Atlantic Canada
Fish Farmers Association

ACFFA Annual Technical Workshop
And
Research Review 2011

FINAL REPORT

November 24 and 25, 2011

Fairmont Algonquin

St. Andrews, NB

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Introduction

The Atlantic Canada Fish Farmers Association hosted its annual technical workshop and research review on November 24th and 25th, 2011. The conference built upon successful ACFFA workshops held in 2009 and 2010 that reviewed and discussed R&D results, new technologies and began to develop multi-disciplinary, collaborator research projects to address priority knowledge gaps. These workshops include 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 continued to be a key focus area and a primary focus of research for the salmon aquaculture industry. An Integrated pest management (IPM) strategy for sea lice requires that many of its components be based on science. Results of ACFFA workshops and subsequent collaborative research projects have contributed to the development of IPM in New Brunswick and this framework can be applied to other jurisdictions in Canada. Regulatory research projects are contributing to the use of new treatment products which will support the full implementation of IPM and effective sea lice management.

Work continues on most research initiatives as they require many years of study to allow us to gain a full understanding of the complexity of sea lice dynamics and the marine environment of the Bay of Fundy. Identified knowledge gaps often change year to year, and are rarely completely answered without leading to additional questions. Development of novel management tools for sea lice also continues and additional research is required to support the Canadian registrations of a variety of sea lice treatment products.

Other R&D projects also continue to increase our knowledge of the environment, enhance our farm management practices, support conservation / enhancement projects, and to enhance communication to our various stakeholder groups.

ACFFA workshops provide a venue for communicating research which is critical in supporting a broad understanding of salmon farming operations, sea lice management and development of best practices.

The 2011 workshop agenda also provided a venue for both federal and provincial regulators to present overviews of their activities and key focus areas in addition to the national aquaculture association to speak to their key focus areas. This benefits the broad aquaculture sector and also community stakeholders.

The final day of the 2011 agenda allowed time for a facilitated review and prioritization of key knowledge gaps and future sea lice research by an interdisciplinary group. Input was provided under five sea lice themed research areas.

Over 130 attended the technical workshop on November 24th and 25th.

Acknowledgements

The ACFFA wishes to acknowledge the support of:

Aquaculture Collaborative Research and Development Program (ACRDP)

Merck Animal Health

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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 Fall Workshop

November 24 - 25, 2011

Fairmont Algonquin, St. Andrews

THURSDAY, NOVEMBER 24, 2011

8:00 **Registration and Coffee**

8:25 Welcome and Introduction

8:30 NB Update on Activities – Sadie Perron, ADM NB DAAF

9:00 NS Update on Activities – Greg Roach, ADM NS DFA

9:30 Aquaculture Act for Canada – Ruth Salmon, CAIA

10:00 **Refreshment Break**

10:30 Sustainable Salmon Aquaculture – Tillmann Benfey, UNB Fredericton

11:00 Sea Lice R&D 2011
- Dye Dispersion Studies - Fred Page, SABS-DFO
- Interox Paramove 50 Regulatory Research - Michael Beattie, NB DAAF

12:00 **Luncheon with Keynote Speaker – Ian Roberts, Marine Harvest Canada**
Progress and Pitfalls: Stakeholder Engagement in BC

1:30 Sea Lice R&D 2011 con't
- Mussels as Natural Biofilters - Andrea Bartsch, DFO-SABS
- Effects of Hydrogen Peroxide on Salmon Skin - Mark Fast, AVC
- New Feed Option "Target" - Gavin Shaw, Skretting

3:00 **Refreshment Break**

3:15 Sea Lice R&D 2011 con't
- Denaturing AlphaMax – Ross Gilders, RPC
- Managing the Use of Sea Lice Treatments: View from Pharma Companies – Allison McKinnon, Novartis

4:15 **Adjournment**

FRIDAY, NOVEMBER 25, 2011

8:00 **Coffee and Mixer**

8:30 Other R&D Developments in 2011

- Lobster population surveys at Cheney Island, Grand Manan - Tara Daggett & Amanda Smith, SIMCorp
- iBoF Atlantic Salmon Recovery Project – Corey Clarke, Fundy National Park
- Forte micro Field trial results & ISAV virulence studies updates– Allison McKinnon, Novartis

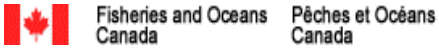
10:00 **Refreshment Break**

10:20 Moving the Research Agenda Forward - *A facilitated discussion on identifying research priorities in 2012*

1:00 **Adjournment**

Thanks to our sponsors!!

Many thanks to our collaborator on this project:



Presentation Synopsis and Speaker Biographies

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

Thursday, November 24, 2011

NEW BRUNSWICK UPDATE ON ACTIVITIES

- *Sadie Perron, NB Department of Agriculture, Aquaculture and Fisheries*

The following is a reprint of Ms. Perron's speaking notes

My objective today is twofold. First, I would like to provide you with an update on changes to the Department with respect to Aquaculture and Fisheries. My second objective is to give you an overview of our priorities as a Division over the coming year. As most of you know, in October 2010, the Department of Agriculture and Aquaculture and the Department of Fisheries were merged into one Department. This change, coupled with the overall Government Renewal process was an opportunity for the Department to take a strategic look at how we were doing business.

For those of you not familiar with the Government Renewal, it is a process that has been established across government with a view to ensuring that the Government of New Brunswick is able to provide appropriate and affordable services to citizens on a sustainable basis. As a first step in the process, all departments were asked to undertake an internal review of its core functions. In doing that analysis, three things came to light. The first was that human resources dedicated to Aquaculture were stretched to the limit. The second was that the Department's Policy and Planning Branch did not have the capacity to provide the needed support to all three sectors within the Department. The third was that the Department's development role and monitoring role in Aquaculture and Fisheries were not clearly delineated.

In looking at how to deal with these challenges, we looked at the benefits of merging the Aquaculture and Fisheries Divisions into one. On one hand, resources could be shared with human resource expertise able to benefit both sectors. The knowledge and understanding of both sectors would only serve to strengthen our capacity in developing policy and programs. I think for example of wharf development or other infrastructure. Staff with an interest and understanding of the needs of both sectors would be better positioned to make better strategic recommendations. Finally, there would be a more seamless and, we believe, a more productive relationship with important partners such as the Department of Fisheries and Oceans with whom we must advocate and promote both sectors on a constant basis. As a result, we now have a Division of Aquaculture and Fisheries which I believe will better serve your sector.

First point of contact for clients will continue to be our three regional offices in Bouctouche, Shippagan and, in your case, the St. George office. Supporting our regional office staff will be key business branches– Aquaculture and Fisheries Development, Business Development, Leasing and Licensing, Fish Health and finally, Policy, Advocacy, Coordination and Strategic Initiatives. A Resource Management Branch will ensure equitable, stable and secure access to fisheries resources. A Fish Health Branch will see greater human resources focused on fish health management. With change, of course, comes the need for trust and cooperation. This is a considerable transition and it is my hope that we will work together to ensure it works to the benefit of both clients and government as we, together, focus our attention on furthering the growth of the aquaculture sector across the province.

I wish to commend the staff. It has been a challenging time but what I see emerging is a stronger team and a renewed commitment to government's role in advocating, promoting and supporting your sector. Over the next year, efforts and energy will be focused on four key priorities.

The first is fish health management including the Integrated Pest Management Plan and changes to the new federal regulations regarding fish pathogen and pest treatment.

Fish health management is key to a sustainable aquaculture industry. We recognize that, and, as I said earlier, have increased our capacity in support of our fish health team. Our immediate focus of course is working with industry to resolve the sea lice issue. But beyond the immediate sea lice issue, we would also like our energies and efforts in fish health management to move in the direction of prevention. With solid research and development to back it up, a focus on prevention will be essential to attracting new investment and maintaining investor confidence in the aquaculture industry. And we believe this is an area in which we can benefit from an Atlantic approach. Collaboration with our Atlantic neighbours on fish health can translate into greater efficiencies, less duplication, potential cost savings and, we believe, will decrease the time it will take to reach our common objectives. On November 17th (Strategic Management Committee) the Atlantic Partnership initiative was viewed as having a leadership role in advancing fish health on a national level. December 9th upcoming DM meeting in Halifax will discuss in depth the fish health file. Discussions with our ACOA partner are very active on the research front.

Other priorities over the next year or two will include the Sustainability Reporting Initiative, business and market development as well as research and development. A preliminary review of the Bay Management policy is scheduled to be conducted in the upcoming fiscal year.

Our two development strategies – for Finfish and for Shellfish, will continue to guide the creation of joint government and industry work plans and priorities.

Sadie Perron

In May 2011, Sadie Perron was made Assistant Deputy Minister of Aquaculture and Fisheries with responsibilities for the development of the Aquaculture and Fisheries sectors in New Brunswick. From 2009 to 2011, she occupied the position of Assistant Deputy Minister of the Business Financial Support and Corporate Services Divisions, including policy and planning within Business New Brunswick. Her responsibilities included the delivery and administration of financial assistance by way of direct loans and/or guarantees. Also, she had responsibility for Corporate Services and Policy and Planning branches. Her past experiences are diversified, focused on people, financial and program management in the field of economic development. She held several senior management positions during her 19 years with the federal government. At the provincial government level, she held the position of Vice-President of Development with the Regional Development Corporation (Interchange Canada Program) from 1998 to 2000. At the local level, she worked several years in Community Economic Development. She holds a Business Degree, Accounting license and is a Certified General Accountant.

***NOVA SCOTIA AQUACULTURE*: Creating Sustainable Wealth in Rural Coastal Nova Scotia**

- *Greg Roach, NS Department of Fisheries and Aquaculture*

Mr. Roach introduced the audience to the roles his Department has in regulating Nova Scotia's aquaculture industry. He provided various facts on the industry, including maps showing the diversity of farmed species and locations of operations within the Province. Although Atlantic salmon/ marine rainbow trout account for approximately 75 per cent of the $42 million farm gate value of the industry there are many other finfish species farmed including halibut, Arctic char, sea bass, and striped bass. Shellfish species cultured include oysters, scallops, and clams, along with lobster and a variety of marine plants. Aquaculture operations are found in every county in the Province and result in 245 full time and 500 part time jobs directly related to the industry.

Mr. Roach presented the vision DFA has for the aquaculture industry while identifying the challenges and the opportunities of development in Nova Scotia. With the continuing growth in demand for farmed seafood products, many companies are looking to enter or expand their operations in Nova Scotia because of its coastline, culture, and infrastructure. World class education, training and research facilities already exist in the Province, including the Nova Scotia Agricultural College. Opportunities for processing and support industries to develop also exist as a result of expansion plans in the shellfish and finfish sectors which would see Nova Scotia's aquaculture production triple by 2017. The acknowledged challenges facing the industry include the need to update the aquaculture

policy, regulatory and framework regime, and also the requirement to manage the competition for ocean space, especially in the coastal zones. Although the industry is already intensely regulated there is poor public perception and misinformation which he highlighted as a difficulty that has created time delays in the site approval process and resulted in a court challenge.

As part of the NS DFA's aquaculture strategy, six key strategic areas were identified which included: public confidence, an aquaculture policy, access to sites, and innovation, productivity and competitiveness. The areas of environmental management and fish health were highlighted and expanded upon to outline new developments. Nova Scotia's Environmental Monitoring Program has evolved with industry now responsible for the collection of samples and reporting to government, while the Department is taking the auditing function. DFA is also working toward more rigorous laboratory testing, standard operating procedures, equipment and additional staff to support industry. The comprehensive fish health plan was presented for disease surveillance, management and reporting as priorities along with identifying the need for diagnostic facilities and fish health research capacity.

In closing, Mr. Roach also stressed the need for the Atlantic Industry to work together on many of the larger issues like biosecurity.

See Attached Presentation

Greg Roach
Mr. Roach was appointed Associate Deputy Minister of Fisheries and Aquaculture and Associate Deputy Minister of Agriculture in May 2011. He was appointed Assistant Deputy Minister of Fisheries and Aquaculture in February 2007. Since then he has been responsible for all fiscal, HR and policy issues addressed by the department, and provided direct support to the Fisheries & Aquaculture Minister. From 2000 - 2007, Greg was the Executive Director of Fisheries and Aquaculture Services (in the Dept of Agriculture and Fisheries) responsible for marine fisheries services, the fisheries field service program, fisheries/aquaculture technology programs, aquaculture management, inland (recreational) fisheries management and the Fisheries Loan Board. Mr. Roach first joined the Fisheries department in 1976 and has carried out many functions including marine biologist, marine advisor, and manager of field services and director of policy and planning.

AQUACULTURE ACT FOR CANADA

- *Ruth Salmon, Canadian Aquaculture Industry Alliance*

After many years of discussion, the Canadian aquaculture industry has identified the need for a federal aquaculture act. The Act would define aquaculture, recognize the industry as a legitimate user of water resources and consolidate and harmonize an enabling regulatory structure with identified federal / provincial roles. The Fisheries Act was not designed to regulate a food producing industry like aquaculture and so among other deficiencies, the rights of farmers in an aquatic setting are not protected. Following this background information, Salmon provided an overview of CAIA's development of a business case to support an aquaculture act.

Through the initial review of the studies and initiatives completed since 1983, the consulting company RIAS identified two overarching issues for the aquaculture industry:

1. Canada's regulatory structure is redundant, burdensome, costly and confusing
2. Canada is the only major producing country without national legislation designed to govern and enable its aquaculture industry

A set of "quick facts" was presented showing the industry position worldwide and statistics outlining how much aquaculture is now producing, how it is the fastest growing food production system in the world and Canada's production volumes and values. In reviewing the data Salmon stressed that though these numbers have been reported over the last number of years and are well known, what has been overlooked is that while the aquaculture industry worldwide has grown by six per cent annually, the Canadian industry has not seen any growth in approximately 10 years. This was demonstrated by a graph showing Canadian production from 1984 to 2010. Charts were also presented to show the Canada's loss of 40 per cent of the world market share since 2002 and the

production growth of key competitors since 1983 versus Canadian production over the same time period. The report outlines causes of the stagnant growth including legislative and regulatory uncertainty, delays in site approvals and lack of timely access, and the regulatory burden on the industry. The cost of the federal regulatory system is estimated $90 million / year so with over 90 federal / provincial / territorial acts impacting the aquaculture industry this estimate is assumed to be low.

Following discussion of the issues and challenges of the current regulatory structure and the elements required for a better governance system, the option of a new Aquaculture Act versus revisions to the Fisheries Act were compared. The comparative table clearly shows that an aquaculture act is the superior option.

While there is acknowledgement that the development and implementation of a federal act would not remove all hurdles for our industry, it would demonstrate an active attempt to address problems and support a competitive and prosperous aquaculture industry.

With this report as a foundation piece, CAIA is now in the process of confirming industry's support for a comprehensive campaign for the development of a federal aquaculture act.

See Attached Presentation

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.

SUSTAINABILITY OF SALMON FARMING

–Tillmann Benfy, University of New Brunswick- Fredericton

We are at a critical juncture in human history, with rapidly increasing population size and wealth at a time when aquatic resources are being harvested at (or beyond) their limits. As a result, we are witnessing a global transition from hunting and gathering wild aquatic foods to farming them. As a case in point, the North Atlantic salmon fishery is currently harvesting only about 10 per cent of maximum historic highs, which reached approximately 12,000 t per year in the early 1970s, whereas farmed salmon production in the North Atlantic is currently well in excess of one million t per year. Salmon farming provides clear advantages over commercial fishing, such as better food conversion efficiency (since fish expend less energy searching for food), no need to expend fuel searching for fish, no by-catch, a fresher product, greater production volume (and therefore lower prices for the consumer) and more humane slaughter. Salmon farming is also more productive than traditional livestock species, since their natural life history is 3-dimensional and high density, they have better food conversion efficiency than herbivores and, being neutrally buoyant and cold-blooded, they convert a greater proportion of their ingested energy into growth. However, there are also numerous concerns with salmon farming as currently practiced; these include (i) nutrient loading (= wastewater management), (ii) shared use of the coastal environment (= coastal zone management), (iii) escapes and their potential for genetic and ecological impacts on wild populations, (iv) the use of fish meal and oil for feed production (with associated concerns about sustainability and food safety), (v) the amplification of pathogen and parasite loads within farms and potential for infection of wild populations and (vi) the use of chemotherapeutics such as antibiotics and pesticides. None of these issues is unique to salmon farming (or aquaculture as a whole), and all are currently being addressed through research, regulation and improvements in farm management. Many of these issues can also be addressed by moving from traditional open-ocean cage culture systems to land-based closed-containment systems, but the infrastructure and operating costs of such systems currently make them uneconomic for salmon farming.

See Attached Presentation

Tillmann Benfey

Tillmann Benfey is a Professor of Biology at UNB Fredericton, where he teaches courses in animal physiology and aquaculture. His research focuses on fish physiology, biochemistry and genetics, especially as applied to improvements in aquaculture production and sustainability. He has collaborated with numerous industry partners and government agencies, as well as the Atlantic Salmon Federation, on research projects that focus on genetic improvement and species diversification for aquaculture in Atlantic Canada.

TRANSPORT AND DISPERSAL OF SEA LICE THERAPEUTANTS FROM NET PENS AND WELL BOAT BATH TREATMENTS CONDUCTED IN SOUTHWEST NEW BRUNSWICK

– Fred Page, Fisheries and Oceans Canada

Dr. Page, presenting this work on behalf of Dr. Les Burridge, himself and their teams at SABS, began the presentation by reminding the audience that this project is a large, ongoing effort and so the data is still considered preliminary. In providing the rationale for the work he said that therapeutant efficacy and environmental impacts are both influenced by the degree of exposure of the sea lice to the active ingredients and the sensitivity or toxicity response of the target or non-target organisms. Page said that in both cases the exposures are controlled by the quantity of therapeutant used along with its transport, dispersal and chemical reaction processes. He explained that while there are theoretical equations to explain transport and dispersal in the marine environment, the parameters values are temporally and spatially. Therefore chosen values will give a general representation of the degree of transport and dispersion (i.e. dilution) but may not exactly represent a specific therapeutant release. In this regard the field work being conducted is important to help understand what the general values are for the hydrographic and farming situations within the Bay, and so give stakeholders the information to help avoid and / or mitigate any potential impacts of therapeutant use.

The review of the data collected during the project began with a re-examination of last year's work when a number of tarp treatments were conducted. Included in this discussion was some of the important data collected on horizontal and vertical mixing, as well as a look at the difference in amount of product used depending on the estimated shape and volume of the net. This work has shown that it can take between 5 minutes to 2.5 hours for a cage to empty of dye and so when discussing horizontal distribution of therapeutant the issue of a prolonged release of therapeutant needs to be considered. When dye was released from a fish cage within an active farm the size of the plume initially increased faster than expected from published information on dispersion rates in the absence of cage infrastructure. Other questions raised included the potential effect on resistance of large plumes stretching through the farm and how the results of this work. Dye dispersion work assessing the vertical distribution of therapeutant has shown that the dye reached down to approximately 10m in 10-20 minutes, and within 2 hours the concentration had reduced by 1-2 orders of dilution.

On well boats, the mixing and flushing time of product is related to the well size and the speed of the recirculation pumps. The dye studies have shown that during flushing the product concentration inside the wells decreases exponentially with time. When the dye was released from a well boat with the side discharge the plume had a typical "v" shape jet and the dye stayed with 5m of the surface. The act of the pumping causes entrainment of water into the discharge jet and this enhances the dilution of the product as it is flushed from the well. Within 15-20 minutes there was a 1 order of magnitude dilution of dye within a few meters from the boat which shows that treatment products are diluted more rapidly when released from a well boat when compared to tarp treatments.

The data collection is continuing and the SABS team is working on the data analyses, modelling, applications and implications of this work.

See Attached Presentation

Fred Page

FRED PAGE (PhD) is a research scientist, the Responsibility Center Manager for the Ocean Coastal Ocean Sciences Section of the Department of Fisheries and Oceans located at the Biological Station in St. Andrews, and is the Director of the DFO virtual national Center of Integrated Aquaculture Science (CIAS). Dr. Page is a member of the DFO-NBDAFA Memorandum of Understanding Aquaculture Environmental Coordinating Committee (AECC) and a frequent scientific advisor to the salmon industry and government regulatory bodies (NBDAA, NBDENV, DFO Habitat) on oceanography in the area and aquaculture interactions. He is a bio-physical oceanographer specializing in the investigation of linkages between the physical characteristics and processes of the coastal and shelf seas and their living resources. He has been actively involved in the development of aspects of the environmental monitoring program for the salmon industry in SWNB and is presently evaluating the DEPOMOD model for its usefulness in indicating sulphide levels in the vicinity of some salmon farms in SWNB.

"WHAT THEY DO NOT TELL YOU" A MULTI-DISCIPLINARY APPROACH

- Michael Beattie, NB Department of Agriculture Aquaculture and Fisheries

Dr Beattie presented information on various R&D projects and preliminary results based on work that he and the staff at DAAF has been conducting with Page, Bartsch, and Robinson from DFO SABS and AVC. The first project identified dealt with determining the depletion curves observed with the use of slice and Ivermectin in the field associated with various treatment regimes. The results showed that the size of the fish did make a difference in withdrawal time required for Slice to be non-detectable in the flesh, with larger fish taking approximately 10 per cent longer. Regardless of the this factor, the tests showed that even with a triple dose of Slice the product was undetectable in the fish flesh within 60 days of completion of the treatment and therefore can be sold to the US market following this withdrawal period. The work to provide the same information with Ivermectin is in progress.

The next project discussed was one to determine the effect of hydrogen peroxide on sea lice survivability and hatch rates. The first trial used small plankton nets to collect sea lice within a well post treatment. Approximately 100 sea lice were collected when roughly 30L (0.01 per cent of well volume) of the well water was filtered. Survivability for pre adults was estimated to be 80 per cent. The second trial made use of a pump to increase the amount of well water filtered to 3000L (1 per cent of well) which also resulted in an increase in the number of sea lice being collected to about 1000. These lice were brought to the lab for monitoring and the survivability 5 days post treatment was approximately 65 per cent for non-gravid females and 61 per cent for gravid females. Of the gravid females collected an estimated 55 per cent had viable egg strings and the hatch rate of these egg strings was the same as egg strings from females that had not been treated with hydrogen peroxide (controls). When the control and treated pre-adult lice were placed in tanks with salmon the lice reattached at the same rate, 46 per cent and 33 per cent respectively. In a third trial a net was briefly placed outside the well boat over one of the discharge valves and this net collected an estimated 220,000 sea lice. When these lice were assessed in the lab the results showed that around 61 per cent of the gravid females and pre-adults had survived the hydrogen peroxide treatment. As shown in the previous experiment, the egg strings from the gravid females hatched at the same rate as the controls. These initial trials indicate that collecting the sea lice post treatment should become a priority.

Based on these initial results with hydrogen peroxide, there was a discussion of the other sea lice treatment products the New Brunswick industry currently has access to and how they work. There was concern raised for the various products for which the mode of action results in paralysis of the sea lice and the need to confirm that this paralysis is permanent. After a review of the factors involved in measuring efficacy and the associated variables there were several suggested action items listed based on this preliminary work including the need to collect lice from all well boat treatments and harvest vessels, and to review and adjust treatment variables in order to maximize the kill rate of the sea lice with all products used.

Michael Beattie

Michael Beattie is the NB DAAF Veterinarian. Michael received a BSc, (hon.) and MSc. in marine biology from the University of New Brunswick, a DVM degree from the AVC and a Marketing certification from the Norwegian School of Business. In 1997 he became a member of the Royal College of Veterinary Surgeons. Since 2003 he has served as the Chief Veterinarian for Aquaculture in the New Brunswick Department of Agriculture, Aquaculture and Fisheries. Prior to joining the Provincial government Mike was the North American Product Manager for the world's largest integrated aquaculture company, Nutreco. He was involved in uncovering new research, carrying out field trials and marketing new products.

STAKEHOLDER ENGAGEMENT: A BC EXPERIENCE

– Ian Roberts, Marine Harvest Canada

Mr. Roberts began his presentation with a brief overview of Marine Harvest Canada (MHC). It is the largest producer of farm-raised salmon in British Columbia with an estimated production of 35,000 T, six freshwater hatcheries, 35 active saltwater farms and two processing plants. MHC employs 500 people. Before directly engaging stakeholders regarding their issues about salmon farming, MHC began by conducting polling research to provide baseline data on who was saying what and how negative messages were being delivered. Using this data MHC identified their goals in developing a communication strategy and determined which of the many stakeholder groups should be included in their communication and identified all the potential ways to communicate with the priority stakeholders. One-way communication options included the use of a web site, editorials, and newsletters. Two-way communication included organizing meetings, presentations, tours and the use of social media. MHC also identified the best communication tool for each of the stakeholders and proceeded to engage with them.

Based on their experience, a list of risks and opportunities with direct stakeholder engagement was identified and discussed. Some of the acknowledged risks were the legitimization of a group or cause, as well as the need for some potentially uncomfortable conversations and the additional stress placed on a company's resources. Equally recognized were the benefits of demonstrating that you are listening and willing to address concerns, that the "noise" created by opponents of the industry can be reduced and that the process can help challenge and improve company / industry performance.

Mr. Roberts added the following final thoughts:

- Know your baseline and direction – polling is critical in supporting this; further polling will tell you if you are achieving your goals
- Engage stakeholders who matter
- Two-way communication is best but requires human resources
- Acknowledge the concerns raised
- Be willing to make changes and communicate those changes back
- Own your story – and be willing to tell your story
- Be patient – it's a long road

Ian Roberts

Ian Roberts is a graduate of Sir Sandford Fleming College's aquaculture technician program. Working for Marine Harvest Canada (MHC) for 19 years, Ian has spent many of those years working with the Kitasoo/Xai'xais First Nation in Klemtu, BC, where the Nation and MHC produce and process over 5000 tonnes of Atlantic salmon annually. Today he is Communication Manager at MHC.

BIO-FILTRATION AND TRAPPING OF LARVAL SEA LICE

- Andrea Bartsch, Fisheries and Oceans Canada

The objectives of this research were to continue lab work started last year on sea lice filtration methods using shellfish and light attractants, test the efficiency of these methods in the field, and continue to build an understanding of sea lice life history.

Both shellfish and light traps were successful in filtering free-swimming sea lice under lab conditions. Shellfish (*Mytilus edulis* and *Placopecten magellanicus*) will filter sea lice in both still and flowing water (on average 51 per cent of the lice were removed by 50 *M. edulis* in 500 L of water after 2.5 hours). Similarly, light traps removed 53 per cent of free-swimming lice in a single pumping event (1 minute of pumping or 25 per cent of the tanks volume). The lice seem to be more attracted to shorter wavelengths than other zooplankton, however this finding requires further investigation.

The light traps were also used in the field where both nauplii and copepodid stages were caught. There trends were 1) more free-swimming lice were caught on active aquaculture sites than fallow aquaculture sites and reference sites as well as 2) more free-swimming lice were caught at the top and bottom of the water column than in the middle. This suggests that at least a portion of the larval population spend part of their development near the bottom before traveling up the water column to find a host. This work was done later in the field season, which meant very few lice were caught. Further work planned for the spring/summer of 2012 will hopefully confirm these trends.

Egg strings were also collected from the field and their settlement velocities were measured in the lab. Loose egg strings will remain within a 300 m radius of the farm and egg strings attached to a dead gravid female will remain within a 150 m radius of the farm (based on a depth of 30 m and an average current of 10 cm/s). Lab studies also showed that egg strings are able to hatch on benthic sediments. This is important because under optimal conditions, larval sea lice can live up to 19 days, which gives them plenty of time to travel up the water column and find a host.
Due to a shortened field season in 2011, the field component of this work is planned to be continued in 2012. Based on the lab work alone, both shellfish and light traps effectively filter free-swimming sea lice and are optimally suited for low level, continual removal of lice from the water column over time.

Andrea Bartsch
Andrea Bartsch recently completed her masters at the University of Victoria during which she utilised sea urchins to control biofouling at an integrated multi-trophic aquaculture site. In July, Andrea joined Dr. Shawn Robinson's team with the Department of Fisheries and Oceans. She has been studying the life history and spatial distribution of sea lice as well as non-toxic alternatives to remove larval sea lice from the water column.

IMMUNOSTIMULATION AND PEROXIDE TREATMENTS IN SEA LICE

– *Mark Fast, Atlantic Veterinary College, UPEI*

Dr. Fast began the presentation by providing some background information on sea lice and host resistance to sea lice before providing the hypothesis of his work: "By boosting Atlantic salmon inflammatory/innate immune responses we will reduce infection level?" The research project sought to answer this question by incorporating three immunostimulants into the feed for test groups of Atlantic salmon, then exposing the salmon to copepodids and monitoring the levels of infestation, inflammation and damage over time. The immunostimulants tested, Provale, CpG and ABN-1, were chosen based on previous work with other lice / host species and / or observations in the field, and were either milled into the feed or top coated. After 2.5 wks on a specific feed, each of the salmon groups were exposed to 15-20 copepodids/fish over an eight hour period on three occasions during the initial experiment. The monitoring these groups of salmon showed a significant reduction in the number of lice per fish within two of the three experimental groups by day 20 (CpG) and day 38 (ABN-1). Of these two better performing experimental feeds, CpG also showed a higher percent reduction in lice and lower prevalence when compared to the other two feeds. The assessment and scoring of the inflammation at the site of parasite attachment in the three experimental groups once again showed that the groups fed with CpG additive was performing better, with less ulceration. When systemic

reactions within the fish were evaluated using head kidney gene expression the groups fed with the ABN-1 additive showed an initial increase (2-fold) in Inflammatory genes at first lice exposure (ca. 4 wks on feed) compared to the other groups. The response to the feed decreased over time showing that when fed over a long period of time the immunostimulants did not continue to induce the same reaction in the salmon.

Dr. Fast then discussed some of the work ongoing at AVC in response to the anecdotal evidence of increased lice settlement post hydrogen peroxide treatment during the 2010 treatment year in the Bay of Fundy. The objectives of the work were to:

- Determine effects on skin of current H202 treatment
- Determine time course of effects
- Determine treatment effects on larval louse settlement
- Determine treatment effects on female lice fecundity

The preliminary work for the first two objectives started in the fall of 2011 with the testing of fish pre-hydrogen peroxide treatment, then at four, 24 and 72 hours post treatment. The initial assessment of skin histology showed that at four hrs post treatment there was loss of epidermis but the salmon were 'recovered' when checked at 24 hours post treatment. This initial result has yet to be confirmed in a laboratory setting and will also be repeated multiple times in the field as well. Field data is currently not available to make any comment on the potential increased lice settlement on salmon after a hydrogen peroxide treatment. It was also noted that this work will also require multiple replicates and lab confirmation. Work to assess female lice fecundity post hydrogen peroxide treatment has begun with lice being collected during two separate treatments. 100 egg strings were collect pre and post treatment and brought to AVC for culture in a static system at 13°C. While the egg strings from the pre-treatment groups produced 2000-10,000 copepodids in the two different experiments by day seven, the eggs strings from the post treatment group produced significantly fewer copepodids which ultimately died by day seven.

Based on the initial results from the work on the immunostimulant (IS) feeds and the effect the hydrogen peroxide may have on salmon skin, future work was identified to assess the use of these IS feeds in combination with treatments.

See Attached Presentation

Mark Fast

Mark began his education with a BSc (honours) in marine biology from Dalhousie in 1999, followed by a MSc in anatomy and physiology from AVC in 2001, and a PhD in biology from Dalhousie in 2005. After several years as a Post-doctoral Research Associate at the Institute for Marine Biosciences his career took him across the border to Stony Brook University in New York where he continues to be an Adjunct Professor. In 2010 Mark was awarded the Novartis Research Chair in Fish Health at the Atlantic Veterinary College-UPEI. He is an Assistant Professor in the Pathology and Microbiology Department with expertise in fish immunology, parasitology, host-pathogen interactions, fish physiology and molecular biology.

SEA LICE RESEARCH IN SKRETTING

- Gavin Shaw, Skretting North America

Skretting's efforts to support the aquaculture industry have resulted in the development of several fish health management products. These products were developed after an evaluation of the health and environmental profile of the various regions of Norway, and an understanding the timing of health challenges throughout the year. A map of Norway identifying areas having specific health issues with accompanying temperature profiles provided the audience with a broad understanding of how these health products are used strategically through the grow out cycle to provide protection. Research to develop products was completed at Skretting's Aquaculture Research Centre; the recent establishment of a sea lice laboratory at this facility means additional long term research can be completed. A detailed description of how sea lice trials are performed from the hatching of the egg strings to infection of the salmon with copepodids and counting procedures was provided. The new sea lice

facility also enables Skretting to develop new products for market, and increase focus on nutritional aspects of lice control. The ability to screen materials and compounds in controlled studies has increased as well as work to compare test substances against current products.

Target Lice, a new lice protection product increases antioxidative capacity and strengthens the immune system and mucus layer of salmon through the use of highly purified beta glucans, gut health modulators and other specific ingredients. Shaw presented data showing results obtained in trials conducted since 2000 using Target Lice. The early documentation showed a 35 per cent reduction in the number of lice per fish between 10 and 12 days post infection after feeding the diet for 14-days. Trials in 2006 using larger salmon and a 70 day feeding period showed fewer fish in the Target Lice fed tanks infected with lice and fewer lice per fish compared to control tanks and another experimental diet. Results were also presented from trials conducted by personnel at the Nofima's model sea farm at Averøy, Norway. These trials monitored salmon infestation, food intake and growth rate of replicates tanks fed for 70 days with various diets, including Target Lice. Data showed that the pens fed with Target Lice had 43 per cent fewer fish with lice and 31per cent fewer lice per fish along with a growth and total food intake rate similar to the high fish meal control diet.

Based on the results, Target Lice is another tool for fish health managers to increase the time between sea lice treatments and protect salmon against lice longer when used after bath treatments. The current recommendation is to use Target Lice in a four and six feeding regime where four weeks of Target are followed by six weeks of regular feed. Better FCRs and growth rates are expected to compensate for any increased feed costs.

Though CFIA's ingredient registration process is presenting a large challenge in providing other products to the Canadian market, 150 candidates are in the process of being evaluated for their potential health benefits.

See Attached Presentation

Gavin Shaw
Gavin has a background in marine hatchery management, larval research, feed management and nutrition and has worked in both Government aquaculture research facilities and commercial aquaculture farms. Gavin has a PhD from the University of Tasmania, Australia which focused on marine fish culture. He has recently moved from Australia where he was the Technical Account Manager for Skretting Australia and is now the Marketing Manager for Skretting North America.

DENATURATION OF DELTAMETHRIN SALMON SEA LICE THERAPEUTANT FROM WELL BOAT TREATED SEAWATER

- Ross Guilder, Research Productivity Council

Supported by the Atlantic Canada Fish Farmers Association, the NB Department of Agriculture, Aquaculture and Fisheries and the aquaculture industry, RPC carried out a series of scoping tests to determine the effectiveness of adsorbents and oxidants to either remove or denature residual sea lice Deltamethrin therapeutant. Preliminary work was also carried out on Azamethiphos. The initial work was very encouraging and was followed with optimization tests with the identified adsorbents and chemical treatments. RPC subsequently carried out site visits to the Colby Pierce docked at the Bayside wharf in Saint Andrews, NB and on site in the Bay of Fundy, to witness sea lice H2O2 treatment. While on site, potential application points and overall feasibility of the treatment using various therapeutants were investigated.

RPC carried out standard 30 minute agitated 2L scoping tests using both adsorbents (activated carbon, diatomaceous earth, zeolite) and chemical treatment (hydrogen peroxide, ozone, Fenton's reagent, sodium hydroxide, sodium thiosulphate, UV, ozone + hydrogen peroxide, ozone + UV, hydrogen peroxide + UV). Validation of results from Deltamethrin and Azamethiphos chemical tests using sodium thiosulfate or sodium hydroxide used to stop the reaction found that both these chemicals can denature the therapeutant on their own (12 per cent denaturing for Deltamethrin, 80 per cent

denaturing for Azamethiphos). Both adsorbents and chemical treatments were effective at removing or denaturing up to 100 per cent of both the Deltamethrin and Azamethiphos. Bench scale tests on denaturing deltamethrin and azamethiphos were expanded where contact time tests were carried out.

A visit was made to the Huntsman Marine Science Centre in St. Andrews, NB in June, 2011 where members of RPC aided members of DAAF and DFO in investigating the toxicity of deltamethrin containing seawater treated with Fenton's Reagent on smolts. Members of RPC made up all reagents and therapeutants. Members of DAAF and DFO carried out sampling and fish observation/testing. Fenton's Reagent doses for the toxicity tests were determined by bench scale testing carried out prior to the visit. The results showed no negative toxic effects to the smolts due to the denaturing process and that Fenton's Reagent was effective at low doses (100ppm hydrogen peroxide and 1ppm Fe2+) with low contact times (95-97 per cent denaturing) based on filtered solutions. Unfiltered treated water assay results found that much of the Deltamethrin had adsorbed on to the Fe precipitate solids. Filtration of the fine Fe particulate would likely be impractical in the field application.

RPC carried out a subsequent program designed specifically for denaturing of deltamethrin therapeutant treated seawater to further develop and optimize the denaturing agents. The denaturation products are being characterized through Mass-Spectrometry, Gas-chromatography and High Resolution Mass Spectrometry to assure that no toxic compounds are formed. Dioxin analysis was done due to the presence of a diphenyl group in Deltamethrin and the chloride present in seawater at 10x the normal concentration where by-product peaks would be more pronounced. No evidence for production of Dioxin by destructive oxidation of Deltamethrin in sea water. Solvent and water extractable compound analyses results also carried out at 10x the normal concentration are pending.

Tests were carried out to develop an effective extraction procedure. A solvent extraction procedure was used in place of sodium thiosulphate where the oxidant would remain in the aqueous phase and the products of the denaturing reaction would be extracted into an organic phase. Hexane and dichloromethane (DCM) were both found to be suitable organic solvents used to extract deltamethrin.
The source of Ferrous ions, which acts as a catalyst to regenerate the peroxide slowly precipitates as an oxide and the standard procedure was to be removed from the solution by gravity filtration. Unfiltered solution samples showed an increase of residual deltamethrin concentration. Tests were carried out to evaluate various Fe sources for the Fenton's reaction to reduce or eliminate forming Deltamethrin adsorbing precipitates using Ethylenediaminetetraacetic Acid (EDTA) Ferric Sodium Salt, Ferric Citrate, Ferric Chloride, Ammonium Ferrous Sulfate and Ferrous Sulfate were evaluated. Ferric citrate and EDTA ferric sodium salt were the only Fe sources that did not produce a precipitate.

Additional Fenton's tests were carried out with varying concentrations of both Fe and H2O2 in one, two or three stages. The results of the Fenton's and the modified Fenton's using ferric citrate obtained required high dosages of both Fe (15ppm) and H2O2 (1500ppm) to achieve 85 per cent denaturing of the Deltamethrin. Ozone, which does not produce a precipitate, was also tested and proved to give the best result ranging from 95-100 per cent denaturing of the Deltamethrin. The level of dissolved O3 was measured by means of colorimetry and found to be very high. The testing was scaled up to 100 L to lower the O3 dosage and dissolution into solution. The dissolution rate versus time was measured and samples were submitted for residual Deltamethrin.

See Attached Presentation

Ross Guilder

Ross Gilders works for RPC and is the Section Head for Process engineering. He is the pilot plant manager with over 35 years of experience on numerous process and development projects serving clients on a worldwide basis. Project experience and expertise over the years has involved the successful development and commercialization of a number of process technologies. Mr. Gilders manages the Minerals and Industrial Services department at RPC, serving both the industrial and mining sectors. Mr. Gilders will be coordinating the overall RPC activities for the therapeutants denaturing project.

MANAGING THE USE OF SEA LICE TREATMENTS: THE VIEW FROM THE PHARMACEUTICAL COMPANIES

- Allison MacKinnon, Novartis Animal Health

Mr McKinnon, representing seven pharmaceutical companies, provided an overview of the development and approval of aquatic health products worldwide. Fish health products, including those for sea lice are a very small market. There are very few compounds available for use and no new product has been introduced since the late 1990's. In addition very few of the global pharmaceutical companies even investigate new compounds for sea lice.

It takes an estimated 3.5 years of research to identify a potential candidate followed by additional time and high costs for further development and evaluation of the product. In 2000 the estimated development cost for a new sea lice medicine was US $10 million. This expenditure was in addition to the basic food and environmental safety testing and assessment costs, and did not include environmental monitoring costs which are higher than any other agricultural sector. A chart showing R&D and return on investment (ROI) timelines demonstrated the high investment risk compared to products for companion animals and other farm animals. A list of items / objectives that must be achieved by a pharmaceutical company to receive approval for a potential product was also provided along with the associated licensing costs in various countries. While a Market Authorization application fee can range from approximately $27,000 to $39,000 USD in Norway and the UK, in Canada the cost is typically $98,900 – $148,355 USD. Increased Canadian cost is associated with additional data and environmental monitoring that is not necessary in most other fish farming countries or in land-based farming sectors.

Pharmaceutical companies continue their stewardship efforts through monitoring and support programs after products are approved. There is ongoing work to optimise performance in the field as farming practices evolve and publish technical guidance on best use/practice. Recommendations from Integrated Sea Lice Management group (ISLM), Responsible Use of Medicines in Agriculture Alliance (RUMA) and Market Authorization (MA) holders were listed and reviewed, and the importance of an integrated approach to sea lice treatment stressed.

Companies that are investigating new medicines require the support of the industry and government. Support can include infrastructure and laboratories in which investment can be made, field stations where lab findings can be scaled up and regulatory frameworks which enable field trials to be undertaken.

See Attached Presentation

Allison McKinnon

Allison has worked for the past 21 years within the health management sector of the aquaculture industry. Allison is a graduate of the University of Guelph with a degree in Animal & Poultry Science with further specialization in the field of fish immunology & vaccinology. For the last 11 years he has been employed with Novartis Animal Health Aquaculture Division in such roles as Territory Manager, Technical Service Manager and most recently Head of Technical Services for the North American Aqua Division. During this period of field support Allison played an integral role in clinical trial testing and product support for the Forte brand of vaccines. He has also worked closely with the Technical Support team in Europe and Chile with both vaccines and pharmaceuticals.

Friday, November 25, 2011

A PRELIMINARY REVIEW OF LOBSTER SURVEY DATA FROM CHENEY ISLAND MF-0503

– Amanda Smith and Bob Sweeney (for Tara Daggett), Sweeney International

Aquaculture site applications are reviewed by 17 government departments and during the process concerns identified by stakeholders are examined and may be used to develop licence conditions in an effort to address these concerns. The area identified for the Cheney Island site was recognized as juvenile scallop habitat and thought to be a lobster summering ground. Local fishermen were concerned about this location as DFO had identified the area as significant habitat for berried female lobster. As well, during the late 1980's an aquaculture site was approved in an area known by DFO to be used by berried females. Their studies showed that the lobsters moved away from the area while the site was in operation and moved back in after it had been removed. A brief comparison of salmon aquaculture operations from 1988 and 2008 was presented illustrating that when this site was in operation multiple year classes of fish were maintained on site, no mandatory fallow periods were observed, farmers used moist feed for extended periods and there was no provincially-regulated environmental monitoring program (EMP). Taking these operational changes into account, and the concern for the potential loss of habitat for berried female lobster, the site approval was granted with the condition that a lobster monitoring program be implemented for 5 years. To determine the impact the site could have on berried females, lobster population data was to be collected prior to the site's existence (2008 and 2009), during the production cycle (2010 and 2011) and following the harvest of the fish (2012).

Methods for the lobster surveys followed those of a survey carried out by DFO in 2007 as closely as possible. In addition, the number and relative size of scallops was recorded and video footage collected. Surveys are scheduled twice per year: one within the first two weeks of August and the second within the first two weeks of September, with the EMP survey for the site completed within one week of the September survey. Numbers of lobsters (size, sex and egg stage) and scallops are recorded from six transects and two free dives located from the northern end of Cheney Island to north of White Head Island (control area). Survey results for the last five years (including some of DFO's 2007 results) for both lobster and scallops were presented. In 2011, total lobster numbers and number of berried females increased somewhat inside the lease over baseline levels. Berried female numbers were higher in September 2010 and 2011 than in other surveys but usage of the inside lease and outside lease areas did not appear to be significantly different. The mean number of lobsters inside the lease increased somewhat in 2011 whereas outside remained fairly consistent. There was no apparent decrease in the use of the lease area by lobsters (male, female, berried or juvenile).

The survey results indicated a trend of increasing scallop numbers both inside and outside the lease with no apparent significant differences between the two locations.

To understand if these changes are due to the presence of the site, or a population trend occurring on Grand Manan, it is recommended that monitoring of Cheney Head continue throughout future cycles, beyond the current production level of 100,000 fish. As well, a comparison with other areas on Grand Manan may help understand natural population fluctuations.

See Attached Presentation

<u>Tara Daggett and Amanda Smith</u>
Tara Daggett and Amanda Smith are marine biologists with Sweeney International Management Corp., a management corporation that provides environmental monitoring and management services to the aquaculture industry. Tara and Amanda both attended Dalhousie University where they earned science degrees in biology. Tara moved on to obtain a Master of Science in biology from UNB Saint John while working full-time as a marine biologist for a sea urchin aquaculture project. Amanda continued her practical education through work experience gained with the Atlantic Salmon Federation and Huntsman. In time, both biologists found themselves working with SIMCorp and over the last 3 years have collaborated on several projects together.

REARING ENDANGERED INNER BAY OF FUNDY (IBOF) SALMON IN COMMERCIAL SEA CAGES FOR CONSERVATION: A COLLABORATIVE PROJECT WITH GOVERNMENT, INDUSTRY, ASF AND UNIVERSITIES

– Corey Clarke, Fundy National Park

As background to the current project, a brief history was provided on Inner Bay of Fundy (iBoF) Atlantic populations. Historic returns of more than 40,000 iBoF salmon have been reduced to as few as 250 leading the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to assess the population as endangered in 2001. Conclusions from '01-'03 assessments of Fundy National Park (FNP) rivers indicated declining juvenile density, concern for genetic diversity and insufficient returns to recover the population. IBoF salmon were designated as Endangered under the Species at Risk Act (SARA) in 2003 and FNP began implementing a recovery plan. This plan included the capture of representatives of remnant families, genotyping and rearing these individuals in captivity prior to river release, capture of sea-ward migrants, and repetition of the process. The current fry / parr release program shows juveniles surviving to leave the river as smolt, however, they are not returning to spawn.

Gaining a better understanding of the marine environment and its influence on iBoF salmon survival requires partnering with diverse groups and organizations including the aquaculture industry, Atlantic Salmon Federation, First Nations and academia.

To assess the best release strategy for conservation and determine if cage rearing wild iBoF salmon is a viable option, beginning in 2009, FNP created a collaborative project which transfers smolt from Upper Salmon River to cage sites. In its pilot year, innovation by the aquaculture industry partners allowed the project to advance to the "Admiral Research Pen System" using halibut cages and custom netting in 2010. Team members also had to overcome challenges with otters and high river conditions. The project has been rewarded with the 2011 Parks Canada CEO Award of Excellence in the category of Engaging Partners. The diverse project partners and their accomplishments were also recognized in the media in September 2011 when 300 cage-reared iBoF salmon were released back into the Bay of Fundy near Alma, along-side some hatchery raised siblings. All the salmon were externally tagged and ASF acoustically tagged 44 of the cage-reared group to enable migration monitoring. Receivers deployed in home and neighbouring rivers for these fish have detected over 50 per cent of the salmon; some detections far from the release site. Receiver data are still preliminary and initial results on homing and stray rates for cage reared fish should be available in spring of 2012. Results from the 2010 yearclass growout portion of the project seem to indicate that cage reared iBoF smolt grew faster, with parr-release origin groups surviving better and with a higher maturation rate than fry-release counterparts. These results will be compared with the 2011 year class currently being held at Mactaquac hatchery and a marine site in Grand Manan.

Comparison of the 2010 year class of marine and hatchery reared iBoF salmon continues at Mactaquac where 200 cage-reared iBoF returned in September to complete the evaluation of the reproductive cycle under controlled conditions. The hatch success of 24 pairs of cage reared salmon will be compared with 24 pairs of hatchery reared siblings. Reproductive success will also be compared between the hatchery and river environments, and between rearing (cage or hatchery) and release (fry or parr origin) groups.

See Attached Presentation

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.

VIRULENCE TESTING – ISAV FIELD ISOLATE

– Allison MacKinnon, Novartis Animal Health

A new field isolate of the Infectious Salmon Anaemia (ISA) virus was recovered from the Bay of Fundy in early 2010 and PCR sequencing revealed slight changes from HPR4 NA strain which caused a clinical outbreak in New Brunswick in 2005. The new isolate (RPC#8) was compared to the 2005 isolate (SP9) and virulence comparison of RPC#8 grown in both Atlantic salmon kidney (ASK) and Chinook salmon embryo (CHSE) cell lines conducted. A cohabitation challenge was conducted with 150 gram Saint John River strain salmon in duplicate tanks of ~ 120 fish per tank. Trojan fish injected with 0.1 ml suspension of ISAV culture were added to each tank of naive salmon and mortality monitored for 80 days post introduction. Cause of mortality was confirmed by rtPCR and gill tissue from 10 per cent of survivors from each tank of was sampled by qRT-PCR.

Results presented indicate a significant difference between isolates in observed mortality rate and in time of infection / transmission as indicated by the cell line comparisons. The Trojan salmon injected with theRPC#8 isolate began to die by day 14 and mortality rose to 70 per cent. Mortalities dues to infection in naive fish were not seen until day 28 with the mortality rate staying below 20 per cent. Mortalities began in the Trojan and naive fish with the SP9 isolate by about day 10 and 24, and increased to 95 per cent and 70 per cent mortality respectively. Mortality rates were lower and infection / transmission times longer using the CHSE cell line, with the morality rates for Trojans with the RPC#8 isolate only reaching 40 per cent. Of the survivors test, 100 per cent of samples tested positive for ISAV but further analysis of kidney tissues is to be performed.

FORTE MICRO FIELD TRIAL RESULTS

- Allison MacKinnon, Novartis Animal Health

To design the optimal vaccine, companies must develop a product that is safe, provides long term protection against multiple diseases, can be administered easily to small fish and produces low levels of post vaccination side effects. Based on the needs to industry to vaccinate smaller size fish and to have fish feeding faster post vaccination, Novartis perfected the next generation of oil vaccines delivered in a microdose format. This vaccine is especially important for S0 production since the label indicated degree days can still be obtained prior to seawater transfer and a reduction in time off feed also allows for a larger smolt at time of transfer.

Aqua vaccines are composed of a water base immunogenic fraction and an oil based adjuvant fraction. The immunogenic fraction can consist of a number of different inactivated bacterial or viral cultures. These bacterins are optimized to remove non protective and possible harmful components. The oil adjuvant is present to enhance immunogenicity. These adjuvants increase long term protection by inducing a higher degree of inflammation post vaccination and providing a depot effect for the bacterins. Perfecting a vaccine to produce enough inflammation for optimal protection without inducing severe long term side effects is a "fine balance".

The reformulated microdose product maintains a 1:1 ratio between the antigen and adjuvant to ensure that the vaccine emulsion is stable over the shelf life of the product. Each antigenic component within the newly formulated micro dose has been optimized to ensure peak protection against the specific pathogen. With a 0.05 ml dose, the vaccine has less adjuvant and an overall reduction in dose mean a lower risk to adverse side effects.

The design and results of a FORTE micro Good Clinical Practice (GCP) field trial were presented. The field trial was initiated in late 2009 at six sites which represented various operational and water source parameters. The hatchery sites in the trial represented surface flow thru, well flow thru, a lake site and recirculation facilities. Three sites were located in British Columbia and three in New Brunswick, all using S0-S1 populations of Atlantic salmon, for a total of 33 tanks of salmon. Safety trials were also conducted with smaller populations of 10 gram fish at three hatcheries.

Weights and lengths at vaccination (50 fish / tank) were recorded and compared to data collected at saltwater transfer and five to seven months post transfer. The 28 day post vaccination mortality and overall mortality was compared between groups as was the days to full feeding. Side effects were assessed at saltwater transfer (30-50 fish / tank) and continued to be evaluated five to seven months post transfer. On average the Forte micro treatment groups of fish on both the East and West Coast were approximately 20 per cent smaller than the control treatment group injected with Lipogen Forte. This negative bias will be closely considered when comparing long term growth. The weight data collected at one year post transfer seems to indicate better growth in the micro group. The 28 day post vaccination mortality data at sites for the treatment and control was compared and the treatment mortality (0.41 per cent) was found to be significantly lower than the control mortality (0.50 per cent). When the average days to full feeding following vaccination were reviewed the data indicates that the Forte micro groups reached this level four days faster than the control group. Pre-transfer side effect data indicates that FORTE micro has significantly lower scores for abdominal adhesion, visceral melanin and parietal melanin compared to the Lipogen Forte group. The side effect data collected at marine site five to seven months post transfer indicates that this trend continues.

Results from a vaccine feeding trial with Lipogen Forte, Forte micro and saline controls demonstrated no significant difference in growth between vaccine groups with smaller fish (18 gram). The larger fish (35 gram) had significantly higher growth (10.6 per cent) in the control and Forte micro groups as compared to Lipogen Forte.

Forte micro received USDA license approval in April, 2011. A conditional license was granted by CFIA Dec 21, 2010 with a full license pending inspection of trial fish at time of harvest, Dec 2011.

See Attached Presentation

Allison McKinnon

Allison has worked for the past 21 years within the health management sector of the aquaculture industry. Allison is a graduate of the University of Guelph with a degree in Animal & Poultry Science with further specialization in the field of fish immunology & vaccinology. For the last 11 years he has been employed with Novartis Animal Health Aquaculture Division in such roles as Territory Manager, Technical Service Manager and most recently Head of Technical Services for the North American Aqua Division. During this period of field support Allison played an integral role in clinical trial testing and product support for the Forte brand of vaccines. He has also worked closely with the Technical Support team in Europe and Chile with both vaccines and pharmaceuticals.

Moving the Research Agenda Forward
Identifying 2012 Research Priorities

The following information is drawn from a facilitated discussion and review of the sea lice focused research priorities identified from the 2010 and 2011 research planning workshops.

In addition to research focused on various aspects of sea lice management, there was general agreement that collaborative research to support the Inner Bay of Fundy Atlantic salmon recovery and possible lobster surveys should move forward in 2012.

2012 Sea Lice Research Priorities:

Regulatory Research

Regulatory research is intended to support the access and eventual licensing of a variety of sea lice treatment products for use in New Brunswick and in other parts of Canada. Under this theme the following activities were identified:

- Continue analysing data we have
- Continue dye dispersion work on multiple sites / locations to inform potential impact from effluent exposure to marine / sentinel species
    - Requires scheduling a week for industry / DFO / DAAF / PMRA for dedicated effort and repeat work to get more data to ensure repeatability of results (F. Page to lead)
    - Specific concerns / questions to be resolved include: duration, frequency and type of exposure of non-targets; are zooplankton populations being impacted by treatment products and what is potential effect on predators
- Industry / researchers need feedback from pharmaceutical companies on research to fill outstanding knowledge gaps to assist in product registrations
- Require regulators to provide objectives to help focus work and ensure the correct answer(s) to the specific question(s); data must assist in assessment process or we will not move forward
- Need to continue cumulative impact study and mesocosym work to evaluate processes in the environment

Novel Treatments / Green Technology

Developing non-chemical treatments and new technology to support sea lice management and control is a priority for the salmon farming industry. Under this theme the following activities were identified:

- Continue evaluation on the use of cunners as cleaner fish – project just starting so need to evaluate logistics, trial design etc.
    - include fish health component to cunner fish research
- Evaluate interest in bacterial control investigation and funding options to complete work
    - Collaborate with Norway / Scotland?
- Continue evaluation of EcoBath technology – evaluate use of product, determine efficacy, sea lice mortality, etc.
- Obtain bridge financing to support evaluation and use of mussel / trap project in the field
    - work to include the use of traps lower in the water column and mussels in upper layers
    - further evaluation of optimal light frequency for light traps to select specifically for sea lice (move from med to short term priority)
- Continue denaturing research in the lab and field
    - determine toxicity of precipitate and it's bioavailability
    - cost analysis of ferric citrate / sulfate
    - Possible re-evaluation of absorbents
    - Field well boat and possible tarped net pen delivery evaluations.
- Evaluate filters to collect lice from well boats and harvest vessels. Potential designs have been developed/evaluated by B. Glebe and M. Beattie

- Suggested that evaluation of lice resistant broodstock programs be moved from long term to medium or short term priority and that this item be added to future research information meetings

Farm Management Methods / Fish Health

Research results will help to support improved farm and fish health management and could result in a reduction in the number of sea lice treatments and the quantity of product required. Research may also address other species interaction and management of other diseases. Under this theme the following activities were identified:

- Completion of additional lice survival / reattachment studies
  - Field research required to evaluate post hydrogen peroxide treatments in 2012
  - Research collaboration should include AVC; S. Robinson has potential tagging process for sea lice to monitor reattachment
- Continue review of technology developments in Norway / Scotland to determine applicability in Canada
- Continue evaluation of therapeutic dose level and mixing systems
- Maintain ongoing staff training

Environmental Dynamics

Improved farm management to avoid sea lice infestations would be better informed through better understanding of the environment.

- Although some of this work is currently being covered through existing projects, continued funding may be needed to maintain the collection of this knowledge

Modelling

Computer and mathematical models can help to inform management decisions and lead to a better understanding of environmental conditions within the Bay of Fundy. Modelling requires accurate data; therefore the following work should be undertaken in 2012:

- Determination of the information that is required to continue the development of model(s)
- Support funding for personnel to enable all available data to be entered into models.
  - Currents questions include the distance between sites that are treated on the same day, and the frequency of 2+ sites treating at the same time

Participants

November 24th and 25th Workshop

Last Name	First Name	Company / Organization
Abbott	Matthew	Fundy Baykeeper
Armstrong	Ian	Aqua Pharma Inc
Backman	Steve	Skretting
Bacon	Bev	RDI Strategies Inc
Bartlett	Graham	DFO
Barlow	Elizabeth	Newfoundland Fisheries and Aquaculture
Bartsch	Andrea	DFO - St. Andrews
Beattie	Mike	NB DAAF
Benfey	Tillmann	UNB Fredericton
Blanchard	Clarence	Future Nets & Supplies Ltd
Boone	Brian	NB DAAF
Bourque	Christine	Mitchell McConnell Insurance
Bourque	Peter	Mitchell McConnell Insurance
Brewer-Dalton	Kathy	NB DAAF
Bridger	Chris	Aquaculture Engineering Group
Brown	Bill	Admiral Fish Farms
Brown	Glen	Admiral Fish Farms
Burridge	Les	DFO - St. Andrews
Busby	Corina	DFO - Ottawa
Calvin	Val	NBCC Student
Canam	Amy	Kelly Cove Salmon
Carney	Rodd	NBCC Instructor
Carr	Jonathan	Atlantic Salmon Federation
Cheung	Leo	Research Productivity Council (RPC)
Chiasson	Yvon	NB DAAF
Chopin	Thierry	CIMTAN- University of New Brunswick
Clarke	Corey	Fundy National Park of Canada
Cleghorn	Kathy	NB DAAF
Cline	Jeff	DFO - St. George
Coombs	Karen	NB DAAF
Cooper	Lara	DFO – St. Andrews
Craig	Danny	Huntsman Marine Science Centre
Currie	Paula	Cooke Aquaculture
Daigle	Amanda	Sweeney International Management Corp
Dale	Carla	DFO - Dartmouth
Donkin	Alan	Northeast Nutrition
Drost	Terry	Four Links Marketing
Dugal	Jacques	Valent Bio Sciences
Enright	William	Merck Animal Health
Fast	Mark	AVC - Aquatic Health Sciences
Feindel	Nathaniel	DFO - St. Andrews
Fielding	Stacy	Kelly Cove Salmon
Fordham	Susan	Huntsman Marine Science Centre
Forward	Ben	Research Productivity Council (RPC)
Frost	Kendra	NBCC Student
Garber	Amber	Huntsman Marine Science Centre
Gaudette	Mario	NB DAAF
Gilders	Ross	Research Productivity Council (RPC)
Giles	Marshall	Nova Scotia Fisheries and Aquaculture
Glebe	Brian	DFO – St. Andrews

Goodfellow	Danielle	Aquaculture Assoc of Nova Scotia
Graham	Caroline	NBCC Instructor
Griffin	Randy	Kelly Cove Salmon
Green	Darrell	Newfoundland Aquaculture Industry Assoc
Halse	Nell	Cooke Aquaculture
Hamilton	Andre	NB DAAF
Hartt	Melanie	Admiral Fish Farms
Hawkins	Leighanne	Kelly Cove Salmon
Hill	Ann	NB DAAF
Hill	Murray	ACFFA Staff
Hoare	James	Fish Vet Group
Holmes	Jason	Northeast Nutrition
House	Betty	ACFFA Staff
Hurley	Trena	Huntsman Marine Science Centre
Hutchin	Lynn	NB DAAF
Ingalls	Larry	Northern Harvest Sea Farms
Ingersoll	Trevor	Admiral Fish Farms
Jackson	Tim	NRC/IRAP
Jones	Elizabeth	Admiral Fish Farms
Kaufield	Kathy	ACFFA Staff
Kean	Jordan	NBCC Student
Kearney	Evan	Admiral Fish Farms
Keddie	Esther	Huntsman Marine Science Centre
Kent-Stoddard	Karen	NBCC Student
Kesselring	Mark	Northern Harvest Sea Farms
Larsen	Johannes	NRC/IRAP
Leadbeater	Steven	DFO - St. Andrews
Little	Rob	Northern Harvest Sea Farms
Lomax	Trevor	Sweeney International Management Corp
Lund	Joe	AVC - Aquatic Health Sciences
Lyons	Monica	DFO
MacKinnon	Allison	Novartis Animal Health
MacNeill	Sean	Canadian Centre for Fisheries Innovation
Marcoux	Ernest	Marsh Canada Ltd
Mazerolle	Dan	Fundy National Park of Canada
McCarthy	Anne	Huntsman Marine Science Centre
McCray	Michelle	Sweeney International Management Corp
McCrea	Courtney	Silk Stevens Limited
McEachreon	Tom	NB DAAF
McGee	Doni	ACFFA Staff
McGladdery	Sharon	DFO - St. Andrews
McLaughlin	Katelyn	NBCC Student
Millar	Harvey W.	DFO - St. George
Morton	Cassie	NBCC Student
Mowatt	Pat	NB DAAF
Ness	Matthew	Research Productivity Council (RPC)
Nickerson	Jeff	Cooke Aquaculture
O'Halloran	John	Aqua Vet Services
O'Neil	Rodney	Cooke Aquaculture
Page	Fred	DFO - St. Andrews
Parker	Pamela	ACFFA Staff
Pedersen	Victoria	Canadian Food Inspection Agency (CFIA)
Perron	Sadie	NB DAAF
Pizarro	Herman	Fish Vet Group
Pryor	Miranda	Newfoundland Aquaculture Industry Assoc
Reid	Gregor	University of New Brunswick

Roach	Greg	ADM NS Fisheries & Aquaculture
Roberts	Ian	Marine Harvest Canada
Robinson	Shawn	DFO - St. Andrews
Ryan	Gail	Aquaculture Association of Canada
Salmon	Ruth	Canadian Aquaculture Industry Alliance (CAIA)
Scouten	Sarah	DFO
Shaw	Gavin	Skretting
Sinclair	Kevin	Northern Harvest Sea Farms
Sinclair	Leonard	Northern Harvest Sea Farms
Smith	Amanda	Sweeney International Management Corp
Smith	Sybil	ACFFA Staff
Stanley	Trevor	Skretting
Stevens	David	Silk Stevens Limited
Storey	Andrew	Open Ocean Systems
Streight	Howard	Admiral Fish Farms
Sweeney	Bob	Sweeney International Management Corp
Szemerda	Michael	Cooke Aquaculture
Taylor	Gary	Skretting
Taylor	Stephanie	Admiral Fish Farms
Taylor	Suzanne	DFO
Taylor	Tom	Northeast Nutrition
Trippel	Ed	DFO - St. Andrews
Waddy	Susan	DFO - St. Andrews
Wallace	Shawna	DFO - St. Andrews
Watkins	Todd	Northern Harvest Sea Farms
Watson	Kimberly	NB DAAF
Whitehead	Jessica	Sweeney International Management Corp
Wiper	Jennifer	Kelly Cove Salmon
Wong	Dave	DFO – St. Andrews

Nova Scotia Aquaculture

Creating Sustainable Wealth in Rural Coastal Nova Scotia

NOVA SCOTIA

Nova Scotia Department of Fisheries and Aquaculture

Lead Provincial Agency for Aquaculture

- Aquaculture development and extension
- Leases and licenses
- Fish health
- Environmental management
- Inspection and enforcement
- Public confidence

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Nova Scotia Aquaculture Facts

- Atlantic salmon/ rainbow trout (marine) – 75% total value
- halibut, Arctic char, sea bass, striped bass
- mussels, quahogs, oysters, scallops, clams, lobsters
- marine plants

- Direct employment- 245 full time & 500 part time
- Aquaculture sites in every county
- More than 300 licences/leases issued
  - (incl 33 First Nation licenses)

Memorandum of Understanding

Canada/Nova Scotia

Environmental sustainability

Effects monitoring & follow up

R&D priority setting

Information/data sharing

Canada

Scientific research

Input on applications

CEAA

National & regional fish diseases

Compile and publish national report

Nova Scotia

Applied development

Licensing & leasing

Site Inspection and compliance

Fish health management

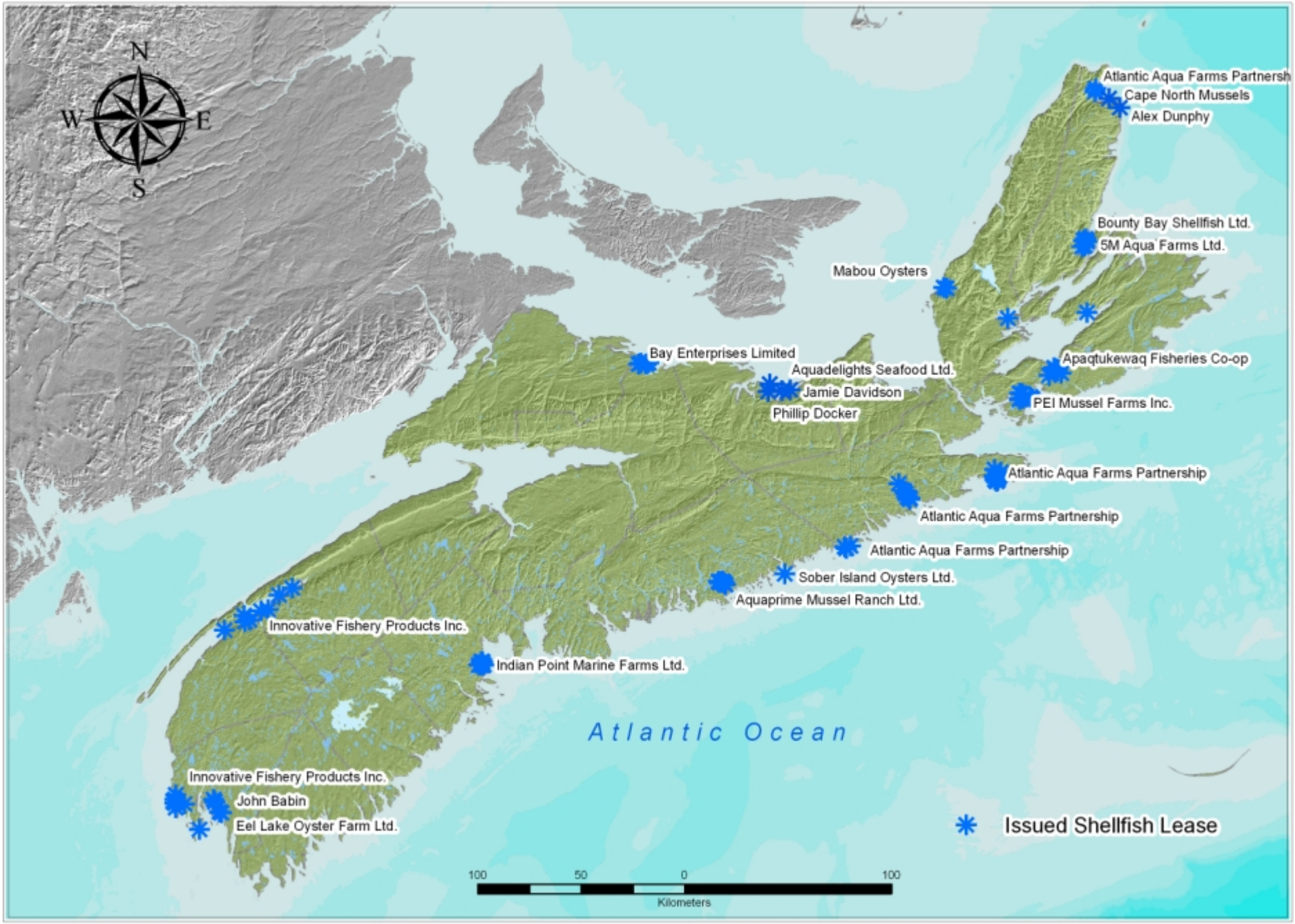
Collect production data

NOVA SCOTIA

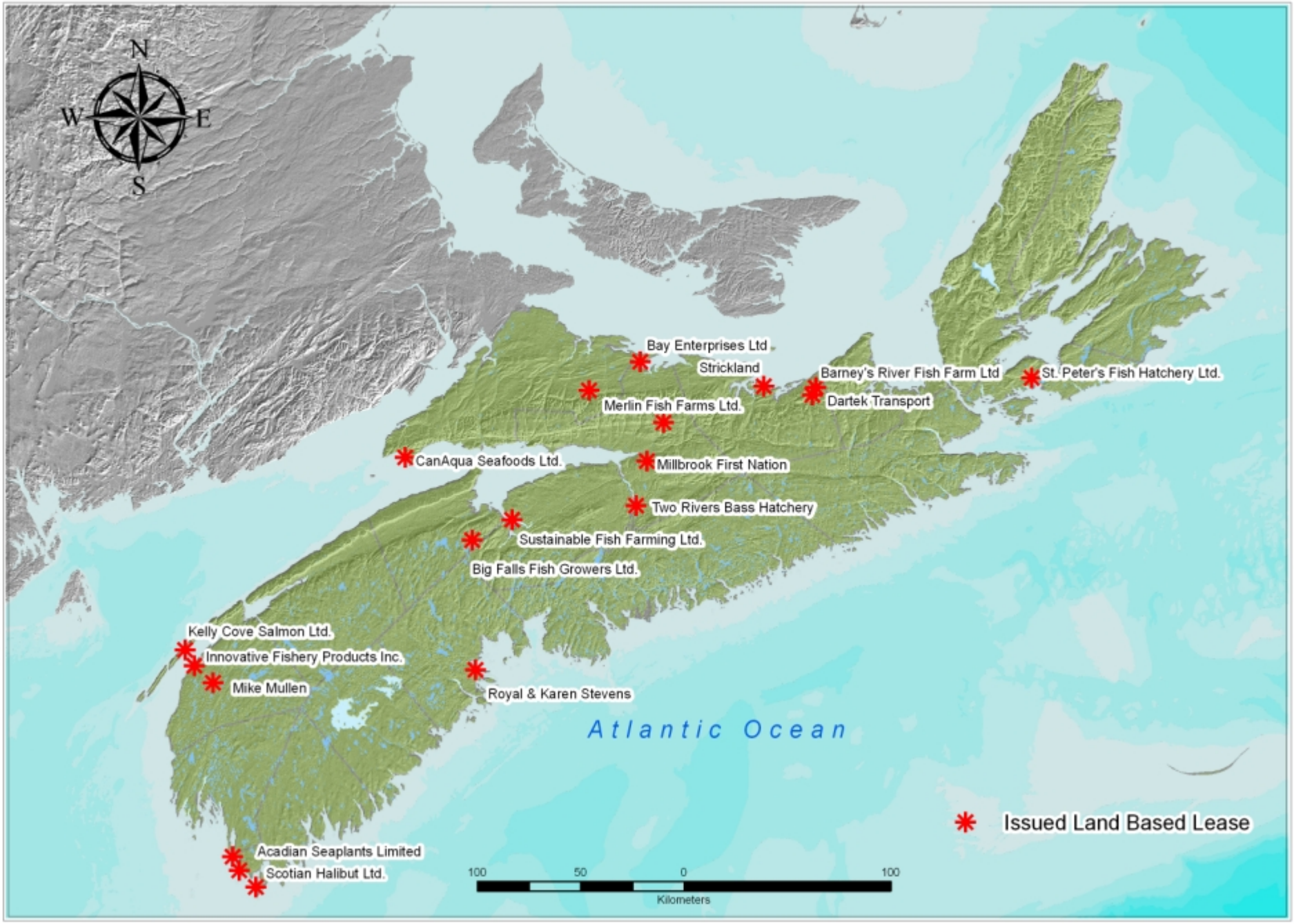
A Diverse Industry

NOVA SCOTIA

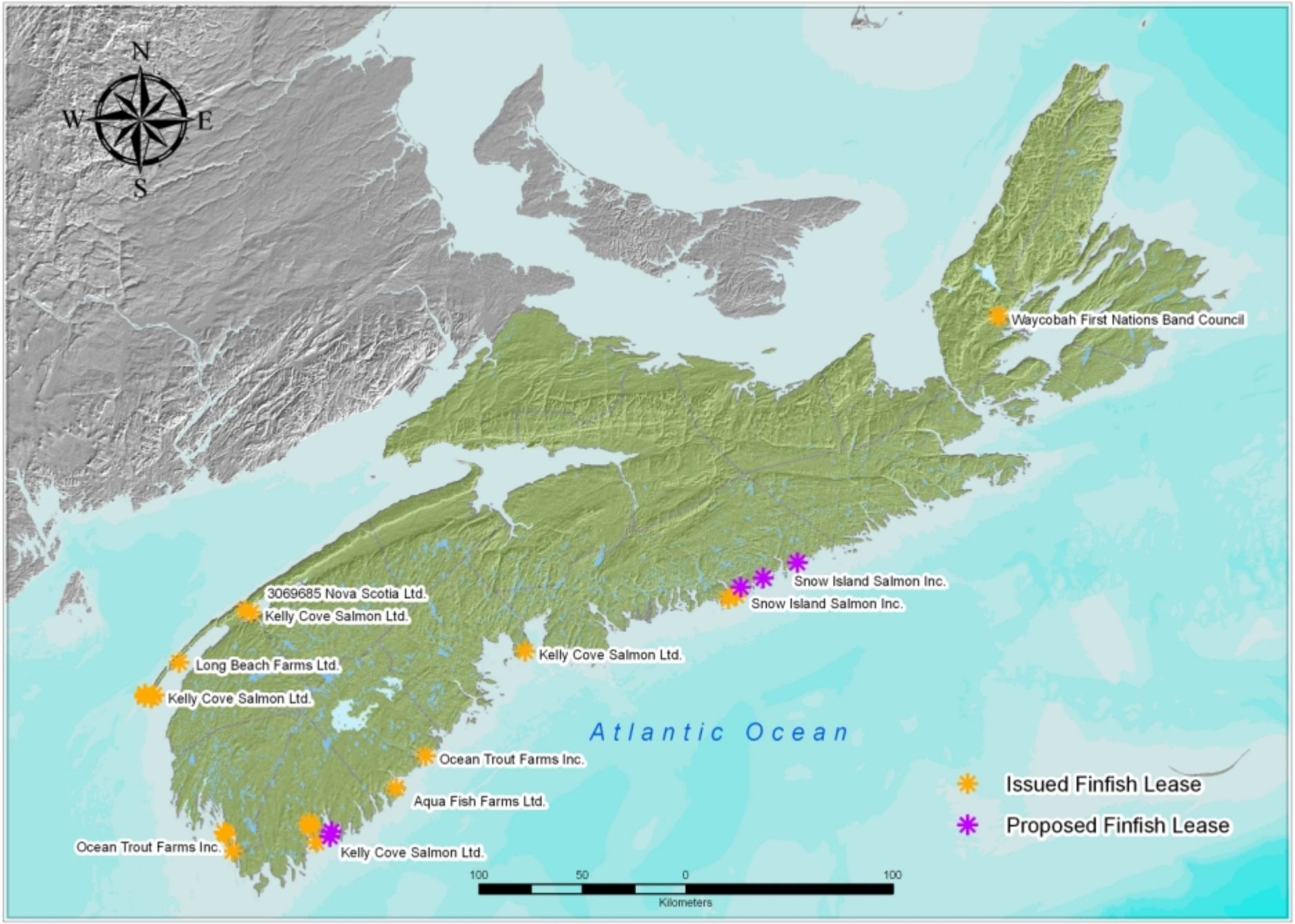
ACTIVE SHELLFISH LEASES IN NOVA SCOTIA



ACTIVE LAND BASED SITES IN NOVA SCOTIA



ACTIVE & PROPOSED FINFISH LEASES IN NOVA SCOTIA



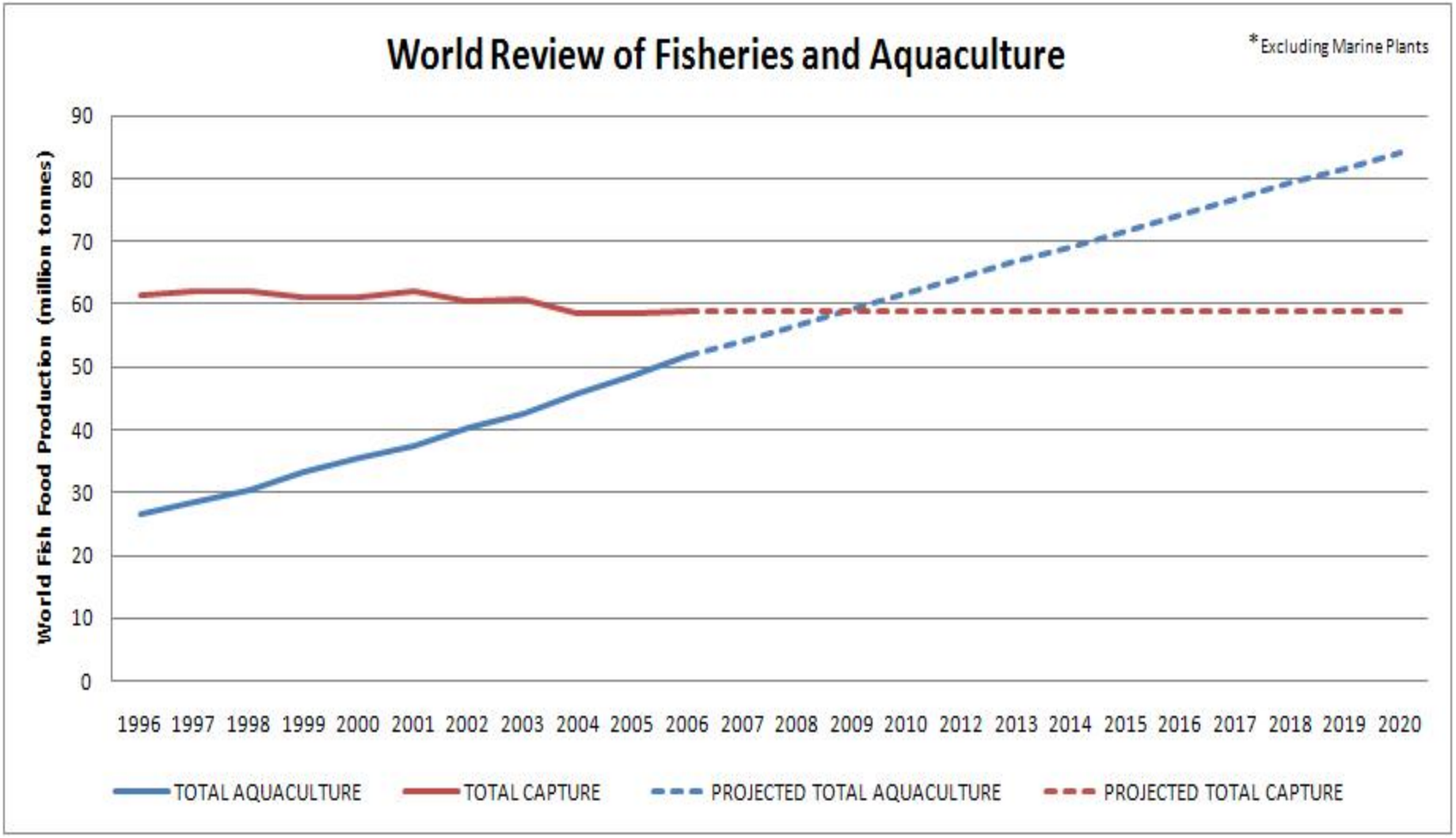
Vision

Within forthcoming aquaculture strategy:

- Vision for aquaculture is the development of a sustainable industry anchored within rural coastal Nova Scotia

The Opportunity

- An international competitive advantage (coastline, culture, infrastructure)
- World class education, training & research facilities including the Nova Scotia Agricultural College
- Strong product demand (continued growth in farmed seafood consumption) and companies looking to expand
- Opportunities for processing and support industries
- In 10 years – One of NS's more valuable natural resource industries


World Review of Fisheries and Aquaculture
*Excluding Marine Plants
World Fish Food Production (million tonnes)
90
80
70
60
50
40
30
20
10
0
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2012 2013 2014 2015 2016 2017 2018 2019 2020
TOTAL AQUACULTURE
TOTAL CAPTURE
PROJECTED TOTAL AQUACULTURE
PROJECTED TOTAL CAPTURE

NOVA SCOTIA

Growth Expectancy
Nova Scotia Expansion

- Cooke Aquaculture potential investments – a processing facility, feedplant expansion, and new hatchery
- Ocean Trout interest in Cape Breton with sites and hatchery
- The Whycobah Band recently activated a trout farm in the Bras d'Or Lakes. The community is excited about training opportunities and employment.
- Renewed interest and work towards additional farms along the Eastern Shore. Applications by Loch Duart/Snow Island
- Digby/Yarmouth – Innovative Fisheries Shellfish Hatchery
- McNutt's Island/Jordan Bay – Cooke Aquaculture
- Nova Scotia overall production expected to triple by 2017

Nova Scotia Challenges

- Community-level opposition and anti-industry lobbyists
- Poor public perception & misinformation
- Intensely regulated industry
- Time delays in site approval process
- Global economics
- Competition for ocean space. Conflict in the coastal zone.
- Updating policy, regulatory and framework regime
- FOIPOP's, court challenges and jurisdictional complexity

Aquaculture Strategy
Six Key Strategic Areas of Emphasis

- Public Confidence
- Access to Sites
- Innovation, Productivity, and Competitiveness
- Fish Health
- Aquaculture Policy
- Environmental Management

Environmental Monitoring Program

Quality monitoring and reporting is key to understanding the impacts of aquaculture operations:

- For 8 years, the Department has operated a respected environmental monitoring program.
- Recently shifted responsibility for sample collection and reporting to the private sector. Establishing audit role and capability.
- Follow-up and mitigation required for farms exceeding acceptable limits of environmental impact.
- Working towards more rigorous laboratory testing, standard operating procedures, equipment and additional staff.
- Forthcoming Federal Fisheries Act Requirements

Fish Health Program

Working to develop a comprehensive approach to fish health including:

- Disease surveillance and reporting
- Diagnostic facilities
- Biosecurity measures
- Regulatory program management and auditing
- Research capacity for emerging disease control
- Atlantic collaboration/cooperation/harmonization

Thank you

NOVA SCOTIA

Policy and Business Case for a Federal *Aquaculture Act*

Presentation to ACFFA

November 24, 2011

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INDUSTRY ALLIANCE

Farming Canadian waters with care.

Introduction/Background

Long history of studies and initiatives

- 1983 Science Council of Canada report
- 1988 Standing Committee on Fisheries and Oceans report
- 1995 Federal Aquaculture Development Strategy
- 1998 Aquaculture Policy Framework
- 1999 Agreement on Inter-jurisdictional Cooperation With Respect to Fisheries and Aquaculture
- 2000 DFO Program for Sustainable Aquaculture, and Aquaculture Action Plan
- 2001 Office of the Commissioner for Aquaculture Development reports
- 2001 Standing Senate Committee on Fisheries report
- 2003 Standing Committee on Fisheries and Oceans report
- 2006 Aquaculture Framework Agreement announced
- 2010 National Aquaculture Strategic Action Plan Initiative

Issue

- Canada's regulatory structure is redundant, burdensome, costly and confusing
- Canada is only major producing country without national legislation designed to govern and enable its aquaculture industry

About RIAS Inc

- Assembled a team of consultants, 150+ years of combined experience
- Legislative, regulatory policy experts – in agriculture, food inspection, fish management and environmental protection
  - Doug Blair
  - Peter Brackenridge
  - Dr. Ronald Doering
  - Craig Marchand
  - David McBain
  - Eric Milligan
  - Dr. Tom Richardson

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Current Situation

Quick Facts

- *Aquaculture is the fastest growing food production system in the world.*
- *Aquaculture produces about 50% of global aquatic food production*
- *Aquaculture accounts for 14% of total seafood production (volume) and 35% of its value in Canada*
- *Aquaculture in Canada generates about $4 billion in economic activity, over $1 billion in GDP and over half a billion dollars in labour income. It creates thousands of direct jobs, and many more in industries throughout the food production value-chain*
- *Canada ranks 27th in world aquaculture in terms of production and 20th in terms of the value of the production*
- *Growth in Canadian aquaculture has "flat-lined" over the past decade while the rest of the world has seen consistent annual growth of over 6%*

- In general, these facts about the state of the industry are well known
- But governments have not focussed on the real story

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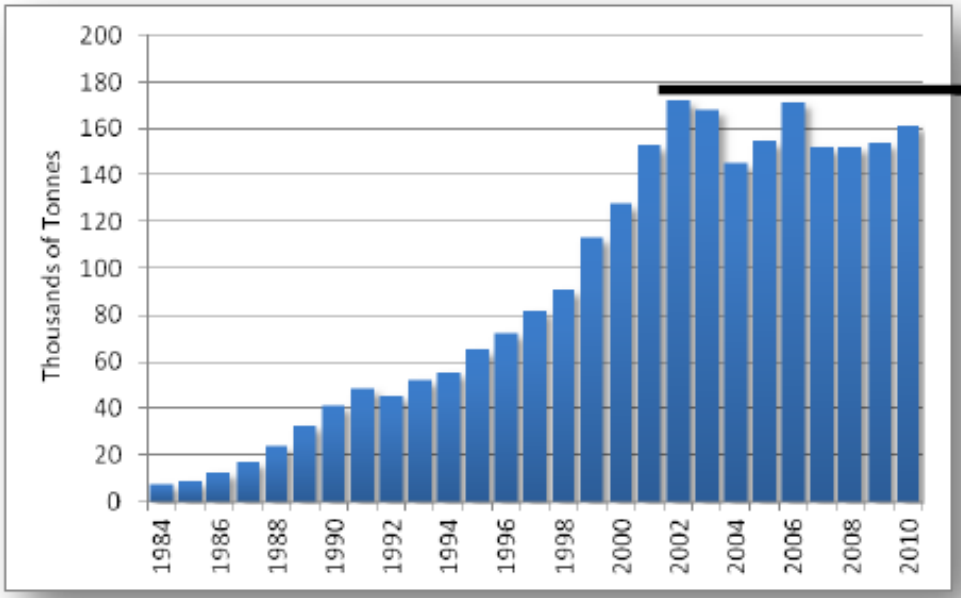
10 years of stagnated growth

Aquaculture Production in Canada (1984 to 2010)



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

Source: FAO Statistics

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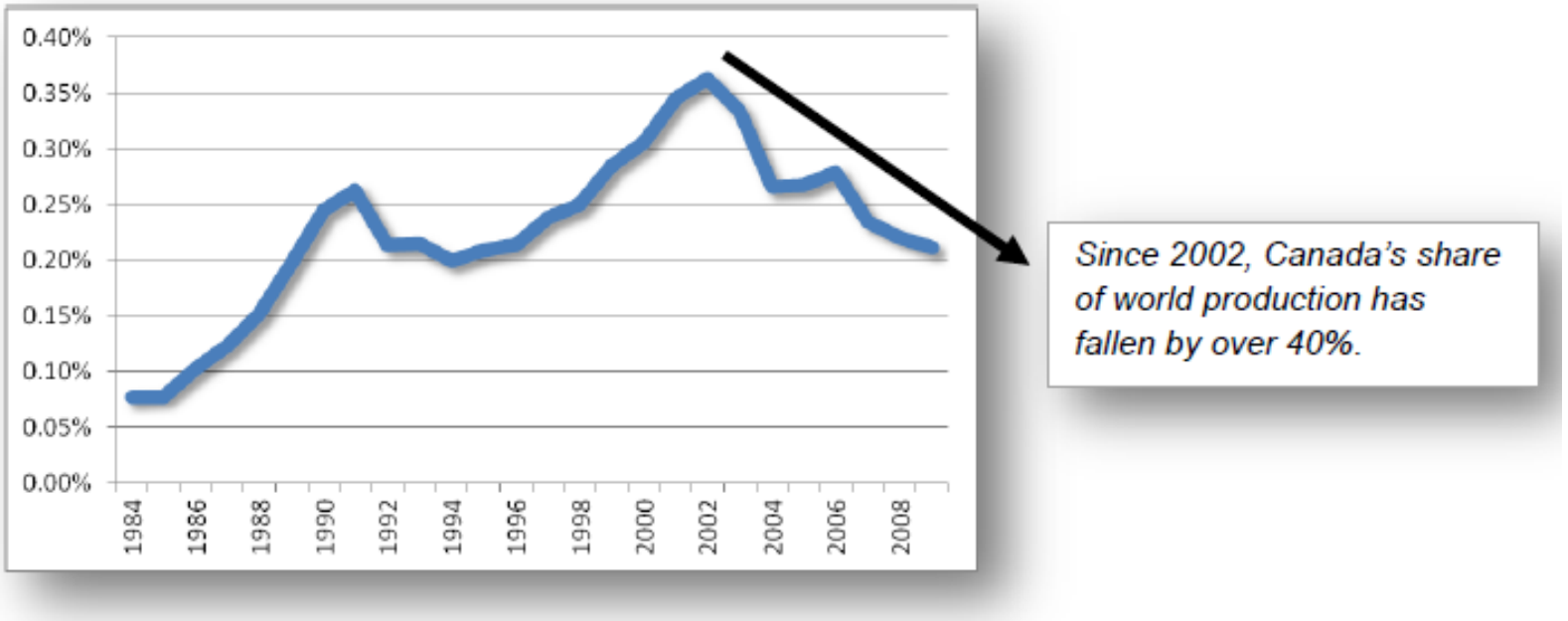
40% drop in share of world market

Canada's Share of World Production– 25 year trend



Source: FAO Statistics

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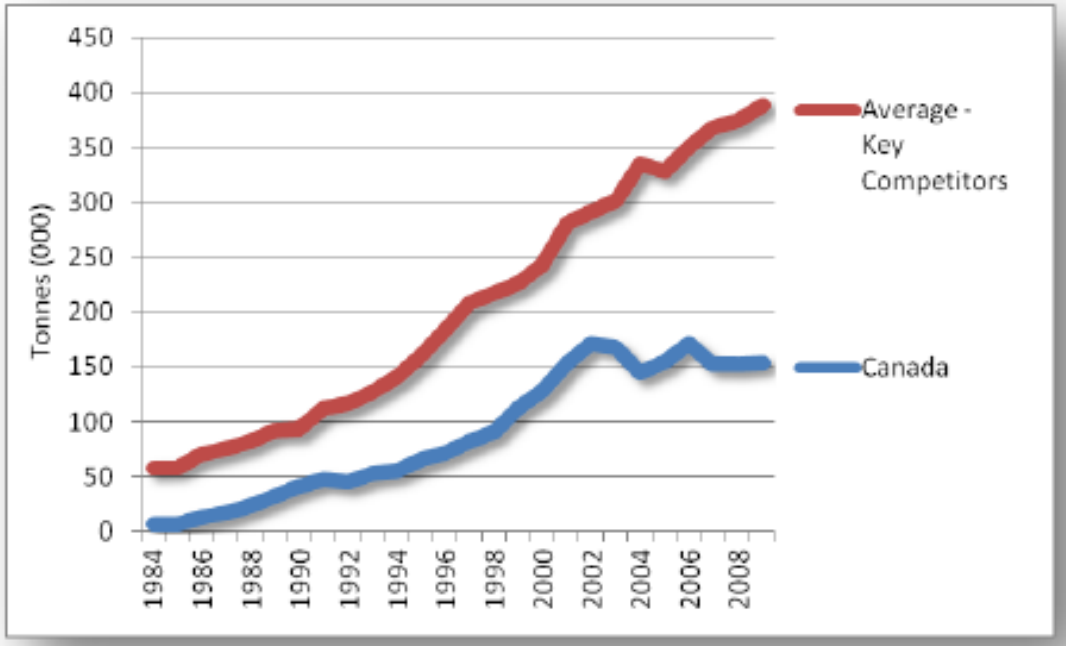
Falling behind key competitors

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



Source: FAO Statistics

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

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What are the Causes?

Numerous studies and initiatives relating specifically to the aquaculture industry in Canada sugg uncertainty ir regulatory ar environment that negative development

Expansion of aquaculture production is impeded because of delays in approval of new growing sites, which missed oppo economic ac creation.

Current levels of federal regulatory burden imposed on the aqu could be a million per

Lack of timely access new production sites has reduced the confidence of the investment community in Canadian aquaculture development.

"Following all the rules is killing us." – CAIA member company

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Legislative, Regulatory and Policy Environment

Report summarizes leg/reg/pol environment of:

- Federal Government
- Provincial/Territorial governments
- Other Leading Jurisdictions identified by CAIA – U.S., Australia, Norway, Chile, New Zealand, Scotland, Ireland

Quick Facts

- *There are over 90 federal/provincial/territorial acts that impact on aquaculture*
- *17 federal departments and agencies play some role in managing the aquaculture industry*
- *The main federal legislation governing fish in Canada is the Fisheries Act, a piece of legislation that dates back to Confederation*
- *Aquaculture is not mentioned by name in the Act*

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Issues and Challenges

- Lack of Definition of “Aquaculture” Under Current Federal Legislation
- Jurisdictional Issues Including Overlap and Duplication
- Lack of Developmental Mandate
- No Recognition of Property Rights
- Incomplete and Inconsistent Approaches to Risk Management

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Nine Elements for Smarter Governance

1. Leadership/vision
2. Accountability
3. Definition of Aquaculture
4. Clarify Policy Objectives
5. Modernize Private Ownership Rights
6. Clarify Roles and Responsibilities
7. Regulatory Streamlining/Elimination of Overlap and Duplication
8. More Efficient and Effective Approaches to Risk Management
9. Development mandate/enabling role

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Aquaculture Act vs. Amended Fisheries Act

Assessment of Options

Elements/Criteria	Creation of an *Aquaculture Act*	Amendments to the *Fisheries Act*
1. Leadership/vision	+	-
2. Accountability	+	-
3. Definition of Aquaculture	+	+
4. Clarify Policy Objectives	+	+
5. Modernize Private Ownership Rights	+	-
6. Clarify Roles and Responsibilities	+	+
7. Regulatory Streamlining/Elimination of Overlap and Duplication	+	+
8. More Efficient and Effective Approaches to Risk Management	+	-
9. Development mandate/enabling role	+	-

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Socio-economic Impacts of an *Aquaculture Act*

Growth in GDP, Jobs and Labour Income

- DFO says industry could increase output by 8% - 214,000 mt in 5 years, 308,000 mt by 2020
- Report suggests this is optimistic – 1.3% to 3% growth more realistic

Other Potential Socio-economic Impacts

- Diversification and wealth generation in rural and coastal areas
- Opportunities for Aboriginal communities
- Food security - reduced pressure on wild fish stocks, assurance of high-quality, safe, competitively priced and nutritious seafood
- Expansion of domestic and export markets for Cdn seafood products

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Conclusions

"Aquaculture requires a modern legal and policy framework that is in concordance with the agri-food aspects of this aquatic farming sector."

- Best course of action = *Aquaculture Act*
- Case has been made repeatedly, and by many
- Minimal cost to the government – offset by income, jobs and tax benefits generated by growth in the industry
- Not a "cure-all" solution, but would provide a strong signal and impetus for real action to fix the problems, and better enable the aquaculture industry to compete and prosper
- Plus, *Aquaculture Act* is consistent with the government's broad economic development strategy – low cost ways to stimulate jobs and growth

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Why Now?

- Majority Conservative Government
- We can offer jobs without a big price tag
- Falling behind competitors & investment is precarious

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Final thoughts

- Public support on our side
- The report = first step, foundation
- 10-page summary being prepared: "**It's Time to *Act***"
- Micro site will be developed with a call to action
- Serious, coordinated campaign needed

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Sustainability of Salmon Farming

Tillmann Benfey

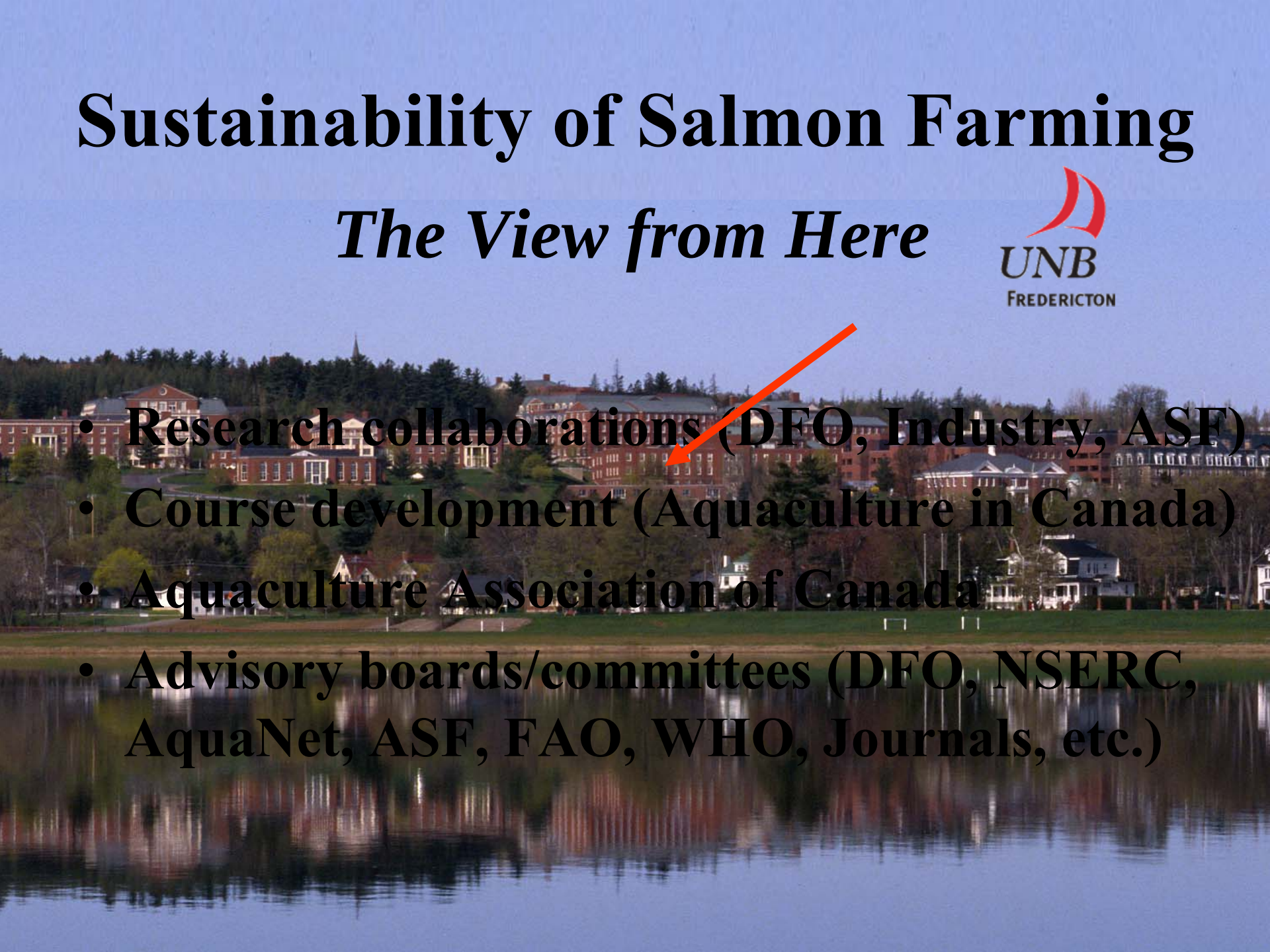
UNB
FREDERICTON

ACFFA Fall Workshop
Nov. 24, 2011

Sustainability of Salmon Farming

The View from Here

UNB
FREDERICTON

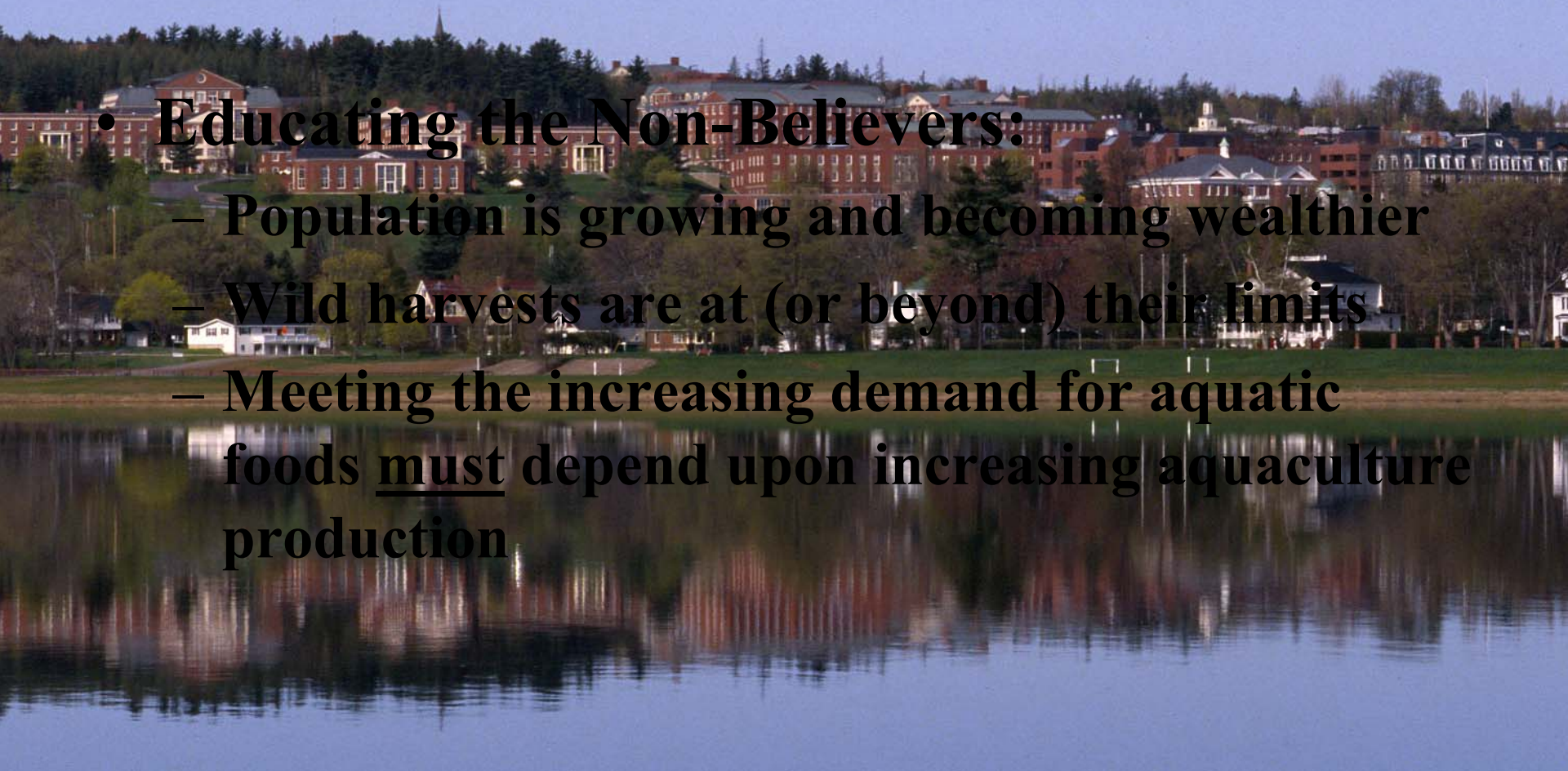


- **Research collaborations (DFO, Industry, ASF)**
- **Course development (Aquaculture in Canada)**
- **Aquaculture Association of Canada**
- **Advisory boards/committees (DFO, NSERC, AquaNet, ASF, FAO, WHO, Journals, etc.)**

Sustainability of Salmon Farming

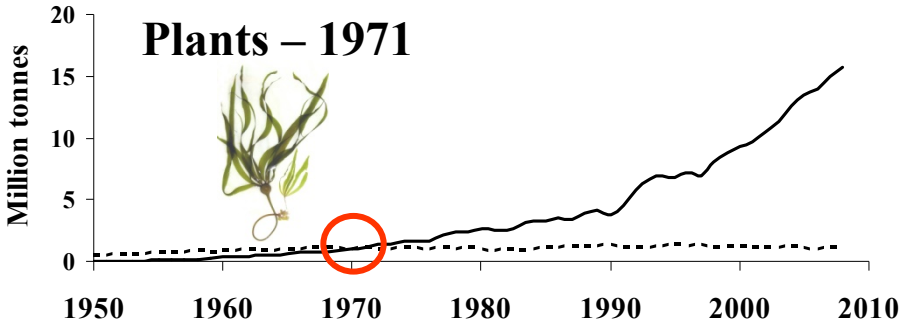
The View from Here

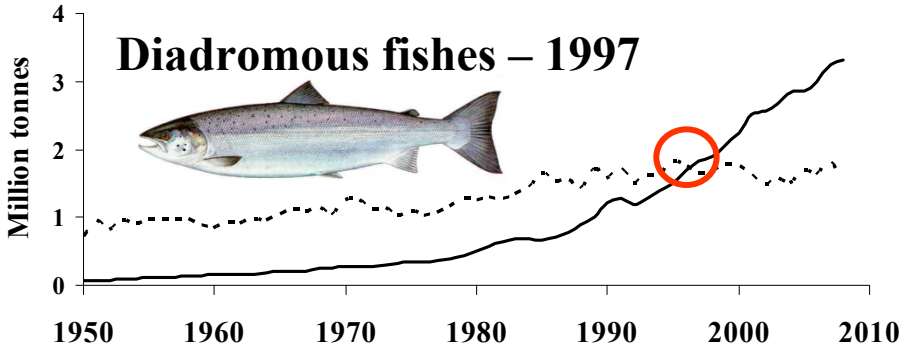
UNB
FREDERICTON

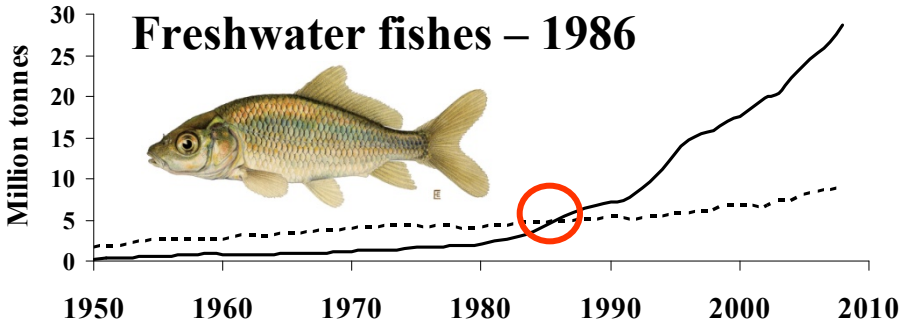


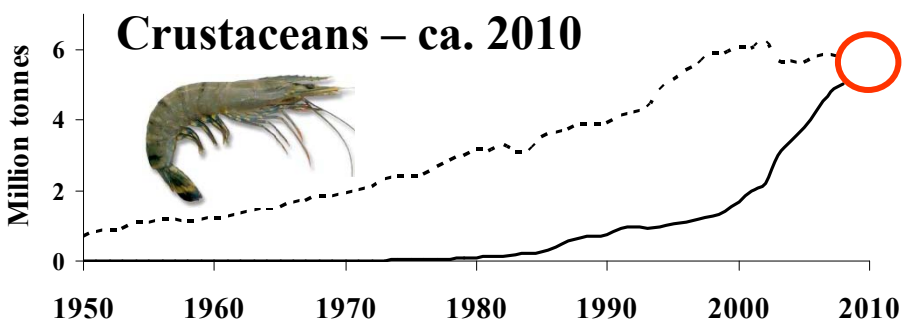
- **Educating the Non-Believers:**
  - **Population is growing and becoming wealthier**
  - **Wild harvests are at (or beyond) their limits**
  - **Meeting the increasing demand for aquatic foods must depend upon increasing aquaculture production**

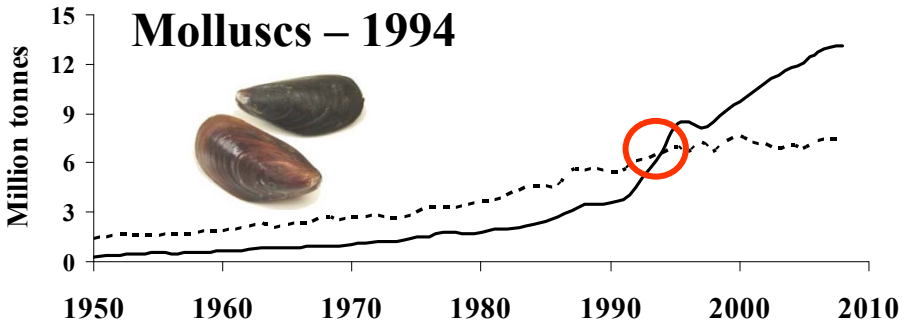
Global Perspective

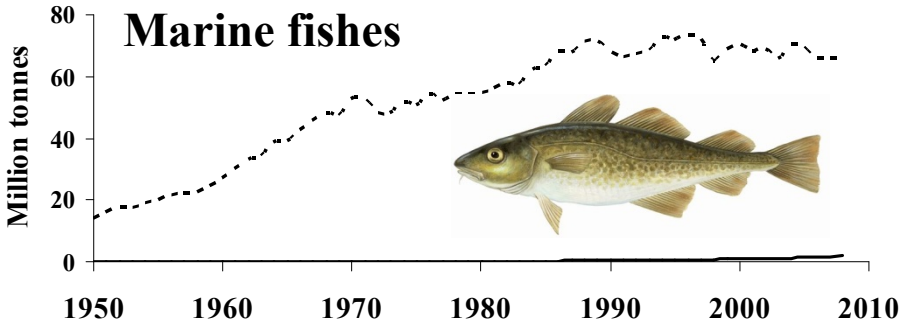












Data source: FAO - Fisheries and Aquaculture Information and Statistics Service


Paul Nicklen
(art.com)

Atlantic Salmon Fishery

Associated Press (www.wsj.com)

Data source: 2011 Report of the ICES Working Group on North Atlantic Salmon
(http://www.ices.dk/reports/ACOM/2011/WGNAS/wgnas_2011_final.pdf)

Atlantic Salmon Farming

Data source: 2011 Report of the ICES Working Group on North Atlantic Salmon
(http://www.ices.dk/reports/ACOM/2011/WGNAS/wgnas_2011_final.pdf)

Atlantic Salmon in Atlantic Canada

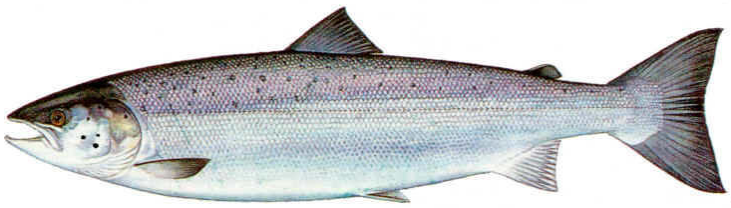
Data source: 2011 Report of the ICES Working Group on North Atlantic Salmon
(http://www.ices.dk/reports/ACOM/2011/WGNAS/wgnas_2011_final.pdf)

Benefits of Salmon Farming

- **Clear advantages over commercial fishing**
  - **Better food conversion efficiency**
  - **More efficient (no searching & no by-catch)**
  - **Fresher product (processing & delivery)**
  - **Greater production volume (= lower price)**
  - **More humane slaughter**

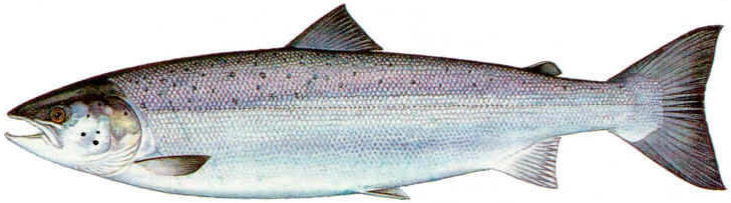
Benefits of Salmon Farming

- **More productive than traditional livestock**
  - **Natural life history is 3-D and high density**
    - **Greater yield per unit surface area**
  - **Better food conversion efficiency**
    - **Neutrally buoyant**
    - **Ectothermic (cold-blooded)**
    - **Carnivores**



Benefits of Salmon Farming

- **Healthier food than traditional livestock**
  - **ω-3 fatty acids, etc.**



Concerns with Salmon Farming

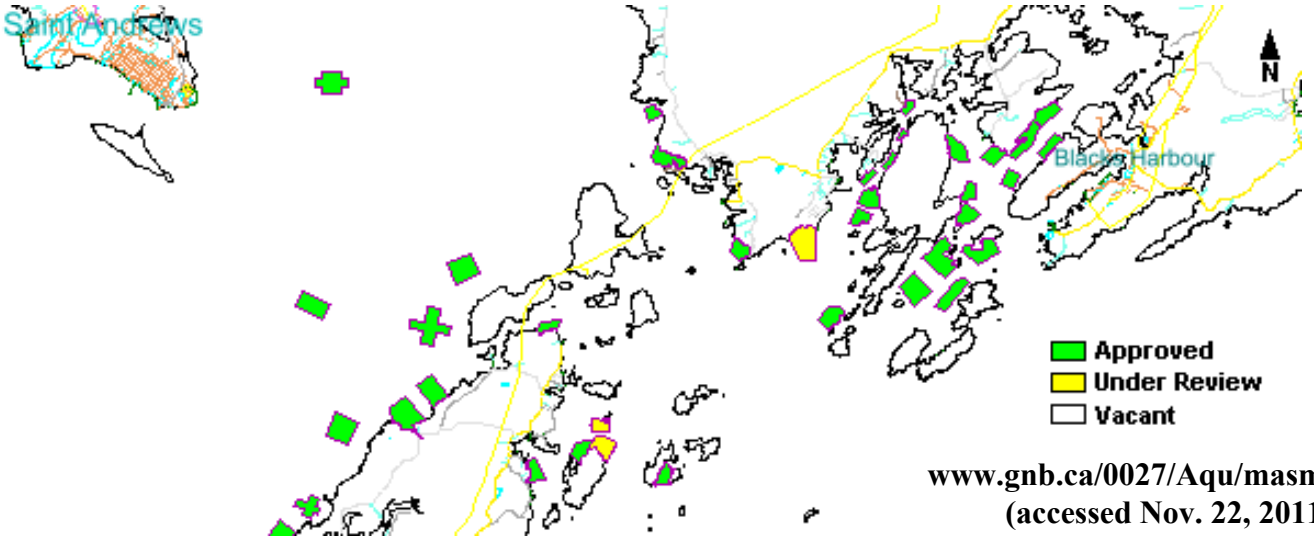
- **Nutrient loading**
- **Shared use of the coastal environment**
- **Escapes**
- **Use of fish meal & oil for feed production**
- **Amplification of pathogen & parasite loads**
- **Use of chemicals**

Concerns with Salmon Farming

- **Nutrient loading**
  - **Wastewater management**
  - **Not unique to aquaculture**
    - **Sewage, farm effluent, agricultural runoff, etc.**
  - **Dilution or capture (for disposal or conversion)**
  - **Is dilution the solution to fish farm pollution?**
    - **What is the baseline in a depopulated ocean?**
  - **Difficult to capture/convert nutrients in open ocean systems (≈ tertiary sewage treatment)**
    - **IMTA (integrated multitrophic aquaculture)?**

Concerns with Salmon Farming

- **Shared use of the coastal environment**
  - **Coastal zone management**
  - **Not unique to aquaculture**
    - **Land use management**
  - **Requires objective and fair allocation of space**



www.gnb.ca/0027/Aqu/masm-e.asp
(accessed Nov. 22, 2011)

Concerns with Salmon Farming

- **Escapes**
  - **Genetic & ecological impacts on wild populations**
  - **Not unique to aquaculture**
    - **Goats, pigs, crop plants, ornamental plants, etc.**
  - **Physical containment**
    - **Difficult with current marine cage culture technology (site location, cage engineering, etc.)**
  - **Closed containment?**
  - **Reproductive containment (triploids)?**

Concerns with Salmon Farming

- **Use of fish meal & oil for feed production**
  - **Concerns with sustainability & contaminants**
  - **Not unique to aquaculture**
    - **Used for pigs, poultry, etc. (although declining)**
  - **Requires sustainable harvest of forage species and inspection of ingredients for contaminants**
  - **Alternative sources of protein and oil**
    - **Fish health and welfare?**
    - **Consumer acceptance?**

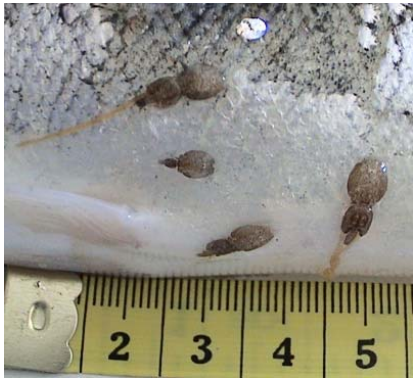
Image sources: equa-equaethicalfashion.blogspot.com; siberiantigernaturals.com

Concerns with Salmon Farming

- **Amplification of pathogen & parasite loads**
  - **Disease management**
  - **Not unique to aquaculture**
    - **E.g., avian flu**
  - **Surveillance, diagnostic testing, certification, control and eradication, etc.**
    - **Done very well in New Brunswick**
  - **National Aquatic Animal Health Program (CFIA / DFO)**

Concerns with Salmon Farming

- **Use of chemicals**
  - **Pesticides, antibiotics and pigments**
  - **Not unique to aquaculture**
    - **Integrated pest/disease management, food additives**
  - **Myths about antibiotics and pigments**
  - **Pesticides a problem (e.g., sea lice)**



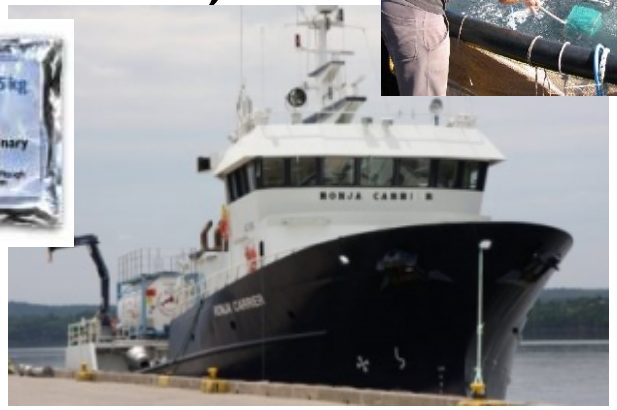


Image sources: asf.ca; nbsga.com; vetcare.gr; shop.thefishsite.com

The Future of Salmon Farming

- **An evolving process (still a new industry)**
- **Short-term: progress with cage culture**
  - **Some (limited) opportunities for improved nutrient capture & recycling**
  - **Some (limited) opportunities for improved containment of fish and exclusion of pathogens**
  - **Improved siting (location, density, rotation)**
  - **Improved fish health management**
  - **Improved diet formulation (plant/yeast-based ingredients for protein, oil and pigment)**

The Future of Salmon Farming

- An evolving process (still a new industry)
- Long-term: closed containment systems?
  - Highly intensive and land-based
    - Complete heat, water and nutrient recovery
    - No need for antibiotics or pesticides, and no escapes
  - Economic and environmental implications
    - Not currently a viable option for salmon
    - Use “high-end” species to develop the technology, e.g., sea bass

SUSTAINABLE BLUE

Final Words …

- **Aquaculture is making the logical transition from hunting/gathering to farming**
- **Important contributor to the local economy**
- **Producing healthy products**
- **Not without its problems, but …**
  - **Very different industry from 20 years ago**
  - **Likely to be a very different industry 20 years from now**

Questions?

Transport and Dispersal of Sea Lice Therapeutants from Net Pens and Well Boat Bath Treatments Conducted in Southwest New Brunswick

by

F.H. Page and Les Burridge

Fisheries and Oceans Canada

Biological Station, St. Andrews, N.B.

Presentation to the acffa workshop
24 November 2011

Presentation Outline

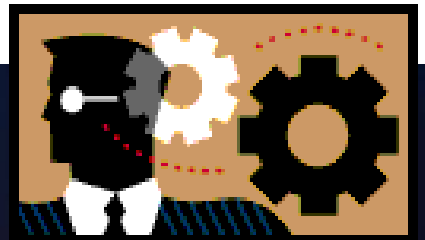
1. **Introduction**
   - i. Rationale
   - ii. Conceptual and Quantitative Foundation
   - iii. Research Scope

2. **Releases from Tarped Cages**
   - i. The treatment process
   - ii. In the tarp
   - iii. At the cage edge/end-of-pipe
   - iv. Within the released plume

3. **Releases from Well Boats**
   - i. The treatment process
   - ii. In the well
   - iii. At the end of the discharge pipe
   - iv. Within the discharge jet
   - v. Within the plume

4. **Summary**

$$\frac{\partial C}{\partial t} = U\frac{\partial C}{\partial x} + V\frac{\partial C}{\partial y} + W\frac{\partial C}{\partial z} + K_x\frac{\partial^2 C}{\partial x^2} + K_y\frac{\partial^2 C}{\partial y^2} + K_z\frac{\partial^2 C}{\partial z^2} + sources + sinks$$

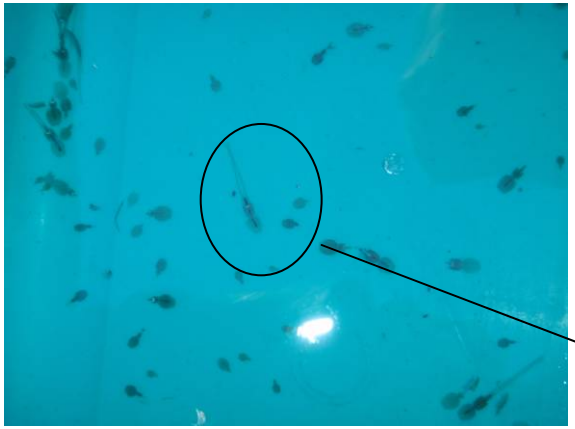


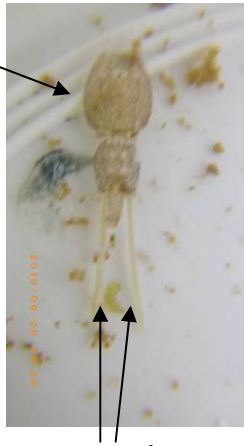
Canada

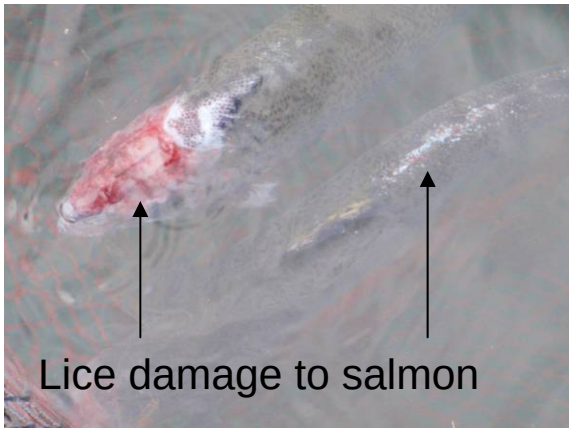
Introduction: Rationale - Why are therapeutants?

- SEA LICE ! a natural parasite of Atlantic salmon that can cause very significant fish health concerns and production, economic and social losses

- Industry and government try to manage and control lice abundance with husbandry, in-feed and bath treatments, cleaner fish, light traps, siting, policies and regulations







Introduction: Rationale - Why transport and dispersal?

- Transport and dispersal dynamics are a fundamental component of therapeutant efficacy and impact dynamics

- When therapeutants are used

  • efficacy and environmental impacts are both influenced by the degree of exposure to the active ingredients and the sensitivity or toxicity response of the target or non-target organisms

  • high efficacy requires target parasite to be exposed to optimum and consistent therapeutant concentrations for known durations

  • minimal environmental impacts requires non-target organism exposures to the therapeutant to be minimal

  • in both cases the exposures are controlled by transport, dispersal and chemical reaction processes

$$\frac{\partial C}{\partial t} = U\frac{\partial C}{\partial x} + V\frac{\partial C}{\partial y} + W\frac{\partial C}{\partial z} + K_x\frac{\partial^2 C}{\partial x^2} + K_y\frac{\partial^2 C}{\partial y^2} + K_z\frac{\partial^2 C}{\partial z^2} + sources + sinks$$

Foundation: Transport and Dispersal

Rate of Change in Concentration | **Transport or Advection** | **Dilution Or Diffusion**

$$\frac{\partial C}{\partial t} = U\frac{\partial C}{\partial x} + V\frac{\partial C}{\partial y} + W\frac{\partial C}{\partial z} + K_x\frac{\partial^2 C}{\partial x^2} + K_y\frac{\partial^2 C}{\partial y^2} + K_z\frac{\partial^2 C}{\partial z^2} + sources + sinks$$

- C is the therapeutant concentration,
- U, V, W are the orthogonal components of water speed
  - W could include a sinking term for the therapeutant
- Kx, Ky and Kz are the orthogonal coefficients of eddy diffusion
- x, y, and z are the orthogonal coordinate axes
- sources are the spatial and temporal inputs of therapeutant
- sinks are the various processes that remove therapeutant from the water
  - reaction, degradation, absorption onto particles, etc.

Research Scope: Transport-Dispersal and Application

Research Foundation

$$\frac{\partial C}{\partial t} = U\frac{\partial C}{\partial x} + V\frac{\partial C}{\partial y} + W\frac{\partial C}{\partial z} + K_x\frac{\partial^2 C}{\partial x^2} + K_y\frac{\partial^2 C}{\partial y^2} + K_z\frac{\partial^2 C}{\partial z^2} + sources + sinks$$

- quantify spatial and temporal characteristics of advection rates
- quantify spatial and temporal characteristics of diffusion or dilution rates
- describe and quantify spatial and temporal characteristics of sources
- describe and quantify sinks

Application to considerations of:

- exposure potentials for target organisms during treatments and implications to therapeutant efficacy, resistance
- exposure potentials for target organisms and integrated pest management planning scenarios
- exposure potentials for non-target organisms and environmental risk assessments for isolated and multiple treatment scenarios
- transport and dispersal scenarios for sea lice, disease vectors, nutrients, etc. and implications for ABMAs

Research Activities:

- **In situ observations** (*continuing: 2010-11, 2011-12+, 2012-13?*)
  - data collected during commercial therapeutant treatments and non-commercial pseudo-treatment situations and at a variety of cages, sites, and weather conditions
  - observations included observations of
    - horizontal water currents (current meters, drifters, dye)
    - horizontal and vertical dilution/dispersion (dye)
    - water sampling for therapeutant concentration
    - surface time lapse photography

- **Modelling** (*underway: 2011-12, 2012-13+*)
  - relatively simple analytical models
  - more complex numerical 4D (x,y,z,t) models

- **Scenario Application and Evaluation** (*commencing: 2012-13+*)
  - linking transport and dispersal with toxicity
  - single treatment scenarios
  - multiple treatment scenarios (eg. Per farm, multiple farms)

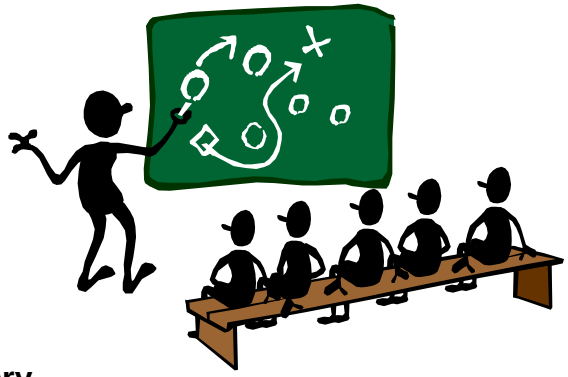
Acknowledgements: The Team Oceanographers, Tarpologists, Wellographers, gifted others

Fisheries & Oceans Canada

- Dr. Fred Page
- Randy Losier
- Paul McCurdy
- Blythe Chang
- Sheila Gidney
- Jack Fife
- John Reid
- Jeff Cline
- Dr. Les Burridge
- David Wong
- Dr. Sharon McGladdery
- Sarah Cheney
- Jiselle Bakker
- Katie Haughn
- Sarah Scouten
- Graham Bartlett
- Tristain L.
- Jerad L.
- Others …

- **Environment Canada**
  - Bill Ernst et al.

- **Health Canada / PMRA**
  - Peter Delorme et al.



- **NBDAAF**

- Dr. Mike Beattie
- Bruce Thorpe
- Kathy Brewer-Dalton
- Jiselle Bakker
- Barry Hill
- Pat Mowat
- Kathy Cleghorne
- Others ….

- **Industry**
  - Cooke Aquaculture Inc
  - Northern Harvest Sea Farms
  - Admiral Fish Farms
  - NBSGA/acffa (Pam Parker, Betty House)
  - Captains and Crews of the
    - Ronia Carrier
    - Ronja
    - Colby Perce
  - Ian Armstrong et al.

- Plus everyone I **missed (sorry)**

Acknowledgements: The Funders and Enablers

Fisheries & Oceans Canada
- A-Base salary and infrastructure for core employees
- O&M for specific projects (PARR)

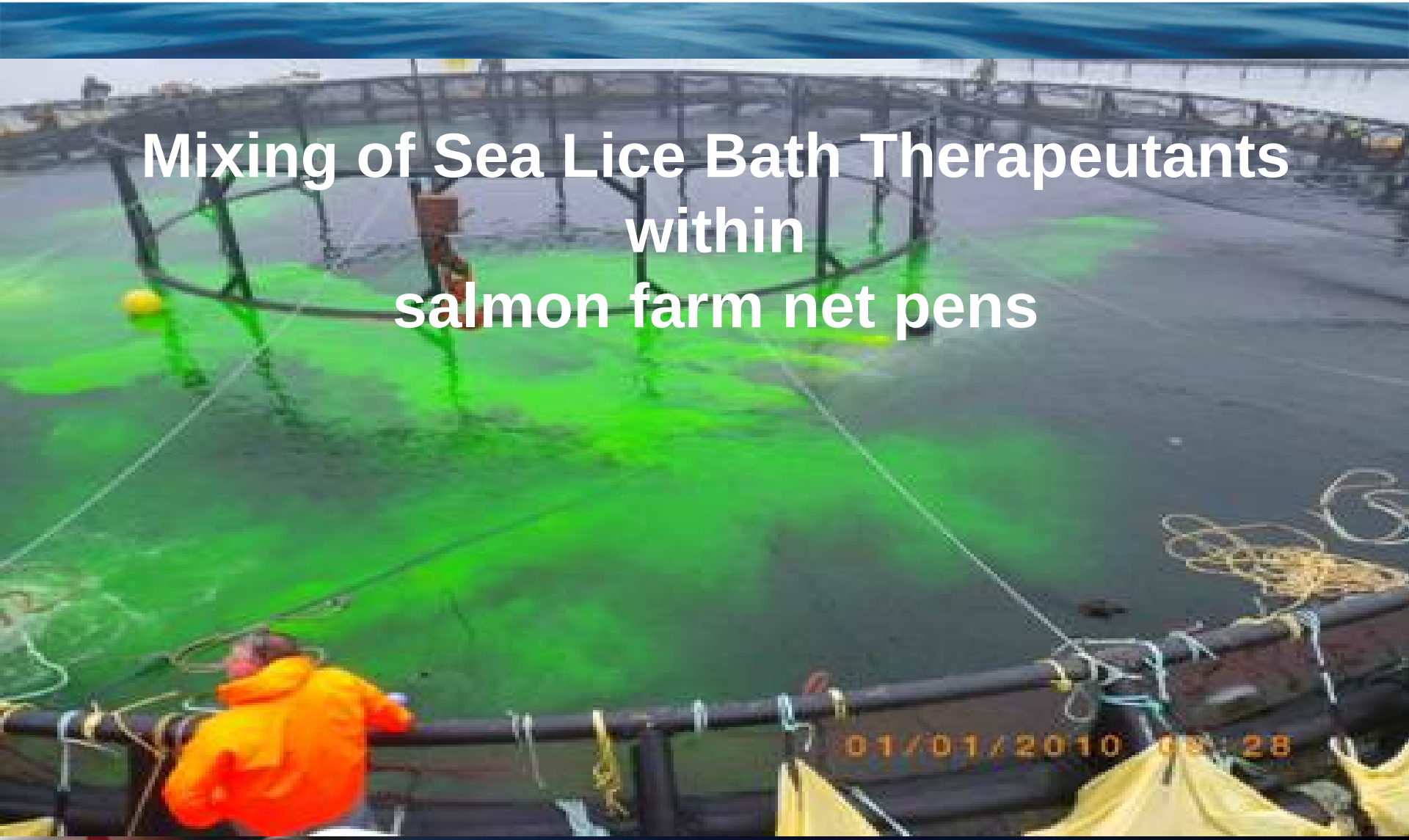
Environment Canada
- A-Base salary and infrastructure for core employees
- O&M for specific projects

Health Canada / PMRA
- A-Base salary and infrastructure for core employees

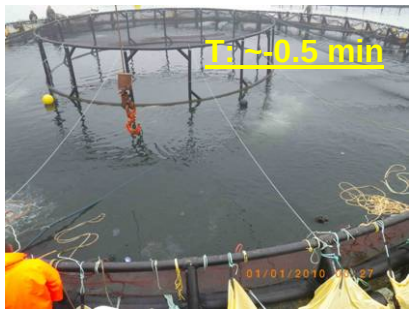
NBDAAF
- A-Base salary and infrastructure for core employees
- O&M for specific projects (PARR)

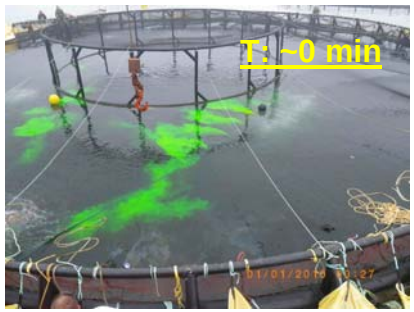
Industry
- Salaries and operating costs associated with operating fish farms, well boats and conducting therapeutant treatments

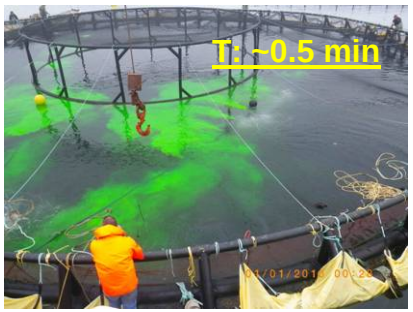
Mixing of Sea Lice Bath Therapeutants within salmon farm net pens

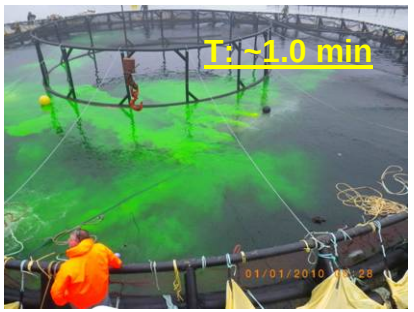


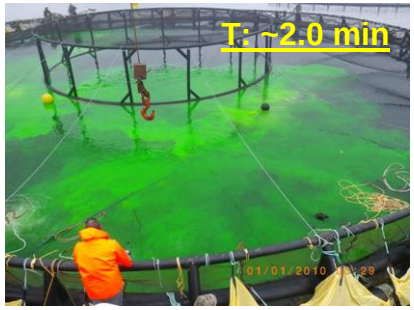
Temporal Evolution of Therapeutant within Tarped Cage

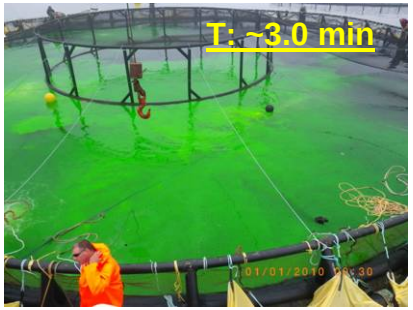


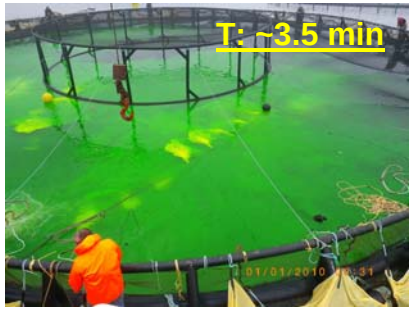


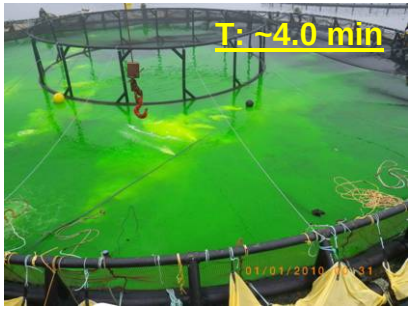


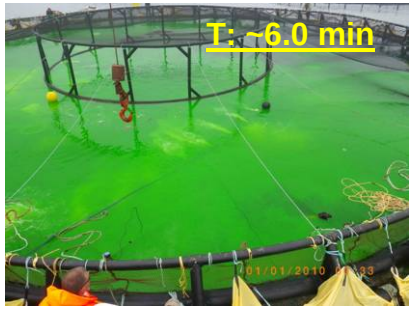


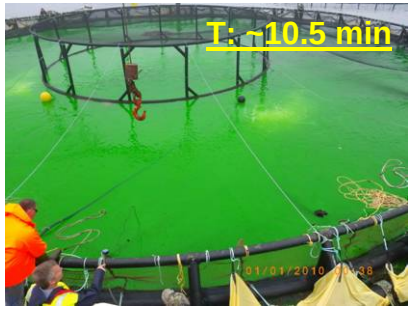


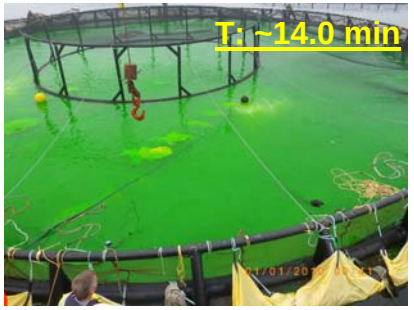












Ca. 17,000 fish in cage

Beginning of Large Dye Injection

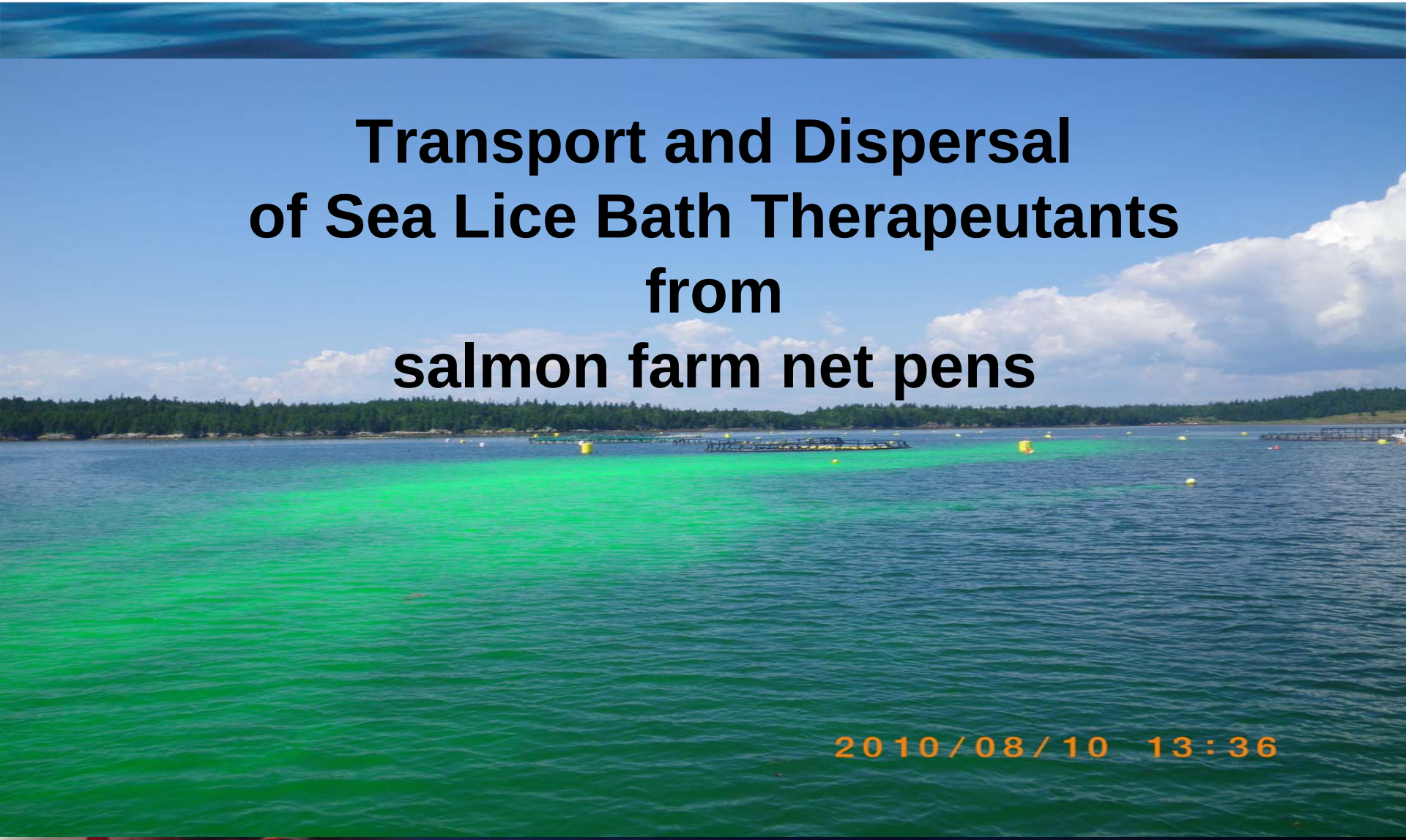
Beginning of Initial Injection Rinse

Table 1: Pre-release tarp volume and therapeutant concentration estimates for a size range of circular fish cages.

- Source concentration of therapeutant estimated as mass (M) over volume (V)
- Estimates of Volume (V) vary
  - by factor of ~2 depending upon assumed shape
  - by a factor of ~2 depending upon assumed depth
- Estimates of therapeutant concentration vary by factor of ~2

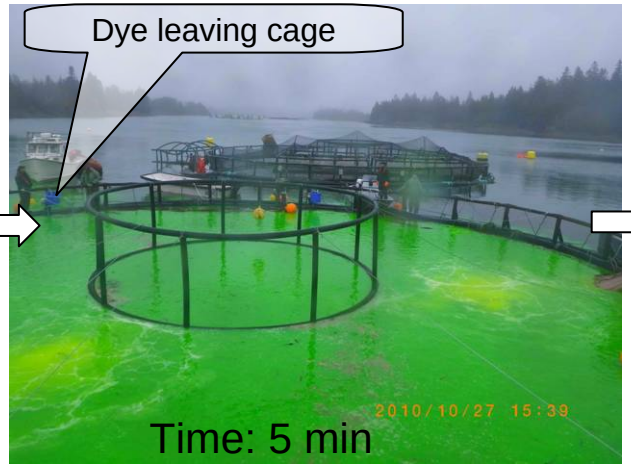
Dimension Type	Dimension Values			
Cage Perimeter or Circumference (P in m)	70	100	120	150
Cage Diameter (d in m)	22.3	31.8	38.2	47.7
Cage Radius (r in m)	11.1	15.9	19.1	23.9
Horizontal length scale (sigma in m)	5.6	8.0	9.5	11.9
Net Depth at cage edge (h_e in m)	4	4	4	4
Net depth at cage center (h_c in m)	6	6	6	6
Vertical length scale (sigma in m)	2 or 3	2 or 3	2 or 3	2 or 3
Volume (V) enclosed (m^3)				
Cylinder $h=h_e$	1560	3183	4584	7162
Semi-Ellipsoid	1560	3183	4584	7162
Cylinder plus cone	1820	3714	5348	8356
Cylinder $h=(h_e + h_c)/2$	1950	3979	5730	8952
Cube	1986	4053	5836	9119
Cylinder $h=h_c$	2340	4775	6875	10743
	2979	6079	8754	13678
Ratio of Vmax/Vmin	**1.9**	**1.9**	**1.9**	**1.9**
Ratio of Min/Cylinder plus cone	0.9	0.9	0.9	0.9
Ratio of Max/Cylinder plus cone	1.6	1.6	1.6	1.6
Ratio of cube/cylinder plus cone	1.1	1.1	1.1	1.1
Mass (M)	1000	1000	1000	1000
Maximum Concentration (Cmax=M/V min)	0.64	0.31	0.22	0.14
Minimum Concentration (Cmin=M/V max)	0.34	0.16	0.11	0.07
Ratio of Cmax/Cmin	**1.9**	**1.9**	**1.9**	**1.9**

Transport and Dispersal of Sea Lice Bath Therapeutants from salmon farm net pens

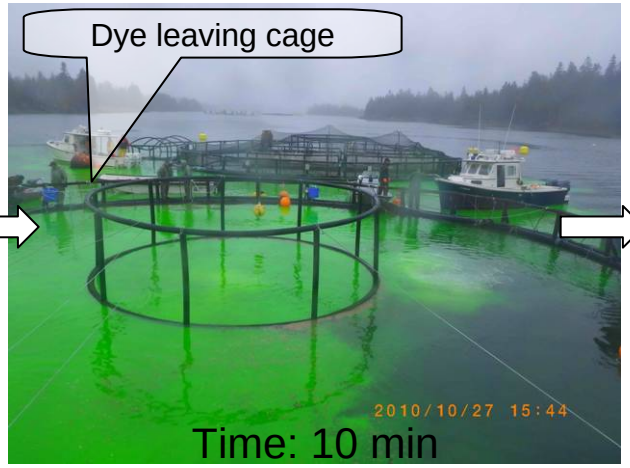


Flushing from Cage

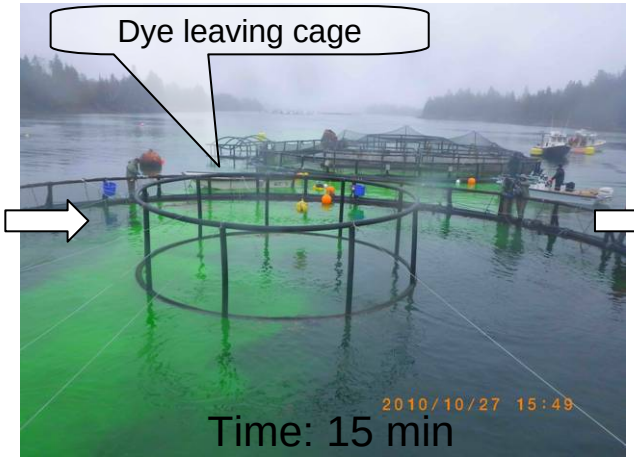
Tarp Dropped Time: 0 min



Time: 5 min

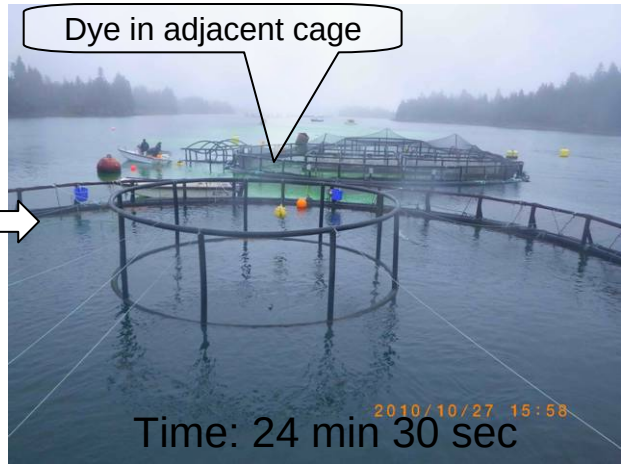


Time: 10 min



Time: 15 min

Time: 20 min



Time: 24 min 30 sec

Dye Gone from Cage

Note: Dye exited cage as a narrow plume, most dye flowed around but some entered adjacent cages; Advection Rate out of cage: ~2 cm/s

Flushing from Cage

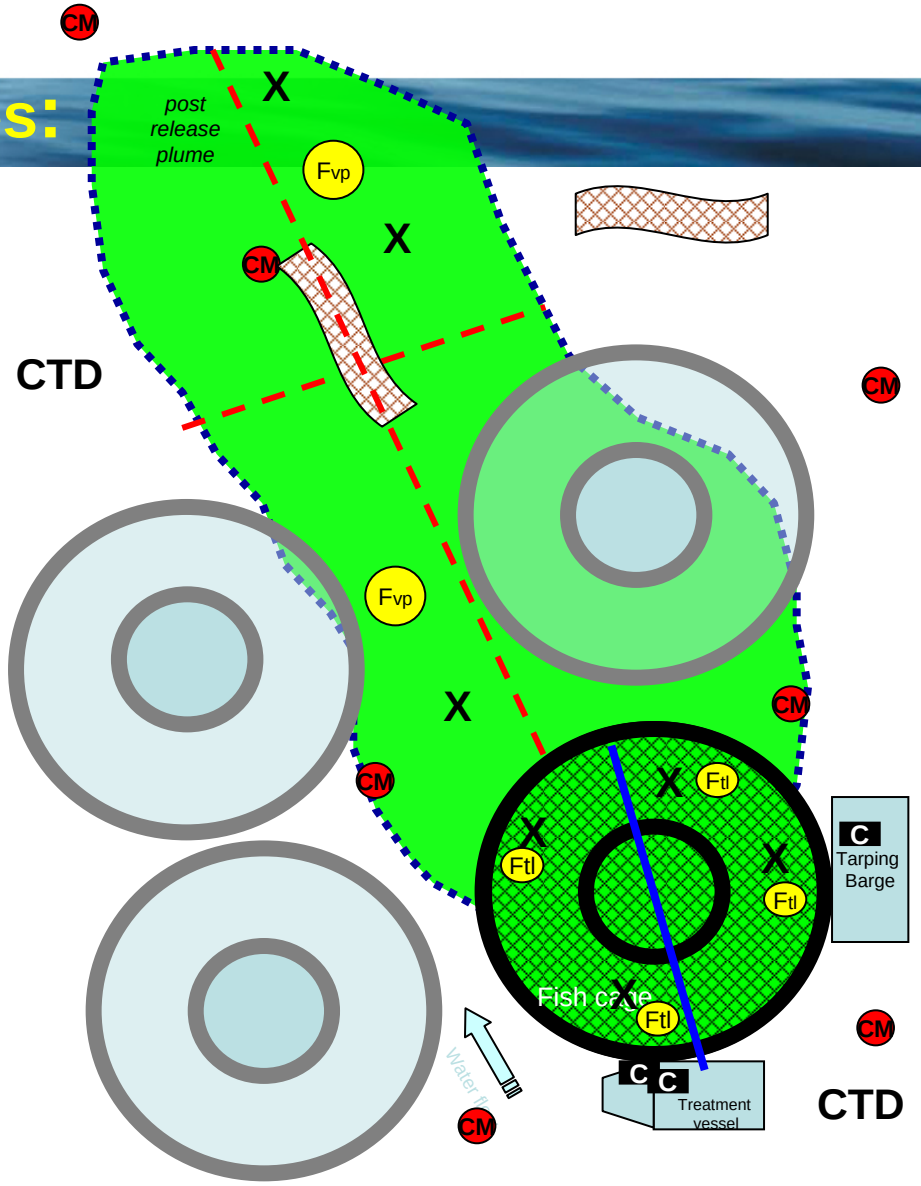
Table 2: Estimates of the time, in units of minutes, needed for ambient water currents to advect therapeutant from the treated cage.

Water Speed ($m\ s^{-1}$)	Cage Size (m)			
	P = 70	P = 100	P = 120	P = 150
	d = 22.3	d = 31.8	d = 38.2	d = 47.7
0.02	18.6	26.5	31.8	39.8
0.05	7.4	10.6	12.7	15.9
0.10	3.7	5.3	6.4	8.0
0.20	1.9	2.7	3.2	4.0
0.30	1.2	1.8	2.1	2.7
0.40	0.9	1.3	1.6	2.0
0.50	0.4	0.6	0.7	0.9

- Flushing time equals cage diameter (l) divided by the water velocity (u) i.e.l/u
- Flushing time ~ 10 min
- Estimates range from <1 to >30 min
- Estimates typically assume cage net not present
- flushing times generally underestimated by ambient current

Field approach for tarp releases:

- Instrument study area
- Record currents and hydrography throughout
- *Mix dye and therapeutant together*
- *Inject mixture into tarped/skirted cage*
- *Monitor mixing within cage*
- Monitor release and evolution of plume
- Sample water for therapeutant & zooplankton



Symbols

- CM — Current meter
- C — Time lapse camera
- Ftl — Fluorometer time series
- CTD — CTD profile(s)
- X — Water sample
- Plume/Patch GPS perimeter
- Fvp — Fluorometer vertical profile(s)
- Fluorometry Transect
- Zooplankton tow

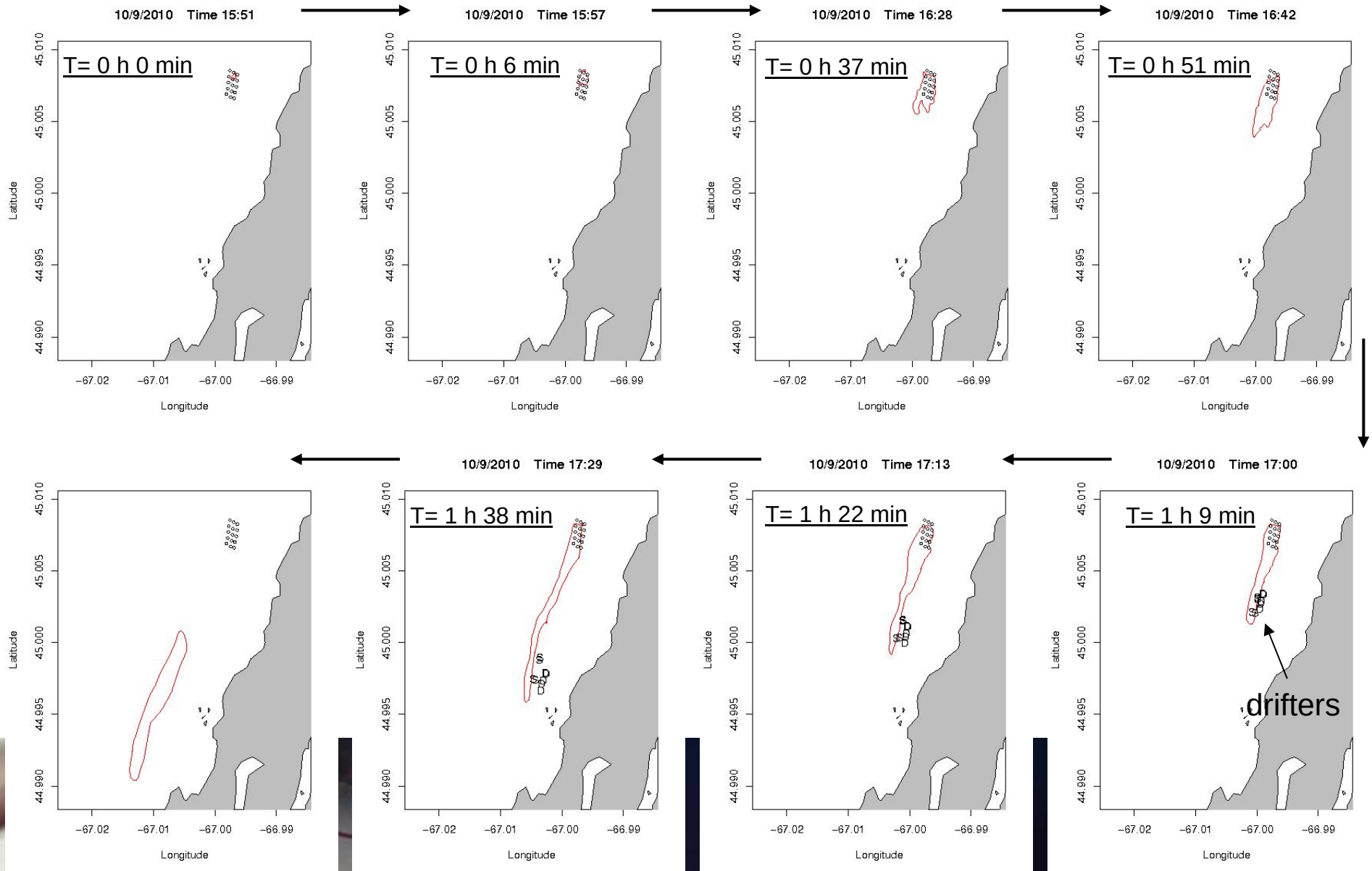
Observations: Transport & Dispersal away from Treatment Cage

- Dye advects and disperses in an elongated fashion

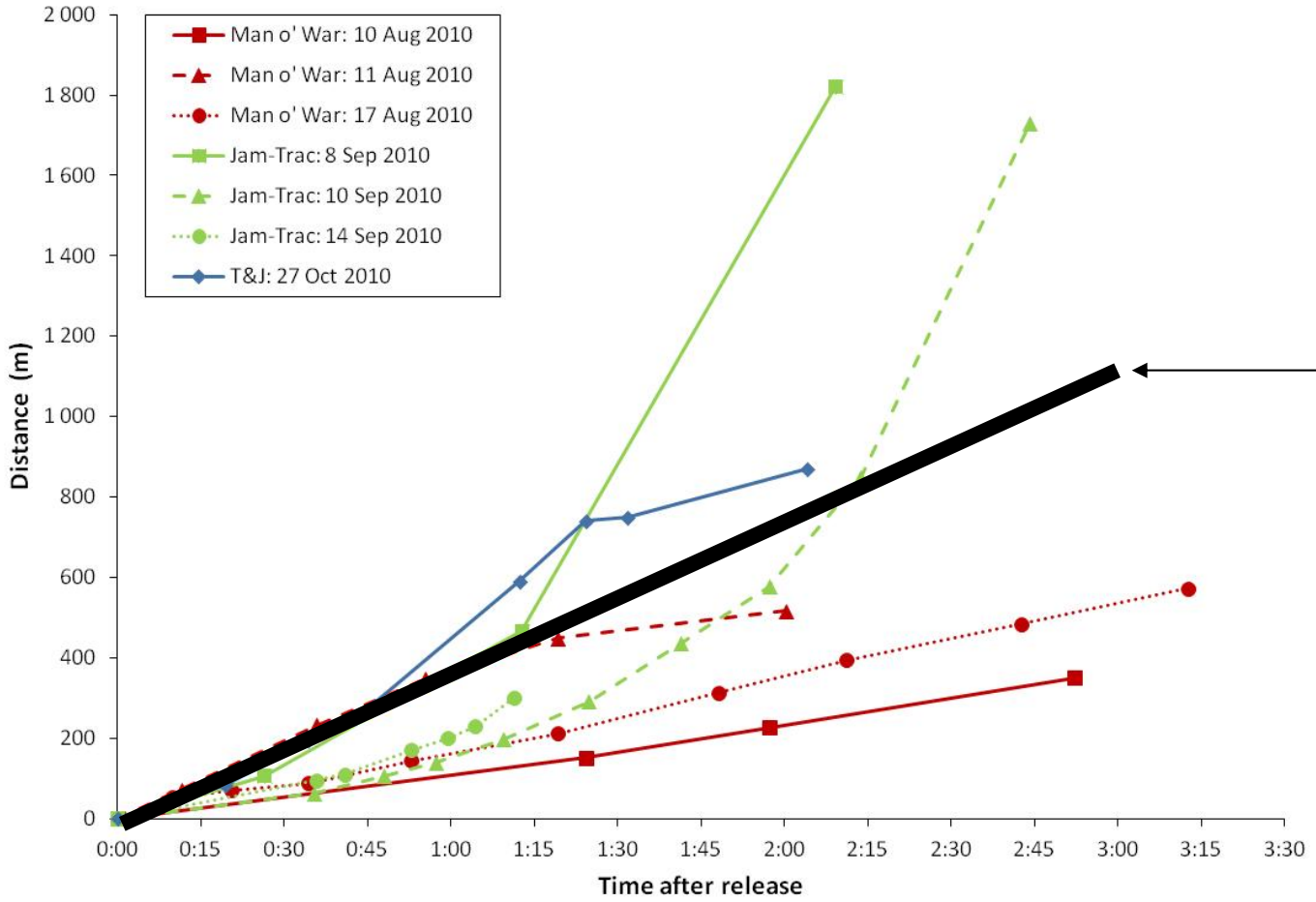
Transport and Dispersal
of Sea Lice Bath Therapeutants
from
salmon farm net pens:

Horizontal Perspective

Observations: Horizontal Evolution of Dye Plume; GPS perimeter



Observations: Distances travelled by patch center



Predicted when U=0.1 m/s

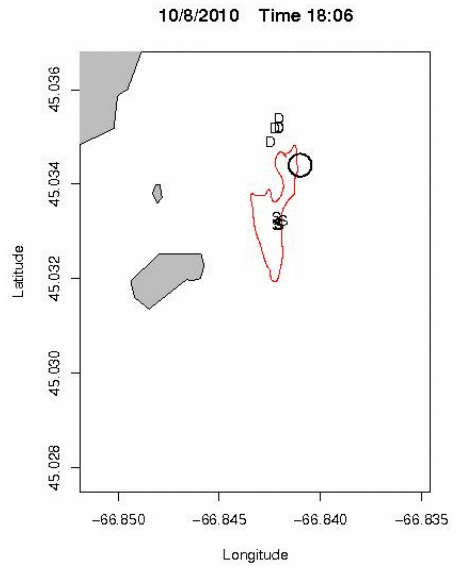
Transport away from Cage

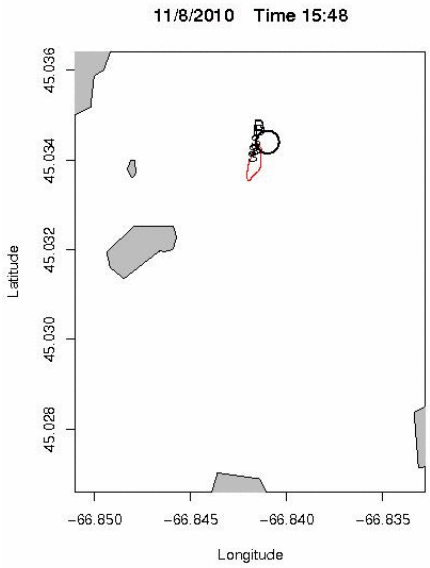
Table 4: Estimated distance traveled over time durations of 1 and 3 h.

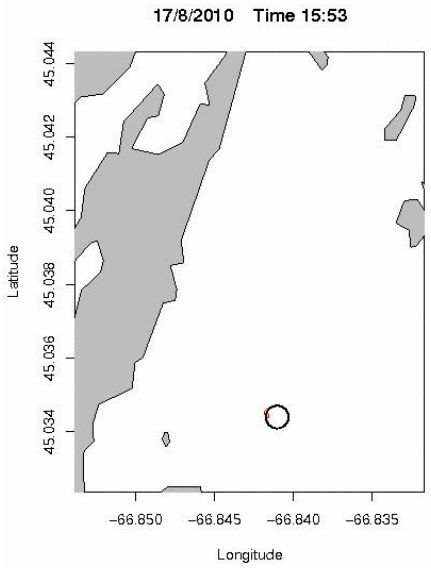
Water Current Speed (m/s)		Distance Travelled (km)	
(m/s)	(knots)	in 1h	in 3 h
0.0	0.0	0.0	0.0
0.1	0.2	0.4	1.1
0.2	**0.4**	**0.7**	**2.2**
0.3	0.6	1.1	3.2
0.4	**0.8**	**1.4**	**4.3**
0.5	1	1.8	5.4
0.6	1.2	2.2	6.5
1.0	2.0	3.6	10.8

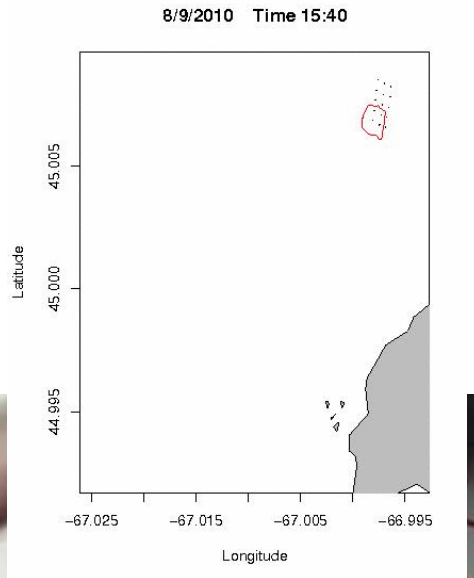
- Distance (d) = velocity (u) x time (t) i.e. d=ut
- Distances 100-1000s m over on time scales of 1-3 hours

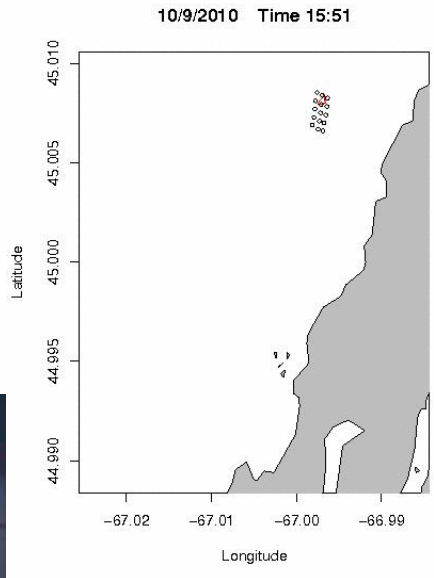
Observations: Horizontal Evolution of Dye Plume; GPS perimeters

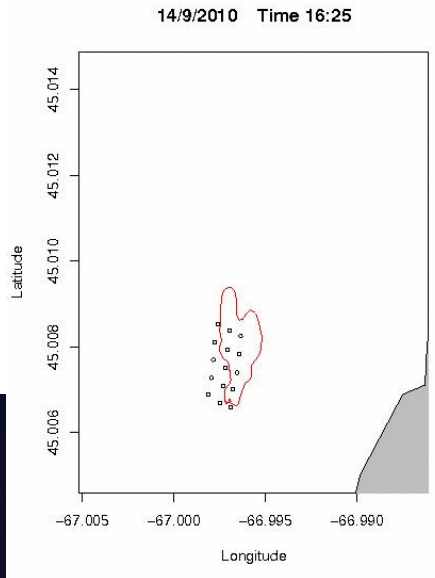






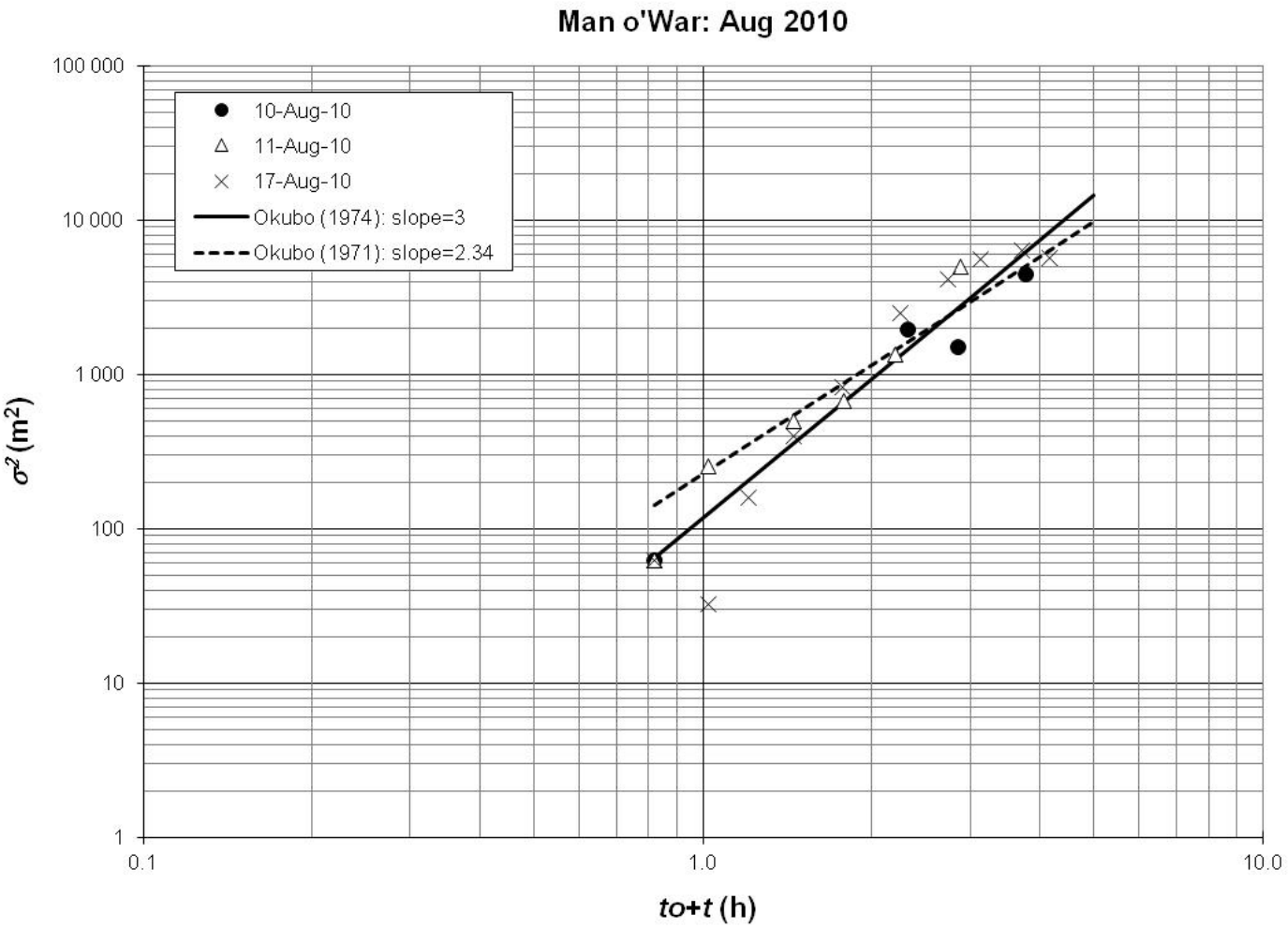






Note:
patches
elliptical

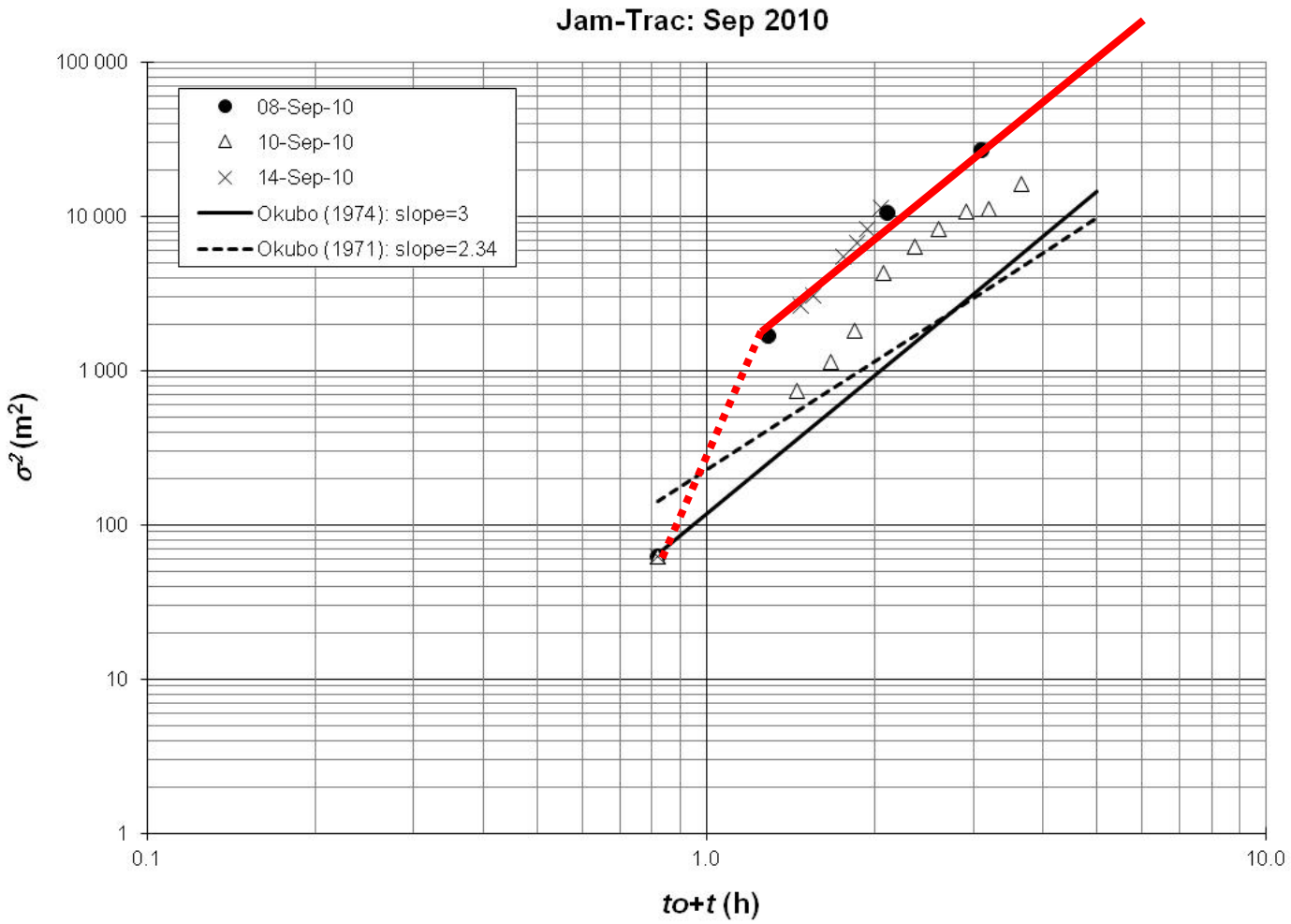
Observations: Horizontal Scale dependence of patch size; no cage



Note:

Patch size increased as expected

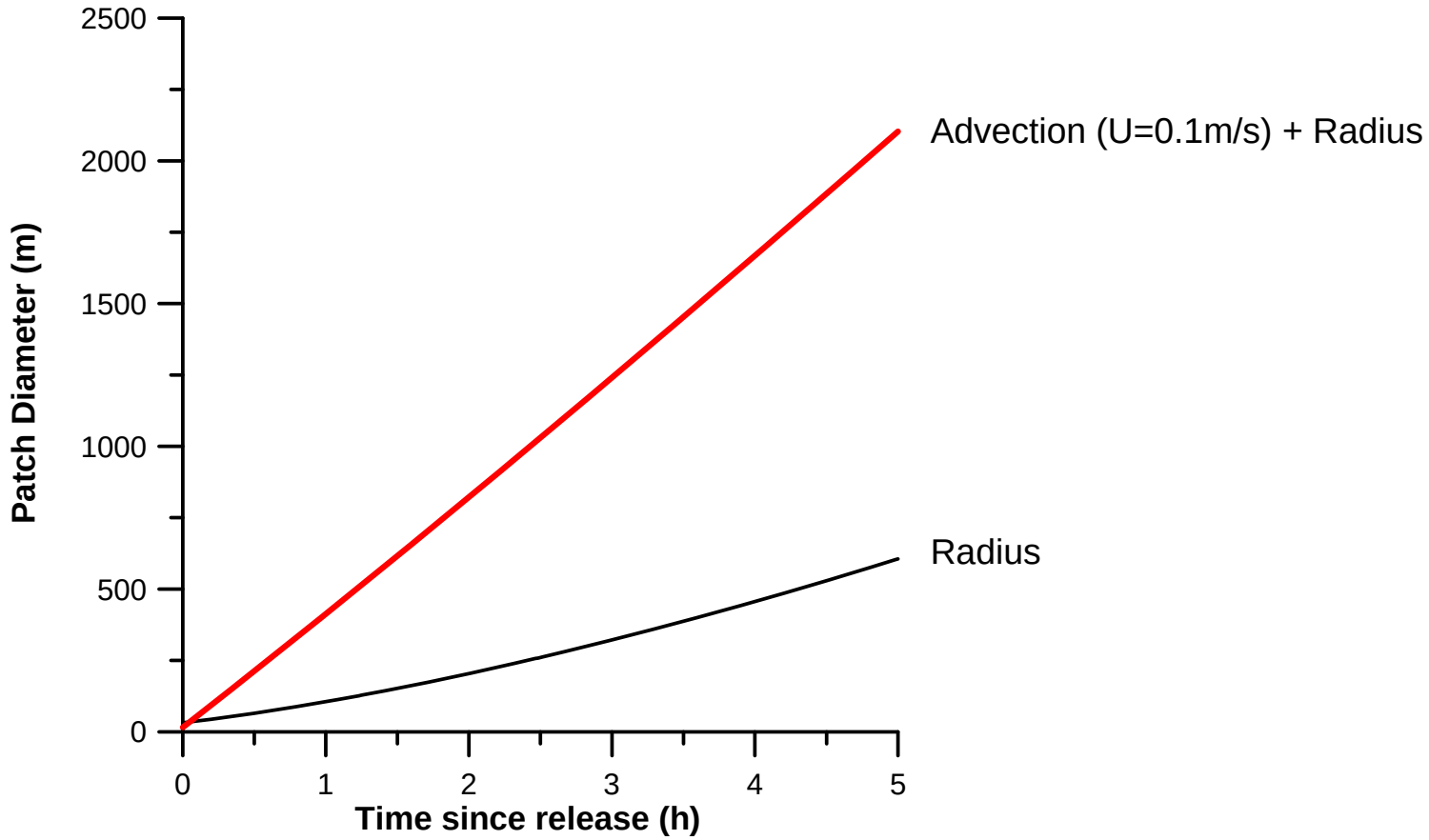
Observations: Horizontal Scale dependence of patch size; with cages and fish



Notes:

- Patch size initially increased faster than expected
- Size of offset varies

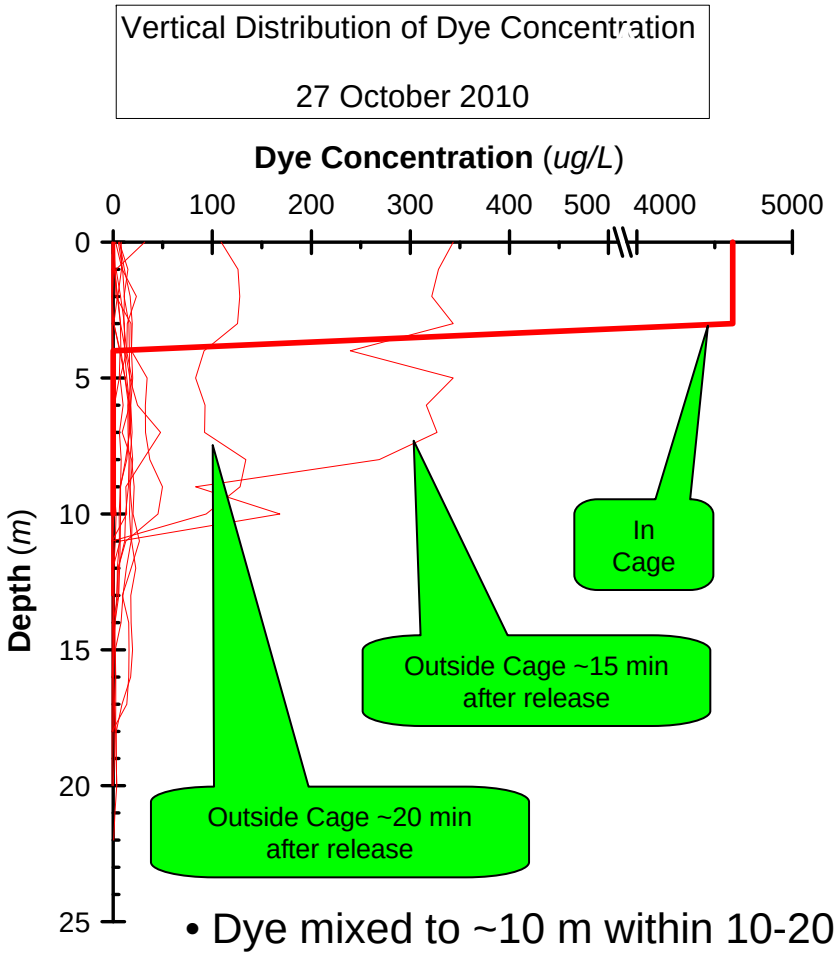
Dispersal Predictions: Circular Patch Diameter



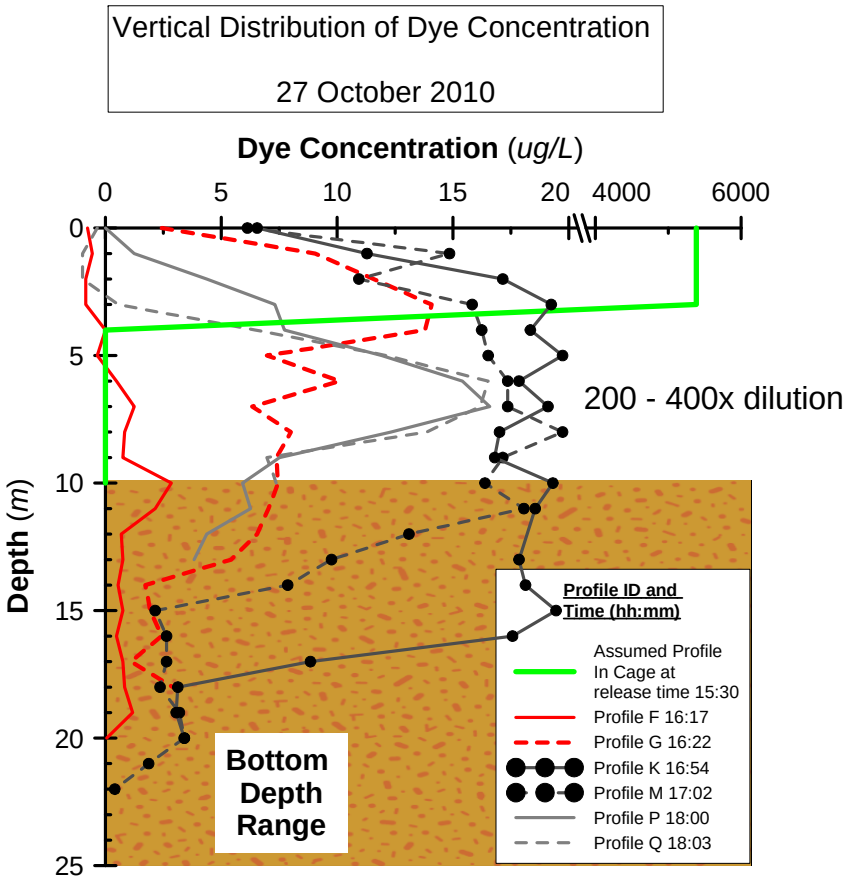
Transport and Dispersal
of Sea Lice Bath Therapeutants
from
salmon farm net pens:

Vertical Perspective

Research & Results: e.g. 27 Oct 2010 Vertical Profile of Dye



Profiles with dye at the sea bed



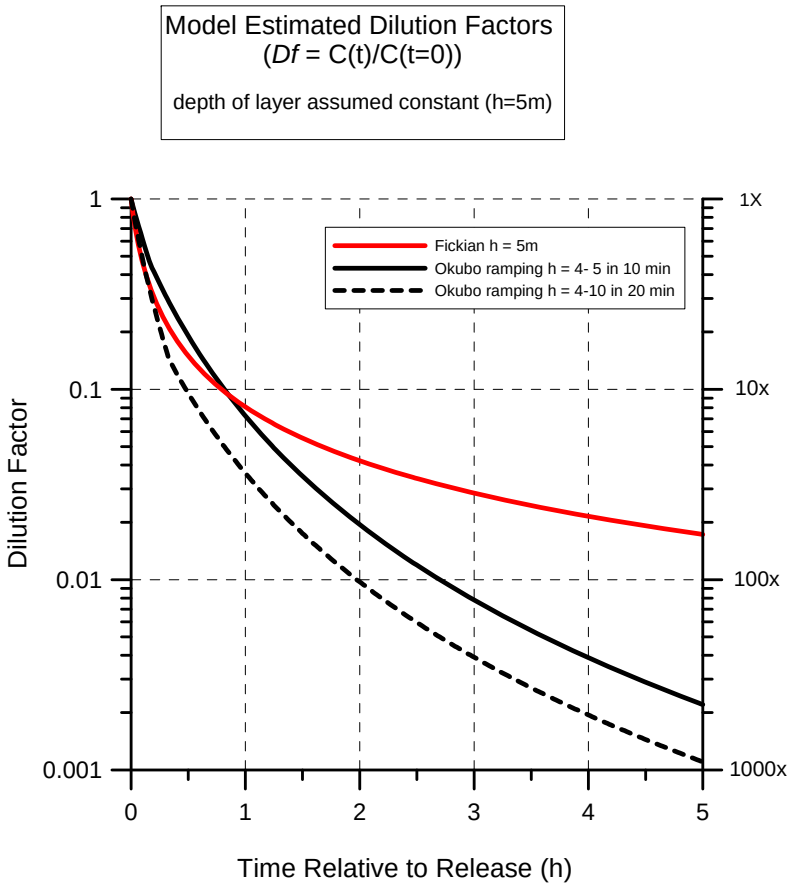
- Dye mixed to ~10 m within 10-20 minutes after tarp drop
- Dye concentration 10 - 100x dilute within 20-30 min of tarp drop
- Dye concentration 100 -1000x dilute after ~1h post tarp drop
- Sea bed exposed to this dilution at some locations
- need to map 3D distribution of dye and bathymetry to estimate area exposed

Vertical Mixing Time Scales: Predicted

Water Depth or Depth of Mixed Layer (m)	Vertical Mixing Time Scale (h) Kz = 0.01 $m^2 \cdot s^{-1}$	Vertical Mixing Time Scale (h) Kz = 0.1 m2·s-1
10	**1**	**0.1 (5 min)**
20	**4**	**0.4 (21 min)**
30	8	0.8 (48 min)
40	14	1.4 (85 min)
50	22	2.2 (133 min)
60	32	3.2 (192 min)

Note: for typical shallow water areas time scale is minutes to ~1h

Preliminary Model Outputs: Dispersal Predictions



Fickian

$$c(0,0,t) = \frac{M}{\pi\left(\sigma_{x0}^2 + \sigma_{xt}^2\right)^{1/2}\left(\sigma_{y0}^2 + \sigma_{yt}^2\right)^{1/2} h}$$

Dilutes more slowly after 1h

Okubo

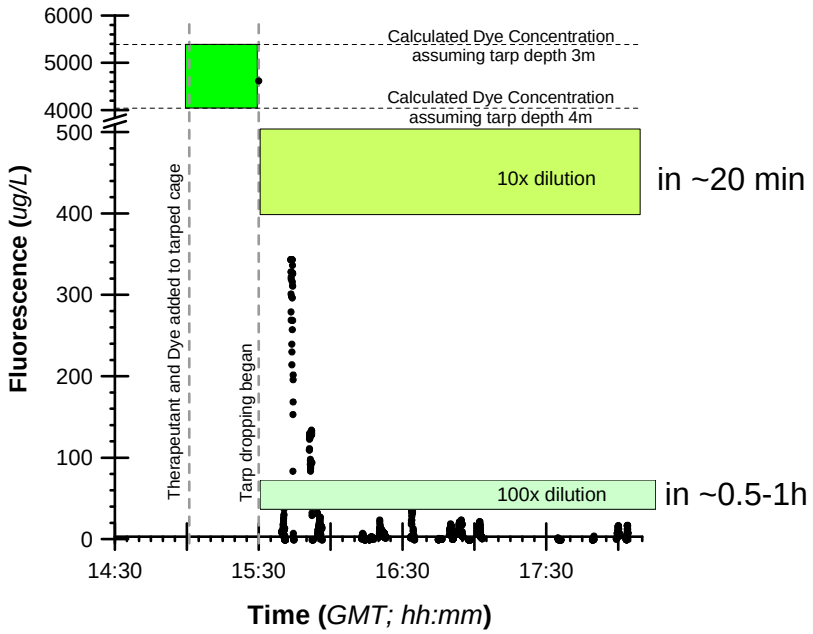
$$\bar{C}(t) = \frac{M}{V} = \frac{M}{Ah} = \frac{M}{4\pi\sigma_{re}^2 h} = \frac{M}{4\pi \cdot 2.5 \cdot 10^{-5}\left(t_0 + \Delta t\right)^3 h}$$

Observations and Model: 70m circular cage

Observed

Time Series of Fluorescence from Within or Near Dye Plume

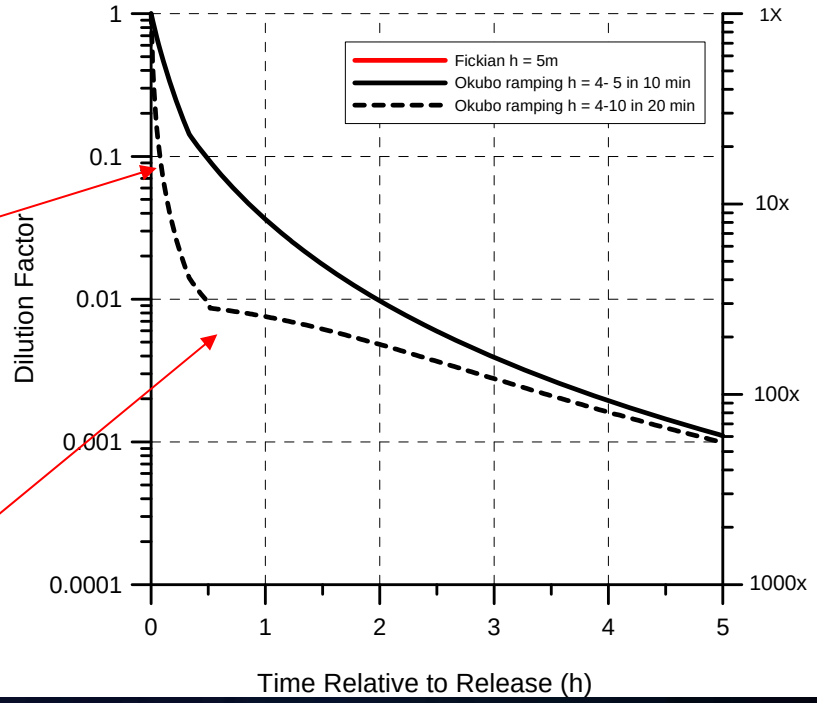
Cage Perimeter: 70 m circle
Number of Fish: ~34,000
Treatment Type: Tarp with Alphamax
Treatment Date: 27 October 2010
Dye Added: 6.3 kg of fluorescein



Model

Model Estimated Dilution Factors
(*Df* = C(t)/C(t=0))

depth of layer assumed constant (h=5m)



in ~20 min

in ~0.5-1h

Calculations for tarped cages assuming an Okubo based dilution

Time to become diluted to the concentration of effect

$$\Delta t = \sqrt[3]{M / C_{loe} \cdot 4\pi \cdot 2.5 \cdot 10^{-5} h} - t_0$$

Surface area of plume at this time

$$A = 4\pi\sigma_{re}^2$$

Length of the major axis of the plume at this time

- i.e. assumes $l_x = 3l_y$

$$l_x = 2\sqrt{3A/\pi}$$

Distance of the patch from the center of release at this time

$$d_{cp} = \bar{u}\Delta t$$

Distance of leading edge from center of release at this time

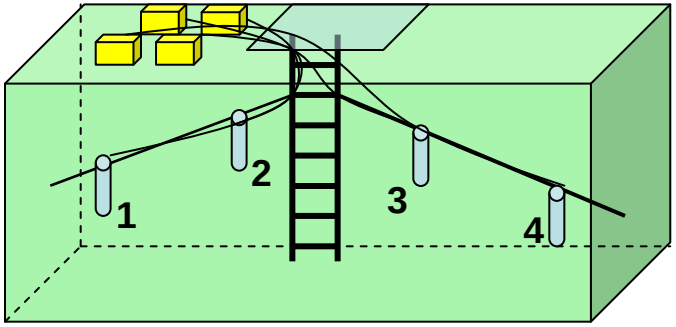
$$d_{le} = u\Delta t + l_x$$

Transport and Dispersal of Sea Lice Bath Therapeutants from well boats

A Flavour of the RESULTS

Mixing within Wells

Instrument Well with Fluorometers



Well

Support Line

Data loggers

Sensor Cable

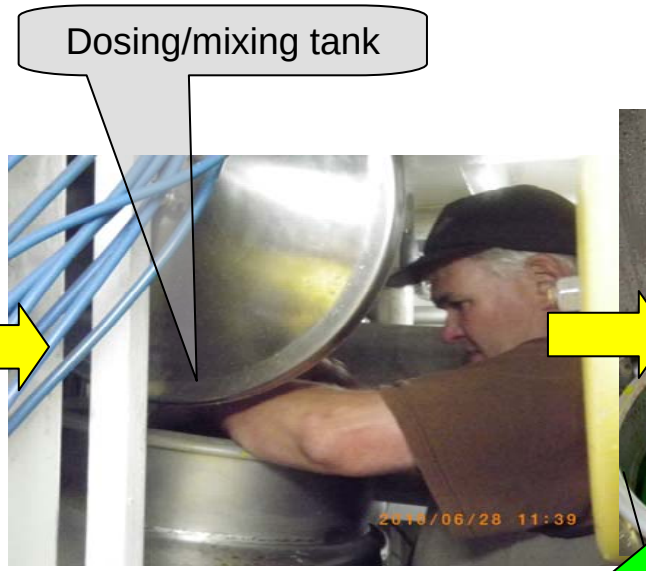
Cyclops Optical sensors

fill well with water, and depending on the test add fish

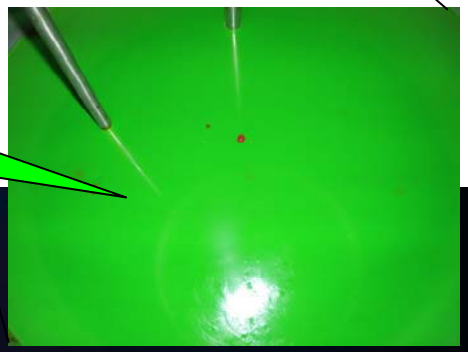
Dosing Well with Dye (and therapeutant)

1) add dye into dosing tank

2) mix for two periods of 4 minutes – 8 minutes total



Fluorescein dissolved in mixing tank (now green)

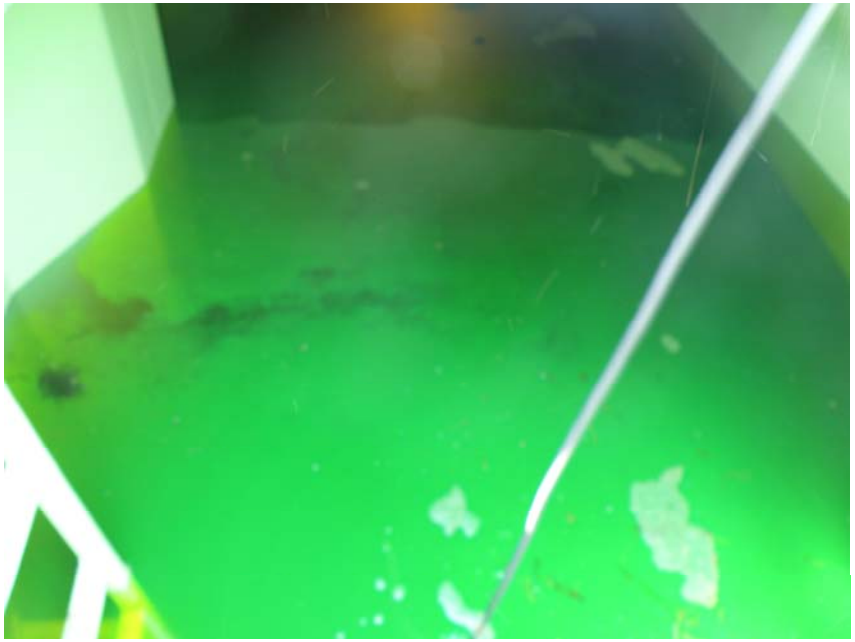


3) inject dye into well

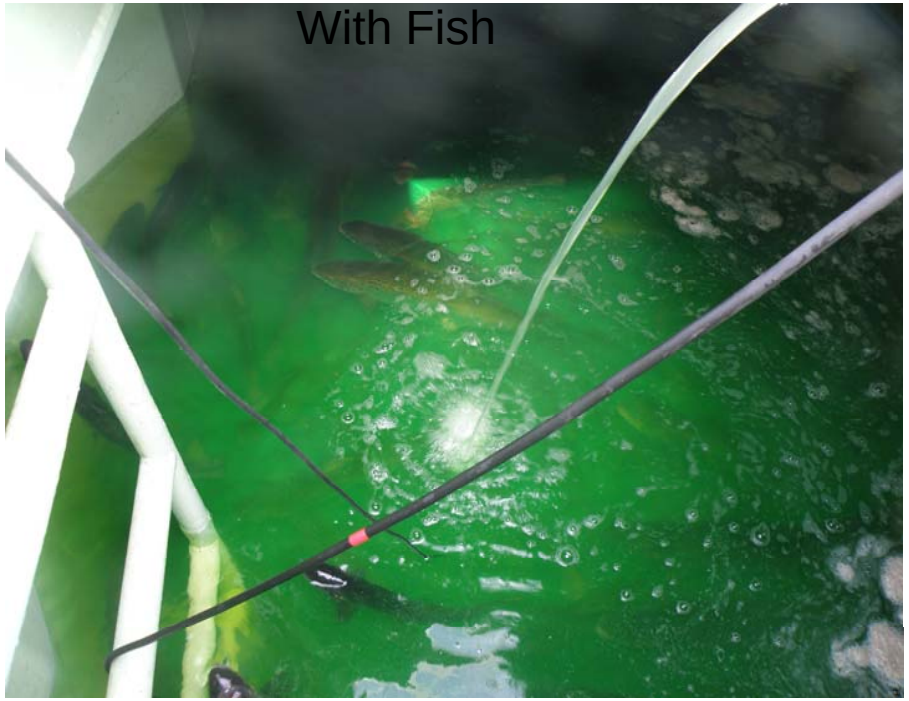
4) rinse dosing tank

Well with Dye, Fluorometers and sometimes Fish

No Fish

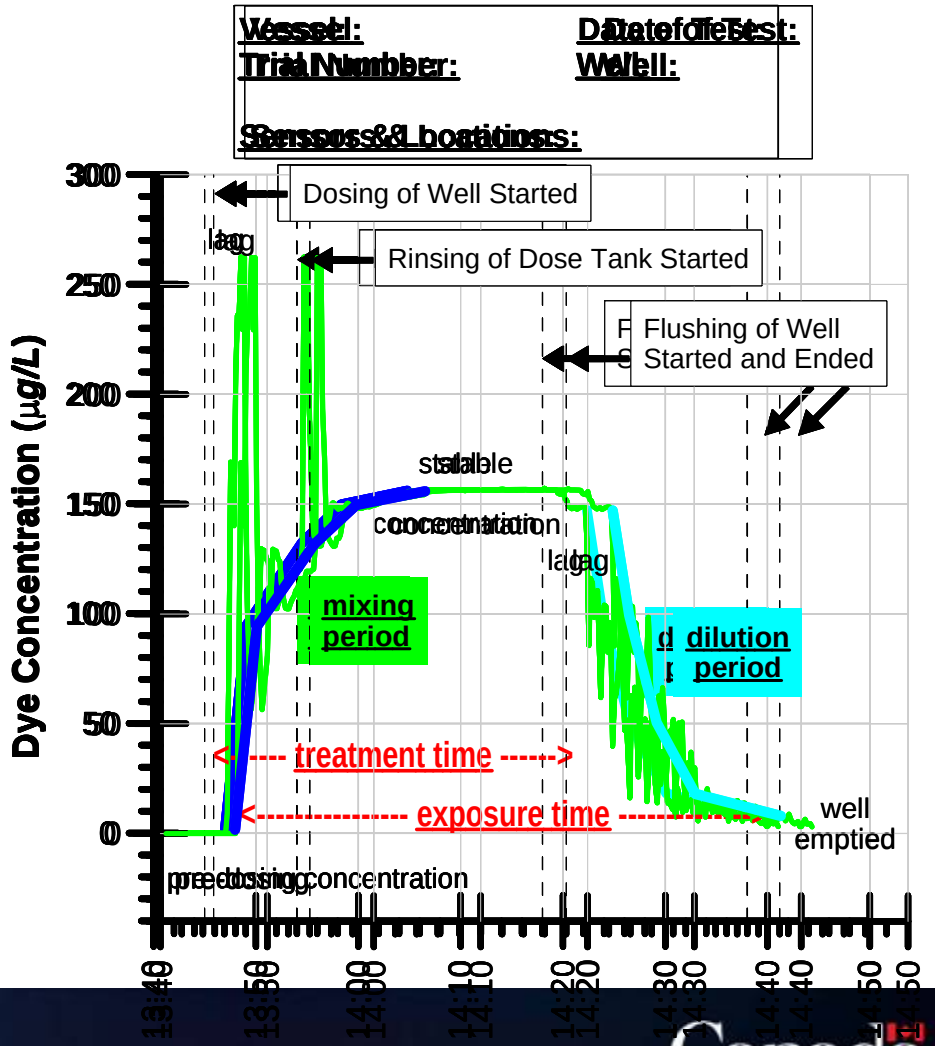


With Fish



Fluorometry Graph Features

Fluorescence sensors and data loggers measure the temporal evolution of the concentration of the fluorescein dye at the various locations within the well



Theory: Flushing from a Well Boat Well

Theory:

- Concentration inside well decreases exponentially with time

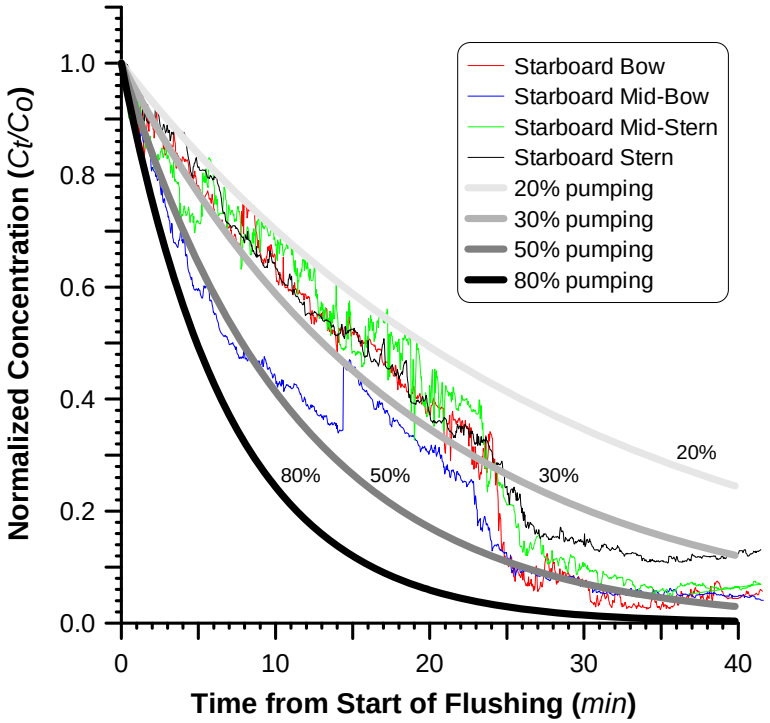
$$\frac{C}{Co} = \exp\left(\frac{-Qt}{V}\right)$$

- *Co* is the well mixed or target treatmetn concentration
- *Q* is the pumping rate
- *V* is the volume of the well

Observations:

- Concentration inside decreases exponentially with time
- Pumping rate generally not known
- Q less than Qmax and variable

Time Series of Normalized Dye Concentration inside the Starboard Well of the Colby Perce during flushing with no fish (14 December 2010)



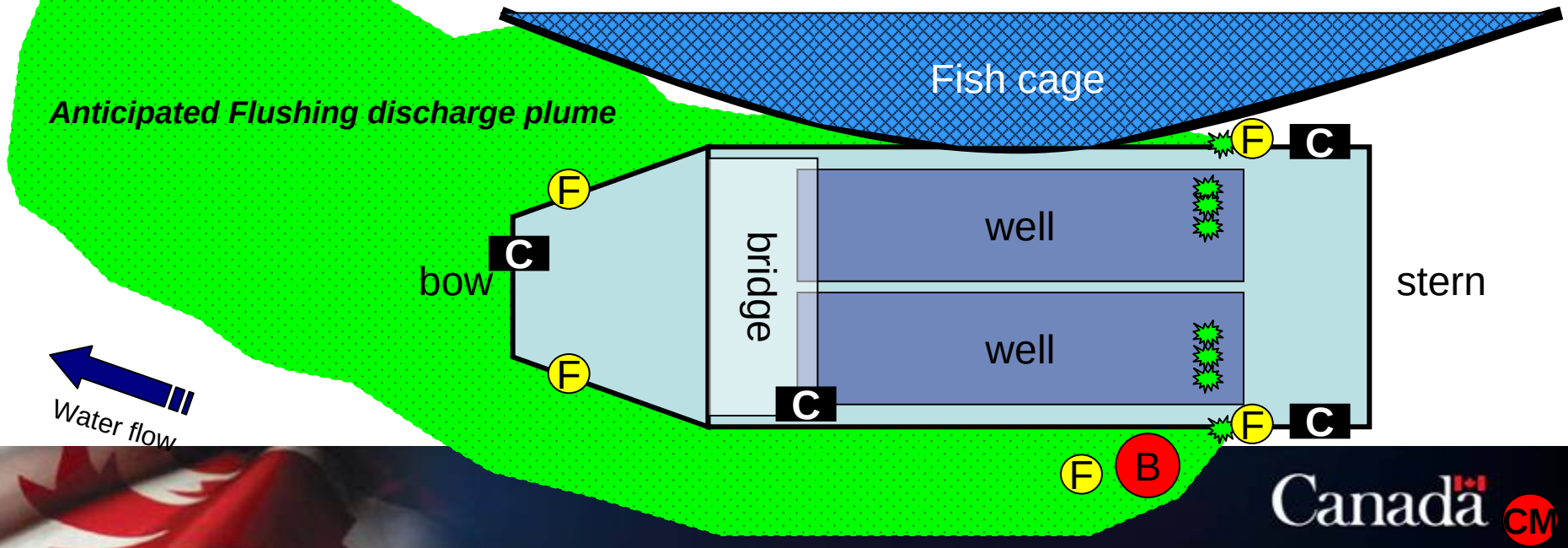
A Flavour of the Results

What comes out of the wells?
and
How is the output dispersed?

e.g. Sampling Locations during Flushing Discharge

Symbols

- Well flushing discharge locations
- CM — Current meter
- C — Time lapse camera
- F — Cyclops fluorometer vertical profiling stations
- B — Buoy mounted fluorometer(s)



Observations: Well Boat Discharges from both sides

Discharge away from cages

~50% of discharges

has potential to quantify

Discharge into cage

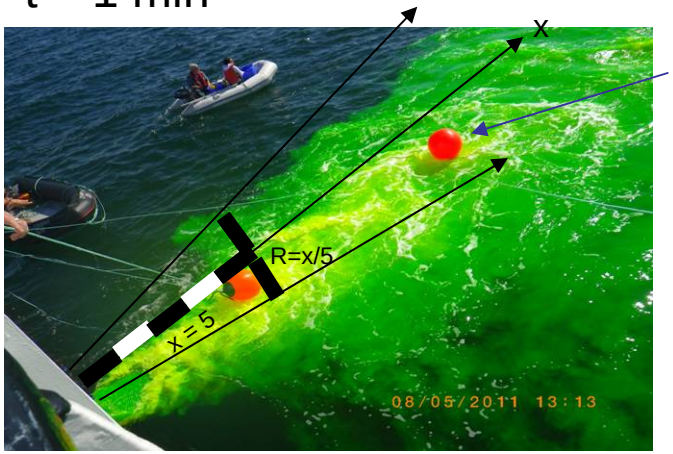
~50% of discharges

challenging to quantify

Observations: Shape of Initial Discharge Jet

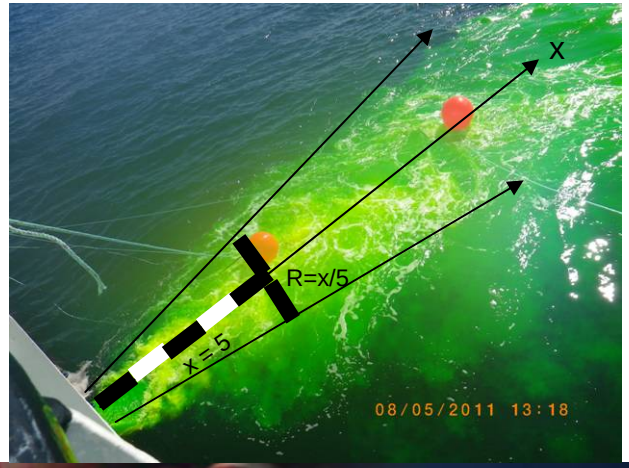
to ~ 0 sec

t = 1 min



Fluorometry buoy

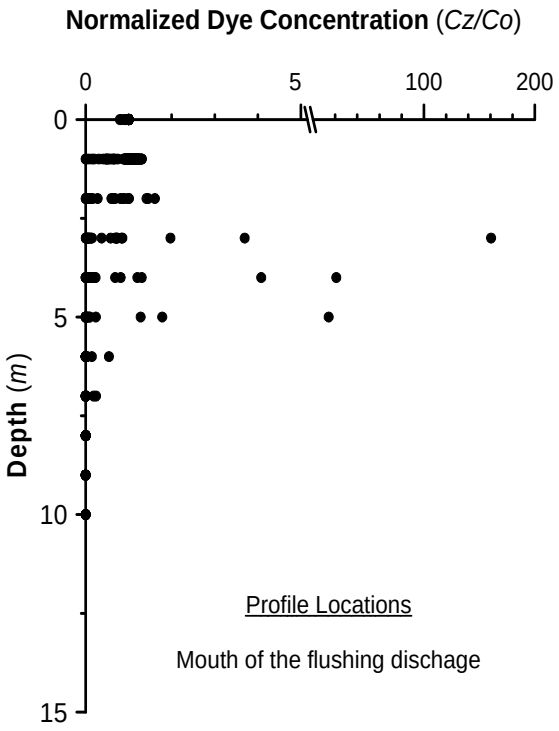
t = 6 min



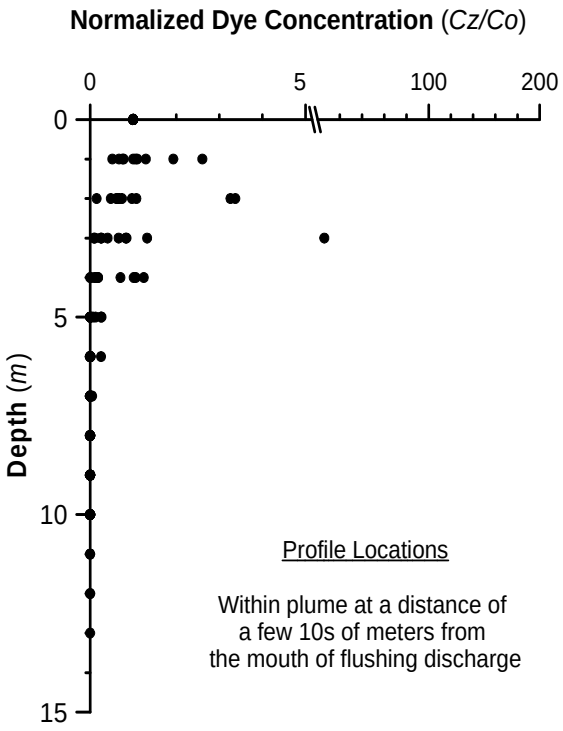
- discharge forms a ‘V’ shaped jet with <1 minute
- jet is distorted toward the right
- jet width approximates theory of jet into a stationary body of water
- measurement buoys in position in jet within 1 min of discharge initiation

e.g. Vertical Distribution

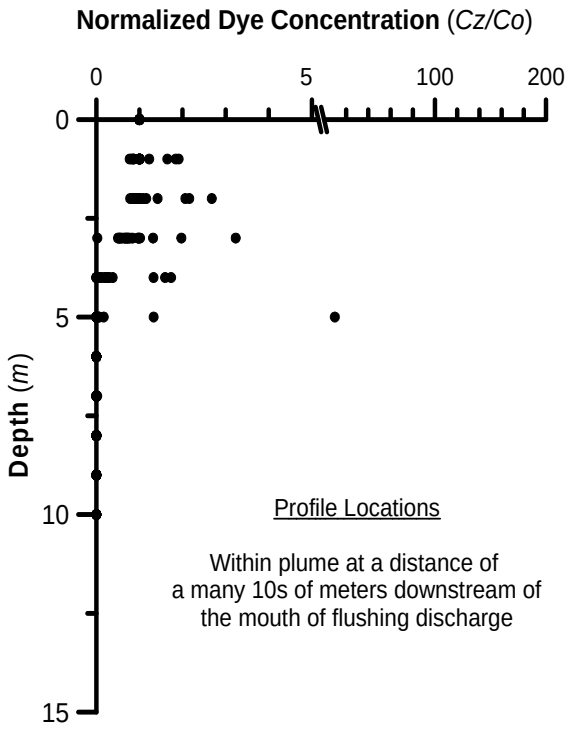
Discharge Mouth



~10-30 downstream

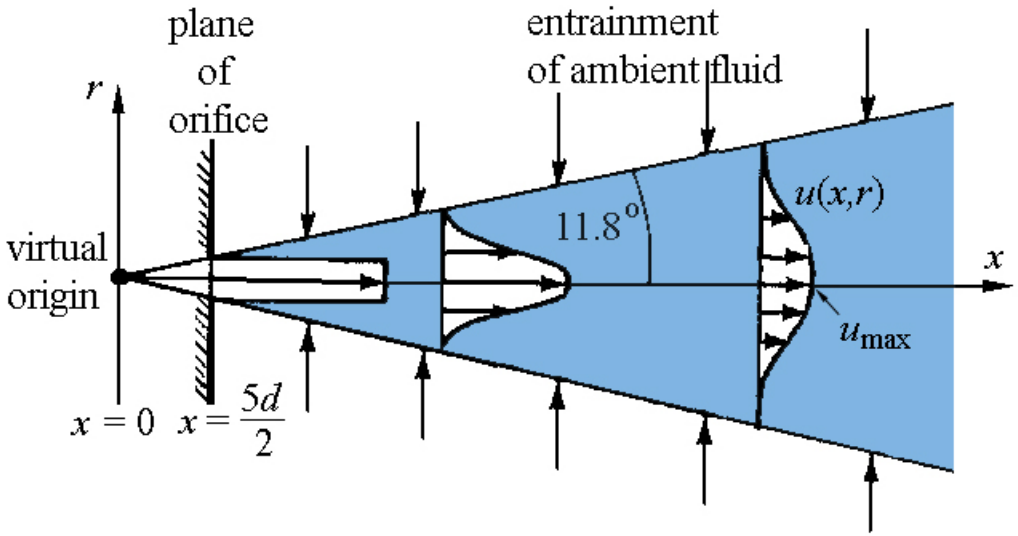


~50-100 m downstream



Dye stayed within upper 5m

Theory: Flushing Discharge from a Well Boat Well



Velocity

$$u(x,r) = u_{\max}(x)\exp\left(-\frac{50r^2}{x^2}\right)$$

$$u_{\max} = \frac{5d}{x}U$$

Concentration

$$c(x,r) = c_{\max}(x)\exp\left(-\frac{50r^2}{x^2}\right)$$

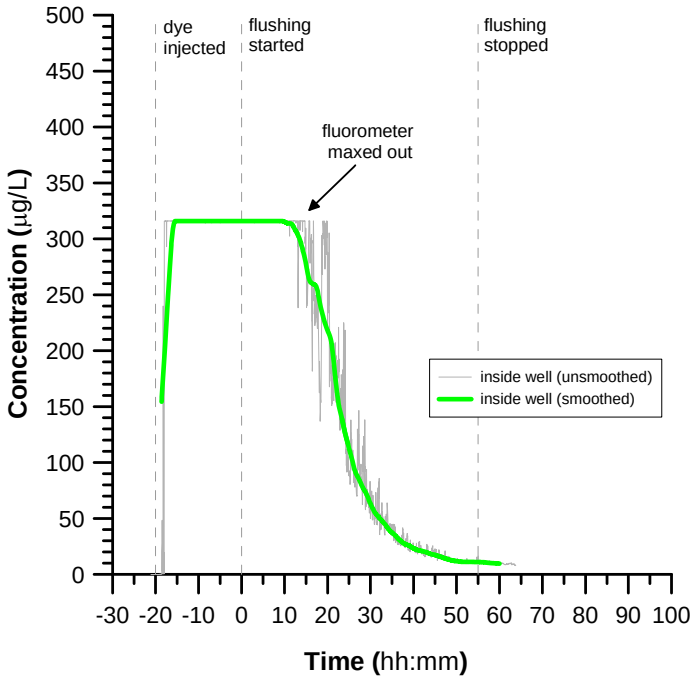
$$C_{\max} = \frac{5d}{x}C_0$$

$$C_{\max} = \frac{5d}{x}(M/V)\exp(-Qt/V)$$

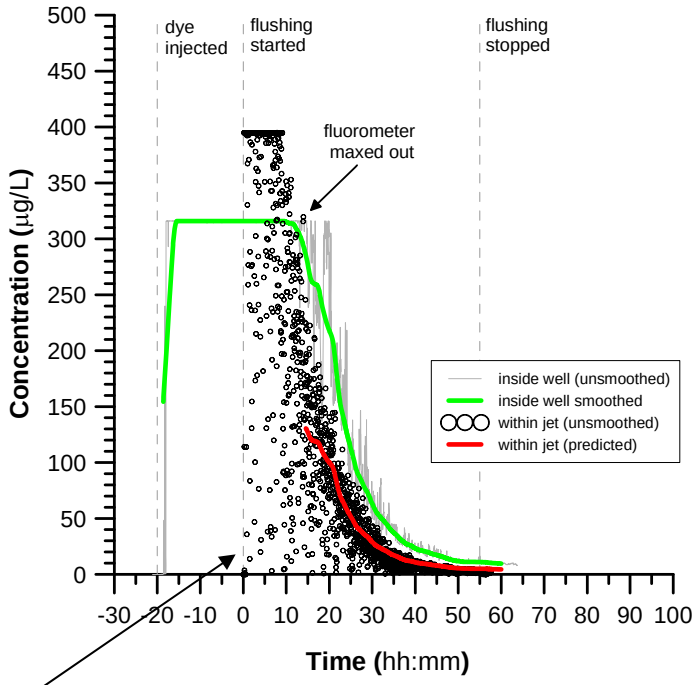
Source: Cushman-Roisin (in press)

Observations: Flushing Discharge from a Well Boat Well

Time Series of the Concentration of Dye within the well of the Colby Perce
5 Aug 2011



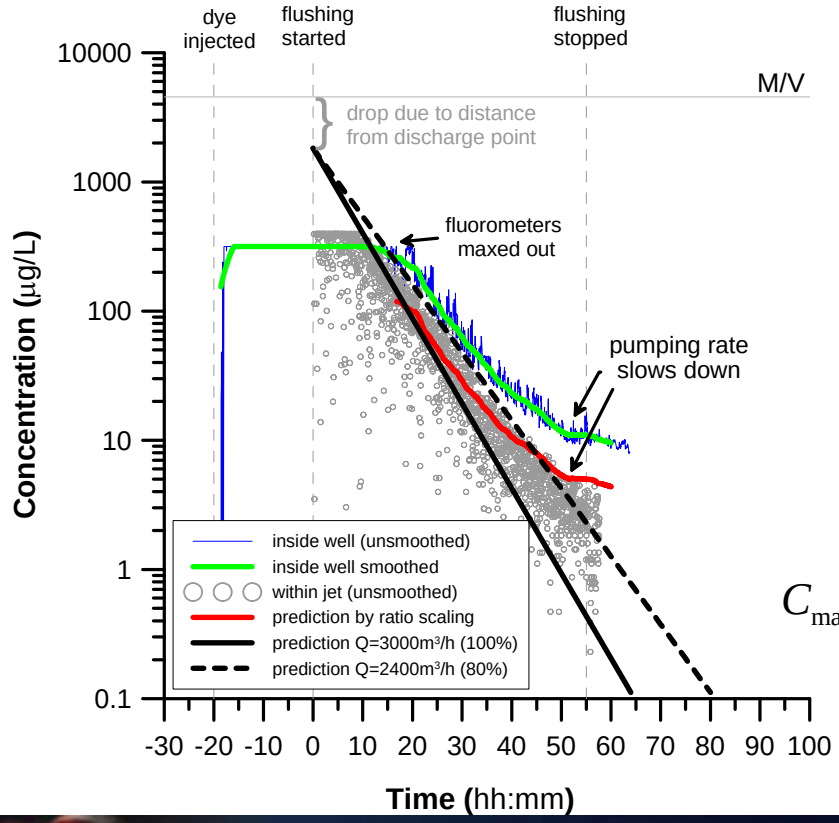
Time Series of the Concentration of Dye within the well of the Colby Perce
5 Aug 2011



Variable due to entrainment

Observations: Flushing Discharge from a Well Boat Well

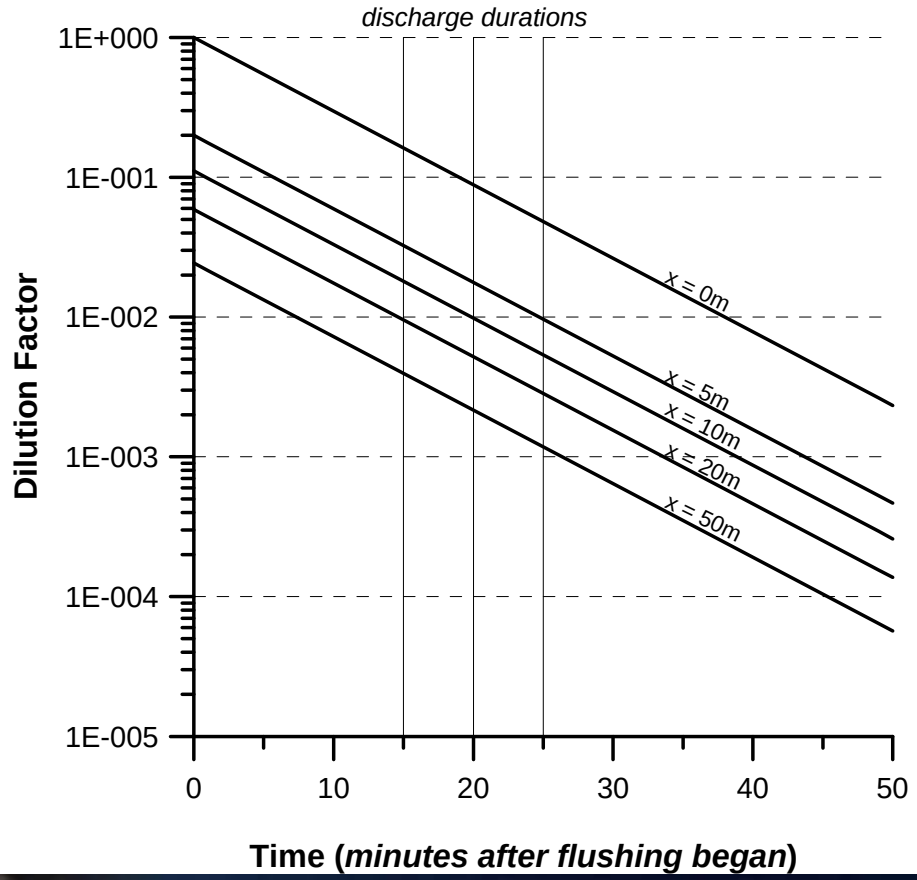
Time Series of the Concentration of Dye within the well of the Colby Perce
5 Aug 2011



$$C_{\max} = \frac{5d}{x}\left(M/V\right)\exp\left(-Qt/V\right)$$

Theory: Flushing Discharge from a Well Boat Well

Predicted Dilutions of Therapeutant Discharged from Well Boats during Flushing
(assuming Q=2400 m^3/h, V=330m^3, d=0.5m)



Calculations for well boat end of discharge pipe

Time average concentration at end of discharge pipe taken over the flushing period

$$\bar{C}_{eop} = \frac{\int_0^{t_{fl}} C_0 \exp(-Qt/V)\,\partial t}{t_{fl}} = \frac{C_0 V}{Qt_{fl}}\left[1-\exp\left(-Qt_{fl}/V\right)\right]$$

Concentration at end of discharge pipe at the end of the flushing period

$$C_{eop}(t) = C_0 \exp\left(-Qt_{fl}/V\right)$$

Flushing time needed to reduce end-of-pipe Concentration to LC_{50}

$$t_{LC50} = -Ln\left(\frac{LC_{50}}{C_0}\right)\frac{V}{Q}$$

Flushing time needed to reduce end-of-pipe Concentration to lethal NOEC

$$t_{NOEC} = -Ln\left(\frac{NOEC}{C_0}\right)\frac{V}{Q}$$

Calculations for well boat end of discharge pipe

Time average concentration at end of discharge pipe taken over the flushing period

$$\bar{C}_{eop} = \frac{\int_0^{t_{fl}} C_0 \exp(-Qt/V)\,\partial t}{t_{fl}} = \frac{C_0 V}{Qt_{fl}}\left[1-\exp\left(-Qt_{fl}/V\right)\right]$$

Concentration at end of discharge pipe at the end of the flushing period

$$C_{eop}(t) = C_0 \exp\left(-Qt_{fl}/V\right)$$

Hazard Quotients or Ratios

$$\bar{C}_{eop}(t)/C_{effect} \qquad C_{eop}(t)/C_{effect}$$

Summary

Summary and A Flavour of the Implications

- We have several good sets of data from tarps and well boats
  - data collection is continuing; e.g. did a well boat dye release last week
  - bottom and angle shooting well boats challenging
  - shallow waters and inter-tidal areas can be exposed to diluted concentrations of therapeutants at times
- Data in general agreement with theoretical expectations
- Hope to continue collecting data to establish robustness of the findings to a wider range of locations and conditions
- Continuing to working on the data analyses, modelling, applications and implications

A Flavour of the Applications

- When combined with toxicity data we can use the quantitative transport and dispersal/dilution relationships to estimate various indices such as time to dilute to regulatory thresholds; zones of potential influence, etc.
  - *first screening estimates: horizontal length scales at which the average concentrations of therapeutant within tarped plumes equals levels of toxicity thresholds varies from 100s-1000s meters depending upon the therapeutant used and the water currents present at the time of discharge*
- Well boat treatments diluted more rapidly than tarp treatments
- Scales of influence Paramove < Salmosan < Alphamax
- Example screening calculations for tarps:

	Salmosan		Alphamax
• treatment conc.	100 ug/L		2000 ng/L
• 1h LC50 (lobster larvae/adults)	>100 / ~32 ug/L		~1/~47 ng/L
• depth of plume		5-10m	
• time to dilute to LC50	17 min (adults)		~2-8 h
• area covered	~2000 m2		~0.1-1 km2
• ~distance travelled	~100 m		~2+ km

That's it for Now

Immunostimulation and Peroxide treatments in sea lice infections

MD Fast, JM Covello, SL Purcell, JF Burka, RJF Markham, AW Donkin, DB Groman

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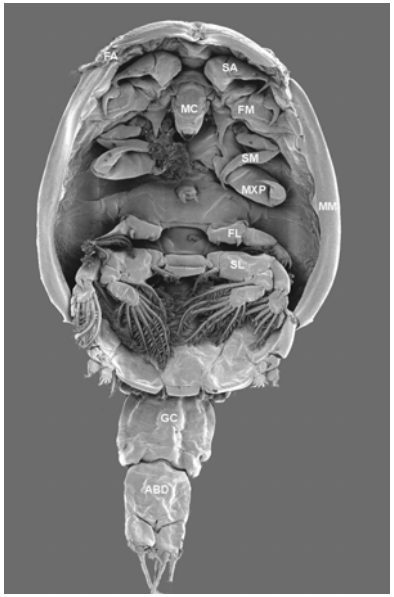
UPEI University of Prince Edward Island

Atlantic Veterinary College · University of Prince Edward Island

Background

- Sea lice
  - Major pathogen of salmonids
  - >100 million € worldwide/yr
  - Ectoparasitic copepod
  - Feeding on mucus, skin, blood
- Parasitic drug resistance (SLICE)
- Host resistance to parasite
  - Atlantic salmon vs. coho salmon
  - Strong inflammatory response and localized hyperplasia (Johnson and Albright, 1992)



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Background on Feeds

- Hypothesis
  - By Boosting Atlantic salmon inflammatory/innate immune responses we will reduce infection level….?
- Incorporate immunostimulants in feed
  - 1-3, 1-6 β-Glucan (ProVale)
    - Provided protection against *L. salmonae* infection (Guselle et al., 2009)
  - CpG ODN (unmethylated Cytosine-Guanine SS DNA)
    - Strong induction of innate and adaptive responses (TLR-9)
    - Strong mucosal responses in oral admin of mice (Lacroix-Lamonde et al., 2009)
  - Commercial yeast extract (ABN1)
    - Anecdotal evidence of protection against sea lice in field

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Background on Feeds

- Incorporate immunostimulants in feed
  - 1-3, 1-6, β-Glucan (ProVale) 200 mg/kg
  - CpG ODN 20 mg/kg
  - Top-coated
  - ABN-1, yeast, 2%
  - Milled into feed

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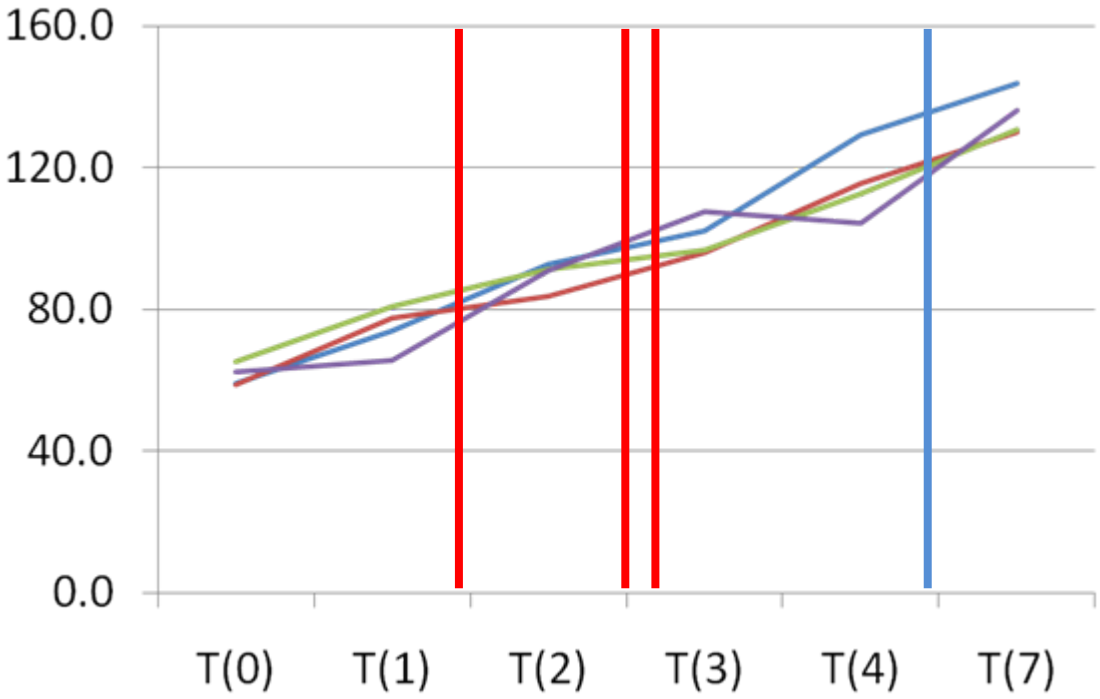
Growth

- 47 days on T-feed
  - No sign diff.
  - Avg. start 60 g
  - 130-143 g by end of trial
- T1 – 2.5 wks on feed
- Exposure to 15-20 copepodids/fish
  - Prior to T2 (4dpi) and 2x after within 3 days
- T (2) 4 wks, T (3) 7 dpi, T (4) 20 dpi, T (7) 38 dpi



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Methods

- Sampled 6 fish/tnk duplicate tanks (n=12) @ 11°C
- 3 exposures to *L. salmonis* copepodids (8 hr)
  - Low-level exposure reduced gill infections (<10%)
- qPCR of standardized skin, HK (Intestine, spleen, Attachment site – chalimus)
- Markers of Inflammation (IL-1, IL-8, MMP-9)
- T-tests with Bonferroni adjustment (we are not concerned about comparisons between CpG and ABN1)
- Histopathology Kruskal-Wallis (NP)-MannWhitney
  - Chi-squared analysis of proportions w lesions

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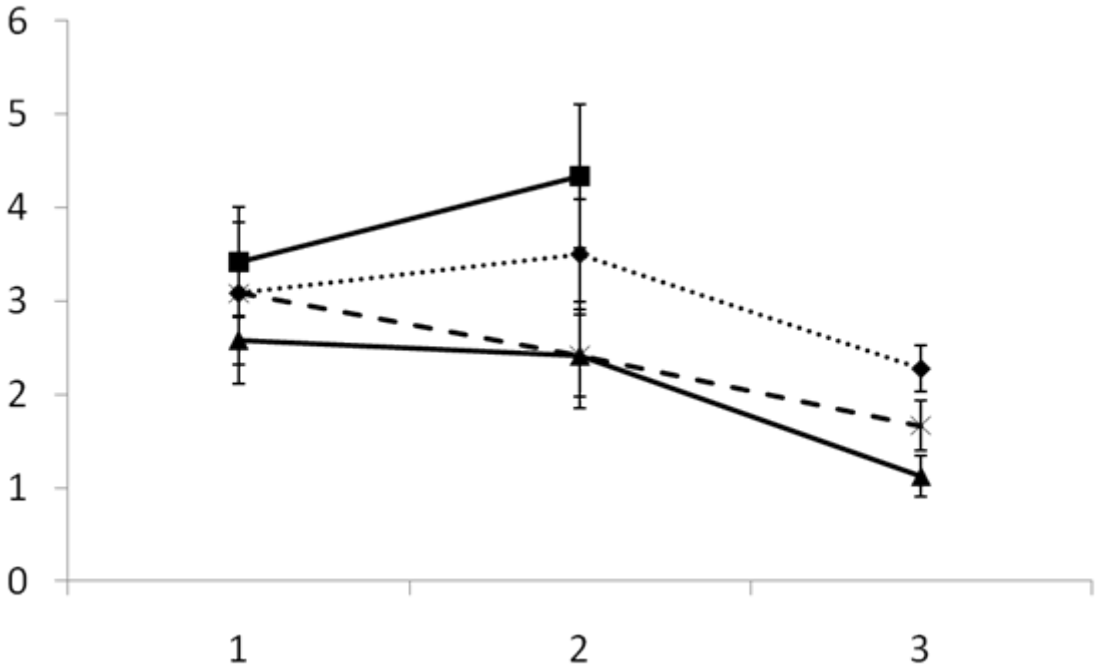
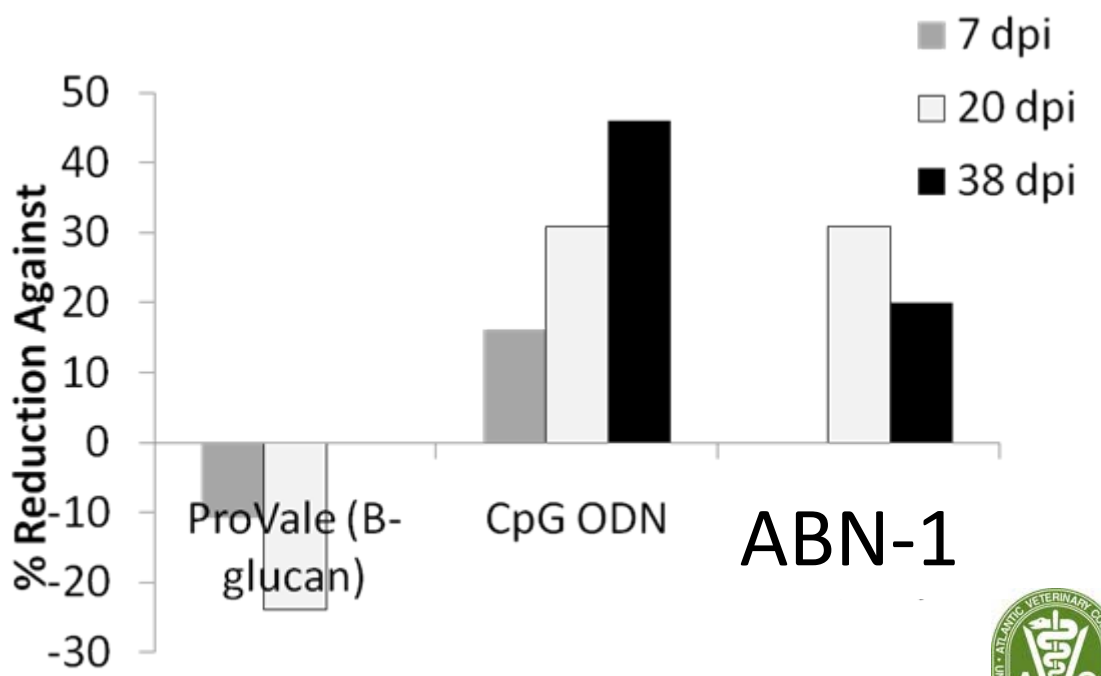
Lice/Fish

- Significant reductions in CpG and ABN-1 at 20 and 38 dpi
- Reduction by 38 dpi
  - CpG 46%
  - ABN-1 20%
  - Prevalence 75% in CpG, 83% others





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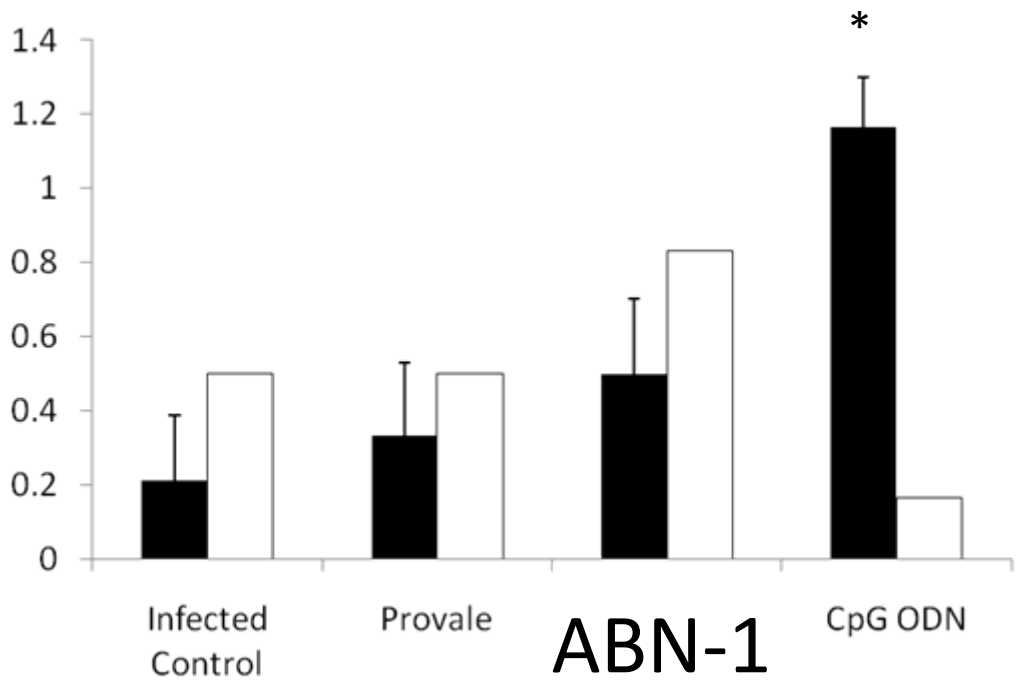
Inflammation Scoring

- Rating 0 = Normal morphology no infiltrate present
- Rating 1 = Mild cellular infiltrate present.
- Rating 2 = Moderate cellular infiltrate present.
- Rating 3 = Marked cellular infiltrate present.
- Ulceration = Yes (Y) or No (N) (white)



*Significantly diff from control ($p<0.05$)
** Chi-squared no diff in ulceration

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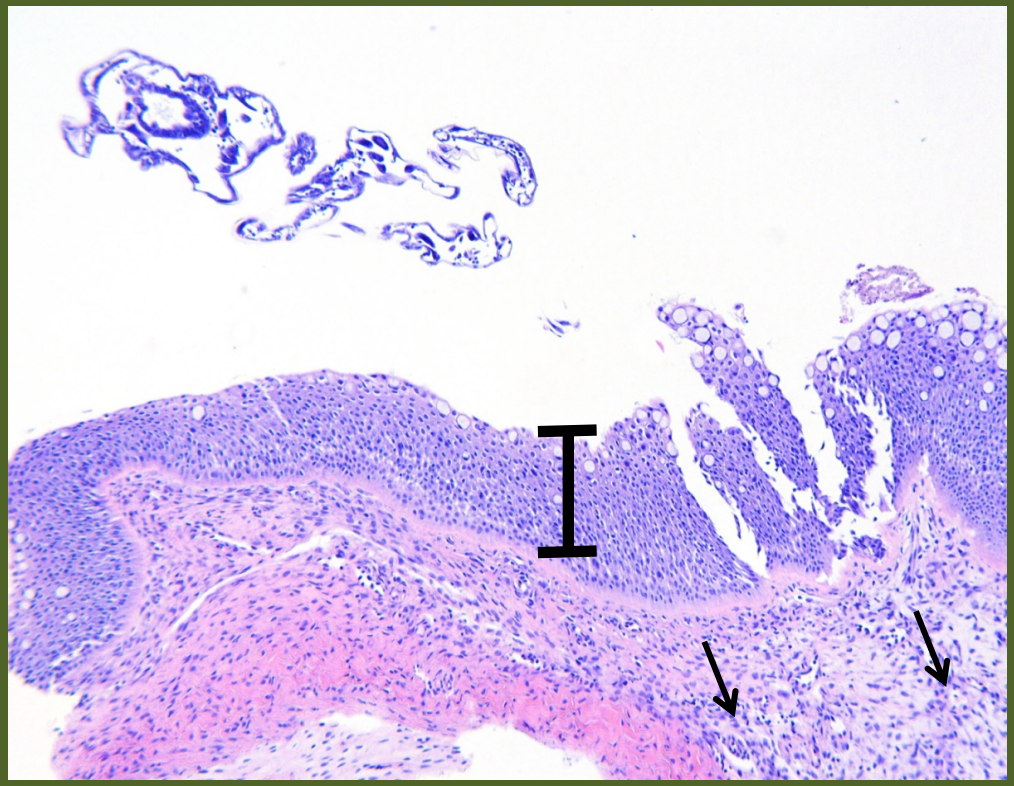

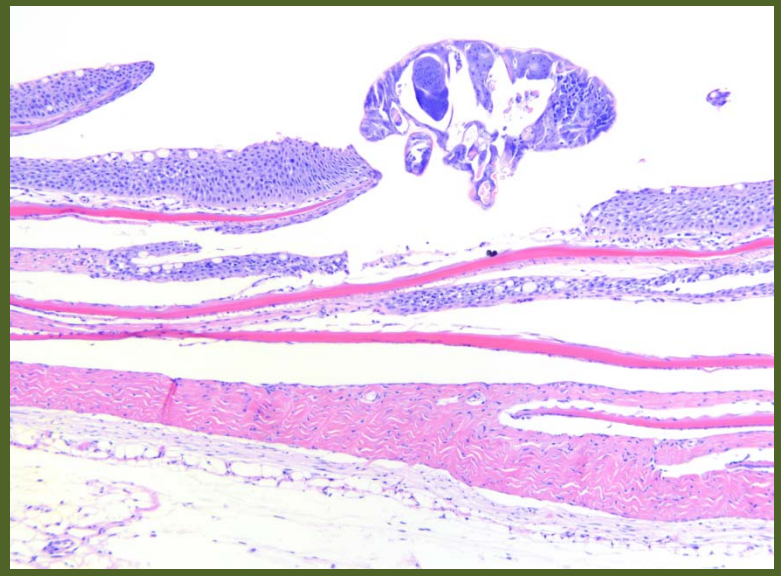

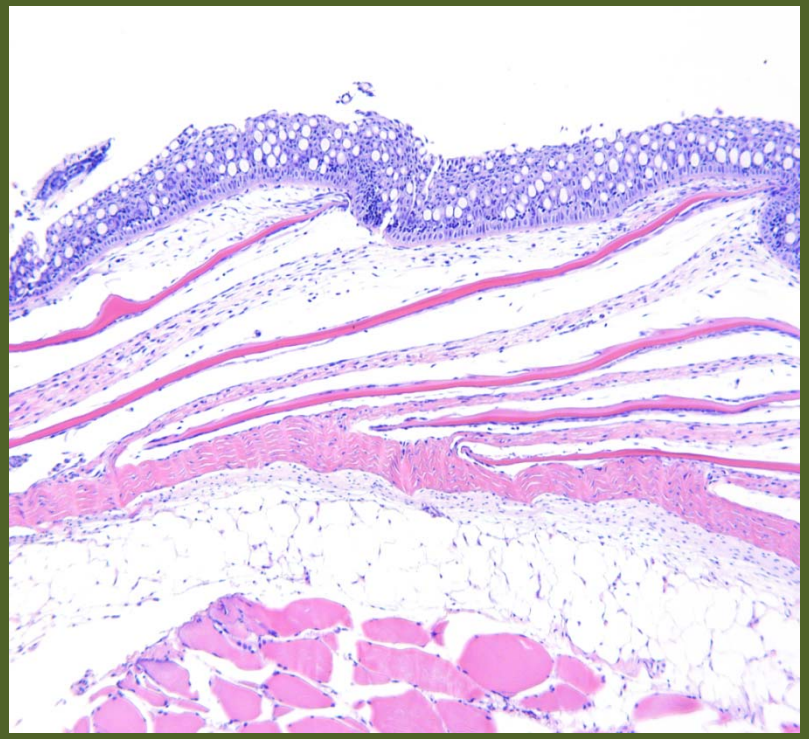

*Mild inflammation always present close to attachment in CpG fed fish

** In some cases moderate inflammation and epithelial hyperplasia

***Not observed at other sites or in other treatments/controls

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Systemic Response

Head Kidney Gene Expression

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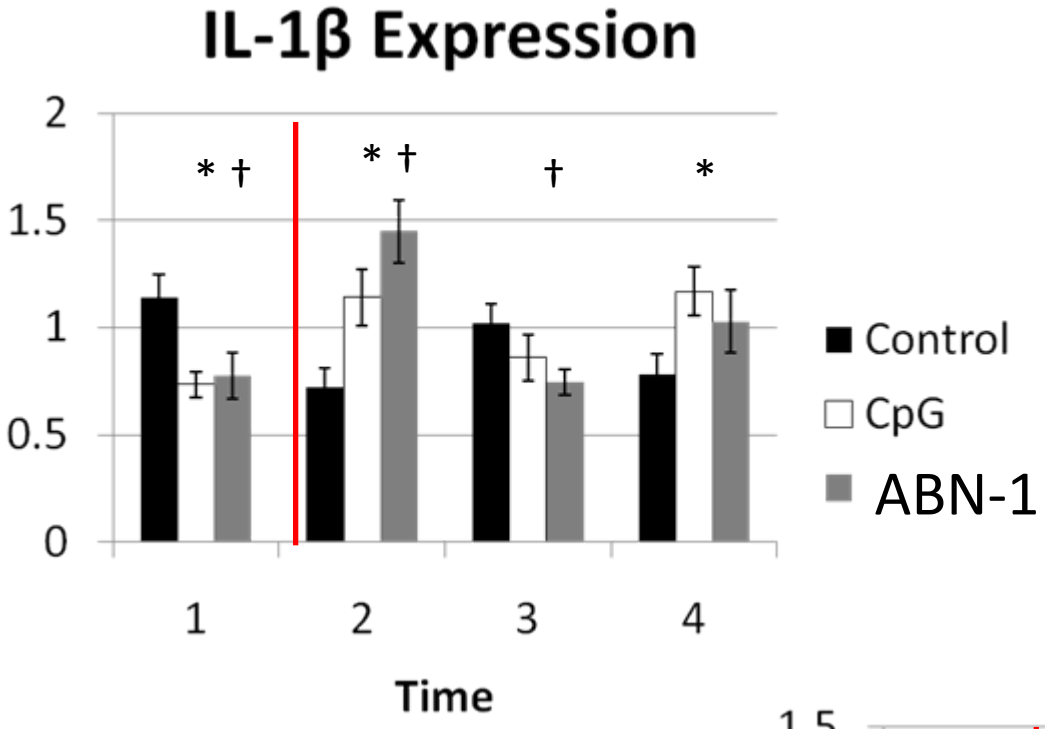
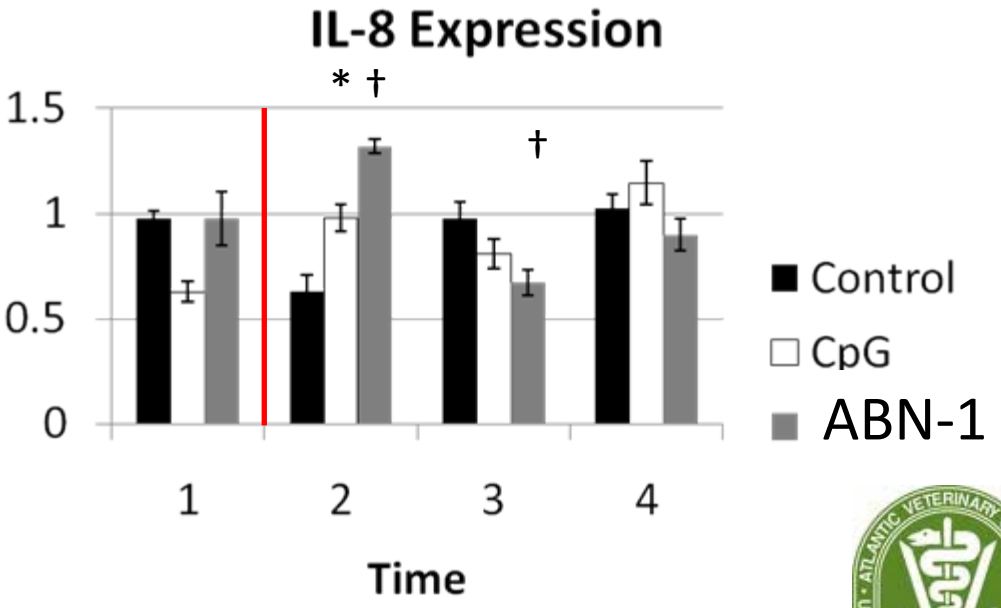


†Approx. 2-fold increase of IL-1 and IL-8 in ABN-1 fed fish compared to infected controls (T2)-initial infection 4dpi
* Sign. Increase in CpG fed fish at T(2)

** Follow up study (2x infection load)
-up to 50% reduction
-See same initial increase (2-fold) in Inflammatory genes at first lice exposure (ca. 4 wks on feed) and decrease thereafter



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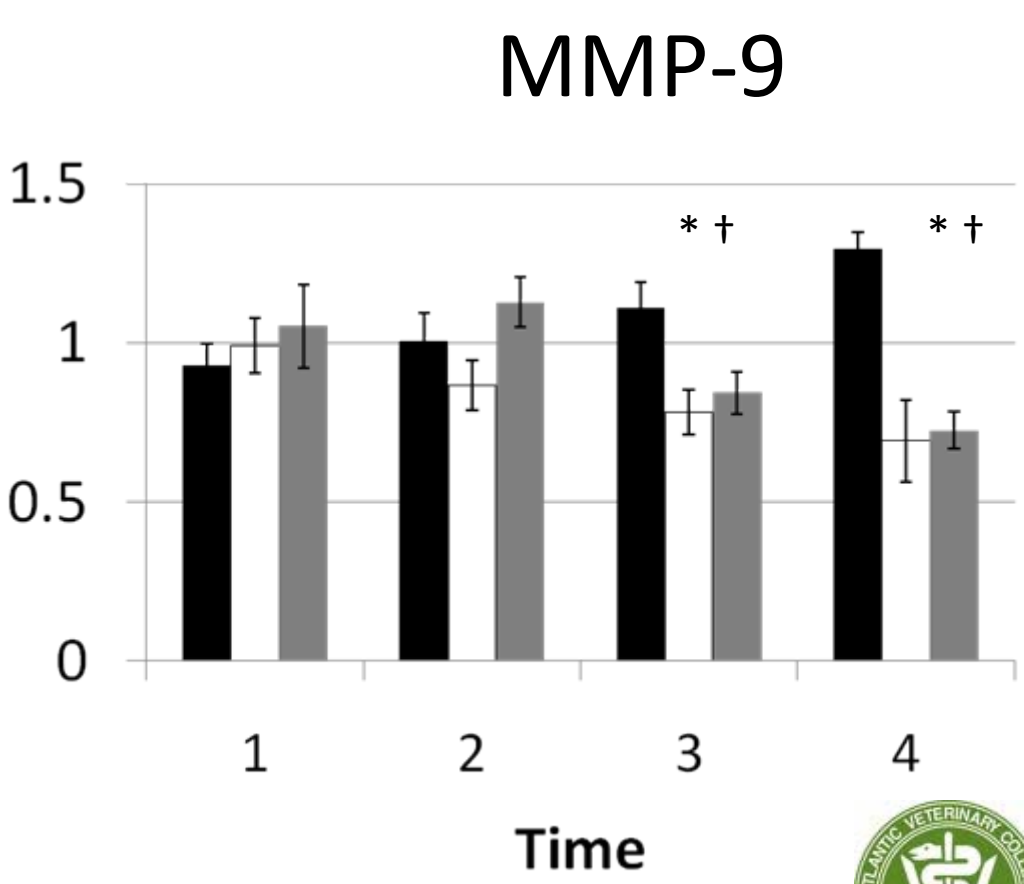
Gene Results (cont'd)

- MMP-9
  - Significantly reduced in CpG ODN and ABN-1 fed fish at T (3, 4)



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Re-infection at high levels

- ProVale fed fish put on ½ dose feed of CpG for 3 weeks
- Exposed to 120 Copepodids/fish on a single day (3 dpf)
- Also re-exposed controls
- Single exposure to originally uninfected fish

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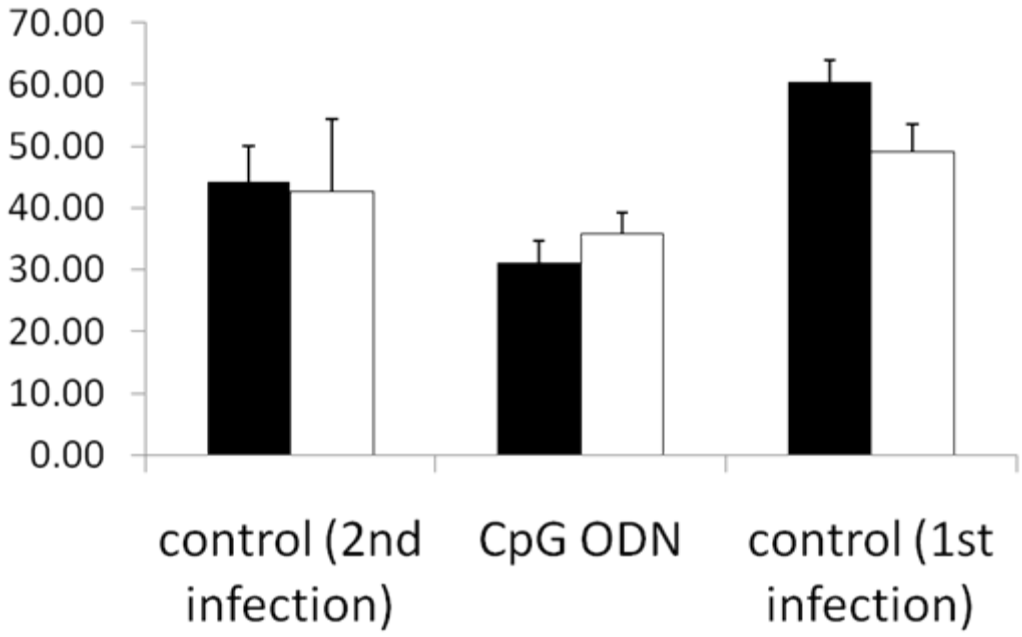
Re-infection – Provale switch to CpG

- 7, 17 dpi
- 26 and 13 % reductions from 1st to second infection
- 29 and 16 % reduction from 2nd infection to CpG
- No histopath differences



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Summary

- Systemic and localized induction of inflammation after initial exposure
- Systemic induction greatest in ABN-1
- CpG and ABN-1 feeds sign. reduced lice infection (may or may not be additive)
- Despite continued feed no further induction of responses
- Localized inflammation at parasite feeding/attachment site in CpG fed fish (vs Systemic markers)
- Further reductions observed at lower CpG dose

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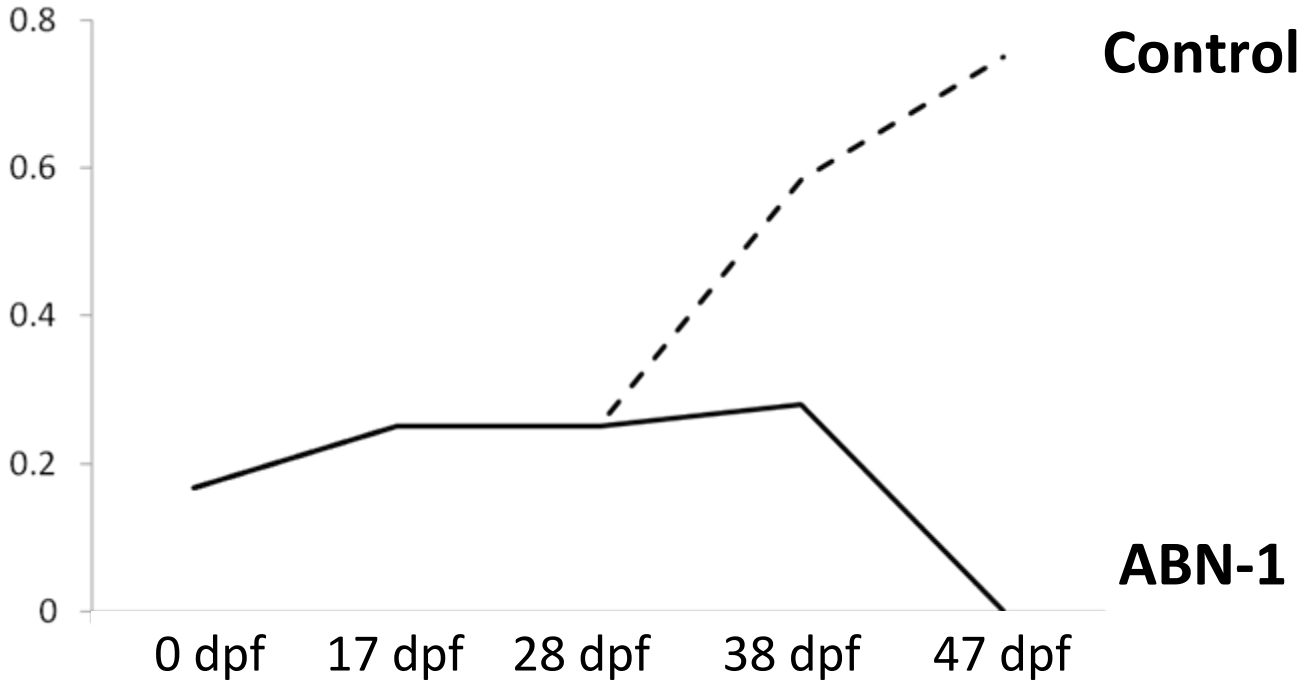
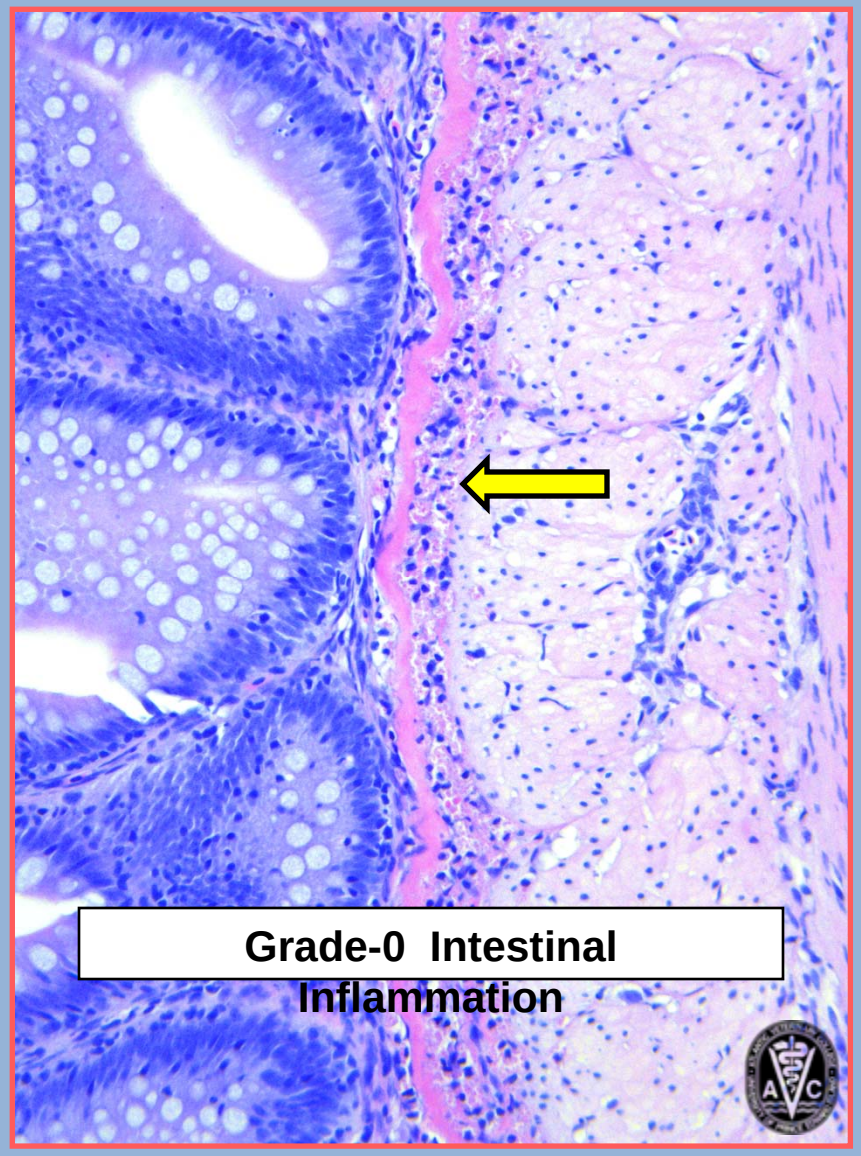
Side Effects of Immunostimulation….?

- Does enhancing inflammation in fish have undesired consequences?
- Intestinal Inflammation
- ABN-1 Protection (n=4/time)?

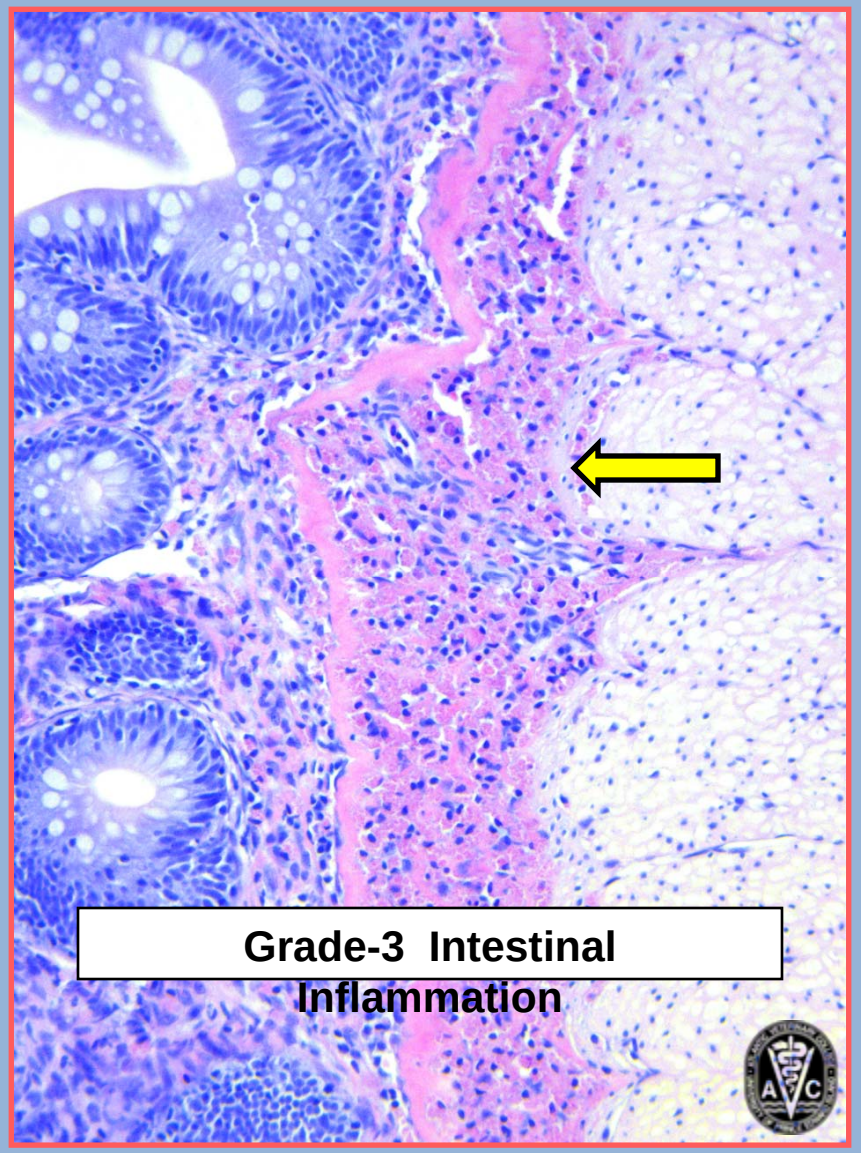


Side Effects of Immunostimulation (Cont'd)

- Tested over 12 weeks
- N=15 per time
- Control vs. 4 different treatment feeds (ABN-2)
- Measure inflammation in intestine and skin



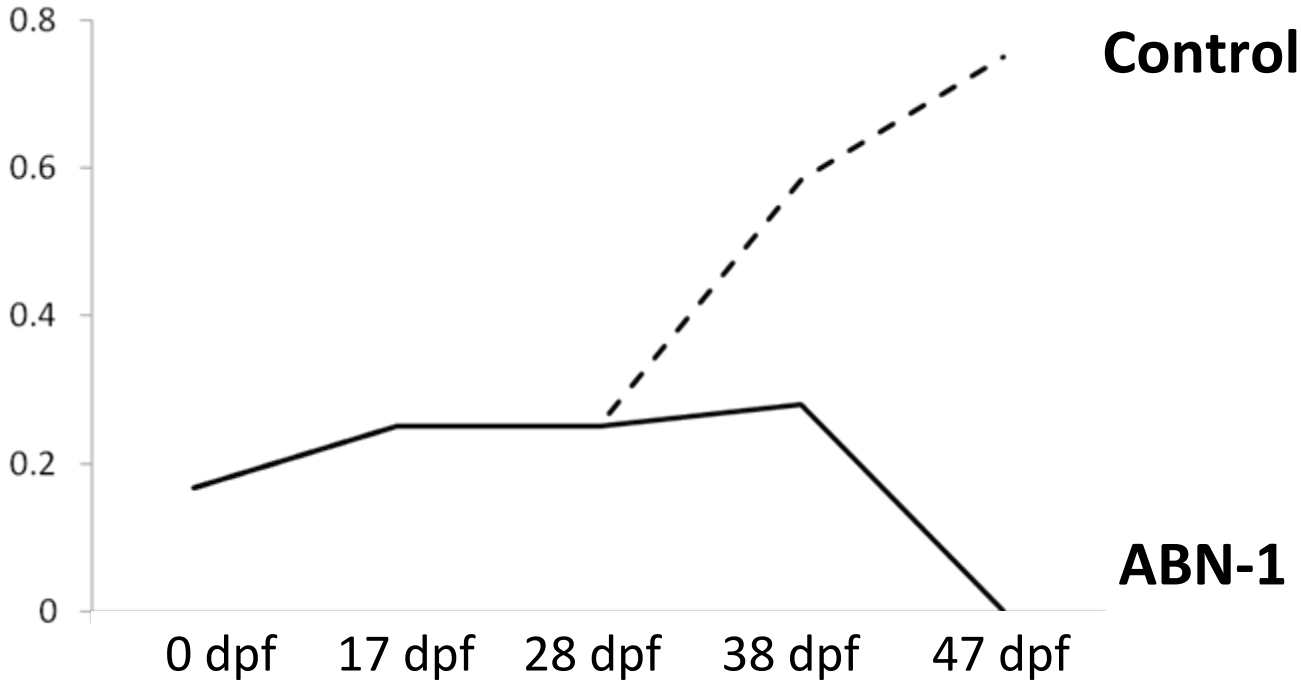
Grade-0 Intestinal Inflammation



Grade-3 Intestinal Inflammation

Side Effects of Immunostimulation (Cont'd)

- No Significant Diff. at 6 wks (0.4-0.5) all groups
- Significantly higher in ABN-2 at 12 weeks (1.5)
- Controls and 2 TF (0.75)



Switch Gears….

Hydrogen Peroxide Treatment of Lice

MD Fast, JM Covello, SL Purcell, M Beattie, L Hammell

Hydrogen Peroxide Treatment

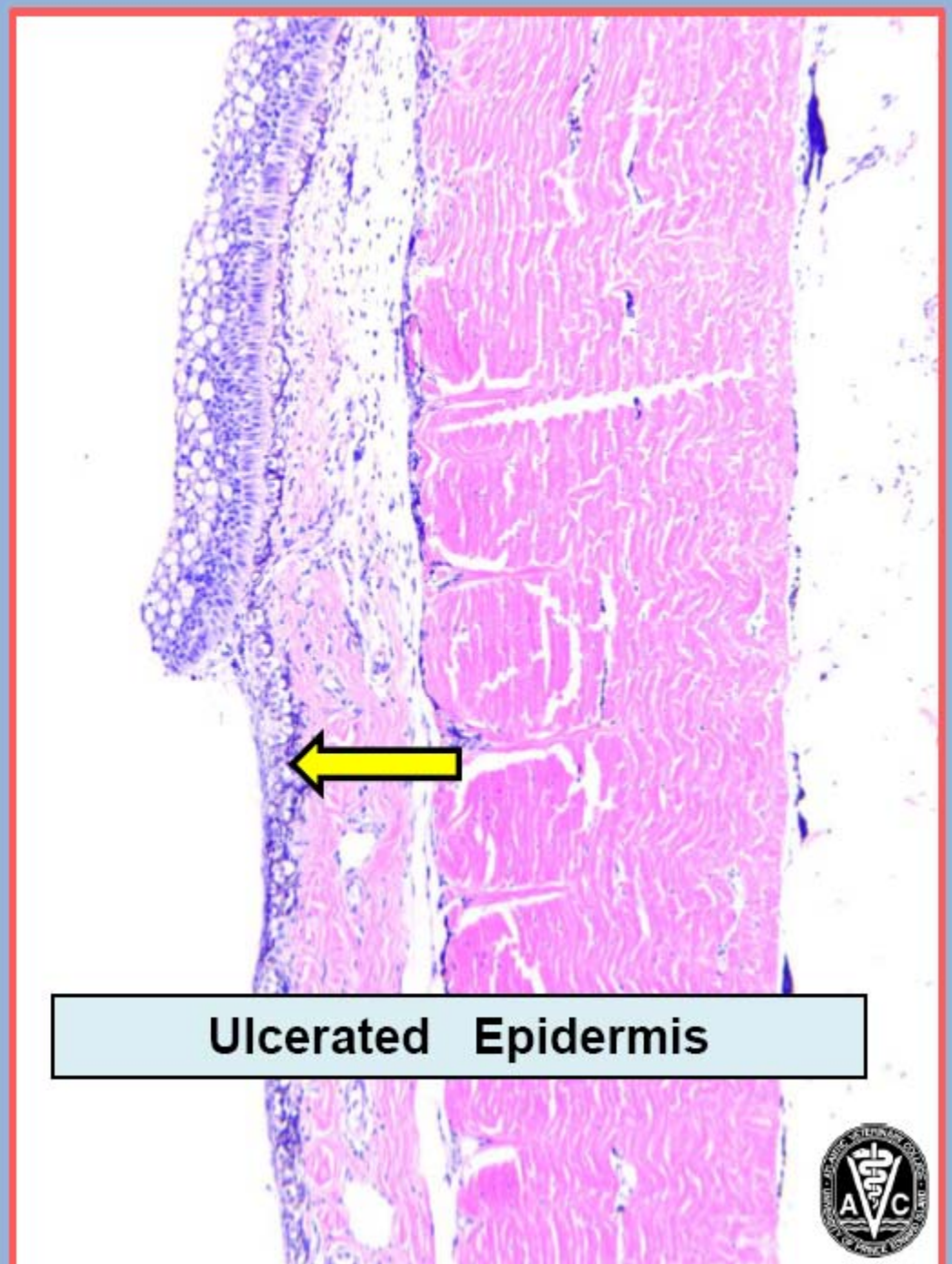
- Anecdotal evidence of increased lice settlement post-treatment
- Intracellular ROS and oxidative damage
- Objectives and Preliminary Results:
  - Determine effects on skin of current H202 treatment
  - Determine time course of effects
  - Determine treatment effects on larval louse settlement
  - Determine treatment effects on female lice fecundity

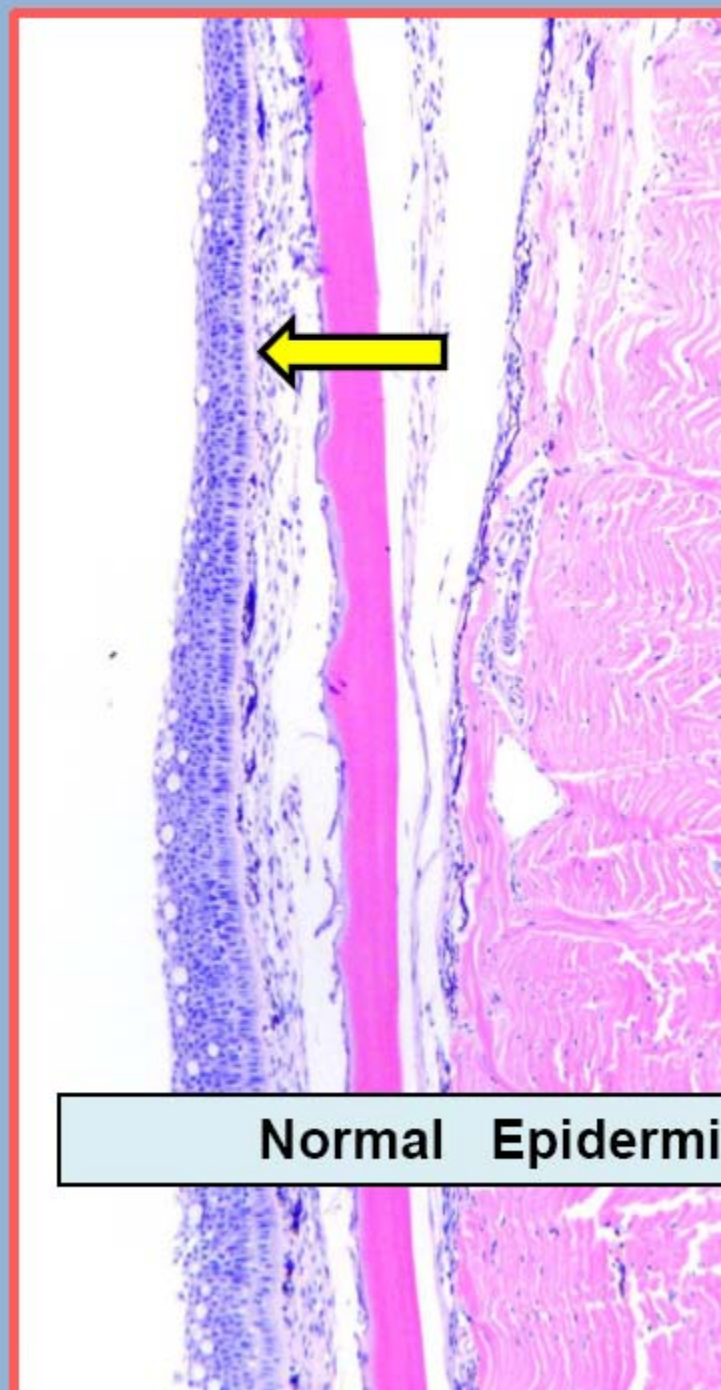
Cage Study Treatments

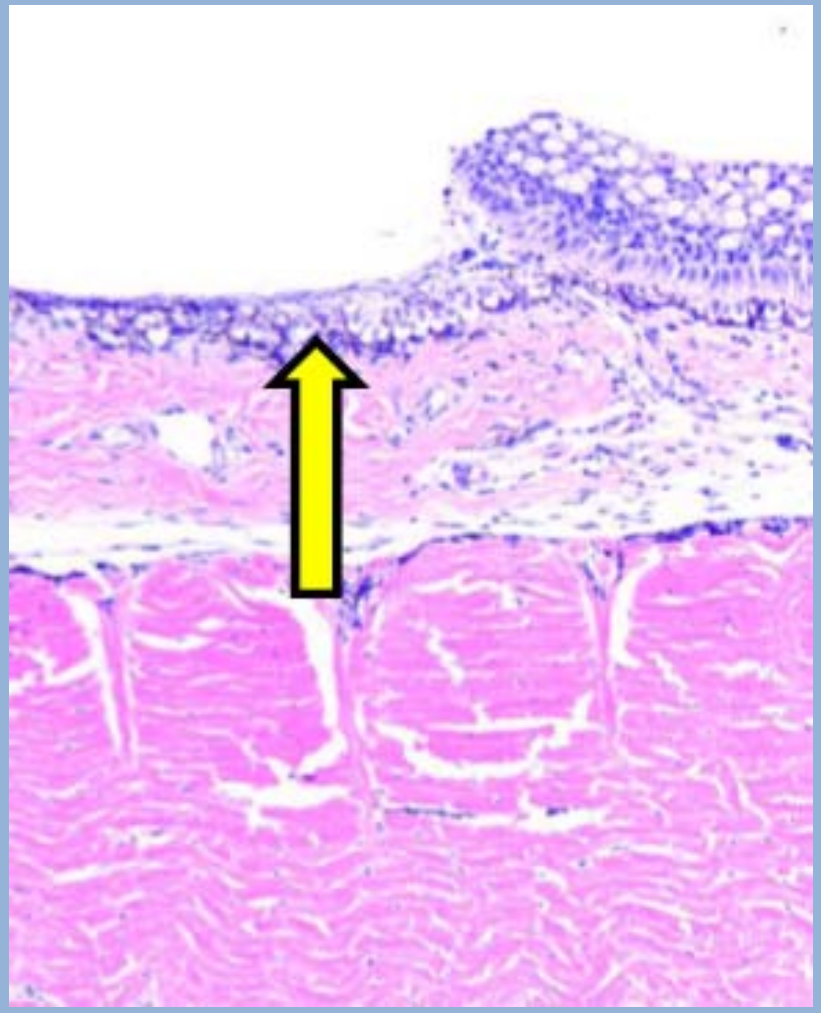
- Preliminary Work in Bay of Fundy (Fall 2011)
- Sites receiving H202 treatment
- Pre-treatment, immediately following treatment, 4 hrs post, 24 hrs, post and 72 hrs post
- Sample 4 fish per group multiple times (i.e. throughout the year)
  - Skin histopathology (Lesions vs Inflammation)
  - Skin gene expression (inflammation/apoptosis)
  - Mucus production
  - Juvenile lice counts post Tx (proxy for settlement)

Skin Histopathology

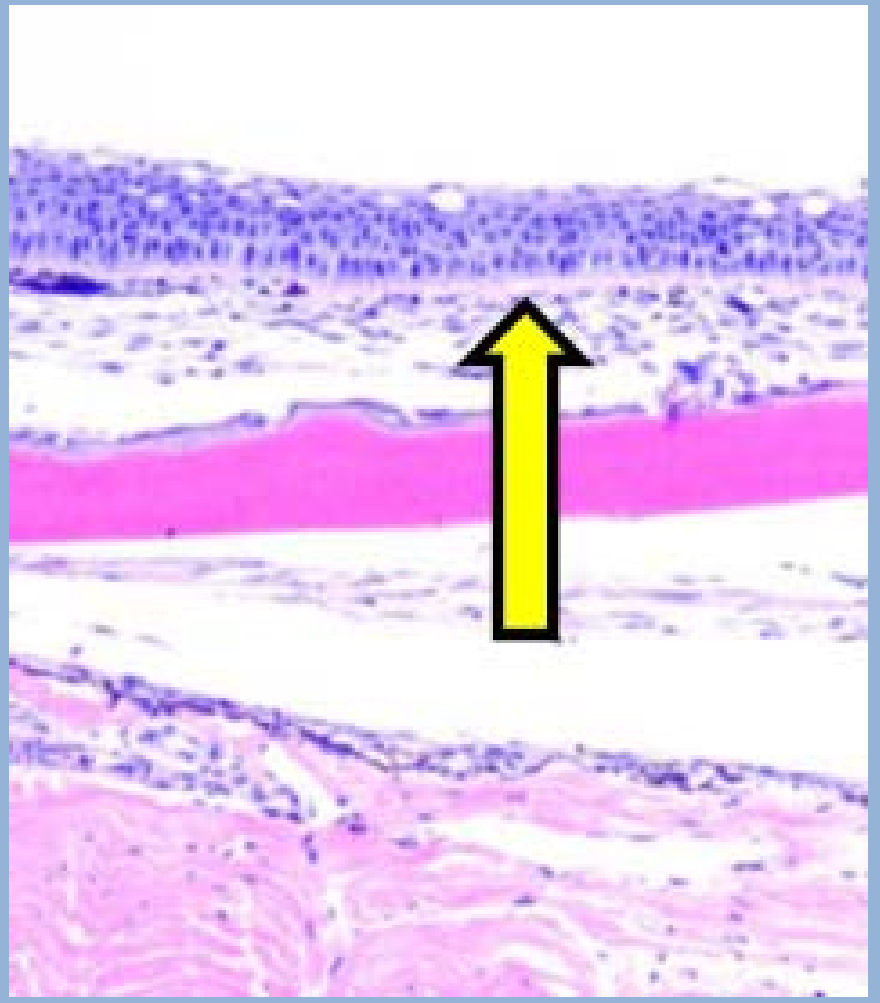
- Field setting make this difficult!!!
- Preliminary results (effects/TC):
  - Will need well controlled lab study for confirmation
  - Background handling lesions (25%)
  - At 4 hrs post treatment consistent epidermal denuding (not just necrosis)
  - 'Recovered' by 24 hrs
- Future repeat (x times) over same time scale


Ulcerated Epidermis


Normal Epidermi



Ulceration



Normal

Objective 3

- Does H202 increase settlement?
  - At the field level we do not have data yet
  - Similar to Obj 1 and 2, need replication and lab confirm
  - We have conducted *in vitro* lab assessments…
- Copepodids cultured in the lab are exposed to Agar plates (EWOS)
  - TSA
  - TSA with salmon mucus
  - Significant (5-6x) higher settlement with mucus than w/o
  - Can also be done w PA, adult males
  - So far no differences…but also not host specific (Flounder)
  - Refining and replicating

Objective 4

- H202 effects on Lice fecundity (2x)
- Female lice collected pre-/immediately post treatment from well boat
- Egg strings collected and cultured at AVC
- 100 egg strings Pre-treatment vs 100 egg strings post-treatment
- >2000 copepodids develop in PreTx (7 d)
- Handful of copepodids develop and die (5 d)

Remember Immunostimulation…?

- Feeds
  - 1 – Induce protection against early life stages
  - 2 – Enhanced skin responses (hyperplasia)
  - 3 – Reduced ulceration due to sea lice
  - 4 – Maintaining on feed not necessary
- IF H202 causes short term ulceration/breakdown of skin….IS feeds may ameliorate these conditions

Current and Future Directions

Future Directions

- What effect do value-added (IS) feeds have on treatment resistance?
  - Recover lost SLICE efficacy?
  - Do they stimulate similar mechanisms?
  - NGS and louse microarray work w B. Koop (UVic)
  - May be a case by case basis (IS and treatment)
  - Just scratching the surface as we know little about functional mechanisms in lice
- How does resistance develop (SLICE et al)?
  - Genomic studies with Norway and BC

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Acknowledgements

- Novartis Animal Health (Fish Health RC)
- Cooke Aquaculture (Northeast Nutrition)
- AVC- Animal Aquatic Facility
- Centre for Aquatic Heath Sciences
- NBDAAF, NSERC Engage program/Springboard Atlantic
- Students: O. Igboeli, H. Wotton, A. Borchardt, A. Gradil, A. Johnston, J. Poley

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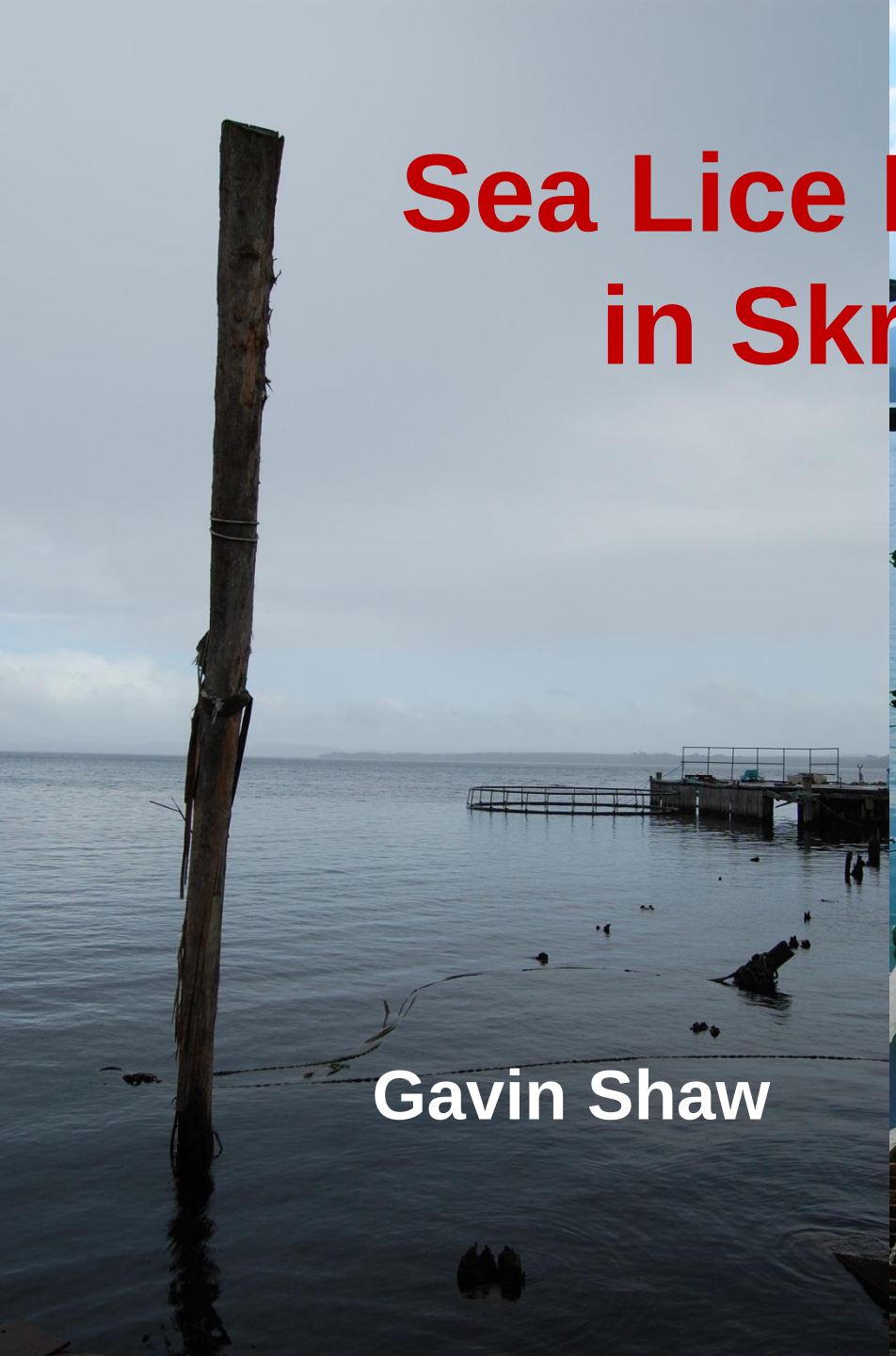
Sea Lice Research in Skretting

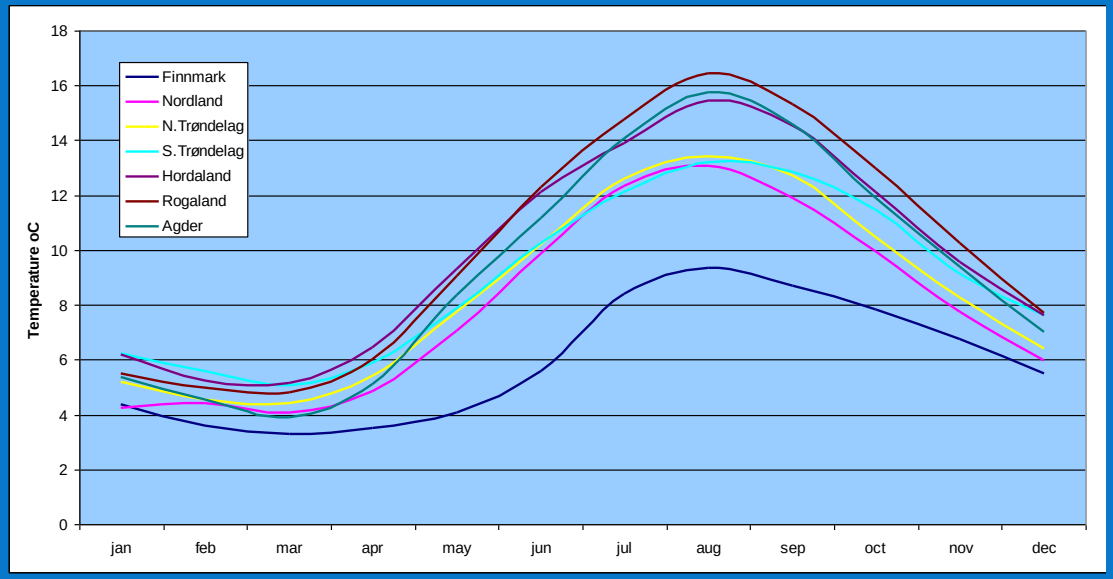


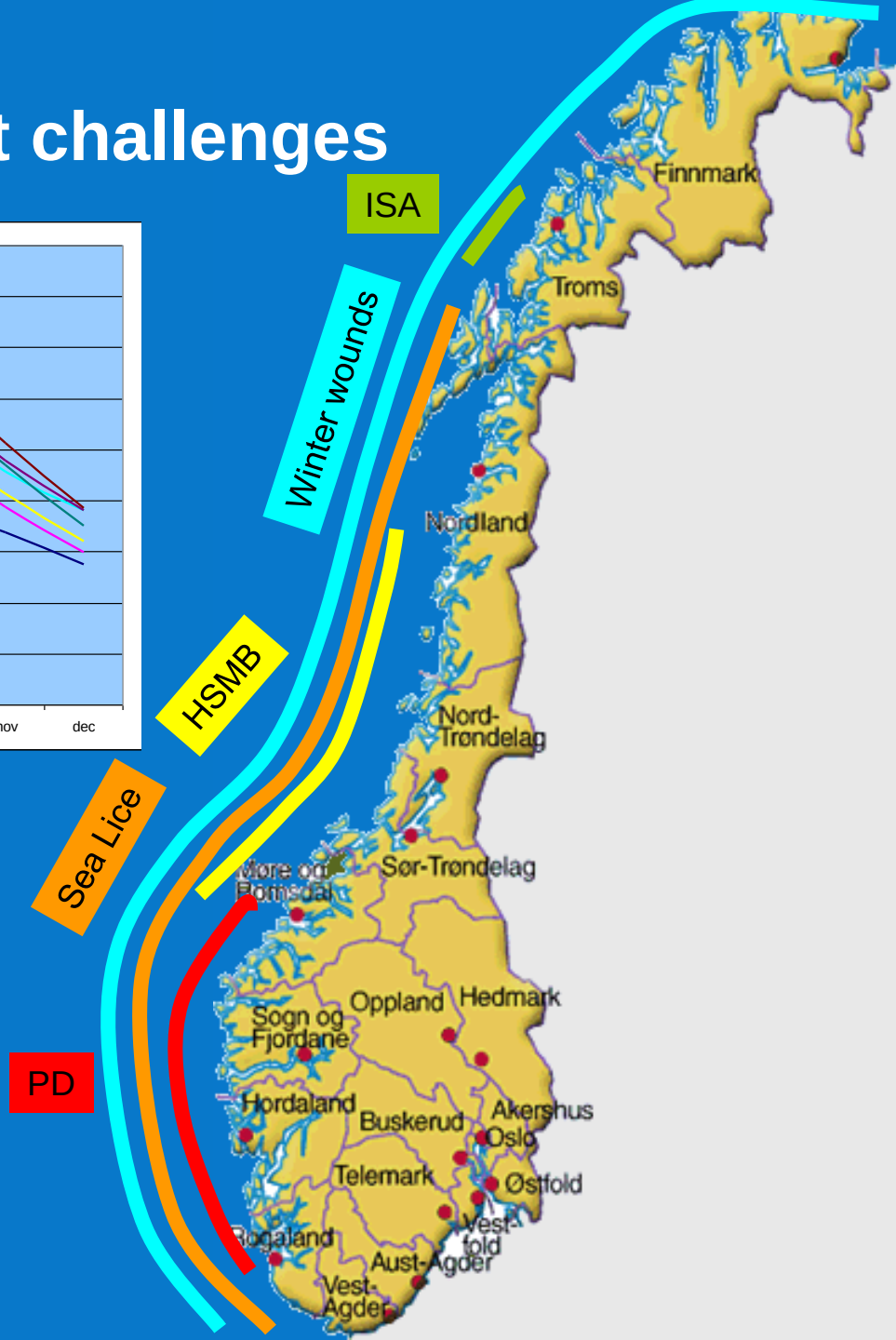
Gavin Shaw

Fish Health Management

- Feed Solutions and techniques around the world
- Research and Development initiatives
- Lice Feed Solutions.
- What next?

Example: Norway
Health and environment challenges





Mid-Norway S0, lowest prod.cost

Many product changes per cycle

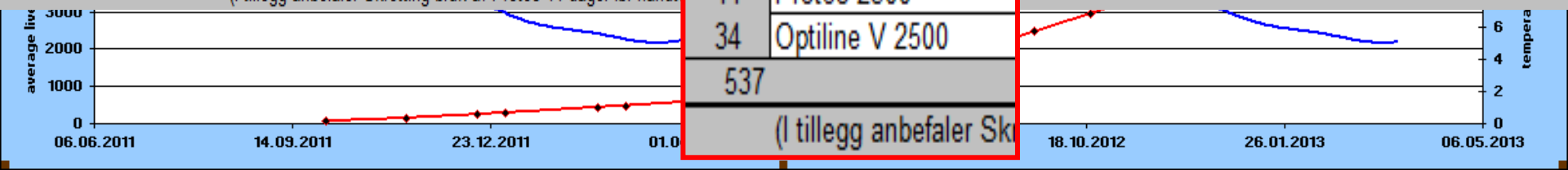
Winter wounds **Lice**

dato fra	dato til	dager	Fôrtype	Vektintervall (g)		Pigment (mg/kg)	Fôrpris (nok pr.kg)	Fôrkost (nok)	Kommentar
1. okt.	10. nov.	40	Spirit ST 75	70	150	50	11.11	0.76	Starterfôr har innebygget Protec egenskaper
10. nov.	16. des.	36	Spirit 150	150	255	50	8.55	0.77	Ny fiskestørrelse, starterperiode ferdig
16. des.	30. des.	14	Protec 150	255	300	50	10.54	0.41	Protec 14 dager mot vintersår
30. des.	15. feb.	47	Spirit V 300	300	450	50	8.16	1.08	Ny fiskestørrelse, vinterfôr
15. feb.	29. feb.	14	Protec 300	450	495	50	10.02	0.40	Protec 14 dager mot vintersår
29. feb.	1. apr.	32	Spirit V 300	495	600	50	8.16	0.77	Tilbake til standardfôr
1. apr.	1. mai.	30	Protec 600	600	740	50	9.60	1.23	Protec mot HSMB
1. mai.	18. mai.	17	Spirit 600	740	850	50	8.20	0.83	Tilbake til standardfôr
18. mai.	1. jun.	14	Protec 600	850	960	50	9.60	0.99	Protec mot HSMB
1. jun.	26. jun.	25	Spirit 600	960	1200	50	8.20	1.87	Tilbake til standardfôr
26. jun.	15. jul.	19	Optiline S 1200	1200	1440	30	7.70	1.81	Ny fiskestørrelse
15. jul.	15. aug.	31	Target 1200	1440	1875	30	7.84	3.45	Target mot lus
15. aug.	22. sep.	38	Optiline S 1200	1875	2500	30	7.70	5.13	Tilbake til standardfôr
22. sep.	20. okt.	28	Target 2500	2500	2980	30	7.65	4.12	Target mot lus, ny fiskestørrelse
20. okt.	1. des.	42	Optiline S 2500	2980	3660	30	7.57	6.08	Tilbake til standardfôr
1. des.	15. des.	14	Protec 2500	3660	3860	30	8.57	2.08	Protec 14 dager mot vintersår
15. des.	1. feb.	48	Optiline V 2500	3860	4480	30	7.40	5.82	Vinterfôr
1. feb.	15. feb.	14	Protec 2500	4480	4640	30	8.57	1.77	Protec 14 dager mot vintersår
15. feb.	21. mar.	34	Optiline V 2500	4640	5000	30	7.40	3.55	Tilbake til standardfôr
SUM		537		70	5000	33.8	kg fisk:	8.59	

(I tillegg anbefaler Skretting bruk av Protec 14 dager før håndt

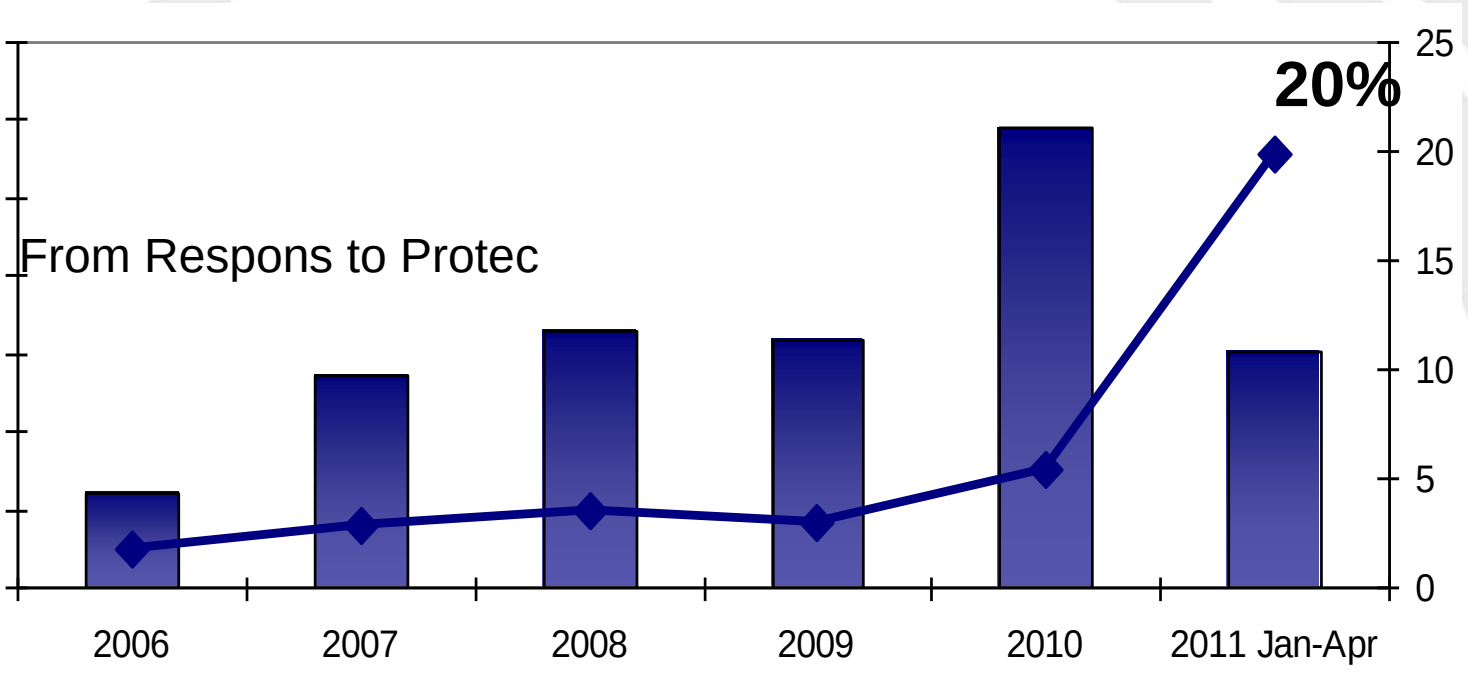
dager	Fôrtype
40	Spirit ST 75
36	Spirit 150
14	Protec 150
47	Spirit V 300
14	Protec 300
32	Spirit V 300
30	Protec 600
17	Spirit 600
14	Protec 600
25	Spirit 600
19	Optiline S 1200
31	Target 1200
38	Optiline S 1200
28	Target 2500
42	Optiline S 2500
14	Protec 2500
48	Optiline V 2500
14	Protec 2500
34	Optiline V 2500
537	

(I tillegg anbefaler Ski



Where are health products used?

Norway – from 5% to 20%



Bars = volume Protec (ton)

Line = % Protec of total

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a nutreco company

PASSIONATELY PURSUING NEW KNOWLEDGE

SKRETTING AQUACULTURE RESEARCH CENTRE

SKRETTING
AQUACULTURE RESEARCH CENTRE

Research and Development

- Nutrition
- Formulation
- Health
  - Lice
  - High Temperatures
  - BKD
  - Low Dissolved Oxygen
- Modelling
- Sustainability

Projects are driven by you.

SKRETTING

Fish Trial station - Lerang

New Sea Lice Laboratory

- New Facility
- Key Part of Research Strategy
- Allows repeatable trials using a standad infection model

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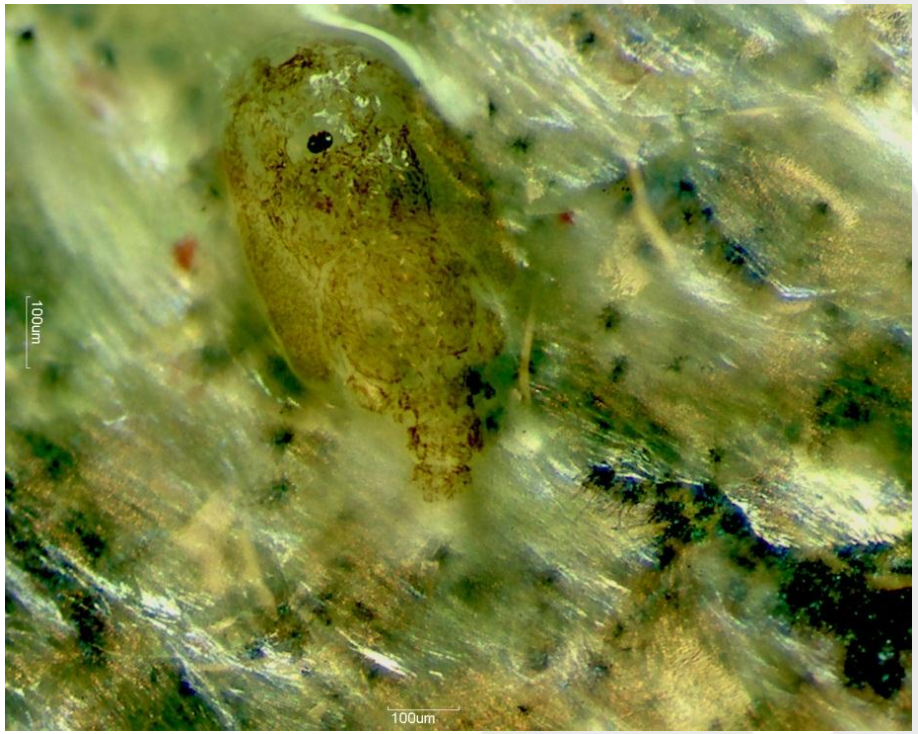
Why a new facility?

- Purpose
  - Learn and understand Lice biology
  - Screen many compounds
  - Comparing infection levels between different diets
- Advantages with our own sea lice lab
  - Not depending on availabilities in other labs
  - Continuous trials
  - Control over parameters
- 10 months old
  - Pilot trials
  - Developing standard infection model

SKRETTING

How to we run trials?

- Eggstrings
- Hatching
- Infection
- Counting lice



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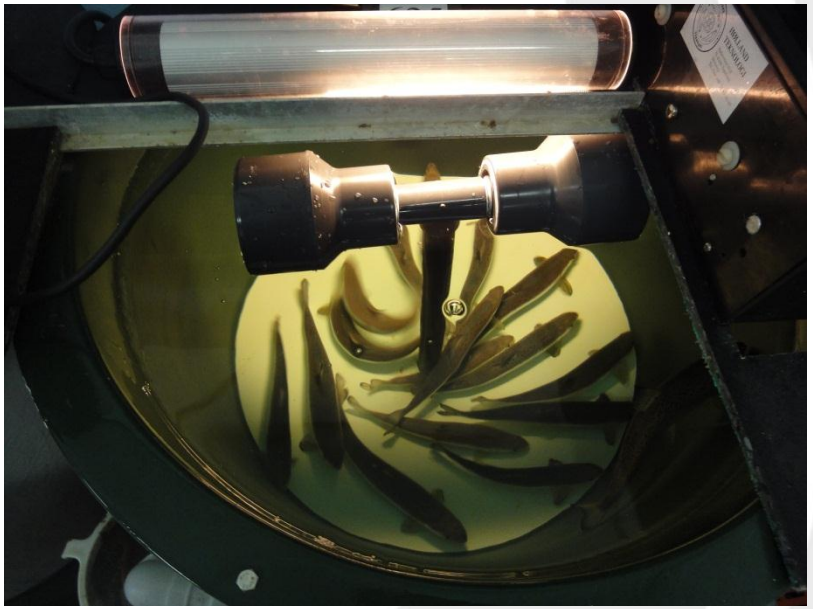
Hatching

- **Eggstrings**
  - Handle transport better than copepodites
  - Different ages (pigmentation)
  - 100-500 eggs per eggstring
  - Same strain (LsGulen) used in all trials
- **Flow through hatching system**
  - plankton mesh
  - Good water quality
  - Hatching rate: 140 copepodites per eggstring
  - 11 days to copepodid stage (12°C)
  - Infect when copepodid numbers are high and viabilety is still good

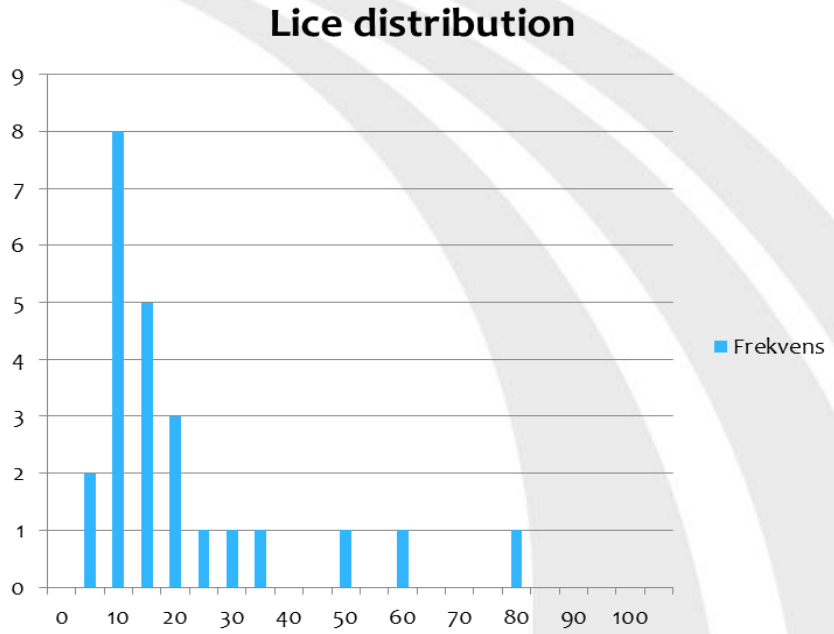
Infection

- How many lice do we add?
- Aim: 10-30 attached per fish
- Infect with equal number of copepodites per tank!
- Infect fish equally?



SKRETTING

Counting lice



- Count lice 9-11 days post infection

– Chalimus stage III/IV
  - Attached and easy to spot
  - Avoid pre-adult stage (can disattach

How does the facility help?

- Improved opportunity to find Sea Lice Achilles Heal
- Ability to Screen materials and compounds in Controlled Studies
- Compare test substances against current products
- Develop New Products to bring to market
- Increased focus on Nutritional aspects of Lice control

SKRETTING

Prevention is better than cure

Target Lice – a new feed to help combat lice

We have now introduced Target Lice, a new proactive feed to be used in those periods of high lice risk. As part of an Integrated Pest Management strategy, Target Lice can make a crucial difference as demonstrated in controlled tests. Target Lice – tailor-made to help farms win the battle against lice.

www.skretting.co.uk

Feeding your passion for fish

SKRETTING

Target

Systematic lice protection from smolt to harvest

SKRETTING

Target: Lice Protection

- Strengthen immune system
- Strengthen mucus layer
- Increased antioxidative capacity

- Tools:
  - highly purified beta 1,3-1,6 glucans, increasing the amount and activity of the macrophages in mucus
  - Inclusion of specific ingredients for high anti-oxidative capacity
  - Inlusion of gut health modulators

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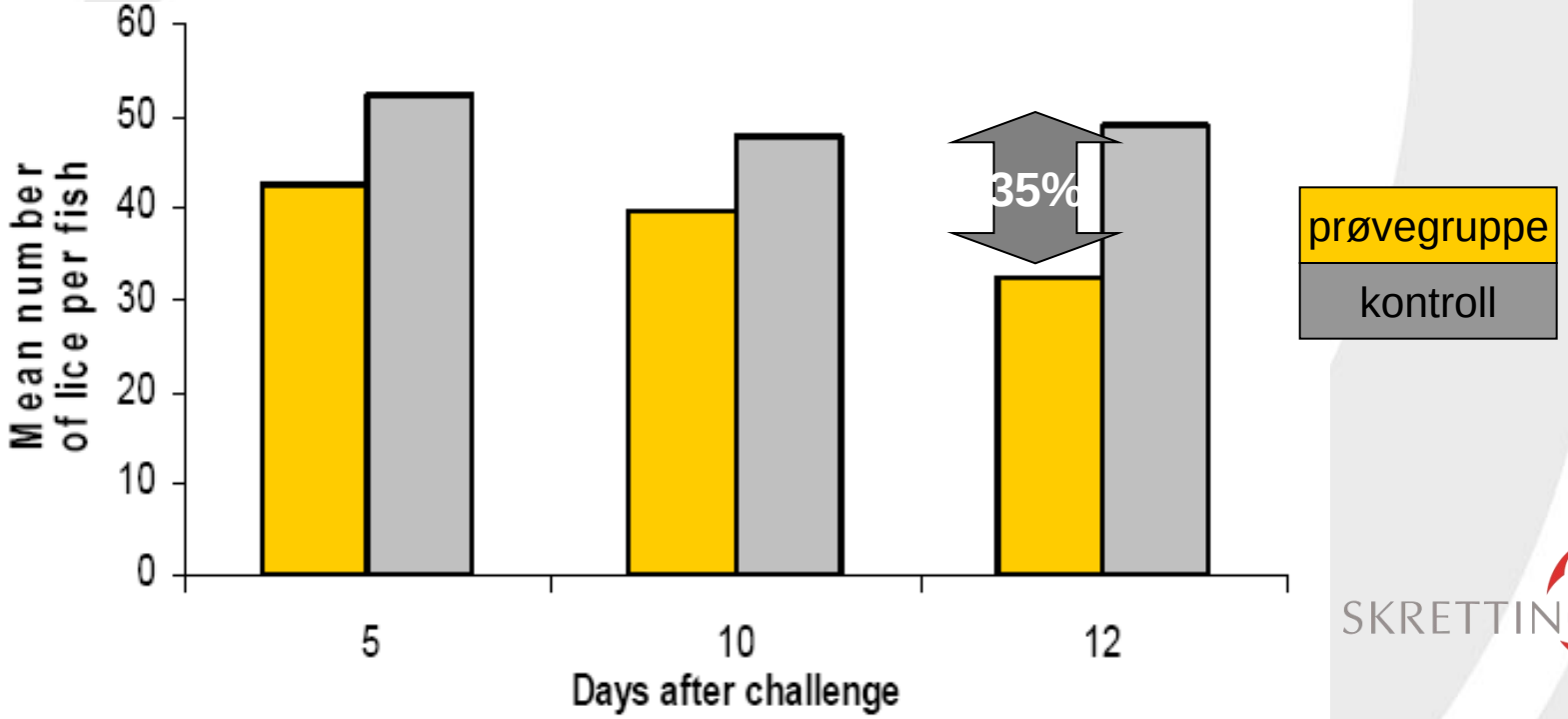
Early Documentation

Marine Harvest Scotland, 2000

Experimental Setup

- Atlantic salmon, 60-100gram
- Individually marked fish
- 14-day experimental feeding infection with lice
- Significant differences between 10 and 12 days after infection

35% reduction in lice per fish



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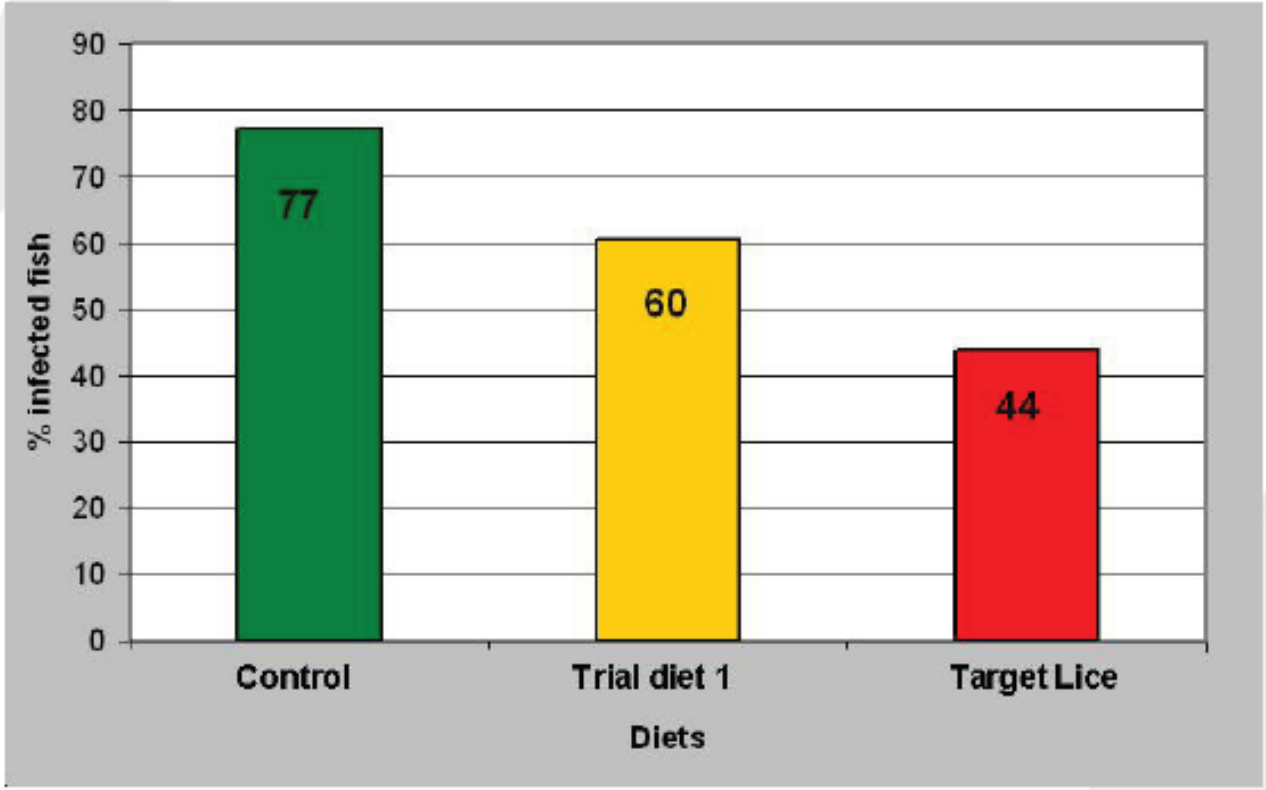
Documented effect

Akvaforsk, 2006

Trial set up

- Atlantic salmon, start weight 679g
- 150 fish/group, 3 tanks per diet
- Temp. 12-17°C
- 70 days feeding
- Natural challenge

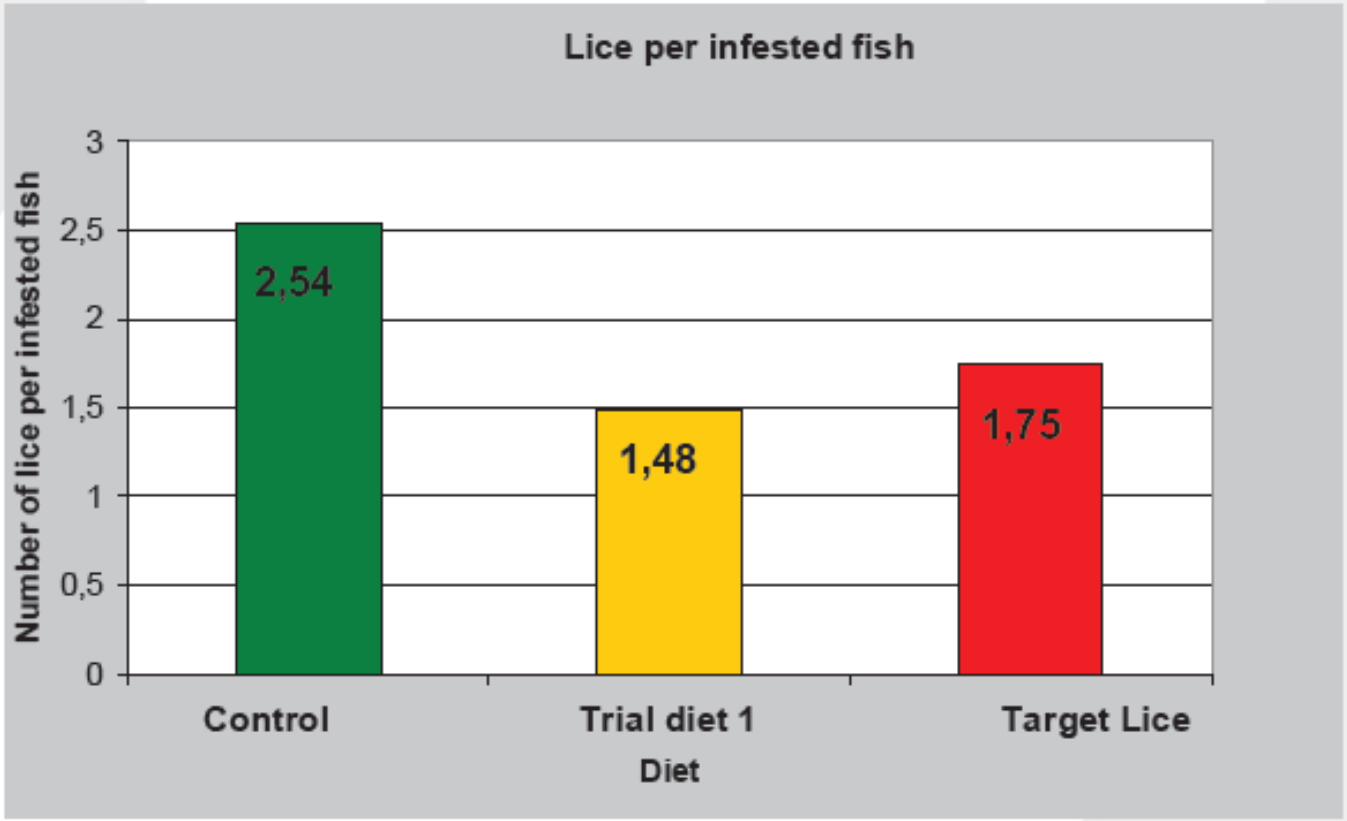
Fewer Fish with Lice



The differences are significant p<0,0001

Documentation cont.

Fewer Lice per Fish



Significant different between control and two treatment diets

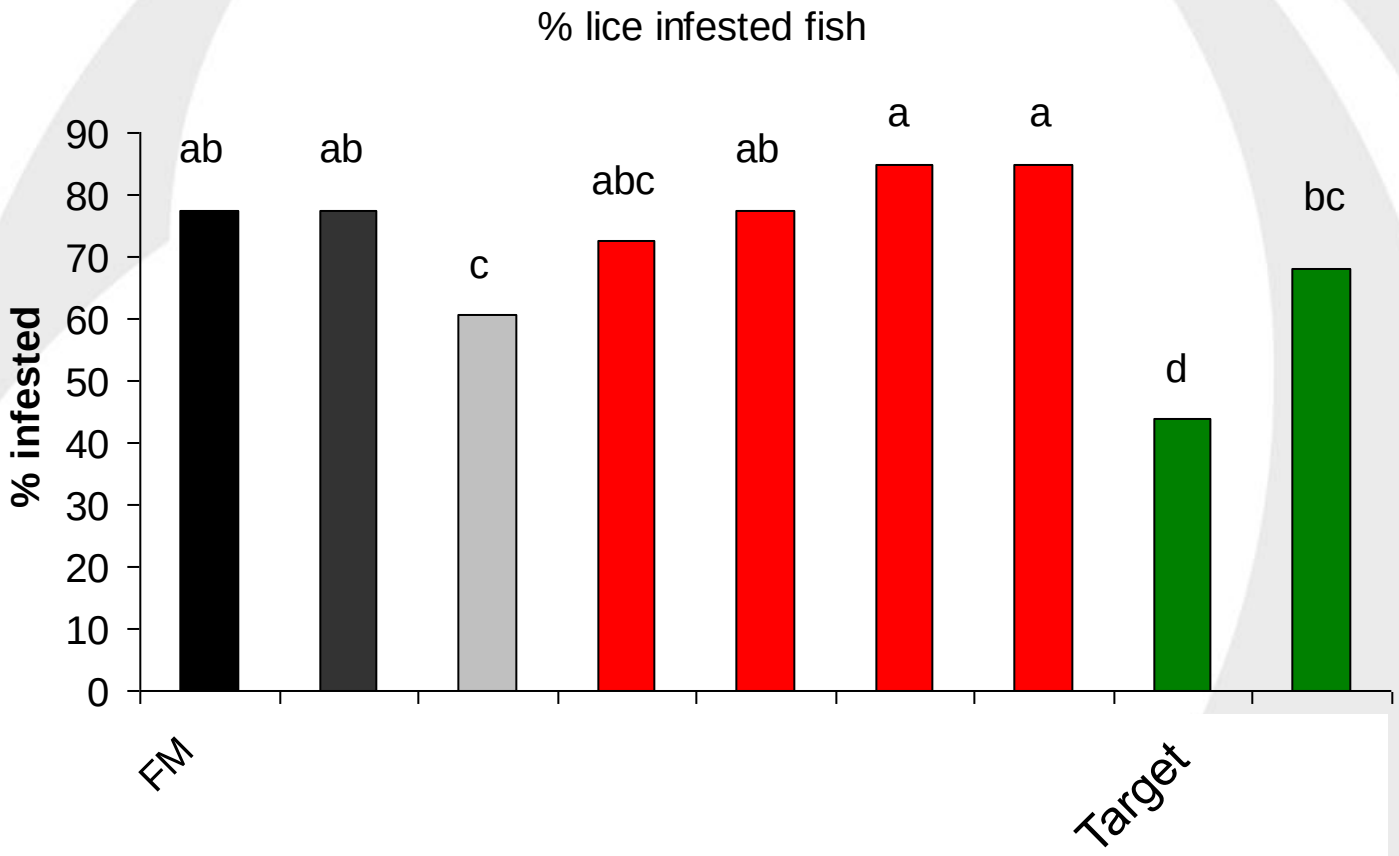
SKRETTING

Fish and Facilities

S. Refstie, G. Baeverfjord,
R. Ripman Seim, & O. Elvebø

- Location: Nofima's model sea farm at Averøy
- Fish: Atlantic salmon
  IBW = 680 g; 150 fish / pen
- Pens: 27 5 x 5 x 5 m
- Replication: 3 pens / treatment
- Saltwater (12-17 ^{o}C)
- 70 feeding days

Salmon Lice Infestation



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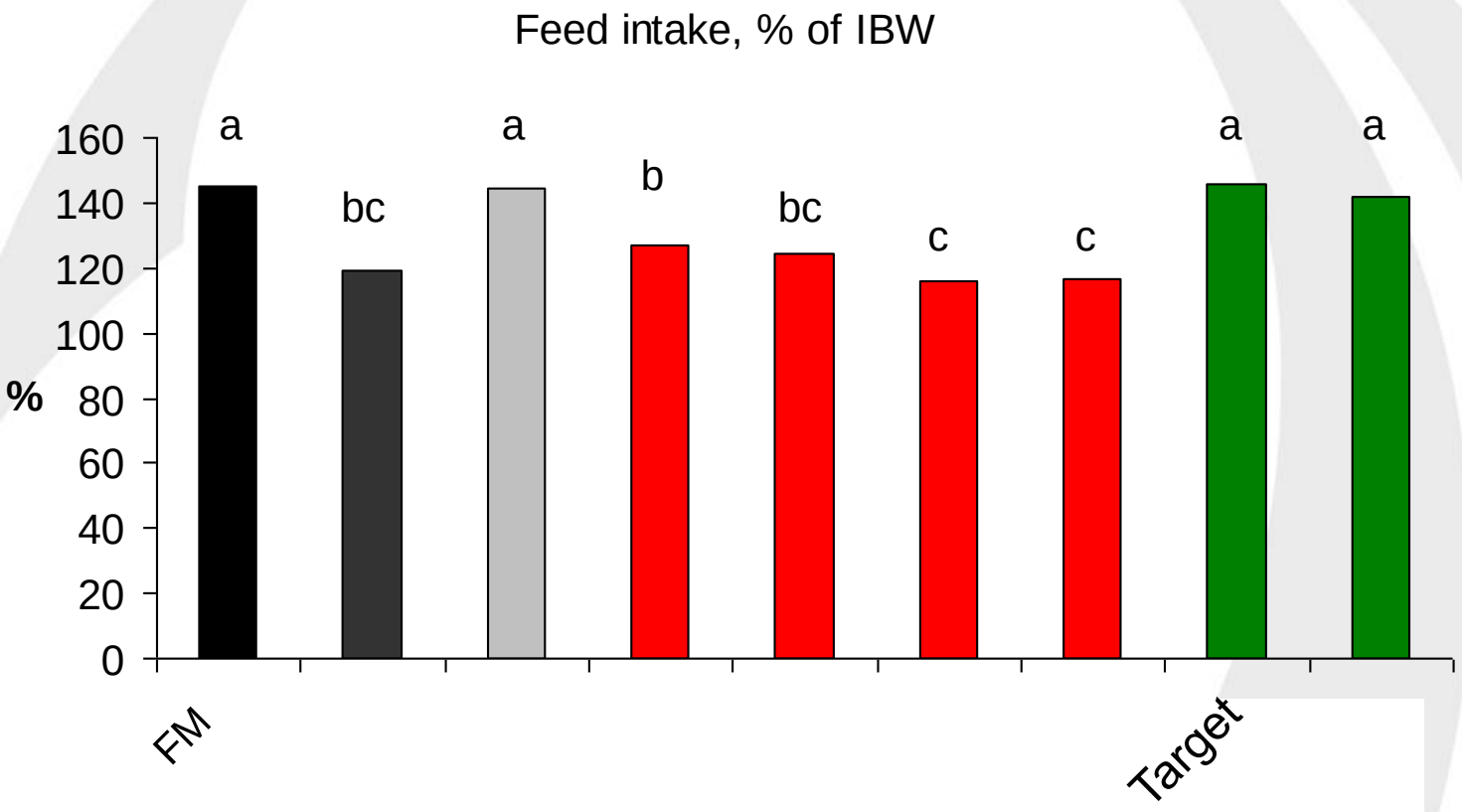
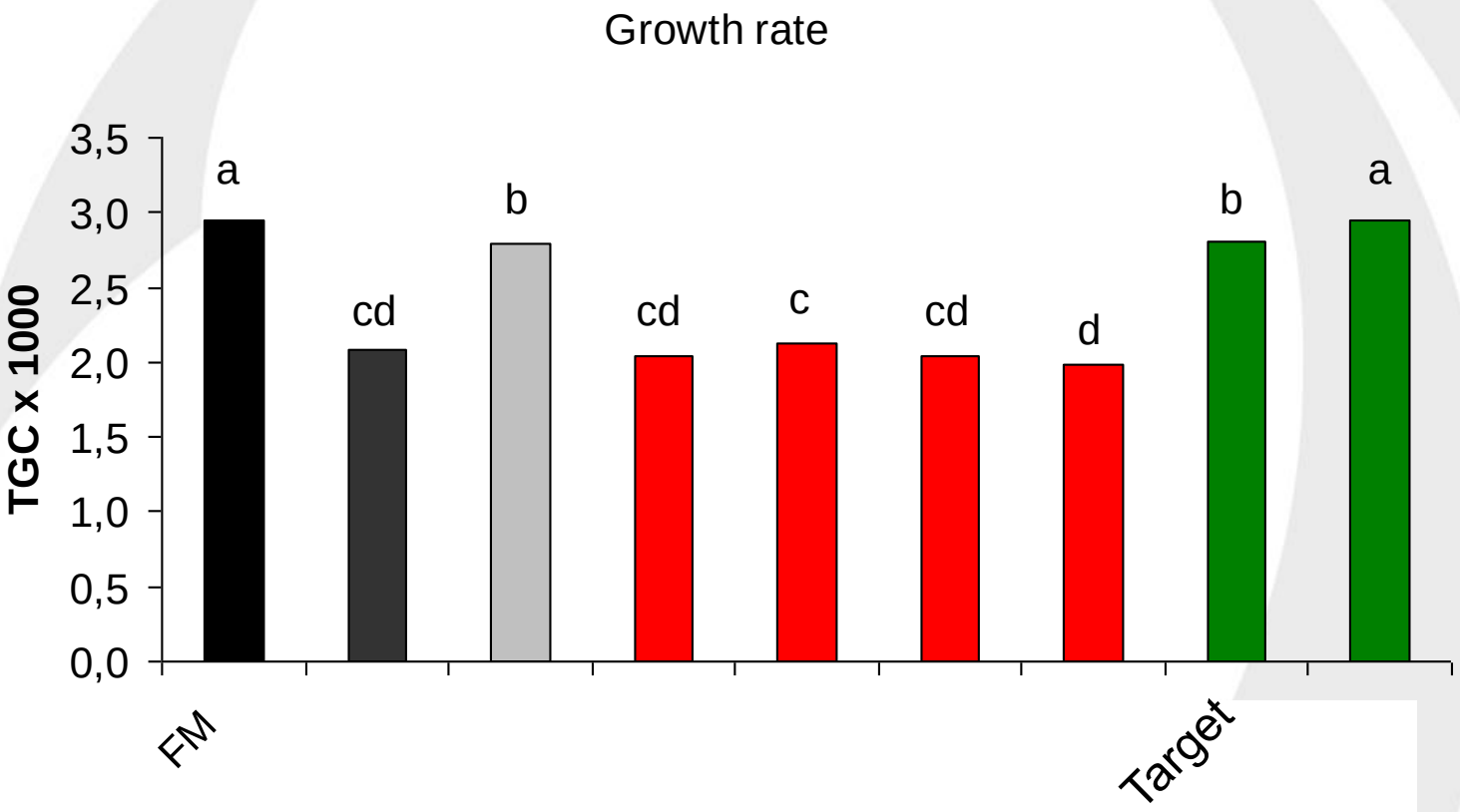
Total Feed Intake, % of IBW



Growth Rate (TGC x 1000)



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What is the effect?

- 43% reduction in the number of fish with lice
- 31% reduction in the number of lice per fish

What does it mean?

- Increase time between alternative sea lice treatments
- Another tool in your lice plan

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How is Target used?

- Target Lice in 4 + 6 regime
  - 4 weeks Target Lice feeding
  - 6 weeks standard feed
  - 4 weeks Target Lice
  - Cont.

Combine medicative treatment with Target

- Minimum **2 weeks Protec** before bath treatment
  - Aim to maximise fish health leading into the stress of the bath.
  - **Ideally we would use Protec here. ***

- Minimum **4-6 weeks Target** after bath treatment

  ⇒Increased protection against re-infection after treatment. May also increase feed intake during and after treatment.

  ⇒Reconstruct the mucus layer, and make the fish more robust after bath treatment

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The next step

- Testing a wide range of ingredients that have the potential to decrease sea lice attachment
  - Aim: To further decrease sea live attachment
  - Ideally we STOP attachment completely

- CFIA
  - Ingredient registration is a big challenge

Centre for Aquaculture Competence

Feeding your

passion

for fish

SKRETTING

Denaturation of Deltamethrin from Alpha Max Treated Seawater

RPC

Introduction

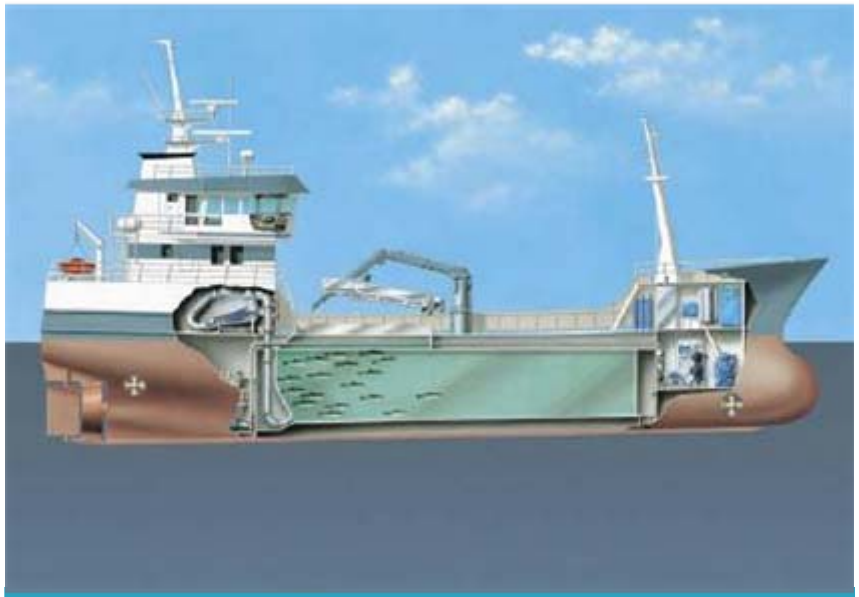
- Sea lice attach to fish feeding on their mucus and tissue impacting the aquaculture industry significantly through the loss of fish
- One way industry controls sea lice infestation is through the use of chemical therapeutants (Alpha Max, Salmosan, Interox Paramove 50, etc.)
- Therapeutant treatment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

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 the active ingredients in the therapeutants prior to discharging the wastewater into the ocean

RPC Research

- Ongoing research is being carried out by RPC to determine the effectiveness of adsorbents and oxidants to either remove or denature residual Deltamethrin in seawater

- This work has been supported by both the Atlantic Canada Fish Farmers Association (ACFFA) and the NB Department of Agriculture, Aquaculture, and Fisheries (DAAF), DFO, the Aquaculture Industry

Chemical Treatment

- 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 on deltamethrin containing seawater

General Bench Scale Procedure

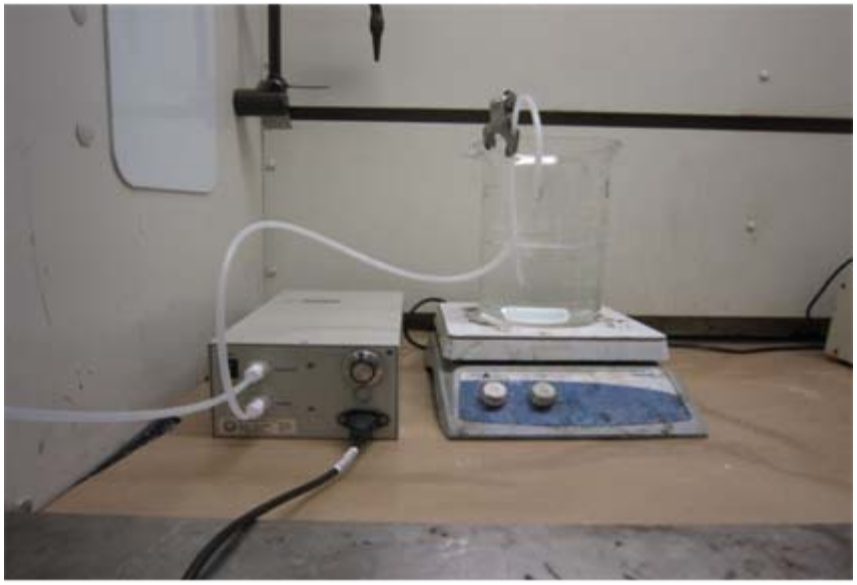
- 1L of seawater containing 2ppb Deltamethrin is made up through a series of dilutions and added to a 2L beaker
- A stir plate/stir bar is used to agitate the solution
- Adsorbent or chemical/chemicals are added and stirred for 30 minutes
- Adsorbent tests stopped by filtering (#2 Whatman)
- Oxidizing chemicals stopped either by chemical addition (sodium thiosulphate) or immediate solvent (DCM) extraction for analyses

Chemical Treatment

Fenton's Reagent

Hydrogen Peroxide

Chemical Treatment



Ozone Apparatus

Deltamethrin Chemical Test Results

- Initial work showed that chemical treatment was effective in denaturing Deltamethrin

Chemical	Dosage (ppm)	Reaction Time (min)	Reduction (%)
H_2O_2	1500-6000	30	72-76
H_2O_2	1500	1-20	75-93
O_3	25-225	30	89-100
$H_2O_2 + Fe^{2+}$	100-1500/1-15	30	93-100
$O_3 + H_2O_2$	225/112	30	99

Result Validation

- Sodium thiosulfate, used to destroy & stop oxidants at the end of the reaction, can denature Deltamethrin by itself
- Needed to find an alternative way to stop the oxidation reaction

Chemical	Dosage (ppm)	Reaction Time (min)	Reduction (%)
$Na_2S_2O_3$	25	30	12

Solvent Extraction

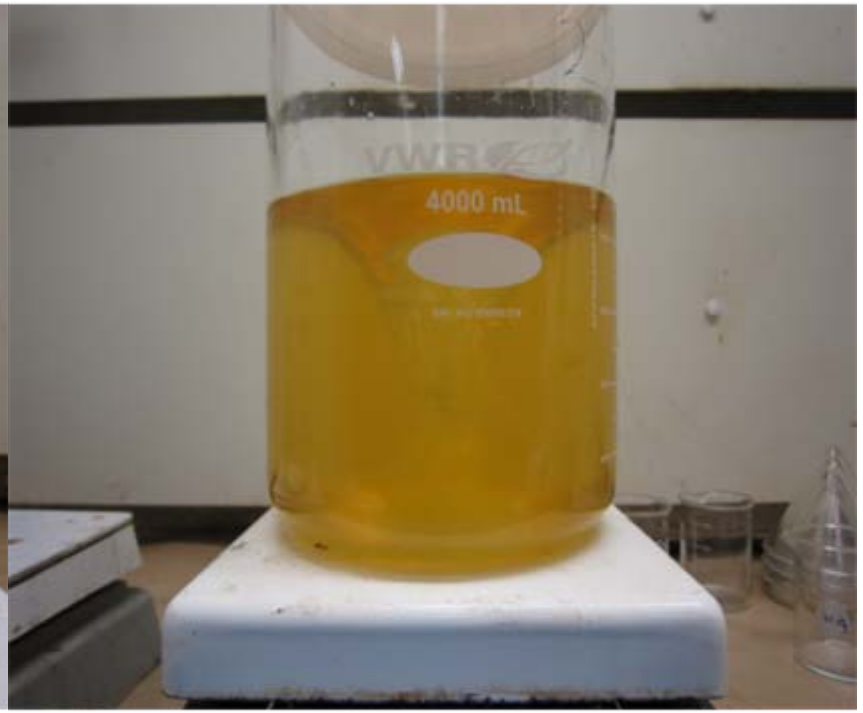
- Solvent extraction with organic solvent removes denaturing products from the aqueous phase containing the oxidants
- Suitable organic solvents included hexane and dichloromethane (DCM)
- DCM chosen – high density (1.33g/mL) relative to water – easier to drain from the separatory funnel

Fenton's Iron Precipitation

- Ferrous sulfate source of iron catalyst
- Fe oxide precipitated out of solution during the reaction
- Filtering out this iron precipitate impacted on the results
- Fe oxide precipitate – adsorbent for Deltamethrin
- Fe precipitate difficult to filter/no ocean discharged
- Alternate non precipitating Fe sources

Chemical	Dosage (ppm)	Filtered	Reaction Time (min)	Reduction (%)
H2O2:Fe	100:1	Yes	20	97
H2O2:Fe	100:1	No	20	62
H2O2:Fe	100:1	Yes	30	98
H2O2:Fe	100:1	No	30	59

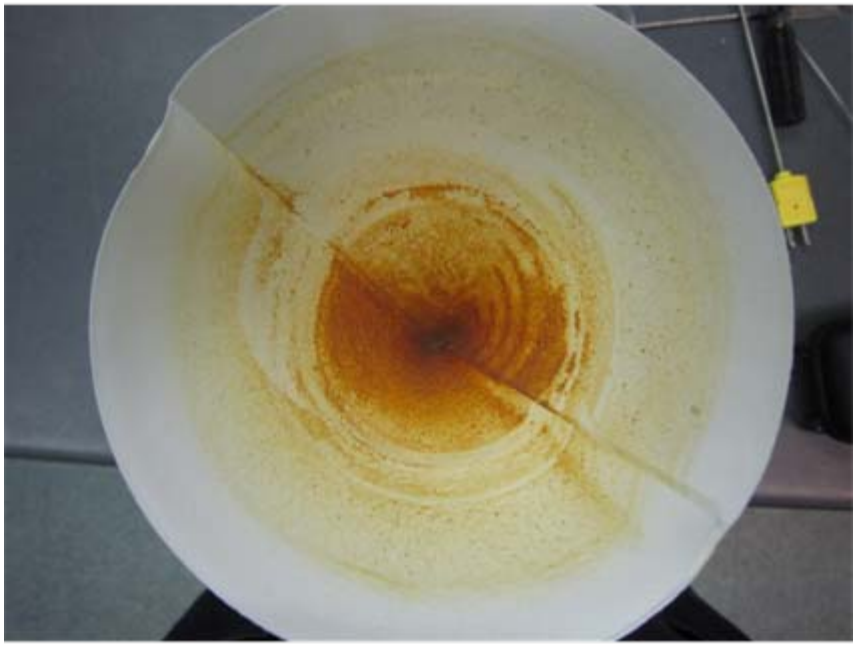
Iron Oxide Precipitation



Fe^{2+} Solution

+ H_2O_2 = Fenton's Reagent

Iron Oxide Precipitation



Filtration

Iron Precipitation Tests

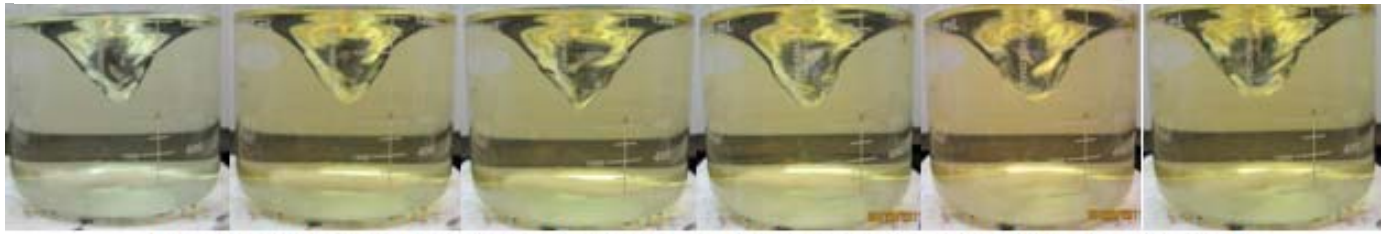
Iron Source	Fe (ppm)	H_2O_2 (ppm)	Precipitate (120min)
EDTA Ferric Sodium Salt	10	1000	Yes
Ferric Citrate	10	1000	No
Ferric Chloride	10	1000	Yes
Ammonium Ferrous Sulfate	10	1000	Yes
Ferrous Sulfate	10	1000	Yes

Fe Precipitation Tests

(1L, 30min stirred, 120min total)

Fe Precipitation Tests

EDTA Ferric Sodium Salt Fenton Reaction, From Left to Right: 0-30min ¶



Ferric Citrate Fenton Reaction, From Left to Right: 0-30min ¶

Ferric Chloride Fenton Reaction, From Left to Right: 0-30min ¶

Ammonium Ferrous Sulfate Fenton Reaction, From Left to Right: 0-30min ¶

Ferrous Sulfate Fenton Reaction, From Left to Right: 0-30min ¶

Chemical Treatment

- Ferric citrate's efficiency as a catalyst for Fenton's reagent tested relative to that of ferrous sulfate
- A series of tests designed to validate previous results using ozone and Fenton's reagent as the denaturing agent
- A DCM solvent extraction used to stop all reactions
- Fenton's reagent validation tests were done using ferric citrate as the source for the iron catalyst

Denaturing Tests (No Precipitation)

Denaturing Agent	Iron Source	Denaturing Agent Dosage (ppm)	Deltamethrin Denatured (%)
H_2O_2 + Fe	EDTA Ferric Sodium Salt	100 (H2O2) + 1 (Fe)	59
H_2O_2 + Fe	Ferric Citrate	100 (H2O2) + 1 (Fe)	64
H_2O_2 + Fe	Ferrous Sulfate	100 (H2O2) + 1 (Fe)	57
H_2O_2 + Fe	Ferric Citrate	250 (H2O2) + 1 (Fe)	61
H_2O_2 + Fe	Ferric Citrate	500 (H2O2) + 1 (Fe)	65
H_2O_2 + Fe	Ferric Citrate	1000 (H2O2) + 1 (Fe)	74
H_2O_2 + Fe	Ferric Citrate	1500 (H2O2) + 1 (Fe)	78
O_3	N/A	100	100
O_3	N/A	150	100
O_3	N/A	250	97
H_2O_2 + Fe	Ferric Citrate	500 (H2O2) + 5 (Fe)	39
H_2O_2 + Fe	Ferric Citrate	1000 (H2O2) + 5 (Fe)	49
H_2O_2 + Fe	Ferric Citrate	1000 (H2O2) + 10 (Fe)	57
H_2O_2 + Fe	Ferric Citrate	1500 (H2O2) + 15 (Fe)	84

Dissolved Ozone

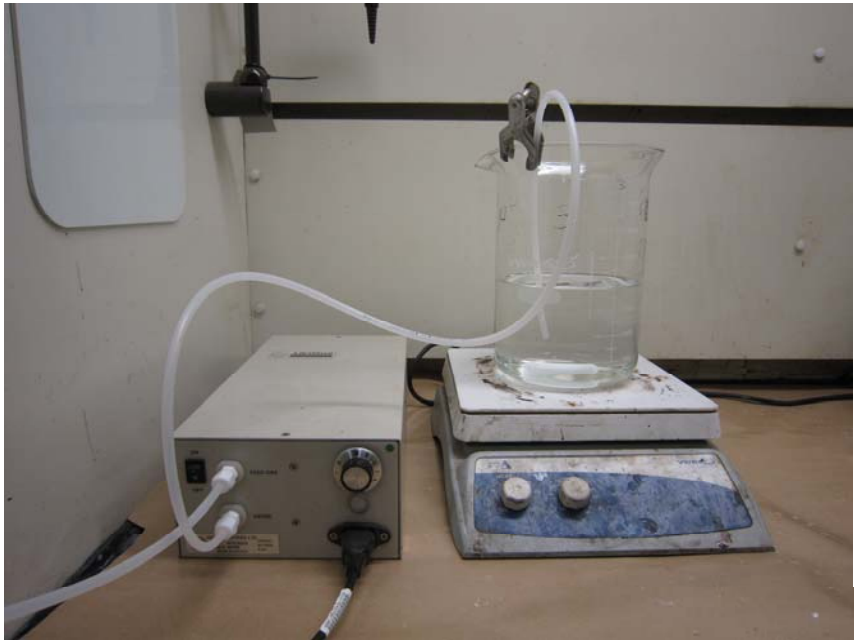
- Fish sensitive to ozone at low concentrations
- Concentration of dissolved ozone in the tests needed to be defined
- A colorimetric dissolved ozone kit was used to define concentrations
- Two tests were set up to quantify the dissolved ozone concentrations: 1 & 100mg/L purged ozone concentrations

Dissolved Ozone

- Seawater solutions: 2ppb Deltamethrin
- Ozone purging stopped after 30min
- Sampled for Deltamethrin analysis

Ozone Purge Rate (mg/30min)	Solution Volume (L)	Dissolved Ozone After 30min (mg/L)	Deltamethrin Denatured (%)
100	1	>2	100
100	100	0.3	45

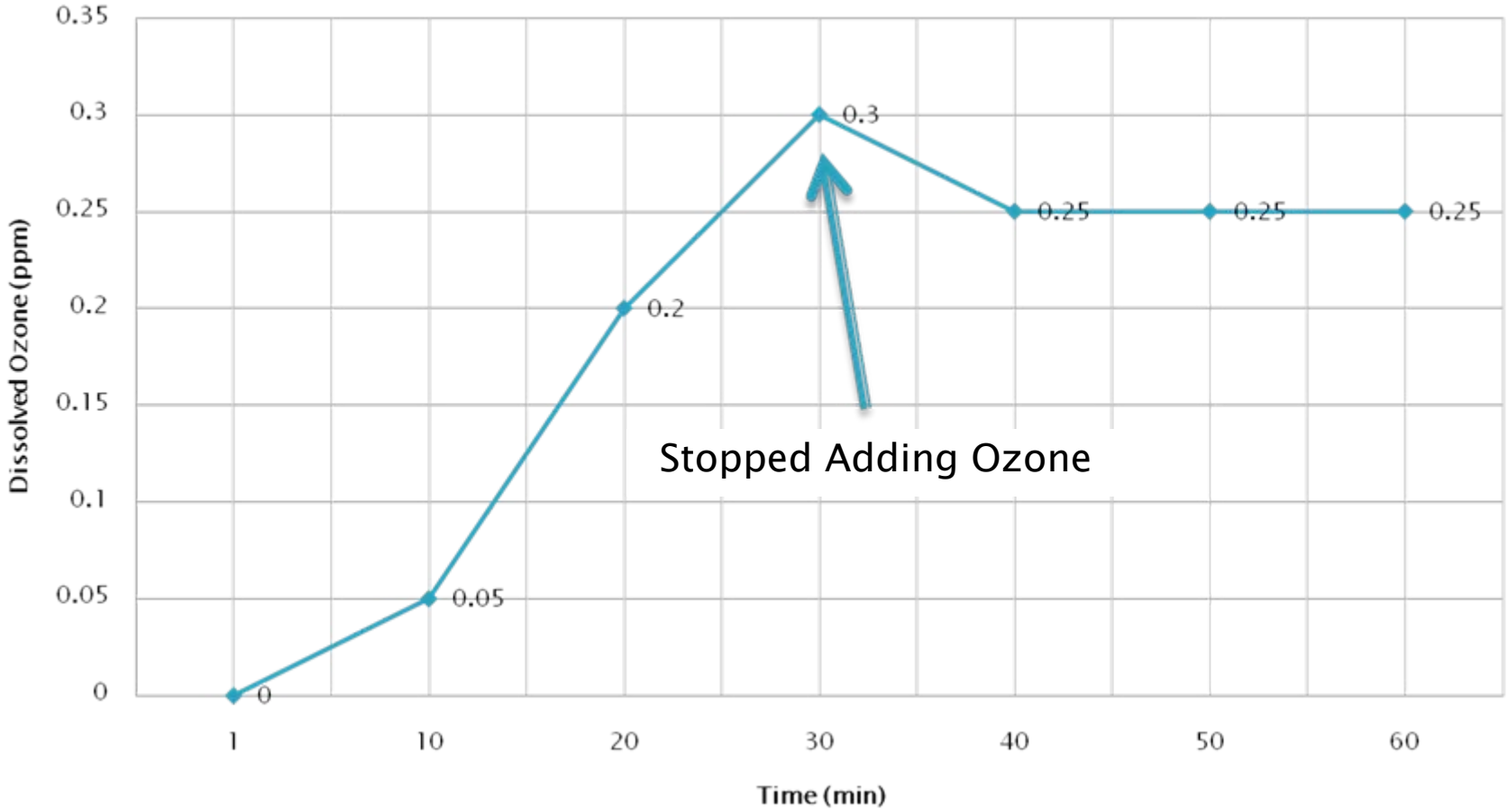
Dissolved Ozone



1L Test

100L Test

100L Dissolved Ozone Test



Fenton's Reagent Staged Addition

- Deltamethrin adsorbs to iron oxide from Ferrous Sulfate in a hydrogen peroxide environment.
- Subsequent additions of hydrogen peroxide were added to the solution in specified time intervals to investigate if adsorbed Deltamethrin would be easier to denature

Fenton's Reagent Staged Addition

Stage 1		Stage 2		Stage 3		Result
H_2O_2:Fe Dosage (ppm)	Contact Time (min)	H_2O_2 Dosage (ppm)	Contact Time (min)	H_2O_2 Dosage (ppm)	Contact Time (min)	Deltamethrin Denatured (%
100:1	30	500	10	N/A	N/A	71
100:1	30	1000	10	N/A	N/A	69
100:1	30	1500	10	N/A	N/A	75
400:1	5	400	5	400	5	65

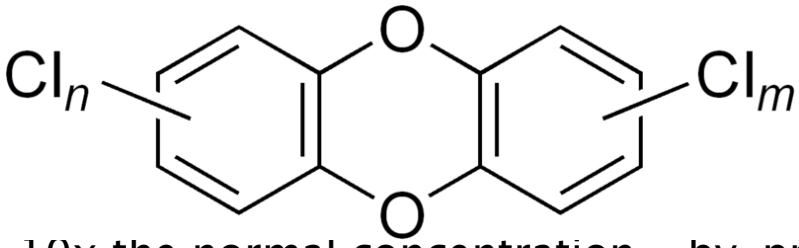
Denatured Product Characterization

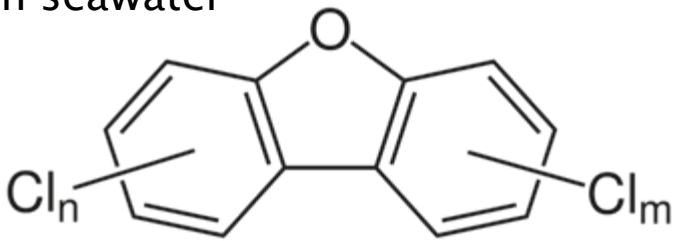
- Tests 10x the normal concentration to make any by-product peaks more pronounced
- Gas Chromatography/Mass Selective Detection (GCMS) General Scan used to identify solvent extractable compounds
- Detected compounds identified using a mass spectral library
- Results pending

Denaturing Agent	Denaturing Agent Dosage (ppm)	Deltamethrin Concentration (ppb)
O_3	1000	0 (Blank)
O_3	1000	20
H_2O_2 + Fe	15000 (H2O2) + 15 (Fe)	0 (Blank)
H_2O_2 + Fe	15000 (H2O2) + 15 (Fe)	20

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

Denaturing Agent	Denaturing Agent Dosage (ppm)	Deltamethrin Concentration (ppb)
O_3	1000	0 (Blank)
O_3	1000	20
H_2O_2 + Fe	15000 (H_2O_2) + 15 (Fe)	0 (Blank)
H_2O_2 + Fe	15000 (H_2O_2) + 15 (Fe)	20

Colby Pierce Visit

Colby Pierce @ Bayside Wharf

Peroxide Storage Tank

Colby Pierce Visit

Colby Pierce Positioned Along Sea Cage

Pumping Salmon into Well for Treatment

Existing Equipment

Therapeutant Dose Tank

Ozone Generator System

Adsorbent Treatment

- Adsorbent treatment of wastewaters and drinking water to remove pesticides and other organics is commonly used
- RPC research is focusing on investigating activated carbon, diatomaceous earth, and zeolite as potential adsorbents
- Activated Carbon - processed microporous carbon
- Diatomaceous Earth – siliceous sedimentary rock composed of porous fossilized diatoms (type of hard shelled algae)
- Zeolite - microporous, aluminosilicate minerals often know as "molecular sieves"

Deltamethrin Adsorption Test Results

Test #	Adsorbent	Retention Time (min)	Dosage (g/L)	Concentration (ppb)	Reduction (%)
Head	-		-	1.7	0
1	Activated Carbon	30	1	0.40	76
2	Activated Carbon	30	2	0.38	78
3	Activated Carbon	30	4	0.23	86
4	Activated Carbon	30	8	0.20	88
6	Zeolite	30	8	0.030	98
22	Zeolite	30	4	0.028	98
23	Zeolite	30	2	0.041	98
24	Zeolite	30	1	0.073	96
25	Zeolite	20	8	0.013	99
26	Zeolite	10	8	0.033	98
27	Zeolite	5	8	0.036	98
5	Diatomaceous Earth	30	8	0.032	98
13	Diatomaceous Earth	30	4	0.030	98
14	Diatomaceous Earth	30	2	0.040	98
15	Diatomaceous Earth	30	1	0.083	95
16	Diatomaceous Earth	30	0.5	0.11	94

Filtered #2 Whatman

Deltamethrin

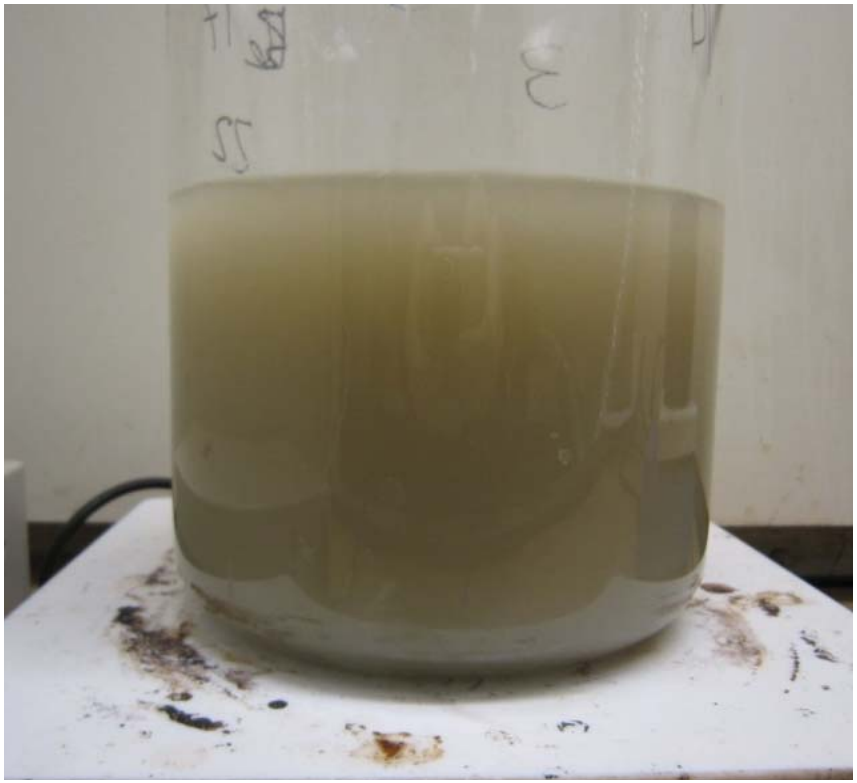
Adsorbent Treatment

Activated Carbon

Slurry Suspension

Adsorbent Treatment

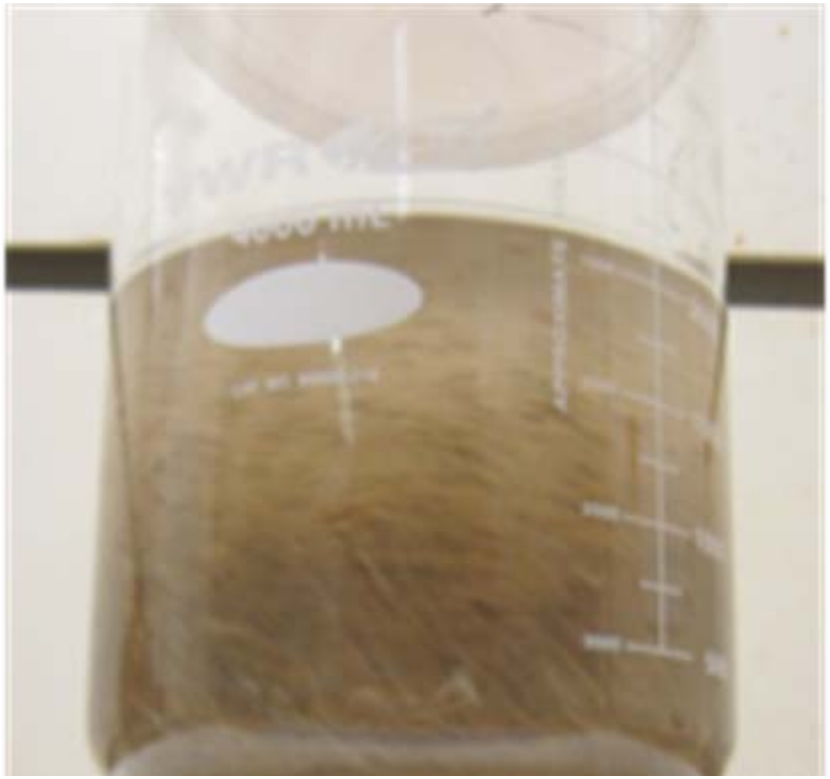
Zeolite



Slurry Suspension

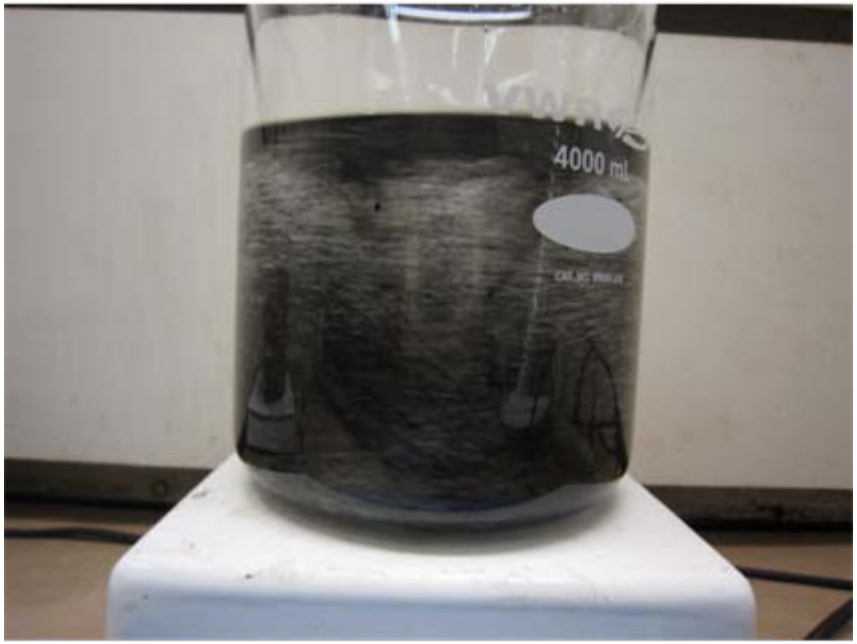
Adsorbent Treatment

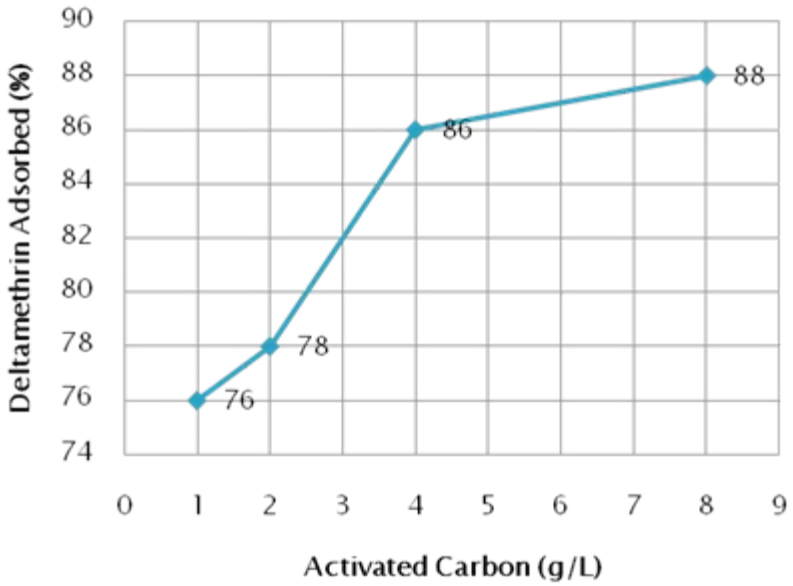
Diatomaceous Earth



Slurry Suspension

Deltamethrin Adsorption Treatment

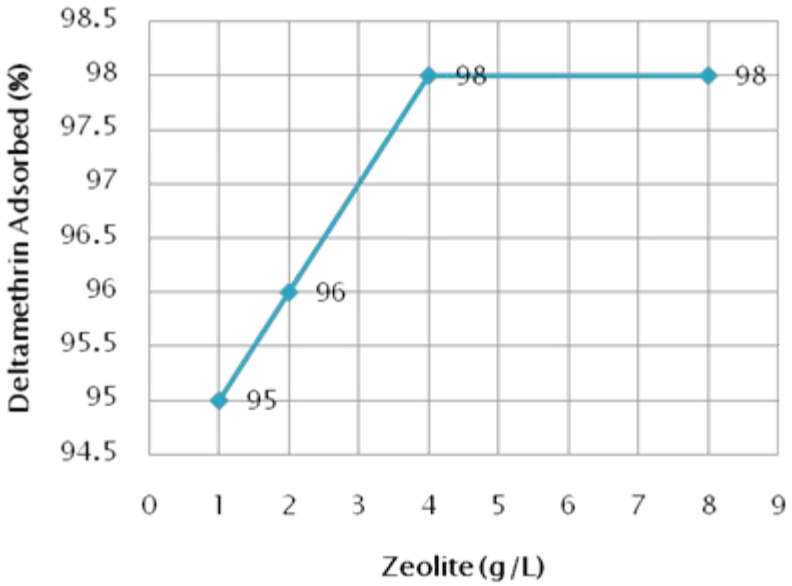




Carbon Black (30 min)

Deltamethrin Adsorption Vs Dosage

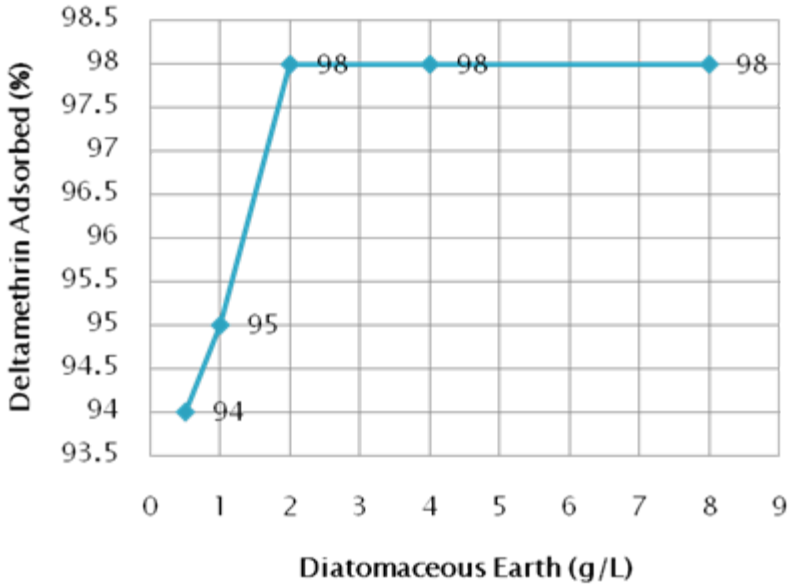
Deltamethrin Adsorption Treatment



Zeolite (30 min)

Deltamethrin Adsorption Vs Dosage

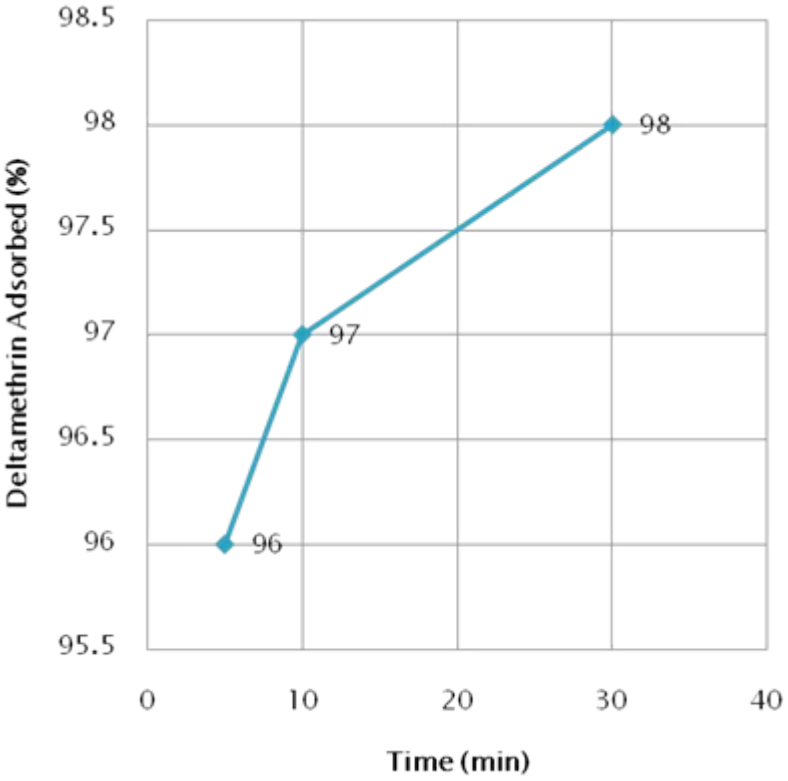
Deltamethrin Adsorption Treatment



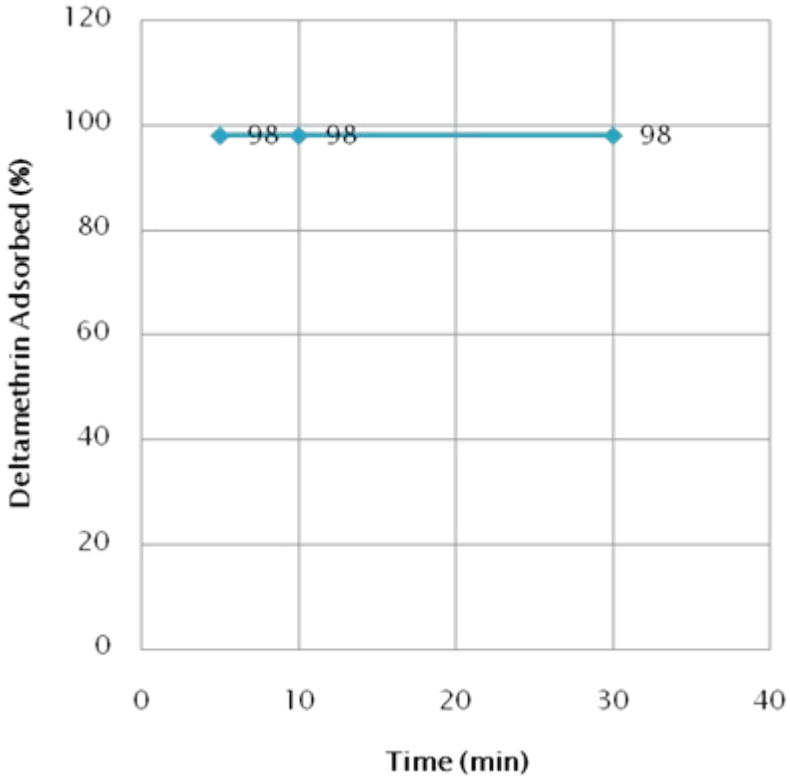
Diatomaceous Earth (30min)

Deltamethrin Adsorption Vs Dosage

Timed Adsorption



Diatomaceous Earth (8g/L)



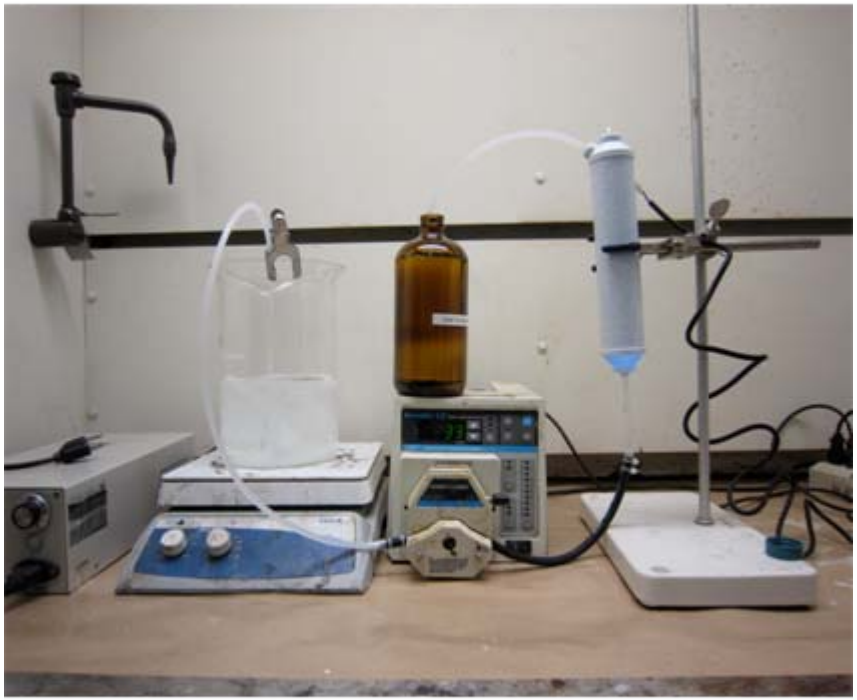
Zeolite (8g/L)

UV Treatment

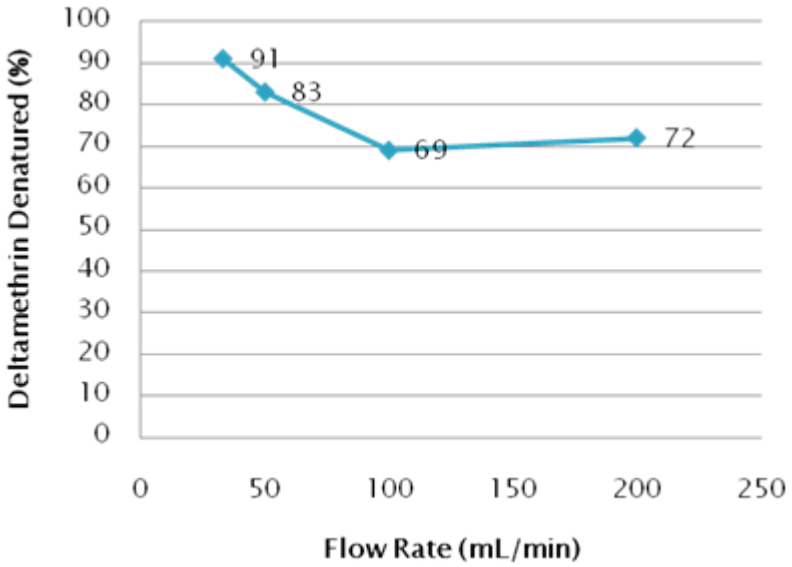
- 2ppb Deltamethrin solution was passed through a UV light source directly into a sample bottle at various flow rates

Flow Rate (mL/min)	Deltamethrin Denatured (%)
33	91
50	83
100	69
200	72

UV Treatment



UV Treatment Setup



Deltamethrin Concentration Vs Flow Rate

The End

Work is still in progress.

FishVet Group

MSD Animal Health

NOVARTIS ANIMAL HEALTH

Managing the Use of Sea Lice Treatments

The view from the Pharmaceutical companies

Pfizer

PHARMAQ

SKRETTING

SOLVAY

The facts

- No active ingredient has ever been developed and licensed specifically for sea lice treatment.
- No new medicine has been introduced since the 1990s.
- Development costs for new sea lice medicine estimated as US$10M in 2000.
  - In addition to basic food & environmental safety testing and assessment costs.
- Environmental monitoring costs
  - Higher than other agricultural sectors.

Available treatments

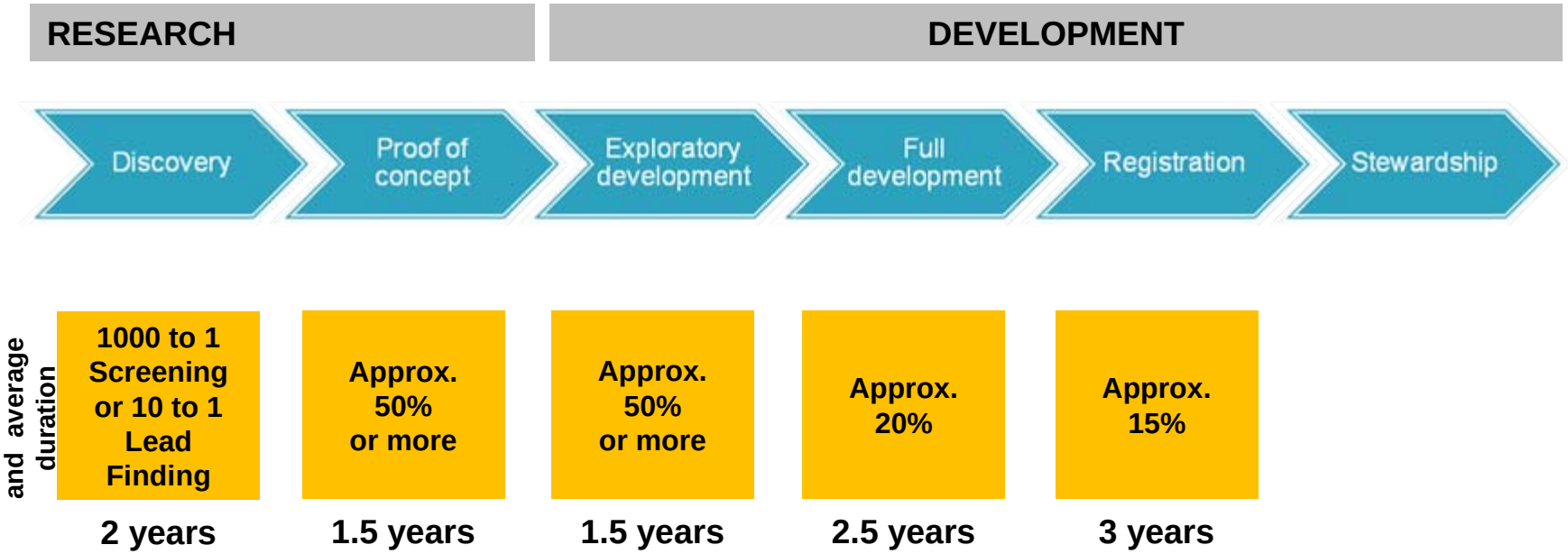
Global

- Salmosan: AZMP
- Interox Paramove: H_2O_2
- Excis: LC cypermethrin
- Calicide: Teflubenzuron
- Releeze: Diflubenzuron
- Alphamax: Deltamethrin
- Betamax: HC cypermethrin
- Slice: Emamectin benzoate

Canada

- Salmosan: AZMP (ER)
- Interox Paramove: H_2O_2 (ER)
- Calicide: Teflubenzuron
- AMX: Deltamethrin (ER ?)
- Slice: Emamectin benzoate

R&D and Roi;
High investment with high risk?



Companion animals
5 years; $33-56 million

Farm animals
up to 10 years; $140-330 million

Fish parasiticides
+5 years environment studies

Parasiticide market

Companion animals
$3600 million

Farm animals
$2400 million

Fish
$450 million

To get a medicine approved

- **Quality** - manufacture in a GMP facility.
- **Safety** - to staff in production and use - GLP/GCP.
- **Safety** - to the patient – the treated fish - GLP/GCP.
- **Efficacy** - against the indicated disease - GCP
- **Safety** -to the environment - GLP.
- **Safety** - to the consumer - GLP.
- **Independent** Expert assessment reports.
- Compile dossier and submit to authorities.

  Pay the fees.

  Assessment by regulatory authorities.

  Address issues.

  Receive Marketing Authorisation.

Licensing costs

	USD
EMEA	
MRL Application*	86,500 / 26,000
MA Application (centralised)	173,600
MA Application	
UK	38,723 / 27,100
Eire	19,534 / 14,548
Norway	34, 611
Canada	98,900 – 148,355
Chile	1,667

To get an approved medicine used in fish farms in Canada

- Generate additional data to satisfy and validate RA consent models.
- Get a farm specific consent, (ER).
- Monitor the environment for active ingredients.
- Monitor the environment for biological impacts.
- **Not required in most other fish farming countries or farming sectors.**

Stewardship: Supporting best practice

- Support the vet, the farmer and the product.
- Monitor efficacy and safety in the field.
- Check lice sensitivity, bioassays.
- Optimise performance in the field to evolving farming practices.
- Publish technical guidance on best use/practice.
- Defend intellectual property.
- Report to authorities – SAE and PVs.

INTEGRATED SEA LICE MANAGEMENT

ISLM

Provides a forum for the exchange of information on the management of sea lice on farmed Atlantic salmon and promotes the development and implementation of environmentally sustainable, integrated control strategies.

Objectives

1. To facilitate the free exchange of information amongst stakeholders including farmers, regulators, research scientists, pharmaceutical companies, wild fishery and environmental interest groups.
2. To identify current best practices in lice control and resistance management and to promote their use in the Scottish salmon farming industry.
3. To provide practical guidance to salmon farmers.
4. To provide information and advice on policy to government and non-governmental organisations and to identify research priorities.

*The ISLM Group first convened in October 1999. It is an informal group and includes representatives of Strathclyde University, Aberdeen University, Rothamsted Research, The Fish Veterinary Society, Scottish Quality Salmon, (SQS), Marine Harvest (Scotland), Fisheries Research Service (FRS), BASF, Novartis Animal Health, Skretting and Schering-Plough Animal Health. A representative from the Scottish Environment Protection Agency (SEPA) attends meeting as an observer. ISLM has links with with research groups both within the UK and abroad.

You can contact the ISLM Group through Scottish Quality Salmon at www.scottishsalmon.co.uk

Copies of this leaflet (produced in February 2005), along with up to date advice, may be downloaded from the ISLM area of the SQS web site.

The generous support of The Crown Estate is gratefully acknowledged

Avoiding Resistance in Sea Lice

INTEGRATED SEA LICE MANAGEMENT

ISLM

ISLM, RUMA & MA holder recommendations

- Use all available approaches, not just medicines.
- All in, all out single year class strategies, fallow, wrasse, feeds.
- Area management.
- Routine monitoring of sea lice populations:
  numbers, life stages and susceptibilities.
- Product rotation - use all available medicines.
  Requires that products are available and can be used.
- Use most appropriate medicine – test sensitivity.
- Avoid consecutive treatments with medicines having the same mode of action on the same lice cohort?
- Use as per medicine data sheet.
- Simultaneous use of different active ingredients discouraged.

Has it worked?

The apparent use of only a few products and the fact that there are few products being developed for sea lice treatment should raise concerns within the industry.

Even drug manufacturers stress the benefits of the availability of a suite of compounds and of the rational application of these products to avoid resistance development.

In fact, several products are now being made available under emergency conditions in Canada because of a severe infestation of sealice in 2009.

An integrated approach to sea lice treatment similar to that employed in Scotland may have allowed the industry to avoid the apparent crisis.

Burridge *et al.*, 2010. Aquaculture 306: 7-23

Developing the tools for Sustainable NA Aquaculture

- Medicine companies are researching new treatments.
- We return profits as investment in Research & Development and sound applied research.

We need:

- Infrastructure for a sound scientific base and laboratories to work on lice, in which we can invest.
- Field stations where the lab findings can be scaled up.
- A regulatory framework which enables field trials to be undertaken.
- Evidence of a mindset which looks to solutions and a sustainable future.

A Preliminary Review of Lobster Survey Data from Cheney Island MF-0503

Benson Aquaculture Ltd.

&

Sweeney International Management Corp

Atlantic Canada Fish Farmers Association
Annual General Meeting

November 2011

Benson Aqua

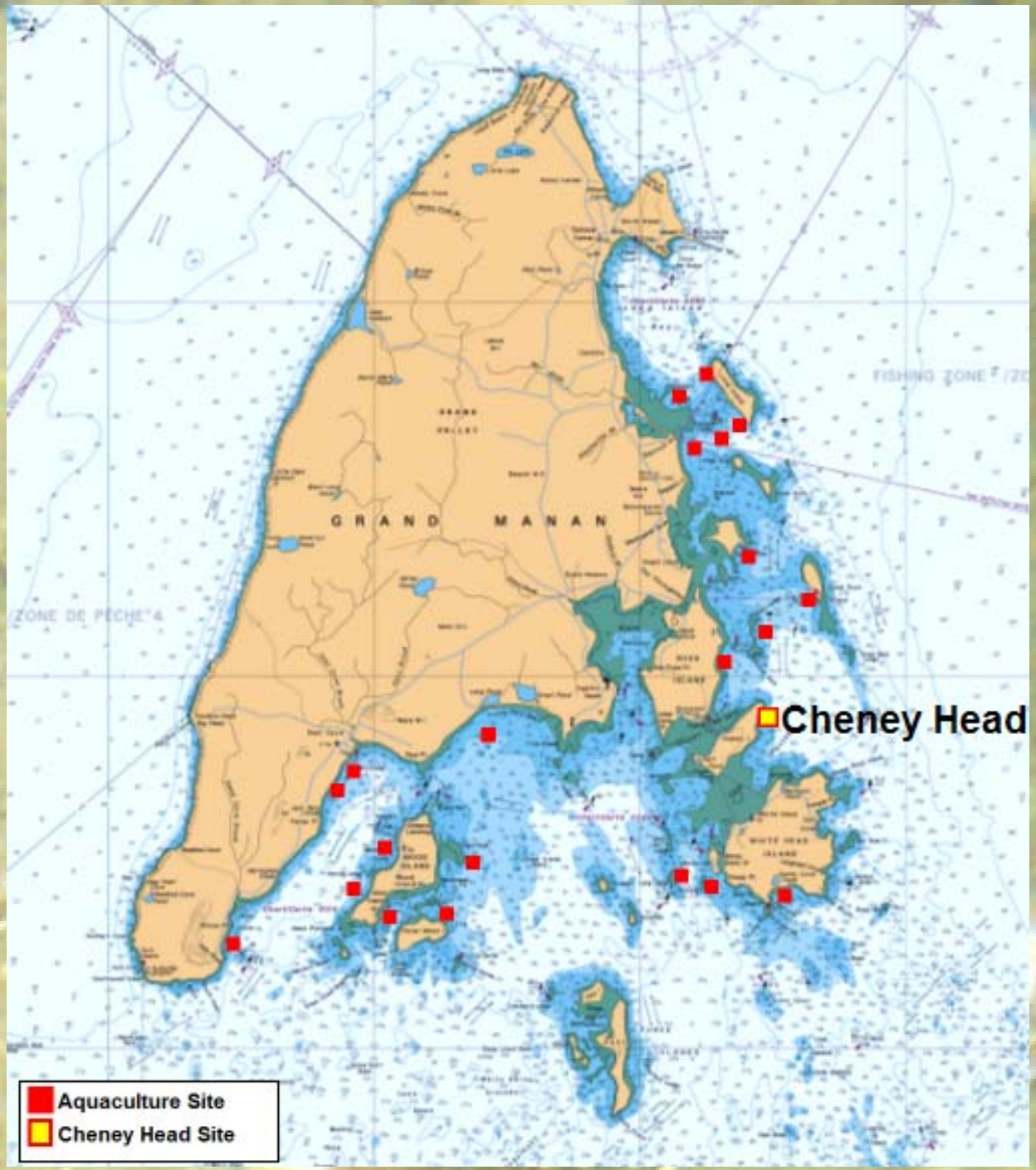
SWEENEY INTERNATIONAL
Management Corp.

Presentation Overview

- Introduction to the project
- Site overview & methods
- Results 2008 - 2011
- Summary
- Tentative conclusions

Area of Study

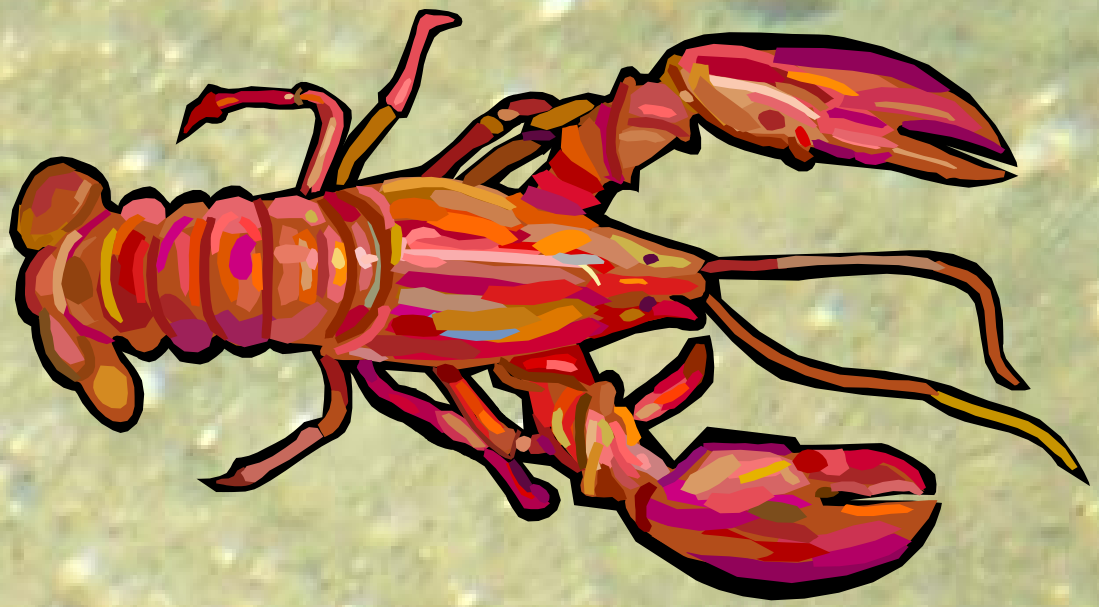
- MF-0503 located on the northeast side of Cheney Island
- Lease area is 26.51 ha



Issues of Concern

- Opposition to the site included concerns for the lobster and scallop industries
  - Juvenile scallop habitat
  - Displacement of fisher harvesters
  - Area was described as a lobster summering ground
  - Concerns then centered on berried females
    - Lobsters may move out of the area (Flaggs Cove cited)

Most Significant Area of Concern

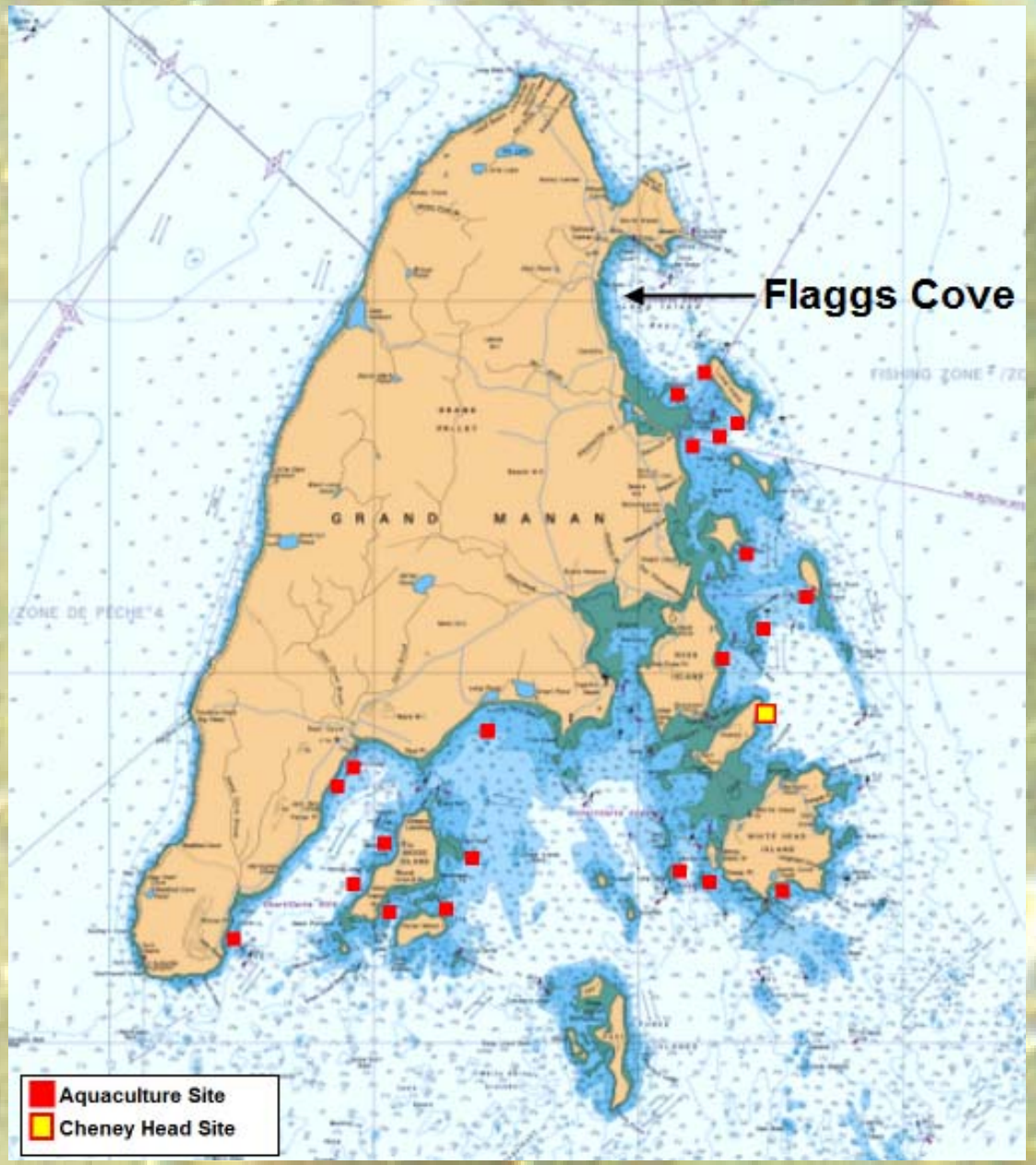


- Lobster population
- Berried female lobster population

Why the concern??

Flaggs Cove

- Known for berried female lobsters
- Aquaculture site was put into place in 1980's
- "Old fashioned" techniques contributed to the demise of the seafloor
- When the site was removed, lobsters returned



Flaggs Cove Comparison

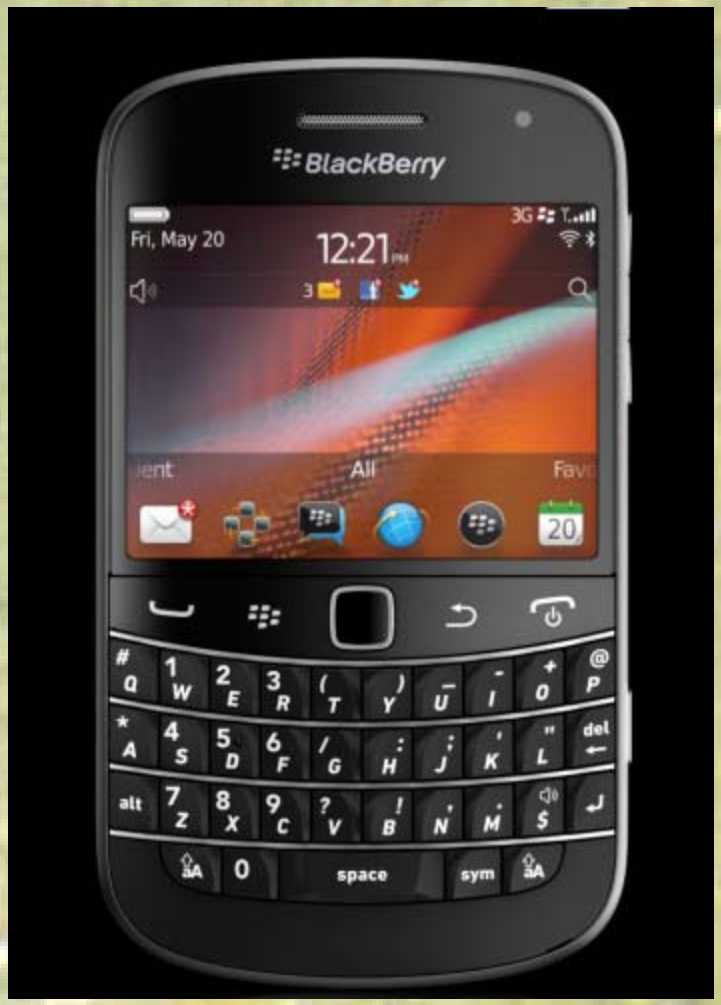
1988

- Moist feed
- FCR was ~3.2:1
- Multiple year classes
- No EMP in place

2008

- Dry feed
- FCR now ~1.2:1
- Single year class
- EMP in place along with a much greater awareness of environmental performance

Just for Fun



Today

1988

Site Approval

- In Oct 2007, the site was approved
- Lobster monitoring became a condition of the lease and was to cover a 5 year period (2008 – 2012)
- Purpose: To assess lobster counts, sizes, sex, egg stage and scallop counts

Survey Protocols

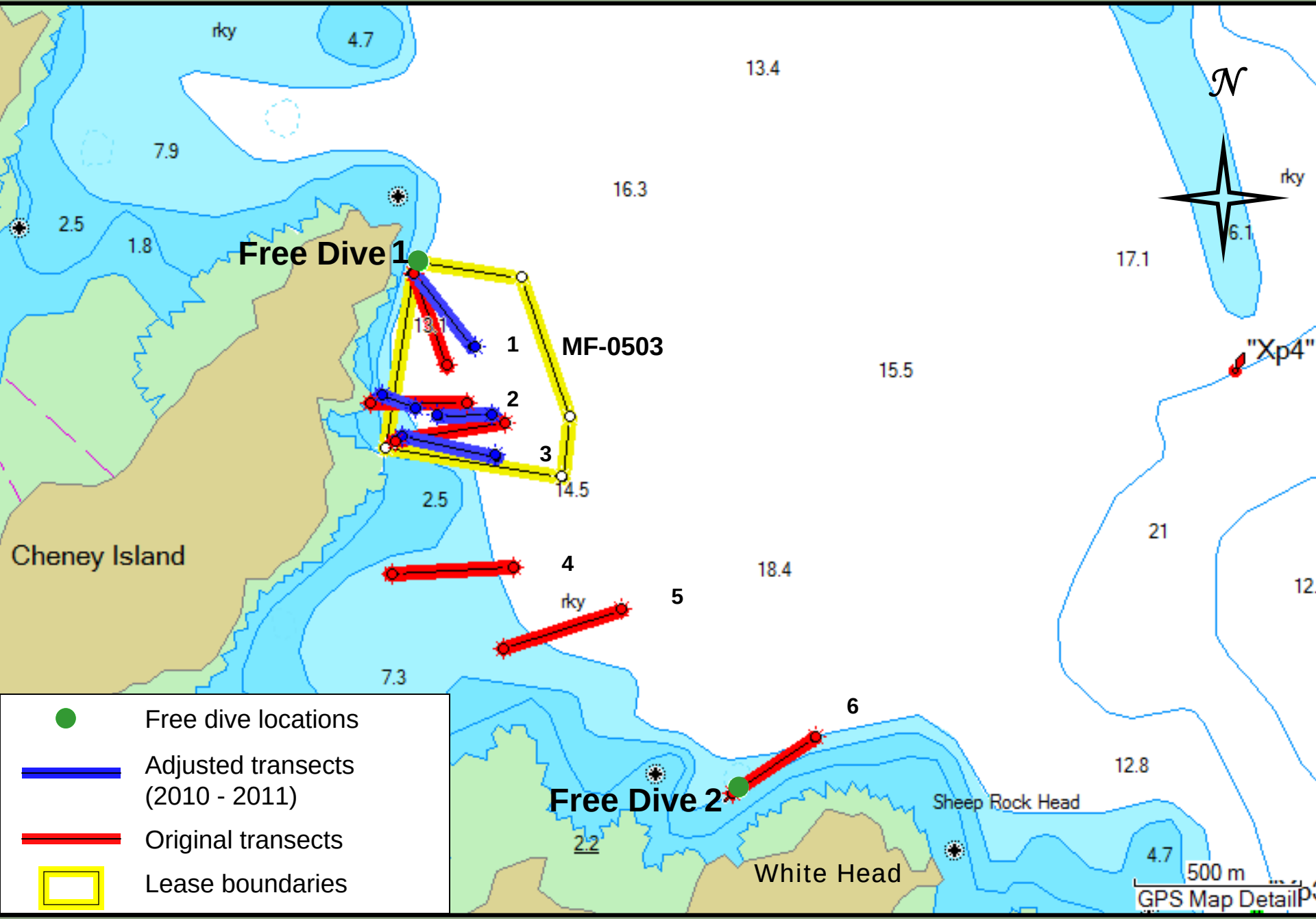
- DFO - SABS did lobster surveys in Sept 2007
- In 2008, we took over the monitoring as a condition of the lease
- 2 surveys per year: within 1st 2 weeks of August & September
  - Timing was to capture the summer population before fall migration (lobsters move inshore as water warms – head offshore in fall)
- Survey of the lobster population within the lease boundaries and at the northern end of Cow Passage

Survey Protocols

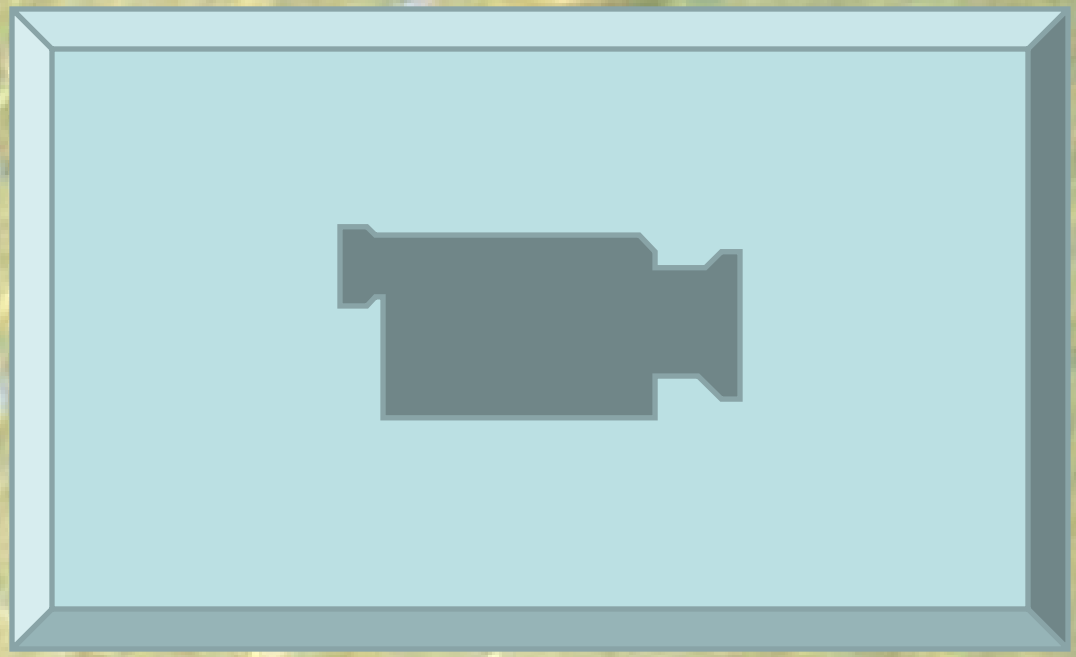
- All our methods followed those of DFO as closely as possible
- In addition, we:
  - Also recorded # of scallops and relative size during each transect dive
  - Video footage
  - EMP survey within 1 week of Sep survey

Methods

- 6 300 m transects
- 2 free, random dive searches 30 – 40 min each, record all lobsters found
- Measure, sex and record condition of all lobsters within 1 m of transect line


rky
4.7
13.4
7.9
16.3
2.5
1.8
Free Dive 1
13.1
1
MF-0503
2
3
14.5
2.5
Cheney Island
4
18.4
rky
5
7.3
6
Free Dive 2
2.2
Sheep Rock Head
White Head
12.8
4.7
500 m
GPS Map Detail
N
rky
6.1
17.1
"Xp4"
15.5
21
Free dive locations
Adjusted transects (2010 - 2011)
Original transects
Lease boundaries

Video Footage

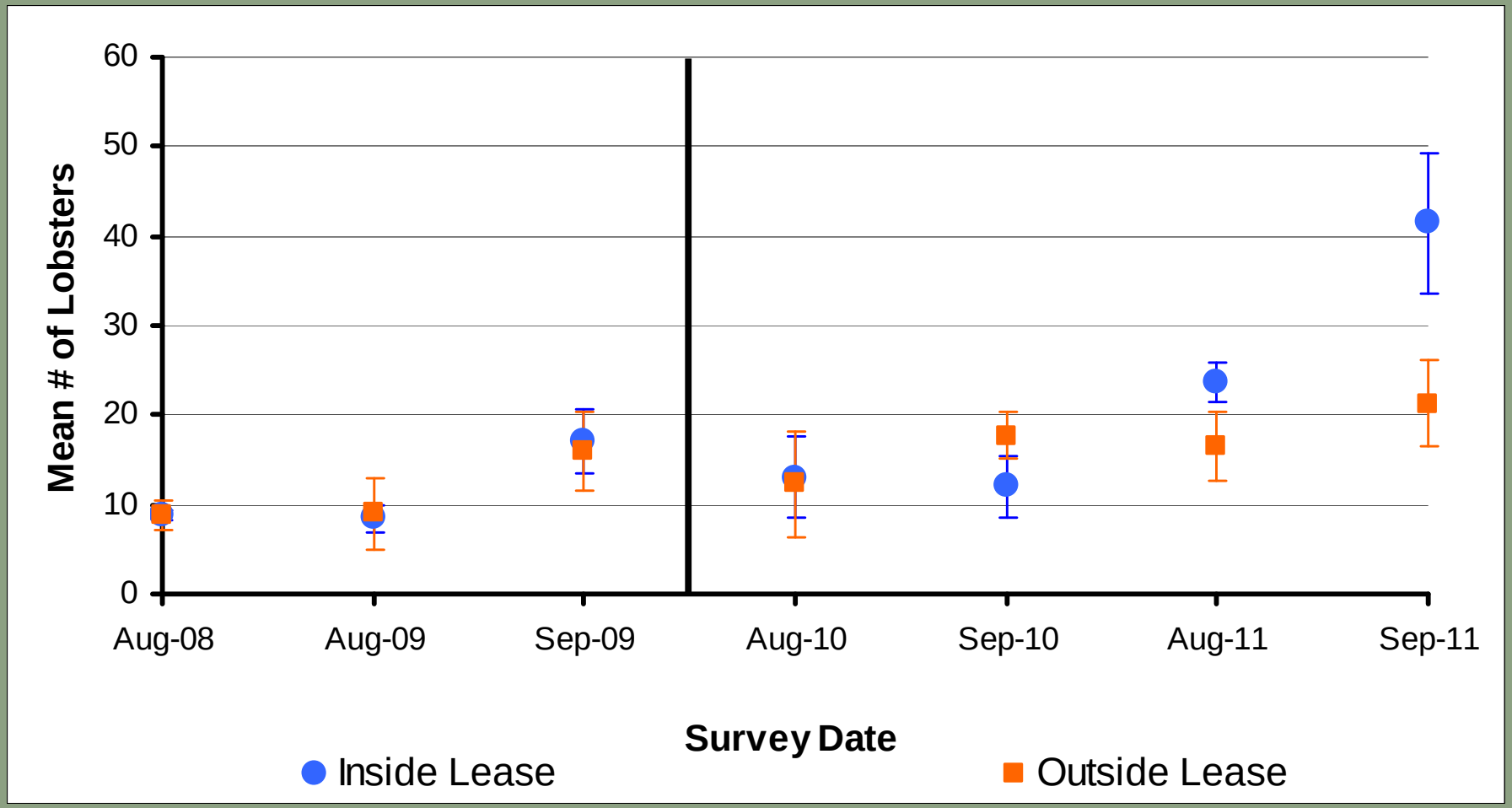


Results

Survey Date	Lobster Total	Within Lease (T1, T2, T3 and Free Dive 1)	Outside Lease (T4, T5, T6 and Free Dive 2)	Male: Female Ratio	# of Berried Females
September 2007	89	54	35		10
August 2008	71	36	35	35:29 (7 unknown)	3
August 2009	70	34	36	36:32 (2 unknown)	4
September 2009	130	68	62	69:59 (2 unknown)	8
August 2010	101	52	49	61:40	4
September 2010	119	48	71	47:65 (7 unknown)	26
August 2011	159	93	66	77:79 (3 unknown)	6
September 2011	251	166	85	137: 112 (2 unknown)	24

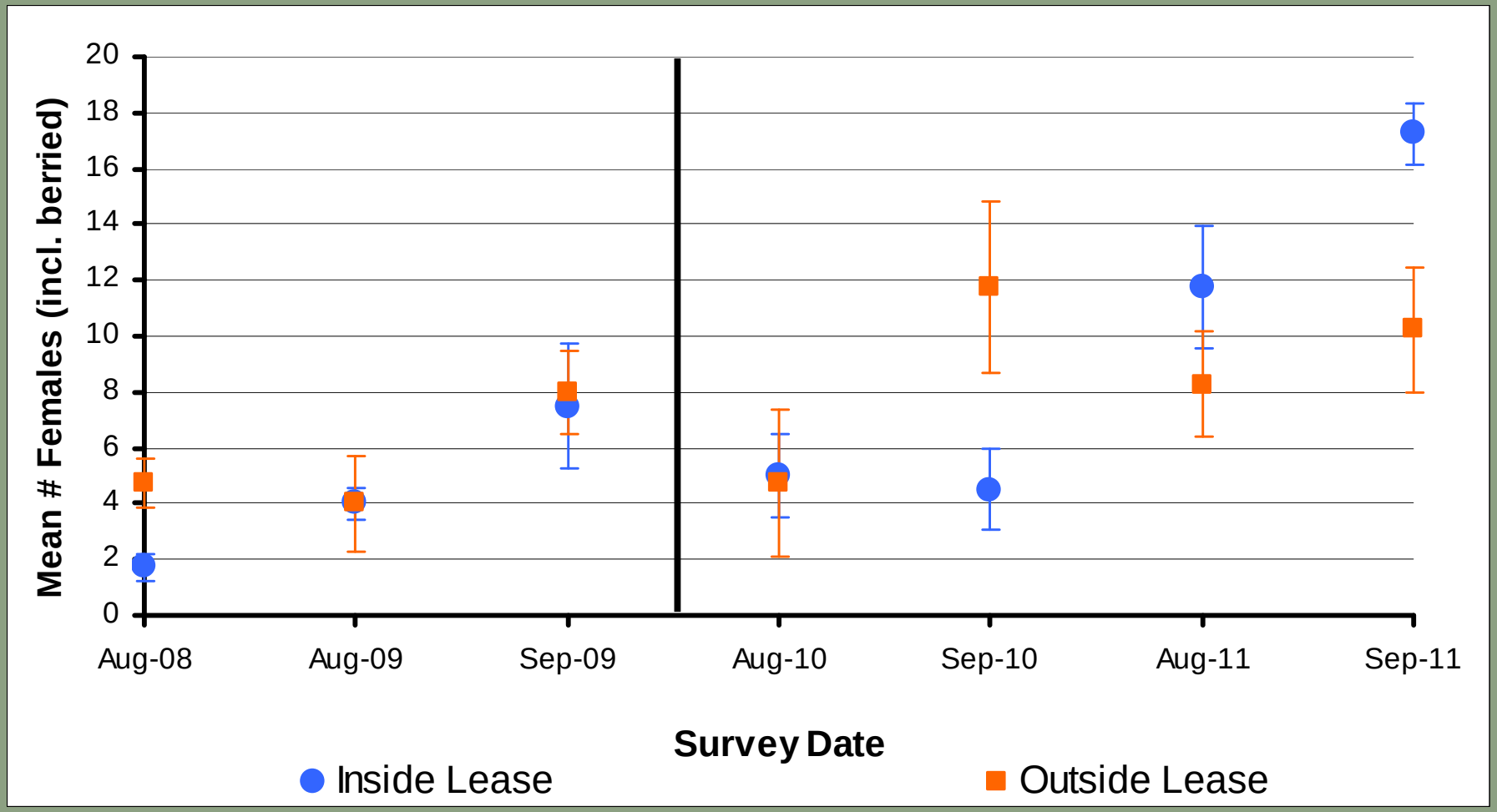
*Spring 2010: site was stocked with 100,000 fish

Lobsters



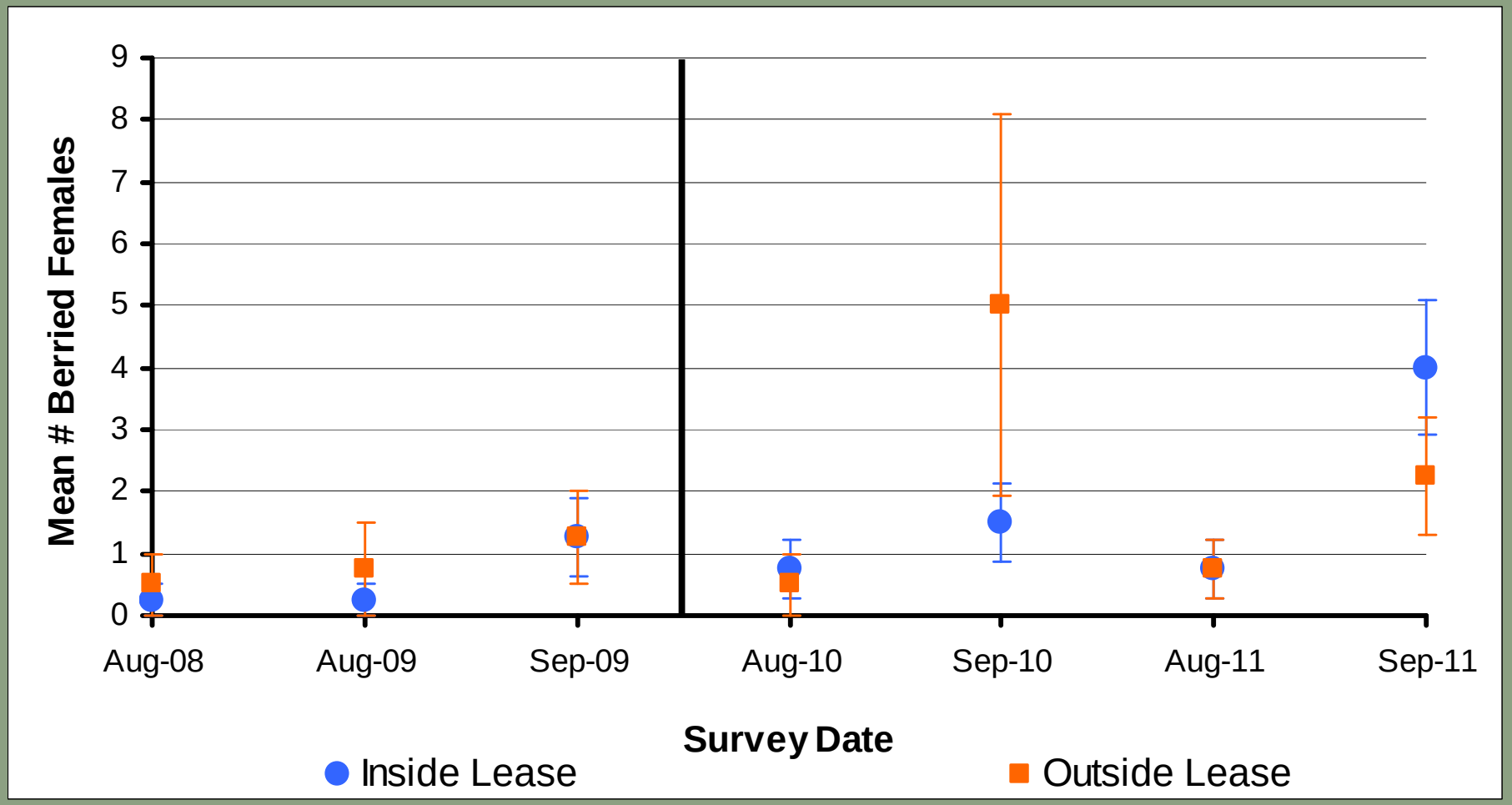
*Based on 3 transects and 1 spot dive per location (n = 4). Error bars represent SE

Females



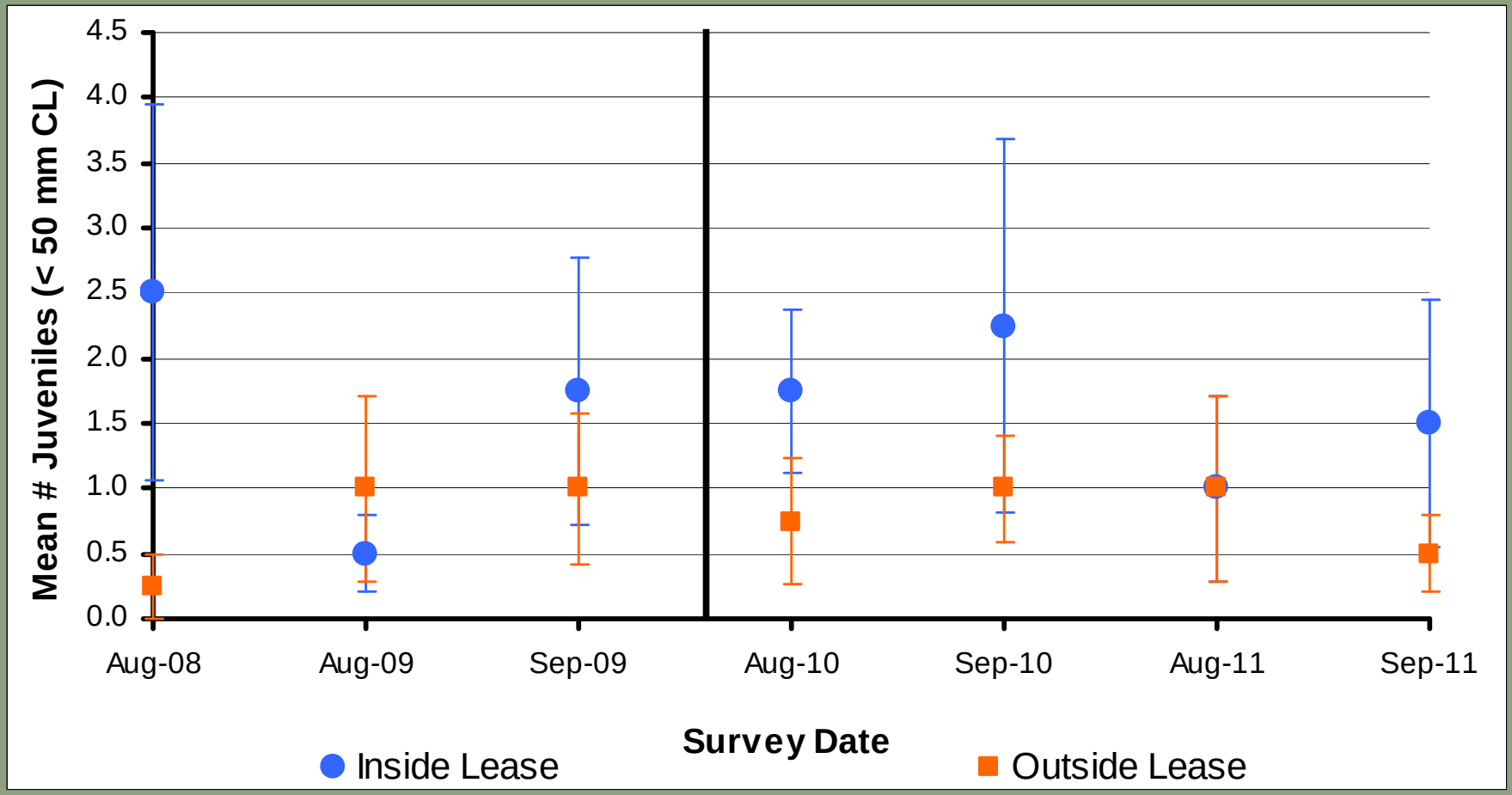
*Based on 3 transects and 1 spot dive per location (n = 4). Error bars represent SE

Berried Females



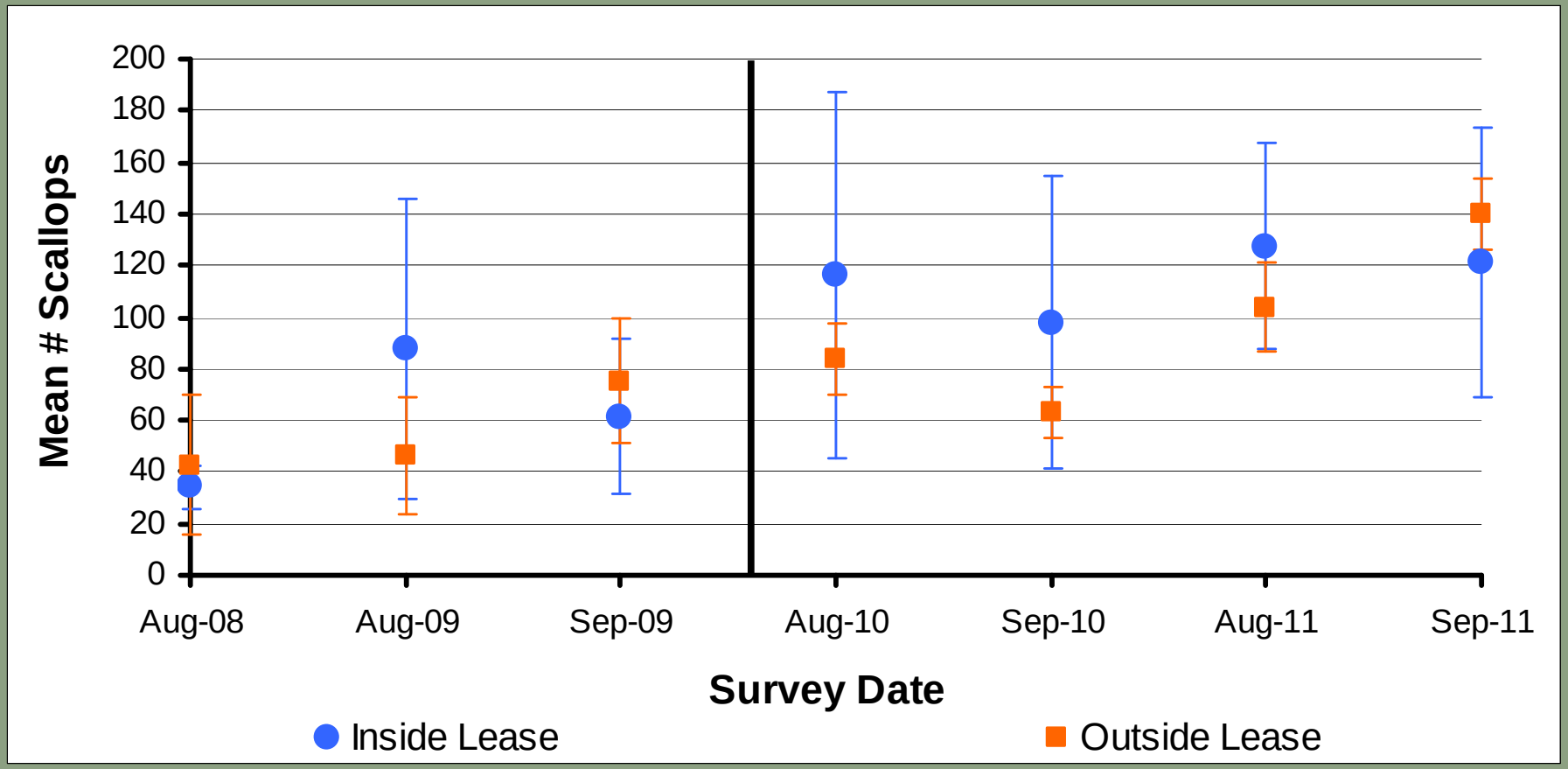
*Based on 3 transects and 1 spot dive per location (n = 4). Error bars represent SE

Juveniles



*Based on 3 transects and 1 spot dive per location (n = 4). Error bars represent SE

Scallops



*Large error bars for “Inside Lease” due to large scallop counts from T1 and low counts from T2

Summary

- Male and female lobsters are fairly equally represented although we see a few more males than females (467 males + 414 females = 904 lobsters) ⟵ all surveys
- Mean # of lobsters inside the lease increased in 2011 whereas outside remained fairly consistent
- Berried female usage of the area in general seems low (most have come from the spot dive locations – closer to shore)
- Juveniles tend to be a little more abundant inside the lease than outside but numbers are low in both areas
- Scallop numbers appear to be increasing
- No apparent significant difference between inside lease and outside regarding scallop presence

Conclusions

- There is no apparent decrease in the use of the lease area by lobsters (male, female, berried or juvenile)
- Scallop numbers have shown an overall increasing trend in the area
- This is only one site with 3 years of baseline data and 2 years of data during operations
- More sites and more years of data (including fallow periods) would help to clarify these findings

Finally….

The Cheney Head aquaculture site does not appear to be having a negative effect on the local lobster populations.

Thank you

Morton Benson

Benson Aquaculture Ltd.

6 Old Factory Roundturn

Grand Manan, NB

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Fax: (506) 467-9503

tdaggett@simcorp.ca

asmith@simcorp.ca

Benson Aqua

SWEENEY INTERNATIONAL Management Corp.

parkscanada.gc.ca

Rearing endangered Inner Bay of Fundy (IBoF) salmon in commercial sea cages for conservation:

A collaborative project with Government, Industry, ASF and Universities

ACFFA Annual Conference

November 23-25th St. Andrews New Brunswick

Corey Clarke, MSc candidate, Resource Management Officer, Fundy National Park

Parks Canada Parcs Canada

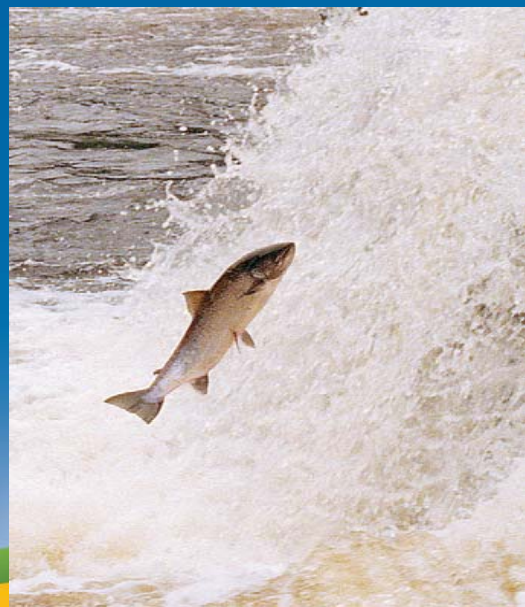
Canada

OVERVIEW

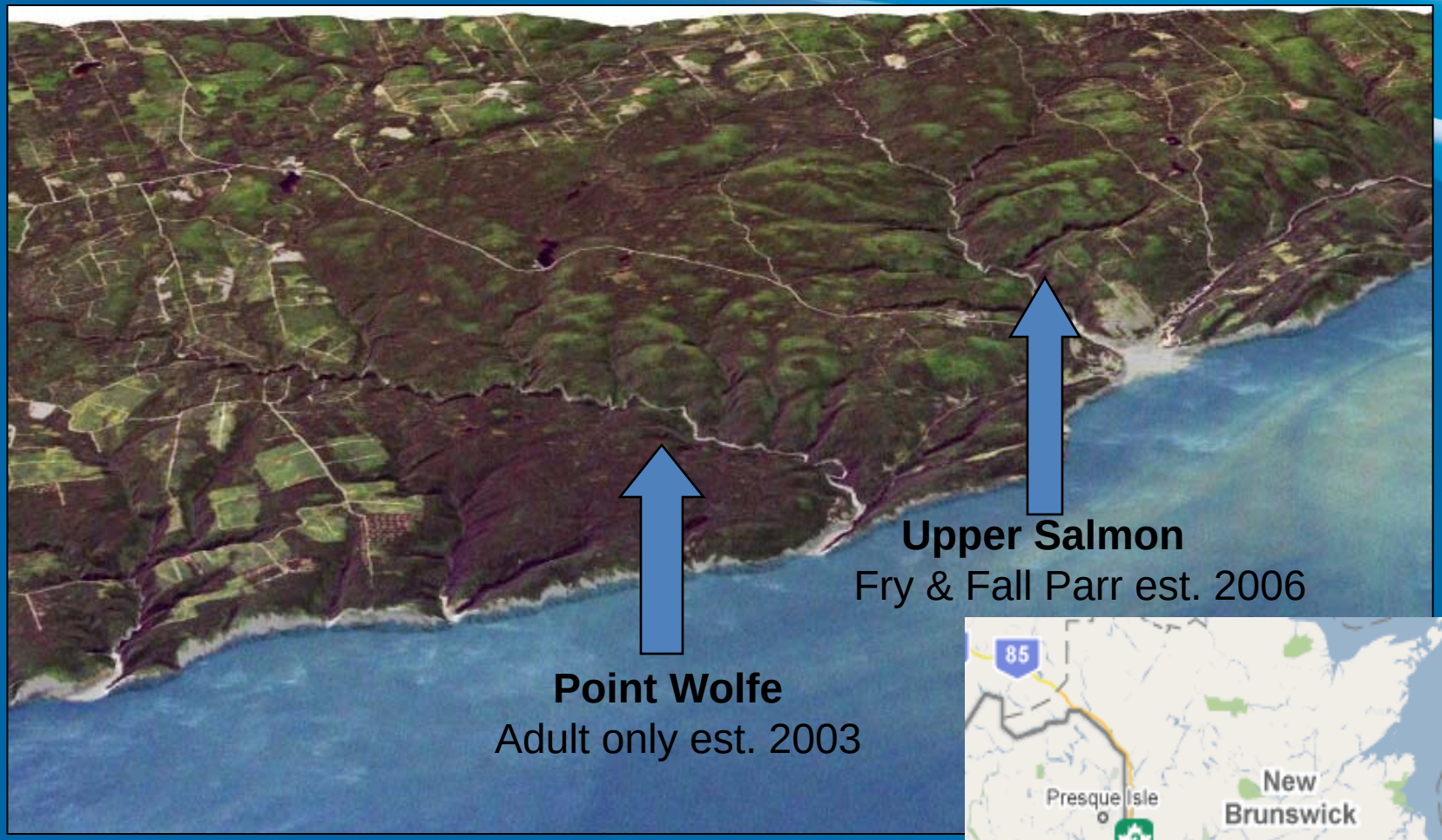
- About IBoF Salmon
- FNP Recovery Program
- Cage project elements
- Preliminary Results
- Discussion

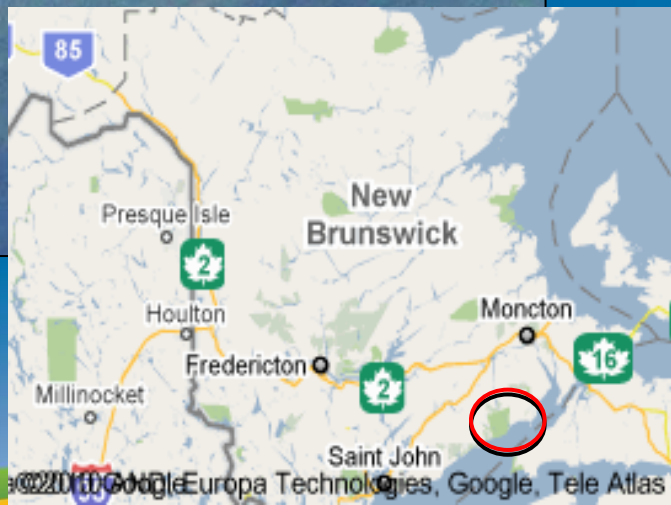
Why are IBoF Salmon Endangered?

- Parks Canada is committed to the recovery of SAR in Parks for all Canadians' enjoyment
- Historic returns of more than 40,000, have been reduced to as few as 250
- Marine survival considered to be most limiting recovery.
- Listed by COSEWIC ‘01 =Assess
- Listed Federally in ’03 = Action



FNP Rivers


Upper Salmon
Fry & Fall Parr est. 2006
Point Wolfe
Adult only est. 2003


85
Presque Isle
New Brunswick
2
Houlton
Moncton
Fredericton
16
2
Millinocket
Saint John
©2010 Google Europa Technologies, Google, Tele Atlas

3yr Assessment (‘01- ’03)

Conclusions from ‘01-’03 Assessment of FNP rivers:

-Juv. Density declining
-Genetic diversity concern
-Insuf. returns to recover

ACTION (‘03-’11):

-Capture Remnant Families
-Genotype & Rear in captivity
-Release to river
-Capture sea-ward migrants

REPEAT

DFO MACTAQUAC LGB

Current Program

Adult (PWR) and Juvenile* (USR) Releases

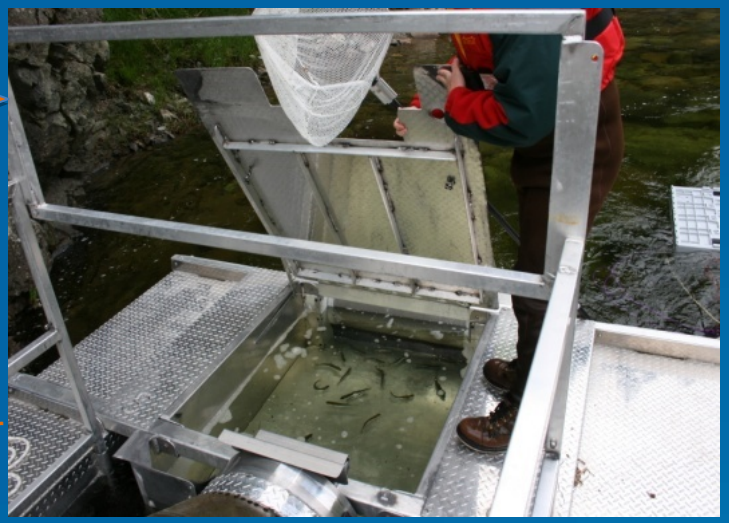
*** (USR) Releases of fry and parr result in various ages and 2 origins of smolt**

DFO LGB

What's Happening Now?

Released fish survive river to Smolt

1-4yrs later

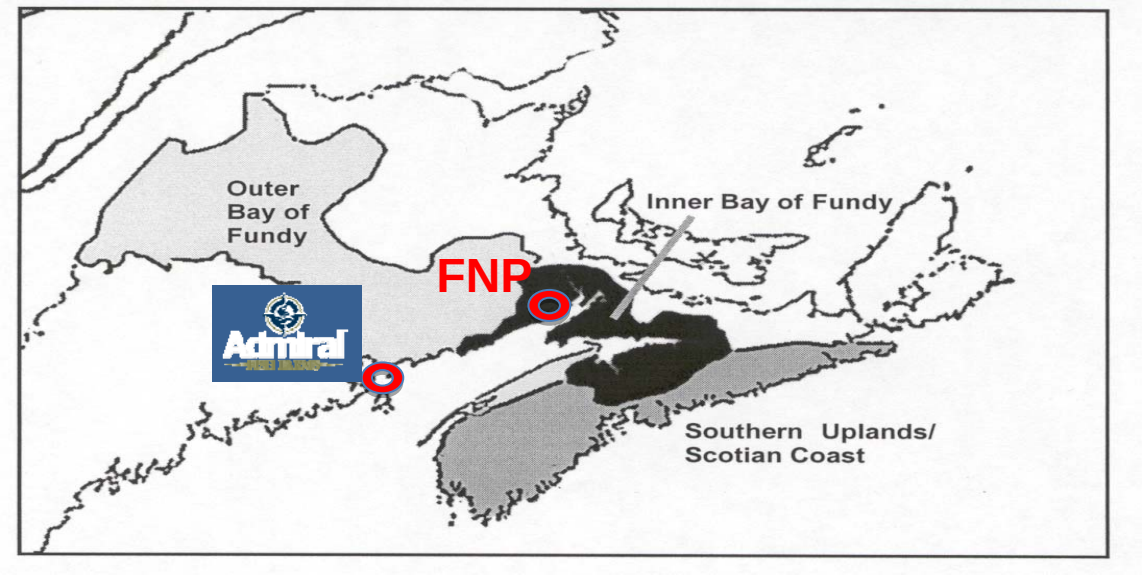


18 months later

BUT!

Salmon aren't returning from the Bay of Fundy!

To gain information in the marine environment, Many partners are required



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Fish Farmers Association

Canada

Admiral
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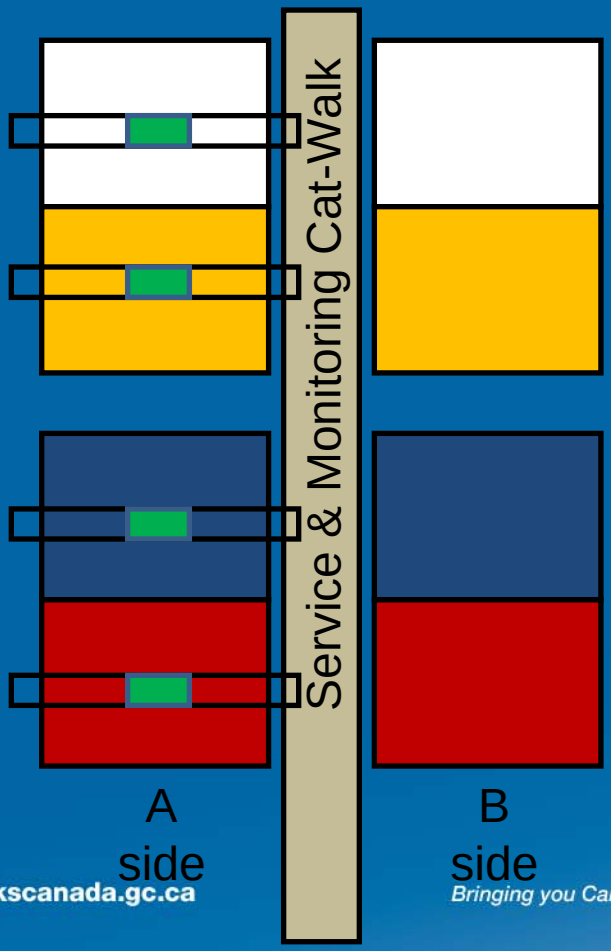
Bringing you Canada's natural and historic treasures

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 .

Come Otter or High Water:

Team innovation prevailed in the face of many challenges

Rewards: (in many forms!)

- 2011 Parks Canada CEO Award of Excellence
- Multiple newspaper articles and references
- Global TV News feature (Youtube: Fundy salmon release)
- A diverse project team

Current project status and Plans:

Bay Release and Tracking (PCA , ASF, OTN)

- 300 cage-reared fish released
- All externally tagged and 44 acoustic
- Receivers have detected >50% so far
- Some detections far from release
- Receivers currently being collected

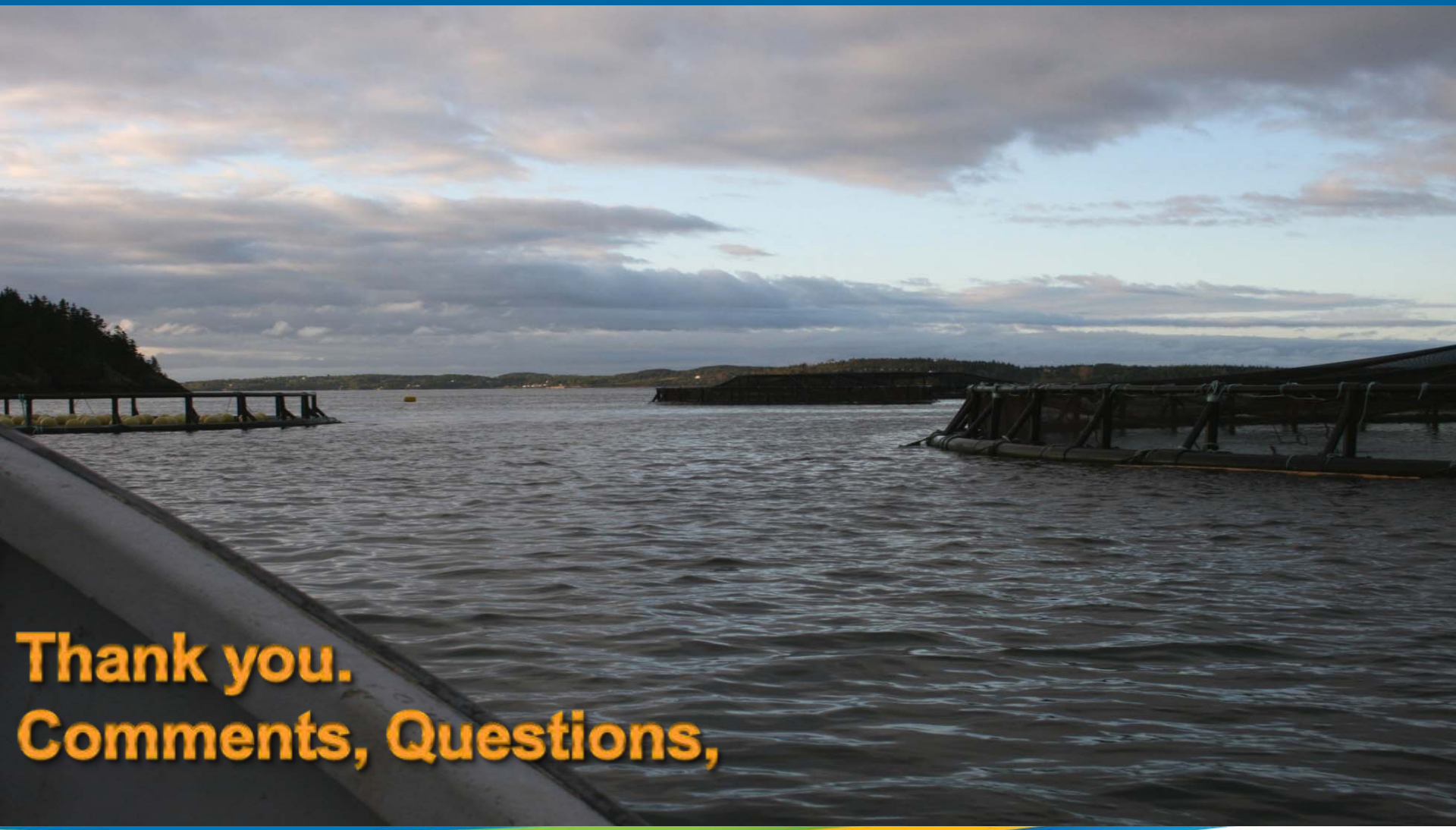
Current project status and Plans:

Egg viability work (PCA DFO)

- 24 pairs cage reared (12 fry 12 parr)
- 24 pairs hatchery siblings (12 fry 12 parr)
- Determine hatch success in hatchery and wild between rearing and release groups.

Early and Expected Results:

- ✓ Release – Smolt survival
  - ✓ Fry and Parr often comparable, different timing
- ✓ Smolt -Grilse growth & survival
  - ✓ Faster growth in cages, parr survived better
- ✓ Maturation ratios
  - ✓ Higher maturation observed in cage reared fish
- Pending: Homing/Stray rates cage fry/parr
- Pending: Hatch success cage/hatchery fry/parr


Thank you.
Comments, Questions,

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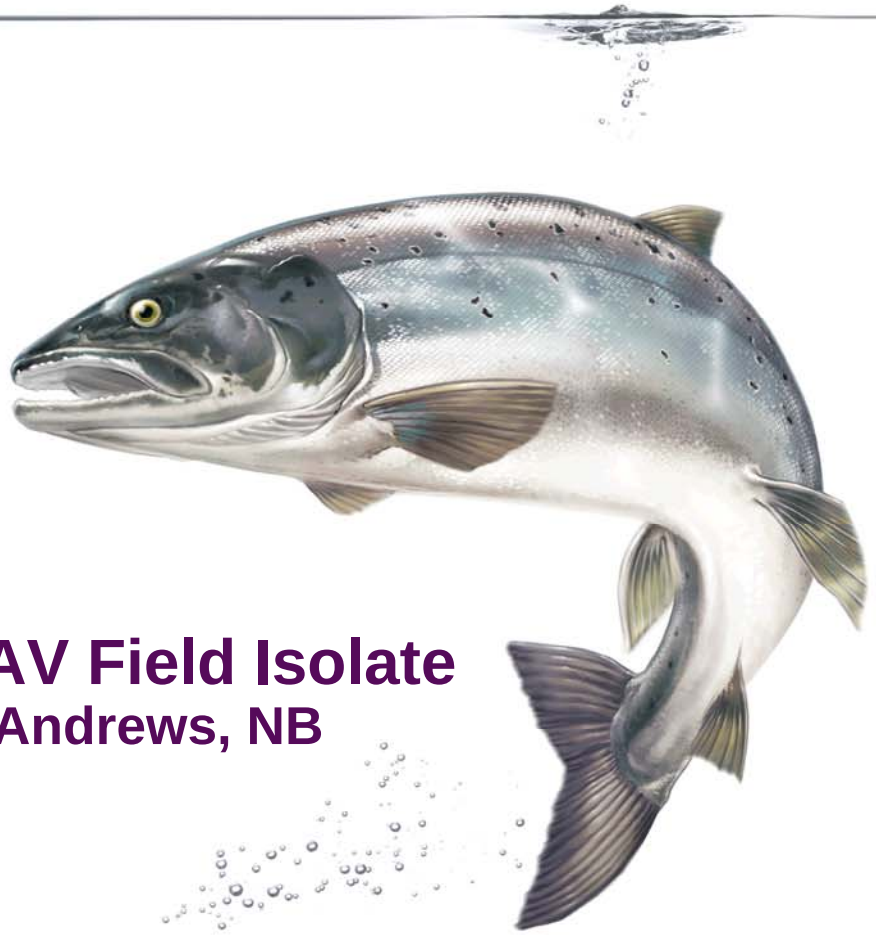

Virulence Testing – ISAV Field Isolate

ACFFA Fall Workshop, St. Andrews, NB

Nov 25, 2011

Allison MacKinnon
Head Technical Support, Canada

EVERY OCEAN. EVERY FISH.

Background

- New field isolate recovered from B of Fundy 03/02/2010
- Cultured on ASK cell line and PCR sequencing revealed slight changes from HPR4 NA strain
- Isolate also cultured in CHSE cell line with CPE
- New isolate (RPC#8) compared to 2005 isolate from NB clinical outbreak (SP9)
- Compared virulence of RPC#8 grown in both cell lines

Segment 6 HPR typing

```
HPR Types (Segment 6)
H0              SLGNTDTLIMREVALHKEMISKLQRNITDVKIRVDAIPPQLNQTFNTNQVEQPSTSVLSNIFISMGV
Hpr2            G......Q....LEAQ....G..G......NN............--------------------MGV
Hpr6            G......Q....LEAQ...TG..G......NN.....-------LGV..........P.........
Hpr4.e          G......Q....LEAQ....G..G......NN....T....----------------SNIFISMGV
Hpr-RPC#8       G......Q....LEAQ....G..G......NN............LG------------SNIFISMGV
```

Trial Design

Cohabitation Challenge

- 150 gram Saint John River strain salmon
- Duplicate tanks of ~ 120 fish per tank
- Fish acclimated to sea water prior to challenge
- 8% Trojan fish infected with ISA added to each tank
- Trojan fish injected with 0.1 ml suspension of ISAV culture
- All cultures diluted to $TCID_{50}=10^5$/ml
- Mortality monitored for 80 days post introduction if infected Trojans
- Confirmation of mortality by rtPCR
- Sampled gill tissue of 10% survivors by qRT-PCR

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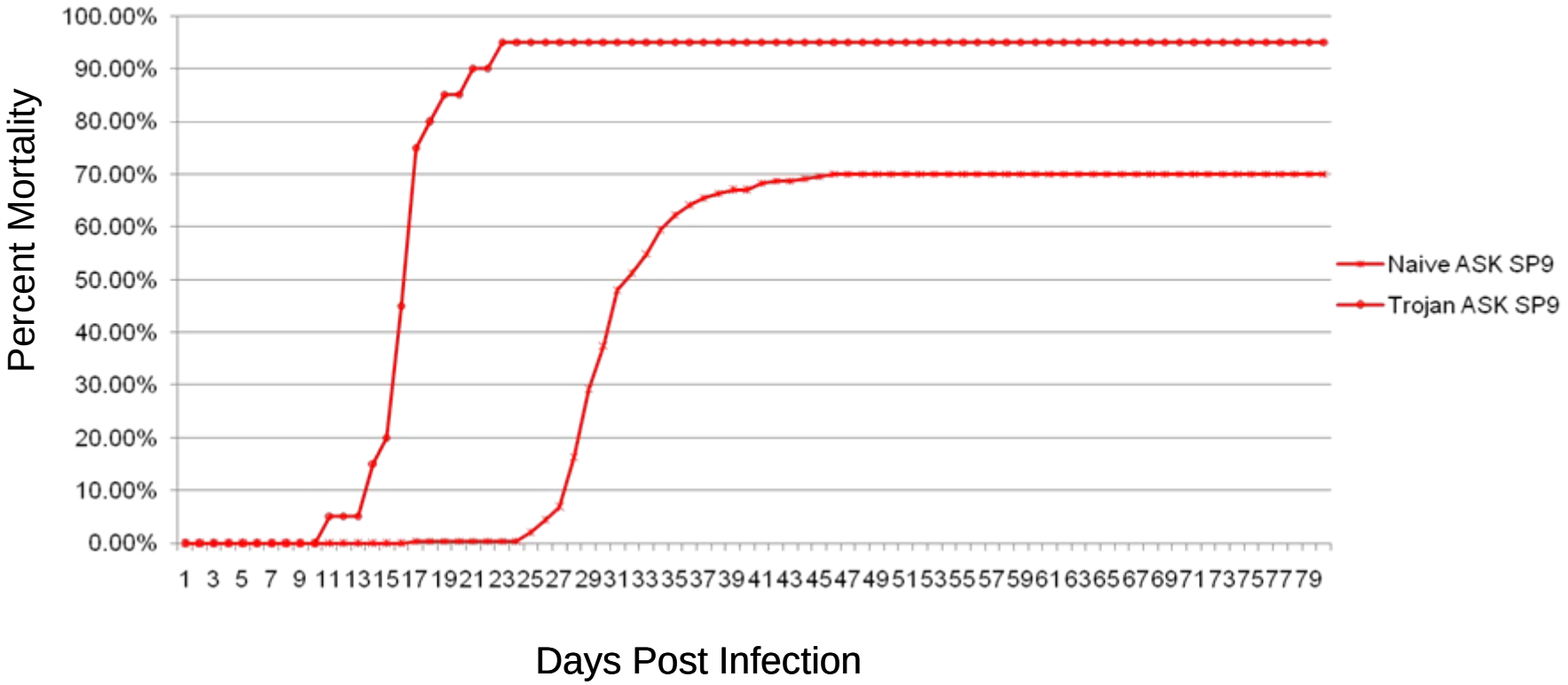
Mortality Results SP9 (2005)



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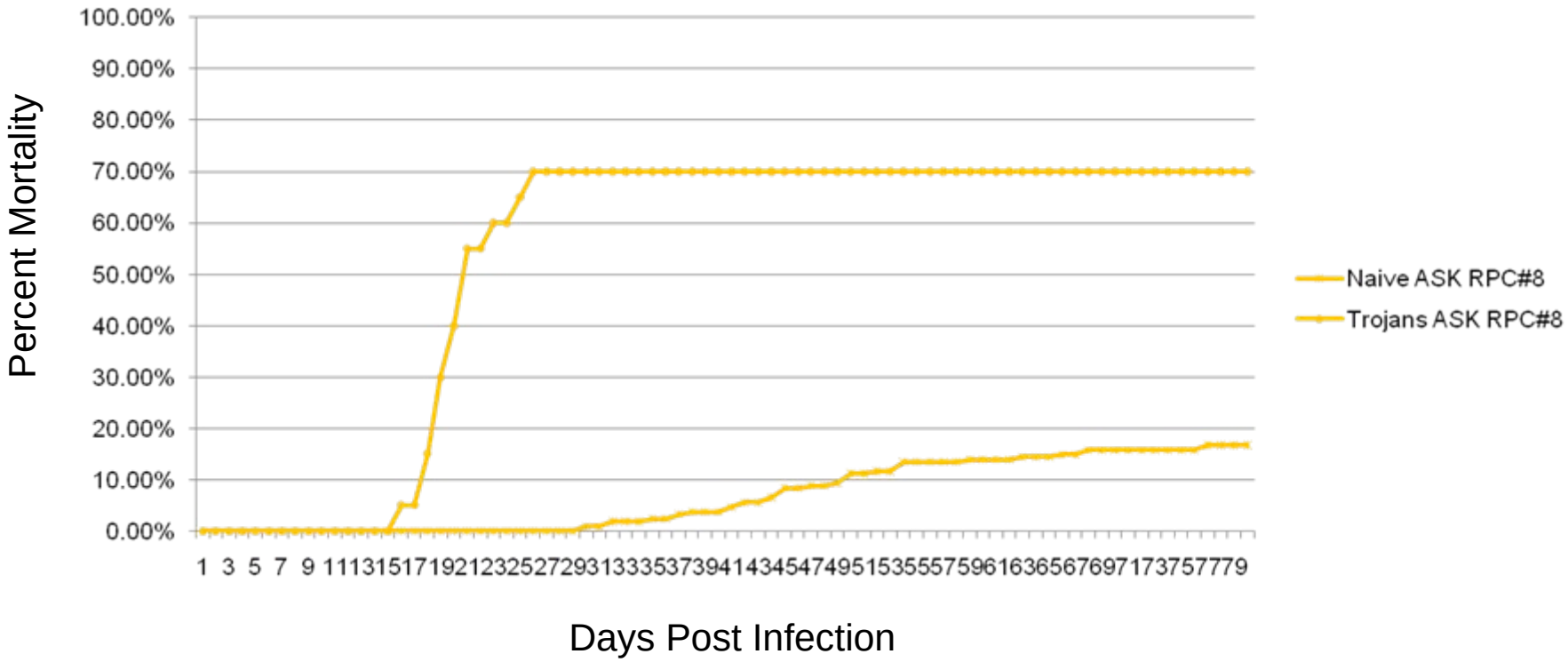
Mortality Results - HPR RPC#8 2010 Cell Line ASK



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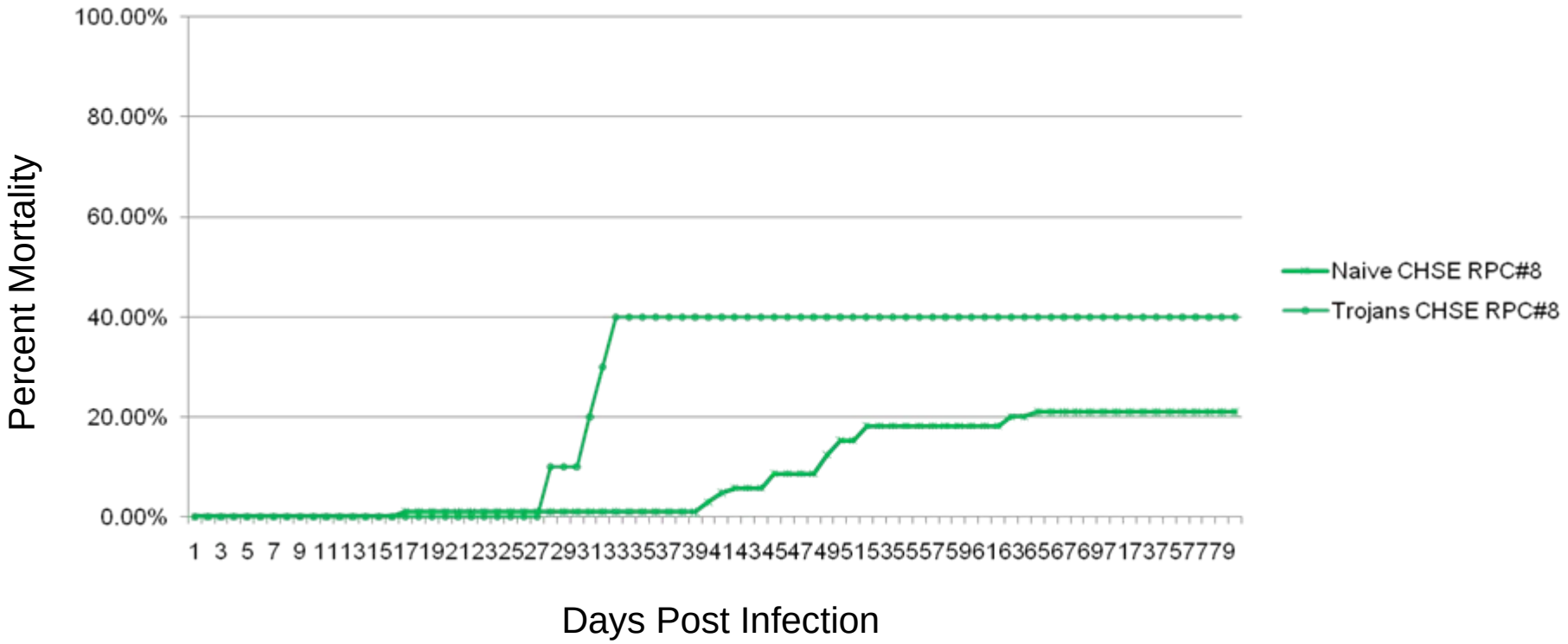
Mortality Results – HPR RPC#8 (2010) Cell Line CHSE



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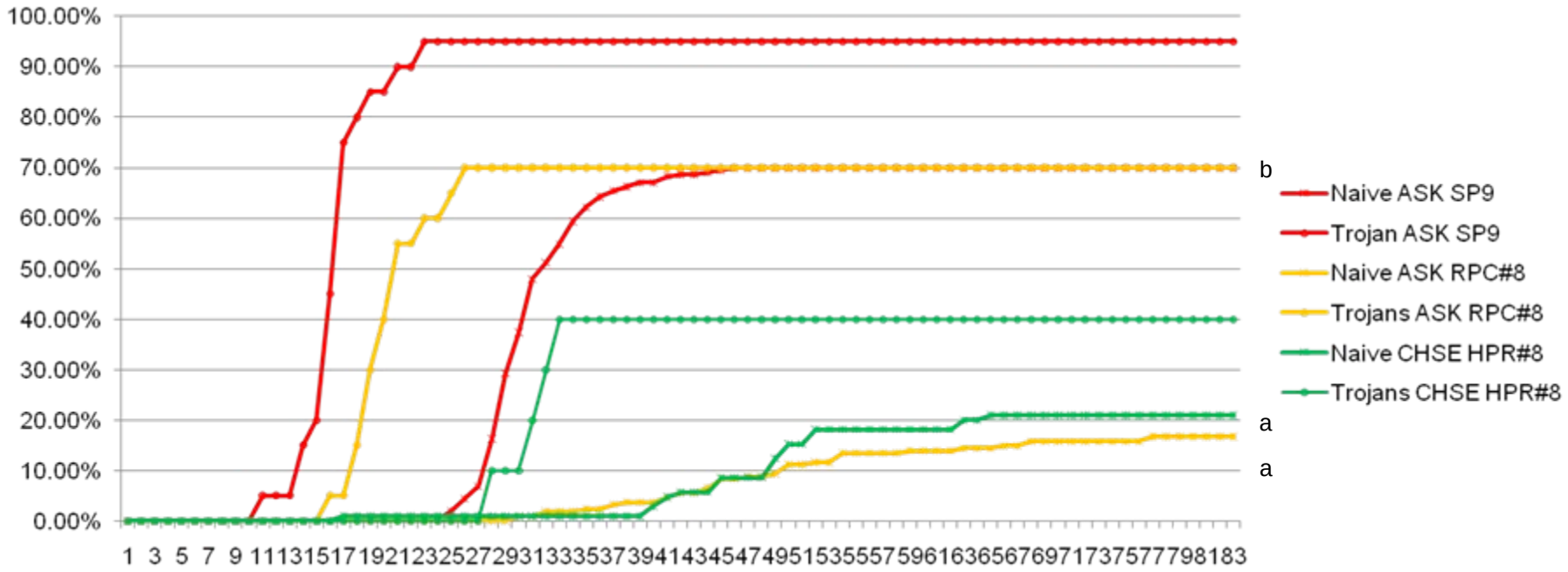
Mortality Results – All Isolates



Diagnostic Results from survivors

- qRT-PCR performed on gill tissue from 10% of survivors from each trial tank
- 100% of samples tested positive
- Further analysis of kidney tissues to be performed

Acknowledgements

- Dr. Brian Glebe, DFO, St. Andrews, NB
- Steve Leadbeater, DFO, St. Andrews, NB
- Tony Manning, RPC, Fredericton, NB
- Dr. Leighanne Hawkins, CAI, Black's Harbour, NB

Healthy fish. Your goal. Our commitment.

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FORTE micro Field Trial Results

Allison MacKinnon
Head Technical Support, Canada

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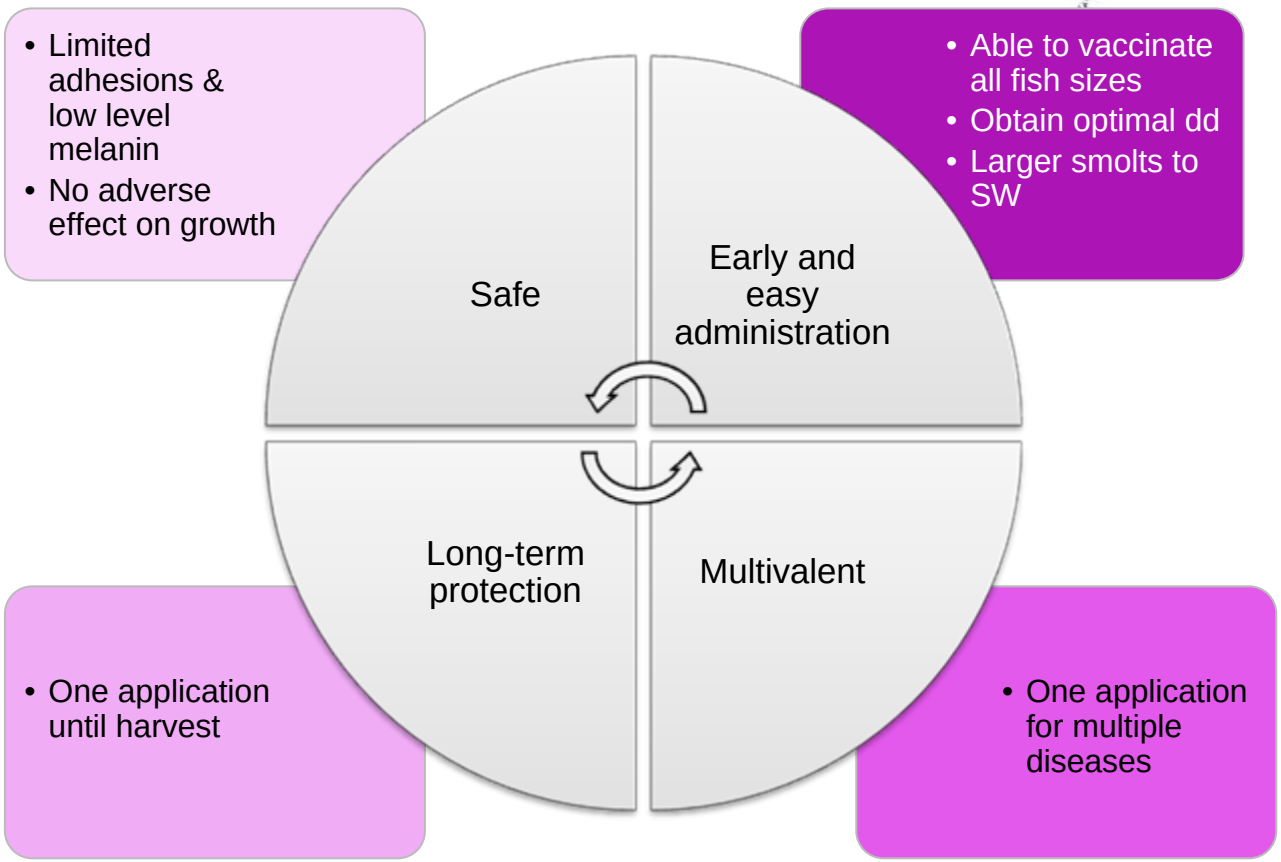
Agenda

- **Vaccine development – The microdose choice**
- FORTE micro field trials - A gentler vaccine
- FORTE micro field trials – Other benefits
- Current regulatory status and next steps

Developing The Optimal Vaccine

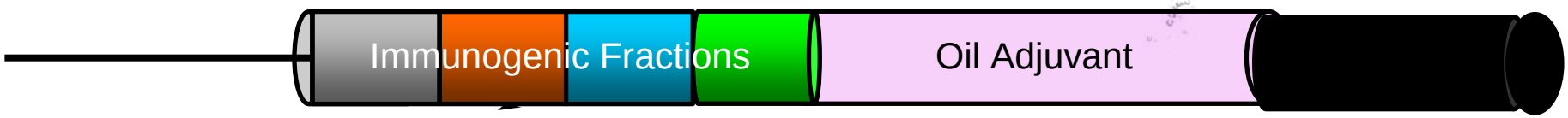


Improving Inactivated Injectable Vaccines

Recombinant protein technology

Microdosing of bacterins

Composition of Injectable Inactivated Vaccines



Inactivated bacterial or viral culture

Protective Immunogenic Components

Non-protective Immunogenic Components

Harmful Components

- Enhance immunogenicity
- Improves long-term efficacy
- Protects antigens from enzymatic degradation

- Can cause excessive inflammation

Composition of the immunogenic fraction may require optimization for best vaccine performance

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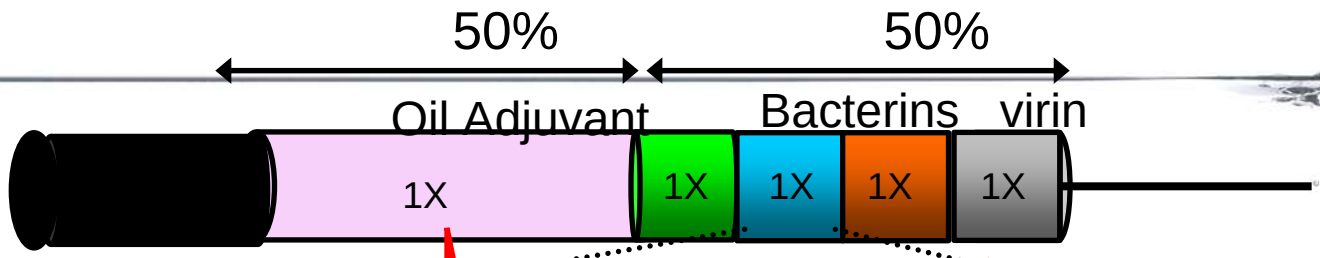
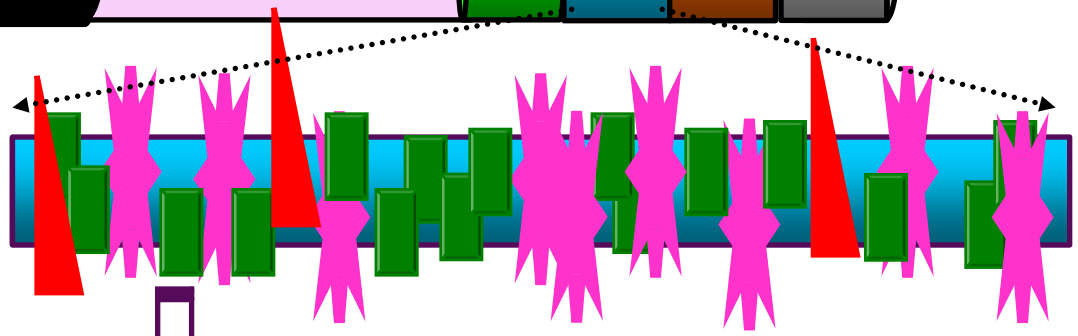
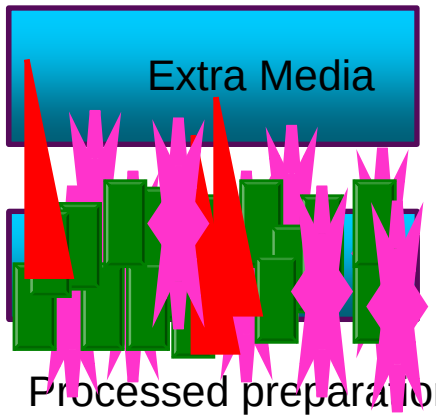
Microdosing Principal



0.1 mL
per injection



Cross-flow
Filtration



Processed preparation
in a reduced volume

Discard

Re-formulate

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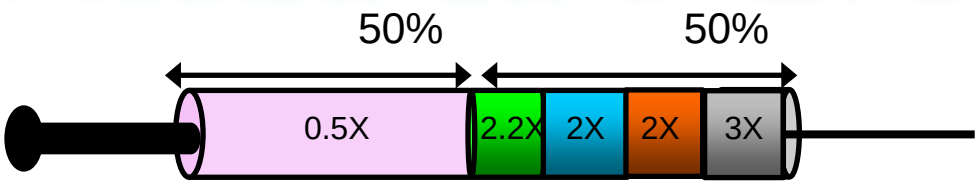
Reformulated Microdose



0.05 mL
per injection

- ✓ Maintain 1:1 ratio between antigen and adjuvant to ensure stability of the vaccine formulation.
- ✓ Less adjuvant volume helps reduce potential adverse effects.
- ✓ Concentration of antigens to optimize dosage and provide highest efficacy against the targeted pathogen.

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Agenda

New vaccine development – The microdose choice

FORTE micro field trials - A gentler vaccine

FORTE micro field trials – Improved results

Current regulatory status and next steps

FORTE micro GCP Field Trial Details

- Field trial initiated at 6 sites in Q3-Q4 2009 with S0-S1 populations of Atlantic Salmon
- Control treatment = Lipogen Forte
- 3 sites BC – Flow Thru / Recirculation / Lake site
- 3 sites NB – Surface Flow Thru / Well Flow Thru / Recirc
- Total of 33 tanks
- Safety also conducted with smaller populations of 10 gram fish at 3 hatcheries

FORTE micro Field Trial Statistical Analysis

Data Collected

- Weights / Lengths at vaccination (50 fish / tank)
- 28 day mortality
- Days to full feeding
- Weights / Lengths at SW transfer (50 fish / tank)
- Side effects at SW transfer (30-50 fish / tank)
- Side effects, mortalities & weight / lengths 5-6 months post transfer (20-30 fish / cage)
- All data and reports reviewed and approved by Investigative Veterinarians

- Safety Data analysis by Chi – Square Testing
- Days to Full feeding, Vaccine Side Effects and Weight data analysis using non-parametric significance analysis employing the Tukey–Kramer statistical test

Trial Populations

Location / Product	Average Weight (g)		Total Fish Vaccinated	
	East Coast	West Coast	East Coast	West Coast
Lipogen Forte	31.6	57.2	392,969	530,866
FORTE micro	25.2	46.2	394,371	641,311

Safety Results

28 Day Post Vaccination Mortality – All Sites

	FORTE micro (Treatment)					Lipogen Forte (Control)				
Field Site	**# Tanks**	**Tank Size (M3)**	**Fish Size (grams)**	**Total Fish**	**% Mortality**	**# Tanks**	**Tank/ Size (M3)**	**Fish Size (grams)**	**Total Fish**	**% Mortality**
A	5	29	24.2	82,163	**0.28**	5	29	23.5	72,860	**0.52**
B	1	150	26.8	52,000	**0.56**	1	150	42.1	52,000	**0.55**
C	4	200	24.7	260,208	**0.58**	3	200	29.1	268,109	**0.69**
D	3	180	60.8	158,153	**0.11**	2	180	63.4	149,928	**0.09**
E	4	1575	35.1	289,835	**0.80**	3	1575	61.0	242,412	**0.83**
F	3	130	42.6	192102	**0.36**	1	130	47.2	138526	**0.42**
Total	**20**			**1035682**	0.41	**15**			**923835**	0.50

The compiled mortality data at sites for the treatment and control was compared and the treatment mortality (8.41%) was found to be significantly lower than the control mortality (10.66%), $p<0.0001$.

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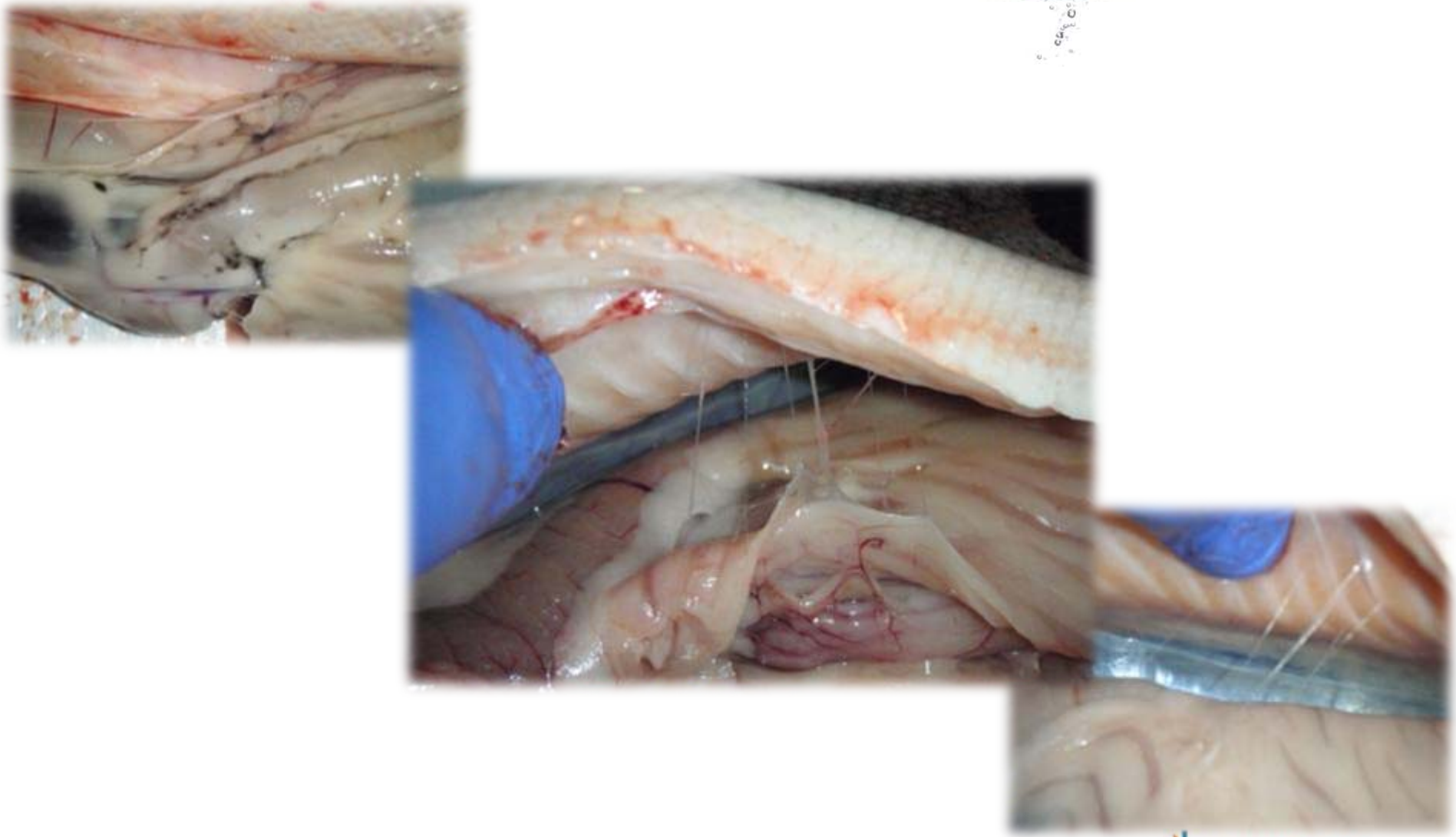
Side Effects Results



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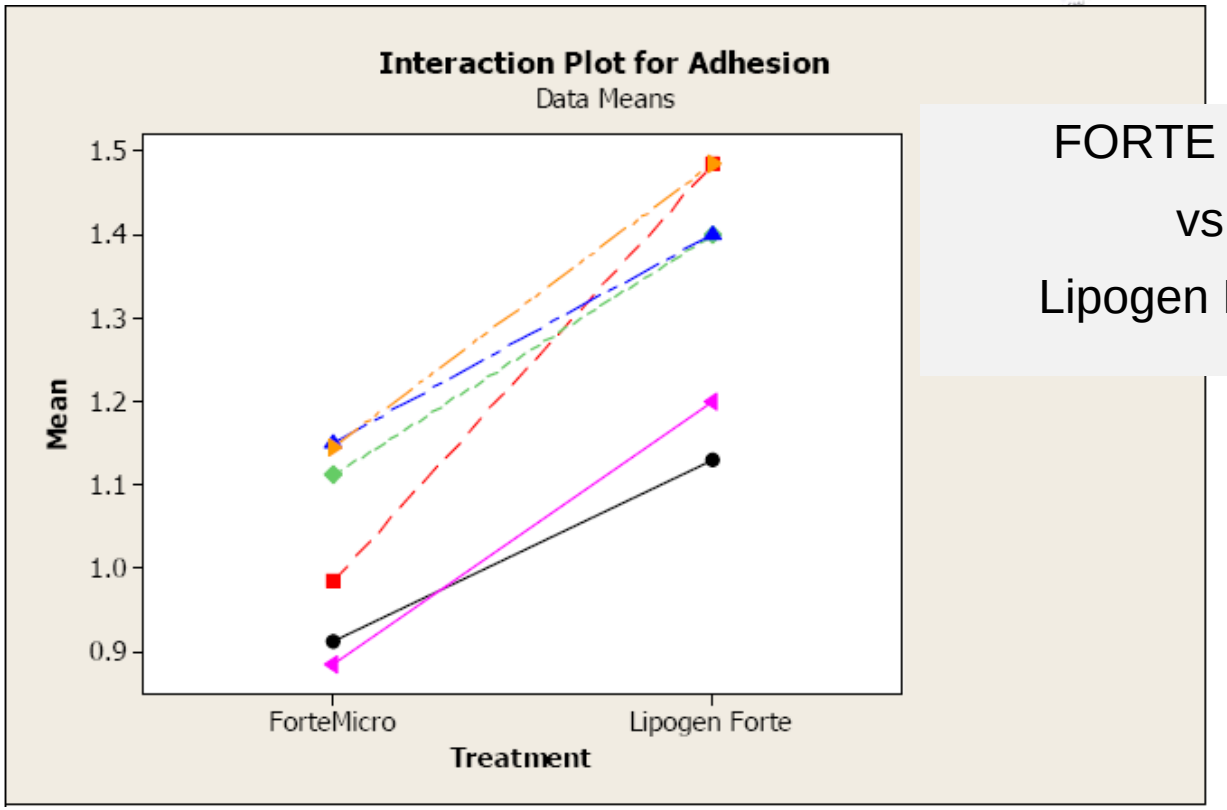
Pretransfer Side Effect Data

	FORTE micro (Treatment)			Lipogen Forte (Control)		
Field Site	**Adhesion Score**	**Visceral Melanin**	**Parietal Melanin**	**Adhesion Score**	**Visceral Melanin**	**Parietal Melanin**
A	0.90	0.07	0.04	1.12	0.49	0.05
B	0.90	0.12	0.00	1.20	0.68	0.00
C	1.13	0.16	0.08	1.40	0.47	0.30
D	1.15	0.74	0.39	1.40	0.65	0.50
E	0.98	0.94	0.36	1.33	1.00	1.03
F	1.14	0.81	0.53	1.48	0.88	0.85
Mean	**1.03**	**0.47**	**0.19**	**1.34**	**0.72**	**0.41**

The compiled pretransfer side effect data indicates that FORTE micro has significantly lower scores for Abdominal Adhesion, (p=0.0000), Visceral Melanin, (p=0.0027) and Parietal Melanin, (p=0.0137) compared to the Lipogen Forte

Adhesion Scores – All Hatcheries at Pretransfer



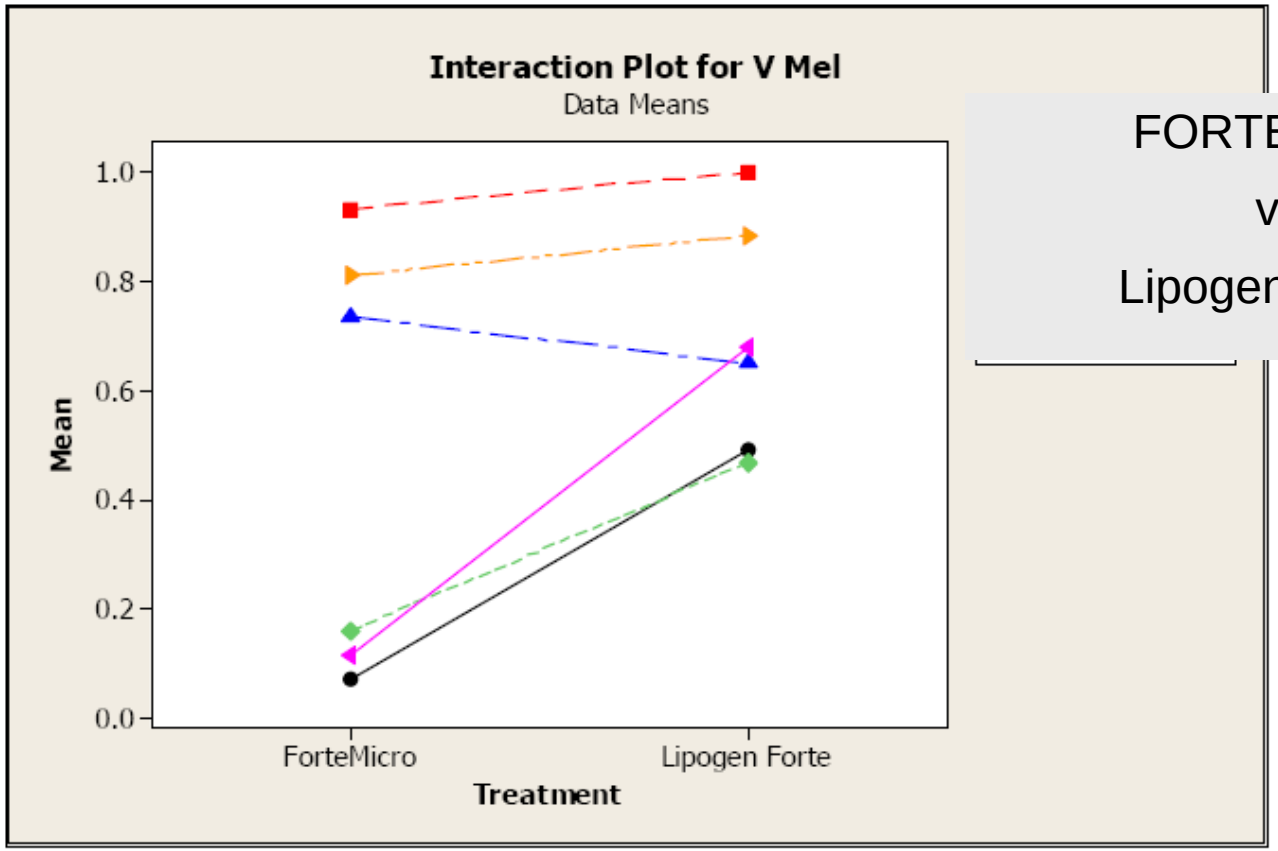
FORTE micro

vs

Lipogen Forte?

p=0.0000

Visceral Melanin - All Hatcheries at Pretransfer



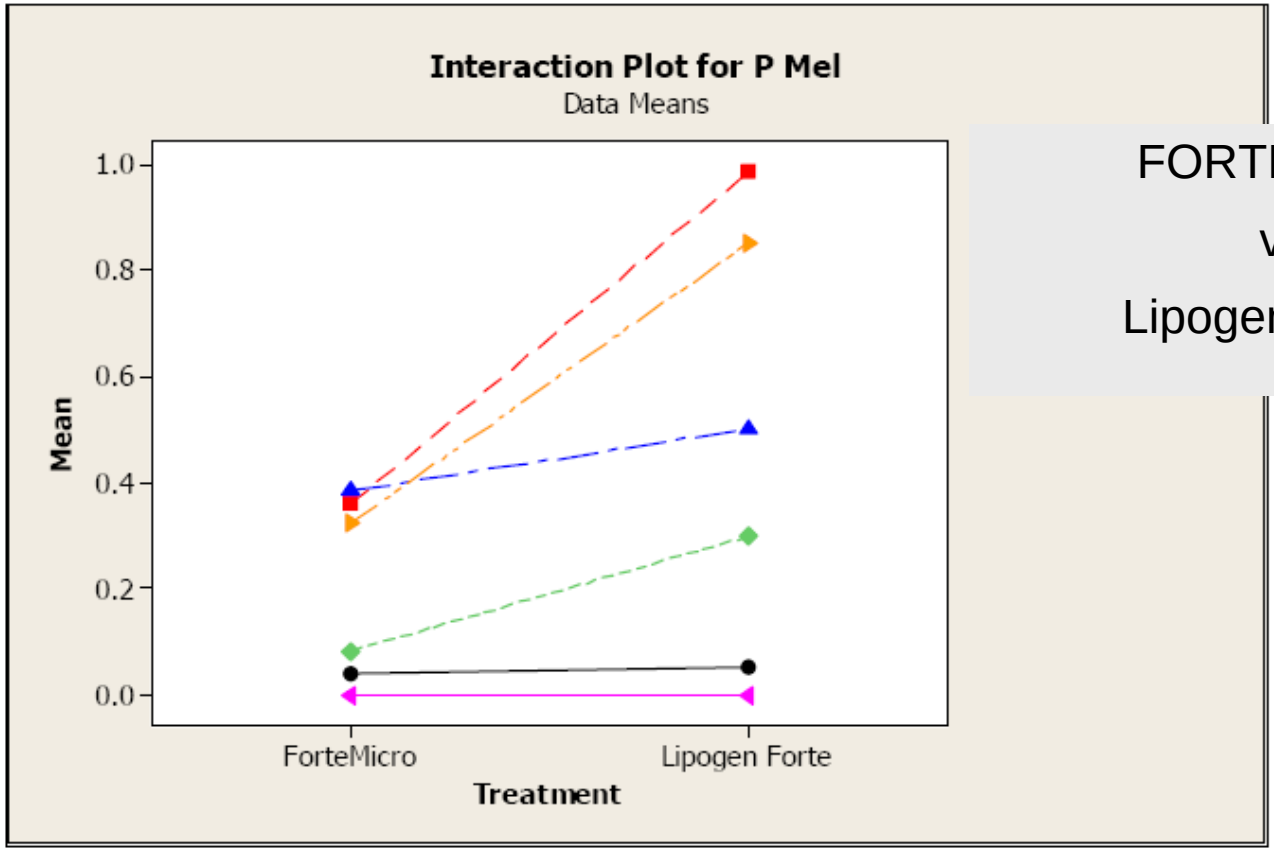
FORTE micro

vs

Lipogen Forte?

p=0.0027

Parietal Melanin – All Hatcheries at Pretransfer



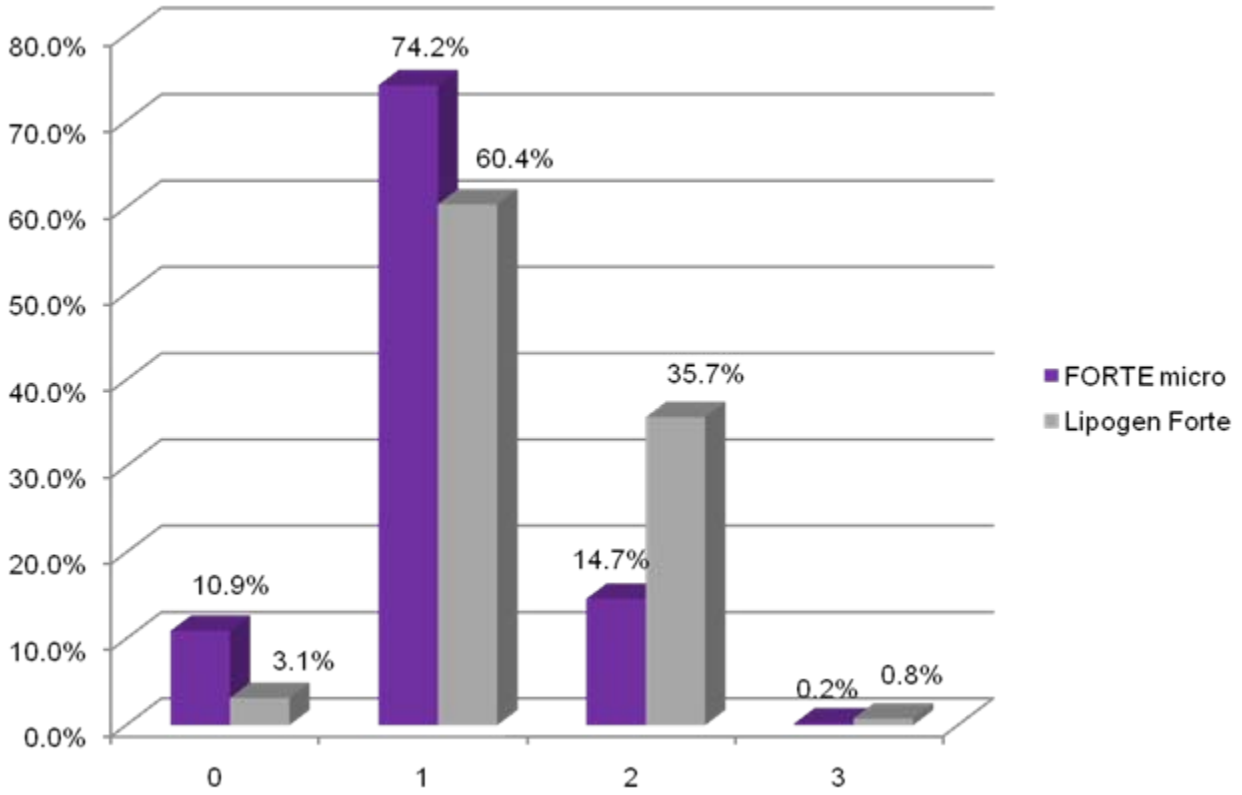
FORTE micro

vs

Lipogen Forte?

p= 0.0137

Adhesion Score Distribution Amongst All Treatment Groups at Pretransfer



Agenda

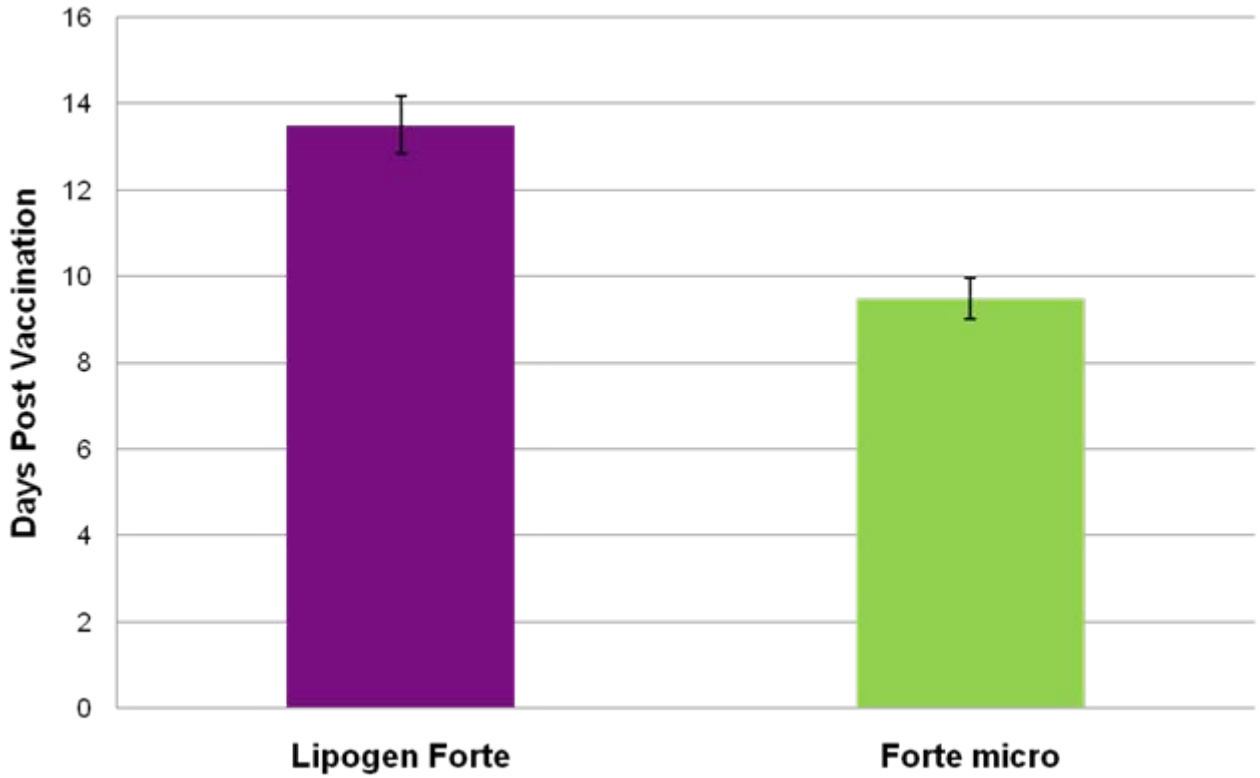
New vaccine development – The microdose choice

FORTE micro field trials - A gentler vaccine

FORTE micro field trials – Other benefits

Current regulatory status and next steps

Average Days to Full Feeding Following Vaccination



4 days faster
time to full feeding

p=0.0002

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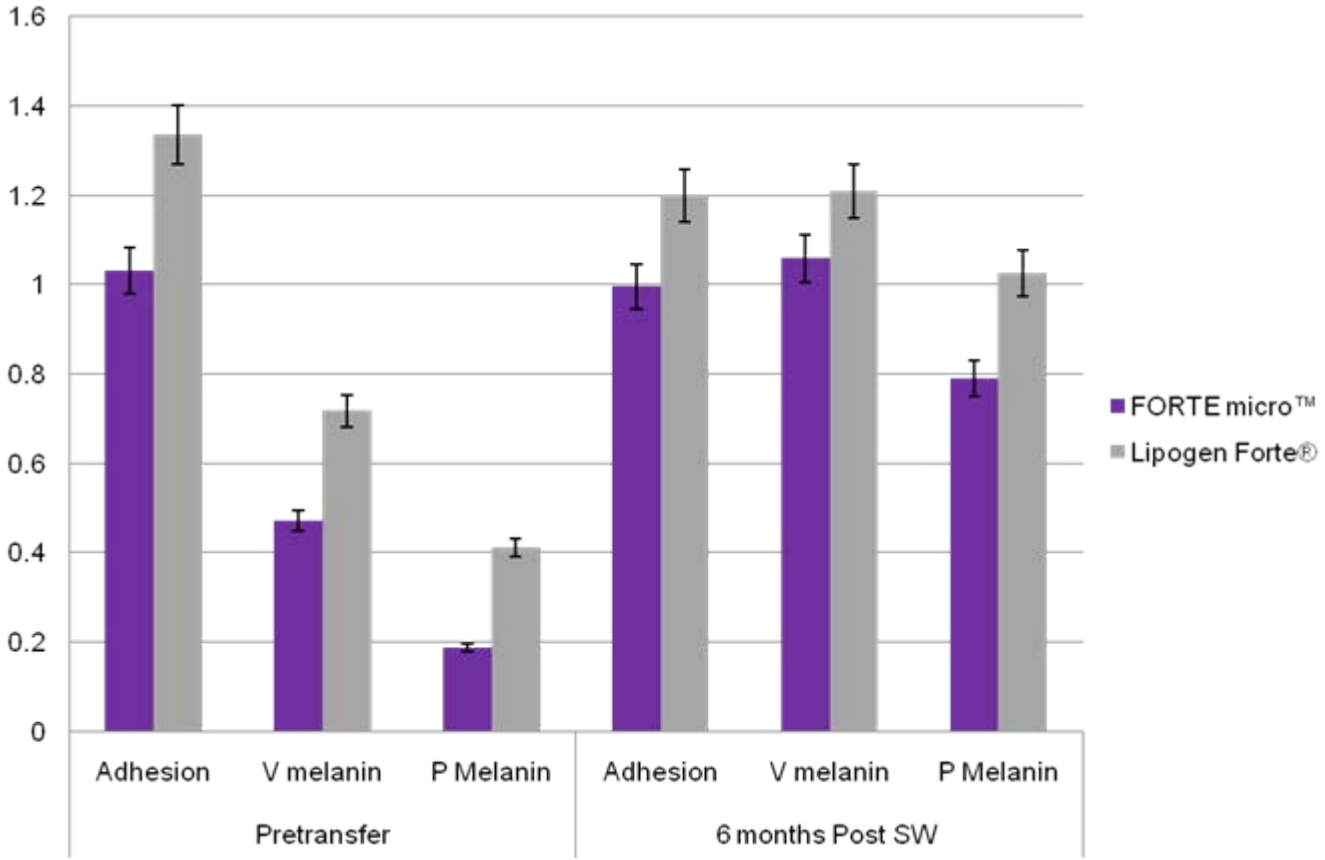
Sea Water Side Effect Data

	FORTE micro (Treatment)			Lipogen Forte (Control)		
Field Site	**Adhesion Score**	**Visceral Melanin**	**Parietal Melanin**	**Adhesion Score**	**Visceral Melanin**	**Parietal Melanin**
A	1.14	0.99	0.38	1.28	1.22	0.78
B	0.90	1.30	0.63	1.13	1.73	1.10
C	0.99	1.00	1.06	1.17	1.00	1.09
D	0.85	1.00	1.00	1.20	1.00	1.00
Mean	**0.97**	**1.05**	**0.79**	**1.20**	**1.21**	**1.03**

The compiled Marine Site side effect data indicates that FORTE micro has significantly lower scores for Abdominal Adhesion, (p=0.0049), Visceral Melanin, (p=0.0036) and Parietal Melanin, (p=0.0147) compared to the Lipogen Forte

Summary Results of Side Effect Scoring at Pretransfer Period And 5-7 Months Post Sea Water Transfer



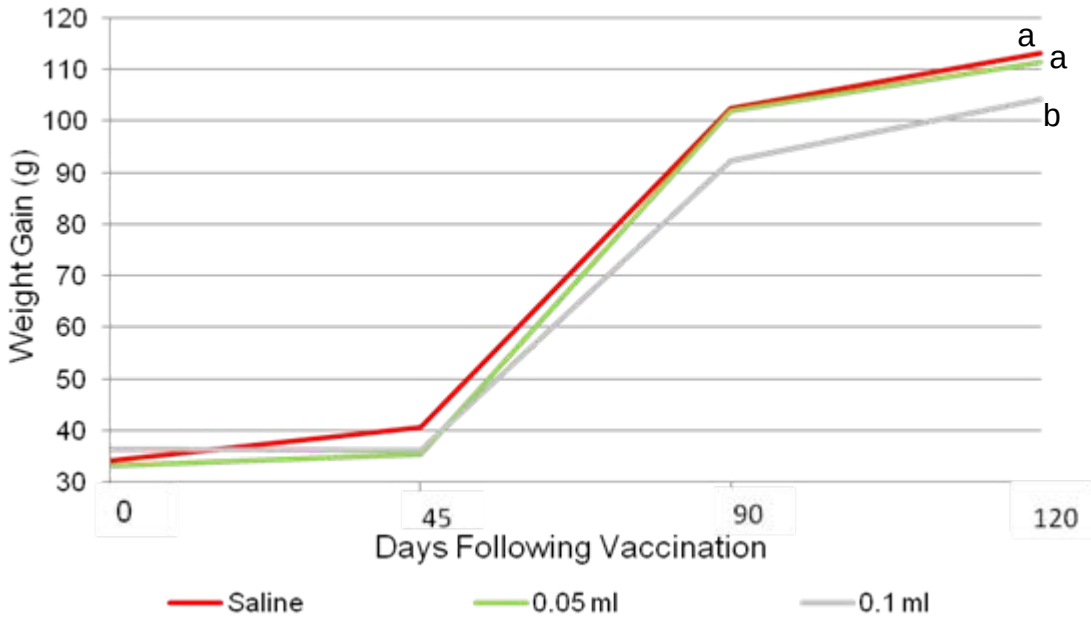
Weight Comparisons – Time of Vaccination & One Year Post Transfer

Site	Weights At Vaccination (g)		
	Lipogen Forte	FORTE micro	Difference (FM vs Control)
1a /1b	23.5 / 42.1	24.2 / 24.7	-7.3 g (-16.7%)
2	29.1	24.7	-4.4 g (-15.1%)
3a / 3b	47.2 / 63.4	42.6 / 60.8	-3.6 g(-6.9%)

Site	Weights 1 Year Post Transfer (g)		
	Lipogen Forte	FORTE micro	Difference
1	1288.8	1496.0	207.2 (+16.1%)
2	1006.0	1099.5	93.5 (+9.3%)
3	1603.7	1549.7	54.0 (-3.5%)

Vaccine Volume and Growth

- 30 gram Atlantic salmon
- All fish PITT tagged
- All treatments in same tank
- Initial weights at time of vaccination ~ 35 g
- Temperature 12°C
- Automatic feeders at 2.5% BW/day
- Weights and lengths at 45, 90 & 120 dpv



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Agenda

New vaccine development – The microdose choice

FORTE micro field trials - A gentler vaccine

FORTE micro field trials – Improved results

Current regulatory status and next steps

License Status

- Conditional license granted by CFIA Dec 21, 2010. Full license pending inspection of trial fish from trial at time of harvest, Dec 2011.
- USDA license approval April, 2011

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Acknowledgment

- Cooke Aquaculture Inc., Blacks Harbour, NB
- Gray Aqua Farms, Northampton, NB
- Marine Harvest Canada, Campbell River, BC
- NL Dept of Fisheries & Aquaculture, St. Albans, NL
- Dr. George Gettinby, U of Strathclyde, Glasgow, Scotland
- Dr. Jim Duston & staff, Nova Scotia Agricultural College

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