Research Module J: Improving Sustainability and Mitigating the Challenges of Aquaculture

Module Lead: Dr. Matt Rise (Dept. of Ocean Sciences, MUN)
Aquaculture

• Very important industry on Canada’s east and west coasts.

• Critical to global food supply – increasing demand for seafood and plateaued fishery production.

OFI’s Research Module J will:

• Strengthen and expand our significant capacity in aquaculture R&D.

• Further establish Memorial, Dalhousie and UPEI as world leaders in cold-ocean sustainable aquaculture.
Examples of Threats Facing Global Aquaculture

- Impacts of climate change (e.g. elevated temperature, hypoxia) on fish health and welfare.
- Infectious diseases (e.g. ISA, BKD, AGD, SRS, sea lice, co-infections) with limited options for prevention/treatment.
- Limited supply of marine ingredients (e.g., fish oil, fish meal) for aquafeeds, and unknown impact of plant-based diets on fish health.
- Canadian finfish industry primarily focused on production of one species – Atlantic salmon – need to diversify further.
Key Objectives of Research
Module J:

1. Develop sustainable and therapeutic diets for salmon.
2. Understand and mitigate the effects of pathogens and climate change on fish health and welfare.
3. Develop sustainable control measures for pathogens of cultured fishes.
4. Lessen the impact of aquaculture on the environment and wild fish populations.
5. Further develop the aquaculture production of emerging/alternative species.
ACADEMIC PARTNER INSTITUTIONS AND RESEARCHERS

- **Memorial University** – Matt Rise, Kurt Gamperl, Chris Parrish, Ian Fleming, Annie Mercier, **Javier Santander**, Kelly Hawboldt, Deepika Dave, **Jillian Westcott**, Iain McGaw, Mark Abrahams

- **Dalhousie University** – **Stefani Coombe**, Sarah Stewart-Clark

- **UPEI** – **Mark Fast**, Dave Speare

- **University of Waterloo** – Brian Dixon

- **Deakin University (Australia)** – Luis Afonso

- **HIOA (Oslo, Norway)** – Rune Andreassen

- **University of Oslo** – Sissel Jentoft

- **LabexMER** – David Mazurais, José Zambonino, Marie Vagner and Philippe Soudant
INDUSTRY AND OTHER STRATEGIC PARTNERS

- **EWOS Innovation** – development of sustainable grower and clinical salmon feeds
- **CATC** – developing SNP panels for selecting disease-resistant salmon broodstock
- **Cooke Aquaculture / Northeast Nutrition** – Atlantic salmon broodstock development; “cleanerfish” research, feed development
- **Somru BioScience** – developing custom antibodies and assays for key markers of salmon health
- **EWOS Chile** – large-scale feeding trials of clinical diets with infection and co-infection challenges
- **Elanco Canada Ltd** – vaccine and pharmaceutical production for salmonids
- **DFO** – Impact of farm salmon escapes on wild populations; impact of pathogens on farm and wild salmon
- **CSIRO (Australia)** – research on salmon environmental tolerances and physiology, and health
Module J: Key Infrastructure

1. Dr. Joe Brown Aquatic Research Building (Ocean Sciences Centre).

2. Cold-Ocean & Deep-Sea Research Facility (Ocean Sciences Centre).


5. Hoplite Research Lab and Aquatic Animal Facility (AVC-UPEI).
Module J, Project 1: Developing Sustainable and Therapeutic Diets for Salmon (Lead: Rise)

- OFI research will: use nutrigenomics and complementary research (e.g. lipid biochemistry, immunology) to assess the impact of sustainable (e.g. plant-based) grower diets and candidate clinical diets (e.g. including immune stimulants) on fish growth and disease susceptibility.

- Research will be conducted in collaboration with aquaculture feed companies (e.g. EWOS Innovation, Northeast Nutrition) and other partners (LabexMER, IMR, DAL).

- Research will utilize level II biocontainment facilities (MUN and UPEI) and functional genomics approaches to assess the impact of novel diets on disease susceptibility (e.g. ISA, SRS, sea lice).

**Research Outcomes:** Accelerate production of sustainable grower and pathogen-specific clinical diets that maximize growth and resistance to disease while maintaining product quality and nutritional value

**Collaborators:** Chris Parrish, Jillian Westcott, Javier Santander (MUN); Richard Taylor, Simon Wadsworth (EWOS Innovation); Mark Fast (UPEI); Stefani Colombo (Dalhousie prospective CRC fish nutrition)
Module J, Project 1: Research Complementary to Existing Collaborations

Novel feeds and ingredients
- Help to improve

Functional genomics

Pathogens and stressors
- Help to fight

Immune and stress biomarkers

Growth and metabolic biomarkers

Optimize growth performance

Optimize fish health and welfare
Module J, Project 2: Understanding and Mitigating the Effects of Pathogens and Climate Change on Fish Health (Lead: Gamperl, MUN)

- **OFI Research will**: provide a road map for adaptation of salmon aquaculture production to climate change, and to work collaboratively with Canadian industries to reduce disease related mortalities and loss of production.

- **This will be accomplished by**:
  
  Determining the lethal and sub-lethal environmental limits of current Atlantic salmon stocks.

  Identifying Atlantic salmon families that have an enhanced capacity to adapt to environmental challenges and mount robust pathogen-specific immune responses.

  Developing functional and diagnostic assays for assessing fish health and immune function, and the efficacy of vaccine formulations.

**Research Outcomes**: The knowledge, tools and framework to not only preserve, but to expand, the Canadian aquaculture and fish health industries.
Module J, Project 3: Developing Sustainable Control Measures for Pathogens of Cultured Fishes
Co-Leads: Santander (MUN) and Fast (UPEI)

• OFI Research will: develop efficient and sustainable methods (including immunological, chemotherapeutic, and biological) to control pathogens that impact current and/or new cultured fish species

• Some projects within this Module will include:

  Determining mode(s) of resistance that develop against therapeutants (e.g. sea lice and antibiotic treatments)

  Develop novel vaccines to combat commercially relevant fish pathogens of Atlantic salmon (e.g. *Piscirickettsia salmonis*, *Aeromonas salmonicida*)

  Further develop the use of “cleaner fish” (i.e., lumpfish and cunner) as a natural (biological) way of controlling sea lice at salmon aquaculture cage-sites

**Research Outcomes:** Novel and efficacious solutions to pathogen management that significantly enhance the sustainability of salmon aquaculture, and reduce the potential impact of pathogen occurrences at cage-sites on wild fish populations.
Module J, Project 4: Lessening the Impact of Aquaculture on the Environment and on Wild Fish Populations (Lead: Fleming, MUN)

OFI Research will:

• Utilize ecological and genomic approaches to study the impact of hybridization (wild x farmed) on the development, growth, survival, immune responses and behaviour of Atlantic salmon, model potential implications of various escape scenarios, and to explore mitigation strategies.

• Address issues related to waste resources management and biosecurity, and implement an integrated biorefinery (bioprocessing) approach for marine waste.

Research Outcomes:

Findings that will inform policy makers and others on conservation and aquaculture management strategies.

A reduction in aquaculture (biological) waste that is put into landfills or disposed of via other methods, and environmentally friendly (‘green’) products based on the extraction of compounds from aquaculture waste.
Module J, Project 5: Alternative Species and Emerging Priorities (Lead: Gamperl, MUN)

- OFI research will: conduct R&D on new candidate species with significant market potential, and respond to production issues and/or emerging priorities that the industry identifies.

1) R&D on new candidate / alternative species, including:

- Shellfish (oysters, mussels, scallops) research on broodstock quality, disease prevention and environmental stressors, and improved production methodologies

- Sablefish: R&D on nutrition during larval rearing and growout, disease prevention, and the optimization of larval rearing

- Sea Cucumbers: holothurian biology (e.g. reproduction, responses to environmental stressors, and ecology)

2) Production Issues and Emerging Priorities: (e.g., disease outbreaks, stocking of polyploid salmon, impact of environmental toxicants on farmed fish and shellfish etc.)

**Research Outcomes:** A strengthened, and diversified, Canadian aquaculture industry, and a research network (academic, government and industry) that works collaboratively and effectively to address threats to the industry.
Major Deliverables of Module J – First 4 Years

A significant number of trainees that have the required skills/expertise, research capacity, and industry connections and knowledge, to make significant contributions to the sustainability and growth of this important sector of the Canadian Economy.

~ 10 M.Sc. Students
~ 4 Post-Docs
~ 8 Ph.D. Students
- 1 Research Associate
- 5 Technical Staff with Key / Relevant Skills

Milestones

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<tr>
<th>Milestones</th>
<th>Time Frame</th>
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<tr>
<td>Biomarker platforms to assess impact of alternative raw materials on fish health</td>
<td>2 years</td>
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<tr>
<td>Develop <em>in vitro</em> methods and biomarker suites for evaluating feed ingredients</td>
<td>2 years</td>
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<tr>
<td>Molecular biomarker suites for assessing impact of clinical diets on co-infection</td>
<td>3 years</td>
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<td>Development of “cleanerfish” protocols and technologies to control sea lice</td>
<td>3 years</td>
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<tr>
<td>Innovative processes to extract marine by-products that are sustainable</td>
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<td>Identify factors that affect survival, dispersal and behaviour of escaped salmon</td>
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<tr>
<td>Determine the reproductive success of escaped salmon</td>
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<tr>
<td>Compare traits and genetics among pure and hybrid (farmed x wild) crosses</td>
<td>3 years</td>
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<tr>
<td>Information on lethal and sublethal environmental tolerances of salmon stocks</td>
<td>3 years</td>
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<td>Best practices for using cleanerfish for sea lice control at Canadian salmon farms</td>
<td>3 years</td>
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<tr>
<td>Novel diagnostics for assessing fish health and vaccine/treatment efficacy</td>
<td>4 years</td>
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<td>Optimization of rearing conditions for sablefish</td>
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SAFE AND SUSTAINABLE DEVELOPMENT OF THE OCEAN FRONTIER

A joint initiative with Dalhousie University, Memorial University and UPEI has been established to combine strengths of three Atlantic Canadian Universities.
CANADA’S COLD OCEAN AND ARCTIC UNIVERSITY

Memorial is poised to become a world-leader in Cold Ocean & Arctic Science, Technology & Society research and innovation.
THE OCEAN FRONTIER INSTITUTE

Ocean Frontier Institute (OFI) – a Canadian-led, transnational, global hub for ocean exploration and discovery.

The vision is to build an unprecedented, world-leading, integrated research program devoted to providing society with knowledge and innovations.

>20,000 sq. ft. dedicated to OFI in the Core Sciences Facility
Fish Vaccine Development at the Ocean Sciences Centre

1. Injectable and bath vaccines against bacterial diseases

• Intraperitoneal (i.p.) injection of inactivated bacteria is the most common method of fish vaccination.

• However, their effectiveness is questionable because vaccines for fish focus on the prevention of disease symptoms as opposed to the prevention of infection and transmission.

• We are focusing on essential virulence factors synthesized during infection to be utilized as broad immune protective antigens.

• Current targets:
  • Aeromonas salmonicida
  • Piscirickettsia salmonis
  • Renibacterium salmoninarum
  • Yersinia ruckeri
  • Vibrio anguillarum