ACFFA Aquaculture Research, Science and Technology Forum

FINAL REPORT

October 25 and 26, 2017
Huntsman Fundy Discovery Centre
St. Andrews, NB

Table of Contents

Acknowledgements

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Thanks to DFO-ACRDP for their collaboration on this workshop.

A special thanks to all the speakers and presenters for their participation.

Introduction

The Atlantic Canada Fish Farmers Association hosted its annual Science, Research and Technology Forum on October 25 and 26, 2017 at the Huntsman Fundy Discovery Centre in St. Andrews, New Brunswick. The annual forum is designed to support the transfer of knowledge on aquaculture related research and development projects. It creates a venue to share results, profile new technologies, determine knowledge gaps and inform industry priorities through a number of networking opportunities.

Presentations at the 2017 forum covered a variety of themes including new technologies, sea lice resistance research, wild salmon conservation activities, understanding wild -farmed interactions, and land-based technology. These sessions were initiated with an overview of the industry advancements in these areas over the past 30 years.

New technology included presentations on genomic selection, a gas infusion system, ultrasound and CleanTreat technology for sea lice, SmoltVision- a new PCR tool, ROVs and a wireless sensor system.

Proposed research under the Ocean Frontier’s Institute funding program was also discussed

140 individuals registered for the forum. Participants included representatives from the aquaculture industry from across Canada, local, national and international researchers, pharmaceutical and feed companies, federal and provincial regulators as well as representatives of tourism, academia, traditional fishery and conservation interests.

AGENDA

Atlantic Canada Fish Farmers Association

WEDNESDAY, OCTOBER 25, 2017

8:00 **Registration and Refreshments**

8:30 Welcome and Introduction – Susan Farquharson, Atlantic Canada Fish Farmers Association
8:45 Science, Research and Technology – 30-year overview – Steve Backman, Skretting
9:10 Fish Health: Then and Now - Larry Hammell, Atlantic Veterinary College - UPEI
9:50 A Perspective on the Application of Oceanography to Finfish Aquaculture Management in the Maritimes - Fred Page, DFO- SABS
10:20 Navigating New Waters: Influencing Public Perception in a Changing Media World - Deborah Irvine Anderson, Canteen Media and Communications

10:45 Refreshment Break

11:00 Innovative Technology for Improved Gas Management in Aquaculture - Mike Beattie, Gas Infusions Systems
11:25 Novel approaches for the application of genomic selection in Atlantic salmon breeding programs: costs, benefits and perspectives – Tiago Hori, Center for Aquaculture Technologies Canada
11:50 Overview of Silk Stevens Limited Recirculating Aquaculture Systems Projects: Benefits and Challenges – Aaron Bennett, Silk Stevens Limited

12:15 Lunch

1:15 Fundy Salmon Recovery- An innovative collaboration restoring wild salmon to the Inner Bay of Fundy – Alex Parker, Fundy National Park
1:40 Fish in Rivers: Ecosystem Services of Atlantic Salmon Supplementation - Kurt Samways, Canadian Rivers Institute / University of New Brunswick
2:05 Use of drone mapping to guide Atlantic Salmon habitat conservation efforts – Jon Grant, Dalhousie University

2:30 **Refreshment Break**

2:45 Assessing the interactions between wild and farmed salmon: a literature review on the migration of Atlantic salmon in coastal waters - Marc Trudel, DFO-SABS
3:10 Lobster and rock crab movement around salmon farms in southwest New Brunswick, Canada - Chris McKindsey, DFO

3:45 Wrap up / Adjournment

THURSDAY, OCTOBER 26, 2017

8:30 **Registration and Refreshments**

9:00 Welcome and Introduction

Technology Advancements Session

9:05 Feeding the World – New ROV Technologies aiding in Regulating Aquaculture Sites for a Sustainable Future – John Wintermeyer, Deep Trekker
9:30 Data driven Ocean Farming – Brad Rogers, Real Time Aquaculture
9:55 Can ultrasound and Nano-Cavitation make a difference within Aquafarming? – Nina Hanssen, Aqua Farming Solutions
10:20 Introducing CleanTreat - enabling zero discharge bath treatments - Keith Morris, Benchmark Animal Health

10:45 **Refreshment Break**

Elanco Sea Lice Resistance Panel

11:00 Sea lice data supporting control decisions and monitoring field responses to treatments - Larry Hammell, Atlantic Veterinary College - UPEI
11:20 Using Agent-Based Modelling to Explore Sea Louse Evolution of Resistance to Chemotherapeutants on Atlantic Salmon Farms- Gregor McEwan, Atlantic Veterinary College - UPEI
11:40 Resistant sea lice - implications for health management of farmed salmon - Kari Helgesen, Norwegian Veterinary Institute
12:00 The selective powers of anti-parasitic treatments on salmon lice - Elena Myhre Jensen, Norwegian University of Life Sciences
12:20 Panel discussion

12:45 **Lunch**

Research Session

1:45 SmoltVision - a PCR based smoltification assessment tool – Nils Steine, Pharmaq / Zoetis
2:10 Application of sea bed mapping to aquaculture assessment and siting - Jon Grant, Dalhousie University
2:35 Evaluation of benthic far-field and site recovery effects from aquaculture within the Letang Inlet, New Brunswick - Andrew Cooper, DFO-SABS
3:00 Ocean Frontier Institute Funding at UPEI: overview of planned research - Ian Gardner, Atlantic Veterinary College, UPEI

3:30 **Plenary Discussion and Wrap up**

Presentation Synopses and Speaker Biographies

The following synopses were approved by the speakers.

Wednesday, October 25, 2017

SCIENCE, RESEARCH AND TECHNOLOGY – 30-YEARS OF INCREDIBLE DEVELOPMENT

-presented by Steve Backman, Skretting

Jacques Cousteau, in 1973, made a statement that inspired a number of individuals to get involved in aquaculture. In part he said "…With earth's burgeoning human populations to feed we must turn to the sea with new understanding and new technology. We need to farm it as we farm the land…. High efficiency sea farms totaling the size of Switzerland would produce more food than all fisheries combined." Many believed that salmon farming could not be conducted here though numerous things came together for those interested which enabled the salmon aquaculture industry. There was a very steep learning curve for those who began the industry with major strides over the next thirty years taking place in all aspects:

- Husbandry
- Cage Technology
- Hatchery Technology
- Feeding and Nutrition
- Fish Health
- Ecology
- Human Medicine

The Atlantic Salmon Federation, seeing the increasing and rapid decline in the wild population, began working toward the development of new brood stock to promote population recovery in a more and more rapidly changing environment. The ASF identified new research talent to bring into the project and was instrumental in providing the stock which would form part of the basis of the new salmon industry in NB. Those involved in the start of the industry learned to embrace failure and learn from it. They moved forward with the idea that if you were not failing, you were not pushing your limits of understanding in order to develop leading edge technology.

The industry has moved from octagon, wooden pens holding 1,500 fish using knotted fishing twine, through many versions of steel and plastic pens using knotless netting, to today's versions of large oil-rig based technology for the open ocean holding over a million fish per pen.

Once it was thought that hatcheries had to be dark, with tanks having no current and point source feeding of the fish. Grating frozen calf liver over the surface of tanks was common practice. Now we have learned to feed fish properly waiting until 900 degree-days with the appropriate current to achieve the best growth and health. Production of 200,000 fish that once took an entire hatchery is now done in one tank and with better health, growth and survival. Land based systems are getting better with the understanding that it isn't all about the engineering, that the biology of the system, especially the diverse ecosystem of the biofilter, is critically important.

Industry personnel are no longer cutting up wild fish to feed to the salmon and much of what was considered the best information before the 1990's has now been shown to be incorrect. Nutritionists and veterinarians now design fish feed diets to match nutrient requirements of the animal and not a perceived need for specific ingredients. This has been achieved for over 60 farmed fish species. Feed formulation and production is now computer PLC controlled. New technologies have allowed feed analysis which once took one hour to process can now be done in 15 seconds allowing for continuous monitoring and adjustment of the feed manufacturing process.

The salmon farming industry started with little understanding on the relationship between fish and the pathogens, their description or treatment. Focus was on bacteriology which was completed on agar plates with indirect assessment of metabolism through sugar fermentations to facilitate identification. Today we have access to modern molecular test methods which are far more accurate rapid and sensitive. The notion that all bacteria are bad has been dispelled, and we now recognize their role as a critically important part of gut / fish health. Viral particles are among the most abundant "life form" found in the ocean and while a few are problematic, the vast majority are essential for maintaining the ecologic balance of the ocean and even driving forward evolution.

We are now increasingly basing our farming practices on the principals of ocean ecology. Our ever-increasing understanding of its processes is being supported by the economic value of the animals under our care. The challenges faced by aquaculture industry has brought together scientists from a huge variety of disciplines including Veterinary Medicine, Marine Biology, Oceanography, Genomics, Benthic Ecology, and phycology; all working cooperatively and generating large amounts of new information on how ecosystems are interconnected. Global Climate change is resulting in the shifting of large numbers of organisms as they move toward more favorable conditions within the ocean and this is creating many interactions which previously didn't exist. Aquaculture has provided a unique way to study the ocean in far more detail than ever before possible providing a real model for understanding climate change and the effects on our ocean. Understanding the effects of water temperature on embryonic development, and carbon dioxide levels in the ocean on fish health are but two examples.

Lastly, by bringing together such a diversity of scientists looking at fish in ways no one has previously thought of has had unexpected spin offs. The zebra fish is rapidly replacing the mouse and rat as a model for studying human disease. Through genomics studies, it has been found to have many homologous genes with humans with similar metabolic processes. It has the advantage of fast generation time and small space requirements. The use of this model is leading to major breakthroughs in cancer, rare genetic diseases, PTSD, new drug discoveries, spinal cord research and the list is growing.

The world is facing a major food challenges, as food supply is unable to keep pace with population growth and climate change. There is no industry better positioned to meet this challenge in a sustainable and environmentally safe way then the aquaculture industry. To quote Kofi Anan from the UN FAO "I do not ask you to change direction, I only ask that you accelerate the process."

See Attached Presentation

<u>Steve Bachman</u>
Dr. Steve Backman has been the Manager of Technical Services for Skretting since 1988. He received his Diploma of Agricultural Science from Nova Scotia Agricultural College in 1982, then attended the University of Guelph where he received his Doctor of Veterinary Medicine in 1987 and a Diploma in Anatomic Pathology in 1989. Steve has been a member of the NB Fish Health Technical Committee and the NB Fish Health Policy Committee since 1996. He holds multiple veterinary licenses and memberships in a number of professional organizations, which includes being Charter President of the Canadian Association of Aquatic Veterinarians. He is also the owner of Magellan Aqua Farms Inc.

FISH HEALTH: THEN AND NOW
-*presented by Larry Hammell, AVC – UPEI*

Many different fish health challenges have presented themselves over the years and New Brunswick has produced a great deal of expertise to address those challenges. In the early 1990s, veterinarians working in aquaculture were not very common, but several came to New Brunswick to work for government, feed companies, and the Atlantic Veterinary College. Individuals who set the stage for others included Gerald Johnson at the AVC and Hugh Ferguson at the Ontario Veterinary College, Dave Groman was doing diagnostic pathology at AVC, Steve Backman was the veterinarian for Moore Clark (feed company) and John O'Halloran and Sandi McGeachy both worked for the NB provincial government. Soon after, I started doing research with Gerald Johnson at salmon farms in Limekiln Bay and Dan MacPhee finished further studies with Hugh Ferguson then started working for Shur Gain (feed company) in NB. Roland Cusack started with NS and Joanne Constantine with NL provincial governments. The next wave of veterinarians started soon after. It was a small group working intensely with a young and innovative industry comprised of more than 20 companies each operating with multiple generations at the same sites.

When I first started on the veterinary faculty at AVC (in the fall of 1992), the first major fish health challenge for the industry had occurred the previous winter with the first cases of Cold Water Vibrio (*V. salmonicida*). This disease occurred during cold water seasons when consumption of medicated feed was an issue. However, Norway had already developed a reliable vaccine. In the fall of 1992, we vaccinated 1 kg salmon that had been transferred to sea in the spring of 1992 but had not been vaccinated in the hatcheries. From that point forward, hatcheries incorporated this vaccine in their usual vaccination program making it unnecessary to stress marine fish with the handling required for injectable vaccines.

Through the next few years, the NB salmon industry dealt with various isolated health issues such as freshwater furunculosis (*Aeromonas salmonicida*), Bacterial Kidney Disease (*Renibacterium salmoninarum*), and other pathogens that concerned individual growers but not causing industry-wide impacts. Based on knowledge gained from other food animals, we knew that multiple year class sites, lack of attention to harvest effluent (at the farm and processing plants), lack of fallowing, lack of disinfectant use, unrestricted movement of people and equipment, and other basic principles were not being followed. However, an industry-wide challenge was not yet forcing better biosecurity practices.

In 1995, our next significant challenge arrived when sea lice (*Lepeophtheirus salmonis*) suddenly increased to the point that emergency treatments were necessary. Sea lice were always present but were previously not at the level that required treatment. Small cages permitted new treatments using tarps and several bath treatments were attempted. Few showed the improvement needed to justify pursing registration. Peroxide was a new product tried in 1995 but during the warm water season, too many mortalities occurred and limited its use. Ivermectin was being used in Ireland at the time and was introduced for smolt treatments in New Brunswick. By 2000, Emamectin Benzoate (Slice®) was introduced and its success against all lice stages dominated the market until resistance emerged in 2009.

In the summer of 1997, veterinarians were dealing with the greatest challenge the industry has faced thus far. There were unexplained mortalities at multiple sites that appeared to have similar pathology, described by pathologists at Ontario Veterinary College as Hemorrhagic Kidney Syndrome (HKS). This was first suspected as a possible new virus or a toxic insult, but it had tested negative to known viruses. By the fall of 1997, the *Orthomyxovirus* responsible for Infectious Salmon Anemia (ISAv) was being isolated from cases of HKS. Control at the industry level had not been enacted for any other infectious disease previously and the province of NB had to take the lead jurisdictionally. There was an industry-veterinary-government advisory committee established and by 2000, we had initiated a surveillance and depopulation program applied to the cages detected as ISAv positive and had elevated mortality. It is fair to say that New Brunswick led the world in research applied to the epidemiology of ISAv, including surveillance performance, risk factors, and clinical trials for vaccines. This is in large part due to the effective communication and cooperation the industry had with the provincial government and also in the provincial government supporting the costs of so many applied research projects.

The industrynow had an incentive to change the more difficult aspects of biosecurity. In the 5 years after ISAv was first detected, the industry addressed the need for single year class sites (and areas) and fallow periods between harvest and stocking. This was a painful process that required entire sites to lay dormant waiting for the transition cycle to allow for area stocking policies. It was also the period when effluent controls for harvests were implemented, reduced or eliminated sharing of equipment and people (divers), and more attention to disinfection practices. Biosecurity audits were implemented by the provincial governments and movement into restricted areas (i.e. ISAv positive areas) was prohibited. All biosecurity practices were examined and many aspects of health management at salmon sites was improved.

Clinical cases of ISA continued to be a severe constraint on the industry through the early 2000s. By 2005, genotype differences were identified, allowing regulations to evolve and have depopulation not applied to non-pathogenic genotypes. This gave improved confidence in the detection program and allowed the industry to wholly support depopulation decisions. After a decade of ISAv being a top consideration for most production decisions, the last clinical case of pathogenic genotype ISAv occurred in 2007. In 2010, the federal National Aquatic Animal Health Program was initiated by CFIA and only a small number of cases have occurred in NB since that time, and only since CFIA's decision to withdraw from mandatory site-level depopulations for detected ISA cases.

The NB industry's most recent challenge emerged in late 2008 with multiple treatment failures using Emamectin Benzoate for sea lice control and widespread resistance being detected by 2009. This created a sudden increased demand for alternative treatments which have primarily relied on bath treatments. Azamethiphos and hydrogen peroxide have been the most common bath treatments, with well boats, key to delivery of peroxide, introduced in 2010. Improvements in tarp enclosures by 2014 have encouraging signs for control and there are some promising non-chemotherapy approaches being developed. As it is for most salmon growing regions, sea lice continue to be our greatest health challenge and may truly limit the industry production in New Brunswick.

We undoubtedly will face new health concerns and we can predict that several pathogens, such as Pancreas Disease or Amoebic Gill Disease, occurring in other salmon producing areas may eventually be detected in our industry. We cannot relax our vigilance nor decrease our capacity to diagnose and manage these new pathogens. One of our most important assets is our regional collaboration and competence made stronger by our collective approaches to these past challenges.

Larry Hammell
As an aquatic veterinary epidemiologist, Dr. Larry Hammell has been the lead proponent on many large, clinical research projects and partnerships with industry and government agencies. Larry is currently the Dean (Interim) of the UPEI School of Graduate Studies. He is also Professor and Associate Dean (Graduate Studies & Research) at the Atlantic Veterinary College, University of Prince Edward Island, and Co-Director of the Collaborating Centre for Epidemiology and Risk Assessment of Aquatic Animal Diseases (ERAAAD) for the World Organisation for Animal Health (OIE). Through his international and regional work, Larry's research focuses on aquatic food animal health studies including disease detection and surveillance, health management through identification of risk factors and disease prevention studies, and clinical trials for improved treatment responses.

THE CONTEXT FOR AQUACULTURE OCEANOGRAPHY AT SABS: THE DEVELOPMENT OF SALMON FARMING IN SWNB
-*presented by Dr. Fred Page, DFO-St. Andrews Biological Station*

There were many issues driving the aquaculture oceanography program at SABS and ultimately the development of the aquaculture bay management areas in southwestern New Brunswick. The interest in oceanography within the aquaculture industry began with nutrients, plankton blooms and super-chill, then disease, oxygen and fish growth concerns. This interest resulted in the development of a multi-disciplinary effort that has evolved over the past 30 years or so. The effort has included provincial government personnel from several departments, local, regional and national representatives of various DFO programs, regional and national representatives of the federal government's Health Canada Pest Management Regulatory Agency (PMRA) and Environment Canada, regional universities including University of New Brunswick (UNBF and UNBSJ) and the Atlantic Veterinary College (AVC), as well as several local and regional aquaculture companies and industry representatives.

In 1980 with only two farms in New Brunswick, one on Deer Island and one on Grand Manan, distance between farms was not an issue. By 1985 there were 19 farms, many of which were located within Limekiln Bay, and inter-farm distances became a concern and initial regulations were established that required a minimum separation distance of 305 meters. With 48 farms in operation by 1990 this minimum distance was felt by some in industry and government to be inadequate and by 1995 when 65 farms were operational, the discussion of aquaculture bay management areas (ABMAs) was initiated. The first proposal had approximately 22 ABMAs and in 2002 an ABMA system structure involving 21-22 areas with a 2-year stocking cycle, single year class stocking and holdovers was formally adopted. Although 21-22 BMAs was recognized at the time as being too many, it was also recognized as a start in the right direction.

When the first outbreaks of what would eventually be identified as ISA occurred in 1996, the real discussions of ABMA and bio-security system changes began. Oceanographers became involved with a suggestion of 4 to 7 ABMAs for the now 86 farms in the industry. A three-year Aquaculture Collaborative Research and development Program (ACRDP) Fish Health and Oceanography Project began in 2001 to investigate water and disease exchange between a few farm sites located in southern Grand Manan. This was a start to the process and the work was subsequently extended to the Fundy Isles, Passamaquoddy Bay and Cobscook Bay areas. This work helped establish that Canada and the state of Maine would need to work together to designate a common ABMA system since the water movements did not stop at the international border, and that the number of AMBAs should be reduced because of the significant potential for water and water borne disease exchange between farms. This work contributed to a two-year ACRDP ABMA Evaluation Project initiated in 2005. From the high of 91 operational farms in 2001, there was a reduction to 63 farms in 2006, and farmers agreed to begin the adaption of a proposed 6 ABMA structure with a 3-year stocking cycle, single year class stocking and no holdovers. This transition was complete by 2009. With data from the drifter tracking and modeling, the minimum distance between farms, if they were to be independent of each other, was recognized as being in the order of 5km rather than 300m.

During the above time frame and to the present day, other concerns such as organic deposition and sea lice pesticide transport and dispersal have prompted additional work that has generated 3D information on the time and space scales of water based exchange between farms. Aquaculture Regulatory Research (PARR) projects and a 3-year ACRDP project started in 2016 are continuing the focus on oceanography, barotropic FVCOM model development and validation, and will eventually aid industry and regulators in reviewing the current ABMA structure. Going forward the effort may continue but possibly in a different way since real-time circulation and drift modelling capability is around the corner, although it requires expensive supercomputing capacity, the industry context has changed, and science experience and perspective has and is being lost as many people retire or leave science and the industry even though both new and historical information are important to understand the context and ensure a holistic strategy and research development.

See Attached Presentation

<u>Fred Page</u>
Dr. Fred Page 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.

NAVIGATING NEW WATERS: INFLUENCING PUBLIC PERCEPTION IN A CHANGING MEDIA WORLD
-presented by Deborah Irvine Anderson, Canteen Media and Communications

With the need to tell the story of the aquaculture industry, think about the audience to be addressed. The direction to take in communications should be to make industry fans love the industry more and increase the fan base.

As the world has changed, the customary ways to influence public perception: traditional media, public relations and advertising, are no longer appropriate. Discussion included reminders of how radio was first used to relate immediate news in 1936, how everyone waited for the 10pm news on TV for all their information and read newspapers. Today’s journalists don't have time to understand the story – news is 24/7 and shared via social media. Since everyone with a phone can be a journalist those with a story have to deliver it as fast as possible.

Where do Canadians get their news? The following breakdown of a recent survey was shared:

- 29 % TV - breaking news
- 21 % Facebook
- 14% traditional media websites
- 6% word of mouth
- 5% Twitter

The suggestion now: to become your own newsroom and narrow the focus since every media source has a different audience. Direct your message and information to those who like you / your industry to enable them to defend you in times of negative media.

See Attached Presentation

Deborah Irvine Anderson

Deborah Irvine Anderson worked for the CBC from coast to coast fore more than two decades. She now runs Canteen Media and Communications a boutique consultancy in Quispamsis.

GAME CHANGER FOR GAS MANAGEMENT

-presented by Michael Beattie, GIS Gas Infusion Systems

As background for the presentation the importance of oxygen as factor in fish health was reviewed. This discussion included work that implicates oxidative stress in the pathogenisis of amoebic gill disease (AGD) and that higher dissolved oxygen concentrations (123%) increases growth in pre-smolts. Oxygen consumption increases 50-80% following a meal for a period dependent on meal size and water temperature, growth is reduced by 40% at dissolved oxygen (DO) levels of 55% and fish consume 20% more feed per unit weight gain at this level as well increasing its Food Conversion Rate. Farmers know these fundamentals, though results of 24-hour monitoring work presented show how much oxygen levels change over time, with salinity and temperature changes, and especially during the night when monitoring is not typically done. Data shown indicated the DO level was <5.5mg/l for over 50% of the time. Information to remind the audience of the importance of carbon dioxide (CO_2) was also presented including the physiological results of high levels of CO_2 in the fish, the toxicity of which increases with decreasing levels of DO. In addition to health and growth impacts, high levels of CO_2 in fish also impact the harvested product due to downgrades from poor colour score, gaping, and reducing shelf life.

GIS Proprietary Gas Infusion Modules work by extracting nitrogen from water and infusing oxygen via a polymer coated micro-porous fibre matter. The oxygen is soluble and extremely stable with a half-life 150 hrs., independent of water temperature. Oxygen levels can be similarly maintained at 4°C or 40°C. There are multiple system designs for incorporation into a variety of situations including in-line for well boats, hatcheries, short / long haul transport unit, and portable in-tank units.

Total gas pressure is not increased in this process so there are no potential health concerns as opposed to other methods. In recent studies Artic charr showed a 24% increase in growth and increased pigment uptake. An upcoming project will investigate gut bacterial changes with system use over time. Direct economic advantages include reduce oxygen usage by minimum 50% and reduced electrical costs.

The biological, economic and environmental advantages of the GIS CO_2 Stripper Units were also presented. As the GIS units are more efficient than other units and can maintain higher and stable pH levels, higher transport densities can be used, and the system does not need massive pumps to achieve head requirements. In addition to reduced operational noise, factors including lower electric generator outputs requirements and reduced fuel usage improve the environmental footprint.

See Attached Presentation

Michael Beattie

Dr. Mike Beattie is the President of Gas Infusion Systems but previously served 14 years as the Chief Veterinarian Aquaculture for the Province of New Brunswick and is an adjunct professor at the Atlantic Veterinary College. He holds multiple degrees in marine biology (BSc Honors, MSc), international marketing (Norwegian School of Business) and Veterinary Medicine, AVC (1994). He was accepted as a member of the Royal College of Veterinary Surgeons in 1997 (UK). Mike is an active reviewer for NSERC and ACRDP national projects and has participated on the Canadian Science Advisory Secretariat regarding aquaculture issues. In the past, Mike spent 10 years with Nutreco N.V. (one of the largest Aquaculture/Agriculture companies in the world) and served in the capacity of Product Manager/Research & Development Manager - North America. Mike was a co- lead researcher for a multi-disciplinary team awarded the Federal "Award of Merit" for oceanic research involving sea lice management and de-naturing of toxic pesticides in 2011. The team was the first group to utilize hydrographic models and flouricine dye, to predict the dispersal/dilution of disease, pesticides and drug residues.

NOVEL APPROACHES FOR THE APPLICATION OF GENOMIC SELECTION IN ATLANTIC SALMON BREEDING PROGRAMS: COSTS, BENEFITS AND PERSPECTIVES

-Presented by Tiago Hori, Center for Aquaculture Technologies Canada

Phenotypic selection (selection based on physical appearance / observable traits) for genetic improvement can have limitations and may be a lengthy and costly process. The genes and other genetic elements that contribute to the observed variation can be identified using genomics and therefore used for selection providing an increased accuracy of selection to 80%. Genome wide selection (GWS) looks for the individuals that are most likely to have good performance based on their genetic makeup.

Genetic estimated breeding values (GEBVs) is often more accurate than the traditional EBVs and can be calculated in early life, which reduces time and cost of selection. For optimal application of genomic selection, the cost would be $120,000 per generation for genotyping alone using genotyping arrays. If the genotype imputation process is used (i.e. predicting missing genotypes for an individual based on other related individuals) cost can be reduced by 1/6 to 1/3 the cost. This is done through targeted genotyping by sequencing (tGBS). A 10% increase in accuracy using this process could results in a 10% decrease in sea lice burden or time to market.

To implement genomic selection for one trait in Atlantic salmon using Targeted GBS would require an investment of half-million dollars over 10 generations. The results could be a 10% to 30% increase in genetic gain per generation compared to traditional processes.

See Attached Presentation

Tiago Hori

Dr. Tiago Hori obtained his Ph.D. from Memorial University of Newfoundland, where he worked on developing genomic resources for the Atlantic cod. During that time, he built and characterized both normalized and subtracted cDNA libraries and helped with the construction of 20,000 features Atlantic cod cDNA microarray. These resources have been since used in several studies looking at the physiology and immune response of Atlantic cod, which have contributed to a better understanding of the biology of this commercially-relevant species. Subsequently, he worked as post-doctoral fellow at Dr. Matthew Rise's laboratory at the Ocean Sciences Centre. During that time, Dr. Hori applied diverse functional genomics techniques such as cDNA libraries, microarrays, RNA-seq and QPCR to investigate the biology of salmonids.

His work with salmonids included investigating the impacts of triploidization, using functional genomics to look into environmental impacts on the brain transcriptome and applying RNA-seq to study differential growth between families of Atlantic salmon. Dr. Hori is currently the associate director of genomics at the Center for Aquaculture Technologies Canada (CATC), where he leads efforts into further developing the genomic tools available for commercially-important fish and their application in the Aquaculture industry. At CATC, he is working to develop cost-effective platforms for single nucleotide polymorphisms (SNPs) at low, medium and high densities, aiming to make genome wide association studies (GWAS), marker assisted selection (MAS) and genomic selection accessible to the aquaculture industry. Dr. Hori also continues his efforts in developing resources for non-model commercially-relevant species, such as Atlantic sturgeon and Arctic Char, using high-throughput sequencing of SNP discovery and genotyping. Lastly, Dr. Hori in a contributing author in more than 25 peer-reviewed publications in journals such as BCM Genomics, Physiological Genomics, PLoS One and Developmental and comparative Immunology.

RECIRCULATING AQUACULTURE SYSTEMS PROJECTS: BENEFITS AND CHALLENGE
-presented by Aaron Bennett, Silk Stevens Limited

Silk Stevens Limited is a professional engineering consulting firm specializing in the design of Recirculating Aquaculture Systems (RAS). Operating globally, Silk Stevens has designed land based systems for species such as salmon, trout, sturgeon, walleye, tilapia, cobia and others.

The benefits and challenges of RAS facilities were discussed. As noted, the primary benefit of such systems, the complete control of the rearing environment. This benefit is balanced by technological challenges for engineering design and equipment selection and in terms of cost for initial capital investment and operating expense. The ability to reduce water consumption gives RAS facilities an advantage over other systems, along with increased growth rates and survival. The design can include multiple water treatments systems to increase biosecurity between life stages and year classes.

Silk Stevens is currently involved in the expansion of a 120,000 sq ft RAS smolt facility in Newfoundland through the addition of a third smolt building. In the smolt buildings, pressure packed columns supply the additional oxygen (when biomass is high), in combination with low head oxygen (LHO) system and degassing system. The egg / fry / parr building has four independent filtration systems with biofilters, drumfilters and LHO to enable independent/biosecure control of each system.

In Nova Scotia the Company is involved with planning a 750 mt / 40,000 sq ft RAS facility for the grow out of Atlantic salmon. The system, which will see 75g smolt grown out to about 5kg and will have 4 independent/biosecure systems. The space this land based facility will use was shown to be equivalent to two grid sections of a 4 x 6, 100m pen ocean site and will produce approx. 750,000Kg HOG salmon in one year.

Projects in Alberta and United Arab Emirates (UAE) involve the re-design of current system to reduce water consumption, and in Costa Rica a commercial scale hatchery facility is being designed to supply tilapia to pen sites for grow out.

Silk Stevens builds solutions from the ground up (buildings, systems and equipment selection) incorporating energy efficiency and readily accessible parts and equipment in the design.

See Attached Presentation

Aaron Bennett
Aaron Bennett is currently the Manager of Aquaculture Services and VP – Operations for Silk Stevens Limited. In his role as Manager of Aquaculture Services, he is responsible for leading aquaculture consulting for all Silk Steven's offices in Canada. Since coming to Silk Stevens he has been the Project Manager for numerous design and construction projects.

Aaron completed successful terms with a variety of governmental and non-governmental organizations including broodstock development; shellfish harvest microbiology monitoring, fish health, and commercial finfish cage culture. In his previous employment with the Provincial Government in New Brunswick, he was the Biologist charged with science based decision-making and environmental effects management policy development for the marine finfish industry. Aaron holds a Bachelor of Science Degree and an Advanced Diploma in Aquaculture from Memorial University, as well as a Diploma in University Teaching from the University of New Brunswick

COLLABORATIVE SALMON RECOVERY IN FUNDY NATIONAL PARK

-presented by Alex Parker, Fundy National Park

The inner Bay of Fundy (iBoF) group of Atlantic salmon here in New Brunswick are special in that their life cycle is spent entirely within Bay of Fundy and Gulf of Maine. The iBoF salmon are federally listed as endangered with Species at Risk Act (SARA) listing in 2003 as in most rivers salmon are extirpated. The Department of Fisheries and Ocean's, the Live Gene Bank (LGB) program began collecting the remnant families and using various release strategies has endeavoured to recover the population. Strategies from 2003 to 2016 included releasing hatchery reared mature adults to spawn naturally and produce smolt, or releasing fry or parr from hatchery spawned adults to grow to smolt and leave the river. Marine survival continues to limit the return of spawning adults.

Initial research and monitoring of these strategies along with a marine farm grow-out phase showed smolt performance differed by strategy with smolts from fry releases migrating as bigger, older smolts, and made bigger adults with better embryo survival. Salmon with the least captive exposure were shown to have increased wild fitness so Fundy National Park (FNP) re-focused its program to work with the aquaculture industry to release mature salmon with minimal captive exposure to produce offspring with no captive exposure. The adult release in 2011 from the early work resulted a 20-yr high number of adult returns in both Park rivers in 2012 and subsequently in 2015 smolt production in both rivers significantly higher than expected from similar past efforts

The current version of recovery program starting in 2016 sees wild hatch smolt and wild exposed fall parr stocked into pens at the wild salmon conservation farm in Dark Harbour, Grand Manan, and only mature adults released back to the rivers. As the project progresses, from 2019 onward it is expected there will be an increase in wild hatch smolt transferred to the farm and fewer wild exposed parr. By 2022 salmon should be returning that are multiple generations away from captive exposure.

Over 840 mature salmon were released at three locations along the Upper Salmon River in FNP in 2016. A critical evaluation feature of the strategy is to determine presence and extent of wild spawning along the river so in 2017 a fry electrofishing study was designed and implemented. Fry were captured at 100% of sites surveyed including sub-optimal habitat. Of the samples submitted for genetic analysis 62% were from the marine adult rearing strategy including contributions from 8 returning salmon from 2015.

Academic research and monitoring projects are being conducted in association with adult releases includes the monitoring the effects of nutrients on the river, tracking behavior and habitat use, and collection of 3-D spatial data for Upper Salmon River to help produce predictive model of habitat use.

These collaborative efforts, along with the adult releases to the Petitcodiac River system and a multi-award winning 7-agency protection coalition, are part of the larger Fundy Salmon Recovery program (FSR). Public engagement as part of FSR efforts include experiences like Swim with the Salmon and Salmon Days which help connect / re-connect people to salmon.

See Attached Presentation

Alex Parker

Alex Parker is a Resource Conservation Officer with Parks Canada Agency. He graduated with a Bachelor of Science from St Francis Xavier University in 2008, followed by a Wildlife and Fisheries Conservation diploma from Lakeland College in 2010. Alex began work with Fundy National Park in 2015 as a part of the Inner Bay of Fundy Atlantic Salmon Recovery Program. He currently leads field-based operations of the recovery program.

FISH IN RIVERS: ECOSYSTEM SERVICES OF ATLANTIC SALMON SUPPLEMENTATION

-presented by Kurt Samways, University of New Brunswick

Salmon do a lot more for the river that just being there. Salmon in a river provide services to the ecosystem, opportunities for education and possibly social-economic impact from eco-tourism and recreational fishing. The inherent value comes from their place within the food web of the river but also the marine derived nutrients (MDN) they bring to the environment which leads to increased diversity, growth, and production of the system.

As in the table presented, the addition each year of over a million extra eggs (from the previous) into the system helps keep river productivity up into the winter period; as food for many species and as a source of phosphorus and nitrogen. Excretory products from the salmon and potential carcasses bring biologically available nutrients to the river, increase biofilm productivity and resource use.

Using chlorophyll as a measure of primary production, graphs presented compare the Point Wolfe River (PWR) to the Upper Salmon River (USR) in August and November of 2016. Salmon had been released to the USR in October 2015 and then again in October 2016. In the November sampling only in the USR showed higher chlorophyll levels than the August sampling. To determine if MDN's increased productivity at all trophic levels, the pathway of incorporation and transfer was evaluated ending with the comparison of the young of the year from both the PWR and USR. Data presented showed the parr from the USR were approximately 2cm longer and 5g heavier than those in the PWR.

A challenge for those managing freshwater ecosystems will be optimizing the number of salmon placed in a river to obtain the services desired and at the level of impact required to deliver that service. The monitoring of released adult salmon includes the use of Passive Integrated Transponder (PIT) telemetry, radio tracking and DIDSON Sonar.

Data presented from the 2016 release showed the number, sex and movement identified from the over 66,000 detections made from October to December. It was noted that 8 of the fish detected were from the 2015 release, and so far in 2017, 16 returning salmon from previous releases had been detected.

See Attached Presentation

Kurt Samways

Dr. Kurt Samways is a Research Associate at the University of New Brunswick. Dr. Samways has 15 years of experience working in aquatic ecology related to natural and impacted rivers and stream fishes, particularly Atlantic salmon, across Canada, in both academia and government (Department of Fisheries and Oceans). Dr. Samways is currently leads UNB scientific monitoring of the Fundy National Park smolt-to-adult supplementation program, studying the effects of stocking adults on fish fitness and ecosystem health. He also currently leads fish passage studies in the Mactaquac Aquatic Ecosystem Study. Dr. Samways has ongoing collaborations with academia, government, industry, First Nations, and NGO's, as well as being a representative in multiple government and local working groups and committees involved in Atlantic salmon restoration.

USE OF DRONE MAPPING TO GUIDE ATLANTIC SALMON HABITAT CONSERVATION EFFORTS

-presented by Jon Grant, Dalhousie University

Atlantic salmon have historically occupied ~50 rivers in the inner Bay of Fundy, but populations are now classified as endangered. Population recovery for these anadromous fish is hampered by conditions in the natal rivers as well as by processes at sea. Restocking of rivers has mixed success in part due to habitat degradation in rivers as well as the need to optimize life stage at release and ocean exposure for hatchery bred fish. In order to focus efforts on rivers that are the best candidates for salmon habitat restoration projects, there is a need for a reliable method of habitat mapping.

The Upper Salmon and Point Wolfe Rivers within Fundy National Park were historically very important breeding rivers for salmon populations and have tremendous potential for restocking. Parks Canada has used sea pen rearing in collaboration with Cooke Aquaculture to maximize survival and subsequent breeding success in fish originating from the Upper Salmon River (www.fundysalmonrecovery.com). Understanding the extent an types of river habitat is important in guiding continued restoration efforts.

River habitat is complex consisting of riffles, pools, etc., and critical to all stages of the Atlantic salmon life cycle. This includes predator avoidance, feeding, reproduction, and egg development. For these reasons, mapping of river habitat size and diversity is an essential component of salmon recovery. Recent development unmanned autonomous vehicles (drones) has led to increased capability in river habitat assessment. We used a DGI Phantom 4 drone to collect 5501 georeferenced images of the Upper Salmon River (over 10 km) to build habitat maps.

Structure from motion (SFM) is a technique for assembling a wide range of photographs into a 3D model, and thus useful in translating aerial reconnaissance into views of river habitat. In the case of rivers, quantitative data are produced including substrate size (boulders, gravel etc.) as well as areas of riffles and pools. Pix4D is specialized software for generating SFM in an involved process of editing and processing. A fly-through video showed the progress to date on a section of the Upper Salmon River and provided the 3D perspective that results from structure from motion.

Concurrent studies conducted by UNB and Parks Canada are focused on groundtruthing salmon habitat use via field surveys. The substrate analysis data will be matched with the substrate requirements for spawning salmon to identify areas with patches containing the appropriate size of cobble, pebbles and finer material. Since ideal substrate for salmon is composed of a specific mixture of these substrate types, analysis of the riverbed for areas that contain large enough patches for salmon to breed will also need to be completed. Ultimately, other tools such as hydrodynamic models and calculation of a Habitat Suitability Index (HSI) will be used as further input to restoration of salmon to the Upper Salmon River as well as other watersheds in Atlantic Canada.

The work of MSc student Chantal Giroux and former Postdoc Jeff Barrell is gratefully acknowledged in conducting this research

See Attached Presentation

Jon Grant

Dr. Jon Grant is the NSERC-Cooke Industrial Research Chair in Sustainable Aquaculture, beginning a multi-year partnership with Cooke Aquaculture, the largest domestic fish farming company in North America. He is a Professor of Oceanography at Dalhousie University, Canada's premiere ocean institution. Trained as a benthic ecologist, he has a BSc from Duke University and PhD from the University of South Carolina. Jon has worked in aquaculture-environment interactions for 30 years and authored well over 140 scientific papers. Working with both the shellfish and finfish farming industry, Jon has pioneered concepts and tools for assessing carrying capacity in field culture. Ecosystem models have been developed for coastal bays including explicit criteria for sustainability. This work has led to rigorous application of ecosystem-based management and marine spatial planning to aquaculture, including incorporation of remote sensing and GIS. With extensive experience in oceanographic instrumentation and environmental assessment, Jon has conducted aquaculture research worldwide. His research involves an intensive field and modelling program as well as collaborations with university, government, and international partners. Jon led the development of the Aquaculture theme in the new Ocean Frontier Institute, the largest marine science initiative in Canadian history.

ASSESSING THE INTERACTIONS BETWEEN WILD AND FARMED SALMON: A (BRIEF) LITERATURE REVIEW ON THE MIGRATION OF ATLANTIC SALMON POST-SMOLTS
-presented by Marc Trudel, DFO-SABS

Salmon aquaculture production in Canada has grown since the mid- 1980s and now involves three Atlantic provinces and British Columbia. Some of the challenges involved with salmon farming include wild fish carrying diseases that are then passed onto the farmed salmon, then potentially back to wild fish. The risk factors for this potential disease transfer were identified including ocean circulation, Residence time of the hosts near aquaculture sites, distribution of potential hosts near aquaculture sites and farm's fish health management plan. An example from BC was discussed since the prevalence of the bacteria causing Bacterial Kidney Disease in Pacific salmon ranges from 10% to 50%, so the combination of how many fish are potentially carrying this bacterium and the length of time the Pacific salmon are around the Atlantic salmon could provide information on the potential risk.

In eastern Canada, wild Atlantic salmon could potentially come close to marine farms during three migration periods – as smolts leaving the river on route to the sea, as adults moving from the sea back into the rivers, and as kelts leaving for the sea post spawning. To estimate the residence time of juvenile salmon near salmon farms, a better understanding of the migration of salmon during their marine life is required. Most of the research to date has focused on the migration of post smolts in coastal waters with telemetry work conducted in the Bay of Fundy, in Cape Breton and Baie d'Espoir.

Work presented from releases of tagged smolt from the Big Salmon River from 1967 to 1973 and found in weirs showed inner Bay of Fundy smolt generally remain within the Bay for their marine phase and locations where they were found, but only 1%-2% of the tagged smolt were ever recovered. Acoustic telemetry is the tool more recently used to study smolt migration and results from Lacroix at al 2004 paper was reviewed. Residence time was about the same for both wild and hatchery smolts released, on average it took about 5 days from release to exit of Passamaquoddy Bay with a maximum time of 12 days. The migration routes of post smolts into the Bay of Fundy were different but seemed to track surface currents during spring and summer.

Later papers by Lacroix (2008, 2012) was also presented showing about 80 acoustic telemetry receivers in the outer Bay of Fundy from New Brunswick and Nova Scotia through Grand Manan Island being used to track outer and inner Bay of Fundy smolt. Outer Bay of Fundy smolts appeared to undertake a rapid migration through the main channel without going near farms and then leaving the area, presumably heading to West Greenland. In contrast, the Inner Bay of Fundy smolt had a more diffuse distribution, with some fish potentially going near the salmon farms but those that did, didn't seem to spend much time in the area. As there were no receivers near the farms, it was not possible to determine the residence time of any of these smolt near the salmon farms and there is no information beyond their first 4 months at sea.

Additional work from Nova Scotia and Newfoundland was presented providing similar results but there is still uncertainty in terms of how much time juvenile salmon remain near the farms and there is no comparable information for returning adults. A new project node is being developed with the Ocean Tracking Network which will see receivers placed in the Bay of Fundy, including some farms sites for smolt monitoring.

See Attached Presentation

<u>Marc Trudel</u>
Dr. Trudel is a research scientist who leads multidisciplinary research program aimed at assessing the long-term effects of climate change on salmon productivity and the limits to marine ecosystems productivity for Pacific salmon. He has extensive experience in designing and managing large-scale field programs in coastal waters of British Columbia, and in studying the migration behavior of juvenile salmon. His research program has contributed to the development of leading indicators of marine survival that are used to forecast adult salmon returns in southern British Columbia and to understanding the interactions between wild and cultured salmon. He recently relocated to St. Andrews where his research will focus on aquaculture-ecosystem impacts and risk mitigation

LOBSTER AND ROCK CRAB MOVEMENT AROUND SALMON FARMS IN SOUTHWEST NEW BRUNSWICK, CANADA

-presented by Chris McKindsey, DFO

As general background for the presentation it was noted that finfish culture adds organic matter (OM) to benthic environments and that fish and crustaceans have been shown to take up and use this OM. Though there has been concern for negative effects on these species, there has been little work done either in North America or specifically on benthic crustaceans. The larger project in progress involves several objectives including the evaluation of the uptake of salmon farm-derived material by lobsters and other species, and their population structure between habitat types (i.e., farm and reference areas). The results to date from the evaluation of lobster and crab use of, and fidelity to, salmon farms relative to natural areas was presented.

It was assumed that lobster and crab movements (speed / distance) and their core range sizes do not differ between salmon farms and reference areas. Two farm locations in southwest New Brunswick were initially chosen based on difference between water depth, bottom type, and hydrodynamic activity. Traps were placed on site to catch lobsters and crabs, acoustic tags were mounted on their cephalothoraxes, and the animals basket surface released back to trap location. Monitoring data presented from July to November 2016 showed the difference in speed of movement for the crab and lobster was due to the site, not species differences as both species moved more rapidly on the less energetic site. Core area calculations added to this information shows a weak effect of the farm on crustacean distribution and use; crabs seem attracted to farm and neither species is repelled from the farm location.

Related work has indicated rock/green crab are more abundant in farms than outside of them but not Jonah crab or lobsters; crustaceans do pick-up a lipid signal from feed and likely farms; and fishing showed mackerel to be most common fish around salmon farms and much more abundant there than in reference areas.

2017 work being completed will look at lobster movement in relation to farm activities with reference areas, and contrast two capture / release methods.

See Attached Presentation

<u>Chris McKindsey</u>

Dr. Chris McKindsey is a Research Scientist with Fisheries and Oceans Canada at Institut Maurice-Lamontagne (Demersal and Benthic Sciences Section) in Mont-Joli, Quebec, and adjunct professor at Institut des Sciences de la Mer de Rimouski (ISMER) in Rimouski and Université Laval in Quebec City. After finishing his MSc in parasitology at Concordia University and a PhD in Coastal Ecology at Université Laval, he did postdoctoral studies in Coastal Ecology and Impact Assessment at the University of Sydney, Australia. Today, Chris' work focuses largely on anthropogenic stressors in coastal areas, with a focus on aquaculture-environment interactions, aquatic invasive species, and habitat-community relationships. His interdisciplinary research involves partners from various levels of government, academia, various organizations, and industry partners. He uses observational, manipulative, and laboratory studies with a strong emphasis on complex field experiments, the results of which lead to the provision of science advice for coastal zone management. He has ongoing collaborations on all Canadian coasts as well as in Europe and Tahiti but most of his work is focused on issues on the Atlantic coast of Canada. Area(s) of Expertise: Coastal/Benthic Ecology; Aquaculture-Environment Interactions; Aquatic Invasive Species;

FEEDING THE WORLD – NEW ROV TECHNOLOGIES IN AQUACULTURE
-presented by John J. Wintermeyer, Deep Trekker

Deep Trekker owners lost a flashlight in Lake Huron and from what they thought would be a recreational toy built to find such objects, the ROV developed turned into an ideal tool for aquaculture after a chance contract from a fish farmer. Designing and implementing new applications to improve the ways ROVs can be used in aquaculture has been part of the business model since the company started.

Inspections are important for maintaining aquaculture farms and may encompass various aspects of the operation such as net integrity, monitoring smolt introductions, compliance inspections and benthic impact monitoring. Some companies are using ROVs to ensure cleaner fish are present, that the artificial hides are working well, and / or they need cleaning since there is no way of knowing this within some of the huge pens used (160-200 m) circle without having an underwater view.

Commercial divers may be expensive for small companies, unavailable to hire or safety does not permit diving so ROVs have become important for visual inspections of mooring lines and anchors. Units are very portable, and generators are not needed as the units are battery powered.

Deep Trekker is working with many academic institutions, including a researcher at DFO's St Andrews Biological Station to understand how far away the enriched soil from aquaculture sites entice new and / or additional species to the location. The project is currently at the proof of concept phase completing remote sampling at two sites near aquaculture farms and so far, the Deep Trekker ROV has collected over 200 samples. Each of the six syringes takes in 50cc of the sediment/water and is then used to distinguish each individual species that is inhabiting that area. Fisheries Conservation and Enforcement Officers are also using ROVs to deploy for investigational purposes when buoy markers are found.

Future work includes upgrades to current sensors, tools and technology and continuous improvement on ways that ROVs can be used in the industry. From a mort pusher tool for uplift systems, to using a ROV with piece of net with clamps for temporary repairs, to the utility crawler to inspect boat hulls and clean tanks, new functions for ROV are being developed as needs arise. There is also new drop camera available with a 360° view, workable depth down to 300m and wipers to clean lens of biofouling that can be used for feeding and monitoring fish behaviour.

See Attached Presentation

John Wintermeyer
John came to Deep Trekker a year ago to join a dynamic sales force. Having worked as part of a start-up company who engineered sensory equipment, John's background in innovative and advanced technology have made him a great asset to the team. Aquaculture has always been of interest to John. He appreciates that when monitored and regulated correctly, aquaculture and the proteins it produces, are a viable and ready sustainable source of food. With lesser-developed countries beginning to embrace best practices and setting up regulated fish farms, not only is this technology feeding poverty-stricken communities, but is assisting in lessening the overfishing which has decimated wild fish populations globally. These factors as well as the rapidly changing technology are what keep John engaged and passionate about aquaculture, and keen to introduce Deep Trekker's line of ROV's to the world as a way to maintain regulations and best practices.

DATA DRIVEN OCEAN FARMING
-presented by Brad Rodgers, Realtime Aquaculture

Real time information allows us to make real time decisions. This is critical when dealing with living inventory in the water." -Scott Leslie, Kelly Cove Salmon

Existing technologies for monitoring water conditions at salmon farms consisted of cabled solutions that proved not to be scalable, and unreliable in harsh ocean environments. Farmers were frustrated with the mess of failure-prone cables and expensive cage furniture that still didn't deliver the real-time data they needed.

Realtime Aquaculture has developed a system that uses wireless underwater sensors that are easy to deploy and scalable to typical saltwater production sites. The Realtime system can send / receive data from hundreds of sensors up to 500m away from the central hub. There are currently many fish farms operating with this system, mostly in North America, but also in Norway and Australia

From the aquaHub, information from all sensors (aquaMeasure or others) is sent to the aquaCurrent software for data management and a dashboard on desktop and / or mobiles provides data in real time. Data ca also be exported into other systems and formats for alternative reporting and analysis. The aquaHub can send data through various communications options. The aquaMeasure sensors can currently monitor tilt, salinity, temperature and dissolved oxygen.

Data visualization capability is being developed so users "see" how factors like water temperature and dissolved oxygen are changing vertically over time and between fish pens on the site. Data Fusion can add tidal cycle information for feeding decisions.

New in development are other components like Cloud Synced Loggers, the aquaMeasure-POD which has seven sensor attachments and the RX-Mini Receiver which is smaller and more deployable than previous versions. Interface updates summarize information for multiple sites or individual pens depending on the needs of the user, along with notifications for system maintenance and data outside the set parameter range.

"The future of ocean farming is data driven and the best way to collect this data is with wireless sensors"

<u>Brad Rogers</u>
Brad completed his studies in Electrical Engineering at the University of New Brunswick and started his career with Amirix Systems in 2000. Since then, Brad has developed technology products for a number of applications including oceanographic research, security, oil & gas and currently aquaculture. Brad complements his technical background with 8 years' experience in Product Management working with customers to understand needs and the process of innovation. In 2015, Brad completed his Master of Technology Entrepreneurship and Innovation at Saint Mary's University. Brad is currently the Vice President of Business Development at Amirix / Realtime Aquaculture.

CAN ULTRASOUND AND NANO-CAVITATION MAKE A DIFFERENCE WITHIN AQUAFARMING?
-presented by Nina Hanssen, Aqua Farming Solutions

The technology used by H2O Technics and Aqua Farming Solutions, was developed by a team of Dutch inventors several years ago, and although it was based on the already well-known technology of ultrasound, the Dutch inventors took more than 12 years to reinvent and customize the technology for various purposes related to water treatments.

The C-Dome technology has been for sale and in use in the Netherlands since 1988 and all that is need is a computer module called the E-Box and a resonator. When powered, the resonators start vibrating so fast that the vibrations shake and tear the water to such an extent that the potential energy stored within the mass of water is released and turned in to kinetic energy….as sound, sound that is travelling in higher altitudes and with more speed through the water than was thought possible. The vibrations and resulting nano-cavitation bubbles create water jets acting like a high-pressure cleaner.

Marine growth can lead to many problems on a farm including compromising pen stability, reduced water exchange, less oxygen, and decreased efficiency of cleaner fish. Fouling organisms such as hydroids and anemones may also be a refuge for various micro-organisms like the amoeba causing AGD and ectoparasites. Costs related to net cleaning was estimated to be 10% to 15% of production. Today, pretty much all the methods used in the ongoing battle against sea lice, are dependent on handling the fish one way or the other and all of them have impact on the mucus layer, some more than others, especially if repeated too often in a short period of time, all weaken the fish.

Within aquafarming, the water-jets that originate from the combination of ultrasound and nano-cavitation prevent bio-fouling and stop the reproduction of ectoparasites. Any reproductive cells of marine growth or early stages of parasites between 0.2 and 0.7 mm that are near the water jets are eliminated making it impossible to reproduce within the pen. The ability to stop sea lice reproduction within individual pens will therefore stop sea lice from spreading within and among farms. The seeds / early stages of marine growth do not survive to become established on the nets as shown in pictures presented showing three months growth on nets with and without a resonator in the pen. The resonators have a working distance of approximately 45m distance and the arrangement / direction of the resonators can be customized based on the farm environment.

The technology uses no chemical so does not spread to, and has no impact on, the marine ecosystem beyond 3 km, nor has any negative effects on the seabed under the pens. The C-Dome units are environmentally friendly, sustainable, low cost and low maintenance.

Aqua Farming Solutions – Using the power of nature.

See Attached Presentation

<u>Nina Hanssen</u>
Nina Hanssen was born and raised above the Arctic Circle in Norway, and has been living in the Netherlands for the last 17 years. After working for the Intelligence Services in her native country, she studied Russian language and literature at the University in Tromsø, prior to entering in to the world of sales. She is the Commercial Director for Aqua Farming Solutions BV, a subsidiary of H2O Technics BV, as well as partner in H2O Technics.

INTRODUCING CLEANTREAT – ENABLING ZERO DISCHARGE BATH TREATMENTS
-presented by Keith Morris, Benchmark Animal Health

Bath treatments have been the mainstay of sea lice control in the salmon aquaculture industry for many years as part of an Integrated Sea Lice Management programme. However, more recently this method has come under scrutiny due to the concern of medicinal treatment discharge into the environment. CleanTreat is designed to address this issue which is one of the industry's challenges related to limits on environmental discharge consents in this highly regulated industry.

CleanTreat is a method of removing medicinal compounds from bath treatment water to enable the treatment water to be discharged into the sea without any environmental concerns. The CleanTreat system can be used on well boats, tankers, platforms and land bases and is effective against all licensed sea lice bath treatments available bath treatments for sea lice. The CleanTreat project has been seven years in development at the Ardtoe Marine Research Facility in Scotland, the epicentre of Benchmark’s R&D efforts in salmonid aquaculture. The scale down of CleanTreat units here allowed optimization of the process and testing of many compounds of interest to aquaculture. Three thousand tests have been undertaken here to ensure the process works, and all scenario’s have been investigated and tested. The actual process on a wellboat was explained by way of a video animation.

The CleanTreat system allows wellboat bath treatments to proceed as normal and the series of containerised purification units can be fitted on to the deck of wellboats. Fish are treated for the allotted time, then crowded to allow pumping over a rinsing and de-watering system before being returned to the cage. The treatment water is pumped back into the well so the wellboat will need to be able to pump fish out separately to the well water for this system to be used. After the fish are pumped out, the water is pumped through a drum filter to remove organic material, including lice, before entering the purification unit. An on-board chemist measures the levels of the compound using HPLC and only when the water is below the level of detection of the medicinal compound does discharge commence. The disinfection of the system is done with a low pH acid flush through for 1 hour, then buffered with sodium bicarbonate to allow discharge of water and salt.

One CleanTreat unit can deal with 200 m3 of water per hour which presents some problem with logistics so as this is a modular system a more effective method would be to utilise a large vessel with several CleanTreat units. This would allow the wellboat to continue treating while the vessel is purifying the treatment water. There is a process to completely remove the resultant bulk compound on land which will comply with all local regulations.

The next step in CleanTreat development is to collaborate with industry to look at how to utilize this system in the various farming areas; to develop a scalable, practical and easy to adopt system. This process has started in Norway with a dry run (no medicine) of the process on an industrial scale and the process worked better than predicted. The next trial runs will be with fish within the next few weeks.

The CleanTreat method opens opportunities for considering new effective compounds for treatments not previously considered due to their environmental profile. It is one part of the toolbox needed for improved aquaculture sustainability.

See Attached Presentation

<u>Keith Morris</u>
Keith Morris has a BSc Hons Marine Biology/Zoology from the University College Wales, Bangor, UK, and a MSc Marine Science and Aquaculture from the University of Aberdeen, Scotland, UK. Keith spent several years in the Public Sector as Veterinary Health Inspector for UK aquaculture at CEFAS before moving to the private sector Pharmaceutical Industry at Schering Plough as Vaccine Development Project Manager for their Aquaculture Business. He then moved across to the Commercial Dept managing sales and marketing of the UK Aquaculture business where he was managing the products Slice, Florfenicol and various salmonid vaccines for 15 years through the transitions from Intervet to Merck. Keith joined Benchmark in May 2015 where he manages Benchmark Animal Health’s aquaculture commercial activities for products and services in the market, and entering the market, with focus on the salmonid, Mediterranean marines and tilapia sectors.

SEA LICE DATA SUPPORTING CONTROL DECISIONS AND MONITORING FIELD RESPONSES TO TREATMENTS

-presented by Larry Hammell, AVC – UPEI

Data from the Fish-iTrends database was presented graphically providing information on a variety of aspects of sea lice management for 2017 and comparing the data for the last seven years.

Data on the number of adult female (AF) lice per fish indicates that 2017 was similar to high lice years of 2010 and 2012, though it was noted that sea lice numbers presented are not adjusted for the number of fish in each BMA during different years which would affect total area burdens. Data presented for BMA 2a specifically for 2010-2017 shows the extent which AF numbers in 2017 were higher than other years. The annual BMA mean number of mobile lice (i.e. pre-adult male and adult male (PAAM) combined with AF lice) indicates that 2010 and 2016 were the highest years, followed by 2017. The annual industry AF lice average presented also indicated that lice levels did not go as low as years 2010 to 2015 during the winter / early spring months.

The Fish-iTrends database provides site compliance reports to indicate that lice counts were completed as per required protocol. The system also produces a weekly report ranking the changing in sea lice number by sites to provide managers a risk assessment tool. Site and BMA graphs are also available to demonstrate levels of lice by life stage in relation to water temperatures. Sites within a BMA may be compared as well with sea lice levels and number of cages treated over the year.

Weekly bath treatment frequency and the proportion by treatment type for 2010 to 2017 were presented. The graphs showed the industry change from primarily using Paramove to more recent years using more Salmosan. The use of in-feed products is tracked in the same manner, indicating the reduced use of Slice starting in 2009 and its minor increase in use frequency in 2013. A graph showing percent sea lice knockdown for adult females in 2017 was presented indicating that the majority of treatments are providing only 50 -80% reduction in lice numbers, with successful treatments defined as over 80% reduction in lice. Individual graphs of specific life stage and product presented comparing data from 2012-2017 indicated that generally Salmosan had the higher number of successful treatments for AF and PAAM life stages. Effectiveness was influenced by factors such as season and pre-treatment level of sea lice. If lead and tag time of sea lice counts were not taken into consideration, treatment effectiveness could be underestimated. The variability in treatment response is caused by unknown factors but its importance to long term success of lice control justifies that industry should investigate all potential sources of variation through more data collection and analysis of treatment mechanics factors.

See Attached Presentation

Larry Hammell

As an aquatic veterinary epidemiologist, Dr. Larry Hammell has been the lead proponent on many large, clinical research projects and partnerships with industry and government agencies. Larry is currently the Dean (Interim) of the UPEI School of Graduate Studies. He is also Professor and Associate Dean (Graduate Studies & Research) at the Atlantic Veterinary College, University of Prince Edward Island, and Co-Director of the Collaborating Centre for Epidemiology and Risk Assessment of Aquatic Animal Diseases (ERAAAD) for the World Organisation for Animal Health (OIE). Through his international and regional work, Larry's research focuses on aquatic food animal health studies including disease detection and surveillance, health management through identification of risk factors and disease prevention studies, and clinical trials for improved treatment responses.

USING AGENT-BASED MODELLING TO EXPLORE SEA LOUSE EVOLUTION OF RESISTANCE TO CHEMOTHERAPEUTANTS ON ATLANTIC SALMON FARMS

- *presented by Gregor McEwan, Atlantic Veterinary College, UPEI*

Sea louse infestations are a worldwide problem for Atlantic salmon farming. While there are potentially many methods for dealing with the infestations, it is difficult to determine the best solution in a particular setting. Individual farms vary in environment (e.g. temperature and salinity), external pressure from other farms, available treatments, resistance to chemicals, and many other parameters. These variations increase the difficulty in exploring management strategies for mitigating sea louse infestations.

Our solution is to build an Agent-Based Model that allows parameterising a particular setting (i.e., farm) and experimenting with different strategies. The strategies can incorporate management decisions such as different kinds of treatments, stock and harvest timing, timing of treatments, and size at stocking. The model will output lice counts and levels of genetic resistance to chemical treatments.

Agent-Based Models model individuals (agents) as entities with simple behaviour and properties. By grouping large numbers of these simple entities, a complex system emerges. In our salmon farm model, the agents are: the farm, which has cages and goes through production cycles; cages, which contain salmon and planktonic lice; salmon, which start small and grow and have lice on them; and sea lice, which mature, attach to salmon, and reproduce. For some experiments, we also model wild groups of salmon that are near enough to the farm for portions of the year to exchange sea lice.

We have used this model for two major explorations already. The first investigated of the influence of wild salmon populations on the resistance levels of lice on the farm. We found that increasing the number of wild salmon had a beneficial effect in extending the use of the chemical. However, surprisingly, we also found that the beneficial effect appeared to peak when the number of wild salmon equalled the number of farmed salmon. The second compared treatment strategies, where we compared between strategies such as applying chemicals in rotation or in combination. We found that applying in combination was most effective over the long term for managing resistance to the chemicals.

Currently, we are primarily engaged in two projects. The first is evaluating control of sea lice using lumpfish. Our early results suggest that there is a threshold, under which sea lice make little difference. The second is calibration and validation of the model with publicly available data from Norway to increase the accuracy of the model.
The next steps for the model are to scale to more realistic farm sizes and to multiple farms, and to get a better understanding of how the model can serve industry in a practical role. With some guidance, the model can be a flexible and powerful tool for managing sea lice on Atlantic salmon farms.

See Attached Presentation

Gregor McEwan
Dr. Gregor McEwan is currently a Postdoctoral Fellow at the Atlantic Veterinary College at the University of Prince Edward Island. While his past research was in the field of Computer Science with a focus in Human Computer Interaction and online game communities, he now models sea louse infestations of Atlantic salmon farms. He completed his Ph.D. at the University of Saskatchewan under the supervision of Professor Carl Gutwin. Previously he worked as a Research Engineer and Research Scientist at joint publicly and privately funded research institutions in Australia.

RESISTANT SEA LICE -IMPLICATIONS FOR HEALTH MANAGEMENT OF FARMED SALMON

-*presented by Kari Olli Helgesen, Norwegian Veterinary Institute*
Resistance to a pesticide is often first discovered when a proportion of the parasites survives a treatment since the genetic background for resistance is often not known and therefore cannot be detected within the population. The first resistant louse was most likely not a result of chemical treatment but due to a random mutation that later proved beneficial for the lice.

Diagrams provided depicted how resistance is developed in a population and how external infestation pressures influence resistance development. The most resistant parasites survive each treatment. These lice produce a new generation of lice which are more resistant than the previous generation. Neighbouring farm’s resistance profiles and thereby your exposure to more sensitive or more resistant lice populations can influence the speed at which resistance may become established at a farm location.

The delousing agents available in Canada and Norway were reviewed along with their resistance status. The table and global map presented shows most of the available delousing agents are no longer effective or only partly effective due to resistance in many regions.

A figure comparing the volume of salmonid production in Norway and the volume treated for sea lice shows resistance started to become an issue around 2008, and the amount treatment generally increased until it peaked in 2014. From 2014-2016 the treatment frequency decreased because reduced efficacy made this management tool ineffective and non-medicinal treatment methods had become more available to farmers.

Optimal sea lice management would be based in biological and mechanical preventatives measures used as the first tool implemented on farms before moving to the various biological and mechanical removal options and leaving medicines as the last management tool implemented. As the list presented shows, there are many potential options under each of these categories being developed in Norway, but they have not all been proved to date and may not work in all environments. Since 2012 there has been a large increase in non-medicinal treatments in Norway including those using fresh water, warm water or using a delousing machine. Mortality rates and expense have unfortunately also increased in association with some of these new methods for the farmer.

Medicines are still used, so to prolong their efficacy an integrated resistance management plan is needed which will delay the development of resistance and prevent the introduction of resistance into new areas.

See Attached Presentation

Kari Helgesen

Kari Olli Helgesen is a Norwegian veterinarian with a PhD in aquatic veterinary pharmacology. She is currently working for the Norwegian Veterinary Institute, where she is leading the sea lice research group at the section of Epidemiology. Her research has focused on mechanisms for resistance in sea lice and methods for resistance detection. Today she is also responsible for the national surveillance program for resistance in sea lice in Norway.

THE SELECTIVE POWERS OF ANTIPARASITIC AGENTS ON SALMON LICE

-presented by Elena Jensen, Norwegian University of Life Sciences

Norway is the largest producer of Atlantic salmon in the world, still relies heavily on anti-parasitic substances to keep infestations at "acceptable" levels but are experiencing problems with failing medicinal treatments against salmon lice. The industry would like to grow but is limited by the development and spread of resistance in salmon lice.
The study presented was designed to evaluate how effective the two of the most utilized anti-parasitic agents, deltamethrin and azamethiphos, are against salmon lice of different resistance status, and to determine how much more likely is a salmon louse with a resistance marker to survive a treatment with azamethiphos or deltamethrin compared to a louse with no such marker.

Copepodids identified by bioassay as sensitive, double resistant or multi-resistant were mixed to represent a 25%:50%:25% mix respectively and used to infect salmon postsmolt. Once the lice reached pre-adult stage the salmon were divided into three groups / tanks, one of which was treated with deltamethrin, the other with azamethiphos, and the third kept as a sea water control. Detaching salmon lice were removed from the filters of each tank at specific time intervals and all lice were analyzed for genetic markers of resistance to both products. 527 lice were genotyped, and each was designated either resistant (R) or sensitive (S) for deltamethrin and either sensitive (SS), resistant (RR) or as having reduced sensitivity (RS) for azamethiphos. Of the total, over 70% of the lice were resistant to deltamethrin and over 50% resistant (RR and RS) to azamethiphos. Only about 18% of the lice were sensitive to both products (S/SS). The treatment efficacies were 13.2% on R lice, 70.3% on S lice in the deltamethrin group, and in the azamethiphos treated group the efficacies were 19.1% on the RR lice, 80% on the RS lice and 100% on the SS lice. The survival analyses show that there are clear differences in survival between the genotypes within each treatment group.

Using the proportion of surviving lice from each genotype group and the Hardy-Weinberg equilibrium equation provided, a prediction of how the allele genotype frequencies will change in subsequent generations shows how even if 95% of all lice were killed, azamethiphos treatments would still be less efficacious on the next generation of lice. When survival is linked to having a specific genotype, this genotype will become much more prevalent, and because salmon lice have relatively short life cycles, with females producing vast numbers of eggs each cycle, the genetic composition of a population can change very quickly. The data demonstrates the potential of a medicinal treatment to act as a selective process, moving the population towards a more resistant genetic composition.

See Attached Presentation

Elena Myhre Jensen

Elena Myhre Jensen is from a town right outside Oslo, Norway. She has a Bachelor's degree in biology and finished a Master's degree in Ecotoxicology (working on Atlantic cod) at the University of Oslo in late 2014. In February 2016, Elena was taken on as a PhD student at NMBU, under Professor Tor Einar Horsberg, where she has since been working on resistance epidemiology with regards to salmon lice (L. salmonis).

SMOLTVISION-A NEW PCR-BASED SMOLTIFICATION ASSESSMENT TOOL

Nils Steine[1], Michael Ness[1], Siri Vike[2], Asbjørn Dyrkorn Løland[2], Elise Hjelle[2], Stian Nylund[2]*

[1]Pharmaq AS, [2]Pharmaq Analytiq AS

ATPase activity has long been used as an indicator of the smoltification process that takes place in juvenile salmonids. Since 2001, the McCormick methodology has been widely accepted to be the "gold standard" globally within commercial salmon farming. PHARMAQ Analytiq, a Bergen-based ISO-accredited fish diagnostics laboratory, has since performed this assay on several hundred thousand fish within Norway. Despite this monitoring, however, the Norwegian salmon farming industry is still experiencing considerable post-salt water transfer mortality, some of which has been linked to suboptimal time of sea transfer. Additionally, corresponding and significant losses in stock productivity have also been suspected. These trends are reported in many other regions where commercial salmon farming is conducted. Since 2009, distinct freshwater and seawater isoforms of ATPase have been identified and characterized. Expression of these ATPase isoforms has been shown to change in a predictable manner throughout the smoltification process. Conventional ATPase monitoring provides a total ATPase sum of all isoforms active in the gills at the time of assessment. SmoltVision, a realtime RT PCR-based analysis offered by PHARMAQ Analytiq, is the only commercially available assay that can differentiate between isoform expression. Several commercial case studies conducted in Norway will be presented where SmoltVision was trialed alongside ATPase monitoring in order to determine its relative ability to understand saltwater tolerance. Additionally, SmoltVision was also trialed in British Columbia, Canada against ATPase, blood chlorides and smolt index. Within commercial salmonid production, the novel ability of the SmoltVision assay to differentiate between saltwater and freshwater ATPase expression is shown to be a beneficial tool for understanding and predicting saltwater tolerance. The assay is also shown to function as a welfare indicator by detecting the presence of suboptimal environmental conditions and health concerns that affect the smoltification apparatus in the gills and the gills themselves.

See Attached Technical Article

Nils Steine

Nils Steine completed a MSc in aquaculture / fish health and so in Norway is called an Authorized Fish Health Biologist. Nils worked in a fish health service company in Northern Norway in the 90's and as the Fish Health Manager for the production company, Atlantic Salmon of Maine from 2000-2004. From 2005-2008 he worked as a fish health consultant in BC, with emphasis on physiology /smolting, vaccines and fish health services. He then moved with the family to Stavanger, Norway and has worked with PHARMAQ since that time, serving as a technical and sales Manager for Canada and parts of Norway.

APPLICATION OF SEA BED MAPPING TO AQUACULTURE ASSESSMENT AND SITING

-presented by Jon Grant, Dalhousie University

Habitat assessment is important in aquaculture for several reasons including site selection, environmental monitoring, and marine spatial planning. Because bottom type is so important to a variety of benthic species, acoustic habitat classification has been used via the principle that soft bottoms absorb sound and hard bottoms have greater echo. Depth and vegetation are also quantified. Habitat may be determined to be “good” via acoustic sampling, but information about its actual use by specific organisms must be added.

Lobsters occupy a variety of bottom types, but like many species, there is preferred habitat. Based on lobster landing data in eastern Canada, abundance has been increasing since about 1975 and yield has doubled since about 1900. Among fisheries that potentially interact with aquaculture, lobsters share similar depths and coastal areas with fish farming. Some of the mechanisms of lobster-aquaculture interaction include the space occupied by salmon farms and therefore lobster trap exclusion, habitat alteration through organic loading, and concerns about pesticide use. Knowledge of lobster habitat may help avoid some of these interactions, but species habitat modelling requires location data on the presence and/or absence of the target species, values which have been traditionally difficult to obtain for lobsters.

Results of two studies were presented. In the first, acoustic bottom mapping was used to characterize habitat, and a drone was flown to count lobster traps as a proxy for lobster location. Subsequent modelling allowed mapping of a habitat suitability index for lobsters. In a second study, diver sampling was used to quantify lobster abundance on and off a fish farm over multiple years. Survey results showed an approximate 150% increase in lobster numbers over time, regardless of sampling location (on or off farm), or timing of sampling (farm fallow or in production). Nearshore fishery statistics in the Bay of Fundy showed similar trends, indicating that lobster populations at the farm simply reflected patterns in the larger fishery, with no impact of aquaculture.

Bottom mapping can also be used to assess benthic impact and the recovery process during fallow periods, e.g. through spatially resolved sulfide measurements. An example was provided comparing a previously farmed site to background sulfides in the surrounding sediment and the time series of recovery but mapped over the larger bay.

In all the above examples, a spatial approach to habitat assessment is employed. This embodies part of a marine spatial planning strategy in which the broader ecosystem view is considered, including a wider variety of coastal resource use beyond aquaculture.

This work was led by Anne McKee as part of her MSc research at Dalhousie.

See Attached Presentation

<u>Jon Grant</u>
Dr. Jon Grant is the NSERC-Cooke Industrial Research Chair in Sustainable Aquaculture, beginning a multi-year partnership with Cooke Aquaculture, the largest domestic fish farming company in North America. He is a Professor of Oceanography at Dalhousie University, Canada's premiere ocean institution. Trained as a benthic ecologist, he has a BSc from Duke University and PhD from the University of South Carolina. Jon has worked in aquaculture-environment interactions for 30 years and authored well over 140 scientific papers. Working with both the shellfish and finfish farming industry, Jon has pioneered concepts and tools for assessing carrying capacity in field culture. Ecosystem models have been developed for coastal bays including explicit criteria for sustainability. This work has led to rigorous application of ecosystem-based management and marine spatial planning to aquaculture, including incorporation of remote sensing and GIS. With extensive experience in oceanographic instrumentation and environmental assessment, Jon has conducted aquaculture research worldwide. His research involves an intensive field and modelling program as well as collaborations with university, government, and international partners. Jon led the development of the Aquaculture theme in the new Ocean Frontier Institute, the largest marine science initiative in Canadian history.

EVALUATION OF BENTHIC FAR-FIELD AND SITE RECOVERY EFFECTS FROM AQUACULTURE WITHIN THE LETANG INLET, NEW BRUNSWICK

-presented by Andrew Cooper, DFO-SABS

The project under discussion had two objectives: to assess far-field effects on benthic community structure within two areas of aquaculture and reference area in Letang Inlet with respect to bay management; and to compare far-field findings to previous baseline study in the same localities. To date work on the second objective remains in progress, so results from work completed on the first objective will be presented.

The work on the three locations with Letang started in 2012 and continued through 2015, with ten to eleven benthic sediment samples collected in the far field (>50m) per location, annually in late September. Macrofaunal communities were investigated to identify species found, abundance and biomass estimates. Sediments were also tested for phospholipid fatty acid profile to identify the microbial community. The sediment and water column were analysed for 36 environmental variables including trace metals, organic content, sulphide, turbidity, and fecal coliform.

The data for benthic macrofauna abundance and biomass for the 208 taxa found in the three locations was reviewed to show that the taxa were significantly different between samples and years. There were some common species for all locations with reduction in some environmentally sensitive species to species that are less sensitive to organic enrichment but with no cyclic effect that would seem to coincide with the production cycles. All three locations changed in a similar way over time indicating larger scale coastal effect. Using an abundance – biomass comparison as index for disturbance (chemical and/or physical) the data showed the reference area was as expected and the two other locations had just a subtle change and then some indication of a recovery response.

There was no difference in the microbial community between locations, though there was a major change from 2012 to 2013 that could be associated with seasonal environmental changes such as light and water temperature. This can occur between years when sampling is targeted for the same dates.

A review of the environmental variables indicated a pattern consistent with results for community structure in that all three locations showed parallel change over time and there was a change in environmental condition 2012 to 2013. As with macrofuana community, the environmental data showed the reference area to be distinct from the two farm locations. There were also significant changes over time with all three areas in parallel trajectories including a slight return to 2012 conditions in 2015. This again supported the potential for broader scale coastal environmental effects within all three areas.

Many of the 36 environmental variables were correlated such that only 9 groups of variables were statistically discernable. Of these 9 groups, 4 were determined to be significant factors to differentiate the three sampling areas over time. These were a lead group $P=0.001$, a fecal coliform group $P=0.013$, organic matter $P=0.018$, and water temperature $P=0.038$ (see presentation for full list of variables within these groups). A comparison of the changes in macrofauna against these environmental groups showed persistently higher levels in the aquaculture locations versus the reference area but there was uncertainly if this was a chronic condition of the location or an indicator of aquaculture in the area. To resolve this, additional information about the variability in the coastal zone is needed. Ultimately there was no evidence of an acute effect associated with a 3-year salmon production cycle.

See Attached Presentation

<u>Andrew Cooper</u>

Dr. J. Andrew Cooper is one of the Biological Station's researchers investigating wild species diversity and habitats in the marine coastal environment. Dr. Cooper has conducted research projects to measure and monitor changes in wild species diversity in the coastal zone. As a former member of the NSERC Canadian Integrated Multi-trophic Aquaculture Network, Dr. Cooper led research to investigate potential effects of aquaculture nutrients on wild species colonisation and growth to develop IMTA as a strategic enhancement within economically sustainable aquaculture production systems. Dr. Cooper is a member of the International Council for the Exploration of the Sea (ICES) Working Group on Biodiversity Science a multinational panel of experts charged to advise marine science organizations on the delivery biodiversity information in order to meet marine resource management needs. He is also a lead researcher in monitoring and assessment of the Musquash Estuary Marine Protected area. For the research presented Dr. Cooper was the DFO liaison to advise on experimental design, conduct field sampling, and to assist with the interpretation of data.

OFI FUNDING AT UPEI/AVC: OVERVIEW OF PLANNED RESEARCH
-presented by Ian Gardner, Derek Price, Raphael Vanderstichel, and Crawford Revie, AVC-UPEI

Funding was announced for an Ocean Frontiers Institute (OFI) in 2016 to assist ground-breaking research driving ocean innovation. Under the general goal of safe and sustainable development of the ocean frontier, the initial focus of the research planned includes work around Changes in Atmosphere Ocean Interactions, Ocean Data Analytics, Shifting Ecosystems and Sustainable Aquaculture. Under the Sustainable Aquaculture theme there are four linked modules being developed at Memorial University of Newfoundland and Labrador, Dalhousie University, and University of Prince Edward Island (UPEI). The UPEI module is called New Models of Salmon Health Management which has within it four projects.

Project 1 – Risk ranking of Atlantic salmon farms to minimize spread of ISAv. A model is to be developed to evaluate seaway distance and hydrodynamic connectivity data for predicting risk after ISAv spread from an “index” site. Case data from 2002 -2004 ISAv outbreaks in Bay of Fundy will be used for validation of the model. The information provided will be general enough to make the output useable for other viruses.

Project 2 – Improving antibacterial treatment efficacy. An industry focus group meeting in September 2018 will identify current issues with antimicrobial treatment efficacy, identify treatment strategies to be assessed and recruit participants for our pilot and observational studies. The Pilot study will assess post-treatment antibiotic tissue concentrations (Nov 2018 – April 2019) using the specific antibiotic treatment strategy(ies) identified by focus group. By May 2019 the focus group meet to discuss the pilot project and make adjustment based on feedback. The full observational study (Sept 2019) will be initiated to assess different antibiotic treatment strategies under different environmental scenarios.

Project 3 – Modelling tools to investigate disease occurrences, transmission patterns, and mitigation strategies, in context of biocapacity. Epidemiological Models operate at an Observation-level, based on Unobserved disease status, or as a Latent variable model. At the observation-level, these statistical models are used to quantifying risk factors and impacts from implementation of mitigation strategies. Unobserved disease status or simulation models like agent-based models are used for ‘individual farm’ simulations and evaluating topics such as the evolution of chemotherapeutant resistance. The goal will be to expand this to represent a larger area with multiple farms and build connectivity among farms. Latent variable models are statistical models with an unobserved (latent) component and so bridge the gap between methods to provide long term predictions. Data from Grand Manan farms will be used to quantify internal and external infection pressure of sea lice on salmon sites and evaluate the prediction ability of the model.

Project 4 – Interpretation of novel data streams (pen sensors and microscale current patterns)
for fish health monitoring and parasite control. This is in Phase 2 of the work proposed so will not commence for approximately three years. There is a lot of pen-level data, including environmental information, which indicates the difference found within a farm, which can made interpretation of data complicated due to water movement/flow patterns within and around cages. This project will employ new methods for interpretation of data, multivariate statistics and machine learning algorithms to detect trends and associations between signals and fish health.

See Attached Presentation

Ian Gardner

Dr. Ian Gardner is the Canada Excellence Research Chair (CERC) in Aquatic Epidemiology at the University of Prince Edward Island (UPEI). The goal of the CERC program is to make UPEI and Canada the global leader in applied aquatic epidemiology research (with an ecosystem health focus). Prior to moving to Canada, Dr. Gardner was a Professor of Epidemiology at the University of California, Davis for 23 years. Dr. Gardner obtained his veterinary degree at the University of Sydney in 1975 and completed post-graduate training (Master of Preventive Veterinary Medicine and PhD) at the University of California, Davis in 1988.

Plenary Discussion - What are the R&D Priorities?

The session was opened by a short presentation by Ian Gardner of AVC to announce the 8th International Symposium of Aquatic Animal Health (ISAAH) is to be held Charlottetown, PE September 2-6, 2018. The theme for the conference is "Integrating Biotechnology in the Advancement of Aquatic Animal Health." Information presented in the attached presentation (in appendix) includes continuing education workshops, keynote speakers, timelines for abstracts and student funding opportunities. Dave Groman at AVC is the Local Organizing Chair and may be contacted for further information. groman@upei.ca www.isaah2018.com

The first priority topic identified, above those identified during presentations, was the need for more research around Bacterial Kidney Disease (BKD) as it is still an issue in New Brunswick and there are losses of big salmon. There were no specific focus or projects identified, though the previously suggested on work to evaluate the pathogenicity of the various strains of the causative bacteria found here was mentioned, along with vaccine usage information.

Diagnostic work involving the bacteria *Moritella viscosa* and assessment of its prevalence in salmon were identified as research needs, along with work to evaluate vaccine response in the field.

Under the theme of bath treatments several areas of research were suggested. Sea lice responses to bath treatment with products available seem highly variable so the factors involved need to be identified and assessed, including bioassays as a decision tool. The suggestion of a model developed to predict success of a bath treatment was identified as another potentially useful tool.

The idea of a Pan-Atlantic research and development fund was put forward as a way to have important projects funded without having to ask individual companies for funding assistance as each project proposal is developed. A percentage of all company sales could be placed in a special account, so funds are continuously accessible to industry approved projects.

The establishment of a monitoring program for new / emerging diseases and other fish health / welfare concerns was suggested. A program that would include information sharing would decrease response time should an event occur.

Forum Wrap-up

Research and science remains essential to ongoing development of the aquaculture industry. It continues to provide the salmon farming industry and broader stakeholders with important information on a range of topics, while providing opportunities for collaborative projects intended to develop a sustainable industry in Canada. These include fish health, operational best practices, environmental monitoring and regulatory frameworks, as well as technological advancement.

Climate change and the impact of the environment on aquaculture / aquaculture on environment were identified in several presentations as an area that requires research focus, though the aspects are diverse. Water quality parameters require monitoring in the short and long term to address changes in the marine environment and identifiable trends to support decision making within the industry. For planning purposes, oceanographic model development and validation is also work to be supported as we move to real time oceanography. Climate change and the potential related change in disease patterns, disease resistance and new diseases were identified as part of the required areas of study. To further understand the potential of benthic impacts of aquaculture additional information about the variability in the coastal zone is needed.

Additional research is needed on other fronts within the fish health theme. Research that develops and assesses fish-health tools (i.e., addressing and monitoring) need to continue especially for concerns such as Amoebic Gill Disease (AGD) and Pancreas Disease (PD).

The multi-faceted challenges of sea lice remain a research priority, as well as the need for more and / or new tools and products. The results of field trials with the ultrasound and CleanTreat technologies discussed need to be assessed as available for potential of application here and evaluation to determine if they can work here or if modifications would be required.

Additionally, research that provides greater understanding of wild salmon and lobster presence and abundance and interactions near aquaculture sites can contribute to productive discussions and interactions with traditional marine users.

The ACFFA is committed to continuing to work on behalf of our members to identify industry research priorities and facilitate collaborative research activities.

As always, we greatly appreciate the contributions of the public and private research community in supporting our annual forum.

Participants

LAST NAME	FIRST NAME	COMPANY
ABBOTT	MATTHEW	CONSERVATION COUNCIL OF NEW BRUNWICK
ACHESON	JENNIFER	DEPT. AGRICULTURE, AQUACULTURE & FISHERIES
AMINI	FARHAD	HUNTSMAN MARINE SCIENCE CENTER
ANDERSON	MIREILLE	FISHERIES AND OCEANS CANADA
ANG	KENG PEE	COOKE AQUACULTURE
ANNIS	ALANAH	NORTHEAST NUTRITION
AYMAR	LUKE	KELLY COVE SALMON
BACKMAN	STEVE	SKRETTING
BEATTIE	MIKE	GAS INFUSION SYSTEMS
BELLE	SEBASTIAN	MAINE AQUACULTURE
BENFEY	TILLMANN	UNIVERSITY OF NEW BRUNSWICK
BENNETT	AARON	SILK STEVENS LIMITED
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BOERSEN	JOHAN	AQUA FARMING SOLUTIONS B.V
BOURQUE	PETER	MITCHELL MCCONNELL INSURANCE
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BUCK	LAURA	FORT FOLLY HABITAT RECOVERY
BURGETZ	INGRID	FISHERIES AND OCEANS CANADA
CANAM	AMY	COOKE AQUACULTURE
CHAFE	GRAHAM	ATLANTIC SALMON FEDERATION
CHEUNG	LEO	RPC
CHOWDHURY	SUBRATA	RPS BIOLOGIQUES INC.
CLARKE	COREY	FUNDY NATIONAL PARK
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COOK	SARAH	SKRETTING
COOPER	ANDREW	FISHERIES AND OCEANS CANADA
COREY	JACK	COREY NUTRITION COMPANY
COX	KASHA	INTERVET CANADA CORP.
CRAIG	AARON	ELANCO
DAGGETT	TARA	SIMCORP
DE JOURDAN	BENJAMIN	HUNTSMAN MARINE SCIENCE CENTER
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EPWORTH	WENDY	FORT FOLLY HABITAT RECOVERY
FARQUHARSON	SUSAN	ACFFA
FEINDEL	NATHANIEL	NOVA SCOTIA FISHERIES AND AQUACULTURE
FILGUEIRA	RAMON	DALHOUSIE UNIVERSITY - MARINE AFFAIRS PROGRAM
FITZGERALD	LEAH	COOKE AQUACULTURE
FITZPATRICK	KAITLIN	COOKE AQUACULTURE

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FOTI	MICHAEL	PHIBRO ANIMAL HEALTH CORP.
GAGNE	JONATHAN	ENTREPRISES SHIPPAGAN
GAILOR	BEN	NATURAL RESOURCES CANADA
GAMEIRO	MARTA	ELANCO
GARBER	AMBER	HUNTSMAN MARINE SCIENCE CENTER
GARDNER	DR. IAN	UNIVERSITY OF PRINCE EDWARD ISLAND
GEORGE	SHELDON	KELLY COVE SALMON
GRANT	JON	DALHOUSIE UNIVERSITY
GREEN	DARRELL	NAIA
GRIFFIN	RANDY	COOKE AQUACULTURE
GURNEY-SMITH	HELENE	FISHERIES AND OCEANS CANADA
HALSE	NELL	COOKE AQUACULTURE
HALSE	JOEL	COOKE AQUACULTURE
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HATT	BRADEN	CARGILL AQUA NUTRITION
HAWKINS	LEIGHANNE	COOKE AQUACULTURE
HELGESEN	KARI	NORWEGIAN VETERINARY INSTITUTE
HENDRY	CHRIS	FISHERIES AND OCEANS CANADA
HOBDEN	KERRY	ONTARIO MINISTRY NATURAL RESOURCES & FORESTRY
HOLMES	JASON	NORTHEAST NUTRITION
HORI	TIAGO	CENTER FOR AQUACULTURE TECHNOLOGIES
HOUSE	BETTY	ACFFA
IRVINE-ANDERSON	DEBORAH	CANTEEN MEDIA
JAMES	SEAN	KELLY COVE SALMON
JENSEN	ELENA	NORWEIGIAN UNIVERSITY OF LIFE SCIENCES
JOHNSTON	MARC	DEPT. AGRICULTURE, AQUACULTURE & FISHERIES
KARLSEN	MARTIN	OPTIMAR
KAUFIELD	KATHY	ACFFA
KENNEDY	TIM	CAIA
KNUDSON	TANYA	ELANCO
KURKIMAKI	PETER	SKRETTING
LAMBERT	JEAN	AGRICULTURE AND AGRI-FOOD CANADA
LANE	MARK	NAIA
LEAVITT	CORY	DEPT. AGRICULTURE, AQUACULTURE & FISHERIES
MACKINNON	ALLISON	ELANCO
MACNEILL	TROY	COOKE AQUACULTURE
MACPHEE	DAN	MVS
MCBRIARTY	GEOFFREY	KELLY COVE SALMON
MCCARTHY	JASON	NORTHEAST NUTRITION
MCEWAN	GREGOR	UNIVERSITY OF PRINCE EDWARD ISLAND
MCGEACHY	SANDI	DEPT. AGRICULTURE, AQUACULTURE & FISHERIES
MCGRATTAN	JASON	ELANCO
MCKINDSEY	CHRIS	FISHERIES AND OCEANS CANADA
MERRITT	OLIVIA	FISHERIES AND OCEANS CANADA
MOFFITT	LAURA	SKRETTING
MORRIS	KEITH	BENCHMARK ANIMAL HEALTH

NERETTE	PASCALE	CANADIAN FOOD INSPECTION AGENCY
NESS	MICHAEL	PHARMAQ
NESS	MATT	RPC
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PARSONS	JAY	FISHERIES AND OCEANS CANADA
PAUL	STACEY	FISHERIES AND OCEANS CANADA
PENTON	NORMAN	NL DEPARTMENT OF FISHERIES AND LAND RESOURCES
PINEAU	AL	NORTHERN HARVEST SEAFARMS
PRICE	DR. DEREK	UNIVERSITY OF PRINCE EDWARD ISLAND
ROSE-QUINN	TAMMY	FISHERIES AND OCEANS CANADA
REID	GREGOR	FISHERIES AND OCEANS CANADA
REVIE	DR. CRAWFORD	UNIVERSITY OF PRINCE EDWARD ISLAND
ROBERTSON	BILL	RETHINK INC.
ROBINSON	SHAWN	FISHERIES AND OCEANS CANADA
ROBINSON	TIM	FORT FOLLY HABITAT RECOVERY
RODGERS	BRAD	REALTIME AQUACULTURE
ROUSE	MIKE	OPPORTUNITIES NB
ROUSSEL	HELENE	ENTREPRISES SHIPPAGAN
SAMWAYS	KURT	UNIVERSITY OF PRINCE EDWARD ISLAND
SEELEY	DAVID	SKRETTING
SMITH	WINSTON	SKRETTING
SMITH	TOM	AQUACULTURE ASSOCIATION OF NOVA SCOTIA
SMITH	JAMEY	HUNTSMAN MARINE SCIENCE CENTER
STANLEY	TREVOR	SKRETTING
STEINE	NILS	PHARMAQ
STEWART	LEN	COOKE AQUACULTURE
STIRLING	DAVID	COOKE AQUACULTURE
STONE	TIM	REALTIME AQUACULTURE
SULLIVAN	MIKE	FISHERIES AND OCEANS CANADA
SWEENEY	MICHELE	SKRETTING
SWIM	AMANDA	NS DEPT. OF FISHERIES AND AQUACULTURE
TAYLOR	GARY	SKRETTING
TAYLOR	TOBI	ACFFA
TAYLOR	TOM	NORTHEAST NUTRITION
TREMBLAY	ISABELLE	AQUACULTURE ASSOCIATION OF NOVA SCOTIA
TRENHOLM	MICHAEL	CANADIAN FOOD INSPECTION AGENCY
TRUDEL	MARC	FISHERIES AND OCEANS CANADA
VANDERSTICHEL	DR. RAPHAEL	UNIVERSITY OF PRINCE EDWARD ISLAND
WEAIRE	TED	COOKE AQUACULTURE
WINTERMEYER	JOHN	DEEP TREKKER INC.
WIPER	JENNIFER	COOKE AQUACULTURE
WONG	DAVID	FISHERIES AND OCEANS CANADA