

# Abstracts by Session / Résumés par session – Aquaculture Canada 2018

**Note: presenters with an underlined name are students to be judged for Best Presentation /  
Note: les présentateurs avec un nom souligné sont les étudiants à être jugés pour la  
meilleure présentation**

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**Monday, May 28<sup>th</sup> / lundi, mai 28**

**KREIGHOFF 2 + BORDUAS**

**LANDBASED AND RAS AQUACULTURE  
PISCICULTURE EN SYSTÈMES OUVERTS ET FERMÉS**

**11:10-11:30**

**FRESHWATER AQUACULTURE IN CANADA - A HISTORY AND FUTURE  
OUTLOOK**

R.D. Moccia\* and R. Smith

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Freshwater aquaculture in Canada has a proud history dating back to at least the early 1800's. Established primarily to support the production of fish for rehabilitation, it has evolved over nearly 2 centuries to enable recreational and tourism opportunities, as well as to produce fish for the human food sector. Canada's salmon industry in fact, has roots in the techniques developed during the freshwater phase of culture. The early freshwater fish 'farms' were nothing more than simple, dug holes in the ground or grain silos turned into round tanks. In the 1900's, ever improving construction approaches using fiberglass and concrete tanks took place, with rapid developments made in feeds, disease management and breeding systems. Net pen culture dominated the 1980's and onwards, especially in large lake systems. Since the early 1990's there has been incremental improvement of recirculation systems (RAS), and these are now emerging as viable alternatives for raising a number of species like Tilapia, barramundi, Arctic charr and others. Sophisticated, multitrophic aquaculture systems are now growing horticultural crops, medical marijuana and fish under the same roof! This talk provides a brief overview of the freshwater sector, with particular emphasis on the promise and opportunities for its future expansion.

**11:30-11:50**

**FRESHWATER NET PEN PRODUCTION IN ONTARIO – WHERE WE’VE COME AND WHERE WE’RE GOING**

S. Naylor

Ontario Ministry of Agriculture, Food & Rural Affairs, 1 Stone Rd W, Guelph, ON N1G 4Y2

Net pen aquaculture of rainbow trout in Ontario has grown from several small farms in the early 80’s to a sector that has recently undergone rapid expansion and consolidation. After nearly 15 years of stable production, the last 4 years has demonstrated growth of 12-15% a year. With recent indigenous involvement in the sector and new growing sites for rainbow trout and whitefish, it’s likely that Ontario’s aquaculture production will at least double in the next 5 years. The overview will look at the history of freshwater net pen aquaculture in Ontario, the lessons learned over the last 4 decades, and the new opportunities that are emerging with recent consolidation and innovation in the sector.

**11:50– 12:10**

**ESSENTIAL ELEMENTS OF RAS DESIGN & MANAGEMENT**

D. Stechey\*<sup>1</sup> and W.D. Robertson<sup>2</sup>

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As in traditional forms of animal husbandry, aquaculture operations are becoming increasingly intensive to enhance productivity and competitiveness – especially in land-based systems. Optimal performance in fish culture necessitates that facilities are designed to be simultaneously technically and mechanically effective and biologically productive; they must meet the environmental needs of the fish (e.g. water quality management, biosecurity) and the management needs of the fish culturist (e.g. feeding, grading and handling) in an operationally efficient manner (e.g. low operational and maintenance costs). RAS technology is well developed, particularly for fish hatcheries. Nevertheless, unlike in traditional animal production systems, there is a critical absence of standardization in land-based aquaculture. This is manifest as a lack of standards and comparable metrics, a wide range of investment required per kilogram of production capacity, variations in energy requirements, etc. It is fair to conclude that most RAS designs are capable of growing fish; however, the objective should be to grow fish and make money. This presentation will review the essential elements of RAS design and management that are essential to successful ventures.

**12:10-12:30**

**UPDATE ON THE STEELHEAD MODEL FARM**

S. Atkinson

Taste of BC Aquafarms is a Pilot Plant Model Aquafarm raising Steelhead Salmon in RAS. Based on the concept of the Canadian Model Aqua Farm developed by IPFSAD, the farm set out to generate research and compile data for advancing freshwater salmonid production and closed containment technology. The farm set out to systematically confirm operational parameters, previously established by lab scale research, and other engineering assumptions, in a commercial size setting and to work toward a blueprint for salmonid RAS. Actual performance metrics were compared to previous studies and engineering assumptions relating to the water treatment system, fish health, growth and quality as well as environmental performance. Standard operating procedures have been developed incorporating the new metrics obtained from operating continuous production for the last five years. This presentation will highlight several of the significant findings in relation to: premature maturation the impact of multiple year classes of fish within one system; the impact of ozone in the culture system and water quality and fish health; handling of fish waste and discharge of waste to the environment, including aquaponics; growth profiles of steelhead within RAS and a new growth curve; the impact of compounding factors such as temperature, feed regime, feed composition, swim speed, genetics and fish maturation on growth with RAS, target dissolved oxygen levels, lighting and light regimes. We will also discuss the “business” touching on production costs, marketing, branding, and distribution of year-round weekly production.

**13:50-14:10**

**THE MANITOBA - CANADIAN MODEL AQUA-FARM / OVERVIEW & ECONOMIC UPDATE**

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In 2010, the Interprovincial Partnership for Sustainable Freshwater Aquaculture Development launched a model farm initiative to design, develop and demonstrate the basic technological, financial and environmental aspects of commercial aquaculture in a modular, replicable recirculating aquaculture system (RAS). Operating at 99% recirculation, the facility was designed with a production capacity of 130 tonnes per year. With investment from the Governments of Manitoba and Canada, the Manitoba – Canadian Model Aqua-Farm was developed on a private poultry farm near Winnipeg for the production of market-sized rainbow trout. The comprehensive data and information collected during the initial 30-month production period by a manager hired to oversee the venture will be presented. Although the venture did not attain a steady-state level of production during the 30-month trial, the performance monitoring results generated sufficient data to indicate what can be expected from this type of facility using a singular concrete raceway design. Using data generated during the review, the financial

projections have been updated to reflect current operating conditions, providing practical insight into the development of similar ventures today.

**14:10-14:30**

**THE ECONOMICS OF SMALL-SCALE (<400 TONNES) RAS**

W.D. Robertson<sup>1</sup> and D. Stechey<sup>2</sup>

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RAS ventures are well established for smolt and fingerling production. Table-fish RAS ventures remain far more sensitive to market prices and rising input costs. Factors important to the effective and efficient operation of RAS ventures will be discussed. The Manitoba – Canadian Model Aqua-Farm (M-CMAF) was developed in 2010 to provide real data and information pertaining to the production of 1-kilogram rainbow trout in RAS. Over a three-year period, the M-CMAF generated considerable value by defining the capital and operational costs of the venture. In recent years, the American market demand for rainbow trout has evolved toward fish weighing more than 2 kilograms, and typically marketed as steelhead. Using data from the M-CMAF, the production plan and operational projections for the venture have been updated to reflect today's market for larger fish and to reflect 2018 input costs. A revised scenario for the M-CMAF has been developed to present present-day conditions. The analysis suggest that, at a scale of 106 tonnes, land-based production of larger trout in a M-CMAF-style RAS is financially viable. An addendum to the Manitoba – Canadian Model Aqua-Farm report presenting this revised scenario is available from the authors.

**14:30-14:50**

**MONITORING THE ENVIRONMENTAL PERFORMANCE OF THE INTENSIVE RECIRCULATING WATER REARING SYSTEM AT THE FISH FARM TASTE OF BC AQUAFARMS**

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The environmental effectiveness of the intensive freshwater recirculating rearing system for rainbow trout (*Oncorhynchus mykiss*) used by the Taste of BC fish farm, was measured 15 times throughout 2016. Total phosphorus, suspended solids and total solids for all inputs and outputs of

the rearing system were measured using 15 24-hour sampling periods between February and October 2016, at the same time as fish production.

To determine the environmental effectiveness, the amounts of waste excreted by fish were added to the waste introduced by new water, and this was compared to the amounts measured in the two effluents: rearing system water overflow and the fish waste recovery line. Based on these samples, the average recovery efficiencies were 83%, 55% and 99% for total phosphorus, total solids and total suspended solids, respectively. At 83%, the recovery efficiency for total phosphorus exceeds the minimum of 40% currently required by Quebec authorities.

With an annual rainbow trout production of 100 tonnes, this fish farm accurately represents the intensive recirculating freshwater system model that the Quebec fish farming industry wishes to develop. Measuring the environmental effectiveness of these systems will provide evidence to better determine their environmental impact and facilitate their establishment in the province.

**14:50-15:10**

**P-TRAP: IN SITU CHELATION OF PHOSPHORUS USING MICROENCAPSULATED ALUMINUM AND IRON SULFATE TO BIND INTESTINAL PHOSPHORUS IN RAINBOW TROUT (*Oncorhynchus mykiss*).**

W. N. Ndiaye<sup>1,3</sup>, M-H. Deschamps<sup>1</sup>, Y. Comeau<sup>2</sup>, M-P. Letourneau-Montminy<sup>1</sup>, G. W. Vandenberg<sup>1</sup>.

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Excess phosphorus in freshwater systems increases primary production which, left uncontrolled, may lead to eutrophication, accelerating the ageing process of receiving water bodies. To limit phosphorus release resulting from feeding fish, we propose to test microencapsulated P-chelating agents incorporated into fish diets. In a first trial, alum ( $\text{Al}_2\text{SO}_4$ ) and ferrous sulfate ( $\text{FeSO}_4$ ) were encapsulated using a spray-chilling method in a hydrogenated lipid matrix. Two practical diets incorporating one of these two active elements ( $6 \text{ g kg}^{-1}$ ) were fed to fish for 5 weeks, and P release from resulting feces were compared. In a second trial, a similar approach was used to evaluate the impact of increasing supplementation of encapsulated alum ( $3, 6, 15 \text{ g kg}^{-1}$  diet). Feces from the fish fed with the diets incorporating alum and ferrous sulfate release of 54% and 38%, respectively, less phosphorus than those from fishes fed with control diets. The second experiment revealed a negative correlation ( $R^2 = 0.81$ ) between the level of encapsulated  $\text{Al}_2\text{SO}_4$  included in the diet and phosphorus released by the feces. Feces from feed incorporating  $\text{Al}_2\text{SO}_4$  at  $0, 3, 6$  and  $15 \text{ g kg}^{-1}$  released 69%, 58%, 43% and 34%, respectively, of the fecal phosphorus after 14 days. Fish fed encapsulated  $\text{Al}_2\text{SO}_4$  have similar growth performance and impeded mineralization. Incorporation of encapsulated P-chelating agents into fish feed may offer an opportunity to manage P levels from effluents.

**15:50-16:10**

**COMPARISON OF THREE SYSTEMS FOR CARBON DIOXIDE REMOVAL IN RECIRCULATING SALMON-SMOLT HATCHERIES**

S. Preston\*<sup>1</sup>, M. Couturier<sup>1</sup>, M. Sorensen<sup>2</sup>, M. Dickie<sup>3</sup>, J.A.K. Elliott<sup>3</sup>

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Maintaining dissolved carbon dioxide (CO<sub>2</sub>) concentrations below the recommended limit of 15 mg/L in RAS is essential for optimal fish health. The objective of this study was to assess different systems for removing CO<sub>2</sub> from RAS. Experimental data was collected on industrial degassing towers, moving-bed biofilters and side-tank degassers operating at a hatchery. Mathematical models were also developed for each system to establish the relationship between CO<sub>2</sub> removal efficiency and key operating variables. The single-pass removal efficiency of the degassing towers, moving-bed biofilters and side-tank degassers were 35%, 35% and 20%, respectively. The conversion of HCO<sub>3</sub><sup>-</sup> to CO<sub>2</sub> during the nitrification process was considered when determining the CO<sub>2</sub> removal efficiency of moving bed biofilters. Degassing towers were found to remove 55 mgCO<sub>2</sub>/kJ while side-tank degassers remove 75 mgCO<sub>2</sub>/kJ at an inlet CO<sub>2</sub> concentration of 10 mg/L. For comparison, 71 mgCO<sub>2</sub>/kJ were removed in the moving-bed biofilters. However, the CO<sub>2</sub> stripping provided by a moving-bed biofilter is a secondary benefit which requires no additional energy beyond what is required for nitrification. Among the systems studied, the most cost-effective and flexible system for CO<sub>2</sub> removal was the combination of a moving-bed biofilter sized for nitrification at peak biomass and a side-tank degasser.

**16:10-16:30**

**PROGRESS ON THE APPLICATION AND EXTENSION OF INTENSIVE CULTURE TECHNIQUES FOR NEWLY-HATCHED WALLEYE (*Sander vitreus*) IN ONTARIO**

T. D. Drew

Ontario Ministry of Natural Resources & Forestry, White Lake Fish Culture Station, Sharbot Lake, Ontario, K0H 2P0, tim.drew@ontario.ca

Over the last four years, the Ontario government's fish culture program has been working to develop expertise in the intensive culture of newly-hatched walleye fry in order to increase its capacity to support fisheries management objectives. Prior to this time, the province relied on pond culture for the production 'summer pond fingerlings'. As part of this developmental effort, intensive culture techniques developed for flow-through systems in the U.S. have been successfully applied to a flow-through system at one the province's fish culture stations, and have also been successfully adapted to a recirculating system at a second provincial fish culture station. In addition, recent studies have been successful in identifying suitable and readily

available starter diets and in generating economies of scale through the use of larger rearing units.

**16:30-16:50**

**INTENSIVE CULTURE OF LAKE WHITEFISH (*Coregonus clupeaformis*) IN ONTARIO'S FISH CULTURE PROGRAM – 30 YEARS OF EXPERIENCE**

T.D. Drew

Ontario Ministry of Natural Resources & Forestry, White Lake Fish Culture Station, Sharbot Lake, Ontario, K0H 2P0, tim.drew@ontario.ca

Lake Whitefish has been reared in Ontario for almost 120 years for the purpose of stocking to help rehabilitate declining fish stocks. For most of this period, stocking was limited to either eyed eggs or newly-hatched fry and was of limited effectiveness. By the early 1970s, the species had almost been extirpated from Lake Simcoe where it had once supported valuable commercial and recreational fisheries. In response, the province launched a successful multi-year effort to develop intensive culture practices for the species. This presentation provides an overview of those efforts, of current culture practices and of recent efforts to develop in-house broodstocks. It also provides a brief update on efforts to rehabilitate the Lake Simcoe population.

**16:50-17:10**

**AQUADVANTAGE SALMON: THE FUTURE OF SALMON FARMING**

H. Clifford

## SALON LEDUC + FORTRIN

# GENOMICS AND EPI-GENETICS GÉNOMIQUE ET ÉPI-GÉNÉTIQUE EN AQUACULTURE

**11:10-11:40**

### **GENOMIC SELECTION: BENEFITS, CURRENT STATUS AND LESSONS FROM COMMERCIAL IMPLEMENTATION**

D. Lourenco

**11:40-12:10**

### **FUNCTIONAL ANNOTATION OF ALL SALMONID GENOMES (FAASG)**

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**The Vision:** To provide solutions for salmonid conservation, sustainable fisheries, and aquaculture through an improved understanding of salmonid biology.

**Mission:** To coordinate the salmonid community to standardize and share data for comprehensive mapping of the functional elements of salmonid genomes.

**Core Principles:** Establish core principles to enable international collaboration to understand the functional elements of all salmonid genes and genomes. These core principles will be modeled on principles agreed on by similar initiatives including FAANG and ENCODE and may include:

- Collaboration to define experimental, meta-data, and bioinformatics standards
- Ensuring experiments conducted adhere to agreed standards
- Timely and open access release of data

Working groups include; 1) Animals, samples and Assays (ASA), 2) Bioinformatics and Data Analysis (BDA), 3) Metadata and Data Sharing (MDS), and Phenotyping (PHE) .

[www.faasg.org](http://www.faasg.org) / BMC Genomics. 2017 18:484. Levels and progress of genome-wide annotation of salmonid genomes, variation, RNA expression, and epigenetic assays within the FAASG framework will be discussed.

**12:10-12:30**

**ATLANTIC SALMON NUTRIGENOMICS: TOWARD DEVELOPMENT OF NOVEL DIETS TO IMPROVE FISH HEALTH**

M.L. Rise<sup>1\*</sup>, A. Caballero-Solares<sup>1</sup>, X. Xue<sup>1</sup>, J.R. Hall<sup>2</sup>, K. Eslamloo<sup>1</sup>, N.C. Smith<sup>1</sup>, S.M. Inkpen<sup>1</sup>, T. Katan<sup>1</sup>, C.C. Parrish<sup>1</sup>, N. Umasuthan<sup>1</sup>, K.S. Parrish<sup>1</sup>, H. Rajabi<sup>1</sup>, S.L. Christian<sup>3</sup>, J. Santander<sup>1</sup>, R. Kvingedal<sup>4</sup>, E. Jakob<sup>5</sup>, C. Hawes<sup>5</sup>, J. Piño<sup>5</sup>, J. Sepulveda<sup>5</sup>, M.D. Fast<sup>6</sup>, and R.G. Taylor<sup>4</sup>

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Further expansion of aquaculture will help fill the protein gap as the world's human population continues to rise while facing plateaued wild fisheries. However, for aquaculture to reach its potential, it must overcome challenges including infectious diseases (caused by single pathogens and co-infections) and the need to replace fish meal and oil with terrestrial alternatives while maintaining or improving fish health. Two Genome Canada supported projects (“Biomarker Platform for Commercial Aquaculture Feed Development”, and “Integrated Pathogen Management of Co-infection in Atlantic Salmon”), involving close collaborations between academic and industry researchers will be discussed. This team uses a combination of 44K microarrays, singleplex and multiplex qPCR (for salmon biomarker genes and pathogen sequences), lipid biochemistry, *in vivo* and *in vitro* (macrophage) immune stimulations [with pathogens (e.g. sea lice, ISAv, *Piscirickettsia salmonis*) or pathogen-associated molecular patterns (PAMPs)], and multivariate statistical analyses to assess the impact of novel experimental diets (e.g. varied levels of EPA+DHA, non-marine ingredients, omega-6:omega-3 fatty acids) on salmon physiology and health. Key discoveries include manipulation of antiviral and antibacterial responses by varying dietary raw materials (e.g. plant products) and/or functional ingredients. This ongoing research provides Cargill with biomarkers and associated data needed to accelerate the development of health-enhancing aquafeeds.

**13:50-14:20**

**SECURING FISH MICROBIOTA ONTOGENY: USEFULNESS FOR AQUACULTURE AND NATURAL POPULATION CONSERVATION.**

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Fish associated microbial communities (e.g. gut microbiota) play multiple functions that are indispensable for their host biology: nutrient metabolization, protection against pathogens, synthesis of essential amino acids, vitamins, hormones, etc.

Microbiota taxonomic and functional compositions are highly dynamic and vary strongly according to successive host organism developmental stages (i.e. host ontogeny). Also, microbiota composition is controlled by main two factors: environment and host genotype. During the earlier developmental stages, fish larvae will recruit pioneering symbionts from their proximal environment. Therefore, environmental community composition is a key factor for sequential recruitment of beneficial microbial functions, promoting both nutrition efficiency and resistance against opportunistic pathogens, for instance. However, in aquaculture settings, fish are usually exposed to very controlled microbial environments, which are different from the wild, thus potentially compromising recruitment of key symbionts.

In this talk, we will state on the current knowledge on gut microbiota ontogeny in teleost fishes, document the respective influence of factors that are mainly involved in shaping microbiota composition, and discuss their importance regarding the development of alternative aquaculture practices promoting recruitment of more resilient microbiota, both in the context of wild population stocking and food production.

**14:20-14:50**

**PHAGES, VACCINES, PROBIOTICS AND GENOMICS: TOWARDS AN INTEGRATED APPROACH FOR THE CONTROL OF FURUNCULOSIS, A SALMONID DISEASE**

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The bacterium *Aeromonas salmonicida* subsp. *salmonicida* is causing furunculosis in salmonids (salmon, trout, char, etc.). This disease has important negative impacts on the aquaculture industry in Canada. Antibiotics are still a treatment of choice against this disease. However, frequent resistance of this bacterium to several antibiotics, even to all antibiotics authorized in aquaculture is more and more reported. In addition, the use of antibiotics imposes significant withdrawal periods. For its part, the vaccination can be an interesting option but usually implies resource-consuming logistics and possible side effects. Alternative approaches to these

treatments are expected. Our team, in collaboration with other researchers and fish farmers, works on the development of an integrated approach for the control of furunculosis. This approach would imply, as a preventive measure, a new generation of naturally attenuated live vaccines, adapted to each fish farm, as well as the use of endogenous probiotics effective to counter the pathogen. The use of viruses (phages) infecting *A. salmonicida* subsp. *salmonicida* is also being developed as a cure against outbreaks. The presentation will detail the progress of these projects and reveals how genomics is essential for the development of this integrated approach.

**14:50-15:10**

**IMPLEMENTATION OF MODERN BREEDING TECHNIQUES IN ATLANTIC SALMON**

T. S. Hori<sup>1\*</sup>, S. Gezan<sup>2</sup>, B. Swift<sup>3</sup>, S. Fukui<sup>4</sup>, J. Buchanan<sup>1</sup>, J. Stannard<sup>1</sup>

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Genomic selection and marker assisted selection have the potential to increase accuracy of selection and per generation genetic gain, which in turn can significantly increase profitability. We present a study conducted in collaboration with Cermaq Canada Ltd. to identify markers significantly associated with early maturation in Atlantic salmon. In addition, based on the same dataset, we tested the feasibility of the use of imputed genotypes to generate genetic breeding values (GEBVs) for this trait. Two-hundred and forty phenotyped fish and their parents were genotyped using 130K Axyom genotyping array. Genome-wide association analysis was conducted by fitting both phenotypic and genotypic data using a mixed linear model. A subset of 50,000 high quality SNPs were selected to test the feasibility of using that density for genomic selection. In addition, 3,000 SNPs evenly distributed across the 29 Atlantic salmon chromosomes were sub-sampled to evaluate accuracy of imputation of ~47,000 missing genotypes using the parental high-density data as a reference set for haplotype estimation. Seven SNPs were identified as significantly associated with early-maturation and a multi-variate linear model fit of these had an  $r^2$  of 0.40. A five-fold cross validation of GBLUP-estimated GEBVs had an average accuracy of 0.523.

**15:50-16:10**

**DEVELOPMENT OF A QUANTITATIVE ASSAY FOR THE IMMUNE MARKER INTERLEUKIN 2 TO ASSESS HEALTH STATUS AND IMMUNE RESPONSES IN SALMONIDS**

G. Heath\*<sup>1</sup>, T. Rodriguez Ramos<sup>1</sup>, S. Semple<sup>1</sup>, C. Soulliere<sup>1</sup>, J. Iwanczyk<sup>2</sup>, J. Rix<sup>3</sup>, B. Dixon<sup>1</sup>

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Aquaculture in Canada is dominated by cold-water salmonid species. Ocean temperatures are expected to rise 2 to 4°C in the next two decades, affecting the distribution, behavior and, importantly for aquaculture, disease susceptibility of these species. Cytokines are small glycoproteins that are important mediators of both innate and adaptive immunity. Efforts to elucidate teleost cytokine function to date have focused on the nucleic acid level, with a paucity of tools to examine these proteins in fish. The purpose of this project was to develop diagnostic tools capable of quantifying cytokine protein levels in salmonids. Interleukin 2 (IL-2) is a primary cytokine in the adaptive immune response as it induces T-cell proliferation. Polyclonal antibodies targeting a bacterially produced recombinant IL-2 were raised in chicken and goat. These were combined in a quantitative sandwich ELISA protocol capable of detecting IL-2 protein levels at picogram levels. This assay was validated in cultured and primary cells. Similar diagnostics will be designed targeting other important fish cytokines (IL-4, IL-6, IL-10 and IFN- $\gamma$ ). Quantification of relevant cytokines at the level of protein will improve selection of broodstock (for disease resistant animals) and aid in vaccine development.

**SALON PILOT**

**SHELLFISH AQUACULTURE**  
**AQUACULTURE DES MOLLUSQUES**

**11:10-11:30**

**ASSESSMENT OF COMMERCIAL, SURVIVAL AND GROWTH PERFORMANCES OF MUSSEL (*Mytilus edulis*) STOCKS FROM THE MAGDALEN ISLANDS, USING A “STOCK-SITE” SPAT TRANSFER DESIGN**

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Over the last 20 years, the Havre-Aubert basin (BHA) is the main spat collection site for mussel growers in Magdalen Islands. This stock is characterized by specific metabolic and genetic particularities providing to mussels a better resistance to stress. Considering two decades of transfers of BHA stock into the other mussel sites of the archipelago, we assessed whether this differential advantage still persists among the available stocks (4). The main objective was to identify alternative strategies for spat supply in order to sustain the development of the local mussel industry. Every stock was transferred to various grow-out sites (3) and harvested 18 months later, following the traditional mussel production cycle. We evaluated the commercial performances of each “Stock-Site” scenario using the producers’ sleeving method (mussel socks). Simultaneously, mussels were kept in cages to have a quantitative measure of survival rates. Our results confirmed that BHA remained the most efficient stock in terms of commercial incomes and survival rates. However, the spat from Havre-aux-Maisons lagoon (HAM) was also very promising and economically advantageous. Otherwise, the best growth rates obtained by all stocks in the open-sea site of Baie-de-Plaisance (BP) emphasized the high potential of the open-sea to optimize the local mussel production.

**11:30-11:50**

**SERIAL KNOTS IN MUSSEL CULTURE ROPES AS ANTI-PREDATOR DEVICE:  
EXPANDING THE SIZE OF SPATIAL REFUGES FOR MUSSELS**

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Predation by sea ducks is a threat to mussel culture in many sites. Mussel survivorship is usually enhanced in crevices. We mimicked the effect of crevices by using loosely knotted spat collector ropes. The knots used were the chain sinnet and variants thereof. The knots were tested in Cascapédia Bay, Quebec, in two similar experiments. Knotted ropes collected more spat than controls, up to 5100 and 5900 individuals per 30.5 cm collector, as compared to 2700 and 1300 individuals per 30.5 cm on controls in 2015 and 2016, respectively. In the 2015 experiment, there were barely any mussels left on the controls after the second winter of the trial. On the variants, few mussels could be ascribed to the initial cohort, although undersized mussels were abundant (roughly 750 individuals per 30.5 cm). This suggests that individual mussels had grown too large to benefit fully from the refuges provided by the knots used in 2015. Therefore in October 2017 we initiated a trial where refuge size was expanded. The trial will be terminated in May 2018. In the 2016 experiment, abundance patterns after the first winter appeared to reflect both higher abundance on the variants and density-dependent patterns in survivorship.

**11:50– 12:10**

**IMPACT OF OIL SPILL (DILUTED BITUMEN AND CONVENTIONAL CRUDE OIL)  
EXPOSITION DURING WINTER ICE-COVER ON BLUE MUSSEL (*Mytilus edulis*)  
GENITORS AND THEIR SUBSEQUENT OFFSPRINGS.**

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Foreseen increase in Canadian oil production and international exportation via tankers enhance spill risk on marine ecosystem, particularly in coastal area used by aquaculture industry. No research has yet been conducted on disastrous environmental consequences of a diluted bitumen (dilbit, Canadian oil sand exportation product) spill in the marine environment with a winter ice cover, making our capacity for tackling such an event highly deficient. Thus, your objective was to determine the impact of dilbit exposition during winter on the cultivated blue mussels (*Mytilus edulis*) genitors and their un-exposed offspring. A small-scale oil spill was simulated in an outdoor 3,500-liter mesocosm filled with sea water from the St. Lawrence Estuary. Adults mussels (n = 288) were exposed to one conventional crude oil (Heidrun) and two dilbits (Cold Lake Blend, Access Western Blend) for seven days under an ice layer and then kept alive until spawning. Bioaccumulation of PAHs in adults was detected after only three days of exposure

and despite a rapid depuration combined with good resilience of exposed genitors, significant negative effects were noted on female oogenesis, gamete productivity, larval growth, metamorphosis success and survival. Dilbits induced higher deleterious toxic effects on larvae produced by exposed genitors than conventional oil.

**12:10-12:30**

**USE OF POINT-OF-VIEW VIDEO CAMERAS TO DOCUMENT FISH INTERACTIONS WITH OYSTER CAGES: LESSONS LEARNED**

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L. Milke<sup>1</sup>, G. Phillips<sup>1,3</sup>, D. Redman<sup>1</sup>, J. Rose<sup>1</sup>

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We used point-of-view video cameras to study interactions of fish with oyster cages and assess habitat services provided by aquaculture gear. Field trials were conducted to determine how cage density influences fish abundance and behavior and compare fish interactions with oyster cages to fish activity on rock reefs. For the density comparison, three cages were placed 50 yards apart close to a shallow oyster farm lease while at a deeper lease and on-bottom oyster culture sites, three cages were placed at discrete locations 90+ yards apart (assuming minimal influence of adjacent cages). Cages were equipped with two Go Pro Hero 3+ cameras. One camera was mounted to view the horizontal surface across the cage top, while a second camera placed at one corner captured activity along two sides and the cage-sediment margin along the bottom. To assess fish activity on the reef, three minimal-size T-platforms, each mounted with two cameras, were positioned by divers adjacent to boulders to provide a field of view similar to cage-mounted cameras. Fish abundance was determined using MaxN counts (video frame with maximum number of fish of each species observed within time interval) while fish behavior was scored with behavioral categories using Observer XT software.

**13:50-14:10**

**INNOVATIVE STRATEGIES FOR BIOFOULING CONTROL IN SHELLFISH FARMING**

N. Toupoint<sup>1\*</sup>, M. Nadeau<sup>1</sup>, N. Lemaire<sup>1</sup>, P. Chevarie<sup>1</sup>, N. Simard<sup>2</sup>, R. Saint-Louis<sup>3</sup>

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Actually, the development of non-biocides approaches arouses a great interest in the control of biofouling on marine structures. Composed of various organisms such as algae, bivalves, crustaceans, echinoderms, cnidarians and tunicates, the control of biofouling constitute a major problem for shellfish farmers, and especially for cost-effectiveness. In association with diverse partners, Merinov leads projects to test the efficiency of different non-biocides solutions to control biofouling on shellfish farming structures: coating and natural competitors. In fact, techniques should absolutely be non-toxic for cultivated organisms and that for both shellfish farmers and consumers. Experimental bioassays were conducted in the field from October 2016 to November 2017 in order to test the antifouling performance of two (2) types of non-biocide fouling release coating and one (1) biological association of fouling consumers (gastropod / crustacean) in a shellfish farming context. These non-biocides solutions were deployed on lantern nets containing oysters (*Crassostrea virginica*) or giant scallops (*Placopecten magellanicus*), but also on several types of nets, such as Polyethylene, Nylon, Vexar or PVC. This presentation will detail the different results obtained during these projects, in relation to both antifouling performances and animal health.

**14:10-14:30**

**LIMITING THE STRESS OF SCALLOP LARVAE IN FLOW-THROUGH SYSTEM: THE KEY FOR A COMMERCIAL PRODUCTION**

M. Holbach<sup>\*1</sup>, R. Robert<sup>2</sup>, P. Miner<sup>3</sup>, P. Boudry<sup>3</sup>, R. Tremblay<sup>4</sup>

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In many countries, mollusc aquaculture depends on the success of artificial spats production in hatcheries. Flow-through larval rearing systems were developed in several commercial hatcheries for oysters, scallops and clams, for example. Those systems allow professionals to produce seeds in a stable environment with a good sanitary quality of the seawater. The rearing of pectinids larvae in a small scale (5L) flow-through tanks registered massive mortality for *Pecten maximus* larvae. All trials collapsed contrary to oysters *Crassostrea gigas* and *Ostrea edulis* which can support high flow rate and high density. In this context I worked during my thesis to understand the sensitivity of pectinids larvae in flow-through larval rearing to increase the production yield of commercial hatcheries such as Fermes Marines du Québec (FMQ). This project provides some indications to improve scallops larval development in a flow-through rearing system through a better understanding of how physical parameters such as: bubbling, water flow intensity and tank shape, directly affect larval development. In this talk, I will present the results obtained during my PhD thesis and how I use my skills to develop the commercial production of *Placopecten magellanicus* spats, phytoplankton and seedlings of *Sacharina latissima* in Fermes marines du Québec.

**14:30-14:50**

**INFLUENCE OF THE PHYSIOLOGICAL CONDITION OF BIVALVE POST-LARVAE ON THEIR SECONDARY DISPERSAL ABILITIES.**

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Secondary migrations of bivalves occur after the first colonization of the benthic substrates by competent larvae. Whereas pelagic larval phase relates on large spatial scale dispersal, post-metamorphic migrations can also drastically change the recruitment spatial patterns. Such mechanisms usually take place just after metamorphosis which involves deep and energy consuming physiological changes. To our knowledge, the energy cost of secondary migrations has never been assessed. The present study, based on experimental flume and fall velocity tube approaches, aim to better understand the physiological state - behaviour link for migrating post-larvae. We used hatchery-reared post-larvae of the Warty venus, *Venus verrucosa* (L. 1758), produced at 15 or 20°C and with 3 contrasting diets (enriched or deficient essential fatty acids diets). We observed that only rearing temperature affected post-larval behaviour acting on secondary migration. Post-larvae reared at 15°C accumulated significantly more lipid content compared to those at 20°C and was positively correlated to lower fall velocity, suggesting higher dispersal abilities. Surprisingly, *V. verrucosa*'s post-larvae selected preferentially fine sediment over coarse sediments which are classically associated to adult's habitats. This specific ontogenic sediment selection suggests that secondary migration could be a general process in the recruitment process of this species. Furthermore, secondary migration process can be largely affected by physiological condition of post-larvae resulting from their larval environment. Thus, environmental conditions of larvae combine with the preferential post-larval selection on fine

sediment not optimal for further ontogenic stages will affect the secondary migration process and probably recruitment success.

**14:50-15:10**

**IMPACT OF GLOBAL WARMING ON MAGDALEN ISLANDS SHELLFISH CULTURE PRODUCTION**

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The objective of this project is to assess the ability of blue mussels, *Mytilus edulis*, american oysters, *Crassostrea gigas* and giant scallops, *Placopecten magellanicus* production in the Magdalen Islands lagoon to adapt to global warming. In recent years, the industry has noted higher mortality rate of some cultivated species within lagoons, which could be related to warming conditions. Between 1995 and 1997, the water temperature in lagoons exceeded 20°C for an average period of 23 days, beginning in August, whereas this period lasted 58 days between 2007 and 2009, from mid-July onward. To help this sector deal with this new problem, we establish connections between aquaculture yields, environmental characteristics, and individuals' physiological condition. This project was realized with help of college students for field and control experimentations and data were related to acclimation potential of each species determined by genomic approach on gene related to metabolism, heat shock and oxidative stress responses and on immunity. Results showed that blue mussels and scallops production should be done in the open sea surrounding the islands in preference to the lagoons, and production in the lagoon should be done with a warmer water tolerant bivalve, the oyster. Genomic study clearly demonstrated the higher sensitivity of scallops on all physiological characteristics measured.

**15:50-16:10**

**THE DYNAMIC AND VIBRANT OYSTER INDUSTRY OF NEW BRUNSWICK**

M-J Maillet\*

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The oyster aquaculture industry in New Brunswick is a unique economic development opportunity for communities along the Province's eastern shore. It is a success story. The industry is making itself known internationally through its quality products, its world-famous

brands, and its leaders. Steady growth in the sector continues to present a significant opportunity for existing entrepreneurs and newcomers. Technology developments, particularly in culture methods and mechanisation, have greatly improved the industry's competitive position both in terms of the quality of the product and its growth rate. The Department of Agriculture, Aquaculture and Fisheries has made the sustainable development of shellfish aquaculture a priority. This is reflected in the new Shellfish Strategy 2017-2021, which provides an action framework for shellfish aquaculture over the next five years. The objectives of the Strategy are to increase current production by 60% in 5 years, reaching 30 million units in 2021 and a farm gate value of \$12 million. The shellfish aquaculture industry provides benefits for the province by creating jobs, expanding the tax base, and increasing the capacity to keep workers and entrepreneurs in their home communities, encouraging those who left to come back or attracting others from outside the province. The industry also offers a unique opportunity for New Brunswick First Nations located in coastal communities. In New Brunswick, American oysters are farmed on the sea bed or in suspension in the water. New Brunswick farmed oysters are a premium product characterized by their shape, meat yield, and taste. This presentation will focus on how the New Brunswick oyster industry has evolved and grown over time adopting new technologies and techniques.

**16:10-16:30**

**DOES PUMPING RATE AFFECT PARTICLE RETENTION EFFICIENCY IN BIVALVES? THE CASE OF OYSTERS AND MUSSELS**

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Bivalve particle retention efficiency has been traditionally attributed solely to particle size, with particles greater than a nominal threshold size assumed to be captured at similar high efficiency. However, recent findings, mostly driven by the use of new technologies, i.e. laser particle counters and DNA sequencing, have challenged this paradigm. A key component of the capture process could be driven by the water flow through the gills, which could affect the angle at which particles approach the filaments. In this study, the retention efficiency of the oyster *Crassostrea virginica* and the mussel *Mytilus edulis* has been measured and explored in relation to their pumping rates, which can be used as a proxy for water velocity for individuals of similar sizes. Preliminary results have revealed a species-specific effect of pumping rate on retention efficiency, with mussels showing similar retention across the observed range of pumping rates, but oysters showing a positive relation between retention and pumping for small particle sizes. These results are important for improving our understanding of bivalve energetics and growth but also bivalve-phytoplankton trophic interactions, which are critical in bivalve aquaculture sites where the cultured population could exert a significant effect on the structure of phytoplankton populations.

# ALTERNATIVE SPECIES DEVELOPMENT DÉVELOPPEMENTS DES NOUVELLES ESPÈCES

16:50-17:10

## TRIGGERS OF SPAWNING AND OOCYTE MATURATION IN THE COMMERCIAL SEA CUCUMBER *Cucumaria frondosa*

B. L. Gianasi<sup>1\*</sup>, J.-F. Hamel<sup>2</sup>, A. Mercier<sup>1</sup>

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Methods used to trigger spawning and artificially induce oocyte maturation were investigated in the commercial cold-water sea cucumber *Cucumaria frondosa*. Live phytoplankton at  $1 \times 10^5$  cells ml<sup>-1</sup> induced the highest proportion of females to spawn, promoted the greatest oocyte release, best quality of eggs and highest survival of embryos. Phytoplankton paste yielded intermediate results, whereas conspecific sperm induced the lowest proportion of females to spawn and all resulting embryos died within 10 d post fertilization. For males, spawning was more readily induced by a low concentration of sperm, followed by live phytoplankton, and phytoplankton paste; the lowest spawning success was observed for a high concentration of conspecific sperm. Thermal shock, desiccation, potassium chloride (injection or bath), and serotonin (injection) did not induce spawning in *C. frondosa*. When oocytes isolated from ovaries were exposed to three different concentrations of 1-Methyladenine (1-MA), 2,3-Dimercapto-1-propanol (BAL), L-cysteine (L-cyst), and Dithiothreitol (DTT), only the latter (at  $10^{-1}$  M) promoted ovulation; the other treatments remained comparable to the control (seawater). Ovulated oocytes obtained with DTT remained unfertilizable. Overall, spawning induction with live phytoplankton emerged as the most suitable and reliable technique to maximize the collection of healthy gametes from this cold-water lecithotrophic species.

**17:10-17:30**

**INVESTIGATING FOR AN ALTERNATIVE EGG SOURCE FOR NOVA SCOTIAN RAINBOW TROUT INDUSTRY.**

I. Tremblay<sup>1</sup>

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Rainbow trout farming has been identified as a growing opportunity for the aquaculture sector in Nova Scotia. However, growing rainbow trout in the cold sea waters around Nova Scotia is a challenge faced by the industry. Hence, sea farmers are looking for a fast growing and slow maturing rainbow trout strain that is well adapted to cold salt-water conditions. The rainbow trout industry in Nova Scotia relies on one egg source from the United States of America. In the event of border closure between Canada and USA, or any other problem in egg supply from the current egg supplier, the rainbow trout industry in Nova Scotia would be imperiled. As well, growing conditions in Nova Scotia can be challenging with cold and sometimes warm seawater temperatures. Access to alternate sources of eggs and breeding programs selecting for Nova Scotian growing conditions would benefit the rainbow trout industry. Locating alternate rainbow trout egg source that will perform well in the cold sea waters of Nova Scotia is an important objective of the industry. As part of an AANS initiative, a mission was organized to investigate for an alternative rainbow trout egg source for the Nova Scotian industry.

**Tuesday, May 29<sup>th</sup> / mardi, mai 29**

**KREIGHOFF 2 +BORDUAS**

**AQUATIC ANIMAL HEALTH  
SANTÉ DES ANIMAUX AQUATIQUES**

**8:40-9:00**

**DFO IN THE FIELD: FISH HEALTH AUDIT AND SURVEILLANCE PROGRAM**

Z Waddington\*

Aquaculture Environmental Operations, Fisheries and Oceans Canada, Courtenay, BC V9N 2M2

The Fish Health Audit and Surveillance Program (FHASP) was established in 2002 under the BC Ministry of Agriculture and Lands. In 2010 the program was transferred to the federal jurisdiction of DFO. The program design is meant to audit the salmon farming industry's compliance with the conditions of their aquaculture licence, but also involves the collection and analysis of independent samples. Up to 120 marine sites and 25 hatcheries are visited annually, with approximately 850 fish sampled and submitted for analysis each year. Independent sea lice counts are also performed during a selection of marine site visits. The program design has remained largely unchanged since its inception, and has generated a wealth of longitudinal data. Efforts are being made to increase public awareness of this field program and better utilize and disseminate the data gathered.

**9:00-9:20**

**A LANDSCAPE ECOLOGY APPROACH TO SEALICE DISPERSION AND ITS IMPLICATIONS FOR SALMON FARM SITING**

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Sea lice are a persistent problem for the salmon farming industry, and a variety of approaches have been used in the management of these parasites. Due to the concentration salmon hosts at fish farms, sea lice proliferate, and depending on farm location and size, of reproduction at farm sites, is critical in increased infection pressure. Application of epidemiology to the resolution of sources and sinks at multiple farms has been important in understanding their population dynamics and subsequent management. Landscape ecology involves the spatial arrangement and pattern of habitats, but is often applied to more static situations, usually on land. However,

application to dynamic variables including farm wastes, pathogens, and therapeutants can be used to describe a characteristic scale of dispersal and thus define an epidemiological landscape. We used a particle tracking model associated with a ROMS circulation model to simulate lice dispersal at multiple farms in Hardangerfjord, an important salmon farming region in Norway with 29 farm sites. Landscape features were defined including patch size and aspect ratio, and these indices compared to constraints of coastal topography and current regime. The potential for this approach as part of an ecosystem approach to aquaculture is discussed.

**9:20-9:40**

### **GENERATING QUANTITATIVE CYTOKINE ASSAYS TO ASSESS SALMONID HEALTH STATUS AND IMMUNE RESPONSES**

A.P. Frenette\*<sup>1</sup>, T. Rodríguez Ramos<sup>1</sup>, S.L. Semple<sup>1</sup>, G. Heath<sup>1</sup>, C. Soulliere<sup>1</sup>, L. Sever<sup>1</sup>, D.A. Ramsay<sup>2</sup>, J. Iwanczyk<sup>3</sup>, J. Rix<sup>4</sup>, A.K. Gamper<sup>3</sup>, and B. Dixon<sup>1</sup>

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<sup>4</sup> Somru BioScience Inc., 19 Innovation Way, BioCommons Research Park, Charlottetown, PE. C1E 0B7.

The Canadian salmonid aquaculture industry faces several climate change-related challenges, including increasing water temperatures and low oxygen events (hypoxia). These will likely threaten salmonid production as these stressors can exacerbate bacterial and viral diseases. In mammals, genes coding for small signalling proteins (cytokines) regulate stress and immune responses during infection. Genes encoding cytokines have been identified in many teleost fishes, but whether their biological function is analogous to the mammalian paradigm has yet to be elucidated. By developing quantitative enzyme-linked immunosorbent assays (ELISAs) for detection and quantification of these cytokines (i.e., proteins), a better understanding of their function will be possible. Herein, we report on the development of a quantitative ELISA for rainbow trout (*Oncorhynchus mykiss*) interleukin-1 beta (IL-1 $\beta$ ) that utilizes polyclonal antibodies. This quantitative ELISA was validated through Western blot assessment of protein profiles and by comparing its results with quantitative polymerase chain reaction data, and its effectiveness was demonstrated through its ability to detect IL-1 $\beta$  at < 10 pg ml<sup>-1</sup> in both fish tissues and cell culture. The development of functional diagnostic assays for immune markers in fish will facilitate more effective aquaculture disease management (including more efficacious vaccines) and improve our scientific understanding of fish immunology.

**9:40-10:00**

**ADJUVANTS IMPROVE THE PROTECTION CONFERRED BY IMMERSION VACCINES AGAINST YERSINIOSIS IN RAINBOW TROUT.**

S. B. Xu, J. Ben Arous, H. Imbault, F. Bertrand

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Injection of inactivated vaccines is an effective method to control infectious diseases in aquaculture, and is widely used in fish production. Injection of vaccines in fish is a tedious and costly process. By comparison, vaccination by immersion in a vaccinal bath is a convenient mass vaccination method to administer in one step a preventive cure to a large number of animals with a minimum of handling. It also offers the possibility to vaccinate fish too small to be treated one by one by injection vaccine, and to protect them at very early stage of their life. However, immersion vaccines are usually less effective than injection vaccines. One option to improve the efficacy of immersion vaccines is the addition of relevant adjuvants to vaccine formulations. The present results show that the addition of a micro-emulsion adjuvant improved the immune response and the protection conferred to rainbow trouts by a *Yersinia ruckeri* whole cell vaccine.

An adjuvanted immersion vaccine was formulated by mixing inactivated whole cells of a virulent strain of *Y. ruckeri* ( $10^8$  cells/ml) with the micro-emulsion adjuvant Montanide™ IMS 1312 VG. 3 groups of 200 healthy rainbow trouts (*Oncorhynchus mykiss*, 100-120g) were vaccinated by immersion vaccination for 2 min at 12-14°C in a bath containing adjuvanted vaccine, non adjuvanted vaccine (dilution 1/5 in PBS), or no vaccine (control, PBS only). Antibody titers and lysozyme activity were measured every 2 weeks from 2 to 8 weeks post vaccination. A homologous challenge procedure was performed at 2, 4, 6, 8 and 10 weeks post-vaccination in duplicate. 2x15 fish randomly picked from each group were IP injected with 0.1ml of the virulent strain of *Y. ruckeri* at  $10^6$  cfu/fish and observed for 14 days after challenge.

For 8 weeks post vaccination, lysozyme activity and antibody titers in fish vaccinated with adjuvanted *Y. ruckeri* vaccine were significantly higher than in fish immunized with non-adjuvanted *Y. ruckeri* antigen. Lysozyme activity in control non vaccinated fish was also significantly lower than in both immunized groups. At all dates, the lowest anti-*Y. ruckeri* antibody titer in vaccinated groups was also significantly higher to antibody titers of the non-vaccinated control group. After challenge procedure, 95-100% of the control fish died. The RPS of fish vaccinated with adjuvanted antigen was 100% at 2 weeks post vaccination and still 94% at 10 weeks post vaccination, whereas the RPS of fish vaccinated with non-adjuvanted antigen reached a maximum of 82%.

These results show that the use of an effective adjuvant can improve the protection conferred by immersion vaccines in trouts. Further studies should be performed to confirm these results in the field.

**10:00-10:20**

**MARENnine, A POTENTIAL ALTERNATIVE ANTIBIOTIC TO POLYMYXINE IN AQUACULTURE**

Z. Bouhlel<sup>1\*</sup>, F. Turcotte<sup>1</sup>, D.E. Warschawski<sup>3,2</sup>, A. Arnold<sup>2</sup>, K. Lemarchand<sup>1</sup>, J-S. Deschênes<sup>1</sup>, I. Marcotte<sup>2</sup> and R. Tremblay<sup>1</sup>

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We explored potential antibiotic effect of Marennine, a blue pigment produced by *Haslea ostrearia* microalgae, on the pathogenicity of *Vibrio splendidus*. These bacteria are Gram-negative marine species often considered as an eminent threat for bivalve hatcheries. Here we demonstrate that in larval rearing conditions, larva of *Mytilus edulis* and scallop *Placopecten magellanicus* showed significant mortalities exposed to high concentrations of *V. splendidus*. However, in the presence of Marennine extracts, the pathogenicity of the bacteria was suppressed. In an attempt to explore the mechanism of such effects we used Nuclear Magnetic Resonance spectroscopy to explore interactions of the pigment with intact viable *V. splendidus* at a molecular level. Our hypothesis was that Marennine interacts with the outer membrane. Purified Marennine was exposed to <sup>2</sup>H-labelled bacteria in artificial sea water and in controlled conditions. NMR results showed that Marennine affects fatty acyl chain fluidity. This effect was more striking when the membrane was already fluid, during the limited nutrient conditions like the stationary phase of bacterial growth. The results suggest that Marennine is a disruptive agent of the membrane dynamics for *V. splendidus*, and that its action mechanism is compared to Polymyxin-B, a highly regarded antibiotic used in aquaculture and known to interact with the outer membrane of Gram negative bacteria.

**10:50-11:10**

**ELEMENTS TO BETTER UNDERSTAND THE RISK OF TRANSMISSION OF INFECTIOUS SALMON ANEMIA VIRUS (ISAV) FROM FARMED TO WILD FISH**

D. Ditlecadet, C. Mimeault, S. Leadbeater, F. LeBlanc, R. Steeves, N. Gagné

Infectious Salmon Anemia (ISA) is a disease of concern for the salmonid industry worldwide caused by a RNA virus (ISAV). In Eastern Canada, the first outbreaks were reported in 1996. Outbreaks are still reported to this day in Atlantic Provinces (NL, NS, NB), but implementation of new management practices and an active surveillance program has reduced occurrences and impacts on the production. Little is known regarding the risk that ISAV represents to wild salmonids that may come in close proximity to farmed salmon. The potential transmission of the virus from farmed to wild fish depends on many factors, including the probability that an outbreak occurs in a cage, the amount of virus shed by infected farmed fish, survival and

dispersal of the virus in the marine environment, potential of ISAV susceptible wild salmon to come in contact with released virus for a period of time sufficient to cause infection, etc. Gathering data related to all these elements is crucial to initiate a risk assessment and reduce its level of uncertainty. This presentation will provide a portrait of the information available including results obtained recently to investigate the importance of these factors and will also discuss challenges and limitations to consider.

**11:10-11:30**

**SKIN ULCER DISEASES; CHALLENGES ARE CHALLENGING, DEVELOPING MODELS FOR *TENACIBACULUM SP.* INFECTIONS**

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*Tenacibaculum sp.* causes a condition called “mouth rot” or Tenacibaculosis. As one of a group of skin ulcerative diseases that affect farmed salmon, it result in animal losses and increased treatment costs as well as downgrading losses at harvest due to scarring on surviving animals. Through an aquaculture collaborative research development program (ACRDP) project, lab challenges are being developed to successfully create ulcerative lesions and successful recovery the pathogen for confirmation; however the pattern and appearance of ulcers can differ from clinical cases or is difficult to establish. Once successful, challenge models with local Canadian isolates will allow for progress towards the study of disease progression and refinement vaccines for use in Canada. By focused research with local isolates increased vaccine efficacy should be possible which will provide industry with alternate and proactive strategies for mitigating the impacts of this disease. In this presentation selected results from a number of trials will be discussed to describe the issues faced in developing a challenge model for this opportunistic pathogen.

**11:30-11:50**

**MOLECULAR DIAGNOSTICS FOR AQUACULTURE.**

D. Plouffe\*<sup>1</sup>, M. Bryenton<sup>1</sup>, A. Fujimoto<sup>2</sup> and J. Stannard<sup>2</sup>

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Owing to their high sensitivity and specificity, as well as the convenience and high-throughput technology platforms, the use of molecular assays for detection and identification of aquatic animal pathogens is becoming more routine. This presentation will review the pros and cons of these assays as tools for pathogen detection including a review of the development of a robust

qPCR-based diagnostic for *Renibacterium salmoninarum*, the causative agent of bacterial kidney disease (BKD) in salmonids. A discussion of the assessment of the quality of molecular pathogen detection assays will be presented and finally, a few examples of the future of molecular diagnostics and pathogen detection technology will be provided.

**SALON LEDUC +FORTRIN**

**SEAWEEEDS AND ALGAE**

**ALGUES**

**8:40-9:00**

**SEAWEEEDS CULTIVATION AND TRANSFORMATION: THE IMPORTANCE OF A TECHNICO-ECONOMIC ANALYSE TO IDENTIFY THE RIGHT OPPORTINITIES**

M. Lionard\*<sup>1</sup>, I. Gendron-Lemieux<sup>2</sup>, P. Chevarie<sup>3</sup>, K. Berger<sup>2</sup> and E. Tamigneaux<sup>2,4</sup>

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While Asia is the leader of this industry, cultivation of seaweeds is now a growing part of the diversification strategies of the western aquaculture industry. In the last years, a large research effort was set up to support the development of this emerging industry in eastern Canada and several seaweed farms and processing companies are now in this new business. Most often, seaweeds were firstly cultivated on a small scale by shellfish growers. In this context, comparisons with the Asian industry are of limited use because, among others, features like the climate, the labor cost, the size of the farms, the shellfish-seaweed co-cultivation model, the remoteness, the regulations and the structure of the seafood industry are quite different. Whereas basic cultivation techniques are properly mastered, the challenge is now to ensure the profitability of the farmers through lowering the production costs, creating high value products and developing North American markets for cultivated seaweeds. In order to properly focus the efforts of all stakeholders, a techno-economic analysis was carried out to identify the cost structure of a small scale seaweed farm in the Gulf of St Lawrence and explore various scenarios for the development of food products.

**9:00-9:20**

**AN EMERGING INDUSTRIAL SECTOR IN THE GULF OF ST LAWRENCE: KELP (*Saccharina latissima* AND *Saccharina longicuris*) CULTIVATION AND PROCESSING IN QUEBEC**

I. Gendron-Lemieux\*<sup>1</sup>, K. Berger<sup>1</sup>, M. Lionard<sup>2</sup>, L. Gilmore-Solomon<sup>3</sup>, E. Tamigneaux<sup>4</sup>, J. Garcia<sup>5</sup>, T. Jabrane<sup>6</sup> and J.-F. Lemay<sup>7</sup>.

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In March 2014, the Cegep de la Gaspésie and Merinov obtained an NSERC grant for a 5 year research program entitled OPTIMAL. This project supports the development of an integrated industrial sector for the commercial exploitation of cultured kelp (*Saccharina latissima* and *Saccharina longicuris*), through the improvement of seaweed culture productivity, the development of food products and extraction methods, and the use of seaweed processing co-products. From 2014-2017, large quantities of culture ropes were seeded and kelp plantlets were cultivated in a private marine hatchery. In Fall of each year, the ropes were transferred to several shellfish grow-out sites in the Gulf of St Lawrence, in order to compare production levels under different oceanographic conditions. Concentration of mannitol and carotenoids in kelp were also measured and compared between the different sites. Furthermore, at the experimental grow-out site in Paspebiac, different sizes of nylon rope and different transfer periods were tested. Part of the biomass produced on this farm was used to develop food products, with the help of an expert sensory panel. The residual kelp stipes and extraction by-products were then used to develop biodegradable food packaging, as well as lacto-fermented products for human consumption.

**9:20-9:40**

**INNOVATION IN THE SEAWEED SECTOR IN QUEBEC: DEVELOPING NEW FOODS AND IMPROVING THE COMPETITIVENESS OF BUSINESSES.**

K. Berger\*<sup>1</sup>, H. Michaud<sup>2</sup>, M. Lapointe<sup>3</sup>, Ève Dupré-Gilbert<sup>4</sup>, I. Gendron-Lemieux<sup>1</sup>, E. Tamigneaux<sup>2</sup>,

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Seaweed is regarded as an opportunity to diversify the fishing and aquaculture industry in Canada's maritime regions. It is a valuable food source, not only because of its exceptional nutritional, functional, and organoleptic qualities, but also due to its health impacts. However, seaweeds are often perceived negatively in the West, because of their “shoreline” sourcing, aspect, smell and texture. In fact, their consumption in Canada is still marginal and mostly limited to sushis and to imported Asian products. The lack of culinary knowledge and the poor availability of local products also appear to be obstacles to seaweed consumption by the general public. Yet, recent studies on consumer receptivity have confirmed that Canadians are curious to try seaweed, especially for their health aspect and as ingredients in traditional products. In this context, Merinov initiated several activities for the development of conservation methods and seaweed-based food products. The organization also created the first-ever expert sensory panel for seaweeds in Canada. The panel was used, among other things, to develop kelp crisps and crackers. Innovation will continue thanks to the setting up of a dedicated seaweed processing line at Grande-Rivière and a market development strategy that will mobilize Quebec seaweed industry.

**9:40-10:00**

**TOWARDS A SEAWEED CULTIVATION INDUSTRY IN NOVA SCOTIA**

I. Tremblay<sup>1</sup> & M. Lionard<sup>2</sup>

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Over the last decade, the mussel farming industry in Nova Scotia has been hit badly by the invasive vase tunicate (*Ciona intestinalis*). The always increasing presence of the tunicates on aquaculture structures and cultivated mussel socks does increase maintenance work needed on the farm which results in important increase of the financial cost for producing mussels. Moreover, many leases where mussels are cultivated are now free of ice all winter long resulting in an increase of mussel predation by sea ducks. Despite various mitigation techniques trials, chasing sea ducks constantly with a boat is still the most efficient way to reduce predation on mussels. Unfortunately, this practice is very costly for the sea farmers making mussel farming

not economically viable anymore in some places around the province. Hence, sea farmers are interested in looking for an alternative crop and many of them see seaweed cultivation as a great opportunity for their operations. In response from their sea farmers members interest in growing seaweeds, the Aquaculture Association of Nova Scotia (AANS) is moving forward with various initiatives to develop a seaweed cultivation industry in Nova Scotia. AANS seaweeds initiatives will be presented during this presentation.

**10:00-10:20**

**A GROWING INTEREST IN SEaweEDS – APPLIED RESEARCH AND COMMUNITY ENGAGEMENT TO SUPPORT COMMERCIALIZATION OPPORTUNITIES IN COASTAL BRITISH COLUMBIA**

S. Cross\*<sup>1</sup>

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Seaweed production continues to grow in the global arena, with a >5% increase annually. Yet despite a clear market demand for a broad range of seaweed products (food, alginates, bioethanol, antiviral agents, fertilizers, etc.), and a coastal environment that supports one of the greatest diversity of species in the world, very little movement has been realized with respect to the development of a seaweed aquaculture sector in western Canada – why? Integrated Multi-Trophic Aquaculture (IMTA) research has delimited the spatial extent of the wastes generated from fish farm operations, revealing that the use of extractive species such as seaweeds offers an opportunity to capitalize on these inorganic wastes and could generate a substantial revenue stream given the high demand and market value of such products. Furthermore, the inorganic fraction has a much broader spatial impact downstream of a fish farm, and these wastes represent a clear commercial opportunity for co-culture while offering important ecosystem services. The use of seaweeds in mitigating impacts of climate change offer additional services for the coastal environment.

This presentation describes a 5-year applied research program we have initiated to facilitate commercialization of seaweed aquaculture in coastal British Columbia, and the unique industry and First Nation partnership that has come together in support of this effort.

**10:50-11:10**

**METABOLIC INDUCTION APPLIED TO *Solieria chordalis* (Gigartinales, Rhodophyta) CULTIVATION: A NEW STEP TO ADD VALUE TO MARINE BIOACTIVES MOLECULES**

E. Deslandes

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The review is intended as an overview of 25 years of research cultivation carried on the red macro-alga *Solieria chordalis* from Coast of Brittany (France) with an emphasis on the metabolic pathways focus and the potential for biomedical applications. All these studies led us to provide a strong knowledge about the carbon metabolic pathways from the red alga *S. chordalis* and its adaptation to face up environmental stresses. Experiments with algal cultures allowed studying the impacts of changes in light intensities, salinity and nutrients on the algal carbon metabolism at its enzymatic regulation level and the consequences on the contents of activated sugars and storage products. These studies have also provided a solid technical background. Covering several fields ranging from algal culture techniques to purification and chemical structure elucidation. The production algal biomass of *Solieria chordalis* as a source of interesting biomolecules for biotechnology applications is also discussed.

**11:10-11:30**

**PEGASUS - PHYCOMORPH EUROPEAN GUIDELINES FOR SUSTAINABLE AQUACULTURE OF SEaweEDS**

M. Barbier\*<sup>1</sup>, B. Charrier<sup>2</sup>, R. Araujo<sup>3</sup>, S. Holdt<sup>4</sup>, B. Jacquemin<sup>5</sup>, C. Rebours<sup>6</sup>  
With contributions from H. Abreu<sup>7</sup>, A. Bruhn<sup>4</sup>, O. de Clerck<sup>8</sup>, J. Funderund<sup>9</sup>, C. Gachon<sup>10</sup>, A. Golberg<sup>11</sup>, A. Handa<sup>12</sup>, L. Ktari<sup>13</sup>, F. Neumann<sup>9</sup>, C. Peteiro<sup>14</sup>, P. Ronan<sup>5</sup>, P. Stévant<sup>15</sup>, E. Tamigneaux<sup>16</sup>, K. Timmermans<sup>17</sup>, T. Wichard<sup>18</sup>.

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Seaweed resources play an increasingly important role in the Blue Growth and Bioeconomy European strategies. European production, mainly based on the harvesting of wild stocks is

anticipated to be boosted with the increasing appeal of seaweed resources together with the need to assure their environmental sustainability. No homogenized regulations across Europe exist, but attention is rising at national levels to accompany industries in the development of seaweed aquaculture in a sustainable way. In the framework of the COST Action FA1406 PHYCOMORPH, a working group developed guidelines for the future development of this sector, taking into account scientific, legal and socio-economic dimensions. Challenges and bottlenecks are identified and presented with a special focus on the risk of using non-indigenous and invasive species, and on issues regarding proliferation, breeding, choice of best cultivar, etc. The legislation and legal aspects for long term sustainable exploitation are also questioned as well as nutrition & health regulation required to ensure food security. The PEGASUS guidelines present scientific and ethical recommendations to overcome these issues and to provide science-based advice to both Policy makers and industries for the sustainable development of seaweed aquaculture in Europe and beyond.

**11:30-11:50**

### **DEVELOPPEMENT DE L'ALGOCULTURE EN NORMANDIE**

P. Garnier\*, I Mussio et AM Rusig

Unité Mixte de Recherche BOREA Biologie des Organismes et Ecosystèmes Aquatiques  
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La région Normandie possède un fort potentiel pour le développement de l'algoculture avec la production de macroalgues indigènes d'intérêt économique mais aussi leur valorisation. Les recherches s'appuyant sur la diversification de l'algoculture nécessitent la détermination de procédés de culture pour *Palmaria palmata*, *Porphyra dioica* et *Saccharina latissima*. Les protocoles nécessitent la maîtrise des paramètres de culture à tous les stades de développement, de l'obtention des semences à la production de plantules et à la croissance de la biomasse algale en mer. Des études approfondies sont menées pour chaque espèce algale sur la sporulation, germination, pré-grossissement, changement d'échelle, pousse en bassin ou en mer avec la conception de structures de culture adaptées au littoral normand. En parallèle, un travail a été entrepris avec les différents acteurs locaux et la direction départementale des territoires et de la mer afin de lever le blocage réglementaire pour disposer d'une concession expérimentale de cultures d'algues en mer en Normandie dans le cadre du schéma des structures de culture marines. La finalité de ce projet consiste à initier la création d'une filière de culture rentable économiquement et capable de garantir une production répétée d'un produit algal normand correspondant aux demandes du marché en qualité, quantité et traçabilité.

**11:50-12:10**

**IMPROVING LIVELIHOODS OF SMALL SCALE SEAWEED FARMERS THROUGH THE INTEGRATED CO-OP BUSINESS MODEL: A CASE STUDY IN SOUTH SULAWESI, INDONESIA**

C.Couturier<sup>1</sup>

<sup>1</sup>Marine Institute of Memorial University, St. John's, NL. [cyr@mi.mun.ca](mailto:cyr@mi.mun.ca)

The Co-operative Development Foundation of Canada (CDF Canada) is undertaking a four-year project to improve the livelihoods of small-scale farmers of seaweeds, milkfish, and shrimp (SMS) in South Sulawesi through an integrated co-op business model approach. The INVEST Co-op Indonesia project is strengthening the position of aquaculture producers by introducing aquaculture practices that are resilient to climate change and increase quality and yield of production, building the capacity of co-operatives and their members, improving access to financial services, and enabling co-operatives to run profitable, sustainable, and gender-equitable businesses. Within one year of implementation, we are already seeing improvements in farm production of seaweeds and other crops in some localities, with a renewed enthusiasm for co-operative development. Further, we are seeing some adaptation to climate change impacts in production practices by some farmers, as well as increased recognition and participation of women in the productive processes on and around the farms. The project's goals and achievements to date will be described in this presentation. The next year will be telling in terms of adoption of best practices for income and food security. The Project is made possible with funding from the Government of Canada (through Global Affairs Canada) with contributions from the CDF Canada and is being implemented in partnership with the Fisheries and Marine Institute and local partner Koperasi Serikat Pekerja Merdeka Indonesia (KOSPERMINDO).

**12:10-12:30**

**\*\*PLEASE NOTE THIS PRESENTATION WILL BE GIVEN IN ENGLISH / VEUILLEZ NOTER QUE CETTE PRÉSENTATION SERA DONNÉE EN ANGLAIS\*\***

**MÉCANISATION DES OPÉRATIONS EN MER EN ALGOCULTURE DE LAMINAIRES SUCRÉES**

T. Provencher<sup>1</sup>, I. Gendron-Lemieux<sup>1</sup>, M-P. Turcotte<sup>1</sup>, J. Brousseau<sup>2</sup> and J-C. Méthot<sup>2</sup>

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<sup>2</sup> Chaire CRSNG-UQAR en génie conception, Université du Québec à Rimouski, Rimouski, QC, G5L 3A1

Au Québec, plusieurs entreprises se sont lancées dans la production commerciale de laminaires sucrées de culture (*Saccharina latissima*). Depuis 2017, les entreprises gaspésiennes Ferme maricole du Grand Large, Fermes Marines du Québec et Seabiosis collaborent avec l'équipe de Merinov et la chaire CRSNG-UQAR en génie conception afin de mécaniser des étapes de production et de récolte d'algues en mer (Fonds d'amorçage de projet du MAPAQ, CRSNG

ICC-RI). Deux étapes sont présentement en processus de mécanisation, soit le transfert des cordelettes ensemencées de plantules sur la filière en mer à l'automne, et la récolte des algues sur les sites au début de l'été. Ces opérations assez longues sont réalisées à la main sur le bateau, ce qui nécessite plusieurs personnes et expose inutilement les plantules aux intempéries. Pour la récolte mécanisée, deux prototypes ont été développés, fabriqués et testés à l'été 2017. Les prototypes sont en cours de modification afin de mieux répondre aux besoins des industriels qui produisent des algues pour le secteur de l'alimentation. Cette présentation vise à expliquer les différentes étapes de recherche et de développement, des prototypes construits et présenter les tests qui seront effectués en 2018.

## **MECHANIZATION OF OPERATIONS AT SEA IN SUGAR KELP ALGOCULTURE**

In Quebec, the commercial production of cultured sugar kelp (*Saccharina latissima*) is growing in popularity. Since 2017, the aquaculture companies from the Gaspé Peninsula Ferme maricole du Grand Large, Fermes Marines du Québec and Seabiosis collaborate with Merinov and the NSERC-UQAR Chair in Design Engineering to mechanize the production of sugar kelp. Two operations at sea are currently in the process of being mechanized: the transfer of cultured rope with plantlets from the nursery to the culture site in the fall, and the harvest of the sugar kelp at the beginning of the summer. These operations are realized manually on boats, and they necessitate lots of manpower and time. Also, during these manual operations, the plantlets and seaweed ready to be harvested are exposed to harsh environments for enough time to be damaged. In 2017, two prototypes aimed to harvest mechanically the seaweed have been developed and tested. The prototypes are currently being improved to meet the demands of the industrials that transform seaweed for the food industry. This presentation aims to explain the research and development steps to achieve mechanization, and present the constructed prototypes and the additional testing of the machines that will be done in 2018.

## SALON PILOT

# AQUACULTURE ENVIRONMENTAL MANAGEMENT GESTION ENVIRONNEMENTALE DE L'AQUACULTURE

**8:40-9:00**

## **CHARACTERIZATION OF BENTHIC BACTERIAL COMMUNITIES DURING PRODUCTION AND FALLOW PERIODS AT HARD-BOTTOM AQUACULTURE SITES IN NEWFOUNDLAND**

R. Knight\*<sup>1</sup>, S. Dufour<sup>1</sup>, F. Salvo<sup>2</sup>, J. Verhoeven<sup>1</sup> and D. Hamoutene<sup>2</sup>

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Salmonid aquaculture is a profitable industry in Newfoundland, providing economic growth to many rural areas. Underneath salmon cages, organic matter consisting mainly of fish pellets and fish feces can accumulate and modify benthic habitats. In Newfoundland, drop-camera surveys are used to monitor organic enrichment on predominantly hard-bottom substrates. While visual indicators of organic enrichment (white bacterial mats and opportunistic polychaete complexes) can be seen on benthic images, little is known on the composition and dynamics of bacterial communities that degrade this organic matter. Here, we use high-throughput sequencing of 16S rDNA to characterize bacterial communities within grab samples collected from a production, a fallowed and a reference site, obtained at different times and distances from salmon pens. We also report on the organic content and trace element composition of the same samples. Bacterial communities were more diverse as distance from salmon net pens increased. An examination of bacterial community composition showed that samples grouped into three clusters with distinct bacterial communities; these groupings were explained by distance from salmon pens more so than by production status. We highlight the potential for benthic bacterial communities associated with aquaculture activity to persist in the environment, even after fallowing.

**9:00-9:20**

## **INVESTIGATING THE USE OF SINGLE BEAM SONAR TO DETECT A BENTHIC AQUACULTURE FOOTPRINT IN NEWFOUNDLAND**

Armstrong E.\*<sup>1</sup>, Salvo, F.<sup>2</sup>, Dufour, S.<sup>1</sup>, Hamoutene, D.<sup>2</sup>

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In Newfoundland, finfish aquaculture has grown substantially in the last decade, and production is expected to double by 2020. Intensive aquaculture production is associated with organic enrichment, which occurs as uneaten feed and animal excretions settle on the seafloor and form a

layer of flocculent matter. Sustained deposition alters seafloor conditions, with high organic loading resulting in changes in benthic communities. Aquaculture-linked organic enrichment can be monitored through diver surveys, grab sampling and substrate imaging along defined transects. In Newfoundland, deep water and the predominately hard-bottom seafloor largely preclude the use of divers and grab sampling; instead, monitoring is performed using drop camera imaging. Single-beam sonar is an attractive alternative to benthic imaging due to its ability to survey larger areas of the seafloor at lower cost. Here, we examine whether single-beam sonar could be used to detect flocculent matter deposition in our region. Data collected from four single-beam surveys around aquaculture sites were overlain with drop camera images that serve as substrate type ground-truthing. With machine learning, feature data from the single-beam sonar was used to create predictive models. From these candidate models, we will test whether machine learning can help identify the footprint of aquaculture production.

**9:20-9:40**

**LOBSTER MOVEMENT AROUND SALMON FARMS IN NEW BRUNSWICK, CANADA**

E. Simard<sup>1\*</sup>, S. M. C. Robinson<sup>2</sup>, and C. W. McKindsey<sup>1</sup>

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Salmon aquaculture is an important economic activity in many temperate coastal communities. As this industry grows, concerns about its interactions with the environment have increased. Although much work has shown how a variety of fish species may be attracted to farms, little is known of the interactions between benthic crustaceans and salmon farms. Three salmon farm areas were studied over 2 years; NI and CI – muddy bottom sites and DC – a hard-bottom and hydrodynamic site, in southwest New Brunswick. Lobsters (*Homarus americanus*) and crabs (*Cancer irroratus*) movements were recorded in and around salmon farms using a passive fine-scale acoustic telemetry positioning system (VPS, VEMCO). A total of 188 lobsters and 39 crabs were tracked. Data on residence time, movement direction, speed and home range were analysed. At NI, lobsters tended to leave the monitored area fairly rapidly whereas crabs were more likely to stay for extended periods. At DC and CI, most animals stayed within the monitored sites for the duration of the observations, remaining around but not necessarily within farm boundaries. Lobsters appear to be less attracted to the farm than are crabs. These results suggest that adult lobsters and crabs are not greatly affected by salmon aquaculture activities.

**9:40-10:00**

**FROM FARMING TO FALLOWING: MARINE BENTHIC SEDIMENT HEALTH AND RECOVERY RATES BELOW A FINFISH AQUACULTURE LEASE IN SHELBURNE, NOVA SCOTIA**

J. Koepke\*<sup>1</sup>, J. Grant<sup>1</sup>, A. McKee<sup>1</sup>, J. Barrell<sup>1</sup>

<sup>1</sup> Department of Oceanography, Dalhousie University 6299 South Street, Halifax, NS B3H 4R2

Organic matter loading from finfish aquaculture is caused by high concentrations of faecal matter and unconsumed fish feed, producing so-called benthic “dead zones” in the near-field of the pens. Understanding zones of hypoxic sediments, both in time and space, is a valuable tool for regulators and science communicators. Lease #0602 in Shelburne, Nova Scotia had salmon farming from 1991 until it was retired in 2011. Sediment redox potential and dissolved sulfides are inter-related and serve as indicators of sediment health. Samples were collected at the site in 2017 and divided into various categories that 1) encompass the lease, 2) are located outside the farm on the same shore, and 3) provide suitable more distant reference sites. Acoustic habitat mapping was used to characterize these regions. Geochemical and acoustic results from 2017 were combined and categorized to map zones of impact and determined relationships between sites. Time series generated from historical and current data provided recovery rates, correlations, and other temporal sediment variation.

**10:00-10:20**

**EVALUATING FAR-FIELD BENTHIC IMPACTS OF FINFISH AQUACULTURE IN COASTAL NOVA SCOTIA**

S. Finnis\*<sup>1</sup>, J. Grant<sup>1</sup>

<sup>1</sup> Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4R2  
*Speaker may be reached at [sfinnis@dal.ca](mailto:sfinnis@dal.ca)*

Increased nutrient loading to the seafloor from open-pen finfish aquaculture can cause changes in sediment chemistry and benthic community structure. However, studies examining these impacts often reach differing conclusions, since research tends to focus on the effects in close proximity to the farm (i.e., near-field). Benthic impacts at large spatial scales (far-field) are rarely studied yet are needed in order to quantify ecosystem-level impacts of finfish aquaculture. To address these knowledge gaps, this research seeks to examine far-field impacts from finfish aquaculture operations in Port Mouton Bay, Nova Scotia. Specifically, the objectives were to (1) assess the spatial extent of finfish aquaculture impacts using measures of macrofaunal diversity and sediment properties, and (2) examine the complex relationship between these diversity indices and environmental variables. Sediment data (grain size, sulfide concentrations, redox potential, and organic matter) and macrofaunal biological data were sampled three ( $n=40$ ) and fifteen ( $n=23$ ) months after fallow using a bay-wide sampling strategy. Preliminary results using spatial autocorrelation statistics show localized impacts at small distances from the farm. This research contributes to strategies for comprehensive bay-scale monitoring protocols and the growing knowledge of ecosystem-level impacts of marine fish farms.

**10:50-11:10**

**3D MAPPING AND SPATIAL ANALYSIS OF RIVER HABITAT FOR ATLANTIC SALMON CONSERVATION IN THE INNER BAY OF FUNDY**

C Giroux\*, J Barrell, J Grant

Department of Oceanography, Dalhousie University, Halifax, NS B3H 4R2

In 2004, the Inner Bay of Fundy Atlantic Salmon were listed as endangered under the Species at Risk Act, their populations having seen rapid declines in recent years. With 33 rivers considered as potential breeding ground, there is a need to understand population bottlenecks related to spawning. Characterization of rivers with aerial habitat mapping provides a quantitative assessment of river quality for growth and reproduction. Fundy National Park contains two well-studied rivers (Upper Salmon & Pointe Wolf rivers), that have historically been known as good salmon habitat. The staff of Fundy National Park, the University of New Brunswick and Cooke Aquaculture have collaborated to rear smolts in sea cages for release back to the river, where they are tracked acoustically and by river surveys. In 2016 the Upper Salmon river was flown and photographed by a DJI Phantom 4 drone. Using Pix4D software, a 3D map of the river was created and is being classified based on water velocity, water depth and stream gradient. Substrate size is also currently being analyzed through segmentation and texture analysis. Our habitat mapping contributes directly to assessing habitat and spawning usage as an approach to understanding the success of this restoration effort.

**11:10-11:30**

**STUDYING MICROBIAL POPULATION ECOLOGY WITH ENVIRONMENTAL DNA TECHNIQUES TO UNDERSTAND ANTHROPOGENIC IMPACTS ON THE ENVIRONMENT**

S.M.C. Robinson<sup>\*1</sup>, B.S. Forward<sup>2</sup>, C.W. McKindsey<sup>3</sup>, P.J. Cranford<sup>1</sup>

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Aquatic environments in the future will require more sophisticated approaches to understand the interactions occurring due to impacts from increasing anthropogenic activities and other processes like climate change. This project is based on the concept that physical ecosystem changes affect trophic levels to create patterns at all size-scales from large macro-scale mobile organisms to the smallest microfauna (e.g. bacteria). To test this theory, we studied bacterial populations distributed around salmon farms in the Bay of Fundy with next-generation, rapid throughput eDNA sequencing technology (Illumina MiSeq). Surface sediment samples were taken from transects out from 3 separate farms at different times of the year. The samples were sequenced for DNA using the 16S ribosomal DNA gene. We also measured total sample ATP. A total of 32 phyla of bacteria were found comprising over 2000 species. Based on multivariate

analysis, there were distinct spatial patterns of bacterial populations that were positively and negatively correlated with proximity to the aquaculture site. Distinct seasonal patterns were found as well as significant differences between hard and soft bottom farm locations. ATP also showed significant spatial patterns. Results suggest eDNA technology appears to be an easily available, powerful tool for studying environmental changes in marine ecosystems.

**11:30-11:50**

**AQUACULTURE FOR GLOBAL HEALTH: SUPPORTING THE UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS WITH REMOTELY OPERATED VEHICLES**

H. A. Franklin\*, R. Major

Deep Trekker Inc., 830 Trillium Drive, Kitchener, Ontario, N2R 1K4  
[hfranklin@deeptrekker.com](mailto:hfranklin@deeptrekker.com)

Aquaculture is a key source of food, nutrition, income and livelihoods for millions of people around the globe. As of 2016, the world capita fish supply reached more than 20 kg, with aquaculture providing half of all fish for human consumption. Moreover, fish continues to be one of the most-traded food commodities worldwide. There is tremendous potential for the oceans and inland waters of the world to contribute significantly to food security and adequate nutrition. Deep Trekker's presentation will speak to the use of Remotely Operated Vehicles (ROVs) to promote good governance, participatory decision making and best practices in aquaculture. The aim of this technology is to harmonize the environmental, social and economic aspects of living aquatic resources to ensure equitable benefits for the world-wide community. The use of underwater monitoring systems, such as an ROV, has proven to be a cost effective, efficient way for fish farmers to comply with global regulations, ensuring healthy fish crop, efficient harvest and intelligent environmental protection. Support for ROV methods will come in the form of case studies - involving site managers, enforcement officers and researchers - evaluating the effects of aquaculture sites on the surrounding environment.

# AQUACULTURE PUBLIC PERCEPTIONS PERCEPTION PUBLIQUE DE L'AQUACULTURE

**12:00-12:20**

## **FIGHTING FOR A “BLUE REVOLUTON”: HOW OCEAN WISE IS REBRANDING AQUACULTURE**

J-A.Trottier\*

Ocean Wise, 845 Avison Way, Vancouver, BC V6G 3E2

Resources from the world's oceans are not as unlimited as we once thought. To meet the continuing demand for seafood, we must *relieve pressure* on *wild fish* stocks. If done sustainably, The “*Blue Revolution*,” the moniker under which *aquaculture presents itself*, could meet the demand for fish for present and future generations without causing widespread degradation of the environment. Unfortunately, fish farming is an issue of emerging public concern in Canada. *The industry cannot afford to ignore these concerns* which can influence the acceptance, investigation, and implementation of *aquaculture*. What Canadians need most is reassurance, based on fact from a trusted third-party organization. Ocean Wise, Canada's leading national sustainable seafood program is opening up new channels of dialogue surrounding the importance of sustainable aquaculture. As a trusted third-party non-profit organization that works directly with consumers and +750 businesses from coast-to-coast including restaurants, markets, food services, suppliers and producers- Ocean Wise is reinventing the way people and businesses think and feel about aquaculture. As a predictable and viable food source that can help feed Canadians and citizens across the globe, learn how Ocean Wise works with, rather than against industry to ensure they have the most current scientific information regarding sustainable seafood to help them make ocean-friendly buying decisions.

**15:20-15:40**

## **EXPLORING THE PUBLIC DISCOURSE ON NET-PEN AQUACULTURE WITHIN THE CANADIAN MEDIA**

J. Weitzman\* and M. Bailey

Marine Affairs Program, Dalhousie University, Halifax, Nova Scotia, B3H 4R2

Finfish net-pen aquaculture in Canada is an important economic industry to support coastal rural livelihoods. Aquaculture development faces several barriers, including technological, environmental, regulatory, and social. Public perceptions linked to the former barriers have largely influenced aquaculture development in Canada, where maintaining social acceptance and public trust have been an enduring challenge. Since the media is important for spreading information and shaping public opinion, this study explored how media portrays aquaculture to better understand the public discourse. Using qualitative and quantitative content analysis to explore the coverage of major Canadian newspapers in 2015 and 2016, we found a complex

discourse expressing a range of aquaculture attributes and stakeholders. Our results indicate that media frames aquaculture in a mostly negative tone, although there are considerable regional variabilities and differences across specific attributes. Risk-oriented frames focused on environmental challenges and management responses, while positive aspects surrounded scientific advances and economic benefits. Complex interactions between environmental, socio-economic, and management attributes further emphasizes the multi-faceted nature of the public discourse surrounding finfish aquaculture in Canada. These findings support a complex aquaculture discourse that requires interdisciplinary management solutions that continues to emphasize transparency, communication, and accountability to improve public trust.

**15:40-16:00**

**FIGHTING FAKE NEWS. THE FACTS OF FARMED SEAFOOD.**

P. Von Finckenstein

## **SALON LEDUC + FORTRIN**

### **AQUACULTURE INNOVATIONS INNOVATIONS EN AQUACULTURE**

**15:20-15:40**

#### **URBAN AGRICULTURE ENGINEERING DESIGN CONCEPTS FOR RECIRCULATING AQUACULTURE/AQUAPONIC SYSTEMS (RAS)**

M. Westphal\*<sup>1</sup> and J. Ebeling<sup>1</sup>

<sup>1</sup> Ripple Root Aquaponics, L.L.C., P.O. BOX 26161 , Yuma, AZ (USA) 85367  
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Local food production supports local economies. Market demand for locally grown fresh produce and sustainably sourced animal products have emerged, encouraging the development of innovative sustainable agriculture systems and the creation of regional food hub markets. This direct-to-consumer distribution network facilitates farm products to be transported over shorter geographic distances and promotes community support and engagement to hearten healthy diets and further society towards sustainable food production. Aquaponics is the environmentally sustainable food production method that combines aquaculture and hydroponics through the cultivation of fish and plants together in a recirculating ecosystem utilizing natural bacterial cycles to convert fish waste into plant nutrients. A range of recirculating aquaculture/aquaponic systems (RAS) have been engineered by the authors to support the local entrepreneur interested in urban agriculture. Three urban agriculture engineering design concepts are presented for a range of production goals based upon 1,000 or 5,000 or 10,000 pounds of fish produced per year. Each system is combined with a hydroponic component (deep-water culture (DWC), nutrient film technique (NFT) or media bed) for secondary crop and vegetable production. These design concepts include component sizing and selection, equipment cost estimates, and detailed construction drawings with system layout that are made available through [RippleRootAquaponics.com](http://RippleRootAquaponics.com)

**15:40-16:00**

**TREATMENT OF AQUACULTURE ADDITIVES – 17BETA-ESTRADIOL AND ITS METABOLITES – TO ENSURE SUSTAINABLE WATER MANAGEMENT**

J. L. Bennett<sup>1,2\*</sup>, A. L. Mackie<sup>1</sup>, Y. Park<sup>1</sup>, G. A. Gagnon<sup>1</sup>

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The American eel has recently become of great interest to the aquaculture industry. One additive that has been used to increase growth and feminization in eels is 17 $\beta$ -estradiol (E2); however there is a need to ensure that wastewater is responsibly treated prior to disposal. Estrogenic compounds (i.e., E2, estrone, E1 and estriol, E3) can have deleterious effects on aquatic organisms in receiving water bodies if not managed properly. Advanced oxidation processes (AOPs) including UV and UV/H<sub>2</sub>O<sub>2</sub>, have been shown to effectively degrade estrogenic compounds (Rosenfeldt et al. 2007). The goal of this study was to test the effect of varying pH in conjunction with UV and UV/H<sub>2</sub>O<sub>2</sub> on the degradation of E2 and its metabolites in aquaculture wastewater. In this study we have found that UV fluence had a greater impact on analyte degradation than the addition of H<sub>2</sub>O<sub>2</sub>. UV and UV/H<sub>2</sub>O<sub>2</sub> treatment removed analytes to below detection limits (<1 $\mu$ g/L). Removal of compounds under UV radiation increased for pH of 8 compared to 4. The results of this study indicate that the pH of wastewater may impact the efficacy of AOP water treatment processes for degrading these analytes. These on-going studies will also report on kinetics and removal in wastewater.

**16:00-16:20**

**ARTIFICIAL INTELLIGENCE TO GAIN VALUABLE INSIGHT ON AQUATIC ORGANISMS**

V. Robitaille\*, S. Couture Brochu, M. Faes, L-D.Coulombe and J. Roy

Xpertsea Solutions Inc 100-1365 Ave Galilee Quebec, QC, G1P4G4, Canada

[Valerie.robitaille@xpertsea.com](mailto:Valerie.robitaille@xpertsea.com)

Data quantity and reliability has been the main driver for yield optimization in agriculture and most livestock industries. In aquaculture however, accurate and reliable data is hard to obtain since counting and sizing small aquatic organisms mostly still relies on manual methods. These manual methods are time consuming, inaccurate and non-repeatable. Inconsistency in inventory assessments of aquatic organisms leads to mismanagement of feed and poor production performances for aquaculture producers.

In recent years, technologies such as computer vision have been explored with moderate success to provide information about aquatic organisms. However, recent development in artificial intelligence are proving to deliver viable options for efficient development of computer vision based solutions in aquaculture. In this project, an artificial intelligence approach using machine

learning and computer vision was used to accurately predict the number of Giant tiger prawn (*Penaeus monodon*) post-larvae in a production setting. Data was gathered using an electronic device that image samples in optimal conditions. A training framework was then used to train and validate a classifying algorithm based on annotated data.

Once trained, the algorithm could count Giant tiger prawn (*Penaeus monodon*) post-larvae with more than 97.6% accuracy and 2.1% standard deviation. Other algorithms were also developed combining different technologies for different species and prediction of the size distribution was also implemented in a similar but more complex way.

**16:20-16:40**

**PRECISION DATA & AQUACULTURE: THE ROLE OF BIG DATA IN MARINE FARMING**

G. Laughlin\*<sup>1</sup>, I. Tremblay<sup>2</sup>

<sup>1</sup> Pelagis Data Solutions, Sydney, Nova Scotia, B2A 4R2

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The next wave of food production will come from greater precision in marine farming. The demand for ocean harvested proteins is increasing dramatically while commercial wild fish stocks are being fished at unsustainable levels. In response to this growing demand, the opportunity to apply precision data at scale has never been more important to the aquaculture industry. This talk presents the findings of a collaborative effort between industry and technology to apply big data frameworks to the operational needs of aquaculture to improve productivity and lower the risks to farmed seafood while still complying with strict regulations around sustainability and traceability.

## **SALON PILOT**

### **HUMAN RESOURCES RESSOURCES HUMAINES**

**16:00-16:20**

**ARTIFICIAL INTELLIGENCE TO GAIN VALUABLE INSIGHT ON AQUATIC THE  
CANADIAN AQUACULTURE FARM LABOUR MARKET – A SUMMARY OF THE  
FINFISH SECTOR AND FUTURE INITIATIVES RELATED TO RECRUITMENT AND  
RETENTION**

P. MacDonald – Dewhirst

Executive Director, Canadian Agricultural Human Resource Council

**16:20-16:40**

**THE CANADIAN AQUACULTURE INDUSTRY – PROSPECTS FOR GROWTH AND  
SUGGESTIONS ON HOW TO FILL THE LABOUR GAP**

T. Kennedy

Executive Director, Canadian Aquaculture Industry Alliance

**16:40-17:00**

**LABOUR MARKET UPDATE FROM NEWFOUNDLAND AND POTENTIAL  
RECRUITMENT AND RETENTION STRATEGIES FOR THE FUTURE**

M. Lane

Executive Director, Newfoundland Aquaculture Industry Association

**Wednesday, May 30<sup>th</sup> / mercredi, mai 30**

**KREIGHOFF 2 + BORDUAS**

**FISH NUTRITION AND FEEDS  
ALIMENTATION ET NUTRITION DES POISSONS**

**10:10-10:30**

**GROWTH PERFORMANCE AND NUTRIENT UTILIZATION OF GROWTH  
HORMONE TRANSGENIC FEMALE TRIPLOID ATLANTIC SALMON (*Salmo salar*)  
REARED AT THREE TEMPERATURES**

E.H. Ignatz<sup>\*1,2</sup>, A. Dumas<sup>3</sup>, C.D. Runighan<sup>1</sup>, L.M. Braden<sup>1</sup>, T. Benfey<sup>4</sup>, T.S. Hori<sup>3</sup>, M.L. Rise<sup>5</sup>,  
J. Westcott<sup>2</sup>

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<sup>5</sup> Memorial University, Department of Ocean Sciences, St. John's, NL A1B 3X9

A study was conducted to determine the effect of rearing temperature on growth performance and nutrient utilization of AquAdvantage<sup>®</sup> salmon (growth hormone transgenic female triploid Atlantic salmon), with fish reared at three temperatures (10.5°C, 13.5°C, 16.5°C) from first feed to 1500 g. All fish were fed the same commercial diet, which was analysed for proximate, amino acid, fatty acid and mineral composition, and daily feed consumption was monitored for the calculation of feed conversion ratios (FCRs). Whole-body samples were collected at 300 g, 500 g, 800 g and 1500 g for proximate composition, and fillet samples at 500 g, 800 g and 1500 g for amino acid, fatty acid, and mineral composition. Fillet astaxanthin concentration and SalmoFan<sup>™</sup> colour were determined at 800 g and 1500 g. Temperature had a significant effect ( $p < 0.05$ ) on growth, FCR, body and fillet composition, nutrient deposition rates and nutrient retention efficiencies. Elevated rearing temperature resulted in faster growth rates, higher FCRs, higher body-lipid content, lower body-protein content and in general, lower and less efficient nutrient deposition rates in the fillet. The information generated from this study will provide insight into the relationships between rearing temperature and nutrient utilization in AquAdvantage<sup>®</sup> salmon for commercial application.

**10:30-10:50**

**GUT OR FEED? BREAKING THE MYTHS OF DIETARY PROTEASE IN AQUACULTURE**

M A Kabir Chowdhury\*

Jefo Nutrition Inc., Saint-Hyacinthe, Quebec J2S 7B6. kchowdhury@jefo.ca

Fluctuating price, supply, and high variations in the quality of commonly used raw materials have been forcing feed formulators worldwide to use poorly characterized alternatives. These alternative raw materials often possess imbalanced amino acid profiles, are poorly digestible, and may contain some antinutrients severely limiting their use in feed. Several alternative in-feed solutions are available today. Among them, enzymes, probiotics or phytobiotics have shown to improve growth performance and gut health in animals. Besides gut health, enzymes are also reported to improve nutrient digestibility of various raw materials.

After phytase, use of proteases in aquaculture is increasing. However, constraints remain because of poor understandings of enzyme composition and their effects on raw materials. Despite significant increase in the use of protease in the last few years, the aquafeed industry is still skeptical about heat-stability and recovery of enzymes. This paper will cover the issues such as heat-stability, substrate preference, physical properties, and temperature and pH optimum of proteases and how they affect major protein sources currently being used. Besides, it will also highlight issues related “feed or gut” to alleviate some of the misunderstandings around dietary enzymes.

**10:50-11:10**

**ANTI-PROTEASE ACTIVITY OF FISH INTESTINAL HOMOGENATES IS CORRELATED TO PROXIMAL COMPOSITION OF LARVAL MEALS FROM BLACK SOLDIER FLY.**

G.W. Vandenberg\*, M-H. Deschamps, A. Tshinyama, Y. Lebeuf & C. Lavigne

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We report a first attempt to identify and characterize protease inhibitors in insect meals using fish intestinal homogenates, the aim of this study was to explore the correlation between the proximal composition of black soldier fly meals and the *in vitro* inhibition of digestive homogenates in rainbow trout and tilapia. Total digestive enzymes were extracted from the proximal intestine of juvenile rainbow trout and tilapia (Moyano et al., 1999), and incubated with increasing levels of homogenized fly meal. Fly meals were obtained from black soldier fly larvae fed on a Gainesville diet for 5, 10, 15, 20, 25 and 30 days post hatch. Larvae were analyzed for

dry matter, ash, protein chitin, energy, lipids and fatty acid profiles using standard methods. Anti-protease activity was found to be correlated to a range of meal components. Our results suggest that the presence of a protein and/or protein complex could be one of the causal factors involved in the reduction of growth performance in fish fed with insect meals. Our study highlights the need to formulate insect-based diets that take into account the appropriate larval stages of development of the insect to meet the digestive requirements of fish species and improve growth performance.

**11:10-11:30**

**INVESTIGATING THE FACTORS AFFECTING THE DIGESTIBILITY OF AMINO ACIDS IN TWO FEATHER MEALS AND IN THEIR PRE-TREATED COUNTERPARTS IN RAINBOW TROUT (*Oncorhynchus mykiss*).**

G. Pfeuti\*, J. Longstaffe, L. S. Brown, A. K. Shoveller, D. P. Bureau

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The effect of a novel enzymatic pre-treatment on the apparent digestibility coefficient (ADC) of crude protein (CP) and amino acids (AAs) in two feather meals (FeM) was assessed in rainbow trout (*Oncorhynchus mykiss*). Two FeMs (FeM1 and FeM2) were incubated in the presence of sodium sulfite and commercial protease to give two pre-treated FeMs (PTFeM1 and PTFeM2). There was no significant difference ( $P < 0.05$ ) of ADC of CP and AAs amongst FeMs and amongst PTFeMs. The pre-treatment of these FeMs significantly improved ( $P < 0.05$ ) their ADC of CP and most AAs.

FT-Raman analyses suggested a reduction in concentration and conformational stability of disulphide bonds in the PTFeMs when compared to their FeM counterparts. These results suggest that the digestibility of protein of FeM is not only governed by disulphide bond content and other variables should be considered. Higher concentrations of the cross-linked amino acids (CLAA) were measured in FeM1 and PTFeM1 as compared to FeM2 and PTFeM2, respectively, indicating a higher degree of heat damage imposed on proteins during manufacturing of FeM1 as compared to FeM2. The digestibility of protein in FeM may be influenced by disulphide bond content and the presence of CLAAs.

11:30-11:50

## DIETARY MANIPULATION OF ATLANTIC SALMON (*Salmo salar*) IMMUNE RESPONSE

X. Xue<sup>\*1</sup>, U. Navaneethaiyer<sup>1</sup>, A. Caballero-Solares<sup>1</sup>, C. C. Parrish<sup>1</sup>, R. G. Taylor<sup>2</sup>, and M. L. Rise<sup>1</sup>

<sup>1</sup> Department of Ocean Sciences, Memorial University of Newfoundland, St. John's, NL, A1C 5S7, Canada. <sup>2</sup> Cargill Innovation Center, 4335 Dirdal, Norway. \*Presenter ([xi.xue@mun.ca](mailto:xi.xue@mun.ca))

Functional feeds are diets designed to have positive effects on both health and growth by supplying additional functional ingredients (e.g. immunostimulants) beyond the basic nutritional requirements of the animal. We investigated the effect of functional feeds (containing nucleotides and peptidoglycan) with different levels of LC-PUFA on the immune response of Atlantic salmon. Fish were fed four experimental diets: diets 1 and 2 had 0.3% and 1.4% of dietary DHA+EPA, respectively. The formulations of diets 3 and 4 were identical to diets 1 and 2, respectively, except for the addition of immunostimulants. Twelve fish from each dietary treatment were subjected to immune challenge at weeks 3 and 12 in the feeding trial by an IP injection of formalin-killed *Aeromonas salmonicida*, viral mimic (polyriboinosinic polyribocytidylic acid, pIC) or phosphate-buffered saline. Preliminary qPCR analyses (singleplex) of week 12 head kidney samples showed that the immunostimulant supplements with low LC-PUFA up-regulated the constitutive expression of antiviral (*isg15a*, *mxh*, *tlr7*, and *irf7b*) and antibacterial (*stlr5a* and *cox2*) transcripts. The pIC-induction of some antiviral transcripts was also found to be enhanced by the immunostimulants regardless of the LC-PUFA levels. Multiplex qPCR (both antiviral and antibacterial biomarker suites) will be applied to obtain a more complete picture of dietary manipulation of Atlantic salmon immunity.

## SALON LEDUC + FORTRIN

### FISH PHYSIOLOGY PHYSIOLOGIE DES POISSONS

**10:10-10:30**

**THE TRANSCRIPTIONAL RESPONSE OF CULTURED ATLANTIC SALMON (*Salmo salar*) TO HIGH TEMPERATURE ALONE, OR IN COMBINATION WITH HYPOXIA**

A. Beemelmans\*, F.S. Zanuzzo, X. Xue, R.M Sandrelli, M.L. Rise and A.K. Gamperl

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Increasing seawater temperatures and hypoxia resulting from climate change may become a challenge for Atlantic salmon kept in cage-sites in Atlantic Canada and negatively affect fish growth, immunology and health, and raise concerns about welfare and productivity. To better understand how these environmental challenges may impact this species, we sampled the liver of fish exposed to control conditions (12°C, 100% air sat), an incremental increase in temperature (1°C / week) to 20°C, and this high temperature treatment in combination with hypoxia (70% air sat.), and used Agilent 44K microarrays to: 1) examine changes in global gene expression; and 2) screen for potential biomarkers of heat stress, oxidative stress, and altered immune function. Overall, there were 4005 significantly dysregulated genes when comparing both experimental groups with the control group. The transcription of most genes was affected similarly in the two treatment groups, with transcripts involved in oxidative stress (e.g. EPX, TRX, PRDX6), the heat-shock response (e.g. HSP90A, HSP90B, HSPA8, HSP70, SERPH1) and immune function (e.g. APOD, CATHL-1, CASP-8, CCL-20, C1QL-2, IRF-2, IL-8, MMP-9, NCKAP-1L) amongst the most prevalent. However, pathways connected to apoptosis, virus/bacteria defense and inflammation were more enriched in fish exposed to high temperature and hypoxia vs. high temperature alone.

**10:30-10:50**

**TRIPLOIDY HAS MINIMAL IMPACT ON HYPOXIA TOLERANCE AT HIGH TEMPERATURE IN RAINBOW TROUT (*Oncorhynchus mykiss*)**

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Triploid fish are sterile and can therefore be used in aquaculture and fisheries management to prevent pre-harvest sexual maturation or the spawning of escaped fish. However, triploids tend to perform poorly under sub-optimal conditions, such as high temperature or low oxygen tension. Given that fundamental changes in cell size and number that accompany triploidy are predicted to affect cellular and whole-animal physiology, potentially altering environmental tolerances and optima, the aim of this study was to determine whether the apparent reduced thermal tolerance of triploids is a result of reduced hypoxia tolerance. This was assessed by holding diploid and triploid rainbow trout for 1 h above their thermal optima (separate trials at eight temperatures between 20 and 27 °C) and then rapidly reducing the oxygen tension (PO<sub>2</sub>) of the water and determining the PO<sub>2</sub> at which they lost equilibrium. Although there was an overall significant ( $p < 0.05$ ) reduction in hypoxia tolerance of the triploids, post-hoc analysis showed that there was no significant effect of ploidy at any specific temperature. Oxygen availability therefore does not appear to play a major role in determining the thermal tolerance of triploids.

**10:50-11:10**

**PERFORMANCE ET VALEUR NUTRITIONNELLE DES NAUPLII DE COPÉPODES COMME NOURRITURE VIVANTE DANS L'ÉLEVAGE DES LARVES DE PLIE ROUGE (*Pseudopleuronectes americanus*)**

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Les copépodes sont la principale nourriture de nombreuses larves de poissons marins en milieu naturel. Cependant, dans l'élevage larvaire, les rotifères enrichis sont les proies vivantes les plus couramment utilisées. Des impacts sur le comportement alimentaire, la croissance, la survie et la composition en acides gras (AG) chez les larves de plie rouge nourries avec des copépodes et des rotifères ont été déterminés et liés à la composition en AG des deux proies. Les nauplii d'*Eurytemora herdmani*, une des principales espèces de copépodes de l'estuaire du Saint-Laurent, n'ont montré aucune différence significative dans leurs profils d'acides gras essentiels suggérant une qualité nutritionnelle similaire en termes des acides gras. Ainsi, seul *Eurytemora herdmani* a été utilisé dans cette étude et comparé aux rotifères. Les nauplii des copépodes sont caractérisés par des niveaux plus élevés d'acides gras essentiels, en particulier de l'acide docosahexaénoïque (DHA) et l'acide eicosapentaénoïque (EPA). Le niveau d'incorporation

sélective des acides gras essentiels dans les tissus larvaires (lipides polaires) a indiqué que les nauplii pourraient mieux remplir les besoins nutritionnels larvaires en DHA que ne le peuvent les rotifères. Finalement, le comportement des larves est modifié selon le régime alimentaire. Les larves nourries avec des nauplii sont plus actives.

### **11:10-11:30**

#### **INFLUENCE OF TEMPERATURE AND HYPOXIA ON THE STRESS RESPONSE OF ATLANTIC SALMON (*Salmo salar*) AND STEELHEAD TROUT (*Oncorhynchus mykiss*)**

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Water temperature and oxygen can fluctuate daily and seasonally, and affect the physiology, health and survival of salmonids held in sea-cages. Given the projected impacts of climate change on these key environmental parameters, we determined the temperature at which current stocks begin to experience thermal stress when exposed to acute (10-24°C, 2°C/h – Steelhead Trout) and chronic (12-23°C, 1°C/week – Atlantic Salmon) temperature increases, and the latter challenge when combined with hypoxia (70% air saturation). Further, we compared post-stress (30s air-exposure) cortisol levels in 12°C-acclimated salmon vs. those exposed to a chronic incremental increase to 20°C. These studies showed that: 1) when exposed to an acute or a chronic increase, 20-21°C is when fish begin to show signs of stress (based on plasma cortisol and catecholamine levels, and cortisol levels, respectively), and that stress levels increase quickly thereafter; 2) cortisol levels were much higher during the acute thermal challenge (max. ~180 vs. 40 ng mL<sup>-1</sup>); 3) hypoxia had no impact on cortisol levels during the chronic challenge; and 4) post-stress cortisol levels peaked earlier and were higher in salmon held at 20°C (1h, ~200 ng mL<sup>-1</sup>) vs. 12°C-acclimated fish (2h, ~125 ng mL<sup>-1</sup>). The implications of these results will be discussed.

### **11:30-11:50**

#### **USING CHALLENGE TESTS TO STUDY PHYSIOLOGICAL PERFORMANCE OF SPECIES OF INTEREST IN AQUACULTURE**

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Challenge tests use the loss of equilibrium of fish as a proxy of “death” and allow to test rapidly the tolerance of a great number of fish without losses. Protocols may be adapted to discriminate performance among individuals or families and challenge tests can be coupled with different

experimental approaches. Two examples will be presented: 1) a hypoxia challenge test that aimed to compare how different families of brook charr respond to stress; 2) a temperature challenge test that aimed to evaluate how the fatty acids content in diets affect the whole performance of juvenile striped bass. In these two examples, the less and the most resistant fish were sampled to measure different physiological variables trying to understand how they may explain the differences observed. Such tools are easy to handle and present a great interest in aquaculture related research.

**11:50-12:10**

**DETERMINING THE EFFECTS OF A MICROSPORIDIAN PARASITE ON THE GROWTH OF CULTURED ATLANTIC COD USING A NOVEL, INTEGRATIVE PARASITOLOGICAL AND MOLECULAR APPROACH FOR QUANTIFYING INFECTIONS**

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Canadian Atlantic cod aquaculture efforts failed in part due to the emergence of a known but poorly characterized microsporidian parasite, *Loma morhua*. We report an integrative parasitological and molecular (quantitative polymerase chain reaction; qPCR) approach for quantifying *L. morhua* infection intensities using host spleens. A hatchery epizootic revealed variable spleen infections among 50 Atlantic cod families from which putatively resistant lines were identified. Fish growth was inversely correlated with infection intensity and 14% fillet loss occurred in those individuals most susceptible to *L. morhua* infections, regardless of family affiliation. Similarly, the first *L. morhua* exposure trial using specific pathogen-free fish induced a significant period of growth rate suppression prior to detection of subclinical spleen infections using a novel qPCR approach. Though growth rates stabilized after initial growth rate suppression, parasitized fish showed a 19.3% fillet loss compared to uninfected controls. Furthermore, experimental infections revealed that gill infections are phasic and an order of magnitude higher than infections observed in spleen during the acute phase of infection. Given the ubiquitous distribution of microsporidia among commercially-relevant fish species and *L. morhua*'s demonstrated effect on fish growth, this research has implications for disease mitigation strategies (e.g. selective breeding, husbandry, vaccine/chemotherapy assessment).

## **SALON PILOT**

# **MARINE AND FRESHWATER INTEGRATED MULTI-TROPHIC AQUACULTURE AQUAPONIE ET AQUACULTURE MULTI-TROPHIQUE INTÉGRÉE**

**10:10-10:30**

**EVOLVING INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA) SYSTEMS, KEY TO THE DEVELOPMENT OF A DIVERSIFIED AQUACULTURE INDUSTRY IN ATLANTIC CANADA AND THE WESTERN WORLD**

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Examination of landing and value data from the four Atlantic provinces of Canada between 1986 and 2016 shows that, though salmon aquaculture in Atlantic Canada developed strongly from 1986 to 2000, landing numbers from 2001 to 2016 have fluctuated annually and have remained relatively stagnant. The production in New Brunswick increased steadily from 1986 to peak at 39,450 t in 2002; since, it has decreased to 17,184 t in 2014, the lowest production since 1998 (14,782 t). Though it increased in 2015-16, it remained below the levels from 2000 to 2010. In addition to the decline in production, direct employment in the aquaculture industry has also decreased since 2005. The only growth in Atlantic Canada has been with shellfish, which experienced the third highest production year on record in 2014, only 1,007 t less than that of finfish aquaculture (28,981 vs. 29,988 t).

How can we, then, still talk about “aquaculture development” in this region when the driving sector (salmon) is showing obvious signs of decline? The development will not come from fish aquaculture and the only hope is diversification by growing invertebrates and seaweeds. At a time when some finfish sites have been inoperative for several years, would it not make sense to reevaluate them and determine their appropriateness for cultivating extractive species? Taking advantage of the ecosystem services these species can provide, an integrated multi-trophic aquaculture (IMTA) multi-crop diversification approach could be an economic risk mitigation and management option, also addressing pending climate change and coastal acidification impacts.

**10:30-10:50**

**WHERE DOES INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA) FIT INTO FOOD PRODUCTION IN CANADA?**

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Challenges to food production systems for human populations will increase over the next century as society will be confronted with demand from increasing population, eroding ecosystems, climate change and socioeconomic demands. In aquatic food production, freshwater is at a premium in many areas, world fisheries landings peaked in the early 1990s and while aquaculture has grown worldwide to comprise over 50% of the world fish production, this has not been uniformly distributed and many areas are looking at a future deficit situation, including Canada. While aquaculture may have the highest probability of future growth, social carrying capacity issues in the Western world limit spatial expansion with the result that intensification of production will be required in the future. Ecologically efficient culture operations require the adoption of a circular economic model which effectively describes the IMTA concept. However, developing IMTA systems requires large-scale demonstrations which are unattractive to currently lucrative monoculture operations. One solution to this developmental roadblock is the establishment of a network of national experimental farms to develop the best practice principles of operation for the next generation of aquaculture. This will require a new configuration of federal-provincial collaboration to maximize the benefit to Canadian society.

**10:50-11:10**

**COMPARING SALMON MONOCULTURE AND INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA) WITH THREE COMPONENTS: A DISCOUNTED CASH-FLOW ANALYSIS OF AQUACULTURE OPERATIONS IN EASTERN CANADA**

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Integrated Multi-Trophic Aquaculture (IMTA) has been proposed as a sustainable aquaculture technology that can help offset some of the environmental impacts of fed finfish aquaculture. It improves on conventional production by integrating extractive components making use of various waste materials considered as co-products. Improving on previous financial analyses, our

study presents a more detailed and complete assessment of the financial performance of Atlantic salmon (*Salmo salar*) monoculture versus IMTA combining Atlantic salmon, blue mussels (*Mytilus edulis*), and kelps (*Saccharina latissima*). Using discounted cash-flow analysis, we assessed profitability in each case over a 10-year period in New Brunswick. The IMTA operation was more profitable than the Atlantic salmon monoculture, with and without the inclusion of a price premium. Adding a 10% price premium on IMTA salmon and mussels resulted in a substantially higher net present value for the IMTA operation. Despite the positive results for IMTA in our study and other IMTA-related financial analyses, the ongoing uncertainty related to IMTA financial and environmental performance, as well as IMTA increased technological and managerial complexity, may act as barriers to IMTA adoption at this time. Further, our analysis suggests that the disproportionately small revenue contribution of extractive species in our initial IMTA configuration may have a negative influence on IMTA adoption by the Atlantic Canada salmon-dominated aquaculture industry. However, as salmon production has declined in recent years, crop diversification could provide economic stability and incent industry development, rendering IMTA a more attractive practice in the future.

**11:10-11:30**

**PERFORMANCE MEASURES AND MODELS FOR OPEN-WATER INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA)**

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<sup>7</sup> The Center for Aquaculture Technologies Canada, Souris, Prince Edward Island, Canada

Quantifying and qualifying nutrient flows within open-water IMTA systems is necessary to determine transfer efficiencies and to assess overall system performance. There are numerous empirical performance metrics such as spatially defined growth and nutrient sequestration that have application. When used in combination with modelling techniques, empirical approaches can be a powerful tool for system assessment or prediction. Simple empirical growth models such as the thermal growth coefficient (TGC) and scope for growth (SFG) are applicable to aquatic animals, and can include nutritional mass balance approaches to estimate nutrient loads. Comparable empirical growth models exist for seaweeds. Mechanistic based dynamic growth and reproduction models such as Dynamic Energy Budget (DEB) are more complex, but have application beyond site-specific empirical models and can therefore be included into larger ecosystem models for application to IMTA. Proximity, ecological transfer efficiencies, particle dynamics, species culture ratios and the timing of multi-species production cycles can have profound implications for IMTA effectiveness and require careful consideration for system assessment. The methods described in this presentation will provide a pragmatic evaluation of

performance measures and models to assess nutrient transfer and growth in open-water IMTA systems.

**11:30-11:50**

**THE BENEFIT OF THE INTEGRATION OF AN AQUAPONICS SYSTEM IN A TECHNICAL AQUACULTURE PROGRAM, THE QUEBEC FISHERIES AND AQUACULTURE SCHOOL (EPAQ) MODEL.**

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Since fall 2016, the technical aquaculture program of the Quebec Fisheries and Aquaculture school have started an aquaponics club. In result, the club formed mainly of students and two directing teachers designed and constructed a hybrid aquaponics system including a NFT, raft and clay pellets bed components. The animal component of the system is composed of various species of crayfish's coming from the surrounding of the Maskinongé town on the Saint-Lawrence River, Qc. Following the foundation of the club, the system have been used as a multidisciplinary tool where many other course of the technical formation and other program have been able to visually demonstrate many theoretical principles. Throughout the whole process, the students also had the chance to test many different plant species to verify different hypothesis and compatibility opportunities. Hence, students have also been allowed to test new designs in a development approach to validate concepts they believe would be worth going in business with, thus encouraging entrepreneurship. The presentation will show the main falls of the project and how it has been a great addition to a multidisciplinary program where the links between all fields could hardly be more tangible than a fresh vegetable.

## POSTER PRESENTATIONS (FOYER)

### ALTERNATIVE SPECIES DEVELOPMENT DÉVELOPPEMENTS DES NOUVELLES ESPÈCES

#### CHOLESTEROL REQUIREMENT OF PENAEID SHRIMP: A REVIEW

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Cholesterol requirement of Penaeid shrimp species, *Penaeus monodon* and *Litopenaeus vannamei* have been reviewed. Shrimp are unable of *de novo* sterol synthesis from acetate. The important roles of cholesterol serves as a precursor of biochemical active compounds such as molting hormones, bile acids, vitamin D and prostaglandins. The main sources of feed ingredients containing high cholesterol are mollusks meal, shrimp head meal and marine animal lipid. Dietary cholesterol level exceed 1% of diet reduce growth rate and high mortality. The optimum dietary cholesterol level for marine shrimp ranges between 0.17-1% of diet. The optimum levels were varied from various laboratory depend on age, laboratory conditions, diet formula. The studies in *P.monodon* indicated that the optimum level of dietary cholesterol for larvae was 1% of diet and for the juvenile was in ranges of 0.17-0.8% of diet. The requirement are slightly lower in *L.vannamei* therefore, larvae stage and juvenile was 0.92% of diet and 0.05-0.35% of diet, respectively. Dietary phospholipid and phytosterol could partially spare the cholesterol requirement of marine shrimp. The optimal level of dietary cholesterol is limited information in broodstock stage. The research efforts are still needed to gain a better understand in cholesterol requirement in shrimp.

# **AQUACULTURE ENVIRONMENTAL MANAGEMENT GESTION ENVIRONNEMENTALE DE L'AQUACULTURE**

## **OPERATIONALIZING THE ECOSYSTEM APPROACH TO AQUACULTURE: DEVELOPING AN INTEGRATED FRAMEWORK FOR ATLANTIC SALMON (*Salmo salar*) CARRYING CAPACITY IN ATLANTIC CANADA**

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The need for an ecosystem approach to aquaculture (EAA) has led to the advancement of tools for estimating carrying capacity (CC) to promote sustainable development and adaptive and holistic management. Carrying capacity has been applied extensively to shellfish aquaculture; this research is comparatively undeveloped for finfish. CC tools have been important to assess aquaculture practices and their impacts to the natural, social, and economic environment. However, most carrying capacity studies focus on either ecological or production CC, while the social pillar is often neglected. A full integration of various carrying capacity types has not been attempted. Therefore, the objective of this PhD research is to develop an integrated carrying capacity framework for salmon aquaculture in Atlantic Canada. This work will integrate ecological, social, economic, and governance factors to build a quantitative CC framework at various spatial scales. A mixed-methods approach will explore individual CC drivers, which will be synthesized onto a single platform using geographic information systems. This could provide managers and planners with a holistic tool to guide their decisions on site selection, monitoring, and policy-making. This research can add new knowledge on carrying capacity, build better tools to inform marine spatial planning, and ultimately, inform EAA implementation.

# AQUATIC ANIMAL HEALTH SANTÉ DES ANIMAUX AQUATIQUES

## FROM A TO L: RECEPTOR ADSORPTION AND CELLULAR LYSIS BY BACTERIOPHAGES TARGETING *Aeromonas salmonicida* SUBSP. *salmonicida*, THE ETIOLOGICAL AGENT OF FURUNCULOSIS.

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Aquaculture provides more than 75% of the freshwater fishes consumed around the world. Fishes in aquaculture are under stress conditions causing diseases and great economic losses. The bacterium *Aeromonas salmonicida* subsp. *salmonicida* (*A. sal.*) is the etiological agent of furunculosis in salmonids. The treatment of this disease, either by antibiotics or vaccination, is often demanding and inefficient. The use of alternative treatment is required. Bacteriophages (phages) are viruses that specifically infect bacteria. Phages adsorb to the bacterial surface via specific receptors in order to penetrate their genetic material in the cell and thus perform their lytic cycle. Until now, we have isolated, characterized and sequenced new phages infecting specifically *A. sal.* We are also exploring the mechanisms of bacterial resistance to phages. We are doing the characterization of phage receptors present on *A. sal.* This is done through the generation of phage-resistant bacterial strains (BIM: bacteriophage-insensitive mutants) and the complementation by cloning of these mutants, which will enable us to identify the key genes and the protein structures for phage adsorption and make it a new therapeutic target. The final step of this project is to test a phage cocktail on fish infected by *A. sal.* in a controlled laboratory.

## **MORE AND MORE PLASMIDS CAUSING ANTIBIOTIC RESISTANCE IN *Aeromonas salmonicida* ssp. *salmonicida*, THE CAUSATIVE AGENT OF FURUNCULOSIS IN SALMONIDS.**

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Furunculosis is a systemic disease affecting fish in the salmonid family characterized by high mortality rates. Caused by the aquatic bacterium *Aeromonas salmonicida* ssp. *salmonicida* (*A. sal.*), this disease has major economic impacts on aquaculture operation worldwide and especially in Quebec where fish production is mainly directed towards salmonids. While antibiotics are commonly used to treat furunculosis, the effectiveness of this approach is becoming increasingly limited against *A. sal.* due to the emergence of resistant and even multidrug-resistant strains. This antibiotic resistance is due to the acquisition of resistance genes. In, *A. sal.*, those genes are usually carried by plasmids that are small extra-chromosomal DNA elements capable of autonomous replication and able to promote the transfer from one bacterium to another. In this study, we present a summary of our work of the last four years, where genomic analyses allowed us to identify and characterize ten plasmids harboring one or more antibiotic resistance genes. Some of these plasmids confer resistance to all antibiotics approved for aquaculture in Canada. The emergence and spread of antimicrobial resistance in *A. sal.* are therefore a major issue and careful monitoring of the progression of antibiotic resistance should be carried out.

## **INCREASING DIVERSITY OF *Aeromonas salmonicida*: A BIRD CARRIER OF A FISH PATHOGEN**

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*Aeromonas salmonicida* is a Gram-negative bacterium which is ubiquitous in fresh water. It is the causative agent of furunculosis, a systemic disease that affects salmonids in the wild and mainly in aquaculture. Up to now, the hosts known for this bacterium are different fish species. However, a new strain, JF2480, has recently been sampled from ill pied avocets, a migratory bird that feeds in shallow lake and mud ponds. A phylogenomic analysis suggests it is taxonomically

distant from other known *Aeromonas salmonicida* subspecies. The genome sequence from Illumina MiSeq confirms that the strain possesses the key virulence genes that are present in *Aeromonas salmonicida* psychrophilic subspecies, with the exception of the gene encoding the type three secretion system (TTSS) which is incomplete. Bacterial virulence assays conducted on the surrogate host *Dictyostelium discoideum* amoeba confirmed that the strain is virulent. Additionally, extensive phenotypic characterization tests have been conducted using API@bioMerieux, demonstrating that *A.sal* JF2480 has a more active metabolism at 37°C than 25°C. The discovery of this strain further demonstrates the extent of the species' phylogenomic tree. This study also suggests that the pied avocet could be a potential virulent *Aeromonas salmonicida* carrier.

## **HOW ARTIFICIAL REARING INFLUENCES THE MICROBIOTA OF ATLANTIC SALMON (*Salmo Salar*) THREE MONTHS AFTER STOCKING**

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Stocking methods are used in the Province of Quebec as to overpass the demographic decline of Atlantic salmon. While the juveniles are generated with wild breeders, they show higher mortality rates than wild ones when introduced into nature. Hatchery environment is known to impact microbiota composition, who is narrowly associated with the development of essential metabolic function for its host. Previously, we demonstrated that hatchery raised parrs recruit a microbial community that differs from their wild relatives. For the present study, we hypothesized that bacteria associated with the artificial rearing will remain in juvenile's microbiota even after being stocked. To do so, we evaluated the microbiota of 10 wild and 10 stocked juveniles that have been stocked three months prior to the sampling. Our results show that the stocked juveniles microbiota still houses bacteria from the hatchery as well as bacteria from the natural environment, showing some ability to adapt to the new environment. Further investigations are needed to understand the impacts of keeping "hatchery bacteria" on the physiological development of stocked juveniles. Our results suggest to implement microbial ecology concepts into conservation management of endangered species as to mitigate bacterial composition divergence between captive and wild juveniles before stocking

# GENOMICS AND EPI-GENETICS GÉNOMIQUE ET ÉPI-GÉNÉTIQUE EN AQUACULTURE

## USING THE ION PROTON AND AMPLISEQ PANELS TO INCREASE THE FEASIBILITY OF IMPUTATION-BASED GENOMIC SELECTION IN ATLANTIC SALMON

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Genomic selection has the potential to revolutionize breeding in aquaculture by increasing accuracy of selection and per generation genetic gain, which in turn can have significant increase in profitability. The wide-spread application of genomic selection in Aquaculture has been hindered by the elevated cost of genotyping large training populations and sets of candidate broodstock in every production cycle. Even if training populations are not genotyped every cycle, the costs are still prohibitive and there is ample evidence that there is significant loss in accuracy if the prediction model is not updated (re-trained) every generation. Genotype imputation represents a powerful tool to reduce genotyping costs in genomic selection applications, but given the size of the salmon genome, the number of SNPs required depending on the accuracy of imputation required is still beyond what most low to medium density genotyping platforms can offer. In this presentation, we highlight the development of a ~3,000 SNP Agriseq Atlantic salmon panel that can be used to genotype large numbers of individuals at an effective cost. Simulation data will also be presented to demonstrate the imputation power of a 3,000 SNP panel and its application on various genomic selection schemes.

## FISH PHYSIOLOGY PHYSIOLOGIE DES POISSONS

### IMPACTS OF HIGH TEMPERATURE AND HYPOXIA ON THE GROWTH PERFORMANCE AND SURVIVAL OF ATLANTIC SALMON (*Salmo salar*)

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Given the predicted effects of climate change on seawater temperatures and water oxygen levels (i.e., the frequency and severity of hypoxia), it is important to understand the impact of these two environmental challenges on salmon used in Atlantic Canada (i.e., of Saint John River origin). Thus, we subjected salmon to: 1) an incremental temperature increase (1°C / week to 20°C) and then held the fish at 20°C for an additional 3 weeks; and 2) an incremental increase in temperature until mortalities reached ~30%. Further, we conducted these temperature challenges under both normoxic and hypoxic (~70% air sat.) conditions. These experiments show that

salmon can be held at 20°C, and 20°C plus moderate hypoxia, for periods up to a month. However, the former condition results in an ~10% increase in food conversion ratio (FCR), and this temperature plus hypoxia results in an increase in FCR, decreased feed intake, and thus, growth (SGR decreased by 15%). However, it is also clear that the salmon used in these studies cannot tolerate further temperature increases. SGR and feed intake dropped dramatically after 21°C (again more-so in hypoxia-acclimated fish), and mortalities were ~15% by 22°C and 30% by 23°C. Interestingly, however, hypoxia did not affect survival.

## **USING DATA STORAGE TAGS TO STUDY THE PHYSIOLOGY AND BEHAVIOUR OF ATLANTIC SALMON (*Salmo salar*)**

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Data storage tags (DSTs) record and store information about animals and their environment. Star-Oddi has recently made a DST available that simultaneously records heart rate (ECGs), 3-D acceleration and temperature (the centi-HRT ACT tag), however, no studies have used these DSTs on fish or determined the quality / value of the data collected. Thus, this research asked: do these DSTs provide accurate and meaningful data? To examine this question, large Atlantic salmon (~ 2.6 – 3.0 kg) were surgically implanted with centi-HRT ACT tags and held in a large (3.5 m diam. x 2.5 m deep) tank with conspecifics for 1 week at 11°C while data was continuously recorded. In a separate experiment, salmon (~ 1.5 kg) were surgically implanted with DSTs, then swam at increasing speeds in a swim tunnel after 1 week of post-surgical recovery. This research shows that: 1) centi-HRT ACT tags provide meaningful data with regards to the heart rate and 'activity' of Atlantic salmon; 2) both heart rate and activity show diurnal patterns; 3) the acceleration data can be used to estimate the swimming speed of fish; and 4) these tags have several potential applications for monitoring fish behavior and physiology in aquaculture, but are not without their limitations.

## LANDBASED AND RAS AQUACULTURE PISCICULTURE EN SYSTÈMES OUVERTS ET FERMÉS

**AQUACULTURE WASTE RETRIVAL FROM BROOK TROUT (*Salvelinus fontinalis*) AND ARCTIC CHAR (*Salvelinus alpinus*): MONITOR LEEK (*Allium porrum*, chinook variety) GROWTH IN AN RECIRCULATING DECOUPLED AQUAPONIC SYSTEM**

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In Quebec, terrestrial aquaculture produces a huge amount of waste directly release in the environment. This project shows a method to add value at fish waste and lower the amount of phosphorus from a collegial aquaculture with leeks (*Allium porrum*) in an decoupled aquaponic system. Traditional waste removal techniques consist of filters who needs periodical cleaning or large terrestrial facilities to settle solid waste. Furthermore, a lot of fish producer don't even have the equipment or techniques to remove dissolve waste like phosphorus. Those waste ends up most of the time in watercourses. To solve this problem, the presented project intends to set an aquaponic leek system that will add value to solid fish waste with a mineralisation treatment and withdraw phosphorus from water in regard to lesser the amount release in the environment. The hypothesis is that the crop will absorb a certain quantity of phosphorus to grow and it will grow faster than a traditional in soil crop. This experiment beginning in February 2018 will be observing the germination rate in two different media, the level of phosphorus in water once leeks are in the aquaponic system and the time they take to reach a consumable size.

## SEAWEEDS AND ALGAE ALGUES

**PHENOLOGICAL STUDY OF THE REPRODUCTION OF *Palmaria palmata* (Palmariales, Rhodophyta) ALONG THE COAST OF THE GASPÉ PENINSULA, IN THE GULF OF ST LAWRENCE, CANADA**

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*Palmaria palmata* is an edible red seaweed. In eastern Canada it is mainly picked up around Grand Manan Island but the wild beds are exploited at their maximum. Therefore, cultivation of this species is considered as an alternative. In this context, availability of spores is an important issue. One objective of this project was to follow the fertility cycle of wild *P. palmata* to identify

when the peak of spore production occurs in the wild. The other objective was to test a method to artificially induce sporogenesis on fronds by manipulating the temperature and the photoperiod. From July 2017, wild fronds were harvested monthly at two locations along the Gaspé Peninsula. The weight and length of the fronds were measured and the percentage of the frond surface covered with spores was assessed. Some non-fertile fronds were cultivated at 5 and 10 °C under either a constant long or short day photoperiod. The preliminary results show that the natural peak of fertility was between October and January with a delay between the two sites. When non-fertile fronds were conditioned, sign of fertility were observed in the 4 treatments but fully mature spores were only produced at 5 °C under a constant short day photoperiod, after 2 months.

### **DEVELOPPEMENT D'UN OUTIL PREDICTIF POUR EVITER LA COLONISATION DU BRYOZOAIRE ENVAHISSANT *Membranipora membranacea* SUR LES LAMINAIRES SUCREES (*Saccharina latissima*) DE CULTURE**

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Le bryozoaire envahissant *Membranipora membranacea* forme des colonies calcaires sur les feuilles et les stipes des laminaires et cause de sérieux problèmes aux aquaculteurs d'algues en diminuant les récoltes et la qualité de celles-ci. L'objectif de ce projet est de développer un outil prédictif simple pour permettre aux producteurs d'algues de déterminer le moment optimal de récolte afin de minimiser les impacts de *Membranipora* et maximiser la biomasse des récoltes. Pour ce faire, nous nous basons sur un modèle de Saunders et collaborateurs (2010) qui utilise la température comme prédicteur du moment de la colonisation larvaire de *Membranipora* en Nouvelle-Écosse. Ce modèle sera testé et calibré pour trois sites aquicoles du Québec, en utilisant des données d'abondance de larves sur les laminaires récoltées pendant deux années de croissance. Pour améliorer le modèle prédictif, nous déterminerons le seuil optimal de température à laquelle le bryozoaire devient actif en utilisant les deux années de données au Québec ainsi que les données récoltées en Nouvelle-Écosse (sept années). Des expériences en laboratoire seront également effectuées afin d'exposer des colonies à différents régimes de température dans le but de corroborer le seuil de température identifié à l'aide des données de terrain. Un transfert technologique aux aquaculteurs est planifié à la fin de ce projet.

# SHELLFISH AQUACULTURE AQUACULTURE DES MOLLUSQUES

## CONTROLLING MASS MORTALITY EVENTS WITH PROBIOTICS DURING THE BLUE MUSSELS (*MYTILUS EDULIS*) LARVAE REARING PROCESS: WHAT ROLE IS PLAYED BY THE LARVAL MICROBIOTA?

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In bivalve hatcheries, opportunistic pathogens have been associated with important larval mass mortality events, observed on a regular basis. Probiotics has been proposed as an alternative to antibiotics to limit the occurrence of such events. Probiotics are microorganisms, or natural molecules, that are associated with beneficial effects such as enhancing host resistance to stressors like bacterial pathogens. The host microbiota composition is known to influence host health. The main objective is to highlight the protective effect of a new probiotic, marennine, on *Mytilus edulis* larvae during bacterial challenges in relation to a potential modification of the microbiota of the marennine-treated larvae. Marennine has demonstrated a positive effect on larvae survival at a 500 µg L<sup>-1</sup> concentration. D-larvae and post-larvae were exposed for 96 h to *Vibrio splendidus* with and without marennine at the latter concentration. Our results demonstrated that benefit effect of marennine was not related to direct antimicrobial effect on *Vibrio splendidus* growth and did not modify the bacterial abundance in the rearing medium. Molecular analyses of the larvae microbiota will allow us to demonstrate if a modification in the larval microbiota's richness might explain the increase of the survival rate during the production of blue mussels.

## BIOENERGETICS STUDY OF CULTIVATED AND WILD BIVALVES IN CONTEXT OF AQUACULTURE MANAGEMENT

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In Atlantic Canada, the shellfish aquaculture industry is mainly supported by the longline suspended culture of blue mussels, *Mytilus edulis* and the suspension and bottom culture of eastern oysters, *Crassostrea virginica*. In Prince Edward Island, cultivation is realized in bays and estuaries but since 1999 there is a moratorium that limits shellfish aquaculture expansion. To validate potential expansion possibilities for shellfish aquaculture, a fine estimation of carrying

capacity is necessary, one that needs to include impacts on wild species. However, basic physiological knowledge on the bioenergetics characteristics of wild species is not available for this area. Thus, this project compares the bioenergetics characteristics of wild bivalves i.e. *C. virginica*, *M. edulis*, the softshell clam *Mya arenaria* and the American clam *Mercenaria mercenaria*. Furthermore, the project's comparative approach extends to cultivated mussels and oysters. The relative impact of each species and their habitat (suspension or bottom) on flows of matter and energy is discussed.

## **IMPACT OF VESSEL NOISE ON BEHAVIOR OF BIVALVE LARVAE AND OTHER ZOOPLANKTONIC SPECIES**

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Anthropogenic noise is a pervasive feature of the coastal ocean soundscape and is intensifying in an unknown way as vessel traffic activity increases. For example, shipping has increased low-frequency noise by 32-fold and may account for 90% of the anthropogenic noise in coastal areas. Low-frequency sound from wave action on reefs has been shown to initiate marine invertebrate larval settlement and accelerate metamorphosis to juvenile stages. Similarly, low-frequency noise produced by vessels has also been shown to enhance larval settlement of benthic-pelagic species. So far nothing is known on the effect of vessel noise on holoplankton. Hence, we designed laboratory experiments to document the response of planktonic invertebrates, such as larval stages of bivalve (*Mytilus edulis*) and zooplankton, to vessel noise recorded from their natural habitats. We tested the hypothesis that vessel noise has an impact on the feeding rate of mussel larvae and on feeding behavior of copepods (*Eurytemora herdmanni* and *Acartia longiremis*). Furthermore, we tested the effect of vessel noise on the growth of rotifers *Brachionus plicatilis*. Our results showed that feeding behavior of mussel juveniles and copepods was not significantly different when exposed to vessel noise.

## **TRIPLOID MUSSELS FOR A STRONGER ATTACHMENT**

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In Prince Edward Island, mussel socks are stocked at 300 to 400 individual per 30 cm. However, as most of them fail to stay attached and fall off, the harvested mussels are only around 100 specimens per 30 cm. This results in important implications at ecological and economical levels. The attachment of mussels is due to the production of a specific tissue, the byssus. The production of the byssus has a cost in energy that can represent around 8% of the energy consumption of the mussel. Studies have shown that the attachment strength of the mussel

byssus depends on different factors, one being the investment in reproduction. It is known since decades that triploid bivalves have reduced or even no reproduction. Reproduction account for a major use of the bivalve energy. Thus, triploid bivalve can relocate this energy need for other metabolic processes. Indeed, it has been shown that triploid oysters have more available energy for their metabolism and are bigger than diploid oysters. Therefore, we believe that the induction of triploidy in *Mytilus edulis* could increase the energy available for the production of the byssus, which will lead to a better attachment of the mussels and less mussel loss.