoparamoeba pemaquidensis

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Aetiology

Neoparamoeba perurans

Confirmed as true agent of AGD in 2007.

Other amoeba species possibly involved in secondary role?

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Neoparamoeba perurans

- Free living and parasitic
- Survives in sediment and net pens
- Survives on the gills of dead fish
- Spread in seawater > 1km
- Survives in seawater for at least 14 days

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The Disease

- Risk factors
- Clinical Signs
- Diagnosis
- Immune mechanisms
- Treatment

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Risk Factors

- High salinity > 32ppt
- High water temperature
  - Clinical disease most common between 12-20°C
- Blooms or swarms?
- Biofouling?
- Poor Smolt quality/size?
- Other infected sites in the area

Clinical signs

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Gross Lesions

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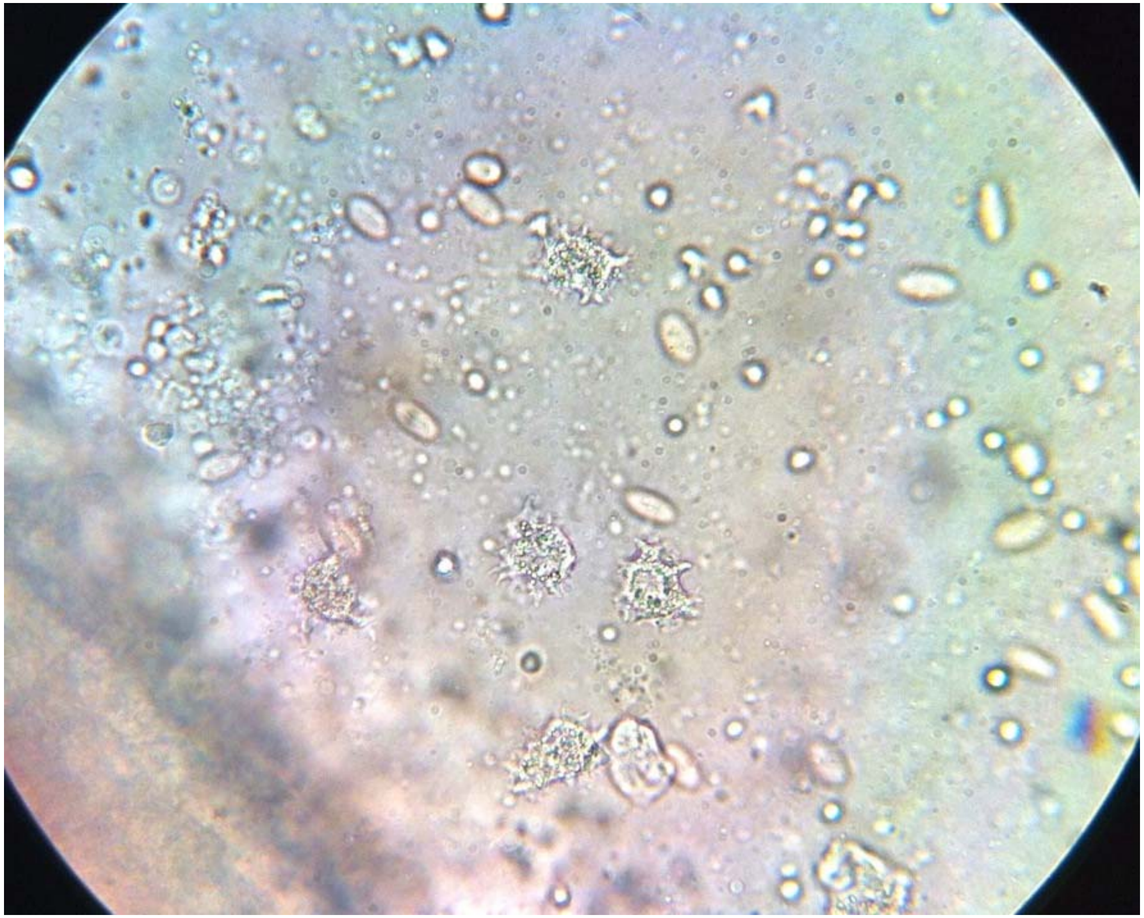
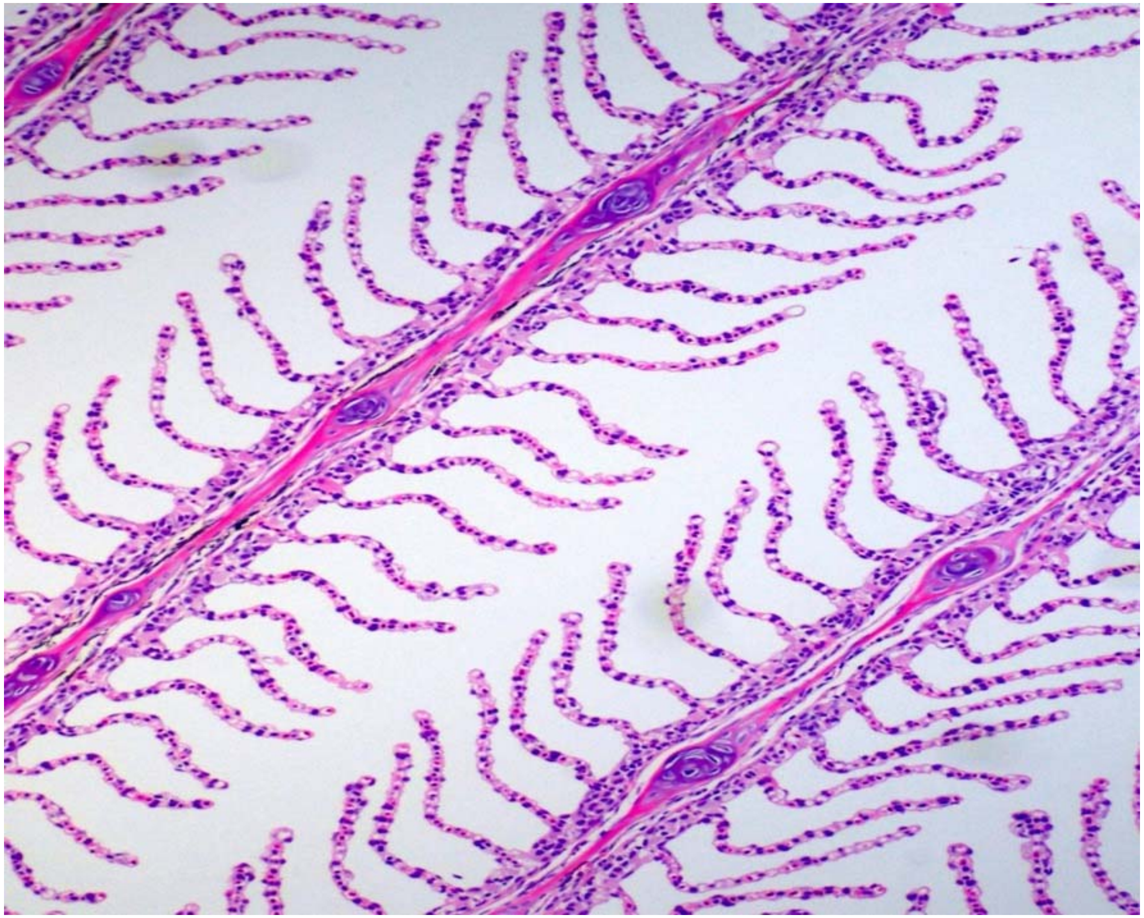
Diagnosis

Fresh Gill Smears…



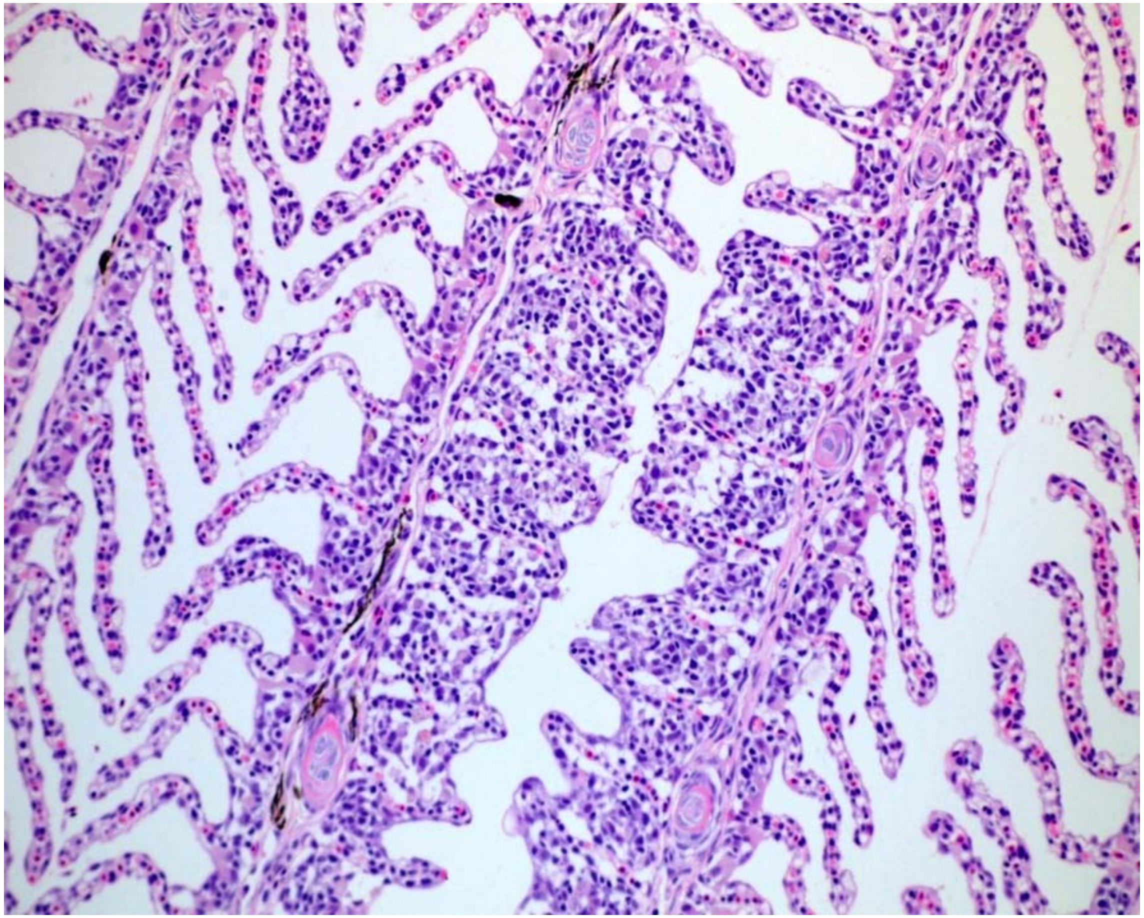
Diagnosis

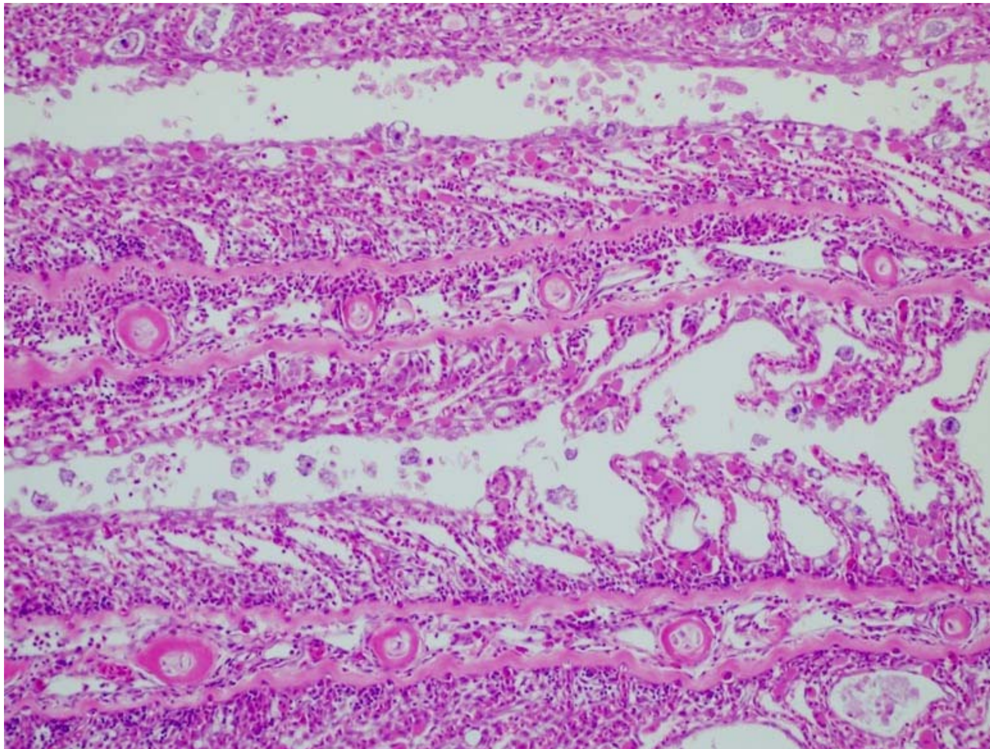
Histology…

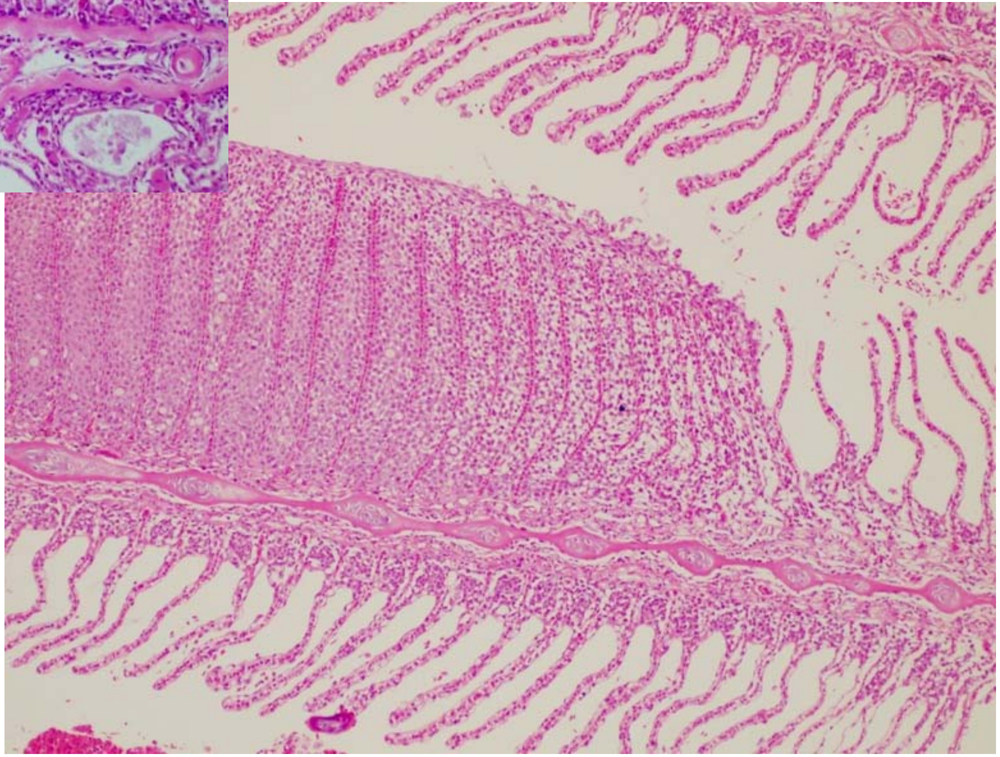


Diagnosis

Histology…







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Diagnosis

PCR…

- *N. Perurans* - duplex Taqman RT-PCR (AFBI, Belfast)

- Also available for *Tenacibaculum maritimum, Paranucleospora* & *Piscichlamydia*

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Immune Mechanisms

- Fish that previously had clinical AGD relatively resistant to re-infection.
- Study in 2010[1] found no evidence that antibodies recognizing wild type *Neoparamoeba* spp. provided significant protection against AGD.
- More recent investigations[2] have indicated that resistance may be associated with specialized responses in the gill mucus or epithelium.

[1]Taylor R.S., Crosbie P.B. & Cook M.T. (2010) Amoebic gill disease resistance is not related to the systemic antibody response of Atlantic salmon, Salmo salar L. Journal of Fish Diseases 33, 1–14.

[2]Vincent B.N., Adams M.B., Nowak B.F. & Morrison R.N. (2009) Cell-surface carbohydrate antigen(s) of wild-type Neoparamoeba spp. are immunodominant in sea-cage cultured Atlantic salmon (Salmo salar L.) affected by amoebic gill disease (AGD). Aquaculture 288, 153–158

Treatment

Bath…

- Freshwater
- Hydrogen Peroxide
- Formalin
- Chloramine T

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Treatment

In-feeds…

- Bithionol?
- Other compounds?

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AGD Outbreak in Scotland 2011-12

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AGD Outbreak in Scotland 2011

First Indications…

- August: AGD reported at 9 sites in Ireland
- Mid-September: First case in Scotland
    - Caused 69% mortality over a five week period
    - No treatment implemented
- Late September: AGD subsequently diagnosed on a number of sites along the West Coast of Scotland
    - Variable morbidity and mortality
    - Bath treatments carried out at some sites

Winter 2011-2012

- General improvement as the water temperature declined
- Low numbers of viable amoebae still evident at 7.5 degree Celsius!
- Real concern regarding Spring rise in temperature

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Spring/Summer 2012

- AGD re-emerged and continues to be an issue
- Increase in the number of sites affected
- Geographically widespread across the country
- High salinity/low rainfall most likely contributed
- Mostly first year fish affected
- Variable mortality…

  Complicated by concurrent disease in some cases

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Treatments

- Initially fire fighting but increasingly strategic in approach

- Early implementation where possible…

  …monitoring programme essential for this

- Compounds utilized…

  …Formalin

  …Freshwater

  …Hydrogen Peroxide

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Treatments

Formalin…

- Emergency permission granted for one site experiencing heavy losses.
- Dose: 200ppm for 40 minutes
- Treatment carried out in well boat - fish tolerated treatment relatively well
- Ambiguous results
- Environmentally unsound
- Unlikely candidate for future treatments

Treatments

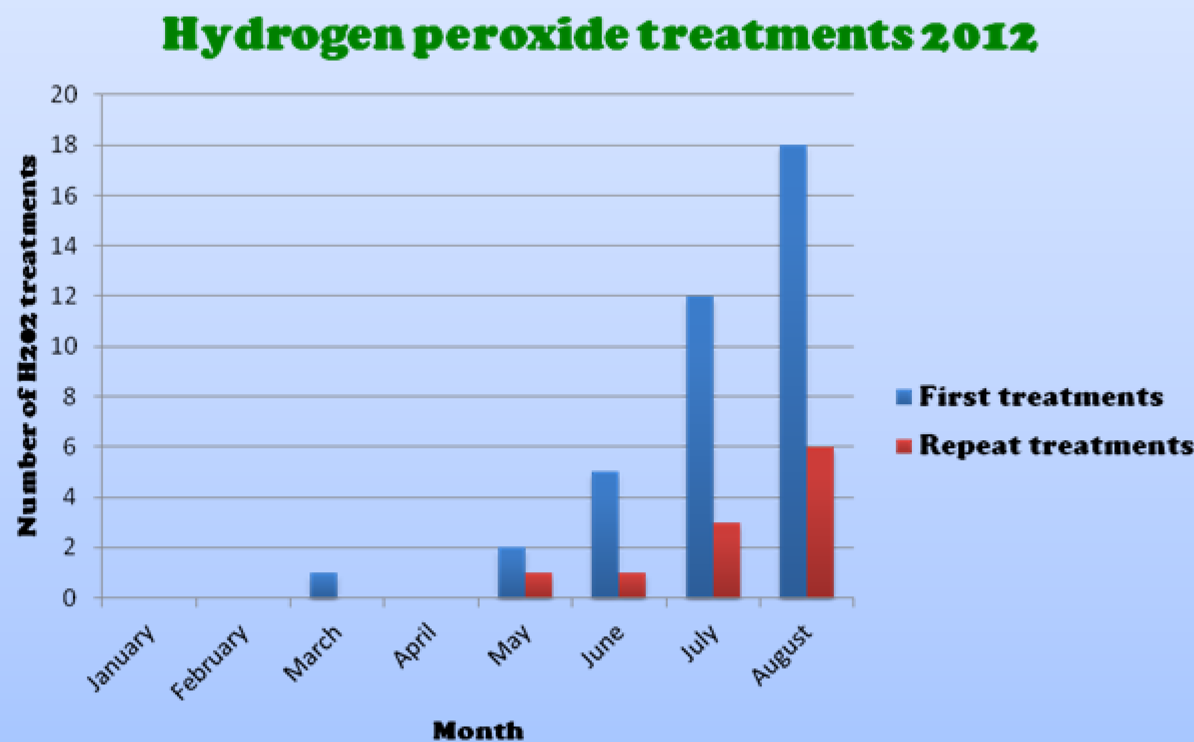
Freshwater…

- Few treatments to date
- Logistically impractical
- Low Rainfall [14.5mm in June cf. normal average of 78.4mm]
- Dose: <3ppt for 2-3 hours
- Well boats utilized [Delivery or Treatments]
- Generally good results
- Still currently treatment of choice for AGD

Treatments

Hydrogen Peroxide…

- Majority of treatments to date



Treatments

Hydrogen Peroxide…

- Majority of treatments to date
- Dose: 900 -1400ppm for 20 minutes
- Most treatments at 1200ppm for 20 minutes
- Most treatments by well boat

Hydrogen peroxide

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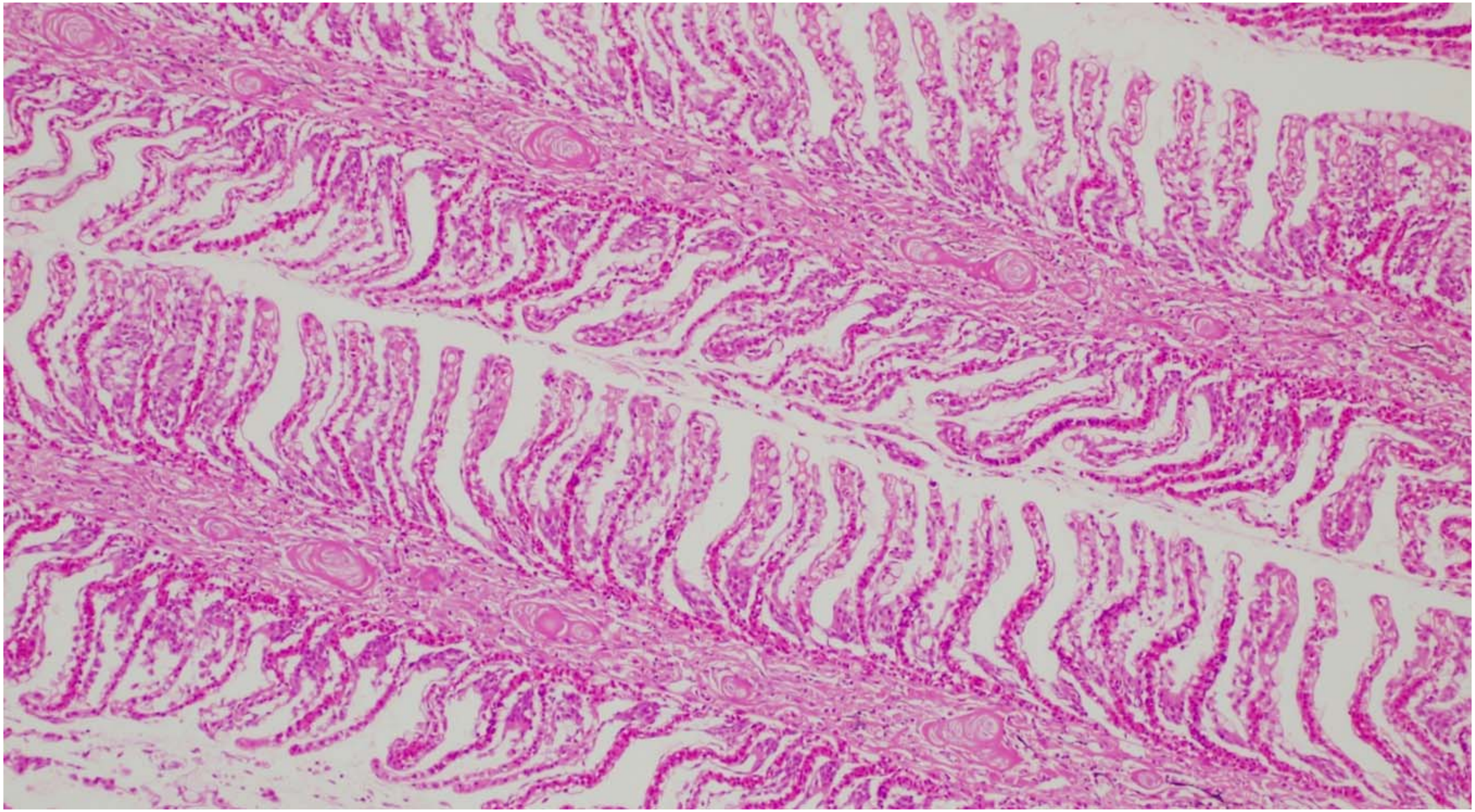
Treatments

Hydrogen Peroxide…

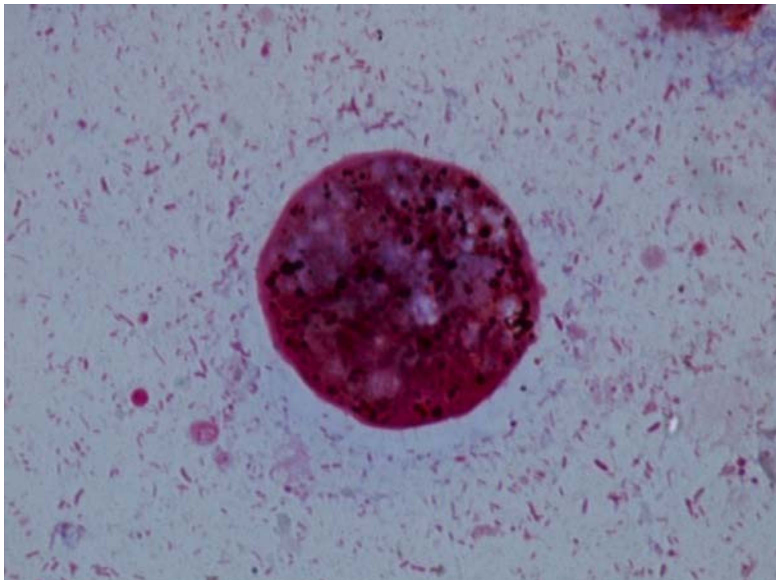
- Relatively effective at reducing amoeba numbers at 48 hours
- Often observe an improvement in appetite and mortality post treatment
- New lesions tend to establish 7-10 days later
- Some reports of treatment related losses

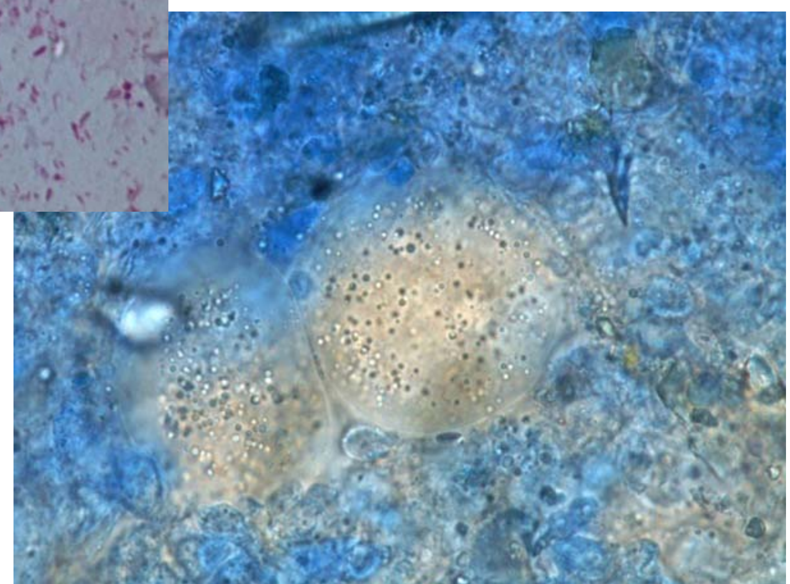
  (Severe AGD pathology, concurrent diseases)
- Not the magic bullet but has helped the Scottish Industry avoid heavier losses to date

Acute Gill Pathology Post Peroxide Treatment [1400ppm]



Amoebae more Rounded Post Treatment





Other Observations

Several sites in the North West of Scotland reported significant improvement in gills following heavy rain at the end of August

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Mitigation

Regular monitoring essential…

- Weekly gill checks for gross lesions

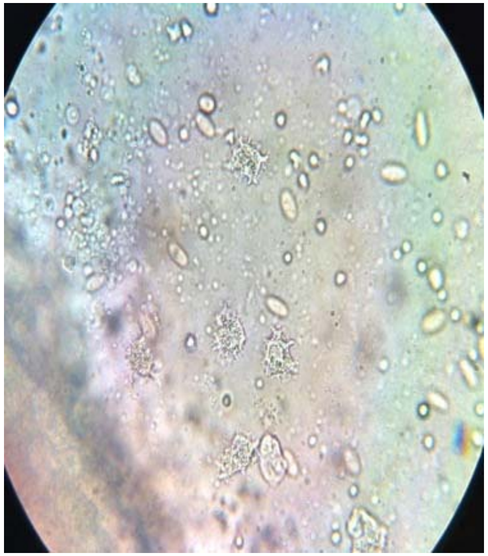
Gill Score		Description
0	**CLEAR**	
1	**VERY LIGHT**	1 white spot/light scarring
2	**LIGHT**	2-3 mucous spots
3	**MODERATE**	Established thick mucous patch or spot groupings up to 20%
4	**ADVANCED**	Mucous lesions up to 50% gill area
5	**EXTENSIVE**	Mucous lesions over 50% gill area

From Taylor *et al* (2009) Aquaculture 290, 1-8- adapted from Tassal Operations Pty.

Mitigation

Regular monitoring essential…

- Weekly gill checks for gross lesions
- Fresh Microscopy during high risk period



Mitigation

- Net cleanliness
- Effective mortality removal

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Future

Short term…

- Improved Bath Treatments

Long term…

- In-feed treatments?
- Vaccine?
- **Genetics**

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Take Home Message

Be prepared and ready for AGD…

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Thank you

Acknowledgements

Chris Matthews & Marianne Pearson, FVG

Reference

Mitchell, S.O. & Rodgers, H.D. (2011) A review of infectious gill disease in marine salmonid fish. *Journal of Fish Diseases* **34**, 411-432

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Fundy National Park's Inner Bay of Fundy Atlantic Salmon Recovery Program



Parks Canada Parcs Canada

Atlantic Salmon Federation / Fédération du saumon atlantique

asf / fsa

Inner Bay of Fundy Atlantic Salmon

Fort Folly Habitat Recovery

Admiral Fish Farms

acffa Atlantic Canada Fish Farmers Association

Université Concordia University

Fisheries and Oceans Canada Pêches et Océans Canada

Memorial University

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PRESENTATION OVERVIEW

- About IBoF Atlantic Salmon
- FNP Recovery Program
- Sea-cage Project
- Exciting New Results

Parks Canada Parcs Canada

Canada

What makes IBoF Salmon different?

- Genetically Distinct
- Unique Life History
  - Stay in the Bay of Fundy
  - Return to spawn after one winter at sea
  - Can spawn multiple times

Why are IBoF Salmon endangered?

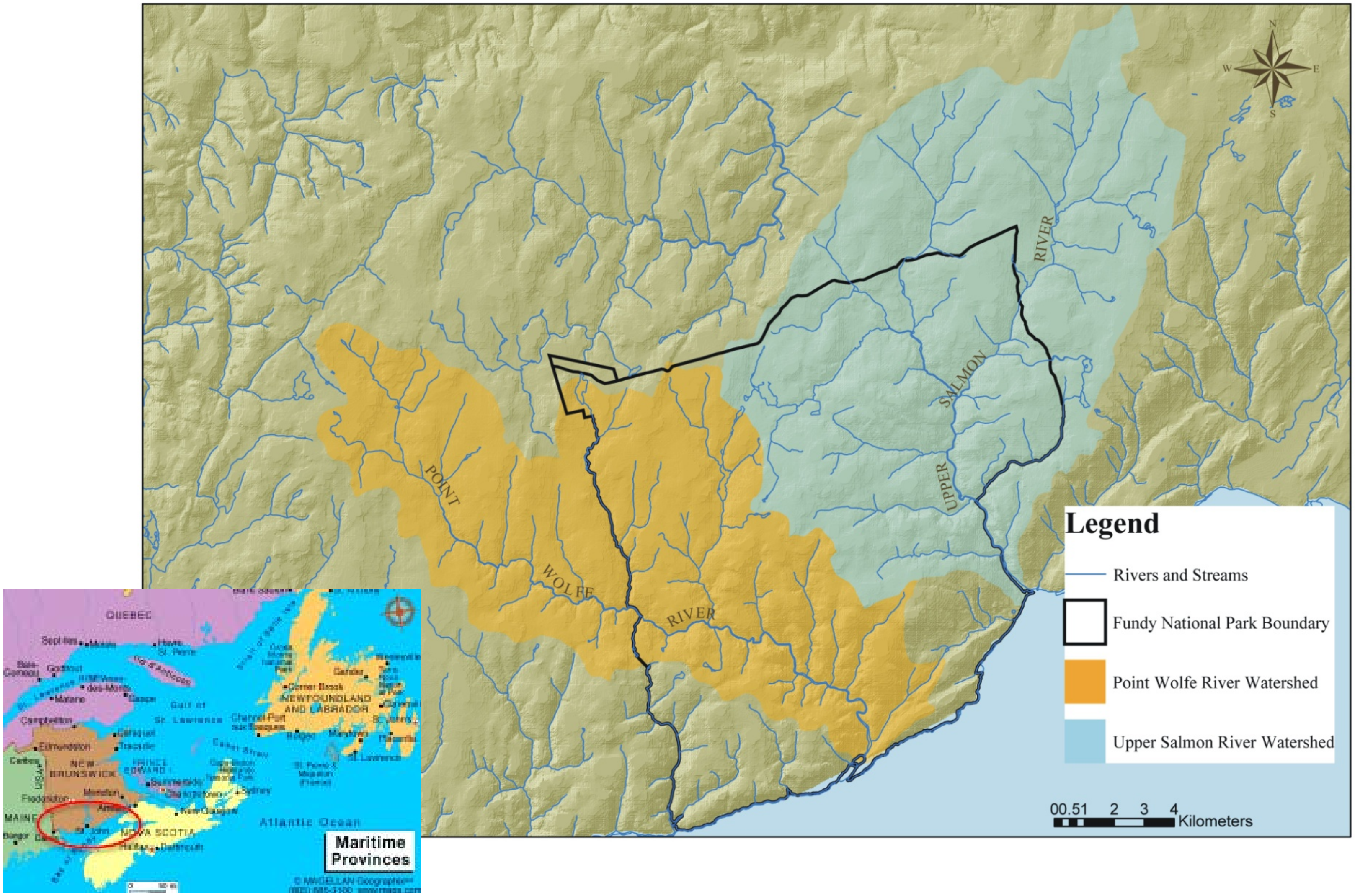
- There used to be 40,000 fish returning to Inner Bay of Fundy rivers.
- Now there are less than 250 fish coming back.

What is limiting recovery?

Or more simply, Why can’t we fix it?

- Fish aren’t returning from the ocean.
- No one knows what is happening to the fish while they are at sea.

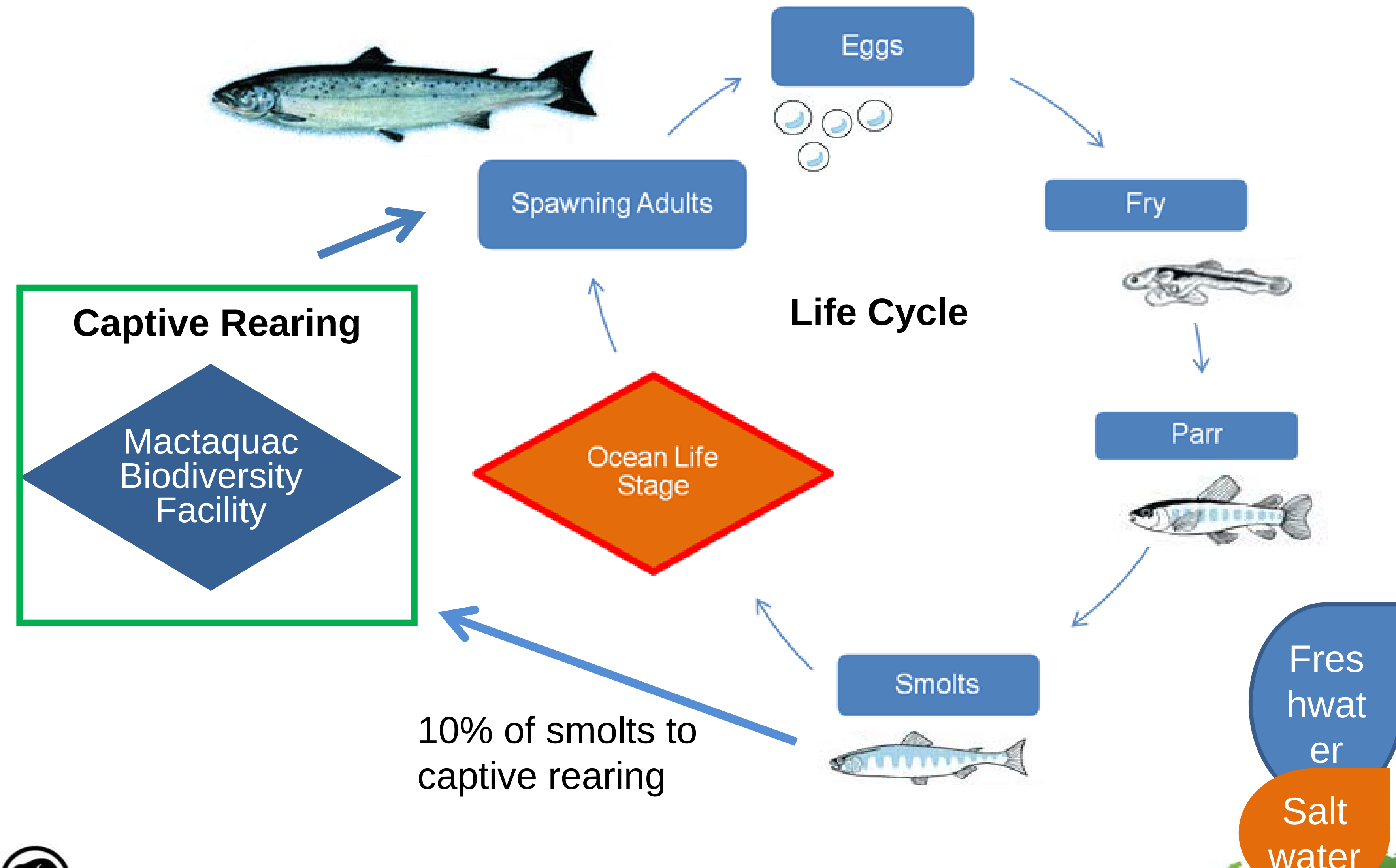
Fundy National Park
Upper Salmon and Point Wolfe Watersheds



First we learned that…

- Initial Assessment
  - Juvenile density ↓
  - Genetic diversity ↓
  - Not enough fish coming back to recover the population

So the Recovery Team took action...



We asked a lot of questions

- Release Strategy
  - Is it better to release fry, parr or adults?
- Rearing Environment
  - When rearing fish in captivity, it is better in freshwater or salt water?
- Each year, we learned a little bit more.

parkscanada.gc.ca

Summary and Update on Releases and Returns

- On the PWR, we released 70 to 300 adult salmon per year.
- On the USR, we released around 25, 000 parr and between 25,000 and 250,000 unfed fry per year.
- A peak 1600 smolts on the USR and 400 on the PWR in 2010.
- These releases resulted in very few (e.g., <10) naturally returning adult salmon

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Canada

Sea Cage Rearing Experiment

Parks Canada Parcs Canada

Atlantic Salmon Federation · Fédération du Saumon Atlantique

Inner Bay of Fundy Atlantic Salmon · Fort Folly Habitat Recovery

Admiral Fish Farms

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Fisheries and Oceans Canada Pêches et Océans Canada

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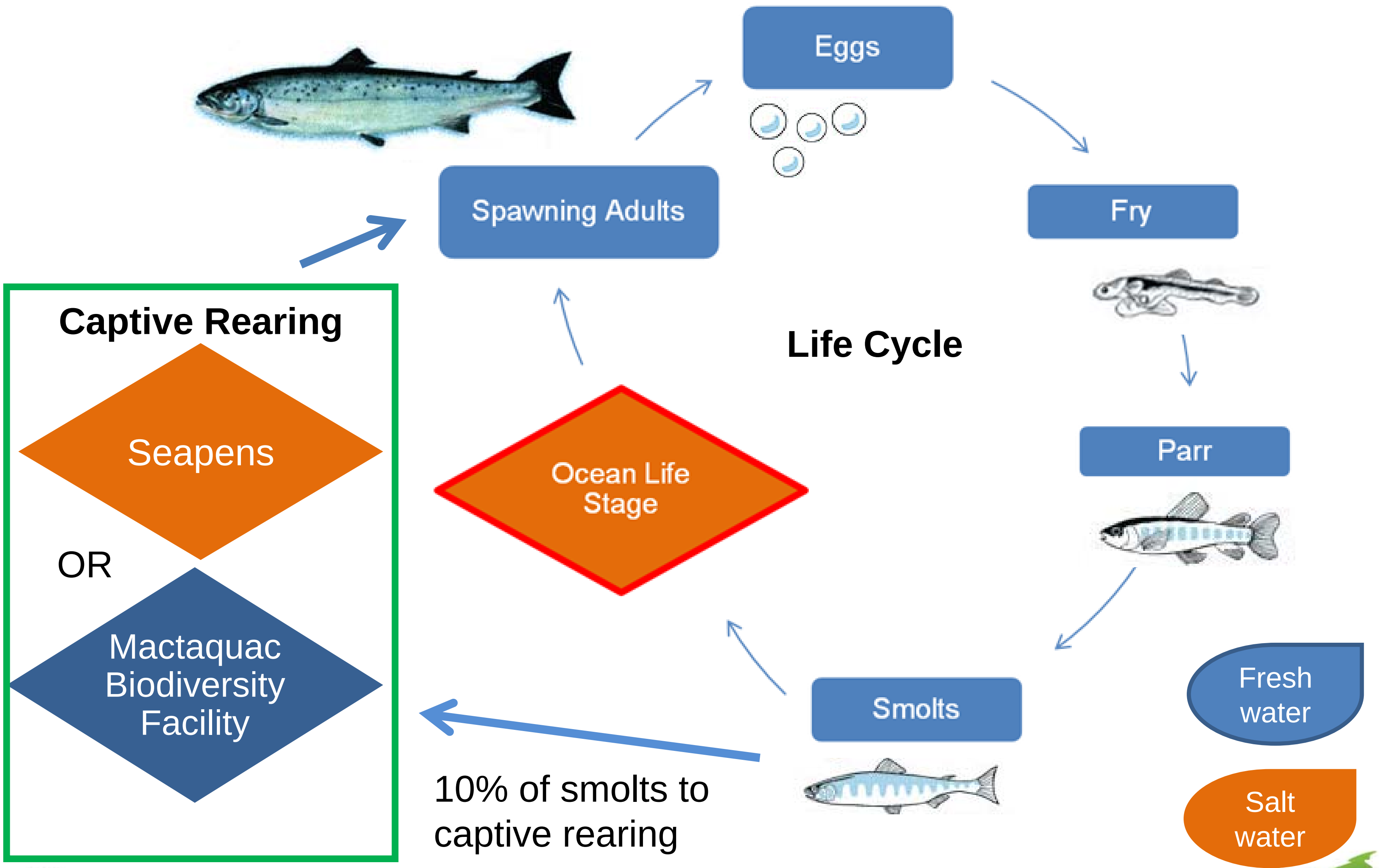
Memorial University

A new option...


Eggs
Fry
Parr
Smolts
Spawning Adults
Life Cycle
Ocean Life Stage
Captive Rearing
Seapens
OR
Mactaquac Biodiversity Facility
10% of smolts to captive rearing
Fresh water
Salt water

New Questions Were Asked

1) Most importantly, can we keep these guys alive in seapens?

2) If salmon were released in Fundy as fry or parr, then caught as smolts, which fish did better when raised in seapens?

3) Where (cage or biodiversity facility) do fish mature faster and/or have better spawning performance? Who resembles their wild counterparts?

4) Which fish have better homing abilities?

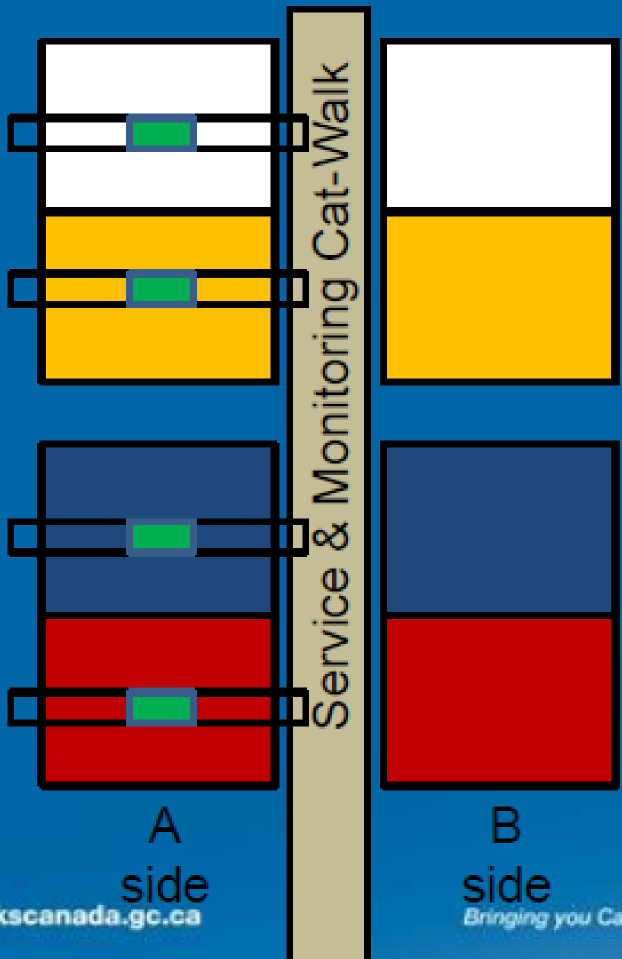
Project Highlights - 2010

- 1600 smolt into 4 sea pens
- Excellent, controlled conditions
- Daily mortality data collected
- Final inventory (Oct 22) included growth measures on all fish

End Result: Cage Rearing is possible!

The 2010 Admiral Research Pen System

Feeders used to duplicate feed regime in hatchery

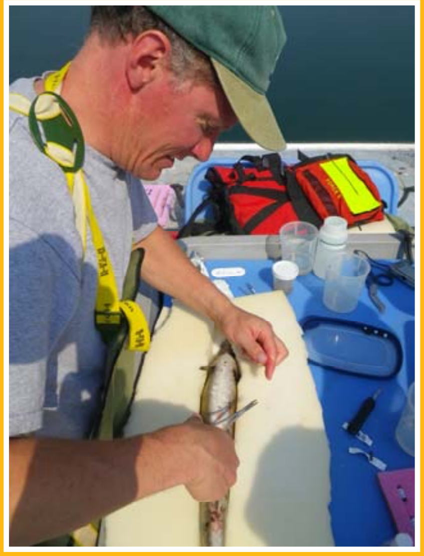


8 pens allowed 4 groups of ~ 400 smolt to be transferred from "A" to "B" side during monthly total inventories .

Answering the Questions...
Homing Study (2011)

(September 2011)

- 500 fish transported from St George, NB and released near Fundy National



- All fish had a visible external tag
- Some fish had implanted acoustic tags

Homing Study

Upper Salmon River

- 7 fish were seen
- 4 were from Bay release.

Point Wolfe River

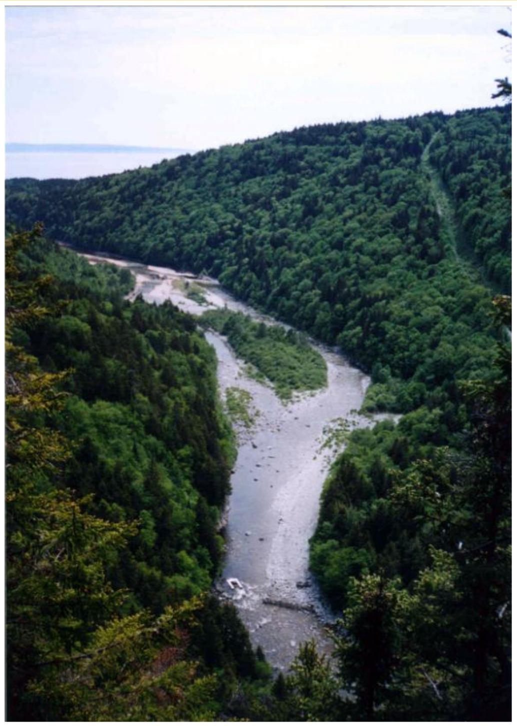
- 36 fish seen.
- 31 were from Bay release.

Acoustic Tracking

- Over half of tags detected at one receiver location.
- Fish come back to FNP and other rivers.

Estuary release (2011)

Adult fish released in the estuary of the Upper Salmon River.



Lots of fish came back – It worked!

• More than 40 adults picked up on the Upper Salmon River during fall 2012 snorkel surveys.

Represents the highest number of returns on this river in 20 years.

Great media coverage on the salmon returns

Fundy salmon show signs of return

CHRIS MORRIS
LEGISLATURE BUREAU

After years of decline to the point of almost disappearing, Atlantic salmon are making a tentative comeback in the inner Bay of Fundy.

In a project designed to restore the endangered and unique inner Bay strain of salmon, scientists at Fundy National Park have counted 40 fish in a park river – the most seen in the area in more than 20 years.

"They are preliminary results but they are very encouraging," Fundy National Park ecologist Dan Mazerolle said in an interview.

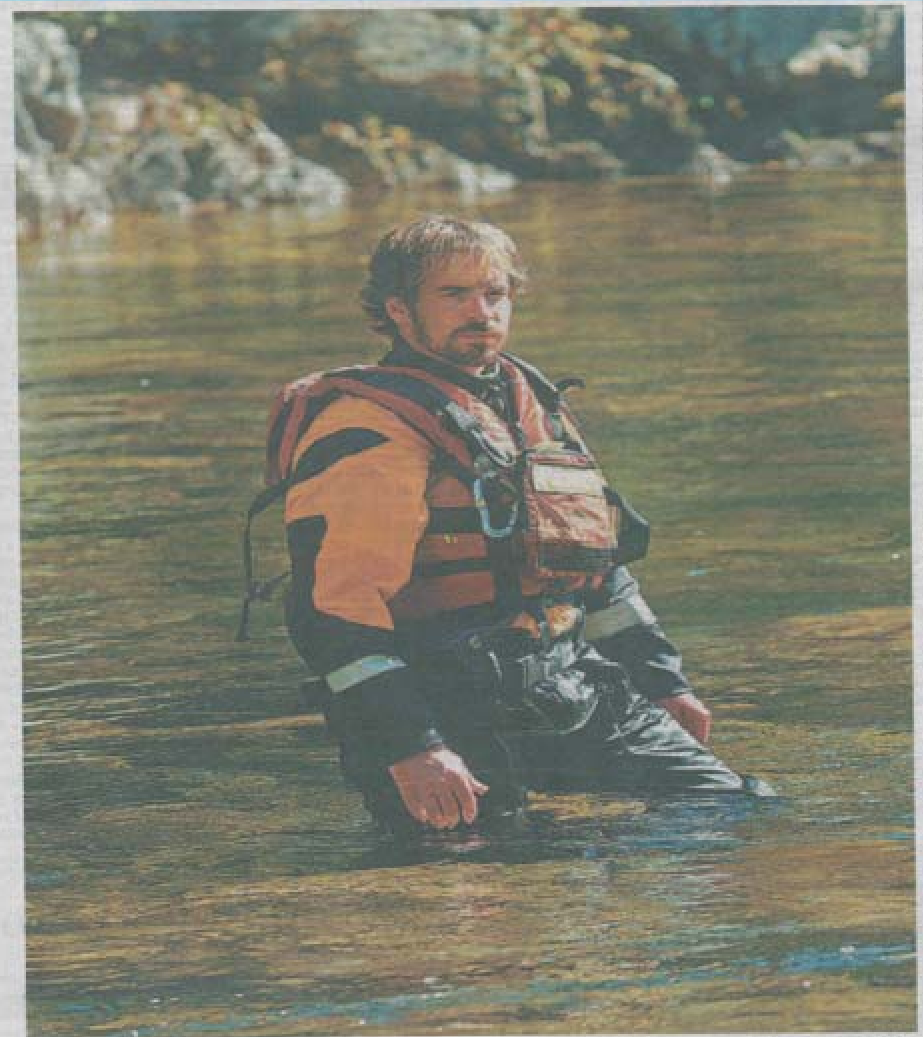
"We are all excited about the potential for these returning adults. ... Hopefully, we can finally turn the tide on these population declines."

The fish that showed up in Upper Salmon River this summer are the product of an innovative experiment designed to protect the salmon from a critical but deadly part of their own environment – the Bay of Fundy itself.

Mazerolle and project leader Corey Clarke said that for reasons that remain a mystery, the Atlantic salmon that head into the bay from the rivers of southern New Brunswick all too often fail to return.

"We really don't know

PLEASE SEE → SALMON, A3

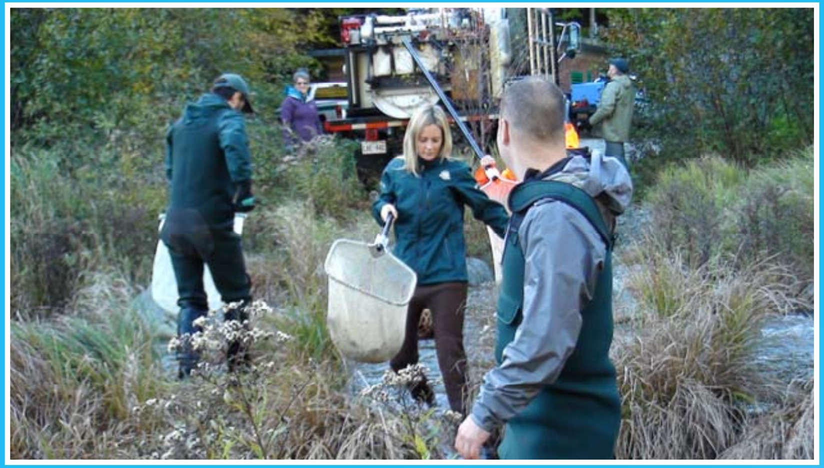


Corey Clarke, a Parks Canada resource conservation technician, is the project lead of a snorkel survey to look for pooling salmon in the Upper Salmon River. PHOTO: JAMIE ROACH/FOR THE TELEGRAPH-JOURNAL

Fall 2012 – More adult releases

Released 289 adult salmon
raised in sea pens by Admiral Fish Farm.

Released 124 adults raised
at the Mactaquac Biodiversity Facility.



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Thank-you

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Inner Bay of Fundy Atlantic Salmon — Fort Folly Habitat Recovery

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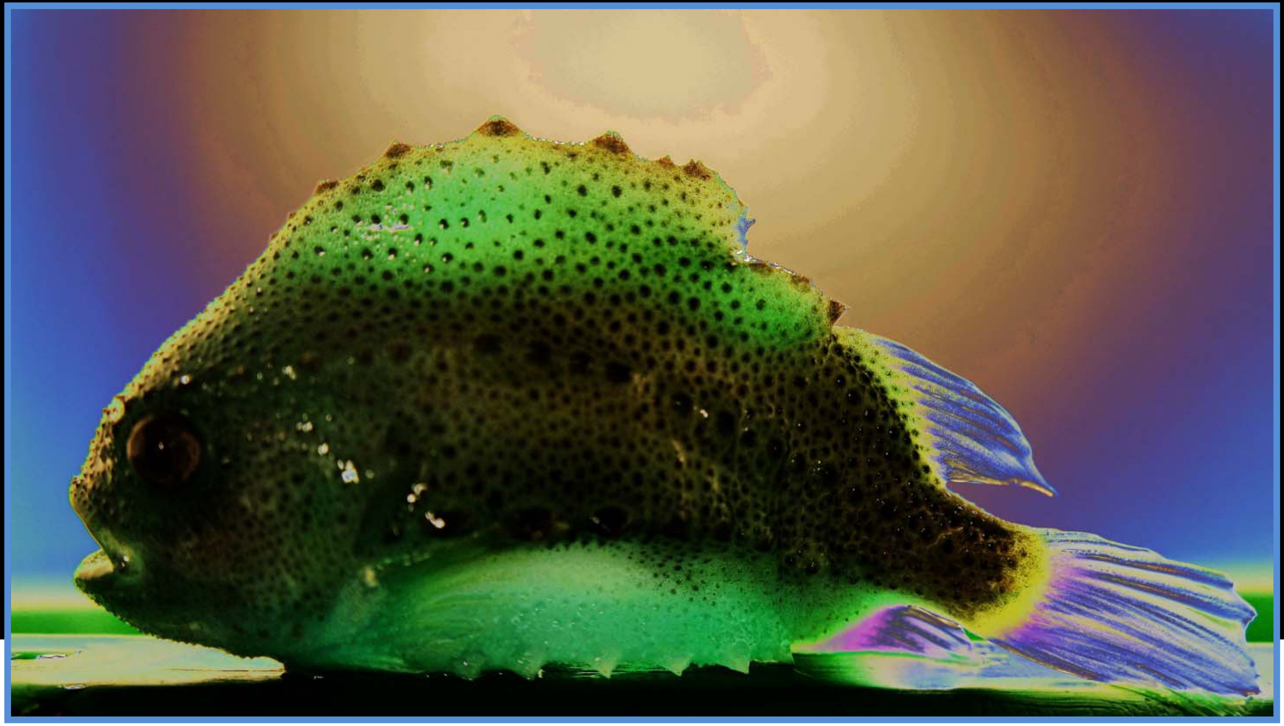
Canada



There's something about the lumpsuckers –

knowledge from initial trials in Norway

By: Nils Vestvik

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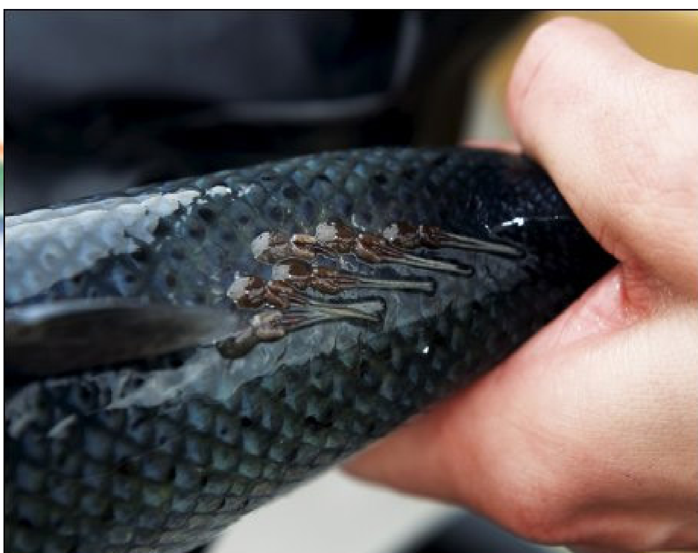
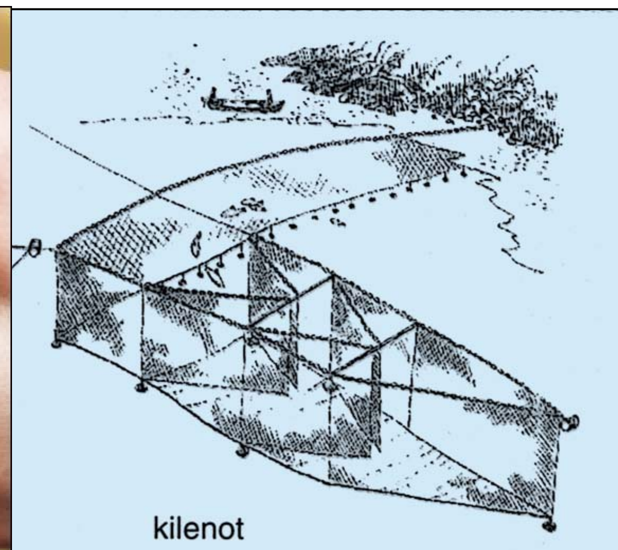
www.aqua-kompetanse.no

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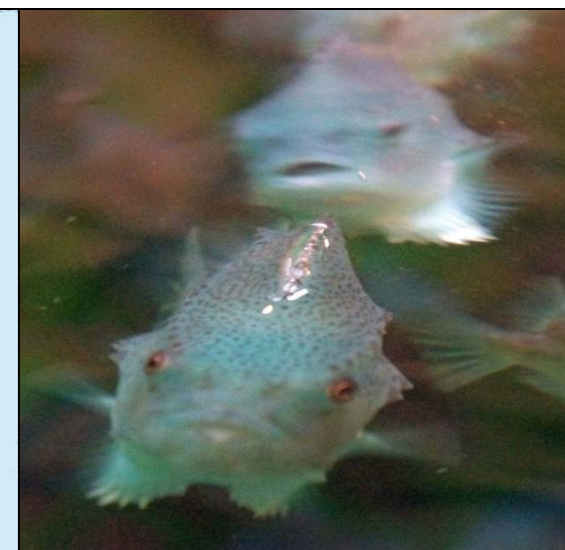


[redacted]

- No swim bladder
- Sustainable
  - Only broodstock fish being caught wild
  - Easy to domesticate?

Photo: Charlotte S. Norberg

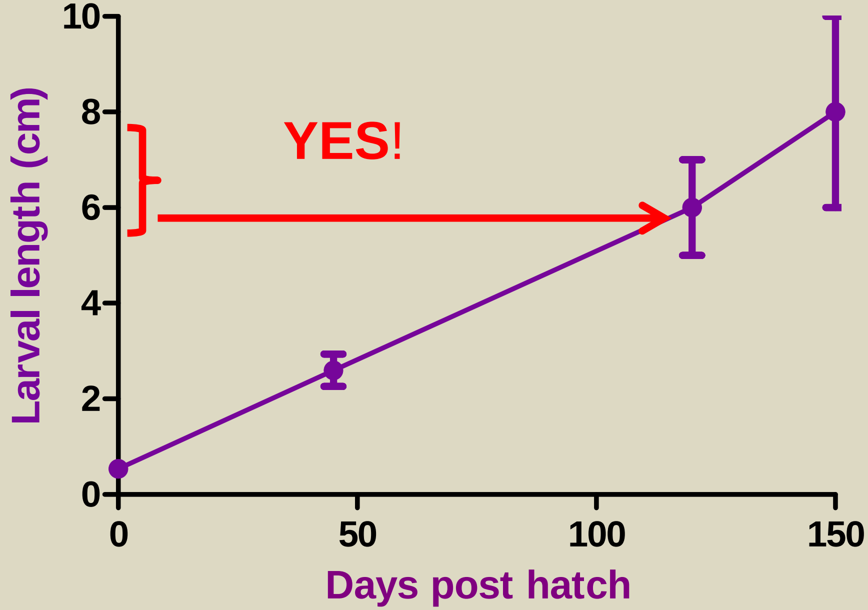
Photo: Ingrid Overrein

[redacted] feeding .

- Transition to dryfeed (Gemma micro, Skretting)

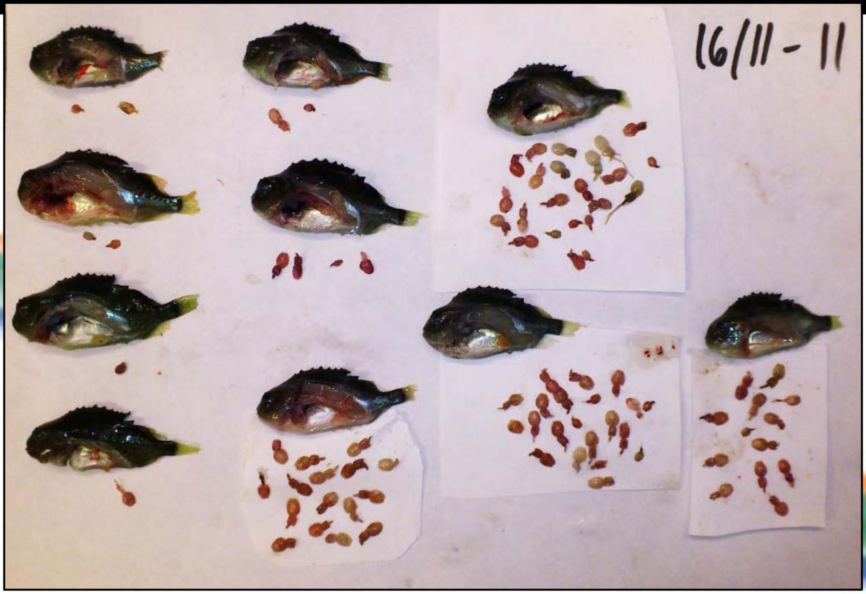
Or

- Directly on dryfeed.



Ingrid Overrein - Nordland Leppefisk Ltd.

- Larval mortality is negligible the first 2mths (3-5%)
- Rearing conditions must be optimised to the fish traits and tanks kept clean!
- Challenges: internal tank area, sorting, tank dynamics, counting, transportation, hygiene!



- The fish
  - 20 lumpsucker (5 cm)
  - 10 salmon (110 – 250g)
    - Approx. 10 lice per salmon
- Salmon and lumpsucker are best buds!
  - Lumpsucker hitchhiking on salmon
  - Salmon seems to be calmer
- **70 – 90% decrease of lice in 24 hours**
- Variation in appetite

- Personally responsible for 3 salmon sites containing lumpsuckers.
- Coordinating/participating on many different projects around Norway.
- Lice is almost always found when dissecting a certain number of fish.
  - Found winter and summer
  - Small and large salmon
  - One site followed since October 2011.

– 1 to 2 fish per 10 fish dissected.

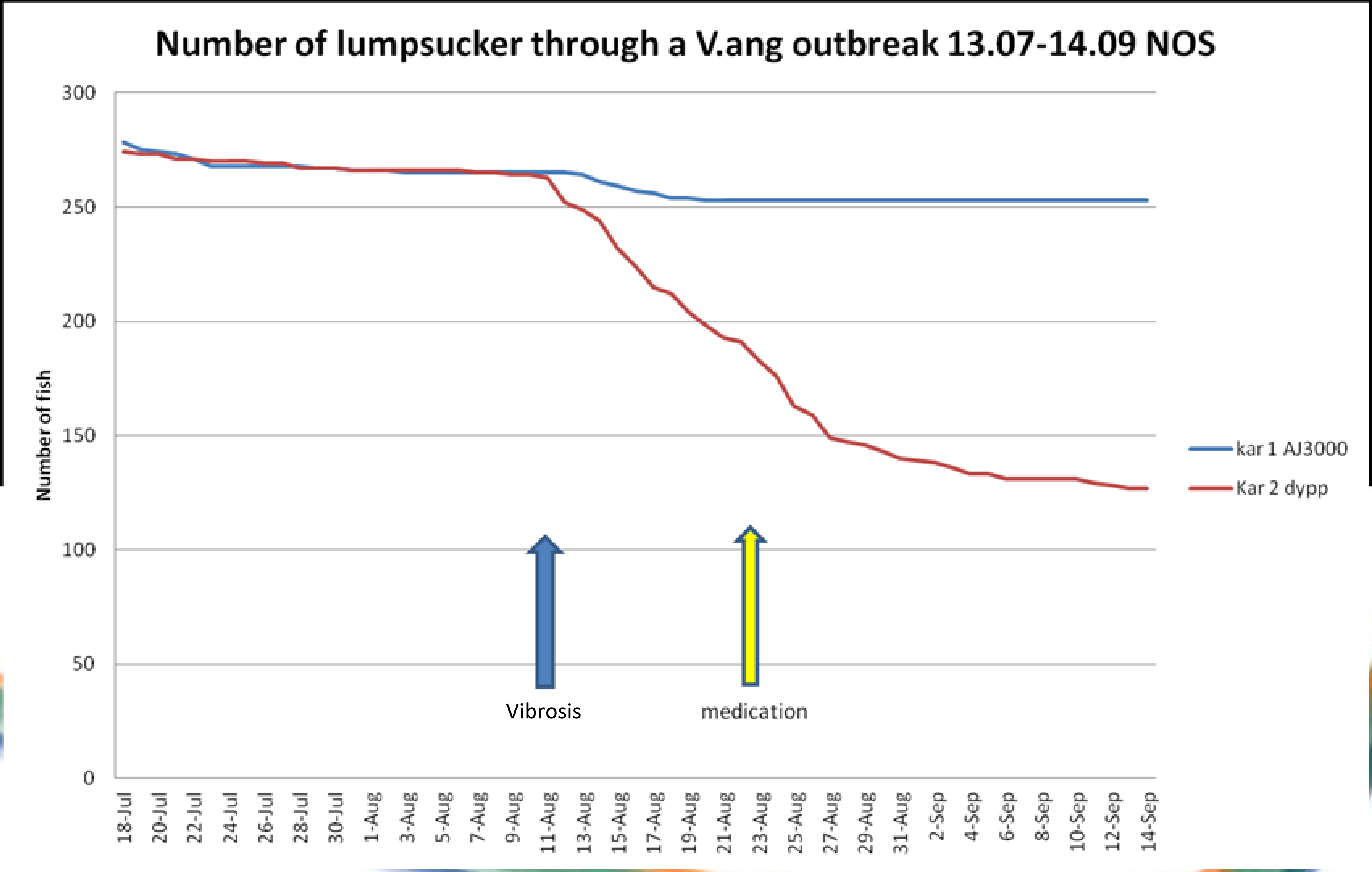
- Some individuals have eaten more than 150 lice.
  - Sea lice is decomposed in the lumpsucker in a couple of hours.

  - Difficulties in registration of deadfish in the early stages.
- Diseases
  - Vibriosis big problem in some land sites. Can also occur a couple of weeks after transfer to the fish cage or at high temperatures.

[redacted]

vaccines.

- PHARMAQ and UIB.
- Successful vaccination of small fish, seemingly good effect
- Antibody measurement hopefully before Christmas.


Number of lumpsucker through a V.ang outbreak 13.07-14.09 NOS
Number of fish
300
250
200
150
100
50
0
18-Jul
20-Jul
22-Jul
24-Jul
26-Jul
28-Jul
30-Jul
1-Aug
3-Aug
5-Aug
7-Aug
9-Aug
11-Aug
13-Aug
15-Aug
17-Aug
19-Aug
21-Aug
23-Aug
25-Aug
27-Aug
29-Aug
31-Aug
2-Sep
4-Sep
6-Sep
8-Sep
10-Sep
12-Sep
14-Sep
kar 1 AJ3000
Kar 2 dypp
Vibrosis
medication

[redacted]

Don’t hesitate to get in touch!

nils@aqua-kompetanse.no

Denaturation of Salmon Sea Lice Therapeutants from Well Boat Treated Seawater

ACFFA Workshop, St. Andrews, NB

November 14th, 2012

Leo Cheung, RPC

rpc Celebrating 50 Years

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RPC Research

- The ongoing therapeutant denautring research work is funded by the growers of the Aquaculture Industry through the Atlantic Canada Fish Farmers Association (ACFFA)

- This ongoing research at RPC is a joint effort involving the NB Department of Agriculture, Aquaculture, and Fisheries (DAAF), Fisheries and Oceans Canada (DFO), the FishVet Group, as well as the growers, suppliers and partners of the Aquaculture Industry

Introduction

- Sea lice attach to fish feeding on their mucus and tissue impacting the aquaculture industry significantly through the loss of fish
- One way industry controls sea lice infestation is through the use of chemical therapeutants (Alpha Max, Salmosan, Interox Paramove 50, etc.)
- Therapeutant treatment is done in either well boats or tarps

Sea Lice Attached to Salmon

Well Boat Treatments

- Well boats are used to pump fish from a cage into wells where they are treated with therapeutants
- Well boat reduce the quantity of therapeutant needed for treatment and improve their efficacy relative to tarp treatments

Well Boat Ronja Carrier, Cooke Aquaculture

Fish Holding Tank

Tarp Treatments

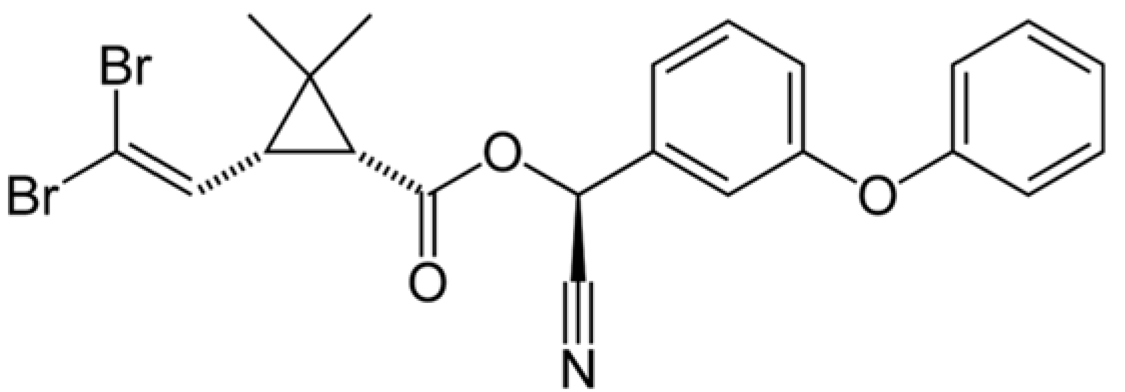
- Salmon cages are surrounded by temporary tarps and the fish are treated with therapeutants

Salmon Cages – New Brunswick

Salmon Cages

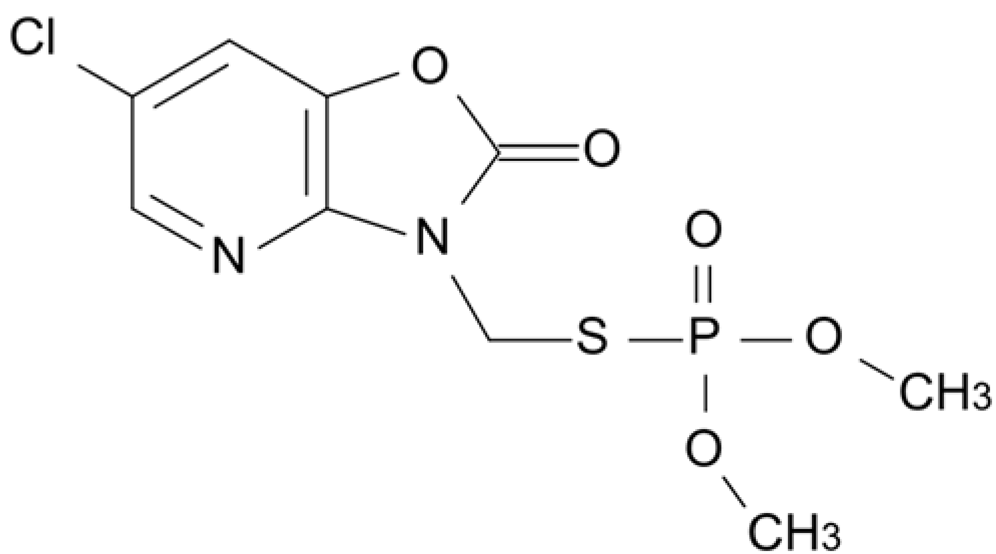
Alpha Max (Deltamethrin) – Pyrethroid pesticide

- blocking the transmission of impulses on its neural pathways



Salmosan (Azamethiphos) – Organophosphorus pesticide

- interfering with the transmission of nerve impulses



The Problem

- Once the therapeutant treatment is done, the wastewater containing the therapeutants is discharged into the ocean
- This has a potential negative impact on other species such as lobster, shrimp, and krill

The Answer

- Capture or destroy (chemical treatment) the active ingredients in the therapeutants before discharging the wastewater into the ocean

Chemical Treatment Research

- Chemical treatment of wastewaters from industrial processes and agriculture as well as treatment of drinking water to remove pesticides has been done for many years.
- Most treatments utilize oxidation chemicals
- RPC research is focusing on investigating the affect of ozone, hydrogen peroxide, and Fenton's Reagent

Chemical Oxidation Reagents

Hydrogen Peroxide (H_2O_2) – 1.8V

By-products – $H_2O + O_2$

Fenton's Reagent ($Fe^{2+/3+}$ & H_2O_2) – 2.8V

(1) $Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^- + OH\cdot$

(2) $Fe^{3+} + H_2O_2 \rightarrow Fe^{2+} + OOH\cdot + H^+$

$OH\cdot$ – Hydroxyl radicals breakdown organics

By-products – Iron Oxide Precipitate

Chemical Oxidation By-products

Alpha Max (Deltamethrin) –

$C_{22}H_{19}Br_2NO_3 \rightarrow H_2O + CO_2 +$ Mineral Salts

Salmosan (Azamethiphos) –

$C_9H_{10}ClN_2O_5PS \rightarrow H_2O + CO_2 +$ Mineral Salts

General Bench Scale Procedure

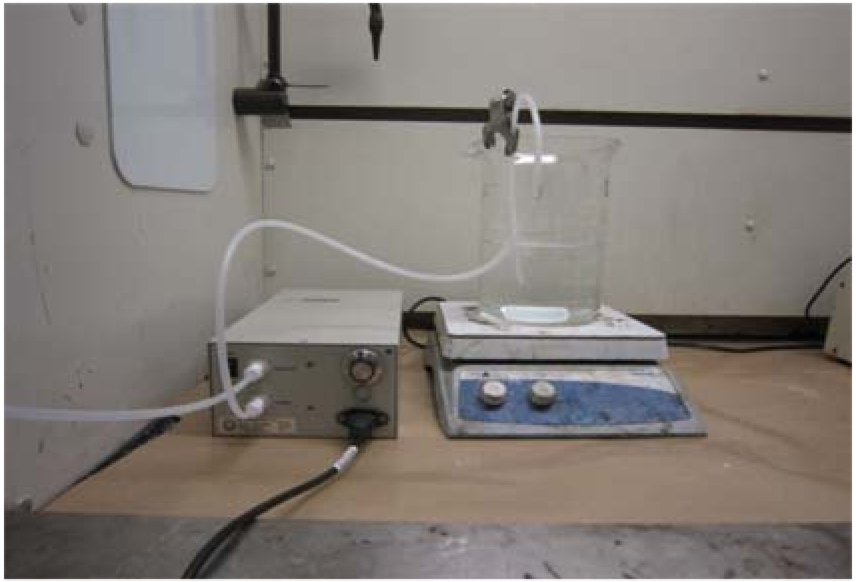
- Seawater spiked with 2ppb Deltamethrin (Alpha Max) or 150 ppb Azamethiphos (Salmosan) is mixed in a beaker on a hot plate/stirrer
- Oxidizing chemicals are added and stirred for up to 30 minutes
- Dichloromethane (DCM) solvent is used to extract the residual deltamethrin or azamethiphos immediately after the chemical treatment from the seawater for analysis

Chemical Treatment

Fenton’s Reagent

Hydrogen Peroxide

Chemical Treatment



Ozone Apparatus

Deltamethrin (Alpha Max)
Chemical Denaturing Tests

- Hydrogen Peroxide (H_2O_2 - Interox Paramove 50)
- Ozone
- Fenton's Reagents (H_2O_2 + Fe^{2+}/Fe^{3+}) – Iron Precipitation Vs No Precipitation

Deltamethrin Test Results

- Hydrogen Peroxide (Interox Paramove 50)

Chemical	Dosage (ppm)	Reaction Time (min)	Reduction (%)
H_2O_2	1500	30	72
H_2O_2	3000	30	75
H_2O_2	6000	30	76

Deltamethrin Test Results

- Ozone (O_3)

Chemical	Dosage (ppm)	Reaction Time (min)	Reduction (%)
O_3	0.3	30	45
O_3	>2	30	100

Effective Denaturing – Fish are sensitive to O_3 level above 0.005 ppm

Deltamethrin Test Results

- Various type of Fenton's Reagent ($H_2O_2 + Fe^{2+}/Fe^{3+}$)

Chemical	Iron Compounds	Precipitate	Reduction (%)
$H_2O_2 + Fe^{3+}$	Ferric Citrate	None	65
$H_2O_2 + Fe^{3+}$	Ferric Sodium EDTA	None	59
$H_2O_2 + Fe^{2+}$	Ferrous Sulphate	Iron Oxide	57

$H_2O_2 + Fe^{2+}/Fe^{3+}$ @ 100ppm + 1ppm

Deltamethrin Test Results

- Fenton's Reagent ($H_2O_2 + Fe^{3+}$) – Soluble Products

Chemical	Iron Compounds	Dosage (ppm)	Reduction (%)
$H_2O_2 + Fe^{3+}$	Ferric Citrate	100 + 1	65
$H_2O_2 + Fe^{3+}$	Ferric Citrate	250 + 1	62
$H_2O_2 + Fe^{3+}$	Ferric Citrate	500 + 1	66
$H_2O_2 + Fe^{3+}$	Ferric Citrate	1000 + 1	74
$H_2O_2 + Fe^{3+}$	Ferric Citrate	1500 + 1	78

Fenton's Reagent (Ferric Citrate) – No Immediate Precipitate in Treated Seawater

Deltamethrin Test Results

- Fenton's Reagent ($H_2O_2 + Fe^{2+}$) – Combined Denaturing and Adsorption

Chemical	Iron Compounds	Dosage (ppm)	Reduction (%)
$H_2O_2 + Fe^{2+}$	Ferrous Sulphate	100 + 1	75
$H_2O_2 + Fe^{2+}$	Ferrous Sulphate	300 + 1	75
$H_2O_2 + Fe^{2+}$	Ferrous Sulphate	500 + 1	87
$H_2O_2 + Fe^{2+}$	Ferrous Sulphate	1000 + 1	96

Iron Oxide Precipitate – Adsorbent
Deltamethrin adsorbed into the Insoluble Iron Oxide Precipitate By-product

Deltamethrin Test Results

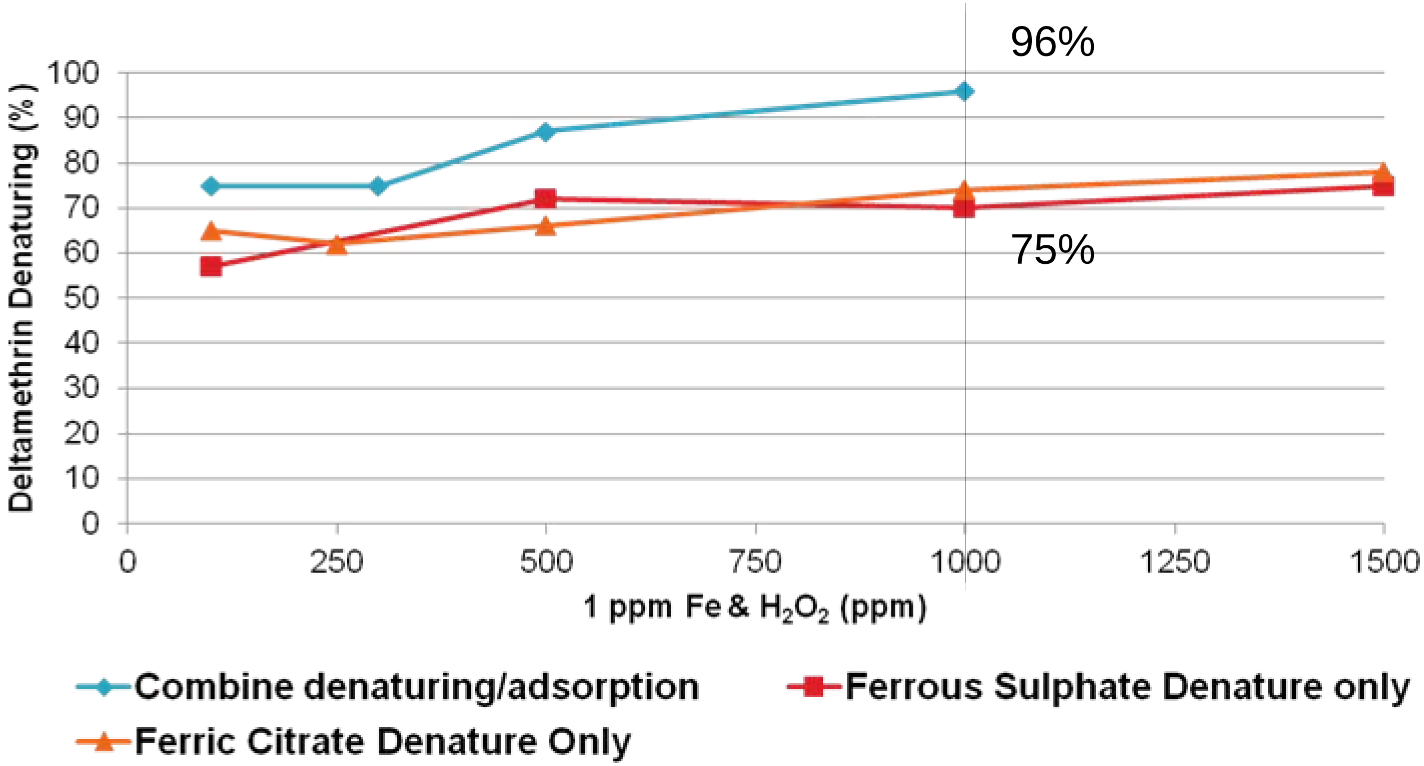
- Fenton's Reagent ($H_2O_2 + Fe^{2+}$) – Denaturing Only

Chemical	Iron Compounds	Dosage (ppm)	Reduction (%)
$H_2O_2 + Fe^{2+}$	Ferrous Sulphate	100 + 1	57
$H_2O_2 + Fe^{2+}$	Ferrous Sulphate	500 + 1	72
$H_2O_2 + Fe^{2+}$	Ferrous Sulphate	1000 + 1	70
$H_2O_2 + Fe^{2+}$	Ferrous Sulphate	1500 + 1	75

Extracted Deltamethrin immediately after reaction

Deltamethrin Test Results

- Fenton's Reagent



Deltamethrin Degradation Tests

- 96% Deltamethrin Removal
- 75% Denatured by Fenton's Reaction
- 21% Adsorbed by Fenton's Reaction Iron Oxide By-product
- Potential Deltamethrin release if no post treatment
- Bio-degradability

Deltamethrin Degradation Tests

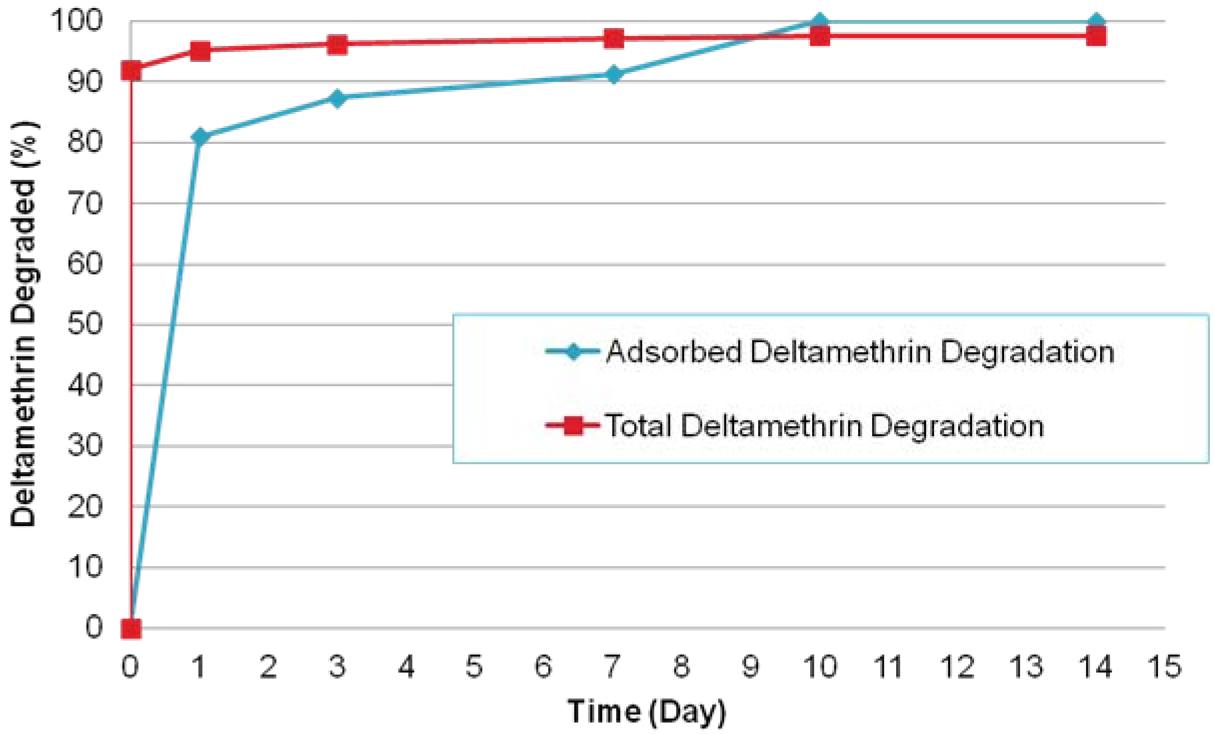
- Fenton's Reagent (H_2O_2 + Fe^{2+}) Chemical Oxidation Treatment Tests
  - 10X concentration (20ppb Deltamethrin/1000ppm H_2O_2/10ppm Fe^{2+})
  - 30 minute reaction time
  - 14 days degradation measurement of deltamethrin
  - Sampled 1/10th of the treated seawater at day 1, 3, 7, 10, 14

Degradation Test Results

- Fenton's Reagent (H_2O_2 + Fe^{2+}) Chemical Oxidation Treatment Degradation Test Results
  - 92.0% Deltamethrin Denatured
  - 5.7% Deltamethrin Adsorbed by Iron Oxide Precipitate
  - 97.7% Total Deltamethrin Denature/Removed

Degradation Test Results

- Deltamethrin Degradation



Degradation Extrapolated Results

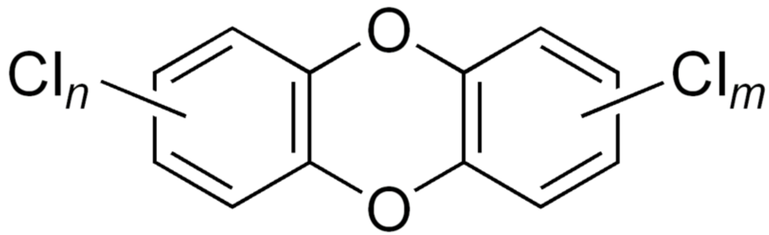
- Degradation Test Results at Fenton's (1ppm Fe^{2+}/1000ppm H_2O_2)
  - Total Deltamethrin removal from seawater = 96%

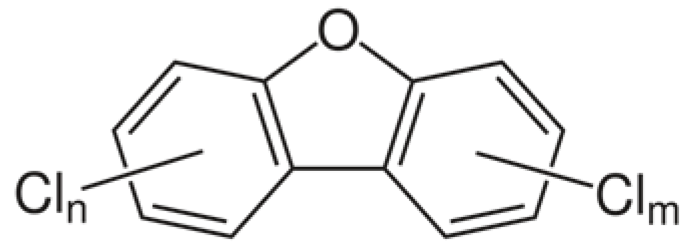
- Extrapolated Results
  - 75% Deltamethrin denatured & 21% adsorbed (96%)
  - 1% Deltamethrin released within 1 day
  - 20% Adsorbed Deltamethrin degraded in 7 – 10 days

- The 96% Deltamethrin removed stayed bound to the iron oxide by-product (did not release back into the seawater)

Dioxin Analysis

- Dioxin analysis was done due to the presence of a diphenyl group in Deltamethrin and the chloride present in seawater





- 10x the normal concentration – by-product peaks more pronounced
- High Resolution Mass Spectrometry
- Result: No evidence for production of Dioxin by destructive oxidation of Deltamethrin in sea water

Denatured Product Characterization

- Fenton's Reagent Tests on Spiked 2ppb Deltamethrin concentration in seawater

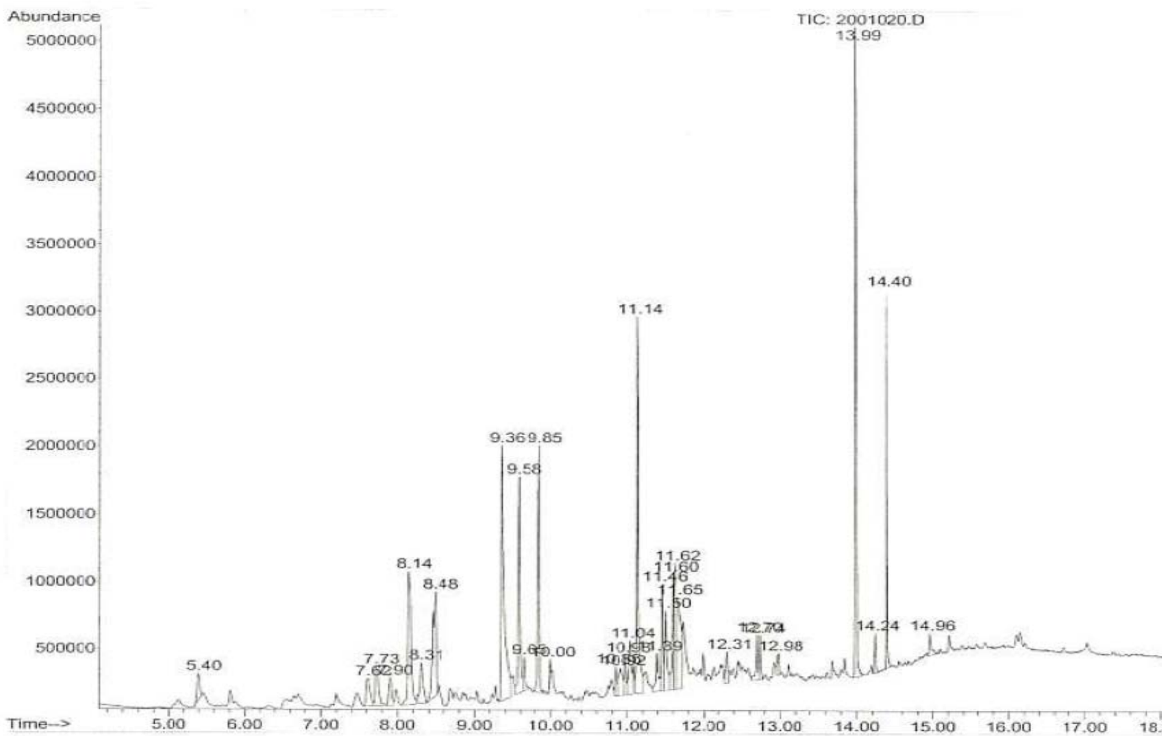
- Fenton's Reagent dosage (Fe^{2+}/H_2O_2 = 1ppm/1000ppm)

- Gas Chromatography/Mass Selective Detection (GCMS) General Scan used to identify solvent extractable compounds

- Detected compounds identified using a mass spectral library

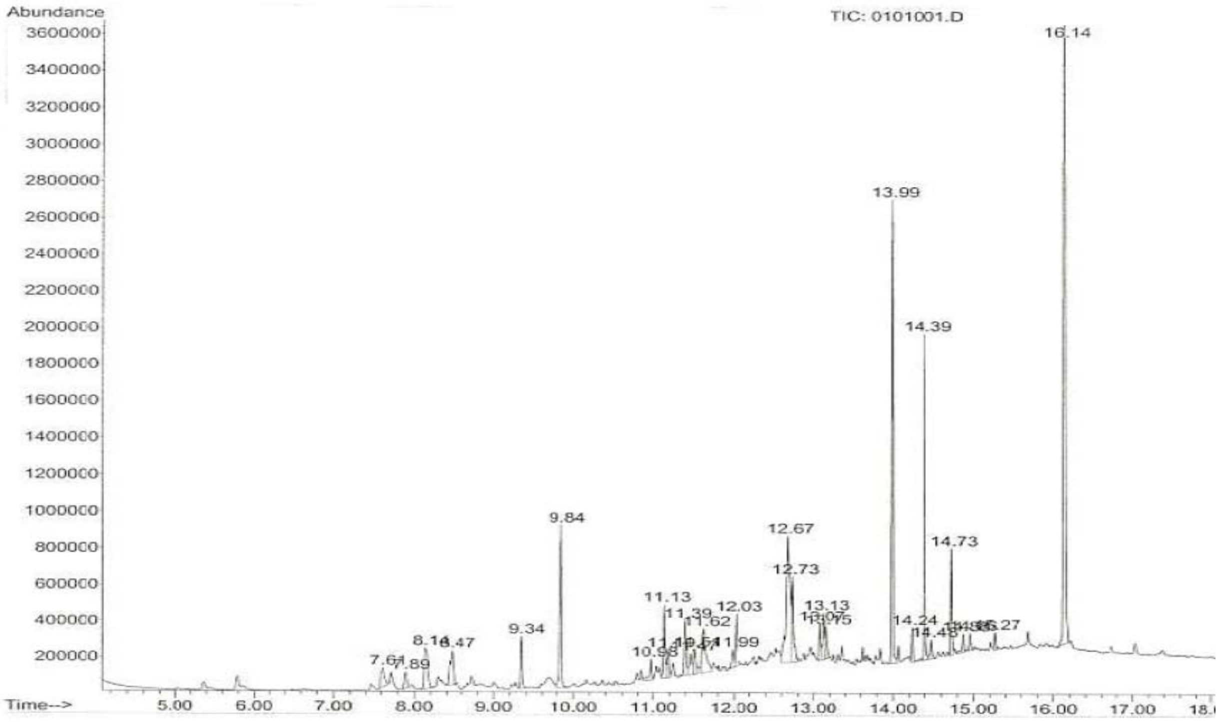
Denatured Product Characterization

- GC/MS Chromatogram (1000 ppm H_2O_2, 1 ppm Fe – Fenton's only as Control)



Denatured Product Characterization

- GC/MS Chromatogram (2ppb Deltamethrin, 1000 ppm H_2O_2, 1ppm Fe – Actual Treatment)



Denatured Product Characterization

- No harmful by-products were produced

Deltamethrin (Alpha Max)
Conclusion

- Optimum Treatment Conditions –
  - Fenton's Reagents (1000ppm H_2O_2 + 1 ppm Fe^{2+})
  - Reaction Time (30 minutes)
  - No Filtration
- Fenton's Denature/Adsorption Treatment
  - 96% Deltamethrin Removal/Reduction
  - No Dioxin formation
  - No harmful denature by-products

Deltamethrin (Alpha Max) Recommendations

- Toxicity testing of the iron oxide by-product
- Follow with Well Boat Field Trials

Azamethiphos (Salmosan)
Chemical Denaturing Tests

- Hydrogen Peroxide (H_2O_2 - Interox Paramove 50)

- Fenton's Reagents (H_2O_2 + Fe^{2+}/Fe^{3+})
  - Ferrous Sulphate
  - Ferric Citrate
  - Ferric EDTA

Azamethiphos Test Results

- Hydrogen Peroxide (Interox Paramove 50)

Chemical	Dosage (ppm)	Reaction Time (min)	Reduction (%)
H_2O_2	100	30	51
H_2O_2	500	30	61
H_2O_2	1000	30	66
H_2O_2	1500	30	78

Spiked Makeup Azamethiphos Concentration Treated = 150ppb

Azamethiphos Test Results

- Fenton's Reagent ($H_2O_2 + Fe^{2+}$) – Combined Denaturing and Adsorption

Chemical	Iron Compounds	Dosage (ppm)	Reduction (%)
$H_2O_2 + Fe^{3+}$	Ferrous Sulphate	100 + 1	51
$H_2O_2 + Fe^{3+}$	Ferrous Sulphate	500 + 1	67
$H_2O_2 + Fe^{3+}$	Ferrous Sulphate	1000 + 1	68
$H_2O_2 + Fe^{3+}$	Ferrous Sulphate	1500 + 1	75

Spiked Makeup Azamethiphos Concentration Treated = 150ppb

Azamethiphos Test Results

- Fenton's Reagent ($H_2O_2 + Fe^{3+}$) – Denaturing Only

Chemical	Iron Compounds	Dosage (ppm)	Reduction (%)
$H_2O_2 + Fe^{3+}$	Ferric Citrate	100 + 1	34
$H_2O_2 + Fe^{3+}$	Ferric Citrate	500 + 1	51
$H_2O_2 + Fe^{3+}$	Ferric Citrate	1000 + 1	58
$H_2O_2 + Fe^{3+}$	Ferric Citrate	1500 + 1	65

Spiked Makeup Azamethiphos Concentration Treated = 150ppb

Azamethiphos Test Results

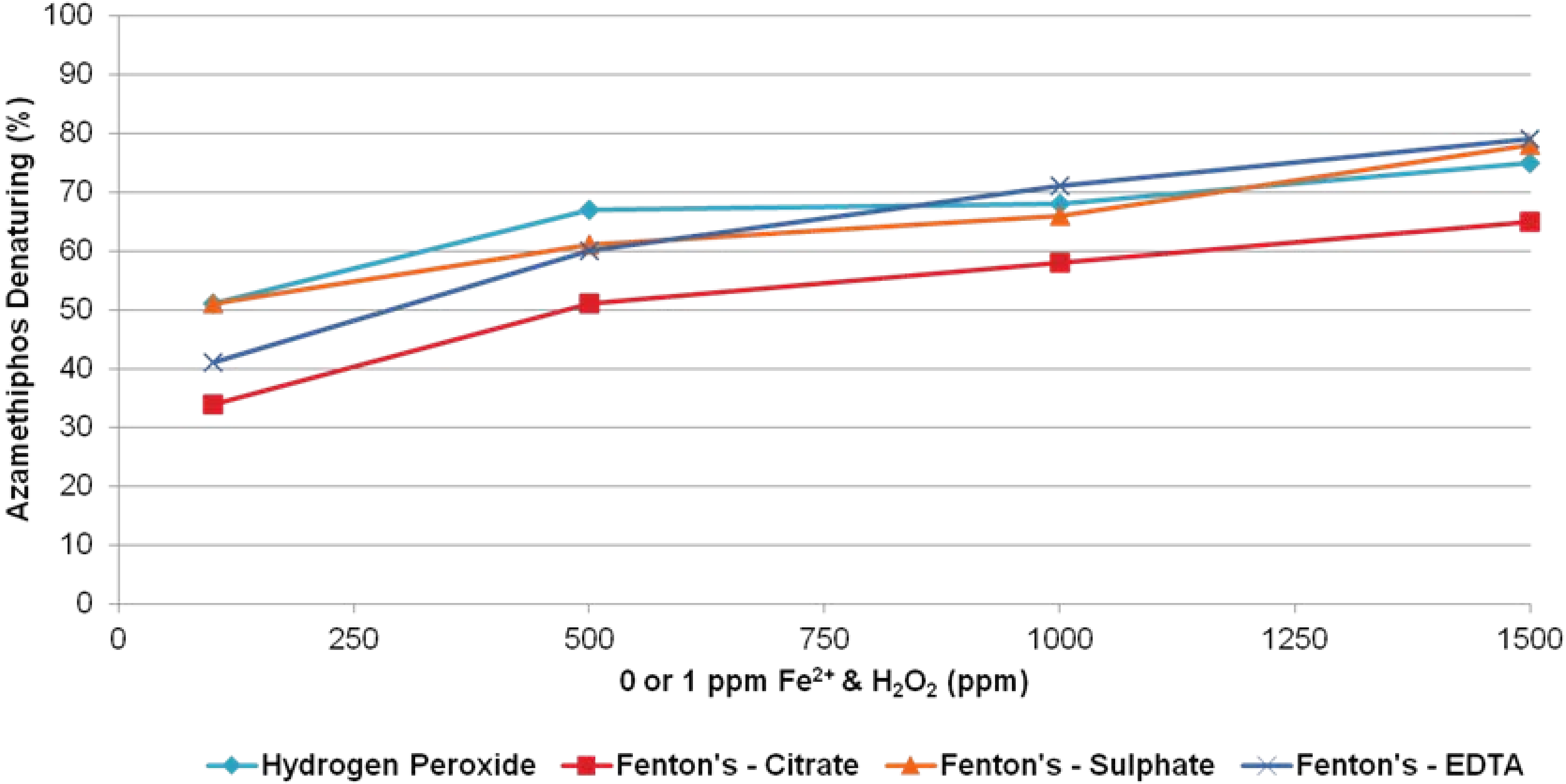
- Fenton's Reagent ($H_2O_2 + Fe^{3+}$) – No Precipitate

Chemical	Iron Compounds	Dosage (ppm)	Reduction (%)
$H_2O_2 + Fe^{3+}$	Ferric EDTA	100 + 1	41
$H_2O_2 + Fe^{3+}$	Ferric EDTA	500 + 1	60
$H_2O_2 + Fe^{3+}$	Ferric EDTA	1000 + 1	71
$H_2O_2 + Fe^{3+}$	Ferric EDTA	1500 + 1	79

Spiked Makeup Azamethiphos Concentration Treated = 150ppb

Azamethiphos Test Results

- Hydrogen Peroxide only & Fenton's Reagent



Azamethiphos Test Results

- Fenton's Reagent ($H_2O_2 + Fe^{2+}$)

Chemical	Iron Compounds	Dosage (ppm)	Filtered	Reduction (%)
$H_2O_2 + Fe^{2+}$	Ferrous Sulphate	1500 + 1	No	75
$H_2O_2 + Fe^{2+}$	Ferrous Sulphate	1500 + 1	Yes	71
$H_2O_2 + Fe^{3+}$	Ferric Sulphate	1500 + 1	No	53
$H_2O_2 + Fe^{3+}$	Ferric Sulphate	1500 + 1	Yes	58
$H_2O_2 + Fe^{3+}$	Ferric Chloride	1500 + 1	No	62
$H_2O_2 + Fe^{3+}$	Ferric Chloride	1500 + 1	Yes	72

Spiked Makeup Azamethiphos Concentration Treated = 150ppb

Azamethiphos Test Results

- Hydrogen Peroxide gave the best results
  - Denatured 78% Azamethiphos

- Fenton's Reagent (H_2O_2 + Fe^{2+}) did not adsorb any significant amount of Azamethiphos
  - Denatured/Adsorbed 75% Azamethiphos

Dioxin Analysis

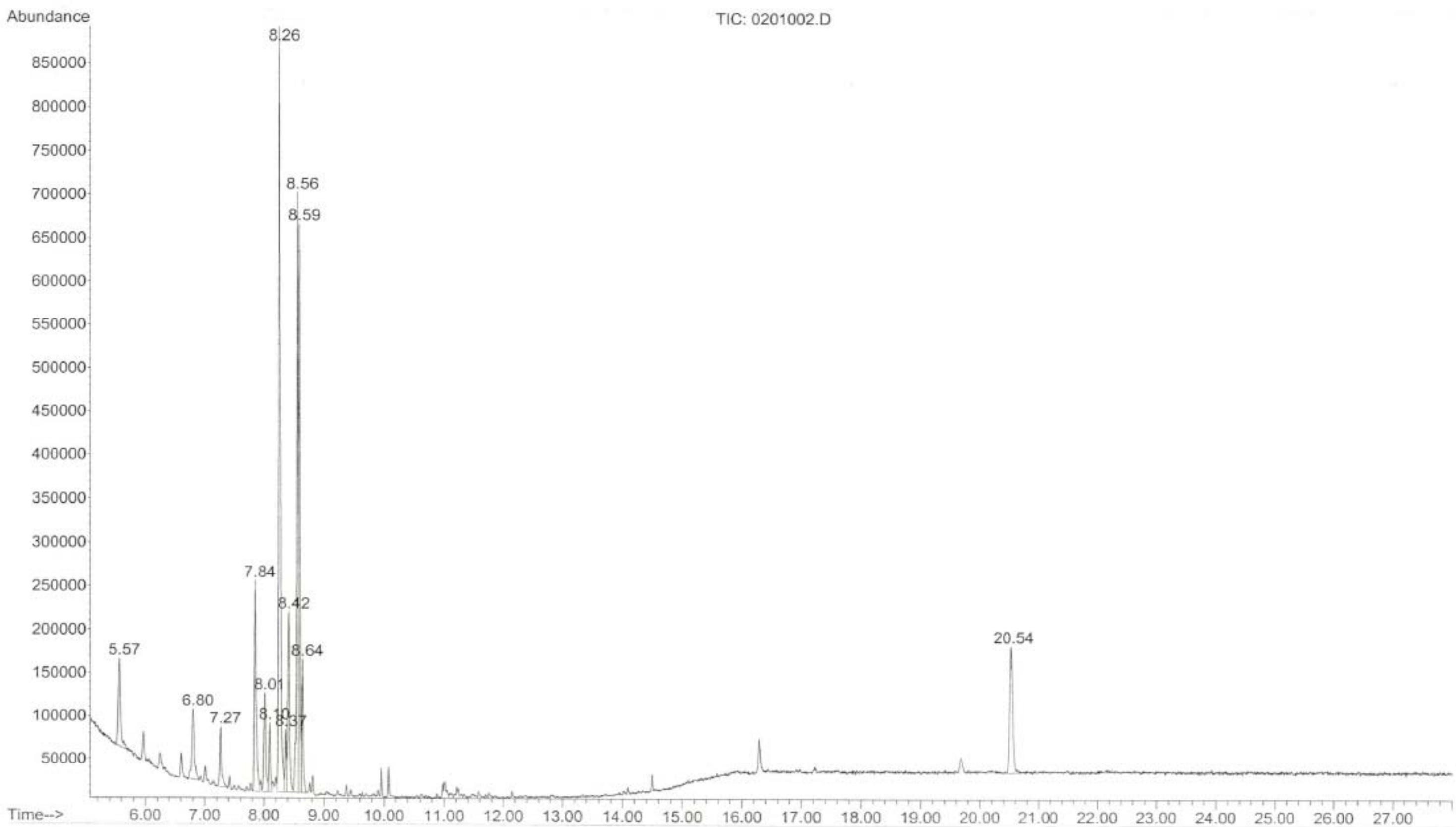
- No Dioxin formation is expected as there is no diphenyl group in Azamethiphos

Denatured Product Characterization

- Hydrogen Peroxide Tests on Spiked 150ppb Azamethiphos in seawater
- Hydrogen Peroxide (H_2O_2) - 1500ppm (Best)
- Gas Chromatography/Mass Selective Detection (GCMS) General Scan used to identify solvent extractable compounds
- Detected compounds identified using a mass spectral library

Denatured Product Characterization

- GC/MS Chromatogram (1500 ppm H_2O_2) – Background



Denatured Product Characterization

- GC/MS Chromatogram (150ppb Azamethiphos, 1500 ppm H_2O_2) – Treated

Azamethiphos (Salmosan)
Conclusion

- Fenton's Reagent (Not Very Effective)
- Best Treatment Option (to date)
  - Hydrogen Peroxide (1500ppm H_2O_2)
- No Dioxin formation
- No harmful by-products

Azamethiphos (Salmosan)
Recommendations

- Well Boat Field Trials for H_2O_2
- Work is still in progress to look at other options for further improvement

Acknowledgement

- Thank the ACFFA for the opportunity to present our denaturing research work during the annual workshop

- Thank Ross Gilders and Matthew Ness (RPC) for providing their valuable inputs in this presentation

Thank You For Your Attention

Questions

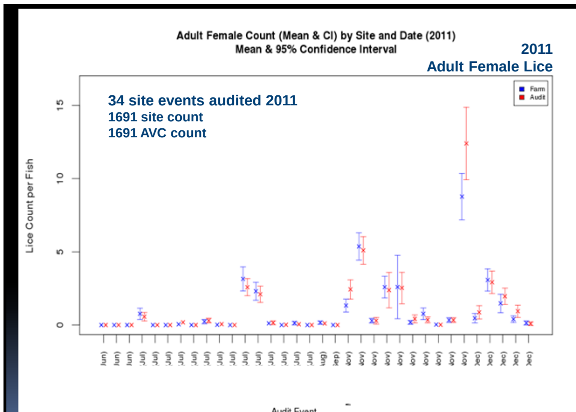
SEA LICE UPDATE

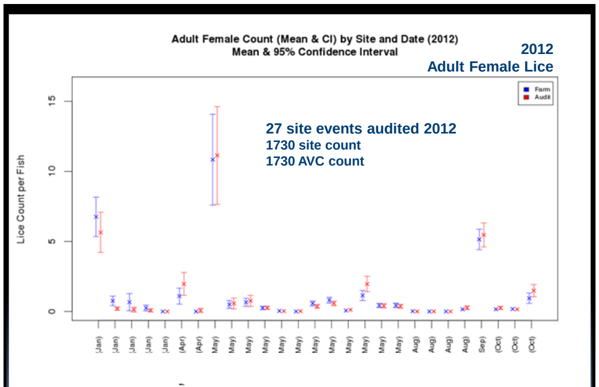
NB INDUSTRY TRENDS & COMPARISONS

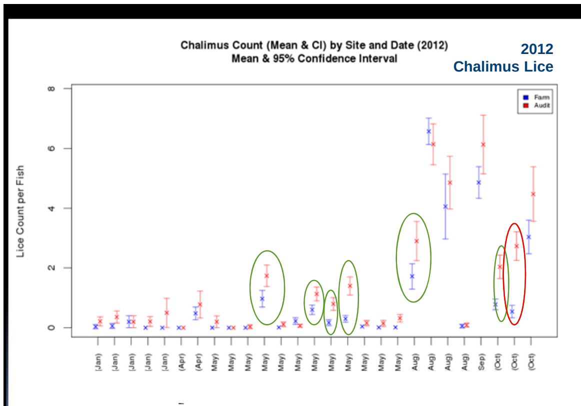
Larry Hammell
Professor, Dept of Health Management
Director, AVC Centre for Aquatic Health Sciences
Innovation (PEI) Research Chair, Aquatic Epidemiology

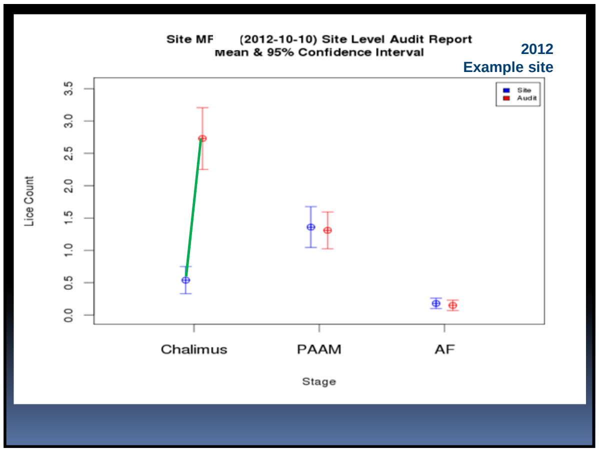
outline

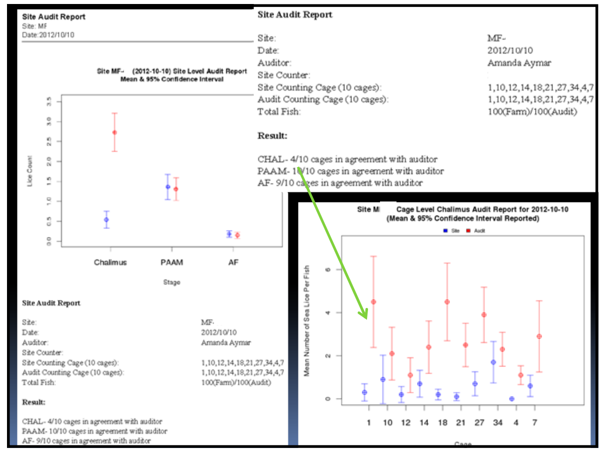
- Decision Support System (DSS) data input by industry (and AVC)
- Verification of industry data (audits)
- Training
- Sea lice trends industry-wide and some more detailed examples
- Sea lice treatment monitoring (focus on market year fish)
- Concluding remarks about industry lice patterns and treatments

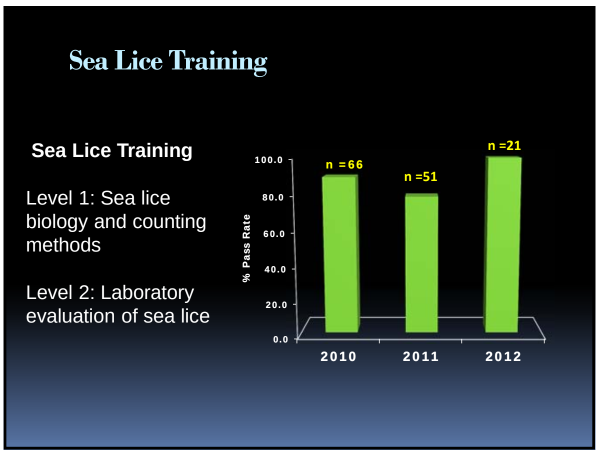


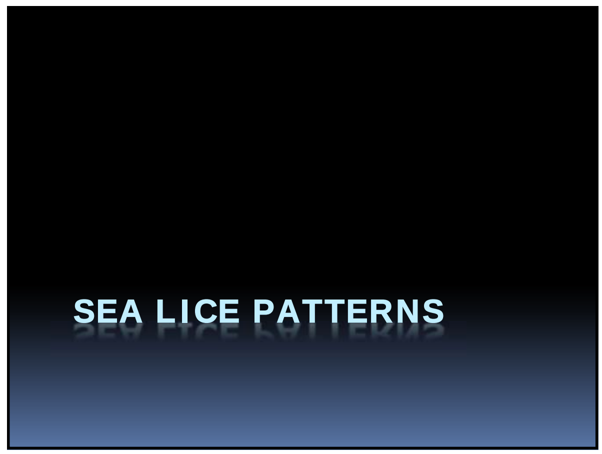


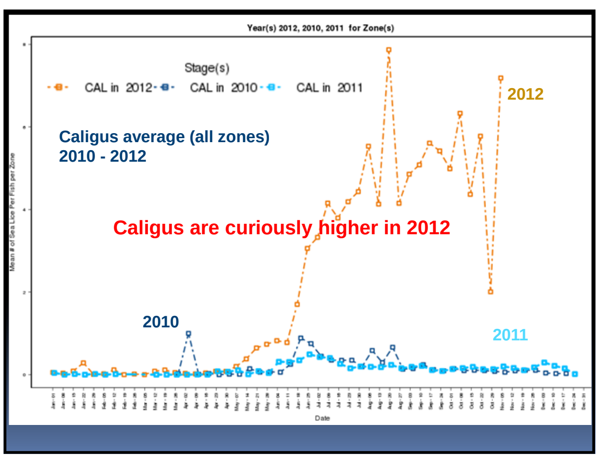


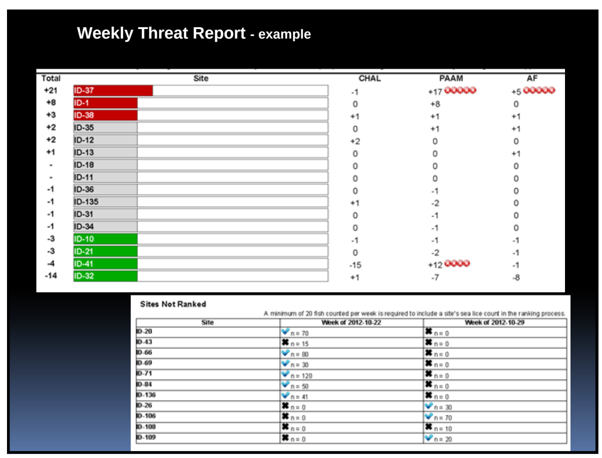










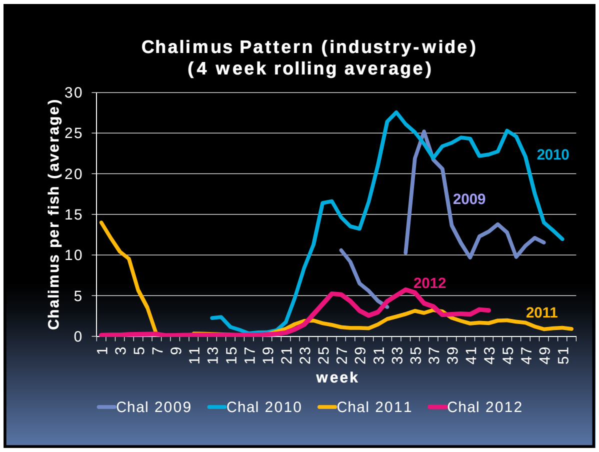


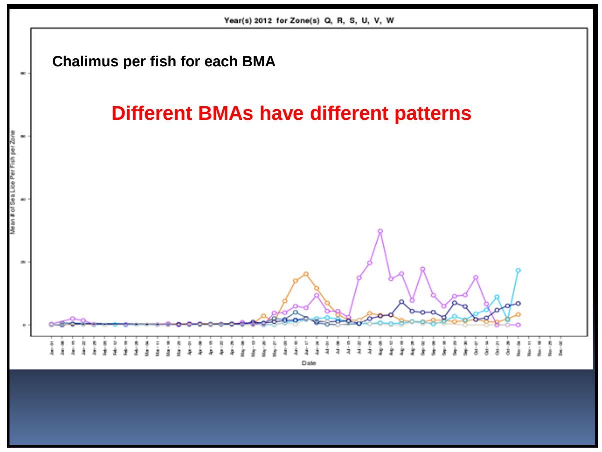
Total	Site	CHAL	PAAM	AF
+21	ID-37	-1	+17	+5
+8	ID-1	0	+8	0
+3	ID-38	+1	+1	+1
+2	ID-35	0	+1	+1
+2	ID-12	+2	0	0
+1	ID-13	0	0	+1
-	ID-18	0	0	0
-	ID-11	0	0	0
-1	ID-36	0	-1	0
-1	ID-135	+1	-2	0
-1	ID-31	0	-1	0
-1	ID-34	0	-1	0
-3	ID-10	-1	-1	-1
-3	ID-21	0	-2	-1
-4	ID-41	-15	+12	-1
-14	ID-32	+1	-7	-8

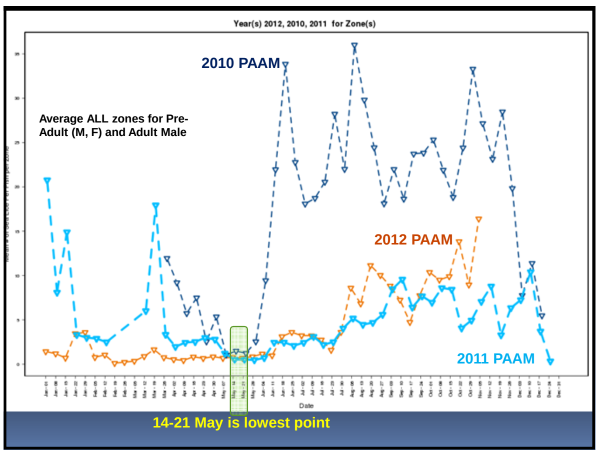
Sites Not Ranked

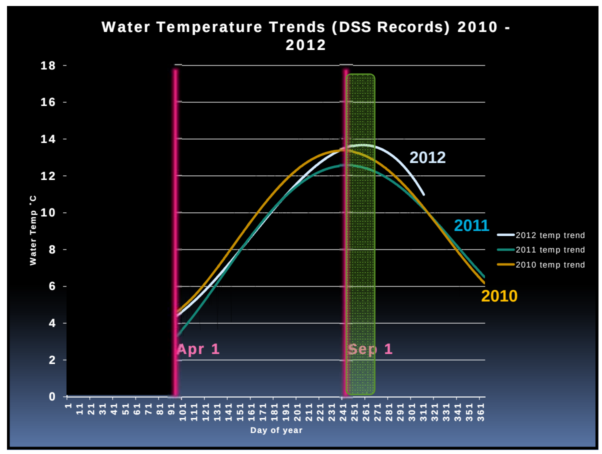
A minimum of 20 fish counted per week is required to include a site's sea lice count in the ranking process.

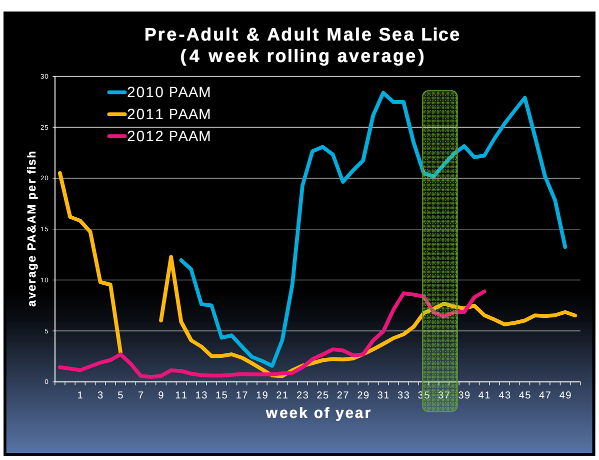
Site	Week of 2012-10-22	Week of 2012-10-29
ID-20	✔ n = 70	✖ n = 0
ID-43	✖ n = 15	✖ n = 0
ID-66	✔ n = 80	✖ n = 0
ID-69	✔ n = 30	✖ n = 0
ID-71	✔ n = 120	✖ n = 0
ID-84	✔ n = 50	✖ n = 0
ID-136	✔ n = 41	✖ n = 0
ID-26	✖ n = 0	✔ n = 30
ID-106	✖ n = 0	✔ n = 70
ID-108	✖ n = 0	✖ n = 10
ID-109	✖ n = 0	✔ n = 20

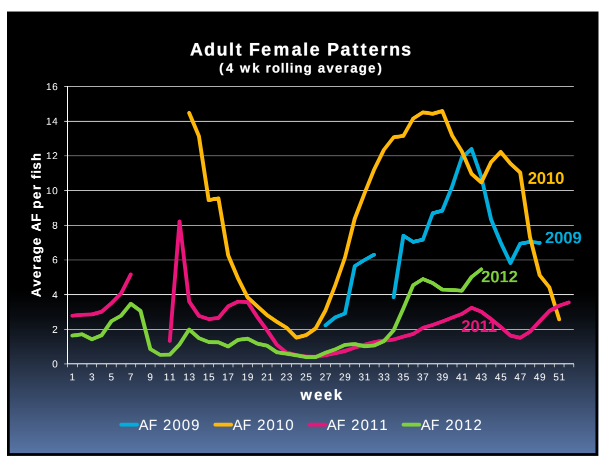

Chalimus Pattern (industry-wide)
(4 week rolling average)
Chalimus per fish (average)
week
2010
2009
2012
2011
Chal 2009
Chal 2010
Chal 2011
Chal 2012


Year(s) 2012 for Zone(s) Q, R, S, U, V, W
Chalimus per fish for each BMA
Different BMAs have different patterns
Date

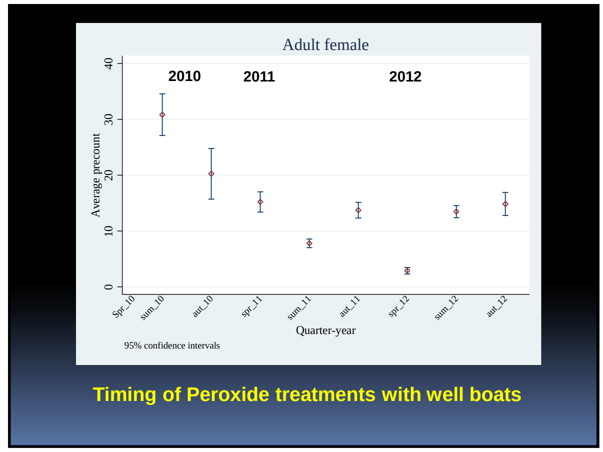

Year(s) 2012, 2010, 2011 for Zone(s)
2010 PAAM
Average ALL zones for Pre-Adult (M, F) and Adult Male
2012 PAAM
2011 PAAM
Date
14-21 May is lowest point

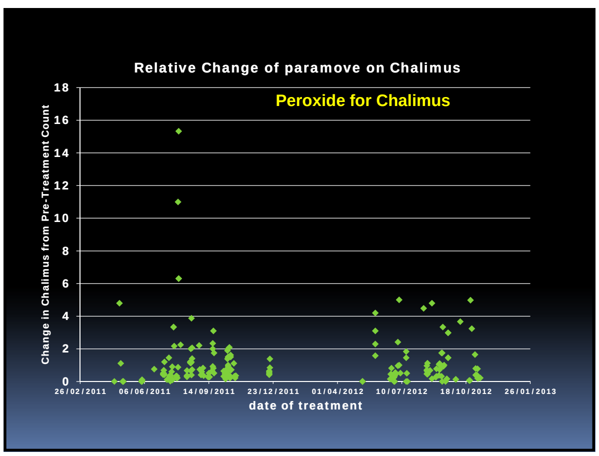

Water Temperature Trends (DSS Records) 2010 - 2012
Water Temp °C
2012
2011
2010
2012 temp trend
2011 temp trend
2010 temp trend
Apr 1
Sep 1
Day of year

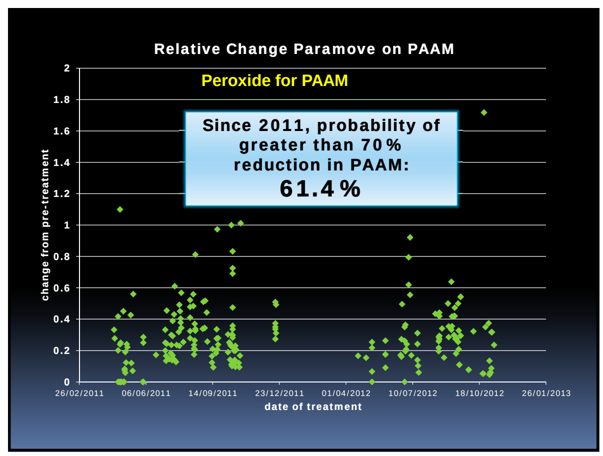

Pre-Adult & Adult Male Sea Lice
(4 week rolling average)
2010 PAAM
2011 PAAM
2012 PAAM
average PA&AM per fish
week of year

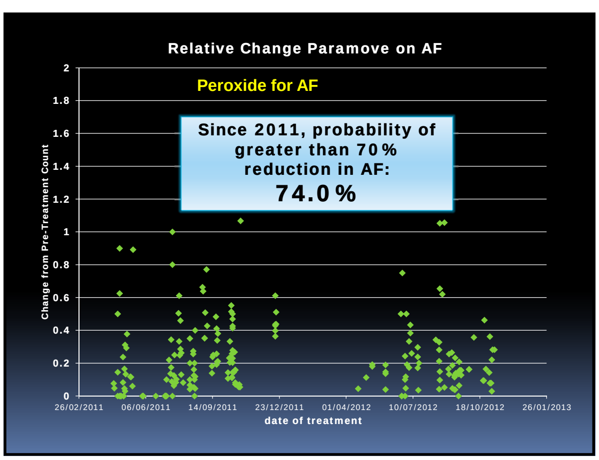

Adult Female Patterns
(4 wk rolling average)
Average AF per fish
2010
2009
2012
2011
week
AF 2009
AF 2010
AF 2011
AF 2012

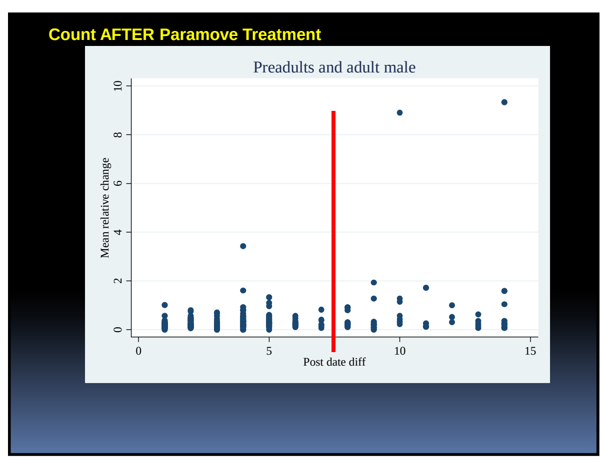

HYDROGEN PEROXIDE
TREATMENTS


Adult female
2010
2011
2012
Average precount
Quarter-year
95% confidence intervals
Timing of Peroxide treatments with well boats


Relative Change of paramove on Chalimus
Peroxide for Chalimus
Change in Chalimus from Pre-Treatment Count
date of treatment


Relative Change Paramove on PAAM
Peroxide for PAAM
Since 2011, probability of greater than 70% reduction in PAAM:
61.4%
change from pre-treatment
date of treatment


Relative Change Paramove on AF
Peroxide for AF
Since 2011, probability of greater than 70% reduction in AF:
74.0%
Change from Pre-Treatment Count
date of treatment


Count AFTER Paramove Treatment
Preadults and adult male
Mean relative change
Post date diff

Concluding Remarks - records

- Excellent participation by NB industry in Decision Support System
- Industry is recording precise sea lice counts, esp for PAAM and AF
- Chalimus levels are under-estimated

Concluding Remarks – sea lice patterns

- 2012 is marginally worse than 2011 overall
- Late increases in all stages in late late summer / autumn of 2012
- 2012 and 2011 are both much better than 2010 (or 2009)
- DSS recorded summer water temp was lower in 2011

Concluding Remarks – sea lice treatments

- Industry generally more aggressive at treating in spring, but pre-treatment count already increased by treatment date in summer / autumn
- Salmosan (tarps) was effective about half the time for PAAM, even less for AF, Chal
- Essentially used sparingly by industry

Concluding Remarks – sea lice treatments

- Counting after Paramove treatment should be done in first 7 days to be reliable
- Industry primarily depends on ONE treatment (peroxide) in well boats
- Paramove (wellboats) was effective 74% of time for AF, 61% for PAAM

acknowledgements

- ACFFA – support for sea lice monitoring and research program and on-going DSS support
- NBDAAF – 5 yr support for AIF + additional support for sea lice monitoring / research program
- NLDFA, PEI Innovation, PEI FARD, NSDFA – 5 yr support for AIF
- ACOA / AIF – *Healthy Fish Healthy Food Healthy Environment* Project

Canadian Organic Aquaculture Standards

Aquaculture Innovation Workshop

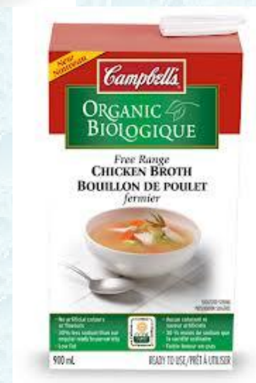
Justin Henry
Target Marine Hatcheries Ltd.
Northern Divine Caviar

November 6th 2012

The 5 W's of the Organic Standards

- Where is the Organic Seafood?
- Why did we Need Standards?
- Who Developed the Standards?
- What is Covered in the Standards?
- When will I answer your questions?

Where is the Organic Seafood?



Why did we Need Standards?

- Meet growing demand for organic food
- Compliment other organic standards (Canada, USA, International)
- Facilitate trade and overcome trade barriers
- Manage importation from other jurisdictions
- Encourage organic farming

Why did we Need Standards?

- **Meet growing demand for organic food**

From 2006 - 2010, the Canadian organic consumer market increased by 160% ($1 to $2.6 billion)
- COTA 2012

Canada is the 5th largest organic market worldwide
- COTA 2012

Why did we Need Standards?

- Meet growing demand for organic food
- Compliment other organic agriculture standards (Canada, USA, International)
- Facilitate trade and overcome trade barriers
- Manage importation from other jurisdictions
- Encourage organic farming

Why did we Need Standards?

- **Facilitate trade and overcome trade barriers**

US and EU Organic equivalency agreements give Canada access to 96% of the global organic market ($59 billion)

- *COTA 2012*

Why did we Need Standards?

- Meet growing demand for organic food
- Compliment other organic standards (Canada, USA, International)
- Facilitate trade and overcome trade barriers
- Manage importation from other jurisdictions
- Encourage organic farming

Why did we Need Standards?

- **Encourage organic farming**

Recognize those farmers who choose to produce their fish according to more rigorous requirements

Who Developed the Standards?

Development Timeline

- 2002 – POSA standard
- 2005 – COAP standard
- 2008 – Working Group
  - Technical experts and stakeholders
  - 25 meetings over ~2 years
- Draft for 60 day public review (June 2010)
- October 2010 – CGSB 40 member Committee

Who Developed the Standards?

CGSB Committee

- Regulatory bodies (Health Canada, CFIA, DFO, ON, QC, AB)
- Academic/Research institutions (BCCAHS, CSR)
- ENGOs (MU, CCNB, LOS)
- Producer associations (IPSFAD, RCC, POSA, BCSGA)
- Consumer advocacy groups (CIA, CCC)
- First Nations (AFN)
- Organic agriculture groups (OFC, COTA)

Who Developed the Standards?

Development Timeline

- April 2011 – 2nd public review
- October 2011 – CGSB Committee vote

Ballots Cast	Affirmative	Negative
27	22 (81%)	5 (19%)

- January 2012 – CGSB final revisions
- April 2012 – standards released

Who Developed the Standards?

CAN/CGSB-32.312-2012

Organic Aquaculture Standards

ICS 65.150

National Standard of Canada

Can be purchased from CGSB website for $88.50

What is Covered in the Standards?

Description (I)

Developed for equivalency with Canada and EU

Agriculture

Aquaculture

What is Covered in the Standards?

General Principles

1. Protect the environment
2. Maintain long term biological stability
3. Recycle materials and resources
4. Provide attentive care
5. Maintain the organic integrity of the products

What is Covered in the Standards?

Scope (1)

- Seaweeds, aquatic plants, aquaculture animals (fish and shellfish)

What is Covered in the Standards?

Scope (1)

- Seaweeds, aquatic plants, aquaculture animals (fish and shellfish)
- Processed products for human consumption
- Aquaculture animal feed
- Processed products for animal consumption
- Prohibited substances, methods, ingredients

What is Covered in the Standards?

Organic Plan (4)

- Detail production, processing, handling, and management practices
- Record keeping and identification
- Traceability
- Transition period
- Parallel production and buffer zones

What is Covered in the Standards?

Seaweeds and Aquatic Plant Aquaculture (5)

- Water quality and environment
- Sustainable harvesting
- Cultivation conditions
- Antifouling measures
- Cleaning of equipment and facilities

What is Covered in the Standards?

Animal Aquaculture (6)

- Water quality and environment
- Animal species and origin
- Reproduction
- Feed and feeding
- Health and welfare – 5 domains
- Cultivation conditions
- Antifouling measures and cleaning
- Harvesting, transporting, slaughtering
- Specific requirements for aquatic invertebrates

What is Covered in the Standards?

Pest Management (7)

Processing, Handling, Transportation and Storage (8)

Permitted Substance Lists (9, 10, 11, 12)

When will I answer your questions?

What is the difference between organic and conventional aquaculture?

- Antibiotics prohibited
- Stocking density limited
- GMOs prohibited
- Artificial pigment prohibited
- Chemical anti-foulants prohibited
- Fish meal and oil must be organic when available

When will I answer your questions?

What products are now certified in Canada?

- None yet
- Certifying Bodies obtaining clarification
- Soon to come. . . Certified Organic Northern Divine Caviar

When will I answer your questions?

Canadian Organic Aquaculture Standards

Aquaculture Innovation Workshop

Justin Henry
Target Marine Hatcheries Ltd.
Northern Divine Caviar

November 6th 2012

Feed Blower Noise Reduction

Project Objectives

- Objectives
  - Reduction of noise levels generated by Feed Blowers
  - Health and Safety
  - Reduce Environmental Impact

Feed Blower Evolution

Reduced Noise Levels

PRW

Acquired

Locally Made

Reduced Manual Effort

General Sawdust

1st Attempt

Reduced RPM

Reduced Noise

Corrosion

Cincinnati

Lower RPM

Reduced Noise

No Corrosion

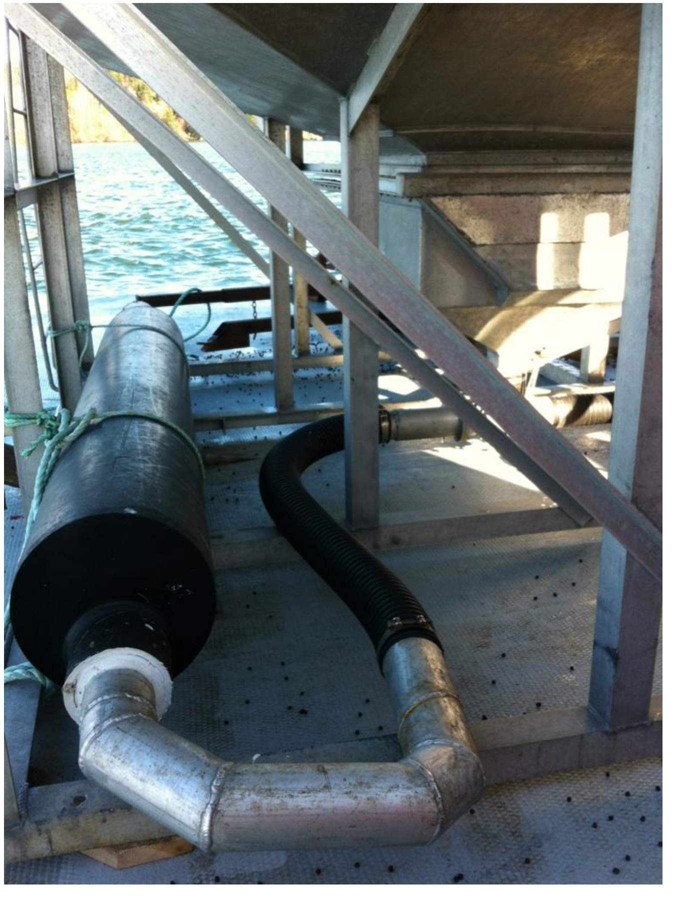
Barge – 1st Silencer

- Relocated blower under deck
- Installed 8ft inlet silencer

- On Vessel:
  - Before: 75 DB
  - After: 61 DB

- At 500ft:
  - Before: 62 DB
  - After: 48 DB

- Issues:
  - Length/Space/Location

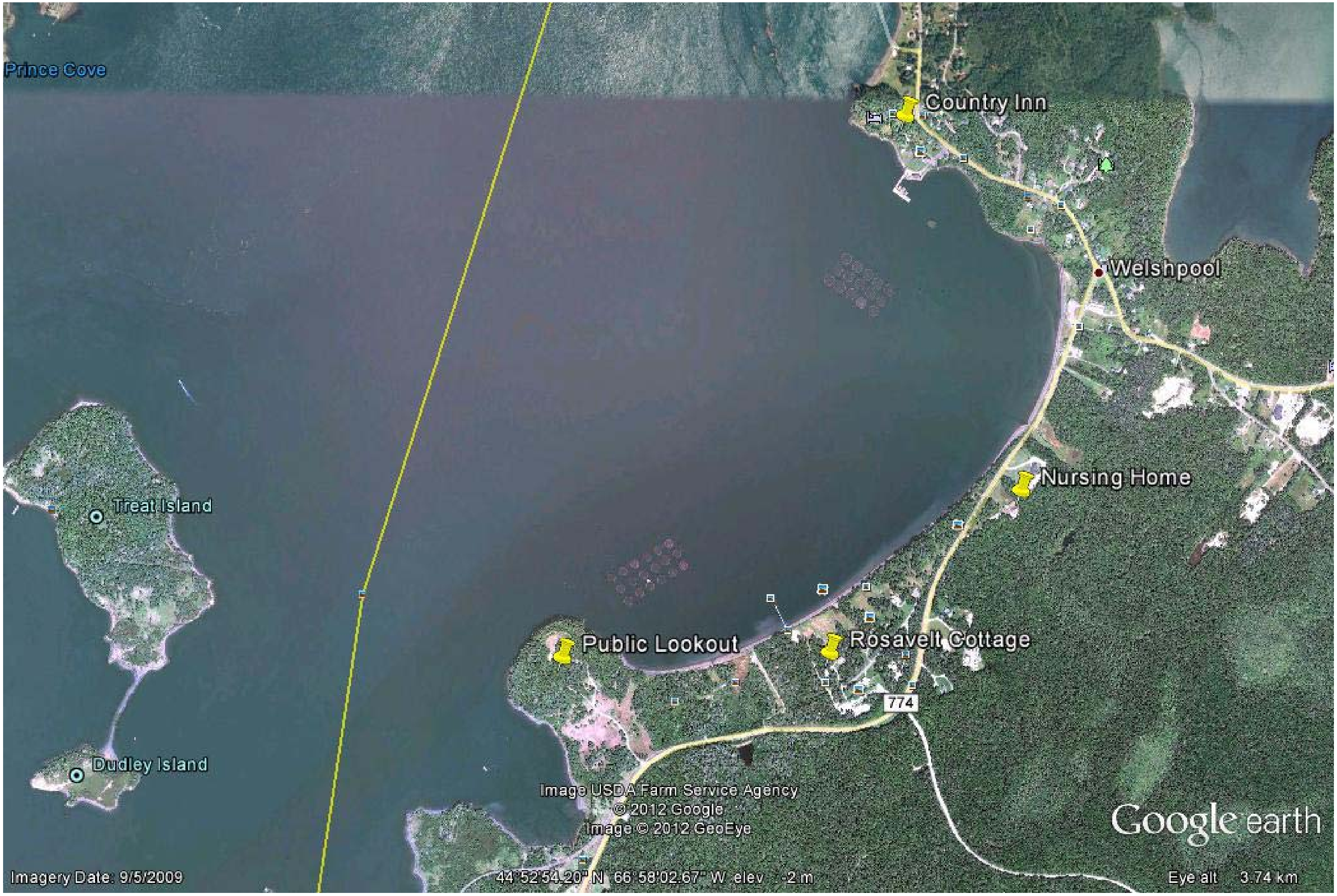


2nd Prototype

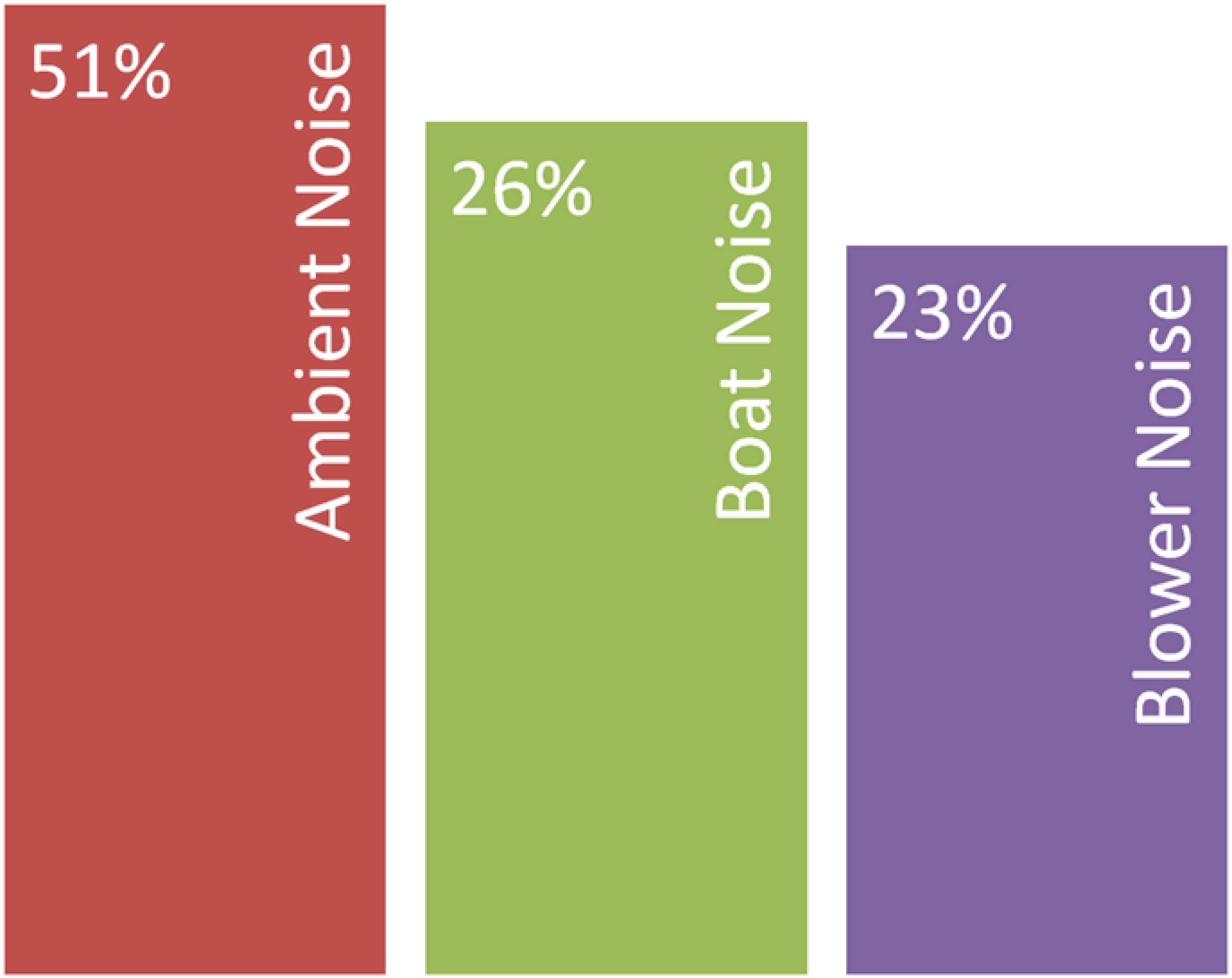
- Inlet and Outlet
- Smaller Footprint

2nd Prototype Images

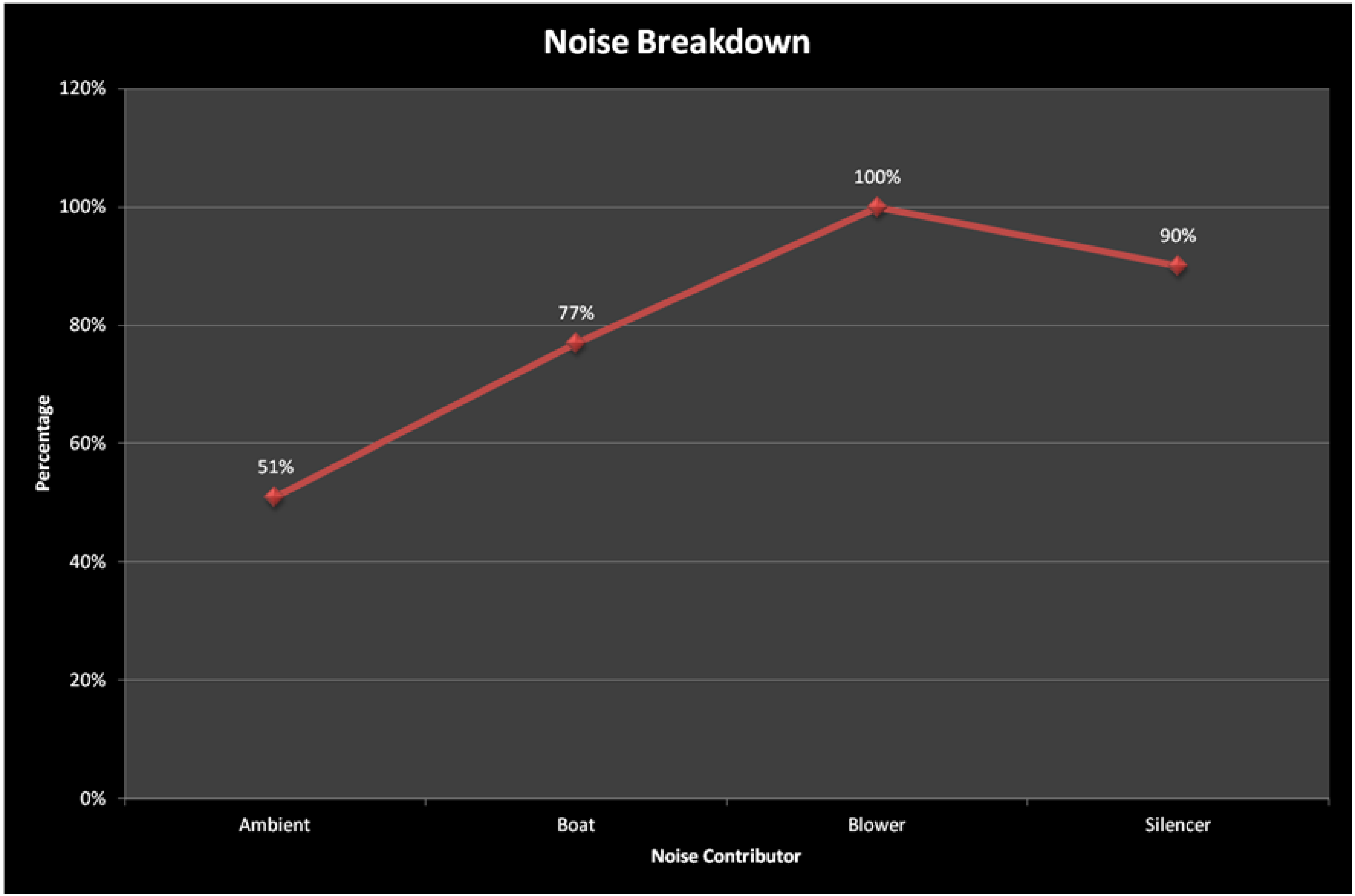
Environmental Sensitivity



Results



Results



Noise Breakdown
120%
100%
80%
60%
40%
20%
0%
Percentage
51%
77%
100%
90%
Ambient
Boat
Blower
Silencer
Noise Contributor

ARIES

Aquaculture Real-time Integrated Environmental System

Tom McKeever, Marine Institute

ACFFA Workshop, November 15 2012

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Topics

- **Overview of project**
- **Activities to date**
- **ARIES Sites**
- **ARIES Equipment**
- **ARIES Web Portal**
- **Findings to date**
- **Next Phase**
- **Future Developments**

ARIES Phase 1

- Commenced in May 2012
- Funded by NL Innovation, Business and Rural Development (IBRD)
- NAIA contracted Marine Institute's CTec & CASD Units
  - Customer requirements as defined by industry
  - Equipment selection and procurement
  - Integration, testing and deployment in Sept 2012
  - Web-portal development and maintenance
- Preceded by SmartBay Placentia Bay Project

naia

Newfoundland Labrador

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SmartBay

PLACENTIA BAY, NEWFOUNDLAND

Applied Ocean Observation System supporting

'Better Information….Better Decisions'

In partnership with

MARINE INSTITUTE

amec

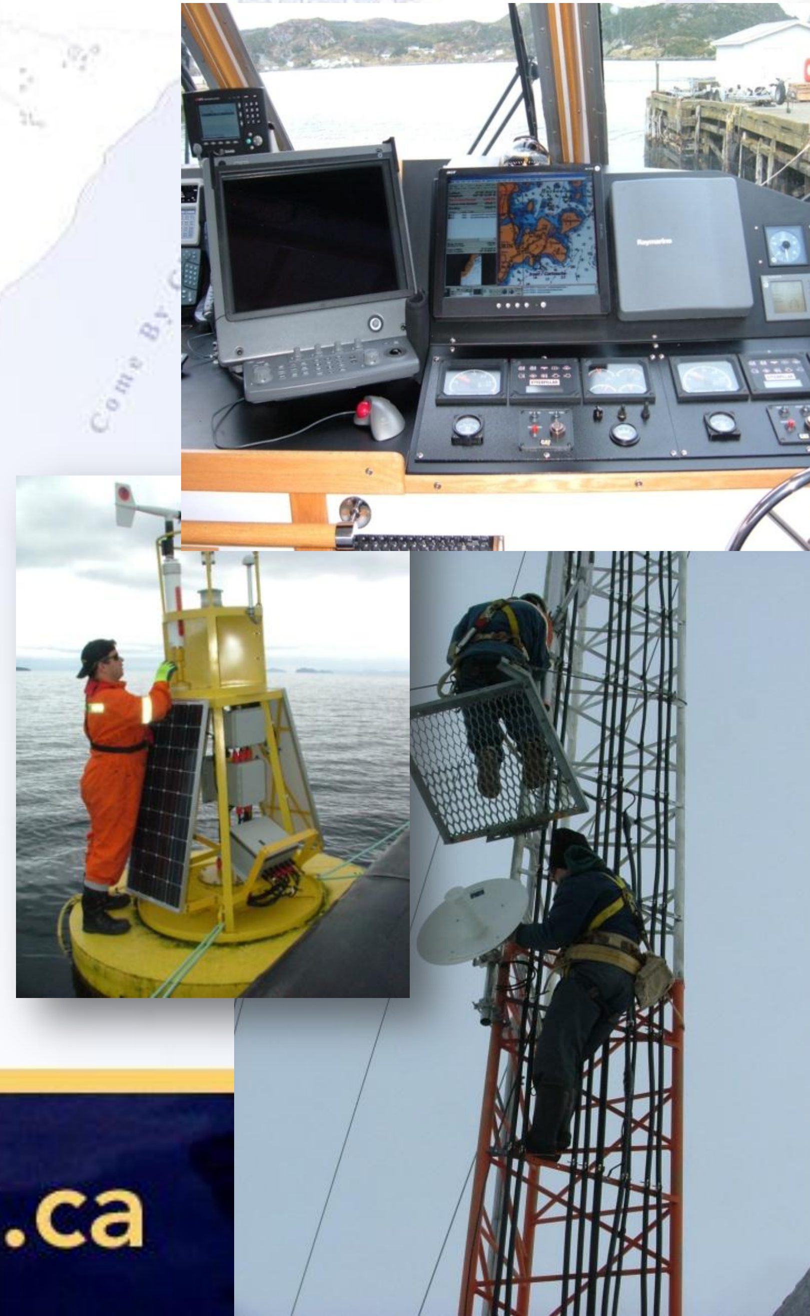
ICAN

Three Key Components

- **Intelligent infrastructure** to support data collection, modeling and forecasting (eg buoys, comms. etc)

- **Ship-board technology** (Electronic Charts, Automatic Identification System – AIS, ATONIS)

- **Simple access to data** and value-added information products (web portal)



www.SmartBay.ca

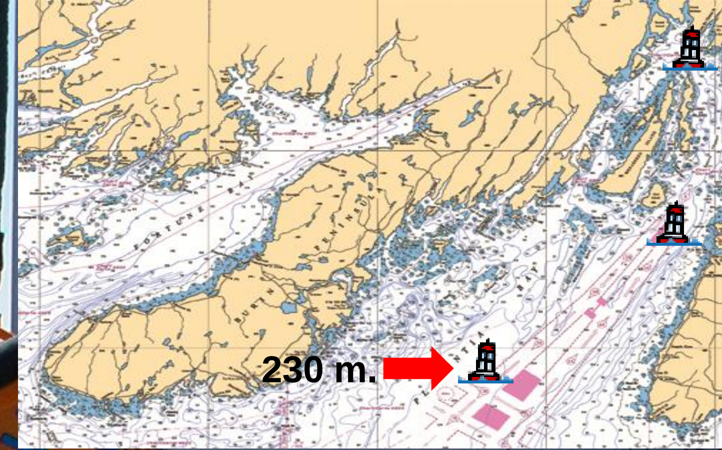
- Wind direction
- air temperature
- humidity
- dew point
- barometric pressure
- wind speed
- water temperature
- salinity
- current speed
- current direction
- wave height
- wave direction
- wave period

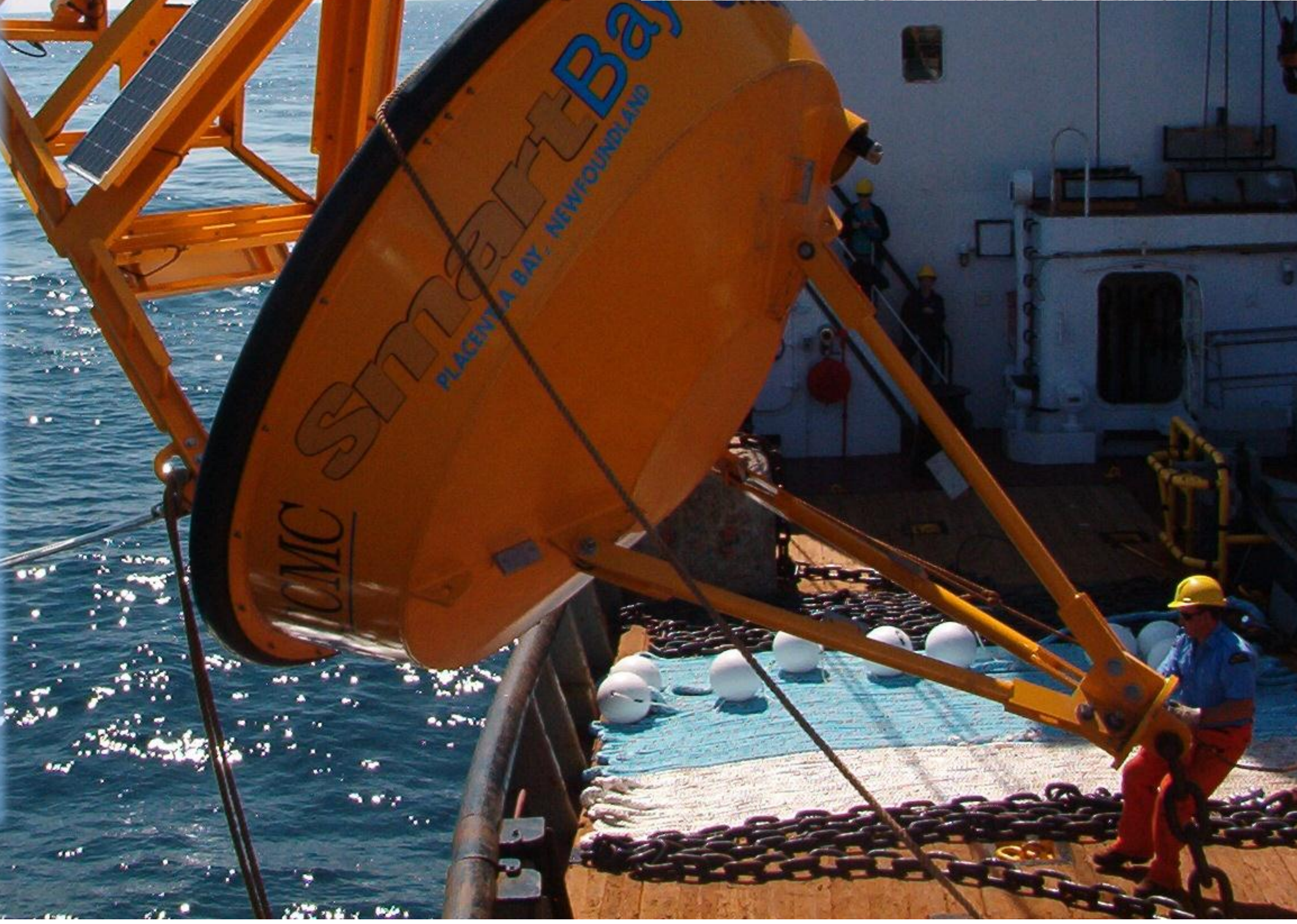
- ATONIS – Aids to Navigation Information System

Communications via Iridium satellite with Inmarsat D+ backup (two way comms.)

Weight: approx. 1820 kgs. (4000 lbs)

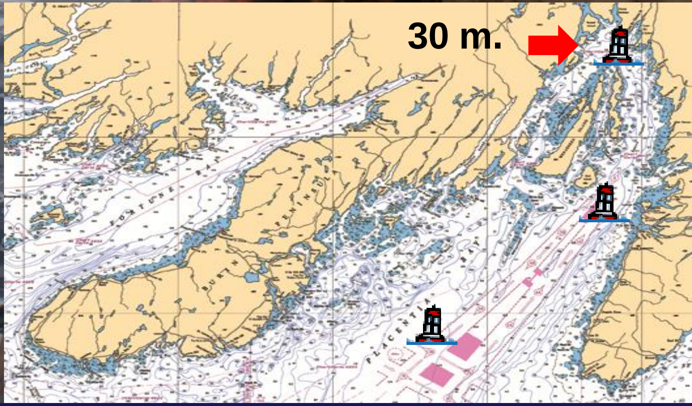
Anchor : 3640 kgs (8,000 lbs)





- Wind direction
- air temperature
- humidity
- dew point
- barometric pressure
- wind speed
- water temperature
- salinity
- current profile
- wave height
- wave direction
- wave period

Communications via VHF Spread Spectruml with Inmarsat D backup (two way comms.)



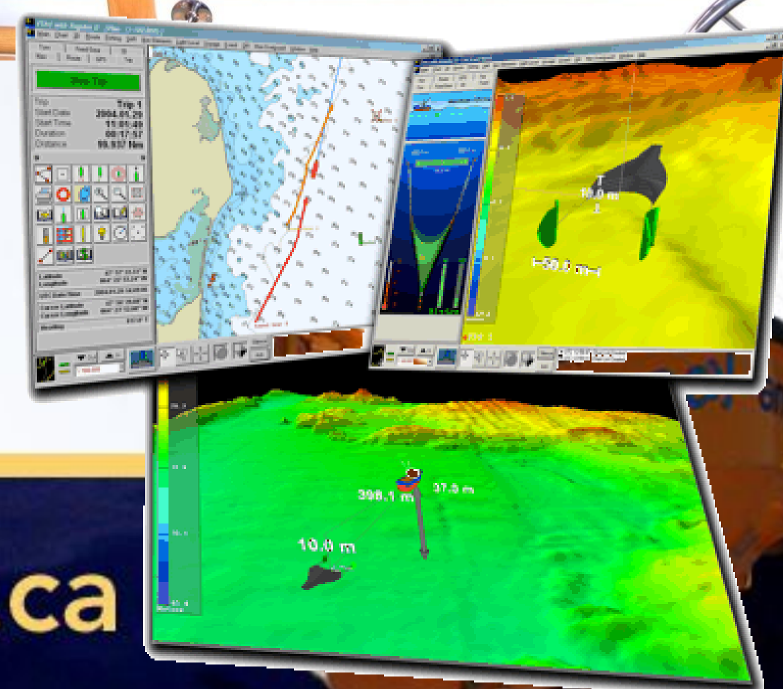
Value Added Products

- General weather synopsis (4/day)
- High Resolution forecasts for areas of interest (2x2/day)
    - *SmartBay is the first commercial application of the Weather Research and Forecast (WRF) hi-res. forecast model in Canada*
- Prediction of wind, waves, air, sea temperature, precipitation, icing potential

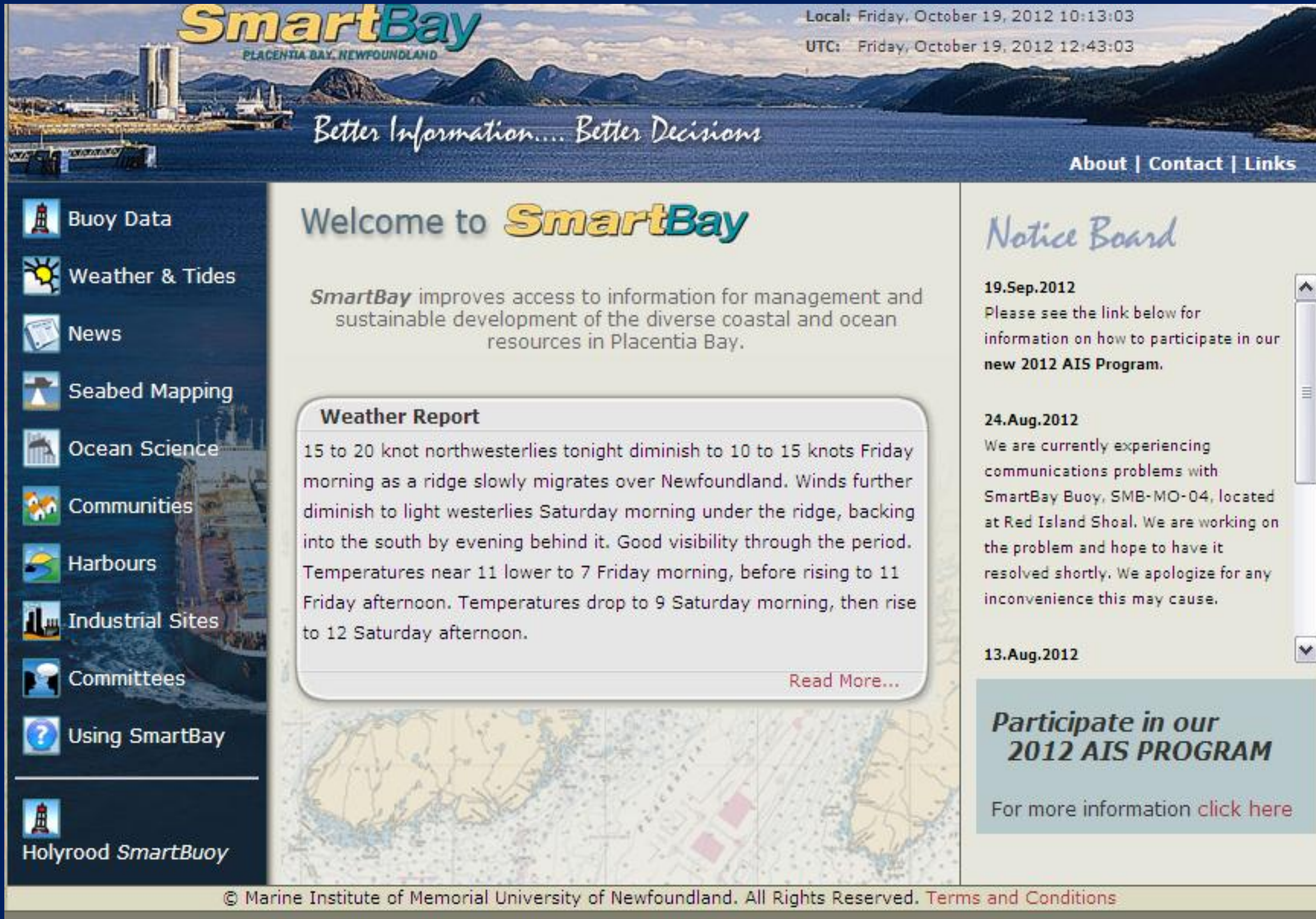
Marine Operations

- Aimed at Shipboard Users
    - Transport, Fishing and workboats
    - ECS based user interface
    - AIS as primary communications backbone
    -“live” met and oceanographic information
- 8 vessels equipped with ECS and AIS
- Vale AIS Program
- Buoys equipped with ATONiS

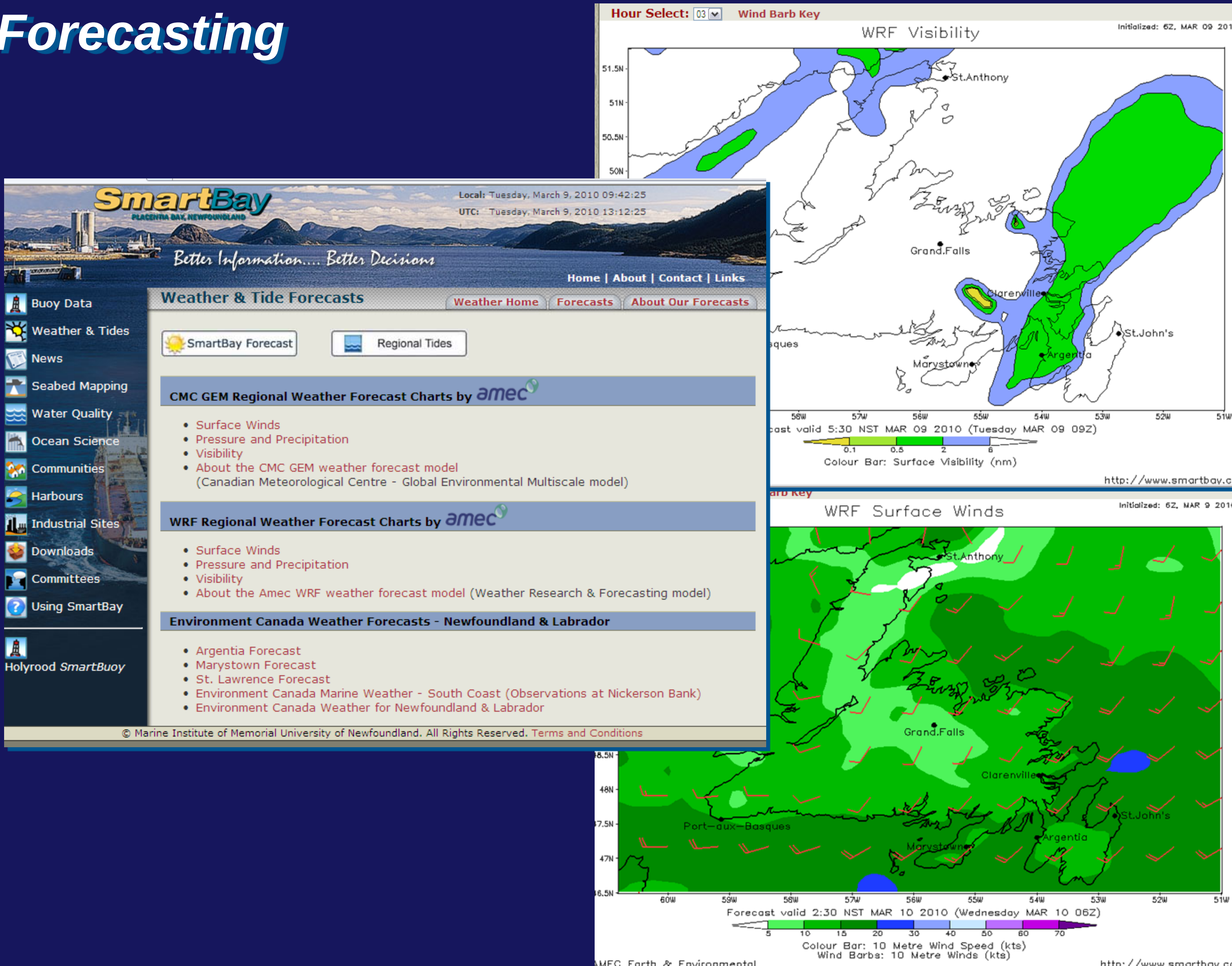
Improves vessel safety and situational awareness in the bay

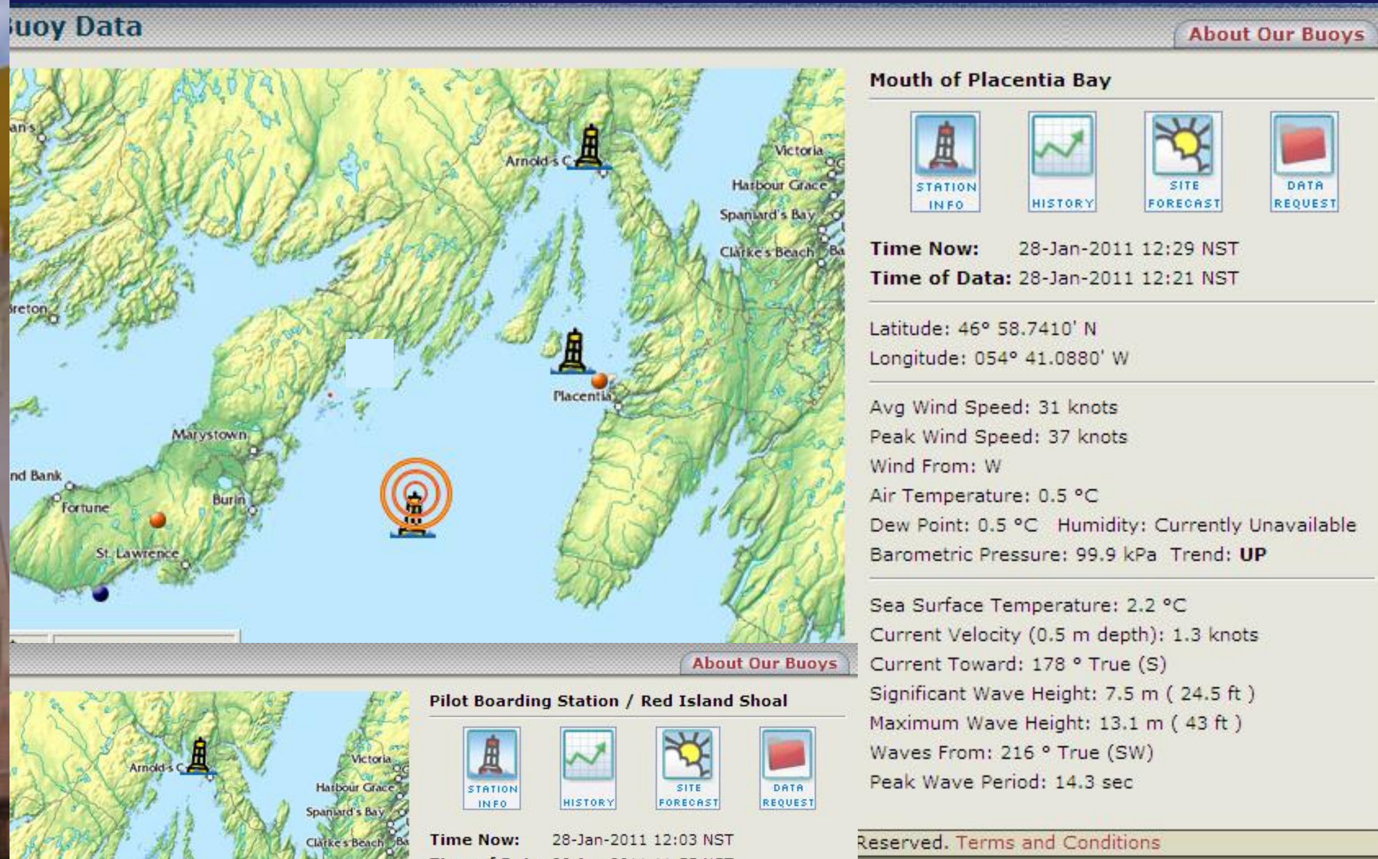


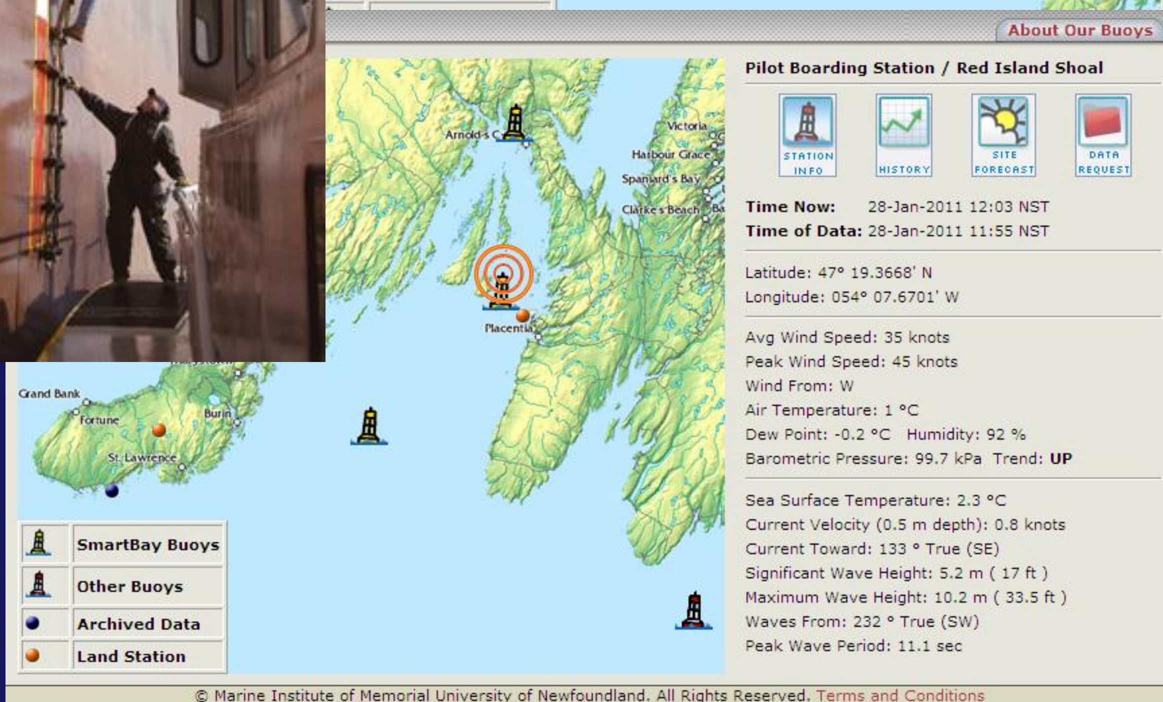
www.SmartBay.ca



Forecasting







"Having the availability of 24-hour 'real-time' weather information has increased one-hundred fold the safe transfer of pilots and movement of vessel traffic within Placentia Bay"

(Captain Anthony McGuinness, Chief Executive Officer, Atlantic Pilotage Authority)

ARIES – Phase 1

- Demonstration project for the aquaculture industry:
  - ***Access to site data in near real-time 24/7 via internet***
- Three companies participated:
  - Northern Harvest Sea Farms
  - Cold Ocean Salmon (Cooke Aquaculture)
  - Nova Fish Farms
- Identified requirements for site monitoring:
  - Dissolved oxygen, temperature and salinity at 3 depths (surface, mid-cage, cage-bottom)
  - Meteorological data from surface

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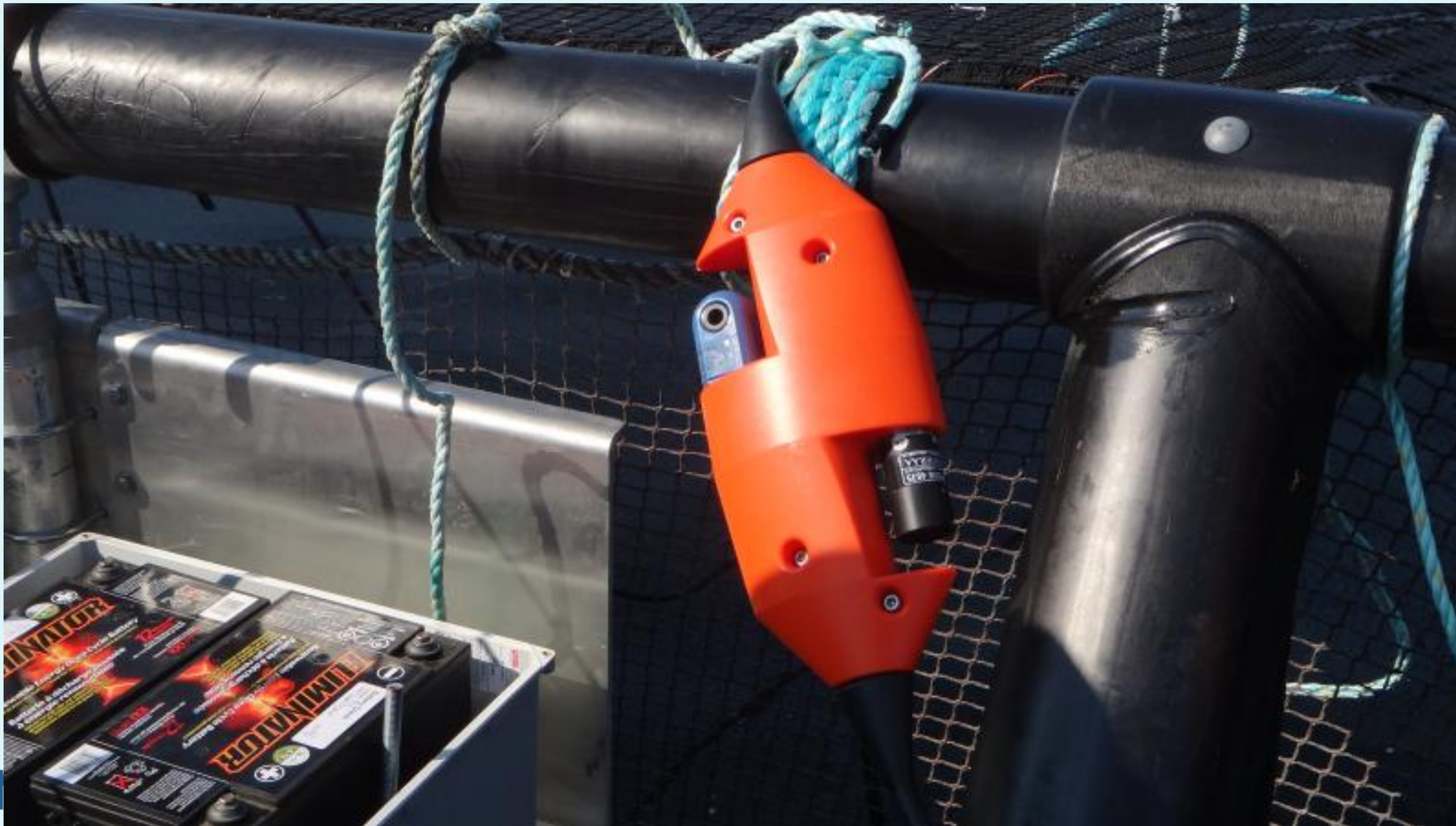
ARIES Phase 1 Sites

- Sensor Strings
- Data logger and communications modules
- Solar Panels, batteries and charge controllers
- Mast – meteorological sensors and antennas

ARIES Sensor String

- Optical oxygen sensors – Optodes
- Conductivity sensors
- Temperature



Sensor String

- Suspended within cage or off barge

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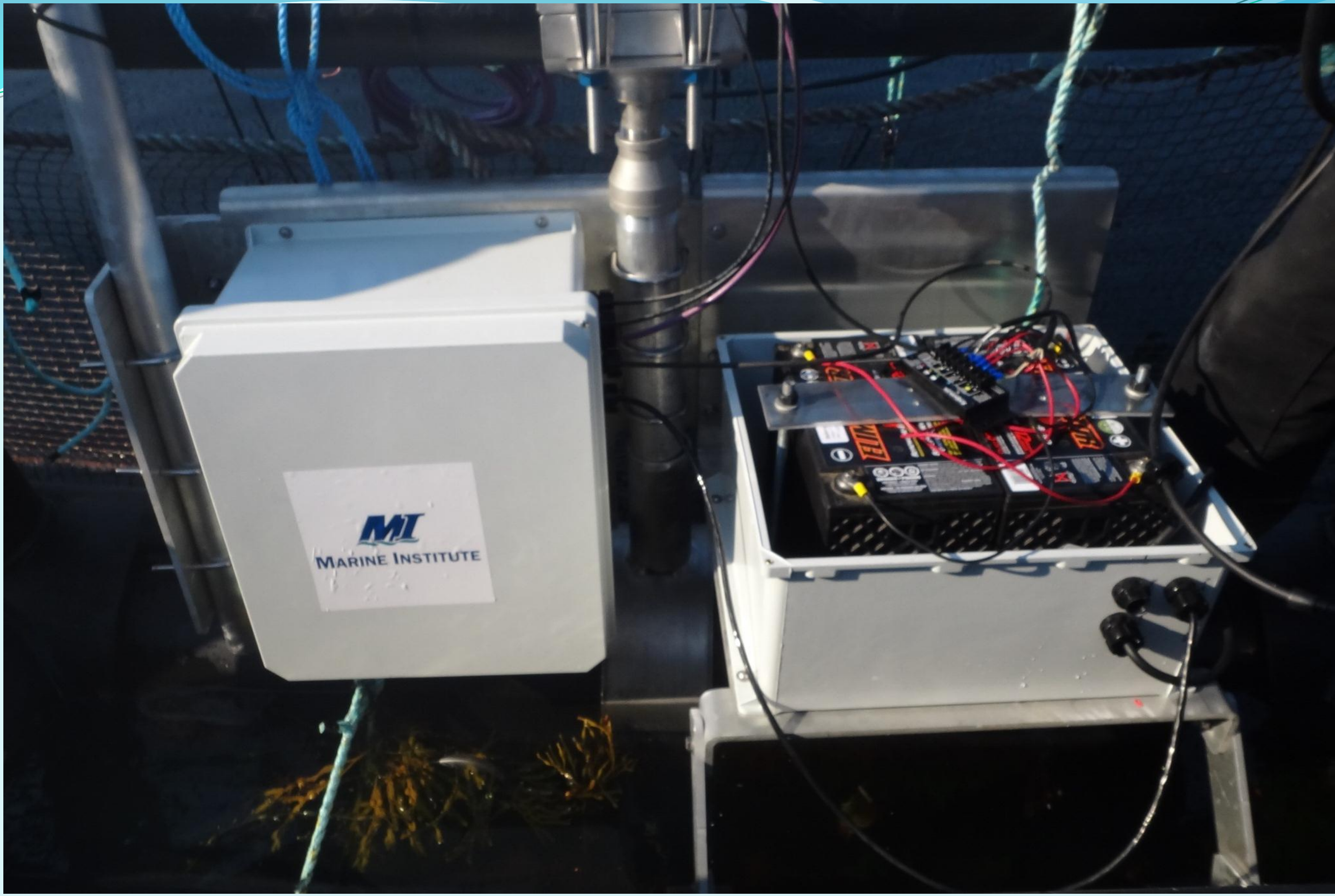

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Cell antennas and met module

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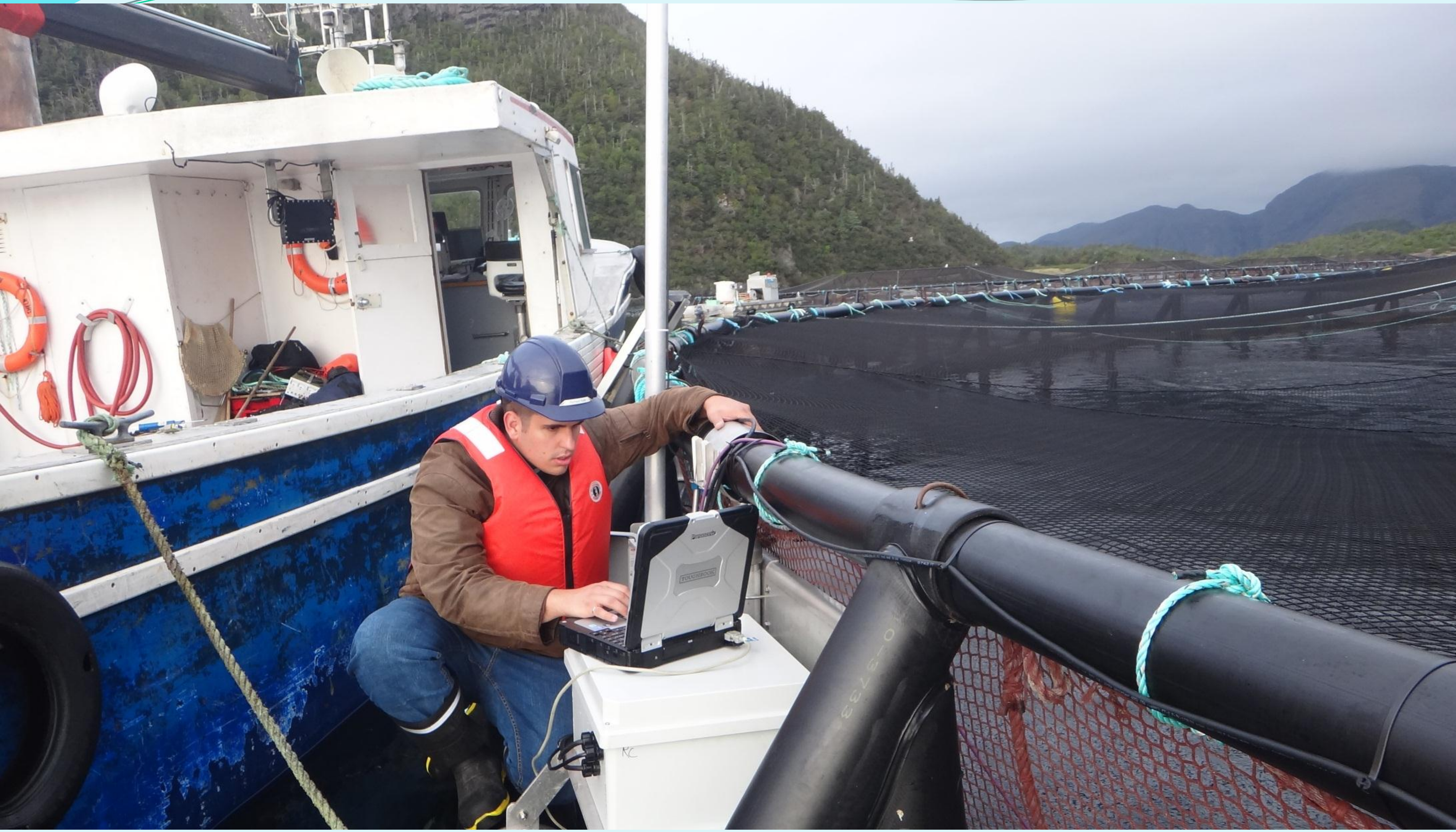

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ARIES Web-portal

- Site data is collected continuously and transmitted automatically every 15 minutes (adjustable) to the ARIES server at the Marine Institute
- Webpage: access restricted to company users only
- Water data: Dissolved oxygen, salinity, temp. at 3 depths
- Met Data: Wind speed & direction, air temp, pressure
- Users can set Alarm Levels; email when level is exceeded
- www.ariesaqua.com

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Cage (water) Data

ARIES: Cooke - Farmers Head

- Cage Data
- Meteorological Data
- Personal Settings
- Add User
- Modify User
- Cage Site Settings
- Contact Us
- Log Out

Timestamp: 2012-11-14 22:30:27 NDT

Depth	Dissolved Oxygen	Temperature	Salinity
	mg/L	° C	PPT (PSS-78)
Surface	9.94	9.19	31.03
Mid	10.08	9.19	31.03
Bottom	9.87	9.19	31.03

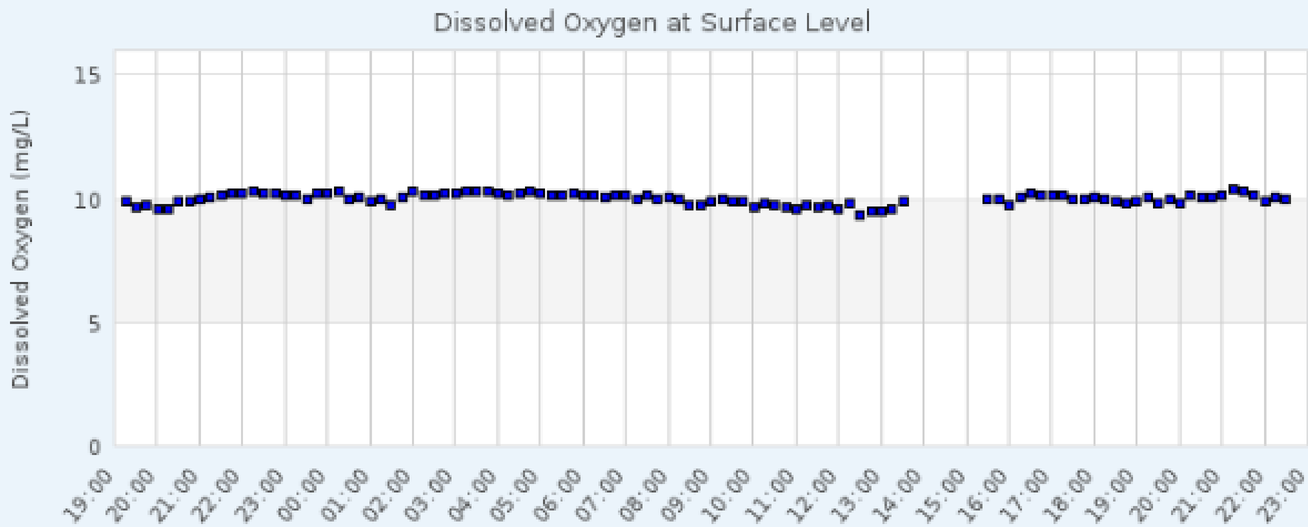
Graphing Function

ARIES: Cooke - Farmers Head

- Cage Data
- Meteorological Data
- Personal Settings
- Add User
- Modify User
- Cage Site Settings
- Contact Us
- Log Out

Timestamp: 2012-11-14 22:30:27 NDT

Depth	**Dissolved Oxygen**	**Temperature**	**Salinity**
	mg/L	**° C**	**PPT (PSS-78)**
Surface	9.94	9.19	31.03
Mid	10.08	9.19	31.03
Bottom	9.87	9.19	31.03



1D | 3D | 5D | 1M | 6M | 9M | 1Y

Meteorological Data

ARIES: Cooke - Farmers Head

- Cage Data
- Meteorological Data
- Personal Settings
- Add User
- Modify User
- Cage Site Settings
- Contact Us
- Log Out

Timestamp: 2012-11-14 22:30:27 NDT

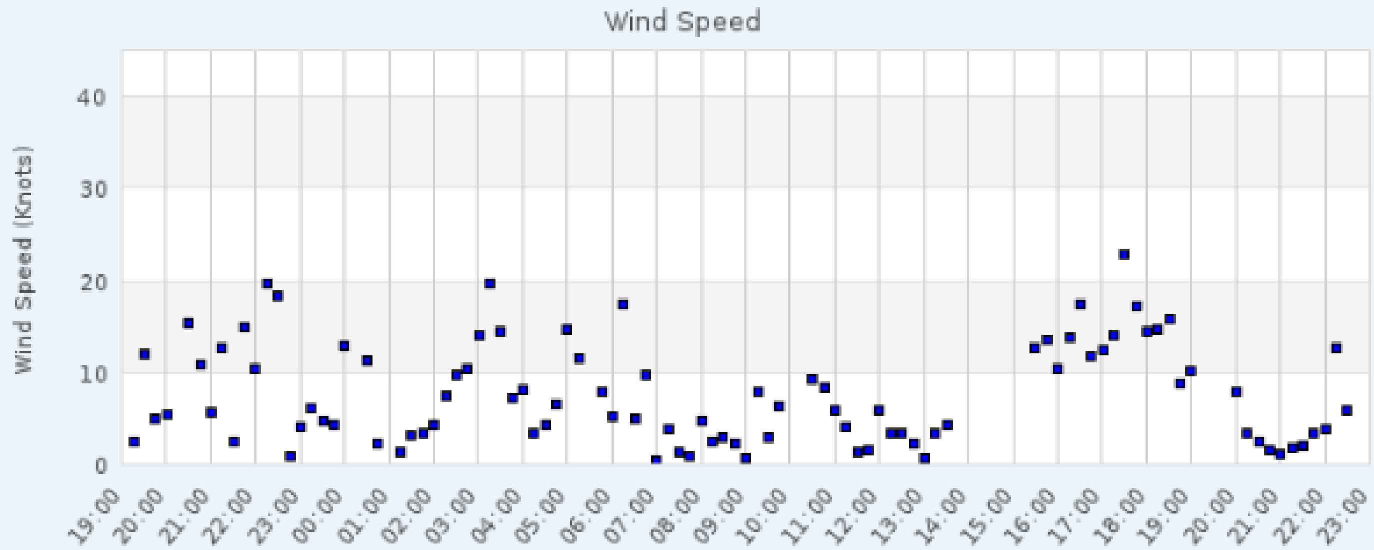
Wind Speed (Knots)	5.9
Wind Direction (° True)	44.2
Barometric Pressure (kPa)	103.2
Air Temperature (° C)	5.1

ARIES: Cooke - Farmers Head

MEMORIAL UNIVERSITY MARINE INSTITUTE

- Cage Data
- Meteorological Data
- Personal Settings
- Add User
- Modify User
- Cage Site Settings
- Contact Us
- Log Out

Timestamp: 2012-11-14 22:30:27 NDT	
Wind Speed (Knots)	5.9
Wind Direction (° True)	44.2
Barometric Pressure (kPa)	103.2
Air Temperature (° C)	5.1



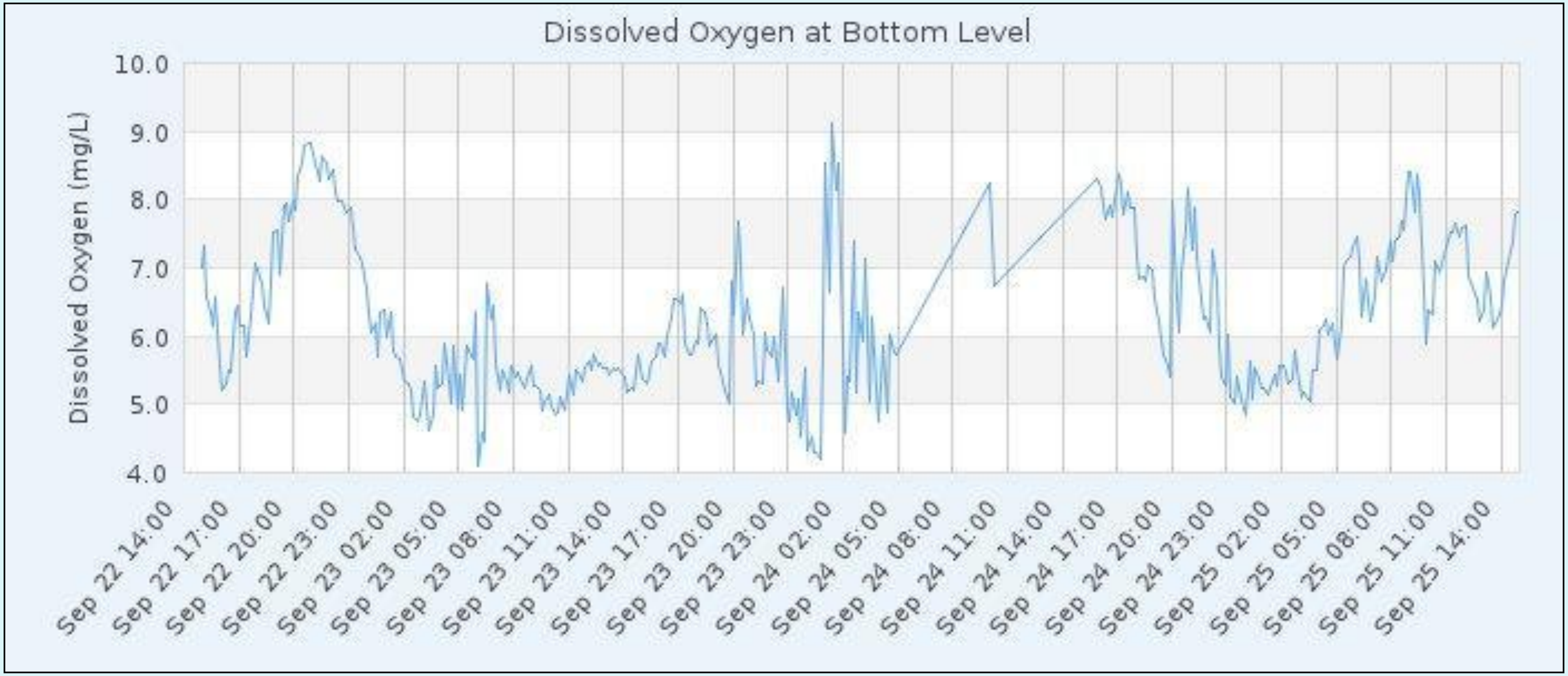
1D 3D 5D 1M 6M 9M 1Y

p?graph=WindSpd1

Findings to Date

- ARIES data accessible, accurate and reliable
- Heavily subscribed – viewing minutes after installation
- Weather event at one site – moved system to barge
- Weak cell comms at one site – investigated options and installed satellite comms
- Interesting data….

Dissolved Oxygen within cage



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Dissolved Oxygen at Mid Level
Dissolved Oxygen (mg/L)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
Sep 22 15:00
Sep 22 18:00
Sep 22 21:00
Sep 23 00:00
Sep 23 03:00
Sep 23 06:00
Sep 23 09:00
Sep 23 12:00
Sep 23 15:00
Sep 23 18:00
Sep 23 21:00
Sep 24 00:00
Sep 24 03:00
Sep 24 06:00
Sep 24 09:00
Sep 24 12:00
Sep 24 15:00
Sep 24 18:00
Sep 24 21:00
Sep 25 00:00
Sep 25 03:00
Sep 25 06:00
Sep 25 09:00
Sep 25 12:00
Sep 25 15:00

Phase 2

- Additional funding from ACOA + others.
- Meeting with industry soon to determine priorities
- Possible tasks include:
  - On-going support for 1 year
  - Addition of still image capture: surface and cage
  - Acoustic Doppler Current Profilers
  - Tide gauge and / or current meters
  - All to be integrated with ARIES equip and web portal

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Proposed Future Developments

- Design of custom data-logger designed for aquaculture
  - Reduce size, weight and power consumption
  - Added flexibility for additional sensors
  - Reduce size of batteries and panels
- Expansion – additional sites
- Integration of additional sensors
- Further study of diurnal changes in dissolved oxygen levels with fish movement and tidal action

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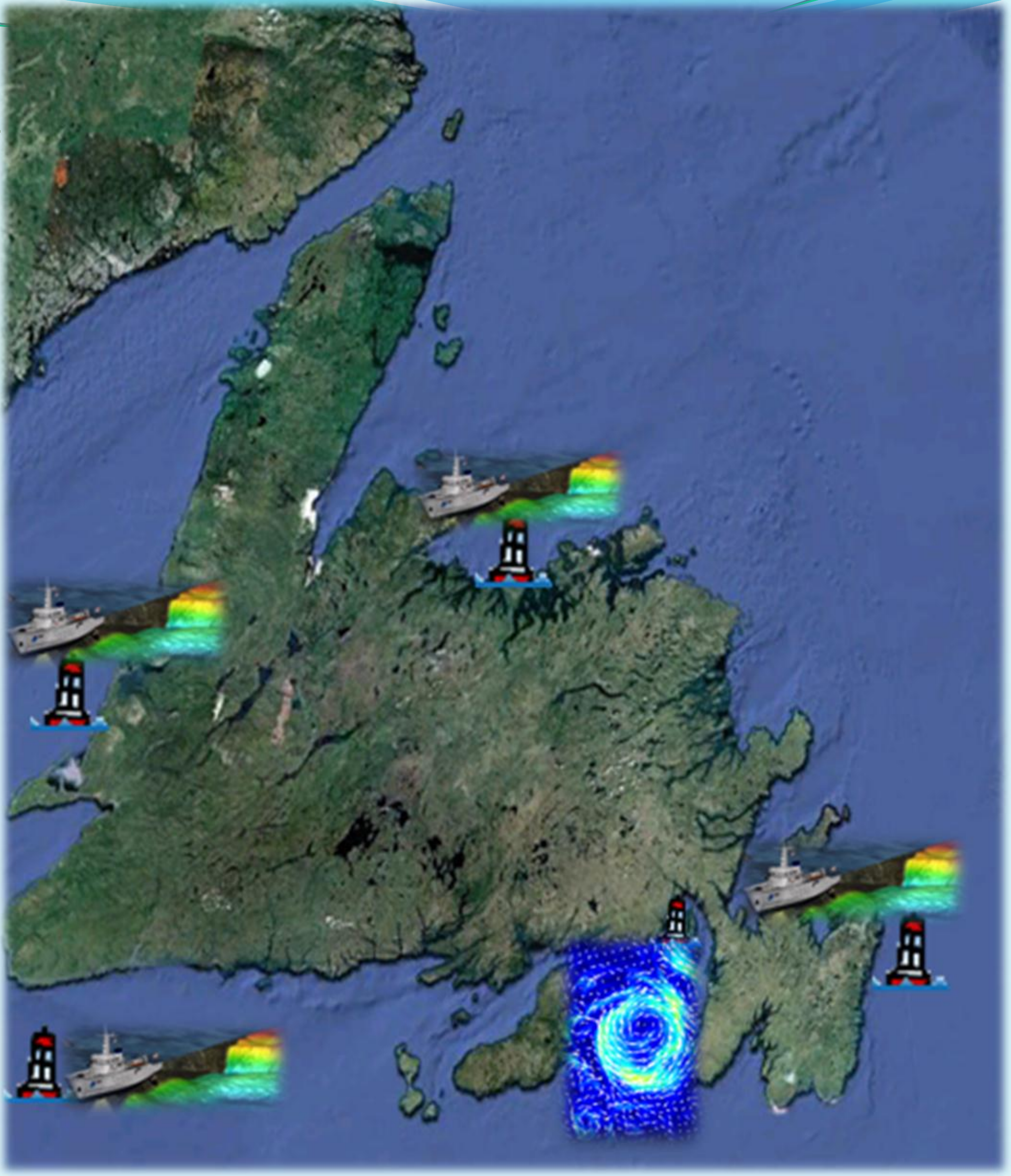
Future…

- **Investigate SmartBay buoys and weather forecasting for the Coast of Bays: Aquaculture**
- Investigate possible applications of vessel AIS – vessel location monitoring – safety, biosecurity, management

SmartBay Expansion - $1,630,000



Port aux Basques, Corner Brook, Lewisporte, St. John's

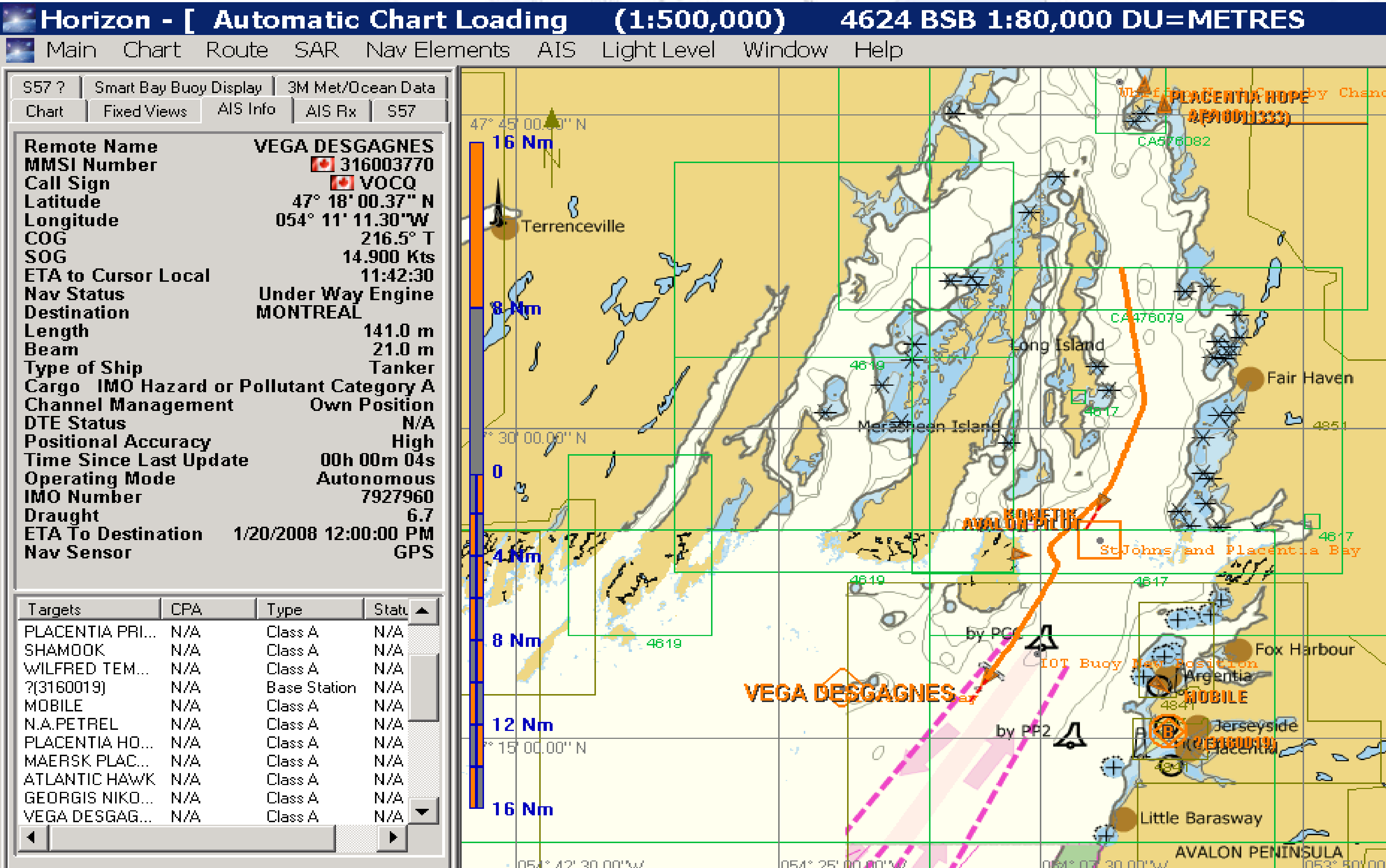
Buoys, tide gauges, met. stations, current profilers

Harbours and approaches mapping program

Chart series production

SmartAtlantic?? – SmartBay Atlantic integration??

Automatic Identification System (AIS) - Improved vessel safety, efficiency and situational awareness



Acknowledgements

- NL IBRD – funding sponsor
- NAIA – Darrell Green and Miranda Pryor
- Industry Partners:
  - Cold Ocean / Cooke: Sheldon George and Farmer’s Head crew
  - Northern Harvest: Jennifer & Doug Caines, Jim Sheppard
  - Nova: Dean Foss and Bill Howse

- ACFFA: Betty House
- ACRDP

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Thank you – questions?

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Wastewater Treatment and Reuse using Membrane Bioreactor

Anthony Z. Tong, Ph.D.
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(902)585-1355

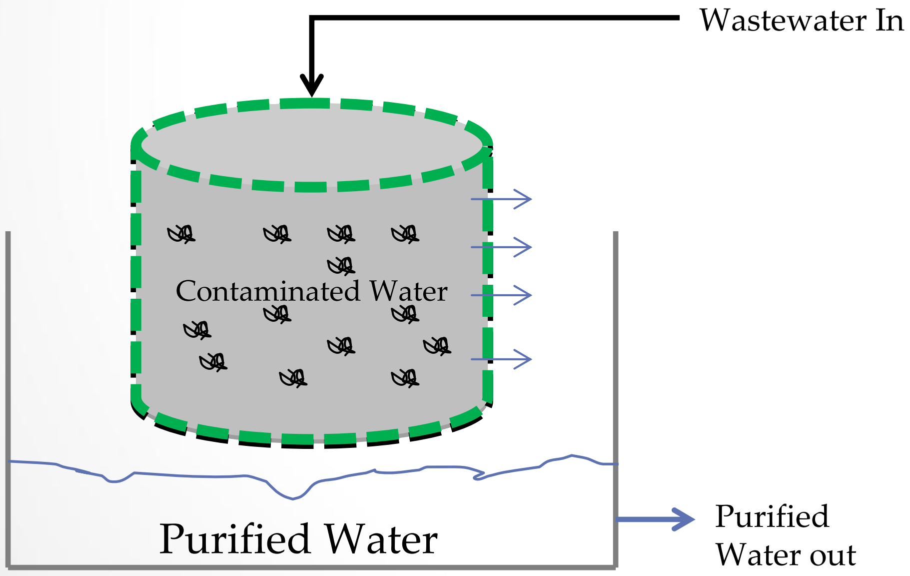
Acadia
University

Membrane Bioreactor Intro

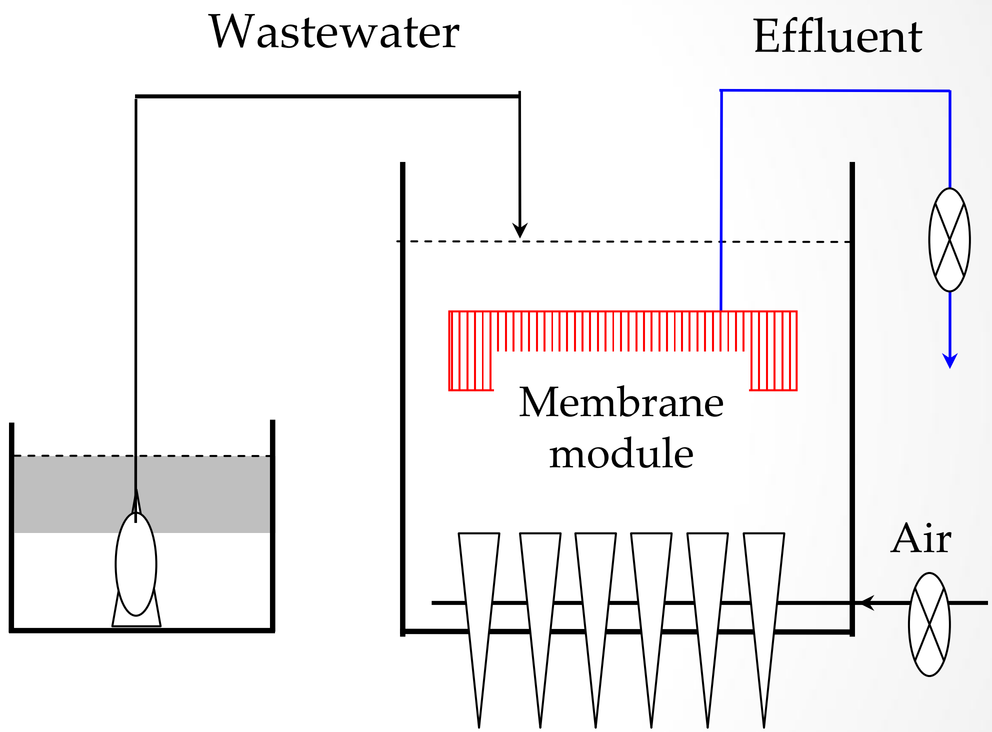
- Known as MBR Technology, originally developed in the 1970's
- R&D efforts have grown the technology with many advancements over the years
- My research at Acadia University is actively pursuing advancements and applications

MBR Technology

- Porous polymer filter that only allows purified water to pass
- Micro-organism "eat" the contaminants in the water
- The micro-organism culture is retained by the membrane



MBR System Schematic



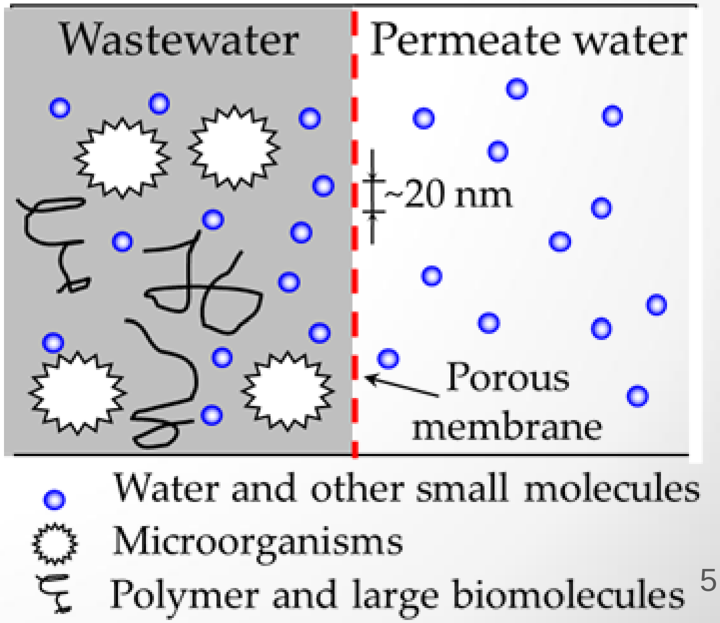
- Great in both municipal and industrial effluent treatment
- Can be optimized for specific application

Key Advantages

- High bacterial concentration ➔ great efficiency
- Effluent is free of pathogens and bacteria
- Low energy consumption
- Small footprint, modular structure
- Low operating costs

Cons:

- Membrane fouling



Membrane Bioreactor 1


Membrane Bioreactor 2

Membrane Bioreactor 3

Compost Leachate

- Composting organic material is very beneficial
- Compost Leachate: wastewater settled out of decomposing organic matter
- Compost leachate is a significant problem

Northridge Farms Inc.

Total Organics

Leachate COD: 116,000 mg/L
Effluent COD: 437 mg/L
Reduction of 99.6%

Individual Chemicals

Unit: μg/L	Leachate	% Reduction
Caffeine	1,330	99.95%
Aluminum	39,800	99.93%
Arsenic	634	97.00%
Iron	297,000	99.87%
Lead	811.0	99.90%
Manganese	51,000	99.95%
Zinc	13,500	99.50%

MBR was demonstrated as a feasible, efficient treatment technology

K. Brown, A. J. Ghoshdastidar, J. Hanmore, J. Frazee and A. Z. Tong*, Submitted.

Fish Farming Wastewater

- Hatchery and processing wastewater
- Nutrient removal (nitrate, phosphate, ammonium, etc.)
- Organic and blood removal
- Water quality analysis and then customized design

Brian C. Wilson Ph.D. – Professor Biology

Research Overview:

• Acute behavioural and endocrine responses to stress in zebrafish; stress pheromones

•Role of relaxin peptides in protecting neural tissue during ischemic stress

R&D Interests and Expertise available:

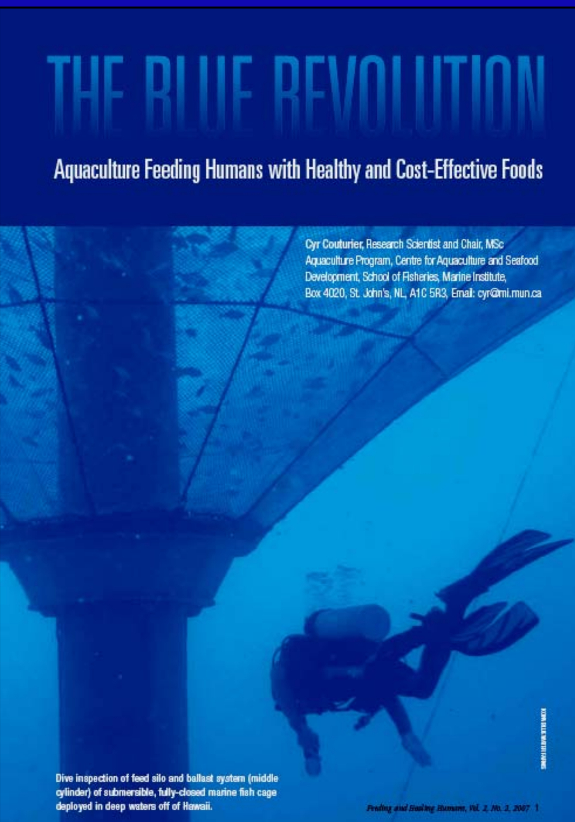
• Interests in connecting stress pheromonal research with industrial applications

•Have expertise in assessing fish behavioural and physiological changes to stress.

CONNECT. COLLABORATE. PROSPER.

Sustainable Aquaculture Applied Research and Development

Cyr Couturier, Research Scientist & Chair Aquaculture Programmes
Marine Institute of Memorial University



Marine Institute

Centre for Aquaculture and Seafood Development

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Research Facilities

CASD

- Aquaculture Research Facility
  - Fresh and salt water recirculation systems
  - Histopathology, bacteriology and necropsy labs
  - Flow through fresh water quarantine facility
- Federally Registered Seafood Processing Pilot Plant
- Fisheries and Aquaculture Marine Bioprocessing Facility
- Dr. Joe Brown Aquatic Research Building (Ocean Sciences Center)*

Research Collaborators

CASD

- Funders
  - DFA, INTRD, DFO, CCFI, NRC, NSERC, CAAP, ACOA, Federation of Agriculture, EFE
- International Collaborators
  - China, Iceland, Ireland, Norway, Malawi, Tanzania, Vietnam, Mozambique, Cambodia, Chile
- Industry Partners
  - Cooke Aqua, Gray Aqua, Seaward Farms, BBMF, Norlantic, Sunrise Fish Farms, Go Deep Intl, Allen's Fisheries, Quinlan's, OCI, NAIA, FFAW, Blue Ocean Sea Products, etc.
- Internal Collaborators (MI/MUN)
  - CSAR, SOT, MII, Biochemistry, Biology, Chemistry, DELT, Engineering, Harris Centre, OSC

CASD

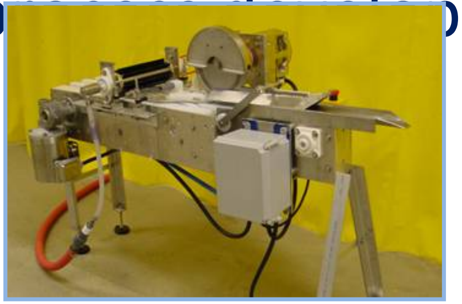
Technical Services

- Sensory Analysis and Training
  - Environmental monitoring
  - **Seafood standards (e.g. CFIA, QCEP)**
- **Food and Feed Nutritional Analysis**
- **3rd Party Auditing (e.g. MSC, CoC, BRC, HACCP) and site assessments**
- Lab Analysis (e.g. Food chemistry, Microbiology)

Applied Research Areas

CASD

- Seafood harvesting and processing
  - Improving quality, yield and processing efficiencies
    - Yellowtail capture fishery – OCI, CSAR, SOT, OSC
    - Mussel processing efficiencies – live holding, live mussels, vac pack, MAP
  - Equipment design and development
  - Product and process development


New Product Development

Produits transformes

Applied Research Areas CASD

- Marine Biotechnology
  - ~ $1 million over next 2 years for waste utilization
    - **Chitin/chitosan extraction**



    - **Oil recovery and alternative fuels**




Applied Research Areas

CASD

- Aquaculture
  - Site & performance evaluation
  - Shellfish culture/hatcheries
  - Strain performance evaluation
  - Fish health & nutrition
  - Diet development & feed formulation
  - Design and development of live holding systems
  - Waste utilization and value addition
  - Fisheries – aquaculture interactions

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Salmon, trout, mussels, char, & oysters with emerging (alternate) species sturgeon, cod, halibut, scallops, clams

Aquaculture Research Projects (recent examples)

- Live holding systems
  - Mussels, lobster, crab, whelk
- Mussel seed supply - 5 year project with NAIA, DFO, and others
- Evaluation of mussel seed settlement materials
- FFAW Lobster enhancement Placentia Bay
- Development of American Oysters
- Netwashing system
- Strain evaluation (rainbow trout)
- ARIES
- Marine biofuels from salmonid and cod waste
- Mobile fishmeal plant technology assessment
- Salsnes filter
- Design, development and evaluation of a small scale commercial Aquaponics system
- Lobster grow out pilot - joint MI/OSC project
- Evaluation of new mussel floats – Ireland & NL partners

Aquaculture Research Projects CASD (Couturier - recent)

Development of benthic monitoring indices for hard bottom substrates:

- Collaboration with DFO, MUN Biology
- MSc students
- Industry partners
- BUNGAY (unpub)

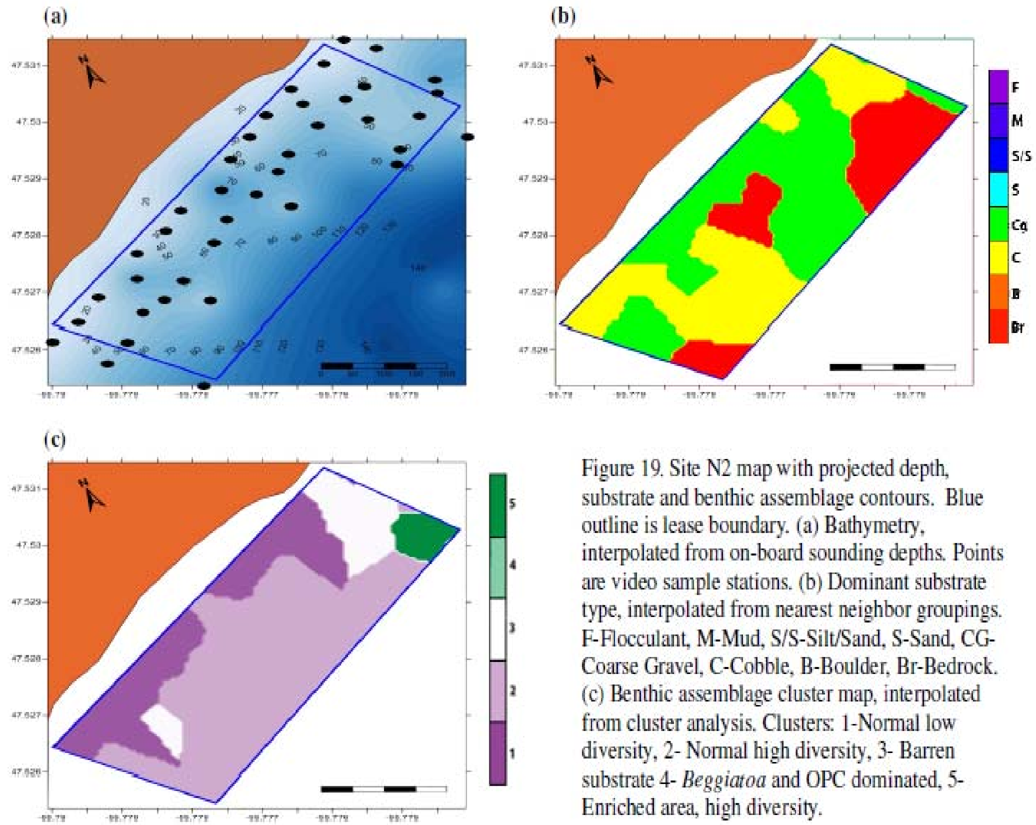

Figure 19. Site N2 map with projected depth, substrate and benthic assemblage contours. Blue outline is lease boundary. (a) Bathymetry, interpolated from on-board sounding depths. Points are video sample stations. (b) Dominant substrate type, interpolated from nearest neighbor groupings. F-Flocculant, M-Mud, S/S-Silt/Sand, S-Sand, CG-Coarse Gravel, C-Cobble, B-Boulder, Br-Bedrock. (c) Benthic assemblage cluster map, interpolated from cluster analysis. Clusters: 1-Normal low diversity, 2- Normal high diversity, 3- Barren substrate 4- *Beggiatoa* and OPC dominated, 5- Enriched area, high diversity.

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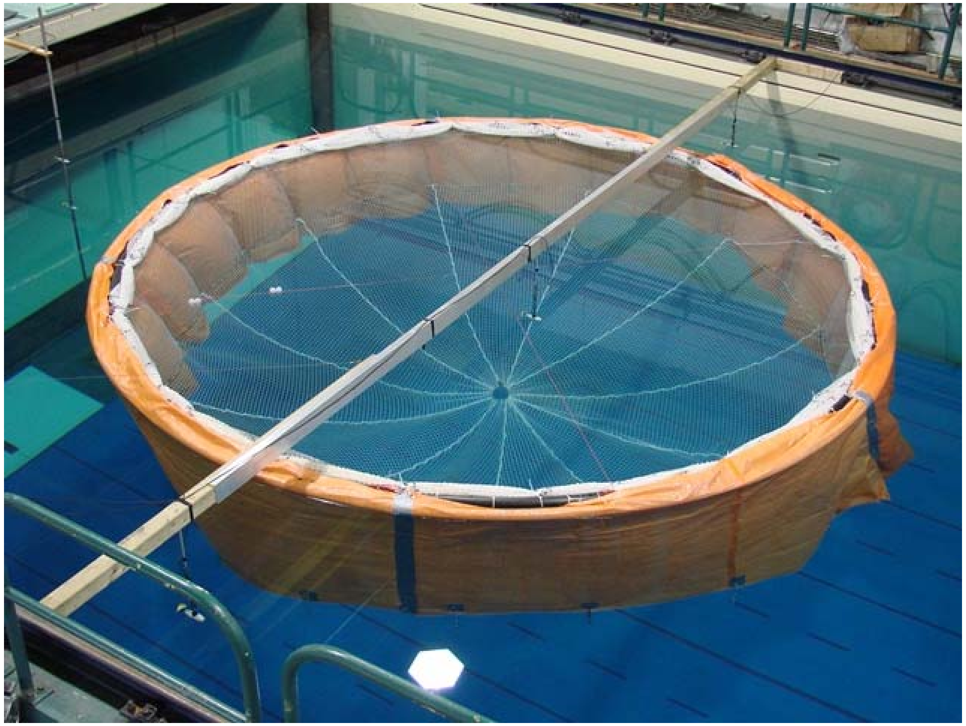
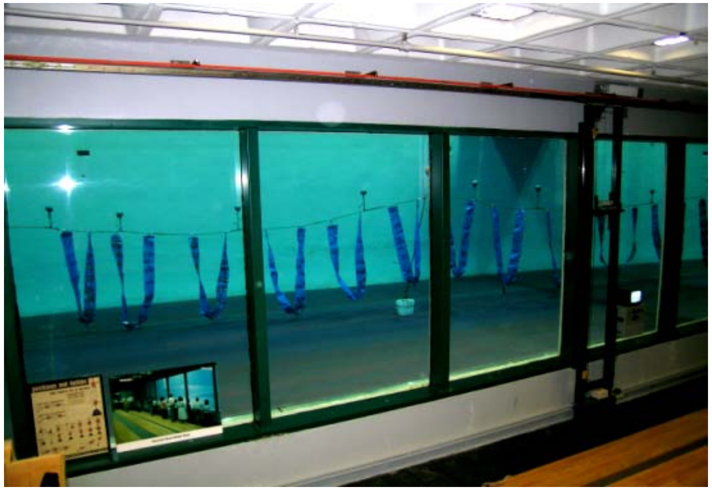
Aquaculture Research Projects (Couturier - recent)

Evaluation of flow dynamics for bath therapeutants:

•Collaboration with DFO

•Risk assessment for non-target organisms



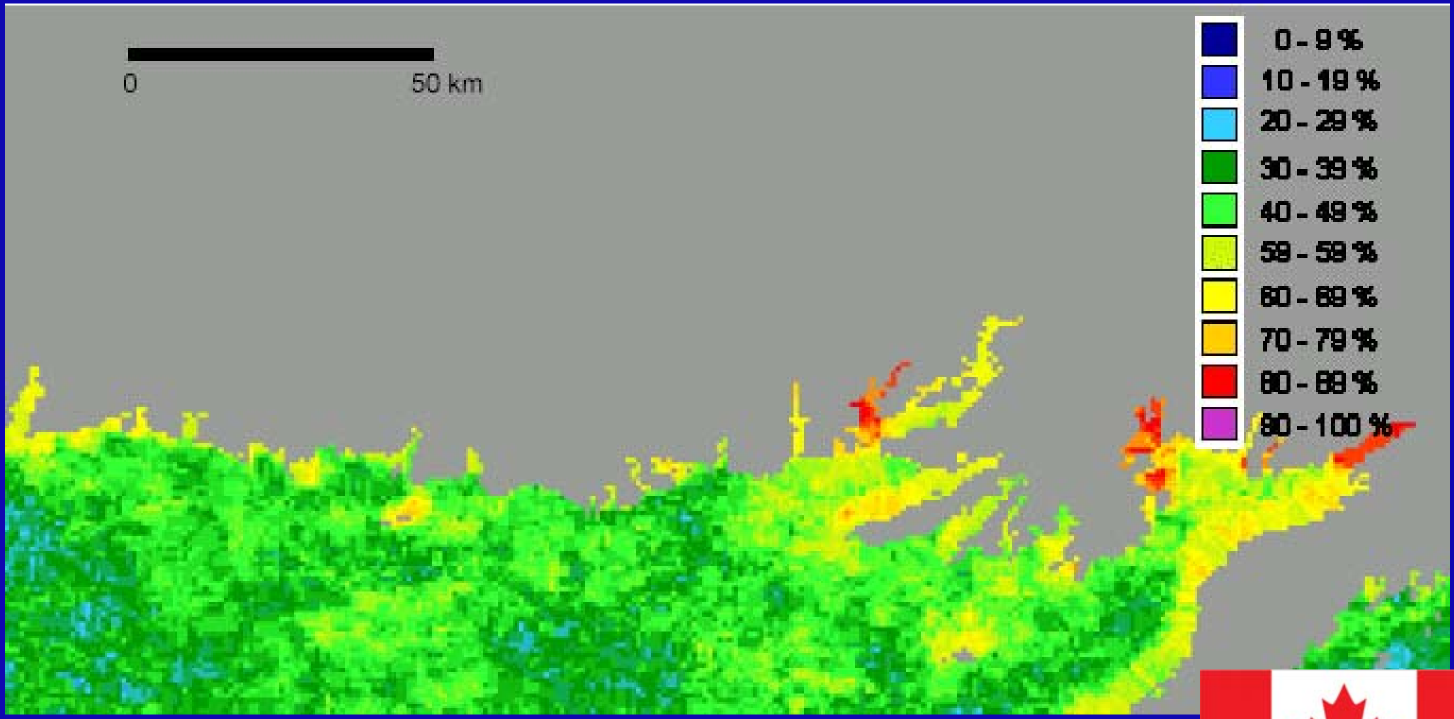


Research – recent initiatives:

Remote sensing and site assessment:

- Collaboration with C-CORE, NAIA, European Space Agency

Should be able to assess sites for production Potential, ice coverage / damage, food patterns, oceanographic anomalies leading to hypoxia, etc.



Aquaculture Research Projects (Couturier - recent)

Bioassays on non-target organisms for therapeutants:

•Collaboration with DFA, Fish Harvesters, NAIA

•Risk assessment for non-target organisms

Marine Institute

Aquaculture Research Projects (Couturier - recent)

CASD

Aquaculture – Fisheries Interactions:

- Collaboration with DFA, Fish Harvesters, NAIA
- Ecological interactions
- **Mussels** and salmonids

Foster et al. (2010)

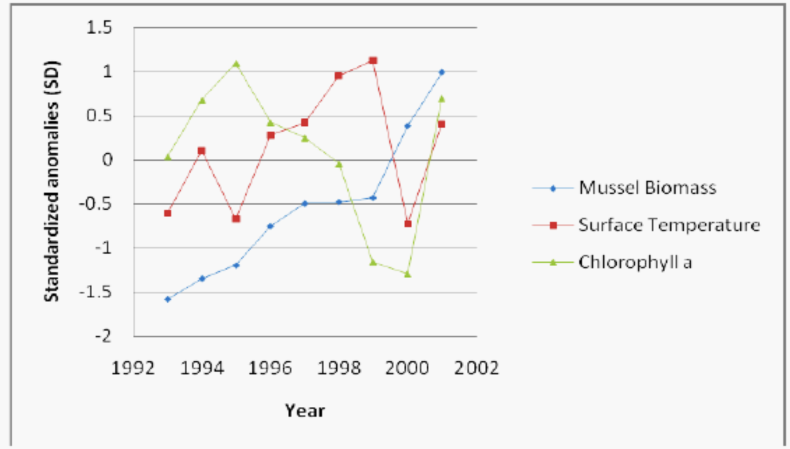
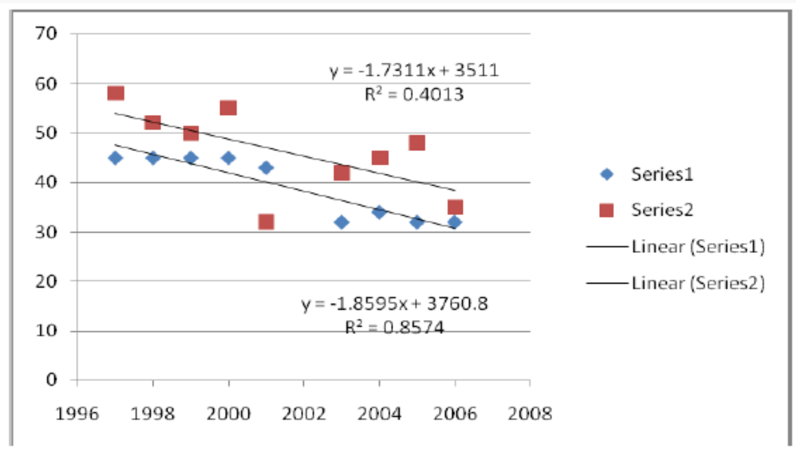


Figure 17. Normalized values of mussel biomass, chlorophyll *a*, surface temper



gure 18. The percent maximum meat yield of mussel in the Green Bay (series 1)

otre Dame Bay (series 2) areas for the years 1997-2006.

Aquaculture Research Projects (Couturier - recent)

Aquaculture – Fisheries Interactions:

- Collaboration with DFA, Fish Harvesters, NAIA
- Ecological interactions
- Mussels and **salmonids**

McLaughlin & Couturier (2005)

Figure 3: Bay of Fundy lobster landings Zone LFA 36 (Robichaud, pers. commun., 2005).

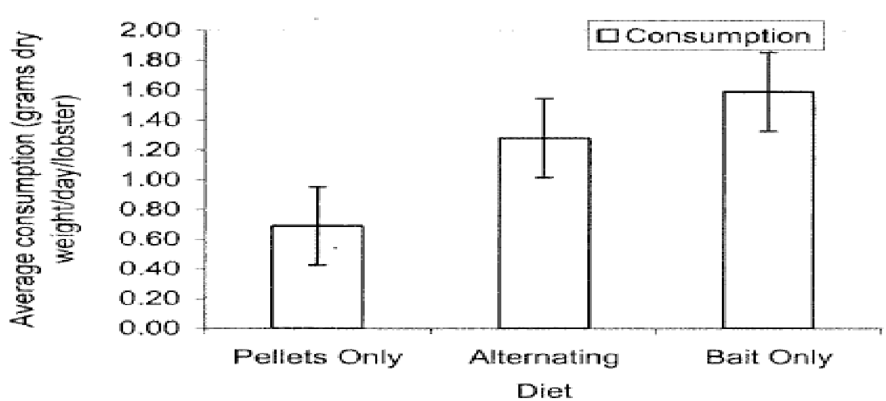


Figure 11: Average daily consumption per lobster for each t
represents x ± S.D., n=216.

Aquaculture Research Projects (Couturier - recent)

CASD

Evaluation of novel egg disinfection protocols against various pathogens:

- Collaboration with DFO, Industry, DFA (vet)
- MSc student
- Cod, salmon, trout

Aquaculture Research Projects (Couturier - recent)

CASD

Evaluation of novel nanostructures for biofouling control

- User friendly, cost effective net fouling control
- Proof of concept being developped

IR3 Rosenhahn, Ederth, and Pettitt: Advanced nanostructures for the control of biofouling IR3

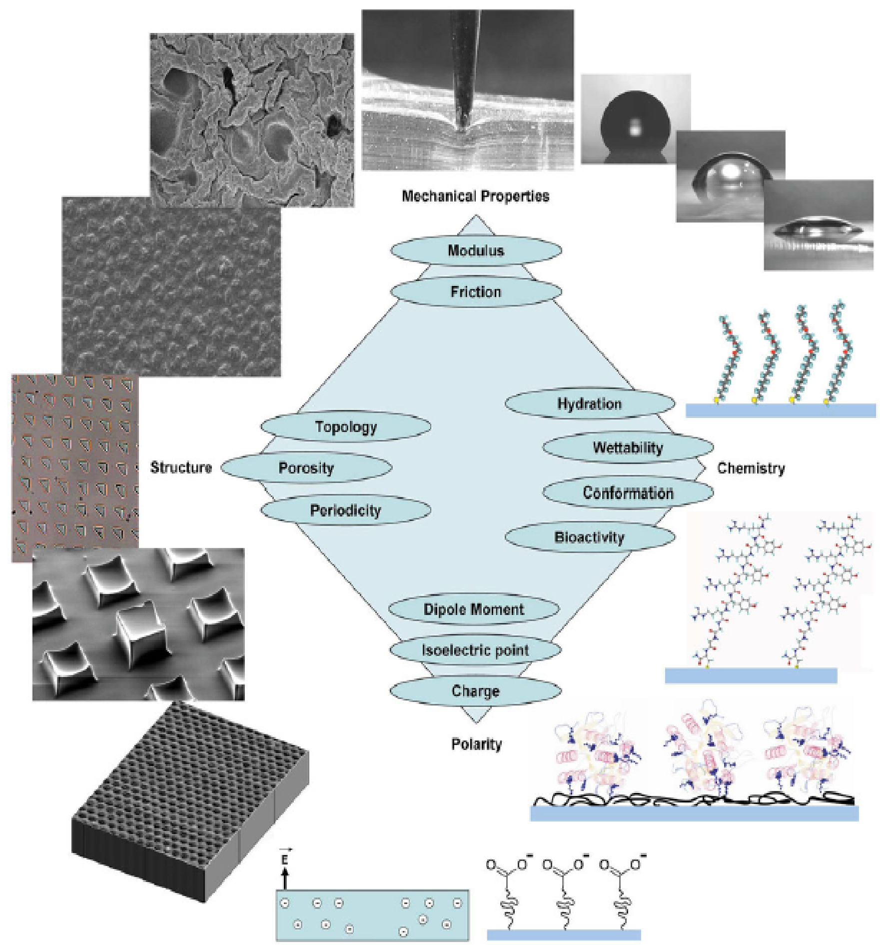


FIG. 2. Selected examples of surface architectures, chemistries, and characteristic properties explored within AMBIO (enzyme picture kindly provided by A. Cordeiro, IPF, Dresden).

Martyniuk lab: Molecular Reproductive Toxicology

- My research focuses on the molecular and physiological impacts of endocrine disrupting chemicals found in aquatic environments

- Gene expression profiling (microarrays) and environmental proteomics are used to better assess the overall impact on fish populations

Key words: genomics, environmental impacts, fish, reproductive physiology, water protection, aquatic toxicology, protein biotechnology, bioinformatics, toxicity testing, bioassays

cmartyn@unb.ca

Chris Martyniuk (Tier II CRC)
CRI Science Director of the Environmental Toxicogenomics Facility

Dr. Chris Martyniuk - Lab focus

Dr Chris Martyniuk's research program is in the area of environmental toxicology, endocrinology, genomics, and bioinformatics. A major objective of the research is to characterize molecular changes in fish during anthropogenic and natural stressors to improve our understanding of adverse impacts on organism health. Some stressors that his group has studied include metals, industrial and municipal effluents, and endocrine disrupting chemicals found in water. They measure reproductive endpoints throughout breeding seasons to learn how hormones (estrogens and androgens) change with gonad growth and how these processes are perturbed by stressors. Studies are conducted that utilize cutting edge molecular tools, for example genomics, to characterize steroid production and how these changes are associated to higher levels of biological organization, such as oocyte growth and maturation. It is important to characterize endogenous reproductive processes in order to gain a better understanding of how normal reproduction is altered by environmental stressors.

His research group also conducts experiments to better understand how environmental factors (e.g. temperature) and chemical stressors (pollution) combine to affect fish development and they measure hatching success, survival, growth, and rates of survival. His laboratory is also studying how early changes in cellular pathways that are involved in sex differentiation are affected by stressors. This has implications for sex ratios in populations as there are genes known to be extremely important in determining if a fish will become male or female.

In short, he develops and adapts molecular bioassays to assess reproductive health and development of fish - these include antibody production, DNA chips, and enzymes assays for stress. Although his research is predominantly focussed on fish, through collaborations his group has worked with other aquatic species that include Queen conch and lobster.

Possible partner projects with aquaculture

1) DNA sequencing approaches and analysis to identify DNA markers of sex or tolerance to stressors, for example disease and temperature. One example is that DNA can be collected non-lethally and examined for variation that is different for males and females and this can lead to improved sexing techniques at earlier stages of development.
2) Studies to improve understanding of how reproductive hormone therapies work in aquatic organisms.
3) Studies to assess the effect of stressors (temperature, dissolved oxygen, metals, effluents) on embryonic development.
4) Development of new tools (molecular, physiological) to improve understanding of immune function and responses in aquatic species.
5) Toxicology of anthropogenic sources. For example, studies can be conducted to explore the effect of metals that include zinc, selenium, copper on sex steroid production and oocyte development.

MEMORIAL UNIVERSITY

Kurt Gamperl

Ocean Sciences Centre
Memorial University

Dept. of Ocean Sciences

Research Mandate: To carry out world-class fundamental and applied research on organisms and processes in cold and temperate oceans.

- over 30 year history of involvement in fish and shellfish aquaculture research and development (R & D).
- played key role in establishing both salmon and mussel aquaculture in Newfoundland.
- internationally recognized centre for cold-ocean aquaculture with experience in designing, executing and managing both small- and large-scale projects.
- over $5 million in funding for aquaculture R & D between 2008 and 2012.

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ONGOING AQUACULTURE PROJECTS

Ocean Sciences Centre
Memorial University

Development of *Camelina sativa* for Substitution of Fishmeal and Oil in Aquaculture Feeds (ACOA-AIF, Genome Atlantic). **Derek Anderson, Chris Parrish, Matt Rise and Collaborators**

Optimization of Diets for the Early Development of Atlantic Cod (ACOA, RDC, Genome Atlantic). **Kurt Gamperl, Matt Rise, Danny Boyce, Chris Parrish and Icelandic and Norwegian Collaborators**

Causes, Consequences and Prevention of Escapes from Marine Fish Farms – Both Salmon and Cod (NSERC Strategic). **Ian Fleming, Garth Fletcher, Craig Purchase, Ed Trippel, John Brattey, and EU Partners**

Reproductive Confinement for the Cultivation of Genetically Improved Lines of Atlantic Salmon (ACOA-AIF). **Matt Rise, Debbie Plouffe, John Buchanan, Tillmann Benfey, Brian Glebe, Mike Reith and others**

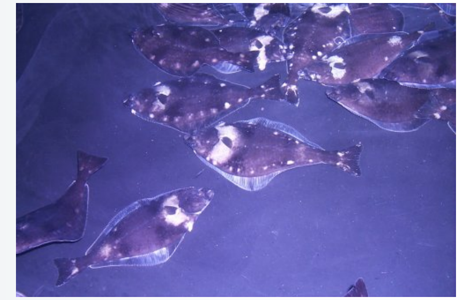
Use of Lobsters in Multi-Trophic Aquaculture (RDC – IRIF, CFI). **Iain McGaw**

Atlantic Salmon Macrophage Responses to *P. salmonis* (Petro-Canada Young Investigator Award). **Matt Rise, Fred Kibenge and Simon Jones.**

CAMELINA
DEVELOPING CANADA'S NEXT OILSEED

AQUACULTURE RESEARCH TEAM

Dr. Chris Parrish –Marine Biochemist

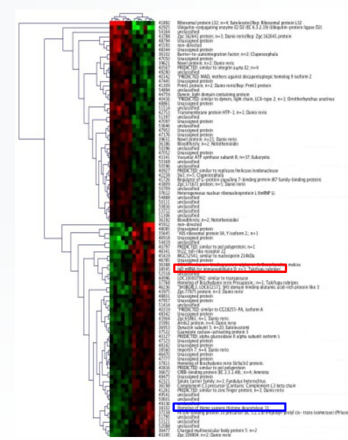


- Finfish nutrition, enhanced production and fillet quality.
- Farm interactions with adjoining ecosystems – nutrient and biomarker uptake by wild and cultured mollusks.

Drs. Ian Fleming and Mark Abrahams – Fish Ecologists

- Aquaculture and environment interactions / sustainability.

Dr. Matt Rise - Canada Research Chair in Marine Biotechnology

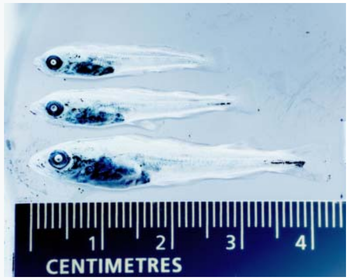


- Use of genomics approaches to study the genetic basis of enhanced growth, and fish responses to pathogens, environmental stressors, and various diet formulations.
- Identification of molecular markers for use in selection of broodstock with optimal production characteristics.

AQUACULTURE RESEARCH TEAM

Dr. Kurt Gamperl – Fish Physiologist

- How environmental changes (e.g. temperature, hypoxia, currents, diet) impact fish performance (growth, stress, disease resistance).



Dr. Iain McGaw – Crustacean Biologist

- Cage-site influences on crustacean behavioural and ecology.
- Incorporation of crustaceans into multi-trophic aquaculture.

Mr. Danny Boyce (M.Sc.) – JBARB Facility and Business Manager

- Technical, management and scientific support for small and large-scale projects.

Dedicated and Experienced Aquaculture Research Staff

Extensive Network of Canadian and International Collaborators

MEMORIAL UNIVERSITY

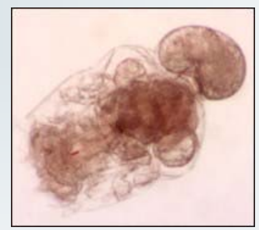
DR. JOE BROWN AQUATIC RESEARCH BUILDING (JBARB)

Ocean Sciences Centre
Memorial University

- state-of-the-art facilities designed to support research, training, pre-commercial production, and small-scale commercial trials, on species for marine aquaculture.

- This 1,300 m^2 facility has a seawater system designed to deliver high quality, temperature controlled, flow through and re-circulating water and contains facilities for:

  - broodstock conditioning and fish on-growing
  - hatchery and nursery (larval) operations
  - juvenile rearing
  - dedicated live food production facility for algae, rotifers and *Artemia.*



OSC RESEARCH INFRASTRUCTURE

FIELD SERVICES: fish transport, and support of research requiring underwater surveying, sampling or observations.

38 LABORATORIES of varying size, 16 with flowing seawater, 22 with instruments for analytical chemistry, biochemistry, physiology, histology, molecular biology & microscopy.

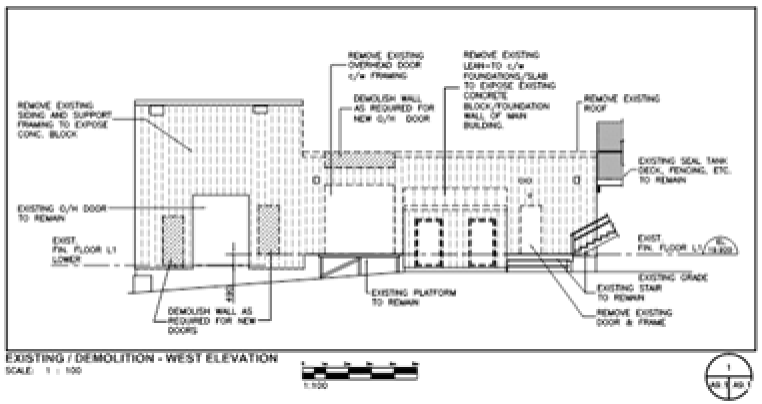
COMMON-USE ROOMS for fish sampling, microscopy/image analysis, radioisotope analyses, histological preparation and histochemistry, and molecular biology, biochemical analyses.

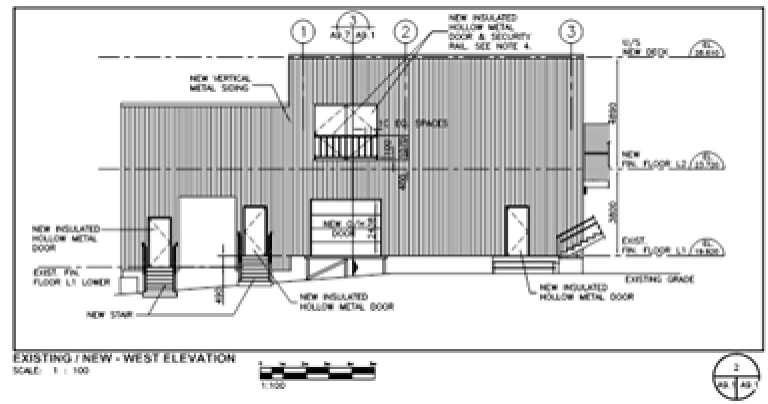
ANALYTICAL INSTRUMENTATION: including total organic carbon (TOC) and carbon hydrogen nitrogen (CHN) analyzers, HPLCs, GCs, a GC/mass spectrometer, Iatroscan system, high-speed centrifuges, beta- and gamma scintillation counters, quantitative real-time polymerase chain reaction (qPCR) machines, a microarray scanner, a genetic analyzer and a high-throughput.

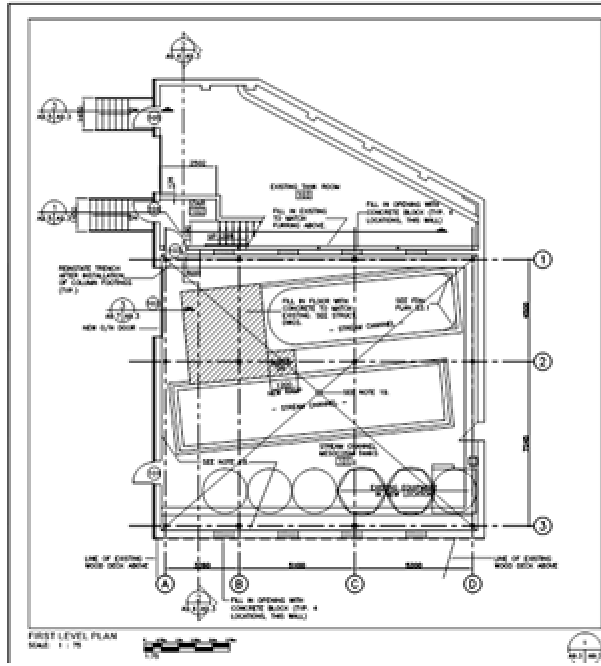
LABORATORY SERVICES: Construction, maintenance and repair of infrastructure in support of research, and research equipment, 24 hour systems monitoring.

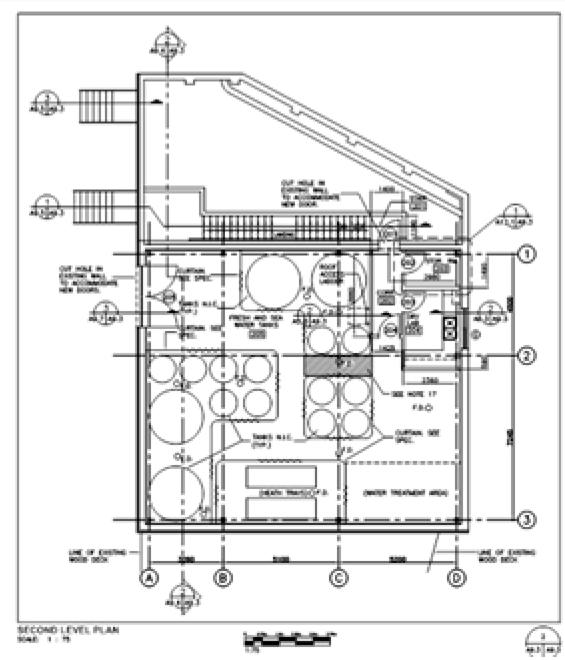



FACILITY EXPANSION – TANK BUILDING

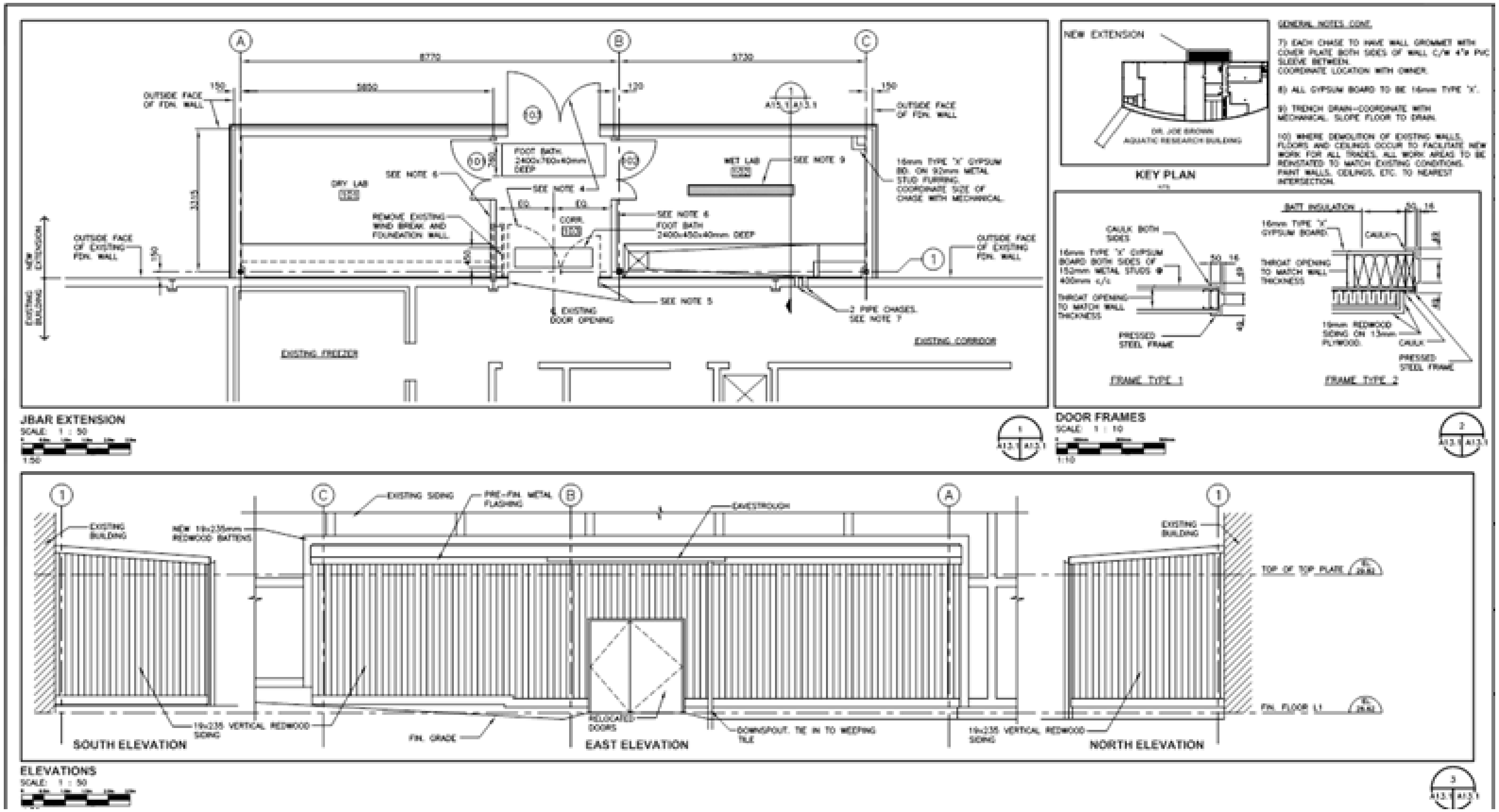




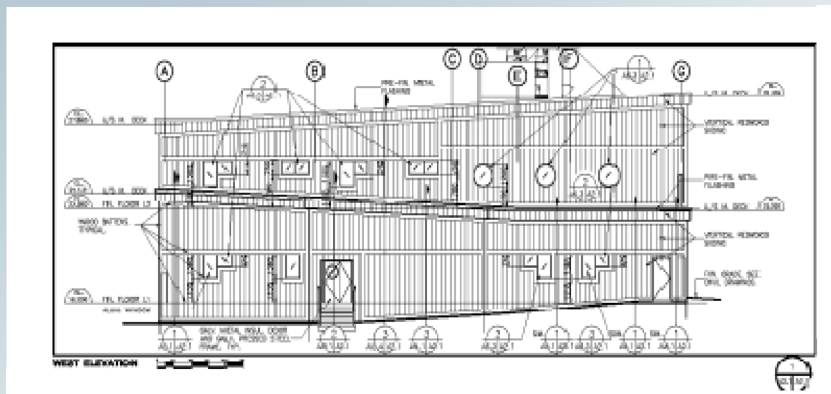




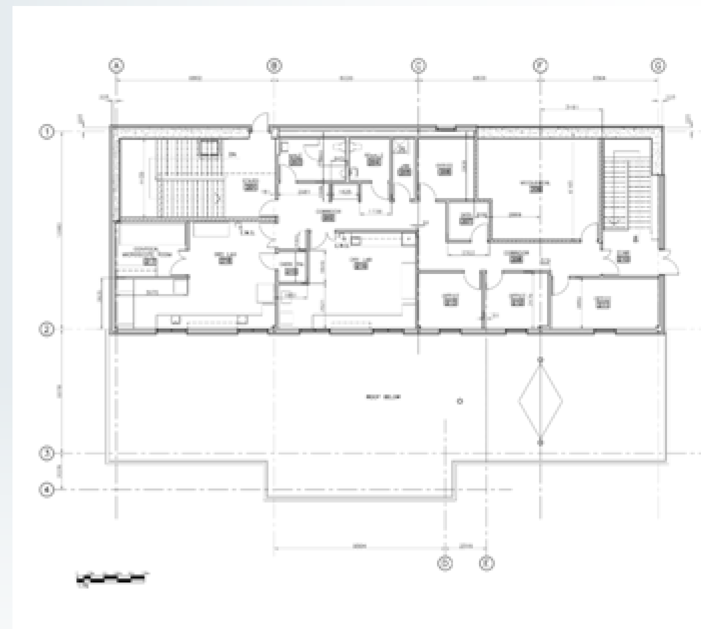
FACILITY EXPANSION - JBARB



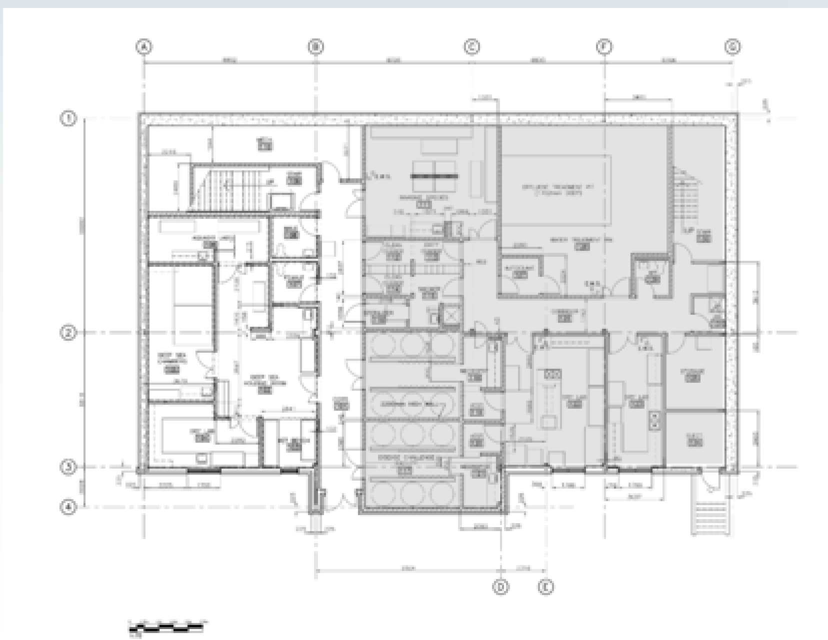
FACILITY EXPANSION - CDRF



Second Floor



First Floor



MEMORIAL UNIVERSITY

CAGE-SITE RESEARCH / OPERATIONS

Ocean Sciences Centre
Memorial University

WE'RE HERE TO CONNECT WITH INDUSTRY

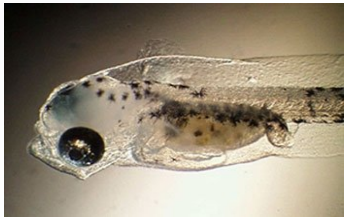
The Dept. of Ocean Sciences has:

- World-class fish / shellfish holding and research facilities
- An experienced research team with a proven track record in fish aquaculture R&D and project management

Identified Research Areas Where We Can Assist:

- Fish health evaluations / toxicology √
- Improving fish health treatment efficacy √
- Biological control of sea lice √
- Immunostimulant evaluation √
- Feed development / testing √
- New technology (diagnostic tools) to support fish health / farm management √

Other Areas of Specialization:



- Environmental interactions / sustainability
- Optimization of culture conditions / determination of limits
- Product quality / nutritional value
- Broodstock development / family rearing programs

Aquacultural Engineering Activities at UNB

presented at
ACCFA's Research Connector Event
St. Andrews, NB
November 15, 2012

by

Dr. Michel Couturier, P. Eng
Professor of Chemical Engineering &
NSERC Design Chair

Research Projects completed during last 6 years

- Contact filter for removal of fine particulates in RAS (Cooke Aquaculture, NBIF, NBDAFA)
- Design of drum filters and large diameter rearing tanks (Atlantech, NBDAFA, CCFI)
- Advanced effluent treatment system for land-based aquaculture facilities (AIF, Atlantech, Cooke Aquaculture)
- Design of a low-head biofilter (NBDAFA, NBIF, CCFI, Cooke Aquaculture)

NSERC-UNB Chair for Collaborative Engineering Design Education

- Wanted: Client-sponsored design projects for our final-year design courses
- Cost: $0.00 but client must meet with students in Sept., Nov., Feb., and April
- Quality assurance: Two teams per client; faculty and industry co-mentors
- Benefits: Two innovative solutions and opportunity to evaluate future graduate engineers

Interested?

Contact:

Dr. Michel Couturier
Chemical Engineering Department
University of New Brunswick
Fredericton, NB E3B 5A3
(506) 453-4690
cout@unb.ca

Integrated
Water Quality Model

Crowell[1], Webster[1], Livingstone[1], G. Rose[2]

[1] *Applied Geomatics Research Group* (nathan.crowell@nscc.ca)
[2] *Golder Associates Ltd (Greg_Rose@golder.com)*

Aquaculture Industry-Researcher Connector Event
Huntsman Marine Science Centre, Saint Andrews NB, Nov 2012

Atlantic Canada Opportunities Agency
Agence de promotion économique du Canada atlantique
Canada

AGRG Applied Geomatics Research Group
Centre of Geographic Sciences
Middleton | Nova Scotia | Canada

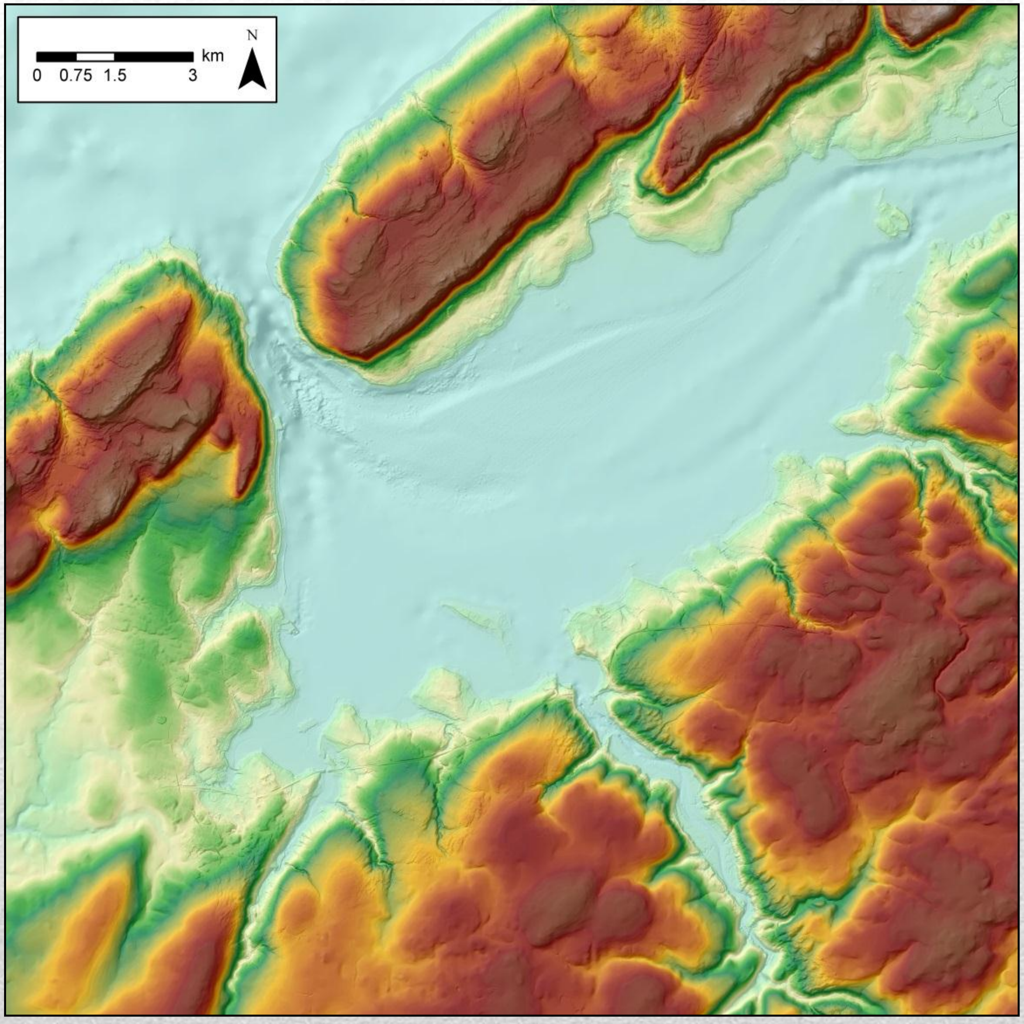
Golder Associates

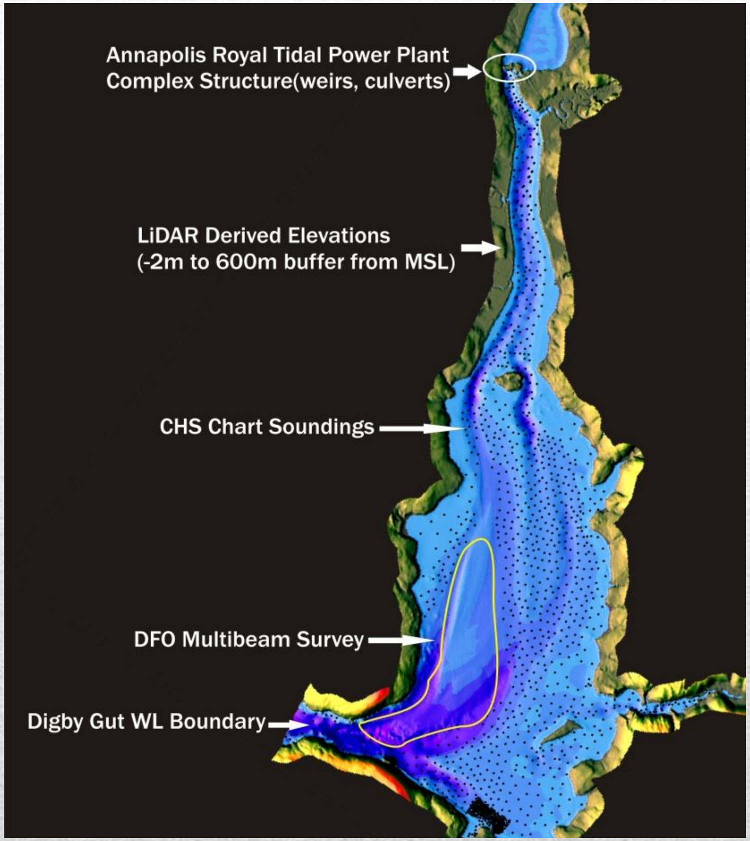
SCOTIA WEATHER SERVICES INC

GeoNet

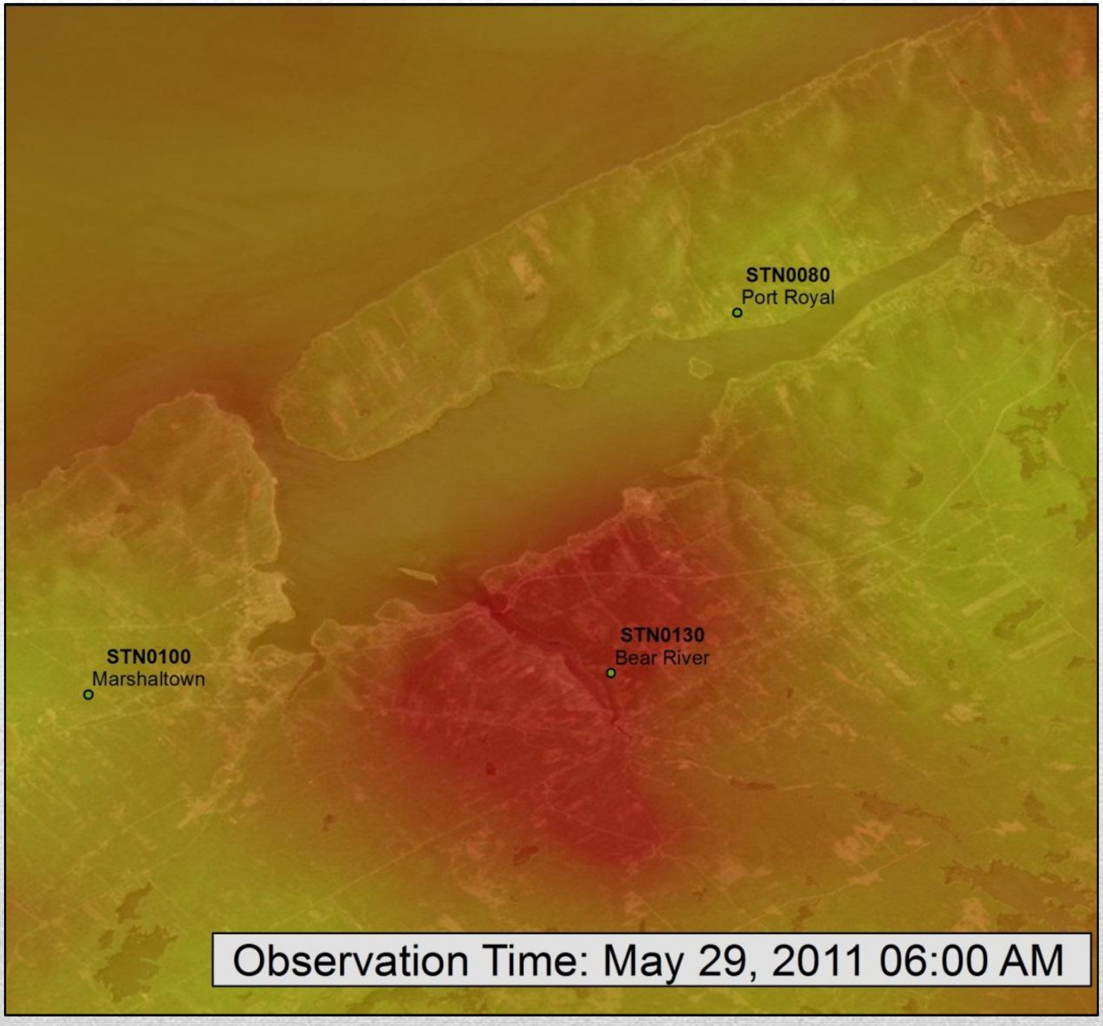
ESRI Canada

- Surface Model





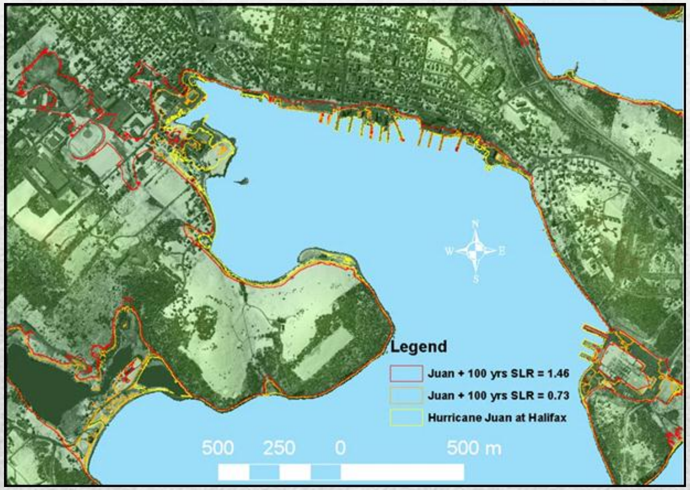
Framework

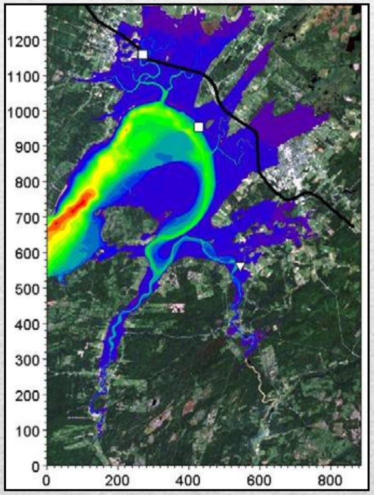


- Environmental Model
  - Precipitation
  - Evapotranspiration
  - Wind speed/direction
  - Ultraviolet light

Framework

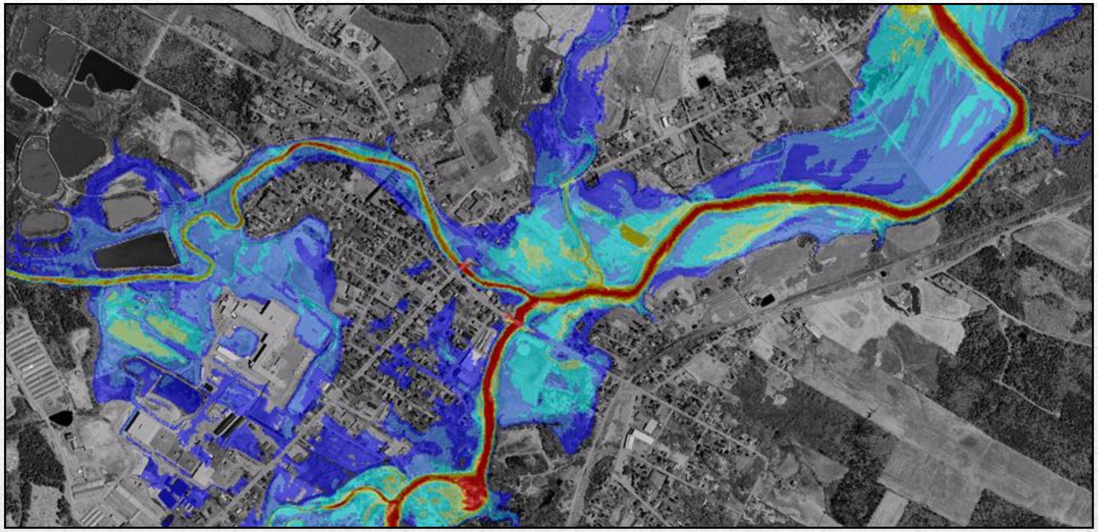
- Vulnerability to wave action
  - Fetch length
  - Weather observations
  - Physical characteristics



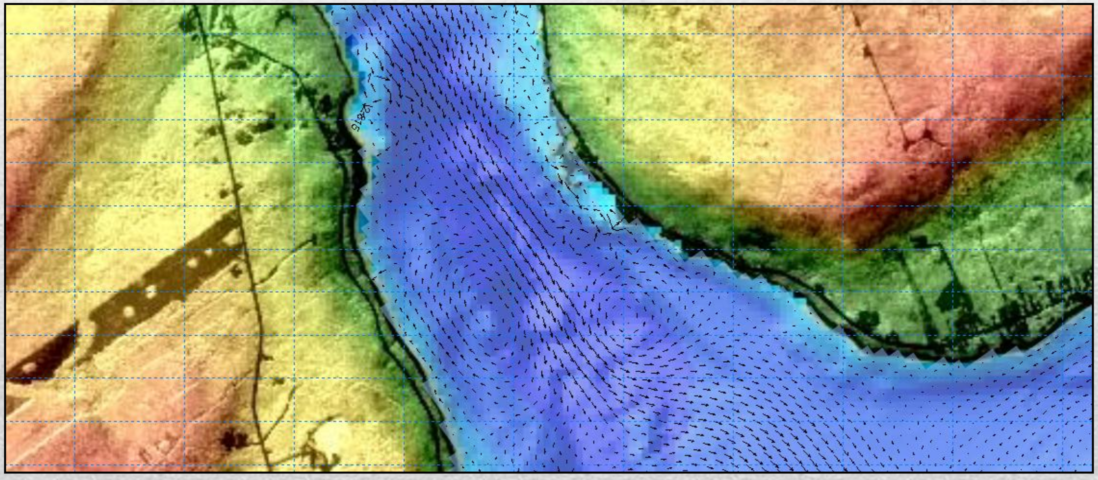


- Vulnerability to storm surge
  - Tidal constituents
  - Historical observations
  - Modeled flood layers

Case 1: Site Selection

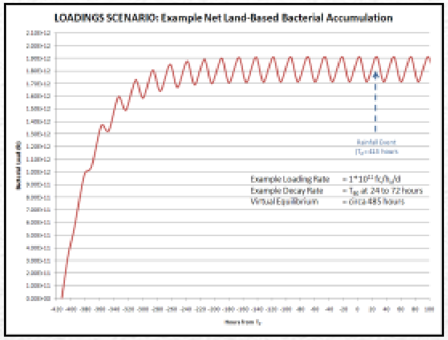


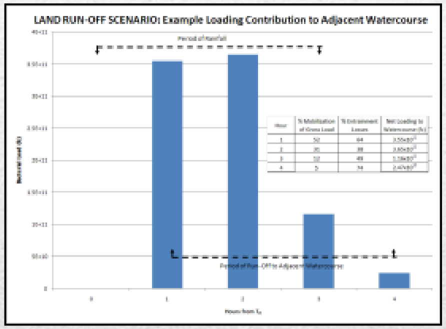
- Watersheds
  - Overland runoff
  - Flooding potential

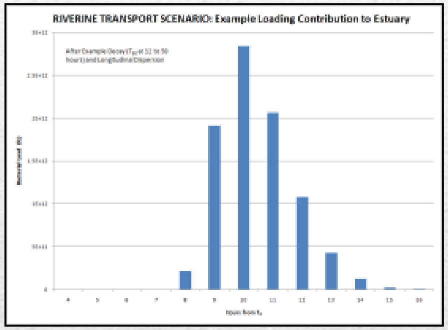


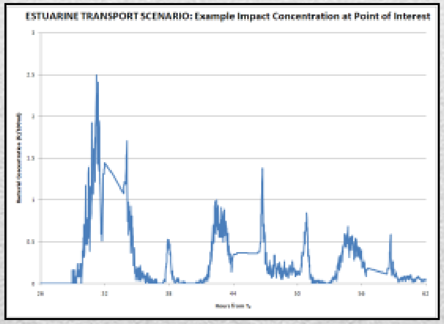
- Estuaries
  - Current magnitude
  - Volume exchange

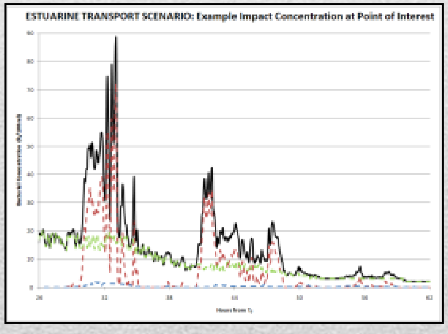
Case 2: Hydrodynamics









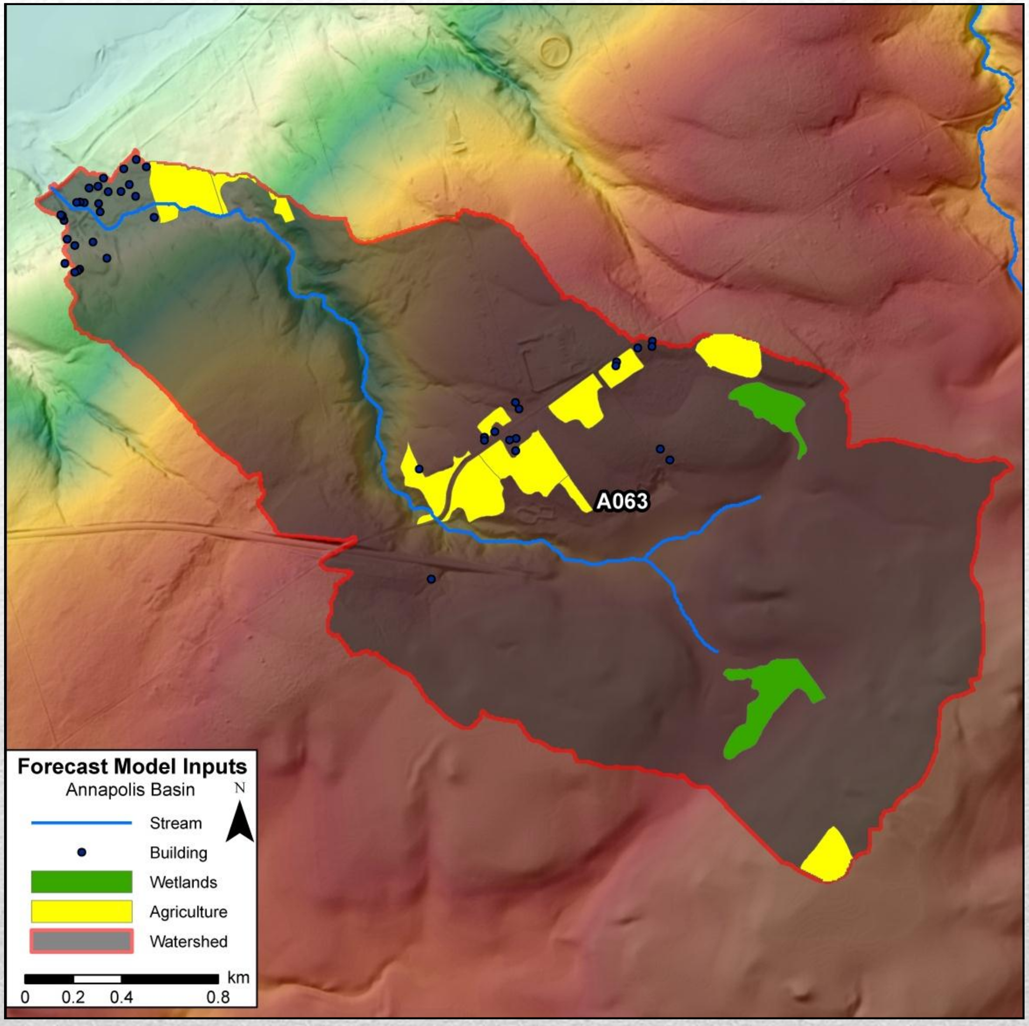


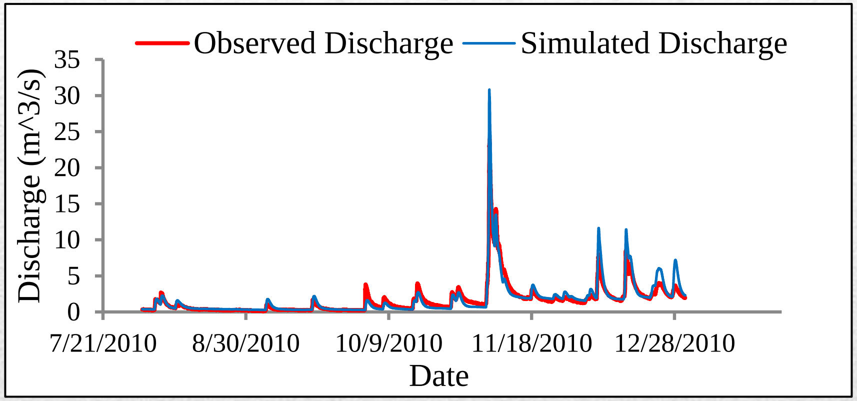
- **Source Tracking**
- **Watershed Transport**
- **Estuarine Transport**

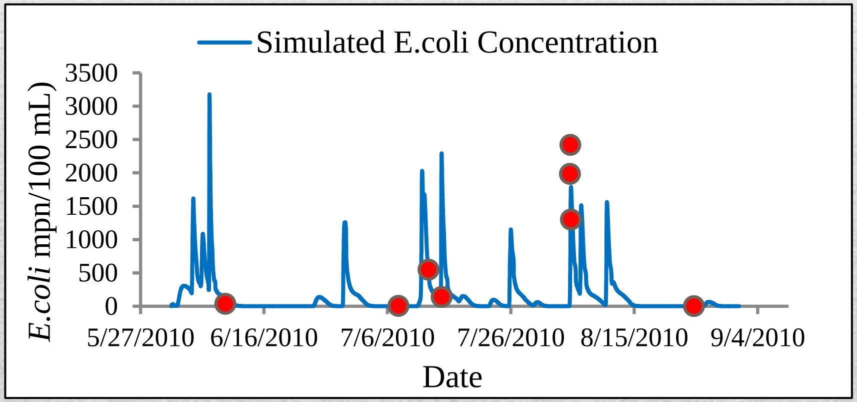
Case 3: Transport

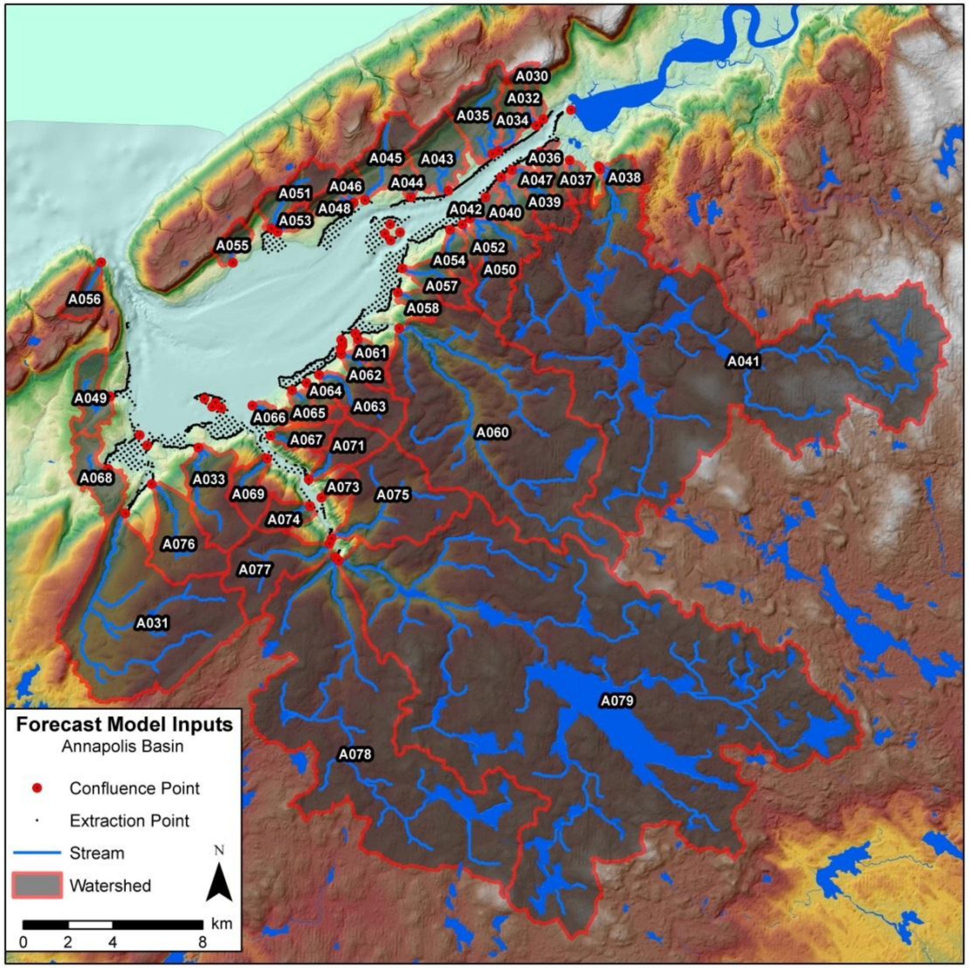
Case 3: Transport

- Watershed Transport
  - Source identification
  - Loading characteristics

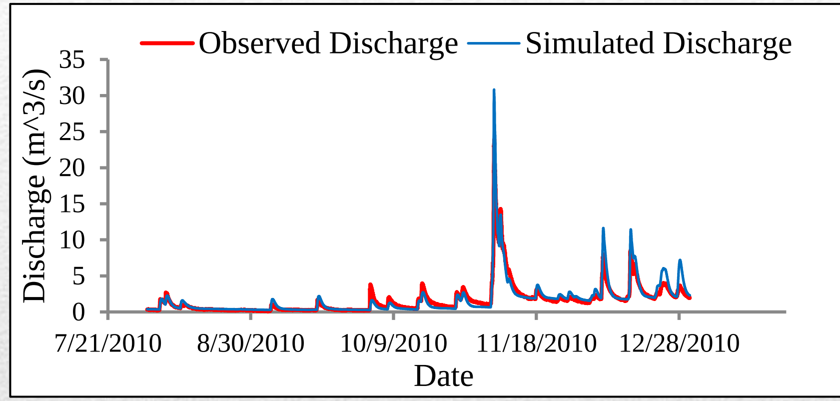


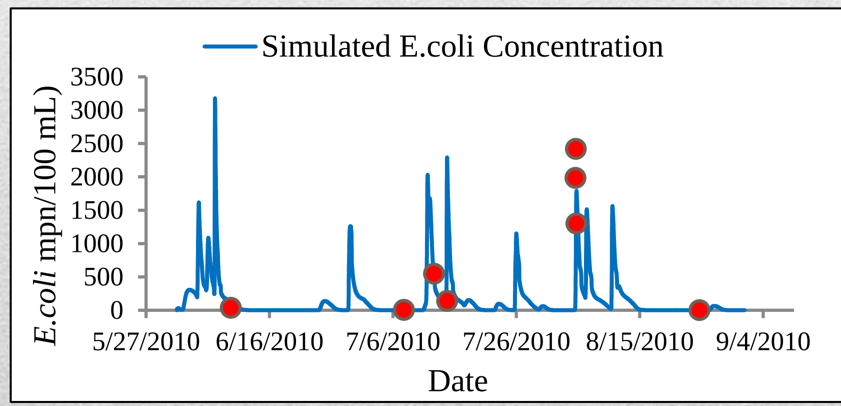




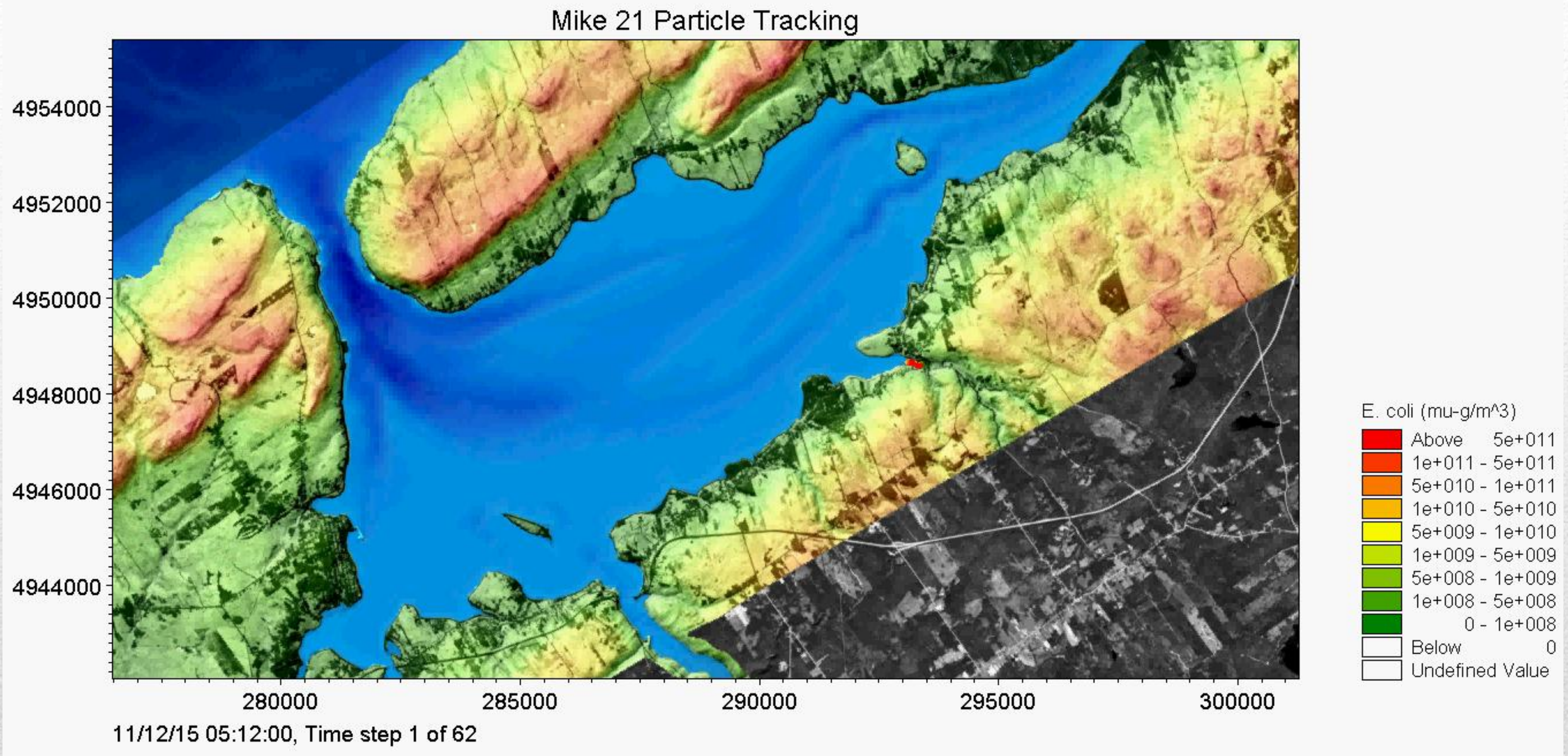


- **Watershed Transport**
  - **Source identification**
  - **Loading characteristics**

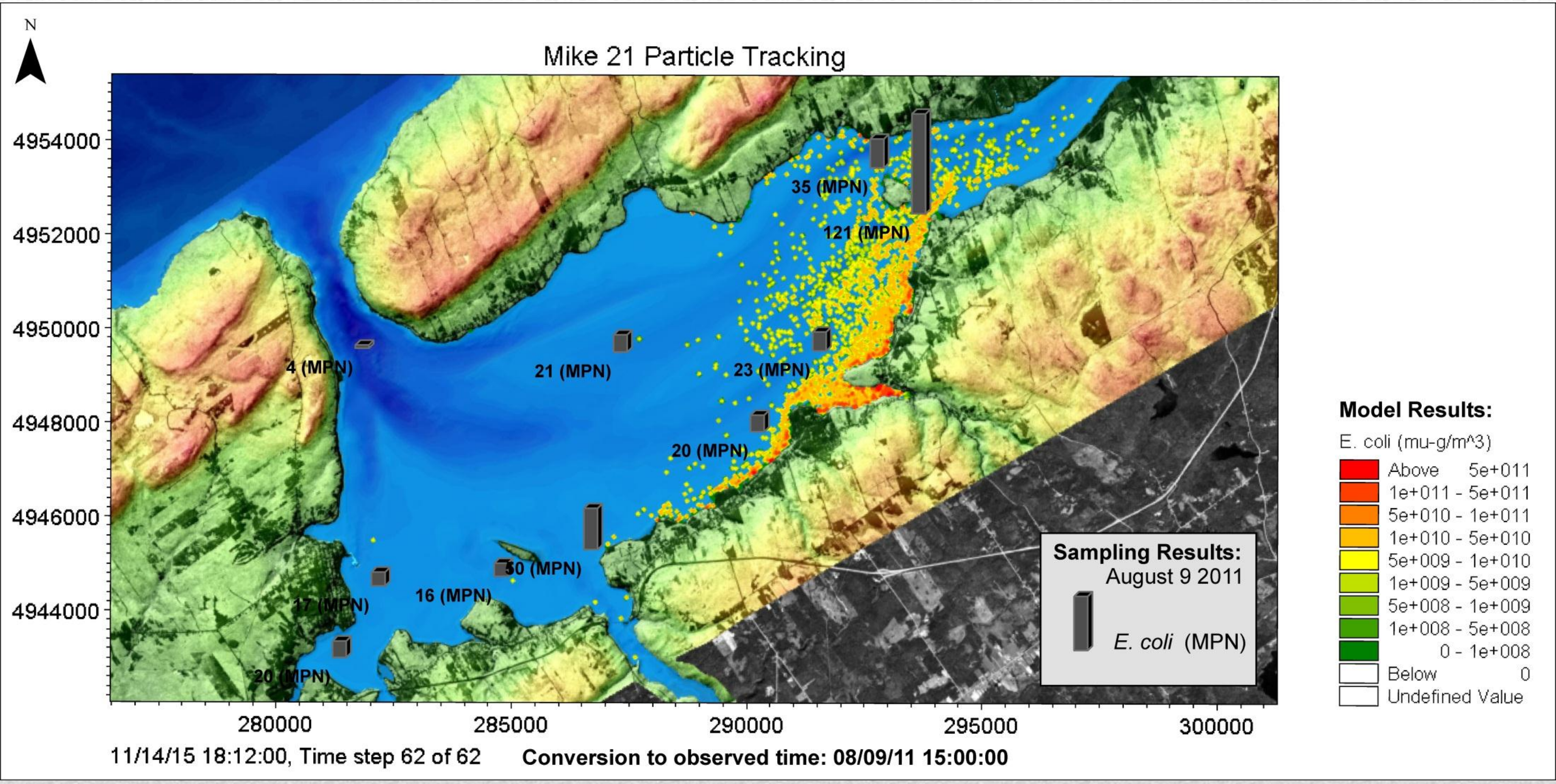




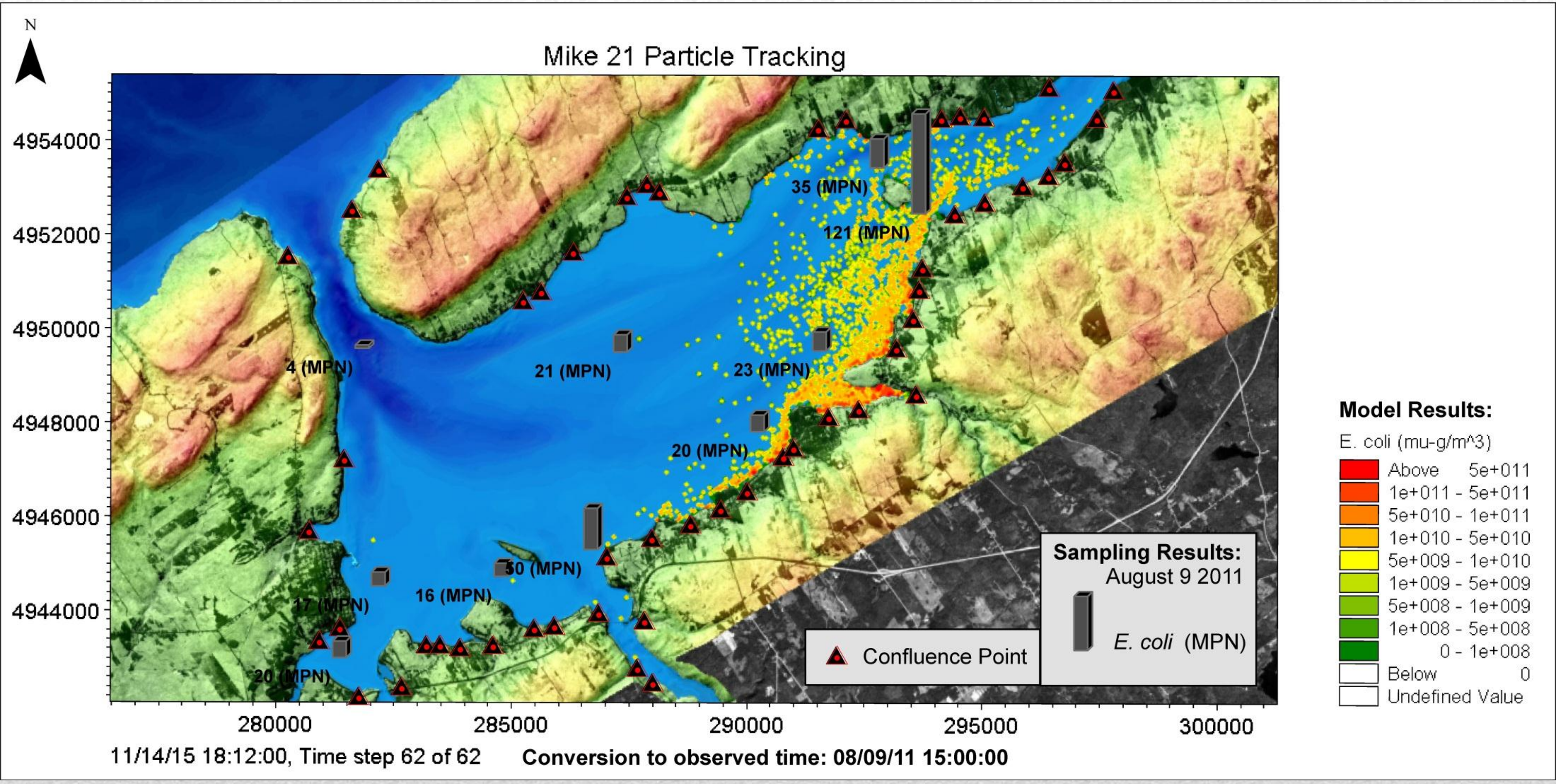
Case 3: Transport



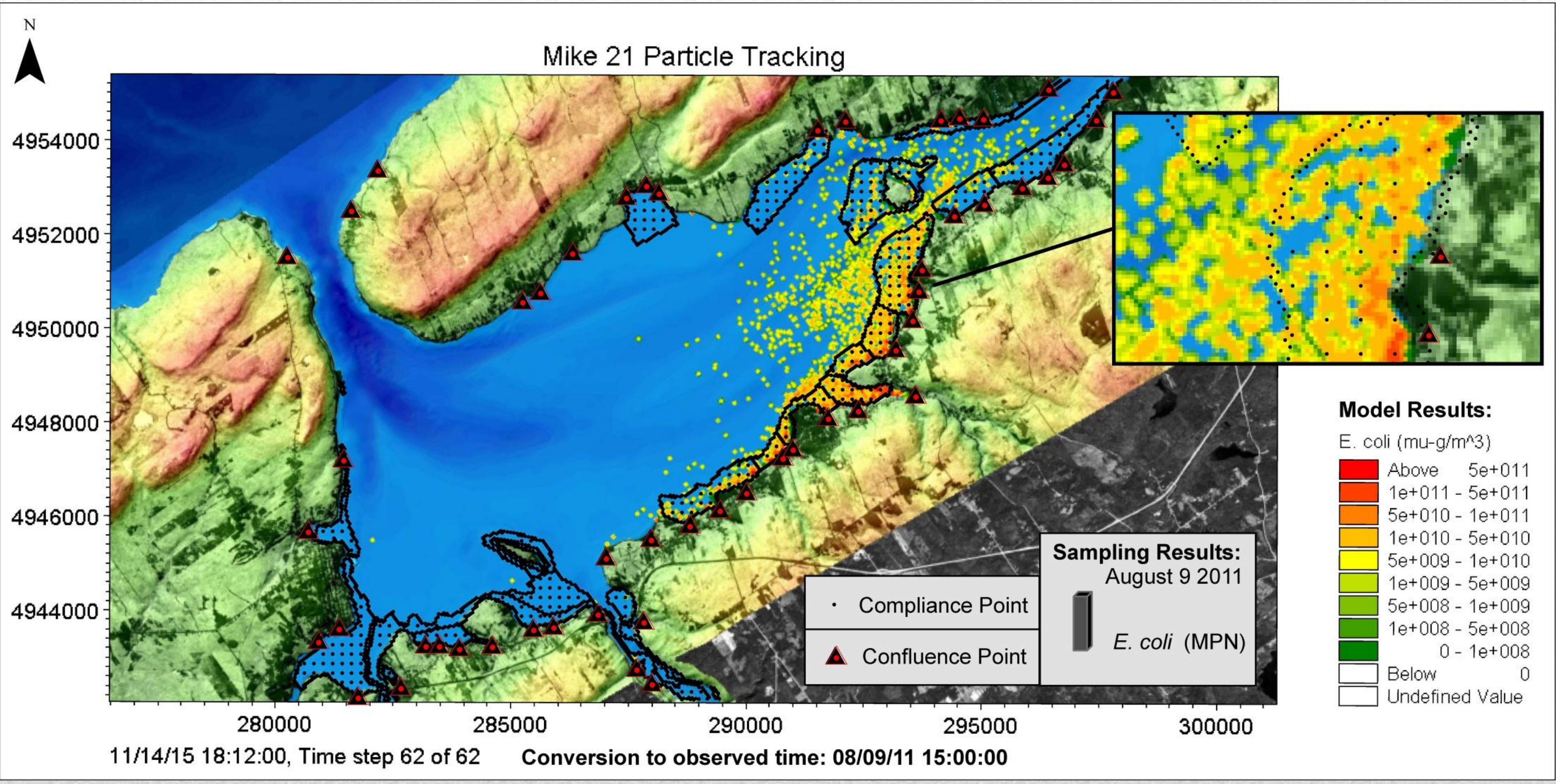
Case 3: Transport



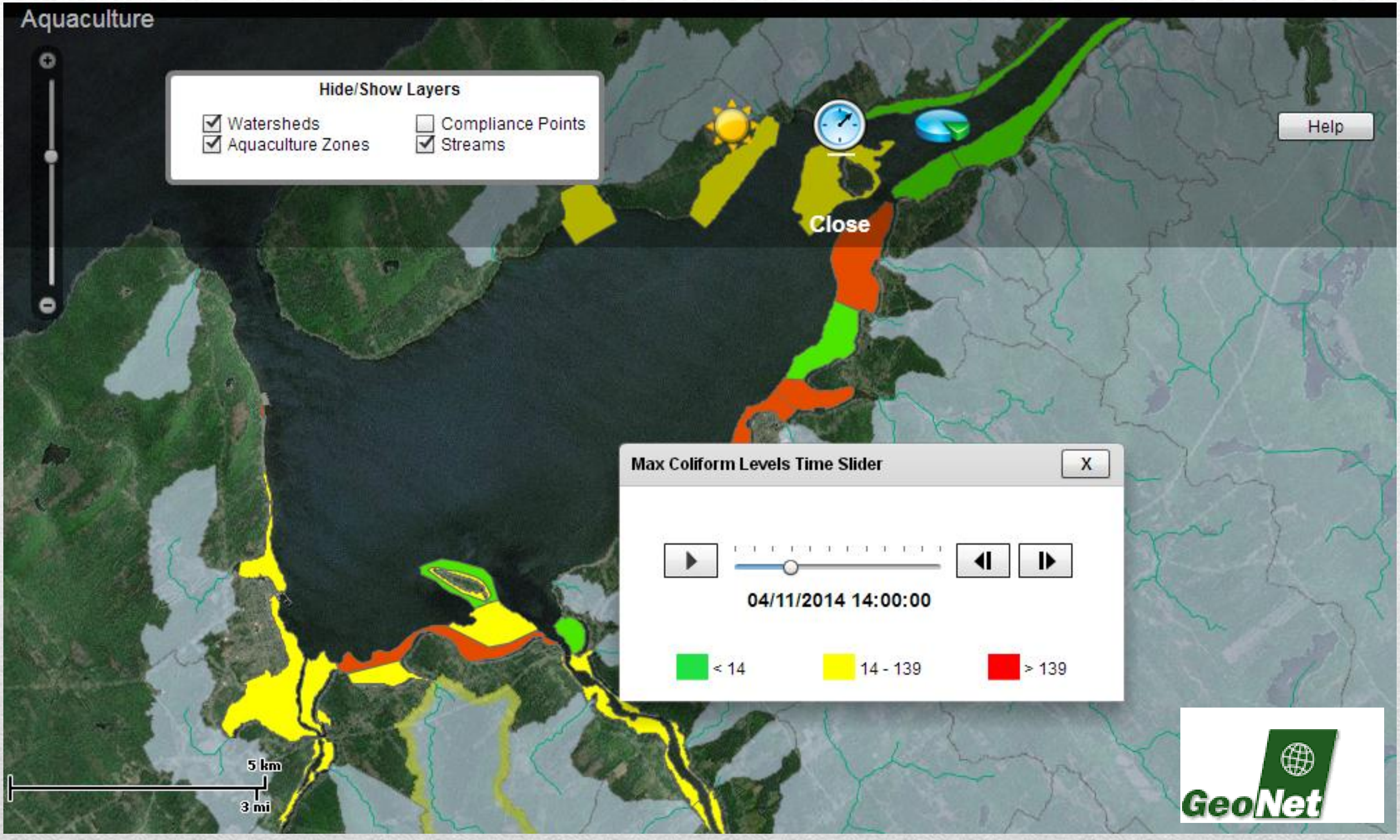
Case 3: Transport



Case 3: Transport



Case 3: Transport



Case 3: Transport

Contact

- Nathan.crowell@nscc.ca
- Timothy.webster@nscc.ca

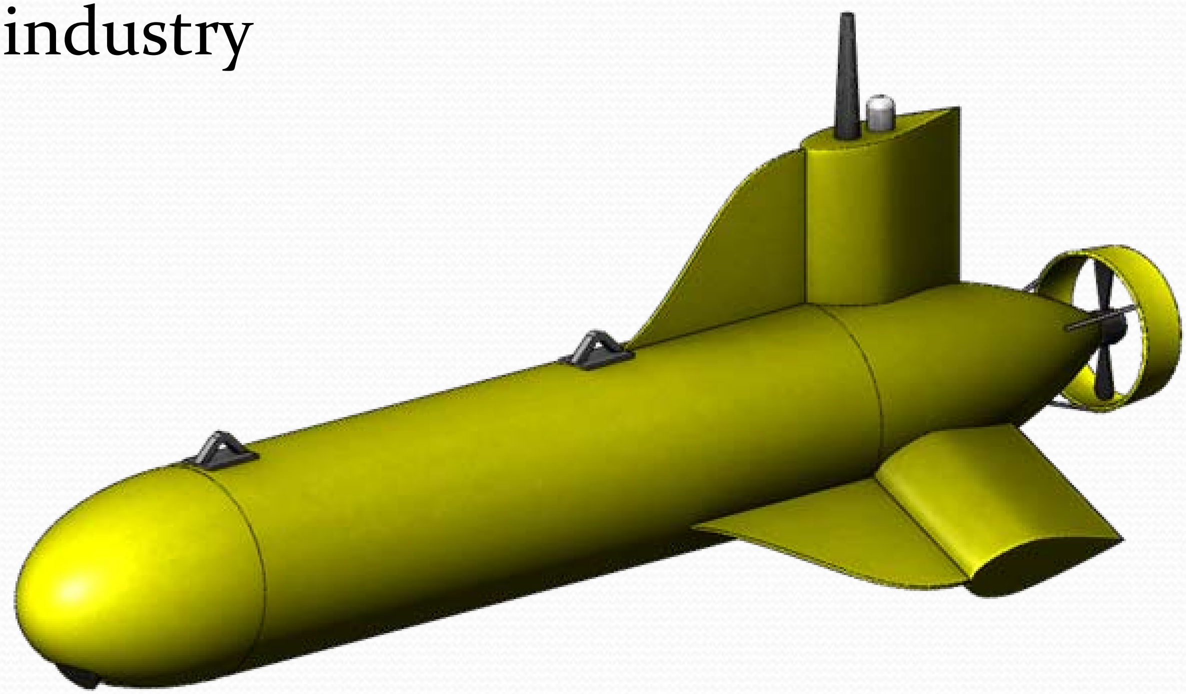
Aquaculture AUV*

A proposed joint project with Memorial University

*Autonomous Underwater Vehicle

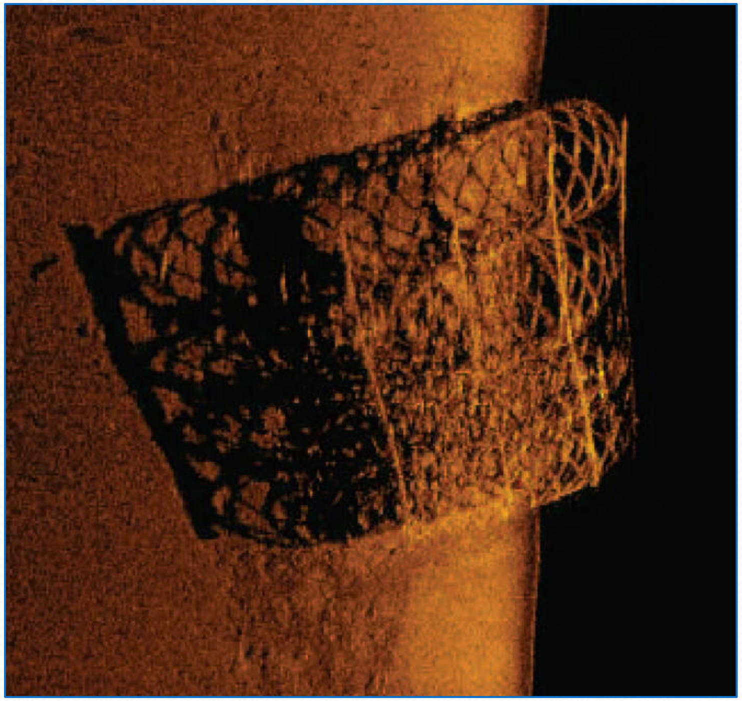
Proposal

- An Autonomous Underwater Vehicle developed specifically to meet needs and challenges of the aquaculture industry



Benefits

- Highly efficient means of repeated data collection with a range of sensors
  - Camera
  - Video
  - Sonar
  - CTD
  - water samples
  - ADCP
  - Dissolved oxygen



Benefits

- Aquaculture AUV would operate safely amongst nets and moorings with a small logistical footprint
  - small number of handlers required
  - shore based operation
  - no need for divers in water
  - equipment more easily sanitized between sites to reduce bio-fouling

Benefits

- MERLIN lab has
  - existing AUV platform
    - Solution looking for problem
  - years of experience in
    - AUV field operations,
    - design
    - payload integration

- This project has a low risk for high TRL output

Industry Partnership

- Commercialization of technology
- Support for in-field demonstration
- Design input to ensure industry needs are met
  - What are your needs?

Working Together to Help Atlantic Canadian Businesses Leverage the Power of Genomics

Shelley King, MSc, MBA
VP Research & Business Development
November 14, 2012

GenomeAtlantic
Life Sciences. Life Solutions.

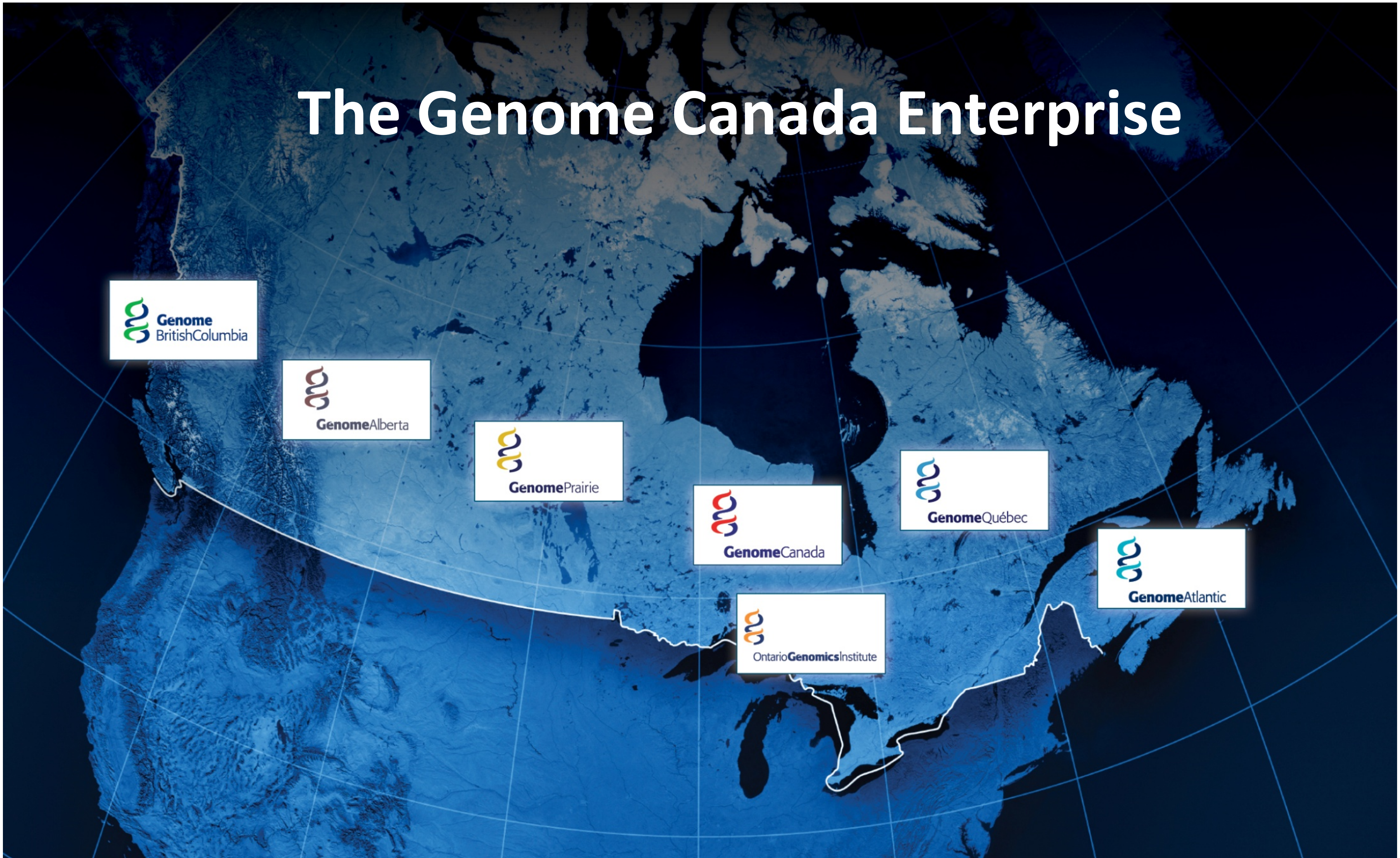
What is Genomics

Genomics is the powerful combination of biology, genetics and computer science.

It is relevant to all sectors.

Our definition of genomics includes all of the ‘omics fields plus bioinformatics

The Genome Canada Enterprise



GenomeAtlantic

Life Sciences. Life Solutions.

What is Genome Atlantic

- NFP corporation, incorporated in 2000.
- Developed to help implement the Atlantic Canadian portion of Genome Canada’s agenda

Increase Canada’s Ability To Benefit From Genomics Research And Development

Collaborations & Impacts to Date

- Facilitation of 35 proposal teams across 5 sectors
- 11 large-scale projects valued at ~$70M
- Liaison with approximately 15-20 companies
- 1 patent awarded & 10 applications
- Over 1000 person years of employment

We are we going?

PAST	FUTURE
• Large-scale projects • Competition-oriented • Genome Canada and AIF-centric	• Large and small scale projects • Industry opportunity-oriented • Broader funding sources

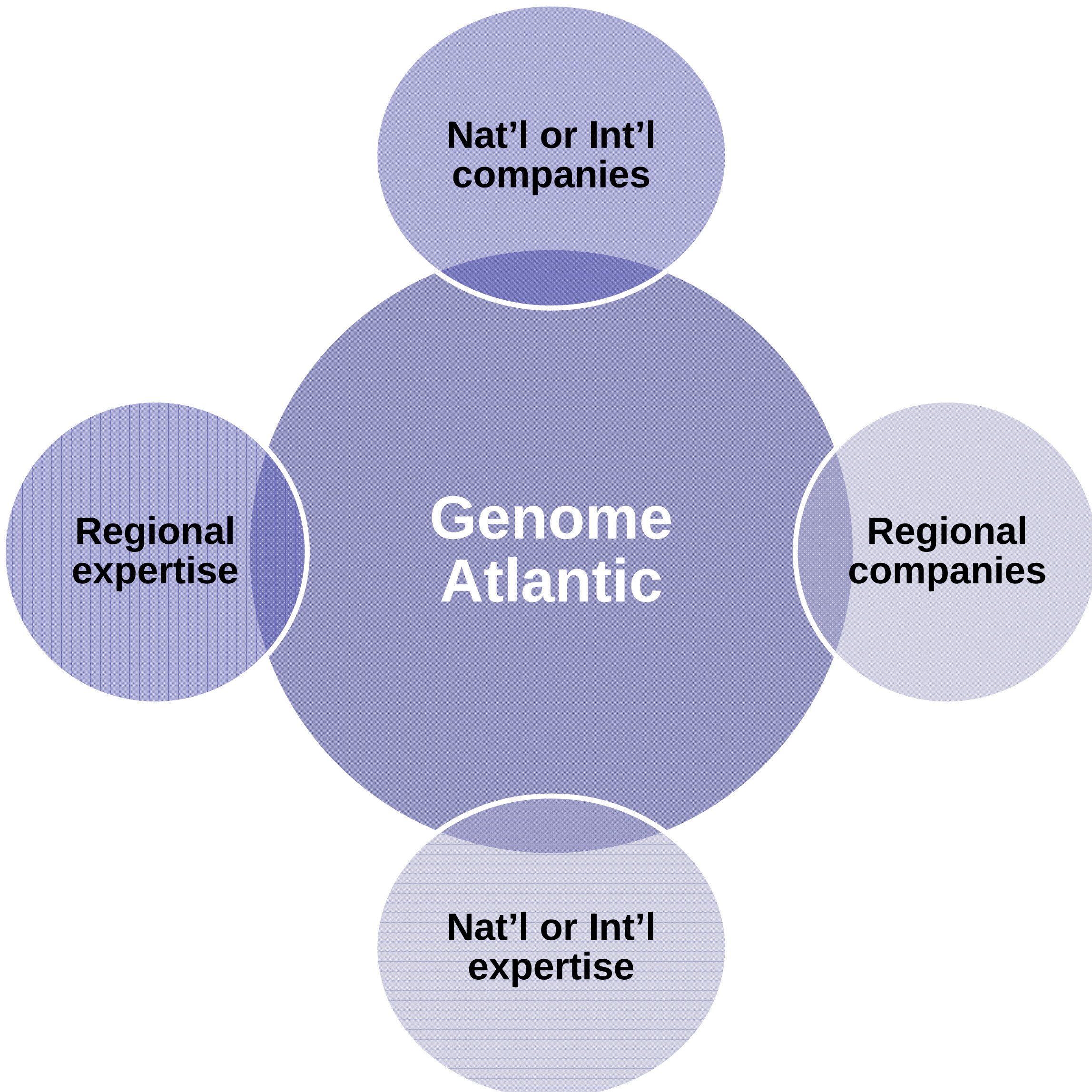
What is our plan?

1. Identify companies that can benefit from ‘omics
2. ‘Omics expert conducts company review to identify and prioritize opportunities
3. Evaluation of opportunities, cost, feasibility
4. Development of blueprint of research and relevant funding
5. Evaluation and decision-making
6. Proposal development, research and implementation

How will we do it?

- Collaboration with our NETWORK of experts and funders including:
  - Genome Canada/Genome Centres
  - Regional/National Academic Institutions
  - Provincial/Federal Governments
  - ILIs and Technology Transfer Offices
  - NSERC, ACOA, NRC
  - Companies

How can we work together?



Thank You

Research on enriched sedimentary habitats

Dr. Suzanne Dufour, Biology Department, MUN

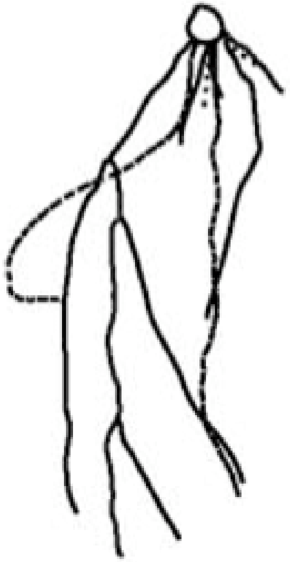
Main research interests:

1. Organisms living in organically enriched sediments, such as near aquaculture sites;

2. Novel approaches for studying how organisms modify sediments.

1. Organisms in enriched sediments

- Thyasirid clams
  - Common in aquaculture sites
  - Form extensive burrows
  - Deplete sulphides through their activities
  - Ecosystem engineers



- Dorvilleid worms (OPC)
  - Indicator species of organic enrichment
  - Opportunistic species

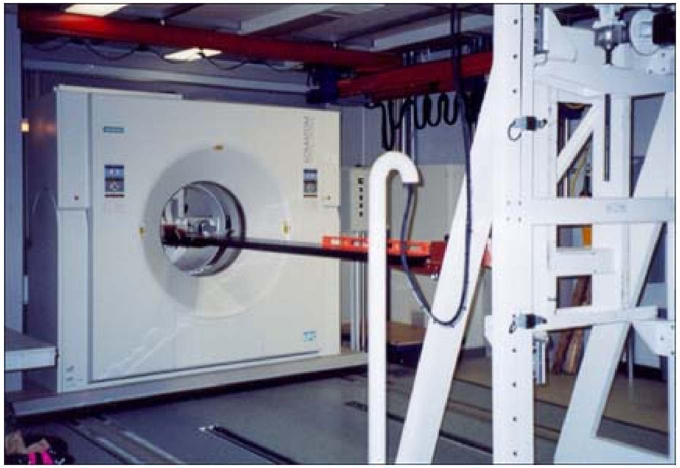
1. Organisms in enriched sediments

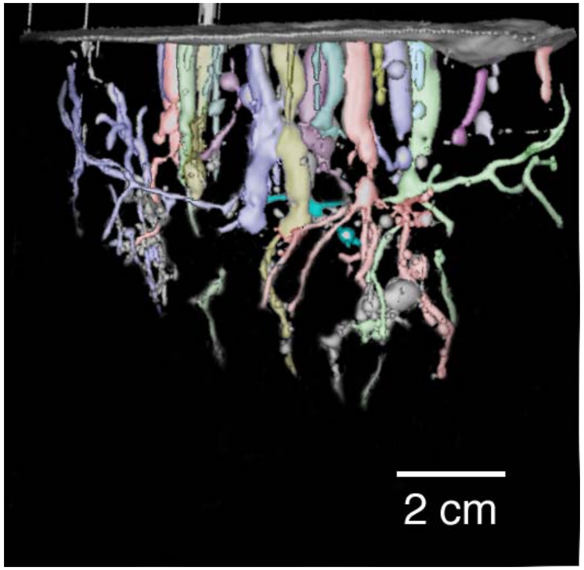
Proposed project (NSERC Engage, MITACS):

- Explore the basic biology of key species in sediments underneath aquaculture cages
  - Who are the important players?
  - What do they eat?
  - Do they have adaptations to tolerate/take advantage of sulphides?
  - Do they modify (or ameliorate) the sediments or water column through their activities?

2. Novel approaches for studying sediments

- Characterization of the space occupied by burrowing organisms by CT-scanning
  - Rapid, quantitative approach
  - Used to describe sediments in different settings
  - Could be useful for monitoring

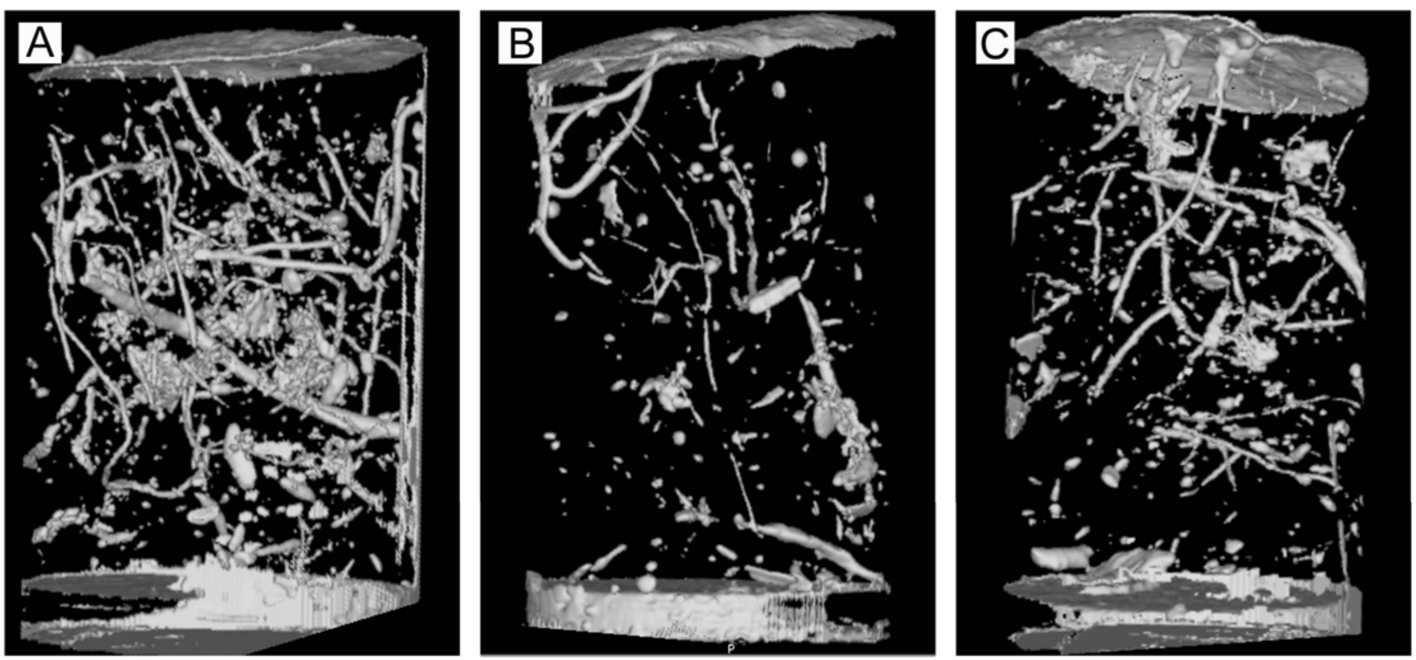




2. Novel approaches for studying sediments

Proposed project (NSERC Engage, MITACS):

- Evaluate the usefulness of CT-scanning as a tool for monitoring the health of sediments (feasibility study)



Your role as partner

- Provide access to sites, background data
- Facilitate access to specimens (grabs, divers)
- No financial contribution required during pilot study

INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA) CAN ALSO BE DEVELOPED FOR THE FIRST PHASE OF SALMON AQUACULTURE TAKING PLACE IN LAND-BASED, CLOSED-CONTAINMENT, FRESHWATER HATCHERIES

Thierry Chopin*, Hamid Khoda Bakhsh, Jake Elliot, Keng-Pee Ang, Cory Taylor, Mitchell Dickie, Glenn Ketchum, Frank Powell and Troy Lyons

Canadian Integrated Multi-Trophic Aquaculture Network
University of New Brunswick
P.O. Box 5050
Saint John, NB, E2L 4L5, Canada
tchopin@unbsj.ca

The concept of Integrated Multi-Trophic Aquaculture (IMTA) is not confined to open-water, marine systems using finfish for the fed component and seaweeds and invertebrates for the extractive component. It has to be conceived as an extremely flexible concept. It is the central/overarching theme on which many variations can be developed. Consequently, the principles of IMTA can also be applied to land-based, closed-containment and freshwater systems (sometimes called aquaponics). What is important is that the appropriate co-cultured organisms are chosen at multiple trophic levels based on their complementary functions, as well as on their economic value or potential.

We have been working on developing IMTA for the seawater grow-out phase of Atlantic salmon (*Salmo salar*) aquaculture. However, Atlantic salmon spends the early part of its life cycle in freshwater and, in the case of aquaculture, in land-based, closed-containment, freshwater hatcheries before being transferred to open-seawater sites. If salmon spend between 1.5 to 2 years in seawater pens, it is after they have spent between 9 and 18 months in freshwater hatcheries.

Freshwater IMTA (FIMTA or aquaponics) is the combination of animal aquaculture with plant hydroponic cultivation. In such systems, effluents become nutrients for the plants instead of accumulating and becoming toxic for the fish or being released downstream from the operation. Consequently, from an environmental perspective, it would be the same strategy of recapturing lost nutrients and energy and converting them into biomass of commercial value. Of course, the extractive species and infrastructures will be different from what we have developed so far at open-seawater sites. From an economic and marketing perspective, it would be most interesting to develop an overall system where salmon would be IMTA-produced from the egg to the plate, as this would help considerably in the certification scheme and in obtaining premium prices.

We are presently investigating the potential for developing FIMTA systems for the Atlantic salmon land-based, closed-containment, freshwater hatcheries operated in New Brunswick, Canada, by Cooke Aquaculture Inc. Both flow-through and recirculating facilities are being assessed to design the most appropriate FIMTA systems, based on water quality and flow, nutrient concentrations and bioavailability, temperature, light, space availability, plant candidates and economic viability.