

# Abstracts by Session

## Aquaculture Canada 2019

### *Partnering for a Sustainable Tomorrow*

**Note: Presenters with an underlined name are students to be judged for Best Presentation**

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**Monday, May 6th**

**SALON C**

**ADVANCES IN AQUACULTURE TECHNOLOGY**

**10:30-10:50**

**COMPREHENSIVE BENEFITS OF DEEPCHILL COOLING FOR SUPERIOR PRESERVATION AND YIELD GAIN IN SHRIMPS**

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Effective and rapid seafood preservation is an important concern for aqua culturists. With better seafood preservation comes higher quality to consumers and higher premium to farmers. The use of flake ice, refrigerated sea water (RSW) or tube ice offers cooling that is fairly laborious, does not provide effective cooling below subzero temperatures, and involves fairly significant drip losses. In addition, handling of any form of crushed ice needs manual intervention thereby increasing the risk of contamination

DeepChill<sup>®</sup> is a proprietary ice slurry technology that is be able to address these concerns. As a true variable state ice slurry, it is pump able and the amount of DeepChill crystals in the slurry can be varied depending on heat transfer requirement. This paper presents the DeepChill<sup>®</sup> advantages for cooling farm raised shrimps. It must be noted that DeepChill is also effective for salmon, mussels and many other aqua cultured species.

**10:50-11:10**

**TARGETED DELIVERY FOR AQUACULTURE WITH MUCOADHESIVE NANOPARTICLE PLATFORM**

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Aquaculture market has seen a drastic increase and set to grow exponentially in the foreseeable future. However, high density fish farming faces major challenges including disease outbreaks and inefficient feed utilization. To control the disease outbreaks and maximize the production rate, the sector is primed for applications of novel technologies in delivery of nutraceuticals, vaccines and drugs. Current delivery methods such as immersion lacks efficiency whereas individual injection method is time-consuming and costly. Nanotechnology has the potential to revolutionize this field to boost a vast economic benefit. Not only can nanoparticles improve the water-stability of ingredients, but they can also enhance the delivery efficiency. We designed a

novel nanoparticle platform with surface ligands to specifically and covalently target the mucosal surfaces on the scale, gill, and digestive systems in fish and shellfish. We demonstrated that the platform can be retained on mucosal surfaces beyond 24 hours *in vivo*. Furthermore, the nanoparticles favourably bound to iridophores on ocular and dorsal regions, and digestive organs. The mucoadhesive nanoparticle system has the potential for significant reduction in overall dosage required for nutraceutical and drug delivery in aquaculture and overcoming ineffectiveness of the vaccination which has been a consistent obstacle in this field.

**11:10-11:30**

**SIMULTANEOUS DETECTION OF MOISTURE, FAT AND PROTEIN IN WHITE FISH COMBINED WITH THE DETECTION OF MICROBIOLOGY COMPOSITION OF WHITE FISH, USING A HANDHELD NIR SCANNER**

I. Hoffman

The high quality of fish and fish-based products necessitates the development of easy-to-use handled and precise tools that can test in real time the quality of the fish without destroying it. The fish industry has a strong need for objective methods to identify chemical composition (fat, protein and moisture) of fish, and its microbiological content (freshness). Near infrared (NIR) spectroscopy as a non-destructive and cost effective analytical method is widely used in food industry for rapid measurement of quality attributes, however, there is still a vast need for simple low cost NIR instruments usable by non-technical personnel in everyday situations.

The aim of this presentation is to present the work developed with European white fish using machine learning models for the prediction of chemical and microbiological composition based on the NIR spectra acquired with a handheld scanner and a user friendly mobile app.

**11:30-11:50**

**THE ACCURACY OF DUAL-ENERGY X-RAY ABSORPTIOMETRY (DXA) TO ASSESS RAINBOW TROUT (*Onchorhynchus mykiss*) PROXIMATE COMPOSITION AND DIET PHOSPHORUS RETENTION.**

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In this study, the accuracy of Dual-energy X-ray absorptiometry (DXA) to estimate body composition of fish carcasses (36-132 g body mass) fed varying levels of phosphorous (P) was examined. A growth trial was conducted between triplicate groups of 700 triploid fish feed with two different diets: supplemented or not in phosphorous (Control-P diet = 11g P/kg and Low-P diet 5.5 g P/kg). Trout were sampled on three occasions during the feeding trial (0, 4, and 9 weeks). DXA scans were performed on frozen and thawed carcasses. Data from the DXA scan

was compared to values from chemical analyses for whole body composition. DXA provided readings of total body mass highly correlated ( $R^2=0.98$ ) with weight from balance. Similarly, bone mineral (BMC) and lean content, from DXA readings, were highly correlated ( $R^2 = 0.87-0.88$  and  $0.72-0.78$ ) with proximal analyses for ash and protein content, for frozen and thawed carcass respectively. The fat mass values were not well correlated between the two methods ( $R^2>0.2$ ). Phosphorous content was predicted with  $R^2$  higher than 0.80 with a low residual standard error (RSE). Two best-fit equations for frozen and thawed carcasses were:  $P_{total} = -0.071 + 0.061(\text{BMC}) + 0.0046(\text{lean})$  (RSE = 0.056 and  $P < 0.0001$ ) and  $P\text{-total} = -0.005 + 0.004 \text{ lean}$  (RSE = 0.05 and  $P < 0.0001$ ). Phosphorus retention and loading estimate using models from frozen carcass are similar than those obtained using chemical methods. Other body components including water and the protein content in fish carcass were accurately predicted using DXA. These results indicate DXA is a reliable method to predict body composition of juvenile trout, except carcass lipid.

**11:50-12:10**

### **REMOTE SENSING ANALYSIS OF RIVER HABITAT FOR THE ATLANTIC SALMON IN THE INNER BAY OF FUNDY**

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The inner Bay of Fundy Salmon are generally considered to be a genetically distinct population. Listed as endangered under the Species at Risk Act in 2004, their populations have seen declines of up to 90% 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 habitat mapping provides a quantitative assessment of river quality. 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 released and are tracking adult salmon in the river that were reared in Cooke Aquaculture sea cages. During the summer of 2016 the Upper Salmon river was flown and photographed by a DJI Phantom 4 drone, to create a DEM of the river, which was then processed to create descriptive environmental raster layers. These layers are being processed through Maxent, with presence data in order to provide predictive distributional maps of spawning habitat. Our habitat mapping contributes to assessing habitat and spawning usage as a method of understanding the success of restoration efforts.

**12:10-12:30**

### **AQUACULTURE AND THE INTERNET OF THINGS**

J. Grant

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Precision aquaculture involves a variety of sensors used for gain insight into the farm environment, make decisions which optimize fish health, growth and economic return, and

reduce risk to the environment. This includes sensors specific to monitoring of oceanographic conditions as well as technology such as fish tags to detect fish movement and behaviour. Sensor networks produce huge volumes of information or Big Data. Aquaculture has become part of the Internet of Things is defined as interconnected sensors which store and serve data, interact with other sensors and devices, and provide decision support. Working with the fish farming (Cooke Aquaculture) and ocean technology industries (RealTime Aquaculture), H2020 GAIN (unive.it/pag/33897), as well as computer scientists (deepsense.ca and IBM), we are collaborating on a fish farming sensor network. Hundreds of sensors are deployed in Canada, with additional networks being established in Spain and Scotland. Our research objectives include resolving (a) scales of variation in sensor deployment, (b) management of Big Data and use of data analytics to mine predictions related to fish growth and health, (c) development of additional sensors for understanding the aquaculture ecosystem, and (d) integration of data into coastal information portals and wider metrics of coastal health.

**1:50-2:10**

**AQUACULTURE SEAWATER OXYGENATION SYSTEM (ASOS)  
DRIVEN BY SUSTAINABLE RENEWABLE ENERGY**

J Matei\*

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Climate change is affecting our oceans and all marine life throughout the world. This change in ocean warming and other factors, is affecting the levels of dissolved oxygen in the oceans throughout the world. AOE has coupled our patented Ocean Wave Energy System and designed and patented our Aquaculture Seawater Oxygenation System to provide a specific level of dissolved oxygen in seawater for both open-pen grow-out and land-based grow-out salmon farms which requires no fossil fuels and will dramatically reduce and eliminate the need for diesel fuel in remote operations.

**2:10-2:30**

**ADVANCES IN SATELLITE EARTH OBSERVATION DATA ANALYTICS FOR  
AQUACULTURE**

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World aquaculture production continues to grow and now provides half of all fish for human consumption (FAO, 2016a), but its sustainability is being impacted by climate change, competition for space and natural resources, pollution and environmental degradation. Effective management of the sector requires appropriate and accessible data to inform management decisions. Satellite earth observation technology has developed rapidly in the past five years, with numerous advances in spatial resolution, spectral information, frequency of observation, and cost-effectiveness (open data). The information can inform aquaculture development (strategic planning, zonation and site suitability), aquaculture practice and management

(inventory, status, monitoring of the environment and monitoring at the farm level), and aquaculture risk management (disaster risk management, response, recovery, monitoring and assessment). While the growing volume of satellite data represents a unique opportunity for aquaculture, it also poses a major challenge to achieve its full potential in terms of extracting valuable management information. A variety of big-data platforms currently seek to address these issues by bringing together satellite data, environmental data, and analytics processing systems. These platforms include the European Space Agency funded Coastal and Food Security Platforms and Google's Earth Engine. Each platform has a variety of benefits which are discussed.

**2:30-2:50**

## **REGULATION OF FISH IMMUNITY THROUGH DYNAMIC TEMPERATURE CONTROL**

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The sustainability and continued growth of Canada's aquaculture sector requires that we identify strategies to reduce fish losses to disease, and continue the evolution of current management practices to adapt to environmental changes. We have recently identified added functionality in the fish immune system based on dynamic behavioural thermoregulation (BTR). In short, although fish lack endogenous metabolic-driven endothermy and largely show immune suppression at lower temperatures, they possess an intrinsic capacity to markedly enhance immune competence through BTR. Importantly, this is achieved through a combination of earlier, tailored defenses that are quickly followed by efficient inflammation control. This allows for both enhanced antimicrobial protection as well as efficient use of energy resources. This is a novel and significant asset for fish health, production efficiency and overall performance. BTR also opens the door to enhance long-term immune memory. Together, this represents a paradigm shift in our understanding of fish immunity and has major applied implications for the aquaculture sector. This presentation will describe the basic mechanisms contributing to the regulation of fish immunity through BTR and outline key opportunities to improve aquaculture health and performance using a natural, drug-free and energy-wise sustainable strategy

# AQUATIC ANIMAL NUTRITION

**3:30-3:50**

## **A FUNCTIONAL DIETARY SUPPLEMENT TO SUPPORT FISH SKIN AND SCALE INTEGRITY**

P. Galloway<sup>1\*</sup>

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Physical damage impacts fish health and welfare as well as growth performance. Damage can result from mechanical treatments, handling or be the result of environmental and disease challenge, such as sea lice and winter sores. Functional micro-ingredients allow culturists to support fish skin and scale integrity and maintain fish health and growth during disease and environmental challenge. These natural supplements boost immune function, increase nutrient absorption, and assist tissue maintenance and repair. Presented is an example of a functional dietary supplement pack, EWOS Dermic, a discussion of its functional components and research showing how it can aid tissue response and promote recovery.

**3:50-4:10**

## **SEASONAL RESPONSE TO SALINITY AND NUTRITIONAL FATTY ACIDS IN JUVENILE STRIPED BASS (*MORONE SAXATILIS*)**

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Since 2002, the Québec government has undertaken a major reintroduction program to re-establish striped bass, which have disappeared from the St. Lawrence River. In order to meet the challenges posed by restocking efforts, a better knowledge of the biology of this species is needed. We tested the hypothesis that variable salinity and food source (terrestrial vs marine source) would markedly impact the physiology of striped bass juveniles. Juveniles were raised in winter conditions at two salinities (0 and 14) and fed with a reference diet (RD; 0.73% n-3 polyunsaturated fatty acid [PUFA] on a dry matter [DM] basis) used as a proxy of an estuarine trophic network, and a lower n-3 PUFA diet (MD; 1.65% n-3 PUFA DM) used as a proxy of a marine trophic network. Results showed that salinity effects were less pronounced compared to those of dietary regimes on total liver and muscle neutral fatty acid (FA) profiles, while muscle polar FA were slightly affected. We proposed a new index—the environmental nutritional index (ENI)—to estimate the impact of specific environmental conditions on specific FA requirements regardless of the dietary regime used. This index highlighted that nutritional needs in essential FA (EPA and DHA respectively) were higher when fish were in fresh water (FW). These results

suggested that FW represented a stressful condition for juvenile striped bass, and this was corroborated by the higher hematocrit value and the lower survival observed in FW.

**4:10-4:30**

**HEALTH AND FLESH QUALITY OF ATLANTIC SALMON (*Salmo salar*) FED A MODERN LOW FISHMEAL DIET SUPPLEMENTED WITH ANTARCTIC KRILL, *Euphausia superba***

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Fish meal and fish oil are the principal ingredients in salmon feeds, but sustainability concerns have stimulated the search for novel ingredients like krill meal. Atlantic salmon (*Salmo salar*) were fed with a diet rich in fish meal (15%) or krill meal (12%) for 10 weeks. The krill group showed a significantly higher condition factor compared to control group. The hepatosomatic and cardiosomatic indices were similar for the dietary groups, but livers of fish fed krill were darker and the amount of visible fat on the heart was significantly lower. Microarray analyses of liver revealed that dietary treatment affected a large number of immune genes, and a panel of structural genes were upregulated in the salmon fed krill diet. Gene enrichment analyses revealed that sugar metabolism was stimulated in fatty hearts and a significant downregulation was observed for complement genes and retinoid metabolism. Additionally, downregulation of extracellular matrix proteins indicated weaker tissue structure of the control group. Fillets of salmon fed with krill diet had firmer texture, better coloration and lower gaping. This study shows that dietary inclusion of krill meal in modern low fish meal diets has a positive effect on health and on fillet quality of Atlantic salmon.

**4:30-4:50**

**ARTIFICIAL INTELLIGENCE IN RELATION TO FEEDING TECHNOLOGY DEVELOPMENTS**

Jennsen

.....

**4:50-5:10**

**NOVEL SALMONID FEEDS FOR FASTER GROWTH AND REDUCED MARINE INGREDIENT DEPENDENCY**

van den Herik

.....

## SIDNEY

# AQUACULTURE ENVIRONMENTAL MANAGEMENT

**10:30-10:50**

### **SUPERVISED CLASSIFICATION OF BACTERIAL eDNA DATA IN THE DEVELOPMENT OF A BENTHIC MONITORING PIPELINE**

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In Newfoundland, finfish aquaculture has grown substantially. Intensive aquaculture production is associated with organic enrichment, which occurs as uneaten feed and animal excretions settle on the seafloor forming a layer of flocculent matter. Sustained deposition alters seafloor conditions, with high organic loading resulting in changes in benthic communities. Benthic microbes respond rapidly to organic enrichment at aquaculture sites and assessing bacterial community composition through environmental DNA (eDNA) sequencing has facilitated the detection of benthic enrichment at numerous aquaculture sites worldwide. Such approaches have involved sequencing bacterial eDNA, identifying taxonomic groups, and comparing bacterial community composition; together, these methods are computationally complex and slow. Here, 16S rRNA gene sequences are introduced as features in a supervised classifier to rapidly determine whether these sequences can correctly identify levels of disturbance. Results show that seafloor condition can be readily identified when examining transformations in the frequencies of these gene sequences with a high degree of accuracy. The development of this pipeline has the potential of streamlining environmental assessments by returning real time, on-site predictions of seafloor condition.

**10:50-11:10**

### **EVOLUTION OF A FRAMEWORK TO FOSTER RESPONSIBLE AQUACULTURE EXPANSION IN NOVA SCOTIA**

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Aquaculture is expanding in Nova Scotia. The province facilitates aquaculture growth by building public and investor confidence, enabling access to productive sites and developing industry support. Proactive governance is embodied by the Province's Aquaculture Licence and Lease Regulations, and the Aquaculture Management Regulations. Collectively, these Regulations outline decision processes, compliance, facilitate transparency and ensure due diligence through requirements such as the Farm Management Plan (FMP). The FMP provides guidance for key operator responsibilities such as fish health management, containment management, hazard assessment and environmental monitoring. Good management and governance are supported by science-based decision making and the province has prioritized research to address knowledge gaps and improve practices. Nova Scotia is now embarking on a new phase of responsible aquaculture development. Applications for new or expanded marine finfish sites, or finfish additions to sites only authorized for shellfish, will be referred to the Nova Scotia Aquaculture Review Board. This is a three-member adjudicative board that will make application decisions through public hearings. Evolution of the province's aquaculture framework, challenges and successes are discussed.

**11:10-11:30**

**ENVIRONMENTAL MONITORING TO ENSURE SUSTAINABLE MARINE  
AQUACULTURE IN NOVA SCOTIA**

Richardson

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**11:30-11:50**

**EVALUATING ECOSYSTEM-LEVEL EFFECTS FINFISH AQUACULTURE USING  
MACROINVERTEBRATES IN COASTAL NOVA SCOTIA**

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

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Particulate organic wastes from open-pen finfish aquaculture can accumulate on the seafloor causing measurable changes in macroinvertebrate community structure. These benthic effects are rarely studied across large spatial scales, yet are needed to quantify the ecosystem-level effects of finfish aquaculture. To address these knowledge gaps, this research seeks to examine the ecosystem-level effects of finfish aquaculture operations in Port Mouton Bay, Nova Scotia using macroinvertebrate data. Both univariate and multivariate statistical approaches were used to explore how macroinvertebrate community composition is altered as a result of organic enrichment from a finfish farm. Specifically, the objectives were (1) to evaluate spatial patterns in the macroinvertebrate community composition throughout the bay and (2) to determine which environmental variables best explain the patterns in assemblage structure. Macroinvertebrate species data and environmental variables (e.g., grain size parameters and organic matter) were sampled three months after fallowing ( $n=40$ ) throughout the bay. Our analyses suggest a localized effect within the farm lease boundaries, with diminishing effects with increasing distance from the farm. Organic matter was identified as the main environmental variable

associated with the macroinvertebrate distributions. This research contributes to bay-scale monitoring strategies and to the growing knowledge of ecosystem-level effects of fish farming activities.

**11:50-12:10**

**ENHANCED BIOPHYSICAL DATA COLLECTION AND MODELLING TO SUPPORT AQUACULTURE DEVELOPMENT IN NOVA SCOTIA**

T. Balch

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The Centre for Marine Applied Research (CMAR) was established to focus on areas of research and collaboration to propel the Nova Scotia Department of Fisheries and Aquaculture's aquaculture growth strategy forward. The office leads and supports projects with industry, communities and stakeholder groups to collect and analyze biophysical and socio-economic data to support informed decision making regarding new site development and to foster innovation that will advance the industry's long-term development potential. Since January 2018, a significant campaign to collect biophysical data was undertaken in coastal waters of Nova Scotia. Long term monitoring stations were established to measure relevant water quality parameters from surface to bottom at over 40 locations as part of gathering better resolution data. In addition, efforts are underway to mine historical data as well as to explore ways of collaboration and data sharing with various stakeholders in coastal waters. CMAR's goal is to manage incoming data streams in a time-sensitive manner and make them broadly available in formats that are easy to interpret and broadly accessible. Additional project work includes collaboration with various project partners to model storm conditions as well as track formation and movement of ice in coastal bays using several remote sensing technologies.

**12:10-12:30**

**APPLYING THE ECOSYSTEM APPROACH TO AQUACULTURE: MAPPING THE FOOTPRINT OF MULTIPLE EFFLUENTS AT A BAY-WIDE SCALE**

L.M. Howarth,\* R. Filgueira, D. Jiang, H. Koepke,<sup>S</sup> Finnis, T. Chopin, and J. Grant

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Aquaculture, agriculture and sewage can elevate coastal nutrient levels. Whilst these effluents are often well monitored and regulated on an individual level, most waters receive effluents from multiple sources. Hence, there is a call for coastal management to move towards an 'ecosystem approach to aquaculture', where the effects of multiple farms and other activities are simultaneously considered at a wider scale. Measuring multiple effluents can be difficult as they can: (1) rapidly dilute and disperse; (2) display strong temporal fluctuations; and (3) mix with one another, making it hard to distinguish between them. As seaweeds rapidly absorb and accumulate nutrients, the elemental composition (N and C) of their tissues may better reflect long-term nutrient levels than traditional analytical measures, and their isotopic composition ( $\delta^{15}\text{N}$ ) may be able to distinguish between multiple effluent sources. To test whether seaweeds can map the footprint of multiple effluents, we translocated two seaweed species to a bay in

Nova Scotia, location to a salmon farm and several other industrial activities. Overall, we found that N and  $\delta^{15}\text{N}$  provided strong indications of the extent of effluents. However, the two species created remarkably different maps, and  $\delta^{15}\text{N}$  responded to effluents in a way we did not anticipate.

**1:50-2:10**

**COUPLING WATER COLUMN ORGANIC MATTER WASTE DISPERSAL AND SEDIMENT DIAGENESIS MODELLING IN THE FINFISH AQUACULTURE ENVIRONMENT**

H. Koepke\*<sup>1</sup>, J. Grant<sup>1</sup>, R. Filgueira<sup>1</sup>, F. Bravo<sup>1</sup>

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The rise in global prevalence of finfish aquaculture sites demand reliable predictive models of waste outputs and impacts that are structured to accommodate environmental regulatory standards. Assessing impacts fish farms have on their environment is instrumental in developing future resiliency models which can be used to regulate location, stocking density, and fallowing periods between harvests. Current organic matter depositional models for finfish aquaculture have yet to satisfactorily couple benthic and pelagic parameters both spatially and temporally. This research will combine a benthic diagenetic model with a three-dimensional hydrodynamic pelagic model developed by UK partners Longline. Verifying the model with field samples taken at sites both locally and abroad can indicate the feasibility and reliability with which a model can be used as a regulatory tool. The benthic component of the model will focus on the sulfide and organic matter content, variables which are seeing a global increase in their use as proxies for sediment health. This will eliminate variables unnecessary for regulation and thereby alleviate computational workload. An effective model allows for proactive decisions to be made, reducing long-term environmental impacts by informing stakeholders of the best sustainability and financially secure practices.

**2:10-2:30**

**PUBLIC REPORTING OF THE MARINE FINFISH AQUACULTURE INDUSTRY IN BRITISH COLUMBIA**

K. Sandberg\*

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Fisheries and Oceans Canada (DFO) has regulated the aquaculture industry in British Columbia since December 2010 when the Pacific Aquaculture Regulations (PAR) came into effect as a result of the Hinkson Decision which deemed aquaculture to be a “fishery”. The Marine Finfish Aquaculture Licence under the *Fisheries Act* outlines operational requirements for licence holders including regular reporting to DFO including, but not limited to: fish health and sea lice, marine mammal interactions, escapes, benthic impacts and capture of wild fish. These reports are submitted on an incidental, monthly, quarterly or annual basis. DFO publically reports on the marine finfish aquaculture sector’s environmental and operational performance in order to

provide timely information and to enhance public confidence in the regulation of the industry. Much of these data are available on the Government of Canada's Open Data Portal (<https://open.canada.ca/en/open-data>) as well as on DFO's regional aquaculture website (<http://www.pac.dfo-mpo.gc.ca/aquaculture/index-eng.html>). This presentation will provide details on select reports and data available from DFO's websites and outline observed trends from recent years. It will also allow external stakeholders an opportunity to provide feedback on the content and format of reporting that could improve the transparency and communication of DFO's regulation of the industry.

**2:30 – 2:50**

**DEVELOPMENT OF AN AREA BASED AQUACULTURE MANAGEMENT APPROACH IN THE PACIFIC REGION**

S. Jepps

Aquaculture Resource Management, Fisheries and Oceans Canada, Nanaimo, BC, V9S 5W8

Fisheries and Oceans Canada (DFO) currently licenses aquaculture activities in British Columbia on a site by site basis. DFO has committed to move towards an area based aquaculture management approach. The approach will allow for:

1. Greater opportunities for Indigenous peoples' engagement in the planning, operations, management, and monitoring of aquaculture in their territories;
2. More comprehensive analysis of spatially-based risk and cumulative effects;
3. Identification of area specific priorities for environmental protection and/or industry growth;
4. Adaptive management at a scale which aligns with the interests of Indigenous groups/stakeholders; and
5. Alignment with Oceans Act priorities related to Integrated Management and Integrated Fisheries Management approaches.

A Northern Vancouver Island pilot area is proposed, consisting of 4 subareas: Quatsino Sound, Queen Charlotte Strait, Broughton Archipelago, and Discovery Islands. Management will shift from a farm focus to an area focus with associated development and changes to data collection, reporting and industry adaptive management response.

DFO is collaborating with Indigenous peoples in the development of the approach and engage in capacity building for participation in research, monitoring and management of aquaculture.

Success of the pilot area will be assessed prior to broadening the approach to other areas.

# **AQUACULTURE SUSTAINABLE DEVELOPMENT**

**3:30-3:50**

## **A NEW AGENDA TO CARRYING CAPACITY IN SUPPORT OF THE ECOSYSTEM APPROACH TO AQUACULTURE**

J. Weitzman\*<sup>1</sup>, R. Filgueira<sup>1</sup>, J. Grant<sup>2</sup>

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Carrying capacity (CC) can be broadly described as the maximum level of aquaculture activity an area can tolerate before unacceptable degradation to the environment. While this may include physical, production, social, or ecological components of the environment, CC assessments most often study these components in isolation. However, decision-making faces emerging challenges across environmental and social aspects and the growing need to manage multiple objectives in increasingly crowded aquatic ecosystems. CC assessments traditionally rely on a range of models, indicators, and approaches to study the relationships between aquaculture and ecosystem components. Data constraints, uncertainties, and practical limitations remain continuous challenges with using CC for site selection, planning, and monitoring. We thus propose a research agenda to operationalize carrying capacity for ecosystem-based management. This will require carrying capacity that recognizes system complexity and is policy-relevant, adaptive, interdisciplinary, and meaningful. This could include adopting interdisciplinary tools that bring science and people together. Tools like ecosystem services, expert judgement, and community engagement might fill this gap. The proposed research agenda can help build carrying capacity as a promising tool to operationalize a holistic ecosystem approach to aquaculture. Future research will apply these strategies towards a decision-framework for integrated salmon aquaculture CC in Atlantic Canada.

**3:50-4:10**

## **MARINE PLASTIC DEBRIS: IMPROVING SHELLFISH AQUACULTURE ENVIRONMENTAL PERFORMANCE IN BRITISH COLUMBIA**

C. Marrie\*

Aquaculture Environmental Operations, Fisheries and Oceans Canada, 1520 Tamarac Street, Campbell River, BC V9W 3M5 [Christopher.Marrie@dfo-mpo.gc.ca](mailto:Christopher.Marrie@dfo-mpo.gc.ca)

Plastic waste, marine debris and ghost fishing have emerged alongside climate change as a global environmental priority, creating increasing momentum for change. Both the G7 and the G20 have adopted plans that focus their efforts on marine debris, and many organizations have advanced global commitments and initiatives to prevent and reduce plastic marine debris. Among the aquaculture sectors active in British Columbia, the shellfish industry is the most

prolific source of marine plastic debris. Fisheries and Oceans Canada (DFO) has undertaken several initiatives to increase the environmental performance across the industry. The presentation will highlight i) drivers behind plastic debris being a priority for DFO aquaculture management; ii) current prevention and mitigation measures; and iii) future mechanisms needed to effect substantial positive change.

#### **4:10-4:30**

#### **HABITAT SUITABILITY MAPPING FOR THE AMERICAN LOBSTER (*Homarus americanus*)**

A. McKee\*<sup>1</sup> and J. Grant<sup>1</sup>

<sup>1</sup> Dalhousie University, Halifax, Nova Scotia, B3H4R2

Marine spatial planning (MSP) is a management tool which could help mitigate the conflict that exists in the Canadian Maritime provinces between the American lobster fishery and the net-pen Atlantic salmon aquaculture industry. However, fine scale lobster habitat suitability maps, which are a necessary feature of effective MSP for this purpose, have not been created in most areas. This study explores an acoustic-based method of developing these maps for adult lobsters in a bay in Nova Scotia. Using a single-beam echosounder, we collected substrate data from a section of the bay. The data was interpolated and checked for accuracy against benthic video footage, then combined with proxy data representing lobster presence to create habitat suitability maps via maximum entropy modeling. In addition to finding these methods appropriate for creating the desired habitat suitability maps to use in MSP, this study also addresses the importance of explicitly analysing and accounting for the effects of spatial resolution in data collected for habitat maps.

#### **4:30-4:50**

#### **INITIATIVES TO SUPPORT THE DEVELOPMENT OF A SUSTAINABLE AQUACULTURE INDUSTRY IN NOVA SCOTIA**

I. Tremblay<sup>1</sup>, M. Lionard<sup>2</sup>, K. H. Hoang<sup>3</sup> and Y. Perrot<sup>3</sup>

<sup>1</sup>Aquaculture Association of Nova Scotia, 2960 Oxford Street, Halifax, NS B3L 2W4. [rdc@seafarmers.ca](mailto:rdc@seafarmers.ca) <sup>2</sup>Merinov, 2960 Oxford Street, Halifax, NS B3L 2W4. <sup>3</sup>Centre Géomatique du Québec Inc., 534 Rue Jacques-Cartier E, Chicoutimi, QC G7H 1Z6.

The clear and pristine waters around Nova Scotia are an ideal environment for growing good quality seafoods. National and international markets recognize the quality of Nova Scotia aquaculture products and the demand for it is growing. The aquaculture industry sector is on a growing path in Nova Scotia. While some sea farmers are looking to expand their current operations, others are looking to diversify their crop by cultivating lower trophic level species such as seaweed. This growing interest for aquaculture also attracts new entrants, more specifically in the shellfish sector.

Sea farmers in Nova Scotia want to ensure that the development of the aquaculture sector is done in a sustainable way, so that good quality seafood can be produced now and for the generations to come. In support to our sea farmers members, the Aquaculture Association of Nova Scotia (AANS) is moving forward with an initiative to support the development of seaweed cultivation. Also, the AANS partners on a project to develop of a tool to monitor the sustainability of shellfish farms. This presentation will talk about these two initiatives that helps moving Nova Scotia aquaculture towards higher sustainability via the production of macroalgae and the development of new technologies.

**4:50-5:10**

**FISHERIES AND AQUACULTURE CLEAN TECHNOLOGY ADOPTION PROGRAM:  
IMPROVING AQUACULTURE SUSTAINABILITY IN BRITISH COLUMBIA**

S. Choi\*

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The Fisheries and Aquaculture Clean Technology Program (FACTAP) is a national contribution program launched by the Government of Canada in December 2017 (<http://www.dfo-mpo.gc.ca/aquaculture/business-entreprises/factap-application-patppa-eng.htm>). The program is investing up to \$20M over a four year period (2017-2021) in partnership with Provincial and Territorial governments, aims to help industry adopt or adapt market-ready clean technologies, processes and/or sustainable practices that will yield improvements in the environmental performance of fishing and aquaculture operations. This presentation will provide an overview of the program, showcase a cross section of innovative aquaculture projects funded in BC over the last year, and describe their attained or expected environmental benefits. Additionally, we will reflect on lessons learned from the first full year of program implementation and provide insights into its future direction for the upcoming year.

**5:10-5:30**

**AN ECONOMICS ANALYSIS OF RESERVOIR FISH FARMING (RE-INVENTED PEN  
CULTURE SYSTEM) - A CASE STUDY OF KANKE RESERVOIR IN JHARKHAND,  
INDIA**

S. Gawa<sup>\*1</sup> N. R. Kumar<sup>2</sup> S. Prakesh<sup>1</sup> R. Sharma<sup>1</sup> and P. Kumar<sup>3</sup>

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The fundamental issue confronting humanity at present is how we utilize our limited resources to meet our unlimited wants. Though human wants can never be satisfied however we can satisfy our needs and one such need is nutritional security for all. An attempt towards this goal is achieving protein security and fish is one of the cheapest source of animal protein. The current study makes a sincere attempt to study

RFF (Reservoir Fish Farming) which is a re-invented pen culture modified to suit the localized hydrological characteristics in the state of Jharkhand. The investigation on fixed inventories observed that for typical RFF total investment of INR.13,66,000 is required out of which hatchery holds the major chunk of share followed by modular cage and boat with 43.99, 21.92 and 13.54% respectively. The cost concept study revealed that feed is most important factor accounting for 17.86% followed by permanent labour and seed with 5.64% and 3.59% of total cost, respectively. The gross income was estimated to about INR.82,4368/ha/year and the return over different cost analysis showed farm business income to be INR.7,56,739/ha/year. The cost of production and cost of cultivation was estimated to be about INR.35.47/kg and INR.20,9037/ha respectively. RFF enterprise is found to be highly profitable which is evident from return per rupee investment of INR.3.94. This model is proving to be an instrumental technology in utilising the untapped open water, generating extra income and livelihood in the state of Jharkhand and the same has the potential to be replicated in other parts of the country.

## SALON B

### INTEGRATED PEST MANAGEMENT

**10:30-10:50**

#### **BIOASSAYS AS PART OF A SEA LICE MANAGEMENT PLAN**

E. Downey\*, D. Collins, K. Bull

BC Centre for Aquatic Health Sciences. 871A Island Hwy, Campbell River, BC. V9W 0B7.

Bioassays are used in toxicology to determine the relative toxicity of chemicals to living organisms and as a result may be an effective way to diagnose and measure increasing tolerance of sea lice to their chemical treatments. Bioassays can be used to investigate instances of apparent lack of efficacy and/or aid in early detection of sensitivity changes within the sea lice population before full resistance develops. At BC Centre for Aquatic Health Sciences, we have been performing EMB bioassays since 2010 and Paramove 50 bioassays since 2015. It is essentially a diagnostic service and management decisions are made based on the results. In BC, early detection of decreasing sensitivity allows for adoption of alternative control methods of sea lice control thus retaining the chemical as an option for treatment.

**10:50-11:10**

#### **ACHIEVING INTEGRATED SEA LICE MANAGEMENT IN BRITISH COLUMBIA**

D.B. Morrison

MOWI, 124-1334 Island Hwy, Campbell River, BC V9W 8C9 [diane.morrison@mowi.com](mailto:diane.morrison@mowi.com)

Salmon farms in British Columbia have been in operation for over 30 years. During that time there have been many changes and improvements in all aspects of farm and fish management. Sea lice management has been a focus of farmers and veterinarians since the switch from farming Pacific to Atlantic salmon. An overview of past and present sea lice management and strategies will be discussed, with a focus on the goal of achieving integrated pest management in British Columbia. Business and regulatory roles in sea lice management strategies will be discussed.

**11:10-11:30**

#### **MAKING THE CONNECTION: INVESTIGATING SALMON LICE (*Lepeophtheirus salmonis*) INFESTATION AT MULTIPLE SALMON (*Salmo salar*) FARMS IN BAY OF FUNDY, NEW BRUNSWICK**

M.I. Parent\*<sup>1</sup>, H. Stryhn<sup>1</sup>, L. Hammell<sup>1</sup>, R. Vanderstichel<sup>1</sup>

<sup>1</sup>Department of Health Management, Atlantic Veterinary College, University of Prince Edward Island, 550 University Avenue, Charlottetown, Prince Edward Island, C1A 4P3

Salmon lice are a serious pest to the Atlantic salmon aquaculture industry. Although a wide range of models to describe salmon sea lice infestation have been developed around the world, there are no such models for the Bay of Fundy. This area is home to over 40 active salmon farms and represents an important economic contributor to Atlantic Canada. We develop a model to examine the role of management and environmental drivers on salmon lice infestation pressure. One of the key variables within the model is a measure of connectivity useful to describe how salmon lice from neighbouring farms interact. Unfortunately, it is difficult to capture field information on how sea lice travel, reproduce and attach to salmon. We adapt the measure of connectivity by examining sea lice travel distances. We experiment with seaway distances from 5 to 60 km to evaluate if the salmon lice make up one or multiple populations. The seaway distance that fits best in the model of adult female salmon lice abundance will represent the connectivity. Previous research has shown that salmon lice may travel up to 30 km which suggests that salmon lice in this area are likely made up of a single population.

**11:30-11:50**

**OPITLICE – THE ENVIRONMENTALLY FRIENDLY WAY TO TREAT SEA LICE**

T. Deligan\*

Optimar U.S., Inc., 2001 West Garfield Street, Bld. C-155, Seattle, WA 98119, United States of America

Optilice is an environmentally friendly safe treatment that targets the persistent problem of sea lice found in salmon aquaculture. This presentation will provide an overview of the issues pertaining to sea lice, system performance with salmon/trout/other species, and how Optilice compares to other modern treatment methods. What is it? Optilice is a solution designed to combat sea lice by submersion of treatment fish in temperature-controlled water ranging from -1° C to 36°C (depending upon conditions) for ~ 25 seconds. The short submersion time shocks the sea lice to release whereby they are collected and destroyed. Scientifically documented findings of little to no harm to treatment fish nor the environment will be presented along with information regarding how the solution incorporates specially modified components to ensure gentle, high capacity, and safe treatment. With more than 50 systems delivered, Optilice has become one of the industry standards for sea lice treatment and real-life applications will be examined and findings of “no harm” regarding multiple treatments will be discussed.

**11:50-12:10**

**IMPACT OF ORIGIN (WILD VS. FARMED) AND SEA LICE (*Lepeophtheirus salmonis*) INFESTATION ON EXPRESSION OF IMMUNE-RELEVANT GENES IN ATLANTIC SALMON (*Salmo salar*) SKIN**

D. Gallardi<sup>1\*</sup>, X. Xue<sup>2</sup>, D. Hamoutene<sup>1</sup>, L. Lush<sup>3</sup> and M. L. Rise<sup>2</sup>

<sup>1</sup> Aquaculture, Biotechnology and Aquatic Animal Health Section, Aquatic Resources Division, Fisheries and Oceans Canada, St. John's, NL A1C 5X1

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The parasitic copepod salmon louse (*Lepeophtheirus salmonis*) is a cause of major concern for Atlantic salmon (*Salmo salar*) aquaculture due to economic losses, ecological impacts and negative influence on public opinion. Sea lice have the potential to spread between farms and from farmed to wild salmon. It is fundamental to understand susceptibility to *L. salmonis* within wild and farmed salmon populations, to manage possible interactions between farmed and wild fish. Two distinct wild salmon populations from rivers adjacent to aquaculture operations (Garnish River and Conne River, Newfoundland) and one farmed population were challenged with *L. salmonis*. Skin samples of non-infested, low-infested ( $\leq 7$  lice) and high-infested ( $\geq 17$  lice) salmon were analyzed by qPCR for the expression of 20 immune-relevant genes. Wild and farmed lice infested salmon presented lice load-responsive up-regulation of key genes (*HAMP*, *CTL-A*, *LECT2*). The wild populations (Garnish River, Conne River) showed a different basal skin transcript profile compared to the farmed population. Wild salmon presented down-regulated *CAMP2* and *IL8*, and up-regulated *IgT*, *GAPDH*, *iNOS*, and *CD8a* transcripts, compared to farmed ones. These results suggest a discrepancy in skin-related immune function between wild and farmed salmon, and warrant further investigation (Gallardi et al., 2019. *Aquaculture* 499, 306-315).

**12:10-12:30**

**THE EVALUATION & EVOLUTION OF SLICE<sup>®</sup> TREATMENTS AS A COMPONENT OF AN INTEGRATED PEST MANAGEMENT (IPM) PROGRAM**

T. Kniffen\*

Merck Animal Health, 35500 W. 91<sup>st</sup> Street, De Soto, KS, USA 66018, [tim.kniffen@merck.com](mailto:tim.kniffen@merck.com)

SLICE is a premix formulation containing emamectin benzoate that is indicated as an aid in the treatment of parasitic infestations caused by all parasitic stages of the sea louse (*Lepeophtheirus salmonis*) on Atlantic salmon (*Salmo salar*). SLICE has been approved for use in Canada since 2009 and was available since 1999 through the Emergency Drug Release (EDR) program. Sea lice have a remarkable ability to develop resistance to seemingly any compound or circumstance

they are exposed to. The SLICE Sustainability Project (SSP) was launched in 2010 to evaluate each SLICE treatment. The components of the SSP include bio-assays, feed and flesh analyses, lice clearance, and a database to capture and analyze the collected information. An Integrated Pest Management (IPM) program to control sea lice infestations requires a broad-based approach that integrates elements of surveillance, parasite biology, environmental factors, mechanical prevention & treatments, parasiticides, production system modifications, and management practices. The paradigm shift that will occur to help control sea lice in farmed salmon is the use of SLICE not only as a single treatment modality but also temporally with other well designed IPM program practices.

**1:50-2:10**

**ELUCIDATING THE MODE OF ACTION FOR NOVEL LOUSICIDES; THE EFFECTS OF LUFENURON ON REPRODUCTIVE PARAMETERS OF *CALIGUS ROGERCRESSEYI* UNDER LABORATORY CONDITIONS**

Marín, S.L.<sup>1\*</sup>, Mancilla, M.<sup>1</sup>, Fariás, A.<sup>1</sup>, Jaramillo, J.<sup>2</sup>, Wolter, M.<sup>3</sup>, Jung, M.<sup>3</sup>, Lewis, R.L.<sup>3</sup>, Rodríguez, J.F.<sup>3</sup>, Hosking, B.C.<sup>3</sup> and Macdonald, A.M.<sup>3\*\*</sup>

<sup>1</sup>Instituto de Acuicultura, Universidad Austral de Chile, Puerto Montt, Chile

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Lufenuron is licensed in Chile for the prevention and control of sea lice (*Caligus rogercresseyi*) on salmonids. Understanding the mode of action and range of effects of developmental and novel lousicides may support eventual strategic decision making for best incorporation of therapeutics in integrated pest management programs. In molting stages of *L. salmonis*, lufenuron inhibits chitin transport, organization and/or abundance. Lufenuron also affects the reproductive capacity of some terrestrial insects, but its effects on reproductive parameters of *C. rogercresseyi* are undescribed. The present study included Atlantic salmon as negative controls or treated orally with lufenuron to obtain two groups of 20 fish with average concentrations of lufenuron in muscle+skin of 245 ppb (Group A) and 489 ppb (Group B). The groups were maintained separately, infested with *C. rogercresseyi* copepodids and followed until development of lice with mature egg strings. Female lice were collected for laboratory assessment of louse fecundity, egg hatch rate and survival to copepodid, phospholipid quantification and phenotype evaluation. There was a reduction in the mean number of viable eggs per egg string (per fish) in Group B compared to the untreated control (p=0.02), and both treated groups exhibited a larger percentage of females carrying non-viable egg strings than the untreated control (K-W: 6.2, n=52, p=0.04). The c17:0 fatty acid component of phosphatidylethanolamine (p=0.003) and phosphatidylcholine (p=0.004) and the overall lipid content (p=0.01) of the egg cell membranes were also reduced in both treated groups compared to the untreated controls. These results, paired with observations of phenotypic abnormalities suggest the reduced fecundity may be related to metabolic impairment during egg development.

**2:10-2:30**

**FEDERAL REGULATORY ROLE IN INTEGRATED SEA LICE MANAGEMENT FOR BC SALMON AQUACULTURE**

S. McConnachie\* and Z. Waddington

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Fisheries and Oceans Canada (DFO) regulates the aquaculture industry in BC, which includes requirements for sea lice (*Lepeophtheirus salmonis*) management under the conditions of license (COL) designed to minimize potential exposure of wild and cultured fish to lice originating from farms. When regulatory thresholds are exceeded, licence holders must initiate management measures to reduce lice levels. Recently, some regions have been experiencing lice resistance to the most widely used approved treatment (SLICE®). An integrated pest management (IPM) approach has been adopted to help reduce the development of resistance to any one treatment modality. Industry has made efforts to diversify the management tools at their disposal. In turn, different government agencies have had to adapt to the increased number of management options to ensure the health of the environment and wild fish is maintained. DFO is currently in the process of updating the COL in relation to sea lice management. The aim is to balance minimizing risk to wild fish to minimal requirement for treatment. Doing so will help maintain treatment efficacies while preventing unnecessary depositions of drugs and pesticides in the environment. This presentation will give an overview on DFO's changing role in the adoption of IPM in BC aquaculture.

**2:30-2:50**

**FACTORS INFLUENCING VARIATION IN SALMON LOUSE *Lepeophtheirus salmonis* ABUNDANCE ON FARMED ATLANTIC SALMON *Salmo salar* IN BRITISH COLUMBIA CANADA**

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In British Columbia, over 90,000 tonnes of Atlantic salmon are produced annually in nine management zones. Control of salmon louse infestations presents an economic challenge and requires systematic monitoring and strategic timing of treatments. Mean louse abundance at the farm level between March and July is required to not exceed three motile copepods. Throughout

the industry, parasite abundance is greater in second year fish, increases in autumn and decreases between winter and summer, however variation in parasite abundance is statistically significant among management zones. The objective of the study was to identify factors associated with this variation. We generated an industry-wide dataset spanning the years 2011 to 2016 and including louse count, production, treatment, and water salinity and temperature data. Sequential descriptive, stratified, and multivariable analyses provided multiple approaches to manage the uneven distribution of variable levels across management zones and at least partially to account for repeated measures in the structure of the dataset. Results suggested that differences in multiple factors, including company, month, fish age, treatment efficacy, pen inventory, water salinity, and water temperature accounted for a third or more of the monthly variation in mean louse counts on farms across different management zones.

# AQUATIC ANIMAL HEALTH

**3:30-3:50**

## **PRE-ANALYTICAL AND ANALYTICAL EFFECTS ON CLINICAL BIOCHEMISTRY**

M Braceland\*<sup>1</sup>

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Clinical biochemistry has long been utilized in human and veterinary medicine as a vital diagnostic tool of pathogenesis and overall health status. However, despite studies showing its usefulness in identifying clinical disease, in a non-destructive manner it has not yet been widely utilized within the aquaculture industry. This is due, in part, to a lack of an agreed protocol for collection, processing, and analytical methodologies for determination of analyte concentrations. In addition, post-analytical interpretation, a lack of reliable reference ranges for normal salmon plasma biochemistry, and high inter intra and biological replicate variability have made it difficult to elicit the worthiness of this analysis in a clinical setting. As such this study highlights the effects of multiple pre-analytical methods have on analyte concentrations samples, establishes best practice, and discusses investigations on altering analytical assay methodology to increase sensitivity and reduce variability of results. In addition, reference ranges for salmon plasma biochemical analytes have been established to inform veterinary practitioners and the aquaculture industry of the importance of clinical biochemistry in health and disease

**3:50-4:10**

## **VARIATION IN RESPONSE OF ATLANTIC SALMON TO EXPOSURE AND EARLY STAGES OF INFECTION OF *Kudoa thyrsites* UNDER NATURAL EXPOSURES AT COMMERCIAL SITES.**

W. Marshall<sup>1\*</sup>, H. Reinholt<sup>1</sup>, H. Van Vliet<sup>1</sup>, T. MacWilliam<sup>2</sup>, D.Morrison<sup>2</sup>

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*Kudoa thyrsites* is a myxozoan parasite that localizes within myocytes of susceptible marine fish. Although infected fish appear unharmed, parasite-derived enzymes degrade the skeletal muscle post-mortem. In some regions of British Columbia, infections negatively affect up to 4-7% of farmed Atlantic salmon fillets, thus impacting the competitiveness of BC's farms. The life-cycle of the parasite includes a period of detection in the blood before encystment in the flesh. We monitored the progression of infection and variation in response in PIT tagged fish from initial exposure through harvest in three populations reared under natural exposure at commercial sites. We defined three general responses where fish were uninfected throughout, infected in blood and flesh, or appeared to recover from blood infections such that the parasite was not detected in the flesh. We measured differences in gene expression in one population during primary and

elevated exposures. Here, ‘recovered’ fish (n=2-3) had significantly different expression compared to the non-recovered (n=7) and uninfected fish (n=7-8), suggesting that reactions in the blood may act to limit flesh infections. Absence of differences in expression between infected and uninfected fish may indicate that responses to limit entry of the parasite occur in different tissues or time-points.

#### **4:10-4:30**

### **BIOFOULING COMMUNITIES ON ATLANTIC SALMON (*Salmo salar*) FARM NETS: EXPLORING LINKS TO FISH GILL HEALTH**

R.G. Loerzer\*<sup>1,2</sup>, L. Curtis<sup>2</sup>, S. Cross<sup>1</sup>, M. Flaherty<sup>1</sup>, B. Vornicu<sup>3</sup>, L. Peck<sup>3</sup>, T. Hewison<sup>3</sup>, N. Haigh<sup>4</sup>, S. Jones<sup>2</sup>, and C.M. Pearce<sup>2</sup>

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<sup>3</sup>Grieg Seafood BC Ltd., Campbell River, BC V9W 5P7

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Biofouling is a widely recognized problem within the finfish aquaculture industry. It can lead to compromised infrastructure and decreased dissolved oxygen availability and become a source of pathogenic diseases. Current mitigation methods often involve the use of automated *in situ* power-washing machines, which expel biotic particulate matter into the water column that can potentially damage fish gills. Gill disorders are most commonly associated with viruses, bacteria, parasites, phytoplankton blooms, and zooplankton swarms. Little investigation, however, has examined the biofouling community composition on nets or the direct effect of biofouling on the health of cultured fish. Thus, this project will investigate the biofouling community across different spatial and temporal scales at three Atlantic salmon (*Salmo salar*) farms along the coast of Vancouver Island and the potential links between the biofouling community and gill health. Environmental parameters such as water quality, phytoplankton, and zooplankton communities will also be examined, alongside biofouling, to assess potential associations with fish health. An improved understanding of how biofouling communities and environmental parameters influence the health of cultured Atlantic salmon will allow industry to develop strategies to manage their impact.

#### **4:30-4:50**

### **QUANTITATIVE ATLANTIC SALMON HEALTH (QASH): BENCHMARKING HEALTH STANDARDS FOR A GLOBAL INDUSTRY**

M Braceland\*<sup>1</sup>, K Pittman<sup>2</sup>, B Hjeltnes<sup>3</sup>, L Andersen<sup>4</sup>, M Powell<sup>5</sup>, R Shields<sup>6</sup>, X Gutierrez<sup>7</sup>, F Briceño<sup>7</sup>

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Salmon aquaculture differs from other livestock rearing in a multitude of ways. For instance, fish are inherently more plastic than mammals, and spend no time in a protected environment to develop, whereas typical farmed land animals spend up to 70% of their total life span in the stable and protected environment of the womb or egg. Furthermore, health assessment/ screening is made more difficult by both environment salmon are raised, and a lack of defined “normalcy”. Therefore, a consortium of international partners, from Norway, Chile, Scotland, and Chile aims to investigate and establish a Global Atlantic Salmon Index, by assessment of established and novel tools for quantifying Atlantic salmon health (QASH). Through such investigations, and industrial and academic collaboration it is hoped that abilities to understand health of stocks will be increased thus allowing for a more sustainable and profitable industry. This presentation will focus on current challenges in regions of production and current activities of the group to help mitigate these and aid understanding of defining health in Atlantic salmon.

**4:50-5:10**

**FORMULATION OF *A. SALMONICIDA* ADJUVANTED VACCINE FOR RAINBOW TROUT : IMPACT OF THE ADJUVANT OIL ORIGIN**

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Injectable inactivated fish vaccines require adjuvants to enhance the immune response. Water-in-oil emulsion adjuvants are widely used in the aquaculture industry due to their cost effectiveness, stability, and long-term effect. However, oil-adjuvanted vaccines can be reactogenic and induce side effects in fish. In this study, we analyzed the impact of adjuvant oil origins in the safety and immunogenicity of *Aeromonas salmonicida* vaccines.

Two different adjuvants were tested, one with non-mineral oil (Montanide™ ISA 763A VG) and one with mineral oil (Montanide™ ISA 761 VG). Following intraperitoneal vaccination of rainbow trout, blood samples were taken at 42 and 53 days post vaccination (dpv) to assess antibody response. Adipose tissues were collected at 3, 14 and 28 dpv for RT-qPCR of genes implied in pro-inflammatory and adaptive responses. Side effects in the peritoneum were scored until 53 dpv.

Both vaccines induced high antibody titer against *A. salmonicida*. Vaccination-induced adhesion scores were both within industry-accepted limits, with lower scores from the non-mineral oil adjuvant group. Compared to the antigen-alone group, an upregulation of immune genes occurred and persisted over time. This upregulation was higher in mineral oil adjuvant group. Furthermore, a strong correlation between gene expression - modulated by the oil origin - and vaccine safety was observed.

These results showed oil origins of adjuvants impact the immunogenicity and safety of fish vaccines, and that Montanide™ ISA 763A VG and Montanide™ ISA 761 VG are efficient adjuvants for inactivated *A. salmonicida* vaccines.

**Tuesday, May 7<sup>th</sup>**

**SALON C**

**GENOMICS IN AQUACULTURE**

**10:10-10:30**

**POLYGENIC NATURE OF GENOMIC LOCI ASSOCIATED WITH EARLY MATURATION IN TWO PACIFIC SALMONIDS, COHO SALMON (*Oncorhynchus kisutch*) AND CHINOOK SALMON (*Oncorhynchus tshawytscha*).**

M.T.T. Crown\*<sup>1,2</sup>, K.A. Christensen<sup>1,3</sup>, S.J. Lehnert<sup>4</sup>, R.E. Withler<sup>5</sup>, J. Supernault<sup>5</sup>, E.B. Rondeau<sup>3</sup>, B.F. Koop<sup>3</sup>, D.D. Heath<sup>4</sup>, R.H. Devlin<sup>1</sup> and W.S. Davidson<sup>2</sup>

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Variation in the number of years spent at sea before spawning, age of maturity, is an evolutionary stable strategy that can also influence reproductive success where fitness is balanced between early and late maturing salmon. The genetic basis of early maturation is not well understood, and it is unclear if the genetic basis for early maturation among salmonids is evolutionarily conserved. Although recent work has found that 39.4% of the phenotypic variation can be explained by a single locus *Vgll3* in European Atlantic salmon (AS), other data suggests this genetic association may not be fully conserved in North American AS. Our current study aims to identify the loci associated with early maturation in coho (*Oncorhynchus kisutch*) and Chinook (*O. tshawytscha*) salmon. Using the GBS approach, we conducted a genome-wide-association-study on six families of coho (n=716) and three families of Chinook (n=494) salmon from British Columbia. Current data analyses revealed highly polygenic associations with early maturation is distinct from *Vgll3* in coho and Chinook salmon populations. Further sanger sequencing and TaqMan analyses on *Vgll3* confirms the lack of association in coho. This may suggest that genetic basis of early maturation may not be evolutionarily conserved among AS, coho and Chinook salmon.

**10:30-10:50**

**THREE-YEAR OUTCOMES FROM THE INTEGRATED PATHOGEN MANAGEMENT OF CO-INFECTION IN ATLANTIC SALMON (IPMC) PROJECT**

A. Caballero-Solares<sup>\*1</sup>, N. Umasuthan<sup>1</sup>, X. Xue<sup>1</sup>, K. Parrish<sup>2</sup>, T. Katan<sup>1</sup>, M. Emam<sup>1</sup>, S. Kumar<sup>1</sup>, J.D. Westcott<sup>3</sup>, Z. Chen<sup>3</sup>, M.D. Fast<sup>2</sup>, C.C. Parrish<sup>1</sup>, J. Santander<sup>1</sup>, S. Skugor<sup>4</sup>, B.F. Nowak<sup>5</sup>, R.G. Taylor<sup>6</sup> and M.L. Rise<sup>1</sup>

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Atlantic salmon (*Salmo salar*) farmed in net-pens face the challenge of exposure to pathogens and parasites, as well as environmental insults. Co-infection by two or more pathogens/parasites is more likely to overwhelm the immune defenses of the salmon than single-pathogen infections, which then translates into higher mortalities. The Integrated Pathogen Management of Co-infection in Atlantic Salmon (IPMC) project searches for functional aquafeeds capable of improving salmon resistance to single infectious diseases and co-infection. Over the last three years, we have tested several immunostimulant additives and feed formulations in challenge-trials and studied their effects on salmon immune system using functional genomics. These studies focused on the co-infection of sea lice (i.e., *Lepeophtheirus salmonis* or *Caligus rogercresseyi*) with a secondary pathogen (e.g., ISAv or *Piscirickettsia salmonis*) or co-stimulation with sea lice and a pathogen-associated molecular pattern [e.g., poly(I:C), formalin-killed *Aeromonas salmonicida*]. Our results demonstrate that fish immunity can be dietarily modulated towards stronger response to bacterial, viral, lice, and co-infection challenges. We anticipate that the findings arising from the IPMC project will shed further light on the molecular mechanisms underlying co-infections in Atlantic salmon and help in the formulation of novel and superior clinical aquafeeds.

**10:50-11:10**

**REARING TEMPERATURE'S EFFECT ON GROWTH PERFORMANCE, IMMUNE RESPONSE AND HEPATIC GENE EXPRESSION OF TRANSGENIC FEMALE TRIPLOID ATLANTIC SALMON (*Salmo salar*)**

E.H. Ignatz<sup>\*1†,2,3</sup>, T.S. Hori<sup>4†,5</sup>, L.M. Braden<sup>1,6</sup>, T.J. Benfey<sup>7</sup>, A. Dumas<sup>4</sup>, A. Caballero-Solares<sup>3</sup>, M.D. Fast<sup>6</sup>, C.D. Runighan<sup>1</sup>, J.D. Westcott<sup>2</sup>, M.L. Rise<sup>3</sup>

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- † denotes past affiliation when study was completed, followed by current affiliation

This study examined the effect of rearing temperature on AquAdvantage<sup>®</sup> salmon (growth hormone transgenic female triploid Atlantic salmon) reared at 10.5°C, 13.5°C, 16.5°C from first feed to 1500 g. Whole-body and fillet samples were collected for compositional analysis at body weights of ~300 g, 500 g, 800 g, and 1500 g. At 800 g, a subset of fish was intraperitoneally injected with either polyriboinosinic polyribocytidylic acid (pIC), a known immunostimulant that elicits an antiviral response, or an equal volume of sterile phosphate-buffered saline (PBS). Blood and head kidney samples were collected before injection and 6, 24 and 48 h post-injection (hpi) for plasma cortisol and targeted reverse transcriptase quantitative polymerase chain reaction (RT-qPCR) analysis, respectively. Liver samples from uninjected fish were also collected at 800 g. RNA-sequencing results showed the greatest difference in number of differentially expressed transcripts (929), as revealed by DESeq2 and edgeR (FDR < 0.01) followed by RT-qPCR validation (8 out of 10 genes validated), was between the 10.5°C and 16.5°C treatments. Temperature had a significant effect ( $p < 0.05$ ) on growth, feed conversion ratio, body and fillet composition, and nutrient deposition rates, but did not appear to have a clear effect on immune and stress response to pIC.

**11:10-11:30**

**EPIGENETIC VARIATION IN SHELLFISH AND IMPLICATIONS FOR AQUACULTURE**

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Epigenetics has attracted considerable attention with respect to its potential value in many areas of agricultural production, particularly under conditions where the environment can be manipulated or natural variation exists. The function of DNA methylation in shellfish where the limited amount of DNA methylation is predominantly found in gene bodies is not completely understood. One emerging possible explanation is that the role of gene body DNA methylation is dependent on gene function, a potential phenomenon that has arisen from selective pressure on lineage-specific life history traits. We know that in other taxa epigenetic marks are associated with phenotypes independent of genetic variation, the environment can influence DNA methylation, and epigenetic marks can be inherited. Specific case studies will be presented including looking at the role of DNA methylation in genomic regulatory function and heredity in oysters, and investigating the underpinnings of environmental memory in clams. These combined data suggest the application of epigenetic knowledge could significantly affect the productivity and sustainability of aquaculture practices.

**11:30-11:50**

**ADVANCES IN NON-MODEL SALMONID GENOMIC RESOURCES**

E. B. Rondeau<sup>1,2\*</sup>, K. A. Christensen<sup>1,2</sup>, D. Sakhrani<sup>1</sup>, R. H. Devlin<sup>1</sup>, B.F. Koop<sup>2</sup>

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Salmonid species represent >68% of production in tonnes and >90% of value in Canadian aquaculture (DFO 2017 Aquaculture Statistics). While dominated by Atlantic salmon, other species are emerging as valuable contributors, including the Pacific salmonids coho, Chinook and sockeye, steelhead and rainbow trout, and in more northerly climates Arctic charr. Genomic resources for these high-value fish have traditionally lagged behind other agricultural species due to a complicating factor – the ancestral salmonid genome experienced a whole-genome duplication event, leaving the modern salmonid genome in a complex pseudo-tetraploid state. Improvements to technology, as demonstrated by the release of a high-quality Atlantic salmon reference genome, have made significant advances in the ability of salmonid researchers to utilise genomic information to tackle complex problems. We will discuss recent advances in genomic tools available for all North American Pacific salmon, Arctic charr and rainbow trout. A particular focus will be on resources for coho salmon including a high-quality reference genome assembly, multi-tissue expression atlas, a high-density SNP array and a comprehensive SNP database that includes a broad geographic distribution across its natural range and multiple coho aquaculture strains. We are now in a position to enter the genomic age for all salmonids of commercial interest.

**11:50-12:10**

**GENOMICS GURUS TO GROUNDWORK GRUNTS**

Sheehan

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**1:30-1:50**

**PROFILING THE HEAD KIDNEY TRANSCRIPTOME RESPONSE OF ATLANTIC SALMON (*Salmo salar*) TO FORMALIN-KILLED *Renibacterium salmoninarum***

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*Renibacterium salmoninarum* is a Gram-positive, intracellular bacterial pathogen that causes Bacterial Kidney Disease (BKD) in Atlantic salmon. The host transcriptomic response to this immune suppressive pathogen remains poorly understood. To identify *R. salmoninarum*-responsive genes in Atlantic salmon, fish ( $n=6$ ) were intraperitoneally injected with a low ( $5 \times 10^5$  cells/kg) or high ( $5 \times 10^7$  cells/kg) dose of formalin-killed *R. salmoninarum* or phosphate-buffered saline (PBS

control); head kidney samples were collected before and 24 h post-injection. Using 44K microarray analysis, we identified 107 and 345 differentially expressed probes in response to formalin-killed *R. salmoninarum* injection by Significance Analysis of Microarrays (SAM) and Rank Products (RP), respectively (FDR/PFP<10%). Twenty-two microarray-identified genes were subjected to qPCR assays, and 17 genes were confirmed as being significantly responsive to *R. salmoninarum* bacterin. There was an up-regulation in expression of genes playing putative roles as immune receptors and antimicrobial effectors. The *R. salmoninarum*-responsive genes identified herein, alongside enrichment analysis, suggested the activation of chemokine- and cytokine-mediated pathways in response to *R. salmoninarum* injection. The present study identified novel biomarker genes (e.g. *ctsl1*, *lipe*, *cldn4* and *ccny*) that can be used to assess Atlantic salmon response to *R. salmoninarum*, and will be valuable in the development of tools to combat BKD.

**1:50-2:10**

### **THE POTENTIAL OF eDNA TO IMPROVE AQUACULTURE ENVIRONMENTAL MONITORING**

A. Lacoursière-Roussel\*<sup>1</sup>, M. Sevellec<sup>2</sup>, N. Leduc<sup>2</sup>, L. Bernatchez<sup>2</sup>, K. Howland<sup>3</sup>, L. Hamilton<sup>4</sup>, S. Robinson<sup>1</sup>.

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Continuous monitoring in aquaculture sites is essential to early detect pathogens and biodiversity changes and to develop effective management and conservation plans. Recent advances in the collection and analysis of environmental DNA (eDNA) provide a new non-invasive approach that can help to fill gaps in monitoring data left by expensive and logistically difficult traditional methods. The interest of eDNA as a biomonitoring tool is growing and this presentation will show how eDNA may assist managers to improve their biosecurity protocols and strengthen their response capability. This presentation will highlight the possible applications and limitations of the eDNA methodology in aquaculture sites such as micro and macro-organism detection and informing on sensitive periods to manage aquaculture inputs decisions for the non-target species. The potential applications for eDNA to improve aquaculture management is immense, but the lack of knowledge about the spatio-temporal variation limits its use to inform regulation. We will demonstrate the contrast between traditional sampling and water eDNA to monitor biodiversity and will illustrate that the tidal, seasonal and annual variation are environmental parameters to consider to improve species detection.

**2:10-2:30**

**CHARACTERIZING THE HOST-PARASITE INTERACTOME IN THE SALMON-LOUSE RELATIONSHIP**

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The host-parasite (HP) relationship between the salmon louse *Lepeophtheirus salmonis* (*Lsal*) and its host involves both an attack response by the parasite and a defense response by the host at the louse-skin attachment site. *Lsal*-derived proteins secreted at the attachment site are predicted to be immunosuppressive, however, little is known about the impact they have on consequent host responses. Furthermore, the relative contribution of louse virulence to variable host susceptibility, or the associated HP-protein:protein interactions (HP-PPIs) are not known. A characterization of *Lsal* virulence would greatly enhance our understanding of this system and facilitate uncovering novel pharmacological/vaccine targets or identifying biomarkers of resistance. Here we use a combination of transcriptomics and proteomics to predict the interactome of *Lsal*-salmon. We identified a cluster of genes associated with feeding in the louse transcriptome, and using LC-MS/MS, identified a suite of proteins in *Lsal* secretory/excretory products to produce a list of interacting louse proteins that were concordant with the transcriptome. Using interolog and domain-based approaches, interactions between louse and salmon proteins were inferred. Expression profiles of key *Lsal* interacting proteins during feeding, *in situ* localization, and RNA interference experiments support the importance of these virulence factors as mediators of the HP interaction.

**2:30-2:50**

**TRANSCRIPTOMIC PROFILES OF SKIN SAMPLES OF ATLANTIC SALMON (*Salmo salar*) DURING SEA LICE (*Lepeophtheirus salmonis*) AND INFECTIOUS SALMON ANEMIA VIRUS (ISAV) CO-INFECTION**

W. Cai\*<sup>1</sup>, L. A. Carvalho<sup>1</sup>, S. K. Whyte<sup>1</sup>, S. L. Purcell<sup>1</sup>, N. Gagne<sup>2</sup>, R. G. Taylor<sup>3</sup>, M. L. Rise<sup>4</sup> and M. D. Fast<sup>1</sup>

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Co-infection with sea lice (*Lepeophtheirus salmonis*) and infectious salmon anemia virus (ISAV) continues to be a big challenge for salmonid aquaculture. In this study, transcriptomic analysis was used to evaluate the impact of four functional feed diets (i.e. control=0.3% EPA/DHA+high- $\omega$ 6, T1= 0.3% EPA/DHA+high- $\omega$ 6+ immunostimulant, T2= 1% EPA/DHA + high- $\omega$ 6, and T3= 1% EPA/DHA + high- $\omega$ 3) on Atlantic salmon (*Salmo salar*) during sea lice and ISAV co-infection. After 28 days of feeding with one of the functional feeds, Atlantic salmon smolts were either challenged with *L. salmonis* alone or with co-infection of *L. salmonis* and then ISAV. Skin samples at 33 days post infection (dpi) were selected for RNA-seq analysis. The overall survival rates for co-infection were between 37%-52%, while no mortality was observed in single-infected fish. Differentially expressed genes (DEGs) due co- infection were identified with up-regulated genes enriched in categories such as glycolysis, the interferon pathway, and heat shock protein family. The down-regulated genes fell into categories including iron homeostasis, T-cell activation response, collagen formation and extracellular matrix. Understanding how functional feeds can impact the host response and trajectory of co-infections will be an important step to identifying efficacious intervention strategies that account for the complexities of disease in open cage culture.

## SIDNEY

# MOVING AQUACULTURE TOWARDS HIGHER SUSTAINABILITY THROUGH PRODUCTION OF LOWER TROPHIC LEVEL SPECIES AND NEW APPROACHES

**10:10-10:30**

## **KELP AQUACULTURE PILOT PROJECTS WITH FIRST NATION-OWNED COMPANIES**

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Kelp and other sea vegetables are a traditional food source for coastal First Nations, and part of a growing aquaculture sector in Canada. North Island College is collaborating with two First Nation-owned companies and Cermaq Canada to pilot sugar kelp (*Saccharina latissima*) aquaculture. The first project is with Nuu-chah-nulth Seafood LP, a fisheries and aquaculture company. Seeded kelp lines were out-planted at four of their vacant aquaculture tenures in Barkley Sound (on the west coast of Vancouver Island). The second project is with Ahous Business Corporation, a company with diverse interests including sustainable aquaculture. Seeded kelp lines were out-planted at their vacant finfish aquaculture tenure, and at a nearby Atlantic salmon farm owned by Cermaq Canada, both in Clayoquot Sound, BC (also on the west coast of Vancouver Island, north of Barkley Sound). In both projects, kelp was seeded in January 2019 and will be harvested in May and June 2019. The research goals, ongoing results, and broader economic development opportunities pertaining to each project will be presented. A common theme of the two projects is building capacity within the companies to continue kelp aquaculture by working with employees on all aspects of the fieldwork – from seed to harvested product.

**10:30-10:50**

## **JUVENILE GEODUCK (*Panopea generosa*) PREDATOR PROTECTION WITH TUBES: ASSESSING EFFECTS OF TUBE DIAMETER, LENGTH, AND MESH SIZE ON GROWTH AND SURVIVORSHIP**

C.M. Pearce<sup>1</sup>, S. Williams<sup>1</sup>, L. Keddy<sup>1</sup>, and J. Blackburn<sup>1</sup>

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Intertidal culture of the Pacific geoduck clam (*Panopea generosa*) involves planting juveniles in sediment in tubes covered with mesh for predator protection. We examined the interactive effects of tube diameter (10.2 and 15.2 cm), length (25.4 and 30.5 cm), and mesh size (6 and 12 mm) on percent shell-length increase, percent wet-weight increase, and percent survivorship of cultured juvenile geoducks (mean shell length  $\pm$  SD =  $29.6 \pm 4.8$  mm) over 12 months. Percent increase in shell length and weight were both significantly affected by the main effects of tube diameter and mesh size, as well as the interaction between the two factors. Shell length was also significantly affected by the main effect of tube length. Geoducks were significantly shorter and lighter in the 10-cm/6-mm (diameter/mesh) treatment than in the 10-cm/12-mm, 15-cm/6-mm, and 15-cm/12-mm treatments. The 25-cm long tubes were associated with significantly longer (but not heavier) individuals than the 30-cm ones. Average survivorship ( $\pm$ SE) ranged from  $38.3 \pm 7.1\%$  to  $55.0 \pm 6.5\%$  (mean  $\pm$  SD:  $47.7 \pm 2.5\%$ ) in the eight treatments and was not significantly affected by any main effects or interaction terms. The results have implications for commercial geoduck culture where clams are protected with solid plastic tubes.

**10 :50-11 :10**

**IMPROVING SCALLOP (*Pecten maximus* AND *Placopecten magellanicus*) SPAT PRODUCTION BY INITIAL LARVAE SIZE, STOCKING DENSITY AND HYDRODYNAMIC CUES USED IN NURSERY SYSTEM**

R. Tremblay<sup>1</sup>, G. Christophersen<sup>3,4</sup>, J-B. Nadalini<sup>1</sup>, I. Redjah<sup>1</sup>, T. Magnesen<sup>3</sup>, S. Andersen<sup>2</sup>

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There are several factors affecting scallops during the metamorphosis process that could explain the relatively low post-larvae yield observed in hatcheries. Competent bivalve larvae respond to different settlement cues to undergo metamorphosis and without adequate cues, larvae delay their metamorphosis. The objective of this study is to improve the settlement ratio of the two scallop species, *Placopecten magellanicus* and *Pecten maximus* by physical cues associated with hydrodynamic conditions, stocking density in settlement units and larval size at time of transfer to settling units. For each treatment, physiological condition was determined by fatty acid analysis to determine the energetic reserves and structural lipids. We observed similar results for the two important commercial pectinid species and validate the hypothesis on the positive effect of increased flow rate and larval size at transfer to settlement systems on settlement success. Increasing flow rate also affects positively the physiological condition of settled post-larvae by a higher accumulation of total fatty acids in neutral lipid fractions. However, no effect of larval stocking density until 90 larvae  $\text{cm}^{-2}$  in the downwelling sieves was observed. To our knowledge this study is the first to characterize the effect of seawater flow rate on settlement success of different pectinid species cultured under similar conditions. The experiments were performed in a close to commercial scale and thus are relevant to industry situations.

**11:10-11 :30**

**GREEN (*Strongylocentrotus droebachiensis*) AND RED (*S. franciscanus*) SEA URCHINS**

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Sea urchins are an ecologically-important species which can drastically alter marine communities due to their consumption of macroalgal beds, creating areas termed “urchin barrens”. Generally, urchins in these barrens have low, non-marketable gonad yields. Sea urchin gonad enhancement entails removing low-gonad-yield urchins from the urchin barrens and feeding a prepared/natural diet to bulk up their gonads to market size. This also offers an opportunity for economic development through the ranching of a new species. Previous studies have achieved large gonad yields using various prepared diets, but none have consistently obtained market-quality taste and colour (bright orange/yellow). This study aimed to improve gonad yield and quality in green (*S. droebachiensis*) and red (*S. franciscanus*) sea urchins using a newly developed urchin pellet feed. The sea urchins were held in specifically designed urchin trays at a sea-based farm site in Departure Bay, Nanaimo, British Columbia and fed either the prepared diet or bull kelp (*Nereocystis luetkeana*) for 12 weeks. While the prepared diet did significantly increase gonad yield in *S. droebachiensis*, the kelp diet produced better gonad quality, as has been seen in previous studies. No effects were seen in *S. franciscanus* fed either feed.

**11:30-11:50**

**EFFECTS OF STOCKING DENSITY ON AGGREGATION, FEED CONSUMPTION, AND ROE YIELD OF GREEN SEA URCHIN (*Strongylocentrotus droebachiensis*) IN A TIERED RACEWAY SYSTEM**

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Green sea urchin (*Strongylocentrotus droebachiensis*) produces one of the finest and most distributed roe on Asia’s top seafood markets. Accordingly, methods are continuously devised to quickly produce high volumes of high-quality green sea urchin roe. We carried out a roe enhancement experiment in a tiered raceway system during which ~1400 sexually mature green sea urchins were fed bi-weekly during seven weeks with advanced aquaculture feed. Urchins were grouped at low (50 individuals m<sup>-2</sup>), intermediate (130), and high (209) stocking densities

in 0.38-m<sup>2</sup> compartments through which seawater at 6°C flowed at a moderate rate of 75 L min<sup>-1</sup>. We used generalized linear mixed models to analyze aggregation, and general linear mixed models to analyze feed consumption and gonadosomatic index (GSI), as a function of density. Urchins aggregated mainly in downstream portions of the compartments. Among the three stocking densities, feed consumption and GSI did not differ, averaging respectively 6.8 g feed per kg urchins per day ( $\pm 0.1$ ) and 20.8% ( $\pm 0.2$ ). The high GSI and low variability achieved, together with low urchin mortality (0.4%), showed the tiered raceway system can quickly produce high volumes of urchin roe regardless of stocking density, which is a major operational advantage for roe producers.

**11:50-12:10**

**SHELLFISH AQUACULTURE ON THE U.S. WEST COAST: SHIFTING PRODUCTION METHODS AND EXPANSION OPPORTUNITIES**

Hudson

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**1:30-1:50**

**USE OF THE CARIBBEAN SPIDER CRAB *Mithrax spinosissimus* FOR BIOFOULING REMOVAL ON MARINE AQUACULTURE CAGES**

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Biofouling is a significant issue for marine aquaculture pens and is conservatively estimated to contribute to 15% of production costs. With a global increase in the demand for sustainable aquaculture products, chemical treatment and manual removal of biofouling organisms is being replaced by non-toxic alternatives such as biological control. Caribbean spider crabs (*Maguimithrax spinosissimus*) were placed on a heavily fouled, unused SeaStation 3000 cage offshore of Eleuthera, The Bahamas to determine their ability to remove fouling organisms. Large crabs (382 g – 1344 g) confined in mesh cages on the outside of the pen effectively removed 40% after 2 weeks, and up to 90% of fouling organisms after a month. Crabs were more effective at removing growth than manual diver scrubbing. Grazing by the crabs was non-discriminatory, with no significant change in the proportional makeup of the algae and epibionts at the end of the trial. The survival rates of crabs inside the cage varied between 42% and 55% during 3 to 15 month trials, with no significant decline in health status (blood protein levels). The Caribbean spider crab is a good candidate both economically and environmentally for controlling biofouling on aquaculture cages, and could be used in multi-trophic aquaculture systems.

**1:50-2:10**

**NUTRIENT LOADING MITIGATION POTENTIAL OF BIVALVE AQUACULTURE**

T. Guyondet<sup>\*1</sup>, R. Filgueira<sup>2</sup>, L.A. Comeau<sup>1</sup>, R. Tremblay<sup>3</sup> and C.M. Pearce<sup>4</sup>

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In addition to the production of food, bivalve aquaculture can provide various ecosystem services, one example being the removal of particulate nitrogenous wastes through filtration. Since bivalves produce particulate wastes themselves (*i.e.* faeces, pseudofaeces), there is debate as to the extent of the overall particulate nitrogen (N) budget and questions surrounding the role played by cultured bivalves in material exchange between coastal and open-sea systems and how this affects their overall N-loading mitigation potential. This may have severe ramifications on N-credit systems developed. In the present study, we investigated this N-removal potential through numerical model simulations that integrate the many non-linear interactions between bivalves and the supporting ecosystem. This approach provides a framework to assess overall contribution of cultured bivalves to N dynamics and, in particular, to estimate the net balance between N retention and removal processes. The numerical tool also enables the testing of how this balance responds to factors such as coastal system topography, N-loading intensity, cultured bivalve species and density, and future temperature regimes. While N-mitigation potential was confirmed by the model, the results vary as a function of the various factors tested, suggesting that a careful, integrative assessment is warranted prior to the implementation of N-credit systems.

**2:10-2:30**

**MUSSELS OR TUNICATES: THAT IS THE QUESTION. EVALUATING EFFICIENT AND SUSTAINABLE RESOURCE USE BY LOW-TROPHIC SPECIES IN AQUACULTURE SETTINGS**

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The growing demand for aquaculture products can only be maintained by increasing the production of lower trophic species such as bivalves and tunicates. Low trophic species avoid the energy losses during trophic transfers to build animal protein, making them ideal candidates to exploit available resources in coastal waters. In the particular case of fjords, forced upwelling of deep nutrient-rich waters can promote phytoplankton growth, or in other words, the growth of

bivalve and tunicate food. However, the density at which bivalves and tunicates are cultured can compromise phytoplankton populations and consequently, marine food chains. A highly configurable environmental model was constructed to study the ecosystem effects and potential biomass production of hypothetical bivalve and tunicate aquaculture scenarios in a Norwegian fjord under forced upwelling conditions. The simulations objectively determined the level of aquaculture development that maximizes the sustainable utilization of resources towards bivalves and tunicates biomass production. The model also highlighted the positive effect of the forced upwelling on both cultured production and phytoplankton abundance under aquaculture scenarios. Finally, the model predicted that tunicates would be more efficient than mussels at extracting resources due to their lower metabolic cost and higher filtration capacity.

### **2:30-2:50**

#### **CRUSTACEAN PREDATION ON VULNERABLE SIZED CULTURED OYSTERS (*C. virginica*) IN ATLANTIC CANADA**

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With an increased emphasis on sustainable aquaculture methods, oyster aquaculturists in Atlantic Canada are attempting to modify the morphological features of young oysters in order to be more resilient to crustacean predation. This is prudent, as along with the presence of native species like American lobster, the invasive European green crab continues to invade into waters where the bottom culture of oysters remains prevalent. An information gap exists on the impact of this crab species on the region's important shellfish industries, and innovative mitigation measures such as shell modification are in high demand. This study examined the potential for green crab predation upon vulnerable sized oysters both in the lab and *in situ*. It also explored predator tactics when encountering young oysters and identified ways to improve future predation trials. Results indicated that oysters reach a size refuge at approximately 40 mm from green crabs, while lobsters are able to prey upon oysters larger than that. Multiple oyster beds surveys revealed that the probability of vulnerable sized oyster mortality was higher in areas with green crab presence. Green crabs employed a tactic wherein they targeted an area of the dorsal shell behind the umbo, while lobsters indiscriminately crushed the oyster.

### **3:30-3:50**

#### **IMPACTS OF MICROPLASTICS ON THE CELLULAR PHYSIOLOGY AND HEALTH OF THE PACIFIC OYSTER (*Crassostrea gigas*)**

M. Raap\*<sup>1</sup>, H.J. Gurney-Smith<sup>1,2</sup>, C.M. Pearce<sup>3</sup>, S. Dudas<sup>1,3</sup>, and B. Koop<sup>1</sup>

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Microplastics (MPs) derived from clothing, personal care products, and the breakdown of primary plastics are considered emerging pollutants of concern that have been found in aquatic environments around the world. MPs have been reported to negatively impact growth, reproduction, and physiology of various marine organisms, but research on the subject has generally focused on artificially high MP concentrations. The sedentary nature of bivalves, their wide geographical distribution, and their ability to accumulate pollutants make bivalves an important indicator species for monitoring environmental pollution. To assess the impacts of MPs at environmentally-relevant concentrations on the health and cellular physiology response of Pacific oysters (*Crassostrea gigas*), adult individuals were exposed to five MP fibres per litre for 30 days alongside oysters not exposed to MPs. These oysters were analyzed for genomic expression, MP load, and condition indices. MPs were found to affect biological pathways associated with oyster cellular defense as well as those involved in reproduction and growth, but had no significant effect on oyster condition over the relatively short 30 days of exposure. Results show that environmentally-relevant concentrations of MPs can negatively affect oyster cellular responses and may have implications for oyster productivity and aquaculture operations.

**3:50-4:10**

**2018 SUMMER MORTALITY EVENT OF PACIFIC OYSTERS IN BAYNES SOUND IS LINKED TO A SEAWATER TEMPERATURE SPIKE AND INFECTION WITH *Vibrio* sp.**

T. Green<sup>1\*</sup>, M. Cowan<sup>2</sup>, D. Winterburn<sup>3</sup>, C. Pierce<sup>4</sup>, G. Meyer<sup>4</sup>

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The Pacific oyster, *Crassostrea gigas* is cultivated in many regions of the world. In cultivation, adult *C. gigas* are prone to mass mortality events during the summer months. A complex combination of environmental and biological parameters has been suggested as the cause of this disease. In recent years, summer mortality has had a significant economic impact on oyster farms in British Columbia, Canada. From late July 2018 to August 2018, mass mortalities were reported in adult Pacific oysters cultivated in Baynes Sound, British Columbia. Up to 95% mortality was reported in diploid and triploid *C. gigas*. Farmers in Baynes Sound first observed mortalities of adult oysters on the 24<sup>th</sup> of July, which coincided with a spike in sea surface temperatures (SST) in the Sound above the 90<sup>th</sup> percentile for 3 days (SST = 20.9 °C, 2.7 °C

above climatology). Histological examination of moribund *C. gigas* collected during the mortality event displayed early stage tissue necrosis combined with systemic bacterial infections comprised of bacteria with uniform short rod-shape morphology. Microbiological characterization, combining 16S rRNA amplicon sequencing with bacterial culture, revealed the microbiome of moribund oysters were dominated by *Vibrio mediterranei*. These observations build upon previous studies that identified summer mortality of *C. gigas* is caused by temperature stress and opportunistic *Vibrio* pathogens.

**4:10-4:30**

**PACIFIC OYSTER SUMMER MORTALITY IN BAYNES SOUND: INFLUENCE OF ENVIRONMENTAL VARIABLES, SOMATIC/GONADAL DEVELOPMENT, AND PATHOGENS**

M. Cowan<sup>\*1,2</sup>, P. de la Bastide<sup>1</sup>, T. Finston<sup>1</sup>, G. Meyer<sup>2</sup>, R. Marshall<sup>3</sup>, W. Evans<sup>4</sup>, T. Sutherland<sup>5</sup>, B. McAmmond<sup>6</sup>, J. Van Hamme<sup>6</sup>, E. Bottos<sup>6</sup>, T. Green<sup>7</sup>, W. Hintz<sup>1</sup>, and C. Pearce<sup>2</sup>

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Pacific oyster (*Crassostrea gigas*) summer mass mortalities have been observed in British Columbia over the last five years. Growers in Baynes Sound, who produce over 50% of the cultured Pacific oysters in the province, have reported cumulative mortalities exceeding 90%. The causes of these mortality events are thought to be interactions among various environmental factors, late-stage gonad development, and the occurrence of pathogens. The objectives of this study are to identify: (1) potentially pathogenic bacteria and (2) environmental factors and stages of oyster development associated with periods of mortality. Summer field work was conducted to measure mortality, temperature, turbidity, dissolved oxygen, chlorophyll-*a*, sediment organics, carbonate chemistry, plankton assemblages, and bacterial species associated with oysters. The dominant bacterial taxa cultured from Pacific oysters during a 2017 summer mortality event were *Vibrio parahaemolyticus*, *V. aestuarianus*, *V. diabolicus*, *Serratia marcescens*, *V. pelagius*, *Vibrio pacinii*, and un-resolved *Vibrio* spp. in the Harveyi clade. In 2018 we observed a mortality event (mean±SE: 52±4.0% mortality) in suspended culture that was concurrent with a marine heatwave, increased abundance of *Vibrio* spp., larger oyster size, and gonad development. Ongoing analysis of field data will identify the principal factors that correlate with oyster mortality.

**4:30-4:50**

**TRANSGENERATIONAL PLASTICITY AND ANTIVIRAL IMMUNITY IN THE PACIFIC OYSTERS (*Crassostrea gigas*) AGAINST OSTREID HERPESVIRUS 1**

T. Green

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Massive mortality events of farmed *Crassostrea gigas* associated with the detection of a microvariant of the ostreid herpesvirus 1 (OsHV-1) has been reported in Europe, New Zealand, Australia and United States of America. It is feared that this disease will spread to Canada and devastate the oyster industry in British Columbia. In this paper, I will present research demonstrating that it might be possible to 'immunize' entire oyster crops against OsHV-1. Oysters injected with a viral mimic (polyI:C) develop resistance to OsHV-1. Improved survival following polyI:C injection was found later in life (within-generational immune priming) and in the next generation (multi-generational immune priming). Inoculating oysters with poly(I:C) has no effect on their survival. Hence, the improved survival cannot be explained by genetic selection, and may reflect epigenetic reprogramming of innate immune pathways. This knowledge will hopefully motivate the development of practical and cost-effective treatments for improving oyster health in aquaculture.

**4:50-5:10**

**DEVELOPMENT OF TTI-LABELS INDICATING RISK OF VIBRIO GROWTH IN FRESH MOLLUSCAN SHELLFISH FOR HUMAN CONSUMPTION**

J. Desrosiers\*

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Problem: During the years 1989 thru 2002, the U.S. FDA recorded 341 cases of Vibriosis. Most of these sicknesses were related to the consumption of raw oysters. Study Objective: Vitsab was approached by the FDA and asked if TTI (time temperature indicator) technology could be adapted to become an indicator of *Vibrio* growth as related to time/temperature exposure. Principle Findings: The FDA provided predictive growth data for *Vibrio vulnificus* and *Vibrio parahaemolyticus*, enabling Vitsab to develop TTI labels that mirror these growth data. The TTIs were then tested in Connecticut USA in conjunction with state regulations to confirm the accuracy and effectiveness of the TTIs as a predictor of potential Vibriosis. Main conclusion: TTI technology can be used to monitor time/temperature for fresh oysters from harvest to consumption to indicate if a risk of vibriosis is present before the oysters are consumed and in-turn reducing illness.

**Wednesday, May 8<sup>th</sup>**

**SIDNEY**

**CERTIFICATIONS**

**8:45-9:05**

**AQUACULTURE STANDARDS AND CERTIFICATION- CAN WE DO A BETTER JOB?**

D. Garforth\*<sup>1</sup> and R. Sanderson<sup>2</sup>

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Third party aquaculture certification is a pre-requisite for access to most seafood markets. A certificate of attainment is not only a statement of good practice but a social license to operate. There are a number of standards and programs that vie for position as the most recognised ‘brand’ in the marketplace for seafood assurance. The most prominent of these; (Global Aquaculture Alliance Best Aquaculture Practice; Aquaculture Stewardship Council Responsible Aquaculture and Global GAP Aquaculture) provide standards for salmon aquaculture (for example) using a combined total of almost 1000 auditable clauses and performance metrics. As to be anticipated, there are core overlapping areas across these programs and standards and there some are differences. This paper provides a ‘working perspective’ on this from an auditor’s perspective. We ask, can more value be gained from the audit experience? Considerable amounts of data are reviewed and evaluated but remains relatively inaccessible for other purposes. But modern day technology can allow access to limitless data sets and digitized information and if this included audit data, a wider horizon of risk management and mitigation information could be made available and ultimately deliver actionable insight. This subject is explored with working examples using Authenticate Systems transparency mapping solutions.

**9:05-9:25**

**RESULTS FROM AN AQUACULTURE STEWARDSHIP COUNCIL SURVEY  
EVALUATING THE BENEFITS OF CERTIFICATION TO THE ENVIRONMENT,  
COMMUNITY, AND FARMERS.**

K. Mullen-Ley\*

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The Aquaculture Stewardship Council's certification and labeling programme is an effective tool for mitigating the environmental and social impacts of aquaculture. To evaluate the benefits of ASC certification to farmers, ASC conducted a survey of farmers in the programme. The results demonstrate that in order to meet all ASC requirements, farmers made improvements that indicate benefits to the environment, local communities, and aquaculture operators' efficiencies. This talk will share highlights from the farmer survey, as well as provide a brief overview of emerging market issues facing the aquaculture industry and how the ASC is planning to address them.

**9:25-9:45**

### **BEST AQUACULTURE PRACTICES – PROGRAM INNOVATIONS**

Corpron

Best Aquaculture Practices (BAP) is the world's most comprehensive third-party aquaculture certification program founded on science-based, performance driven standards. BAP certification encompasses four pillars of responsible aquaculture including environmental sustainability, social accountability, food safety, and animal welfare, validated through robust traceability measures. BAP is the only certification program to cover the entire aquaculture production chain including hatcheries, farms, feed mills, and processing facilities. The BAP program continually strives to improve responsible aquaculture practices across the world and is recognized by the Global Food Safety Initiative (GFSI), Global Social Compliance Programme (GSCP), and the Global Sustainable Seafood Initiative (GSSI). To date, the BAP program certified more than 2,200 facilities in 33 countries and continues to grow. Over the past year BAP has furthered its commitment to continuous improvement by banning the use of Critically Important Antimicrobials designated by the World Health Organization in finfish and salmon farms, strengthening an innovative food safety testing program for antimicrobial drugs, developing a Biosecurity Area Management standard, and piloting an enhanced social accountability audit model. This presentation will focus on the benefits of BAP certification, how our program continues to evolve, and opportunities for aquaculture producers to help BAP continue to lead the way in responsible seafood production.

**9:45-10:05**

### **EMPOWERING SALMON FARMERS: ACHIEVING ASC SUCCESS THROUGH ACCOUNTABILITY**

Hamel

Mowi Canada West is the largest salmon farming company on the British Columbian coast. Employing approximately 600 people in rural Vancouver Island and the central coast, Mowi Canada West produces over 40,000 mT of fresh Atlantic salmon annually.

Mowi Canada West is rapidly accumulating ASC certified sites and is on target to meet the 100% ASC certification by 2020 goal. At 22+ ASC certified sites, it is the most successful

business unit in the Mowi Group in ASC certification achievements. Through training, support and positive reinforcement, Mowi Canada West experiences substantial employee buy-in to the ASC program. By using a “bottom-up” approach to ASC certification, the Mowi Canada West certification team credits much of their success to those on the front lines.

**10:30-10:50**

**THE BENEFITS, CHALLENGES AND FUTURE TRENDS OF AQUACULTURE CERTIFICATION**

McLaren

Aquaculture Certification has developed over the last 20 years to address concerns in Food Safety, Animal Welfare, Environmental, Social Responsibility and Traceability. With certified production growing at an average rate of 76% annually in the last decade, third-party aquaculture certification and eco-labels have made strides in gaining influence and market place recognition. Complexity of standards has developed as a challenge, with more sophisticated and consolidated industry able to achieve certification. The demand for more certified sustainable seafood coupled with pressure on industry to achieve higher standards of production continues to take a considerable amount of time and resources from producers. However growing consumer awareness of sustainability issues, eco standards and their content ensures market access for those who do achieve sustainability certification.

**10:50-11:10**

**AQUA CARE365®: A PRACTICAL APPROACH TO ADVANCING FISH CARE & FISH WELFARE**

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Merck Animal Health, 35500 W. 91<sup>st</sup> Street, De Soto, KS, USA 66018

A demonstrable fish welfare program is becoming increasingly important to all segments of aquaculture production and the entire aquaculture value chain. Aqua Care365 is an internet-based education & training resource that addresses aspects of fish care and fish welfare. The components of Aqua Care365 include video training modules with individual topic lessons, quizzes, completion certificates, and Standard Operating Procedures/Best Practices for each lesson. Aqua Care365 was developed in a collaborative manner with participation by production companies, fish veterinarians, aquaculture industry allied organizations, subject matter experts, & Merck Animal Health. Since Aqua Care365 was developed in conjunction with certification groups, this program can be a valuable tool to help salmon producers meet the requirements of standards. The Aqua Care365 program is intended to support fish farmers and fish farm employees by promoting the health, well-being, and care of the fish they raise.

**11:10-11:30**

**UNDERSTANDING ISO16488 - AN INTERNATIONAL STANDARD FOR THE DESIGN AND OPERATION OF MARINE FIN-FISH FARMS. IS IT RIGHT FOR CANADIAN PRODUCERS?**

D. Steinke<sup>1</sup>

DSA, 201-754 Broughton St, Victoria, BC, V8W1E1

ISO16488 is an internationally developed standard that was approved by ISO member countries including Canada, Norway, Scotland, and Chile. The standard was released in mid-2015. The title of the standard is “Marine finfish farms – Open net cage – Design and operation”. This standard was developed to enable finfish producers to certify that the equipment and operation of their sites are in line with industry-accepted best practices. The standard covers a wide range of requirements, including what needs to be considered in a site survey, mooring analyses, and in the general operation of a site using a site handbook. As stated in the introduction to the standard, “This international technical standard is intended to reduce technical and operational failures, consequently enhancing the sustainability of the industry.” Much of the material for the ISO standard was developed by considering the NS9415 standard. NS9415 is used as part of a certification and regulatory framework in Norway. All sites and equipment in Norway must be certified to NS9415. It is argued that this standard has reduced fish escapes in Norway and created a framework for the industry to proceed safely and with social acceptance. ISO16488 leverages comprehensive ISO standards for mooring system analysis and determination of met-ocean conditions. However, there are some uncertainties how this standard could play a role in the regulatory and professional engineering context in Canada, specifically the impact it would have on producers. This presentation will review the ISO16488 standard, and present questions for consideration as Canada moves forward. It will help to answer the question: Is ISO16488 right for Canadian producers?

## POSTER PRESENTATIONS

### ANTHROPOGENIC SOUND EFFECTS ON LARVAL DEVELOPMENT AND SETTLEMENT OF BIVALVE AQUACULTURE SPECIES

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Among invertebrates, powerful sound effects generated by offshore human activities are still poorly studied. Invertebrates and fish larvae use natural soundscapes to orientate inshore and choose their optimal habitat. Anthropogenic sounds may affect the larval development and settlement, and eventually, the recruitment success of benthic species populations. The project IMPAIC led in France aims to assess effects of pile driving and drilling sounds to the larval stages of the great scallop, the warty venus and bittersweet clams. Adult spawners are exposed to different levels of each sound treatment. Larvae produced by these spawners will be exposed to the same noisy environment to understand intergenerational impacts. Experimental tanks have been built to expose the different larval stages to sound treatments with an appropriate acoustic signature of each sound. The tank's top holds several cylinders and experimental chambers in order to assess the larval development, feeding and settlement rates under different intensities of sound treatments. Lipids analysis will be used to evaluate the energy allocation of larvae. This experimental design opens new opportunities to study the effect of anthropogenic sounds in the laboratory, particularly on the larval stages of aquaculture bivalve and fish species.

### USING AIRLIFT PUMP IN BIOREACTOR APPLICATION

A. J. Chau<sup>\*1</sup>, B. W. H. Ahmed <sup>2</sup> and C. A. Heyland <sup>3</sup>

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For the sustainable operation of inland aquaculture, nutrients must be removed from water, especially in recirculating systems with salt water. We are therefore developing a photo-bioreactor with novel aeration and mixing technology for continuous operation of nutrient removal and algae production. A 60-Liters bioreactor prototype is designed, manufactured and

tested using a special airlift-pump designed specifically for the aeration and mixing of algal cells within the reactor. Galvanic dissolved oxygen sensor with accuracy of  $\pm 0.05$  mg/L is used to run the mass transfer experiments. The objective of this study is to evaluate the mass transfer characteristic inside the growth chamber to investigate the effects of gas flow rate on its operation. Furthermore, the effect of different column geometry and radial orientation on the mixing efficiency was examined. Using the start-up dynamic method, the overall mass transfer coefficient was found to be in the range of  $0.00164\text{--}0.0074\text{s}^{-1}$ . The results show an even distribution of dissolved oxygen level across the reactor core which demonstrated a good mixing ability of the airlift-pump. Also, a flow visualization was used to relate bubble distribution to mass transfer capabilities in the reactor. The findings support the use of this technology and provide preliminary evidence for scalability.

**POLYGENIC NATURE OF GENOMIC LOCI ASSOCIATED WITH EARLY MATURATION IN TWO PACIFIC SALMONIDS, COHO SALMON (*Oncorhynchus kisutch*) AND CHINOOK SALMON (*Oncorhynchus tshawytscha*).**

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Variation in the number of years spent at sea before spawning, age of maturity, is an evolutionary stable strategy that can also influence reproductive success where fitness is balanced between early and late maturing salmon. The genetic basis of early maturation is not well understood, and it is unclear if the genetic basis for early maturation among salmonids is evolutionarily conserved. Although recent work has found that 39.4% of the phenotypic variation can be explained by a single locus *Vgll3* in European Atlantic salmon (AS), other data suggests this genetic association may not be fully conserved in North American AS. Our current study aims to identify the loci associated with early maturation in coho (*Oncorhynchus kisutch*) and Chinook (*O. tshawytscha*) salmon. Using the GBS approach, we conducted a genome-wide-association-study on six families of coho (n=716) and three families of Chinook (n=494) salmon from British Columbia. Current data analyses revealed highly polygenic associations with early maturation is distinct from *Vgll3* in coho and Chinook salmon populations. Further sanger sequencing and TaqMan analyses on *Vgll3* confirms the lack of association in coho. This may suggest that genetic basis of early maturation may not be evolutionarily conserved among AS, coho and Chinook salmon.

## **BEST AQUACULTURE PRACTICES FOR SEAWEED CULTURE (*Kappaphycus spp*) IN SOUTH SULAWESI, INDONESIA**

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South Sulawesi is the largest seaweed producing of Indonesia, and one of the largest in the world. The most common species farmed is the carrageenophyte *Kappaphycus alvarezii* (cottonii). Farmers in South Sulawesi are experiencing variable production as a result of changing climatic conditions. Two experiments were conducted: 1) seasonal production characteristics (growth, yield, seed density) on farm sites in Takalar for a variety of seaweeds and 2) growth and production of F1 generation "cottonii" seedlings in 4 different regencies in South Sulawesi, differing in local environmental conditions. In the first experiment, the farmer best practices yielded the best growth with a tripling in individual biomass over the trial, averaging 4.3-4.6% daily growth rate. However, dry weight yield (and carrageenan) were highest in the highest density seedings yielding 50% more biomass than farmer or lower seeding densities (3.3 kg per line vs 2.5 kg per line). In the second trial, all seaweeds grew well, but the farmers' seeding densities and seedlings (F40+) grew best. Subsequent observations showed the F1 seedlings has adapted to local conditions, grow as well as local seedlings, and have fewer pests or parasites. The best growth coincided with the lowest average nitrate levels, stable phosphate level, and lowest temperature profiles in all regencies.

## **THE FEASIBILITY OF YOGURT AS A PARTIAL SUBSTITUTION OF MICROALGAE FOR THE EASTERN OYSTER (*Crassostrea virginica*) JUVENILE**

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Demand for a reliable oyster seed for farmers is high. Live microalgae production and expensive commercial algal pastes are bottlenecks for bivalve hatchery seed production, and several substitute diets for microalgae have been reported. In this study, the feasibility of yogurt as a partial substitute diet for commercial algal paste was fed to Eastern oyster juveniles. The oysters were fed four different diets groups (in triplicate), and consisted of the Control diet microalgae paste Shellfish Diet 1800<sup>®</sup> and three other treatment diets of yogurt mixtures at three levels: 75/25%, 50/50% and 25/75% (Shellfish Diet 1800<sup>®</sup>/yogurt), for 56 days. Survival was highest in

the juveniles fed the 25 % yogurt substituted diet and lowest in the juveniles fed the Control diet. There were no significant differences in the body wet weight, wet meat weight and condition index of the juveniles among diet groups at the end of experiment. The results suggest that the substitution of commercial algal paste with yogurt is possible in terms of improving survival and reducing the use of expensive commercial diets for juvenile oysters without adverse effects. The feasibility of the yogurt substitution for oyster spat is worth future consideration.

## **FORMULATION OF A. SALMONICIDA ADJUVANTED VACCINE FOR RAINBOW TROUT : IMPACT OF THE ADJUVANT OIL ORIGIN**

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Injectable inactivated fish vaccines require adjuvants to enhance the immune response. Water-in-oil emulsion adjuvants are widely used in the aquaculture industry due to their cost effectiveness, stability, and long-term effect. However, oil-adjuvanted vaccines can be reactogenic and induce side effects in fish. In this study, we analyzed the impact of adjuvant oil origins in the safety and immunogenicity of *Aeromonas salmonicida* vaccines. Two different adjuvants were tested, one with non-mineral oil (Montanide™ ISA 763A VG) and one with mineral oil (Montanide™ ISA 761 VG). Following intraperitoneal vaccination of rainbow trout, blood samples were taken at 42 and 53 days post vaccination (dpv) to assess antibody response. Adipose tissues were collected at 3, 14 and 28 dpv for RT-qPCR of genes implied in pro-inflammatory and adaptive responses. Side effects in the peritoneum were scored until 53 dpv. Both vaccines induced high antibody titer against *A. salmonicida*. Vaccination-induced adhesion scores were both within industry-accepted limits, with lower scores from the non-mineral oil adjuvant group. Compared to the antigen-alone group, an upregulation of immune genes occurred and persisted over time. This upregulation was higher in mineral oil adjuvant group. Furthermore, a strong correlation between gene expression - modulated by the oil origin - and vaccine safety was observed. These results showed oil origins of adjuvants impact the immunogenicity and safety of fish vaccines, and that Montanide™ ISA 763A VG and Montanide™ ISA 761 VG are efficient adjuvants for inactivated *A. salmonicida* vaccines.

## **VARIABILITY IN TANK SCALE SEA LICE INFECTION MODELS – ISSUES AND SOLUTIONS.**

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Laboratory infection of salmon with sea lice is a required practice. In order study efficacy of treatments, inherent differences populations or families, or to study the lethal or sub-lethal impacts of parasite and host interaction a reliable starting point for comparison is required. At the Saint Andrews Biological Station, (Fisheries and Oceans Canada) Infection models and procedures have been developed and refined for over ten years. Often the preferred model is a single pulse method where fish are exposed to copepodid stage lice and then followed through development as they interact with their host. Over the course of many experiments using this model, variability has been noticed and has resulted in the need for developing more precise methods to try to reduce batch and tank variability which can result in difficulties interpreting results. The use of multi-tank exposures separated in time and using different collections of egg strings as well as details linked to copepodid concentration all impact infection success. Minimizing tank number, batch overlap and reliable copepodid estimation are very important variables to control. In this poster continuing difficulties and solutions to these issues will be discussed.

### **AQUACULTURE SEAWATER OXYGENTION SYSTEM (ASOS) DRIVEN BY SUSTAINABLE RENEWABLE ENERGY**

J Matei\*

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Climate change is affecting our oceans and all marine life throughout the world. This change in ocean warming and other factors, is affecting the levels of dissolved oxygen in the oceans throughout the world. AOE has coupled our patented Ocean Wave Energy System and designed and patented our Aquaculture Seawater Oxygenation System to provide a specific level of dissolved oxygen in seawater for both open-pen grow-out and land-based grow-out salmon farms which requires no fossil fuels and will dramatically reduce and eliminate the need for diesel fuel in remote operations.

### **EFFECTS OF STARVATION AND CHLOROQUINE ON AUTOPHAGY GENE EXPRESSION IN RAINBOW TROUT (*Oncorhynchus mykiss*) CELL LINES.**

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With gaps in knowledge regarding autophagy expression in fishes under variable conditions, comparisons need to be made between different cell lines on various media over time. The first

objective was to investigate the expression of ten genes related to autophagy in rainbow trout (*Oncorhynchus mykiss*) cell lines (liver (RTL) and gut (RTgut)) using nutrient-deprived (L15/ex and 2%FBS/L15) and nutrient-abundant media (10%FBS/L15). The second objective was to investigate how chloroquine (50 and 100µM) impacts the expression of genes related to autophagy in the RTL cell line over time. Several genes (*atg4*, *gabapap*, *lc3*) in the RTL and RTgut cell line experienced an upregulation at day one. Throughout the six-day experiment gene expression for *atg4*, *atg7*, *atg12*, *atg13*, *gabapap*, and *lc3* was increased in nutrient-deprived media, specifically the L15/ex. Chloroquine induced cell rounding and vacuolization, and the application of chloroquine in nutrient-deprived media further increased gene expression at day one. In conclusion, nutrient limitation in *O. mykiss* cell lines induces expression of numerous autophagy genes within one day, and with greater nutrient restriction (L15/ex media vs. 2%FBS/L15) more genes are upregulated. Finally, chloroquine up-regulated several autophagy genes, which is likely due to negative feedback from inhibition of downstream autophagy processes.

### **EVALUATING ECOCERTIFICATION STANDARDS FOR ATLANTIC SALMON (*Salmo salar*)**

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Given growth in aquaculture production and recognition of its effects on ecosystem functions, there is growing support for an Ecosystem Approach to Aquaculture (EAA) that promotes social and ecological sustainability. Governance tools that support EAA will be required to help manage current and future aquaculture in a way that maintains ecosystem services, improves human wellbeing, and is integrated with other sectors. Ecocertification is a potential tool in the operationalization of EAA and many ecocertification schemes include social, economic, and environmental standards; however, the proliferation of ecocertification schemes along with criticism of their credibility casts confusion and skepticism on them as effective tools. Therefore, the goal of this research is to critically assess the perceptions and relevance of indicators used in ecocertification and provide recommendations for incorporating EAA in this market-based form of aquaculture governance. Using a mixed-methods approach, this research will provide an evaluation of ecocertification standards based on (1) indicator responses to aquaculture stressors in a temporally and spatially patchy marine environment, (2) perceptions of the value, validity, and barriers that indicators bring to ecocertification, and (3) comparison of major ecocertification standards and their inclusion of indicators that reflect EAA principles. This analysis will provide insights into the role of ecocertification and ecosystem indicators in providing social licence in addition to operationalizing EAA.

### **PHYSIOLOGICAL AND TRANSCRIPTOMIC RESPONSE OF JUVENILE CHINOOK AND ATLANTIC SALMON EXPOSED TO MICROCYSTINS: AN INVESTIGATION INTO THE ETIOLOGY OF NET-PEN LIVER DISEASE**

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Net pen liver disease (NPLD) is toxicopathic liver disease of salmon characterized by liver damage including hepatic meglocystosis and liver inflammation. NPLD is thought to be caused by microcystin (MC) exposure. Historically, NPLD has been reported occasionally in wild and farmed salmonids in British Columbia, however, in recent years, the incidence and severity of NPLD has increased. We are examining the role of MC in the development of NPLD, as well as characterizing sub-lethal MC exposure effects on physiological processes (e.g. immune, endocrine, cardiac and metabolic) in Atlantic and Chinook Salmon. To this end we orally gavaged juvenile Atlantic and Chinook Salmon with different concentrations of MC-producing cyanobacteria, non-toxic cyanobacteria, and saline. Fish were sampled at 5 time points post-gavage (6, 12, 24, 72h and 2 weeks) and tissues (liver, kidney, brain, and muscle) were collected for histology, gene expression, and toxin analysis. Preliminary histopathology indicates hepatic structural changes beginning at 72h in both species. Changes observed in the laboratory are being compared to those reported for fish with NPLD collected at various sites in BC. We are also examining the transcriptional response of genes associated with liver structure, MC transport, immune and inflammatory response.

## **INTESTINAL ABSORPTION OF METHIONINE IN RAINBOW TROUT (*Oncorhynchus mykiss*)**

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Methionine (Met) is known as an essential amino acid (EAA) that participates in multiple important metabolic processes of animals. Salmonid species are highly efficient utilizing Met. Despite its importance, the physiological mechanism of Met absorption in the fish intestine is not thoroughly studied. Hence, this study is conducted to investigate different pathways of the intestinal absorption of Met in rainbow trout (*Oncorhynchus mykiss*) using <sup>14</sup>C radiolabeled Met flux. Ussing chamber was used to perform unidirectional mucosal to serosal DL-[<sup>14</sup>C]Met flux study at the concentration of substrate lower than 200 μM. The transport studies were carried out in the presence or absence of Na<sup>+</sup> to explore the Na<sup>+</sup>-dependent Met transport across pyloric caeca (PC), midgut (MG) and hindgut (HG). In the Na<sup>+</sup>-dependent transport study, the result showed that DL-[<sup>14</sup>C]Met flux rate exhibited saturable mechanism Michaelis-Menten with high affinity (K<sub>m</sub> < 10 μM). Meanwhile, the flux rate reduced substantially when sodium was removed from the buffer in the Na<sup>+</sup>-independent transport study. Additionally, the flux rate was higher in PC and MG than in HG. This could be attributed to higher expression of Na<sup>+</sup>-dependent transporter ASCT2 in PC and MG, and lower expression of y<sup>+</sup>LAT1 in HG. In conclusion, Met absorption was strictly dependent on sodium; and PC and MG had greater absorption capacity compared to HG.

**ALTERNATIVE BAIT FOR SNOW CRABS (*CHIONOECETES OPILIO*) AND AMERICAN LOBSTERS (*HOMARUS AMERICANUS*) TO IMPROVE THE SUSTAINABILITY OF CRUSTACEAN FISHERIES, AND INSIGHTS ON FEED ATTRACTANTS FOR CULTURED LOBSTERS**

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Snow crabs and lobsters are the most valuable exported species in commercial fisheries in Atlantic Canada; however, challenges are emerging in these industries. Changes in fishing seasons and restricted fishing zones have been implemented as one of the protective measures for endangered North Atlantic right whale. As a result, the commercial fishery season has been shortened in limited zones. Changes in fishing practices and an increase in aquaculture-raised crustaceans may be required in order to meet consumer demand. Fish bait is commonly used in traps to attract crustaceans, and traditional fish bait is generally caught or purchased from previous fishing seasons by fishermen. We tested two types of alternative feed/bait attractants and two types of lights to determine, and/or improve catchability given shorter fishery seasons, which supplemented traditional bait. The alternative attractants contain no fish meal and were stable at room temperature. Catchability was demonstrated in sea trials and lab experiments conducted on snow crabs and lobsters, respectively. Results from this project will suggest alternative options for bait in wild-capture fisheries, as well as insights on feed attraction techniques for use in aquaculture operations rearing lobsters and other crustacean species.