

WOAH Collaborative Centre Reports Activities 2022

Activities in 2022

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Centre Information

Title of WOA Collaborating Centre	Epidemiology & Risk Assessment of Aquatic Animal Diseases (Americas)
Address of WOA Collaborating Centre	Atlantic Veterinary College, University of Prince Edward Island, Charlottetown, Canada
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Name Director of Institute (Responsible Official):	Dr. K. Larry Hammell
Name (including Title and Position) of Head of the Collaborating Centre (WOAH Contact Point):	Professor Larry Hammell
Name of the writer:	Larry Hammell

TOR1 AND 2: SERVICES PROVIDED

1. Activities as a centre of research, expertise, standardisation and dissemination of techniques within the remit of the mandate given by WOA

Epidemiology; aquatic animal diseases	
Title of activity	Scope
	Provides a database for use of industry and government to

Fish-iTrends health data support system	input and track selected fish health information at active marine farms in Atlantic Canada
Epidemiology, surveillance; aquatic animal diseases	
Title of activity	Scope
ISAV detection using different laboratories in Atlantic Canada.	Bayesian analysis of diagnostic sensitivity and specificity for detecting infectious salmon anemia virus (ISAV) using either IFAT or real-time RT-PCR testing from laboratories in Atlantic Canada.
Epidemiology, surveillance; aquatic animal diseases	
Title of activity	Scope
ISAV genotype evaluations	Associations of genotype viral CT values and disease detection.
Epidemiology, risk assessment; aquatic animal diseases	
Title of activity	Scope
Risk factors associated with ISAV occurrence in Atlantic Canada.	Quantification of risk factors related to ISAV outbreaks in Atlantic Canada based on retrospective environmental, production, mortality, treatment, and diagnostic records.
Epidemiology, risk assessment; aquatic animal diseases	
Title of activity	Scope
Infectious salmon anemia virus (ISAV) transmission models.	Computer model simulations of dynamics of ISAV transmission among Atlantic salmon farms with scenarios to mitigate spread and cost impacts.
Epidemiology, risk assessment; aquatic animal diseases	
Title of activity	Scope
Complex gill disease risk factors and mitigation measures.	Risk factors associated with complex gill disease (CGD) in farmed Atlantic salmon.
Training, Capacity building; aquatic animal diseases	
Title of activity	Scope
	Provide industry and government participants with

Training to support ongoing epidemiological research and data management for veterinarians and farmers.	standardized training on how to identify and classify life stages of skin parasites (particularly sea lice).
Wildlife; aquatic animal diseases	
Title of activity	Scope
Climate change impacts on epidemiological, genomic and ecological determinants of lobster disease.	Characterization of carapace, hemolymph, cuticular microbiomes of Canadian lobsters with and without epizootic shell disease (ESD); Risk of ESD in lobster fishing areas.
Aquatic animal diseases, epidemiology, surveillance	
Title of activity	Scope
Changes in virulence and pathogenicity of Infectious salmon anemia virus.	Review of diagnostic tests associated with changing patterns in disease events and pathogen detection
Aquatic animal diseases, epidemiology, surveillance	
Title of activity	Scope
Winter mortality patterns in Atlantic salmon.	Investigation into causes of increased mortalities of marine farmed Atlantic salmon during winter months using health surveillance data.
Aquatic animal diseases, epidemiology, surveillance	
Title of activity	Scope
Epidemiological investigation of emerging infectious diseases of farmed fish in Canada.	Evaluation of associations between ISAV and mouth rot, their causative agents, host, and environmental factors leading to clinical disease outbreaks.
Aquatic animal diseases, wildlife, epidemiology, surveillance	
Title of activity	Scope
Prudent antibiotic use and treatment management in Atlantic salmon farms.	Evaluation of effectiveness of current treatment practices at Atlantic salmon farms; develop novel intervention strategies; examine genetic AM resistance profiles of bacterial assemblages associated with farmed/wild populations.
Aquatic animal diseases, wildlife, epidemiology, surveillance	
Title of activity	Scope
Evaluation of sea lice infestation susceptibility of different	Investigation of cross-species variation in host resistance to sea lice; identification of genes responsible to inform long term

salmonid species.

integrated pest management strategy.

TOR3: HARMONISATION OF STANDARDS

2. Proposal or development of any procedure that will facilitate harmonisation of international regulations applicable to the main focus area for which you were designated

Proposal title	Scope/Content	Applicable area
Research and Harmonization of Aquatic Animal Health Management in Atlantic Canada – ONE COAST APPROACH TO FISH HEALTH	Proposed Harmonized Disease Monitoring, Prevention and Control Standards: Farm level fish health management for prevention of disease introduction and management of transmission and spread within and between localities.	Laboratory expertise Training and education health management Veterinary products

4. Did your Collaborating Centre maintain a network with other WOAHA Collaborating Centres (CC), Reference Laboratories (RL), or organisations designated for the same speciality, to coordinate scientific and technical studies?

Yes

Name of OIE CC/RL/other organisation(s)	Location	Region of networking Centre	Purpose

TOR4 AND 5: NETWORKING AND COLLABORATION

5. Did your Collaborating Centre maintain a network with other WOAHA Collaborating Centres, Reference laboratories, or organisations in other disciplines, to coordinate scientific and technical studies?

Yes

Name of OIE CC/RL/other organisation(s)	Location	Region of networking Centre	Purpose
Epidemiology and Risk Assessment of Aquatic Animal Diseases	Oslo, Norway	Europe	

Global Burden of Animal Diseases	Liverpool, UK	Europe	Discussion of opportunities to include aquatic food animal diseases in GBAD
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TOR6: EXPERT CONSULTANTS

6. Did your Collaborating Centre place expert consultants at the disposal of WOA?H?

Yes

NAME OF EXPERT	KIND OF CONSULTANCY	SUBJECT
Larry Hammell	Bulletin - Panorama	Capacity building using WOA?H Collaborating Centres
Larry Hammell	Aquatic Animal Focal Points regional seminar (Americas)	Activities and opportunities for interactions with WOA?H Collaborating Centre ERAAAD

TOR7: SCIENTIFIC AND TECHNICAL TRAINING

7. Did your Collaborating Centre provide advice/services to requests from Members in your main focus area?

Yes

Participated (virtually) in Aquatic Animal Focal Points meeting in Bogota, Columbia, March 2022.

8. Did your Collaborating Centre provide scientific and technical training, within the remit of the mandate given by WOA?H, to personnel from WOA?H Members?

Yes

a) Technical visit :

b) Seminars : 1

c) Hands-on training courses: 4

d) Internships (>1 month) :

TYPE OF TECHNICAL TRAINING PROVIDED (A, B, C OR D)	CONTENT	COUNTRY OF ORIGIN OF THE EXPERT(S) PROVIDED WITH TRAINING	NO. PARTICIPANTS FROM THE CORRESPONDING COUNTRY
b) seminars	Continuing Education virtual training for aquatic veterinarians	Canada, USA	23
c) hands-on training courses	Identification and life cycle staging for salmon parasites - multiple courses	Canada	68

TOR8: SCIENTIFIC MEETINGS

9. Did your Collaborating Centre organise or participate in the organisation of scientific meetings related to your main focus area on behalf of WOA?H?

Yes

NATIONAL/INTERNATIONAL	TITLE OF EVENT	CO-ORGANISER	DATE (MM/YY)	LOCATION	NO. PARTICIPANTS
International	Aquatic Epidemiology Session of International Society for Veterinary Epidemiology and Economics Conference	Larry Hammell, Krishna Thakur	2022-08-21	Halifax, NS, Canada	100-200
International	Eastern Aquaculture Veterinary Association annual conference (virtual)	Larry Hammell	2022-02-08	Charlottetown, PE, Canada	23

TOR9: DATA AND INFORMATION DISSEMINATION

10. Publication and dissemination of any information within the remit of the mandate given by WOA?H that may be useful to Members of WOA?H

a) Articles published in peer-reviewed journals:

15

Caballero-Solares A, Umasuthan N, Xue X, Katan T, Kumar S, Westcott JD, Chen Z, Fast MD, Skugor S, Taylor RG, Rise ML (2022).

*Interacting Effects of Sea Louse (*Lepeophtheirus salmonis*) Infection and Formalin-Killed *Aeromonas salmonicida* on Atlantic Salmon Skin Transcriptome. *Front Immunol.* Mar 24;13:804987. doi: 10.3389/fimmu.2022.804987.*

*Cai W, Kumar S, Navaneethaiyer U, Caballero-Solares A, Carvalho LA, Whyte SK, Purcell SL, Gagne N, Hori TS, Allen M, Taylor RG, Balder R, Parrish CC, Rise ML, Fast MD (2022). Transcriptome Analysis of Atlantic Salmon (*Salmo salar*) Skin in Response to Sea Lice and Infectious Salmon Anemia Virus Co-Infection Under Different Experimental Functional Diets. *Frontiers in Immunology.* 03 January Sec. Comparative Immunology, Vol 12. <https://doi.org/10.3389/fimmu.2021.787033>*

*Crossman AH, Ignatz EH, Hall JR, Kumar S, Fast MD, Eslamloo K, Rise ML (In Press 2023). Basal and immune-responsive transcript expression of two Atlantic salmon interferon regulatory factor 2 (*irf2*) paralogues. *Developmental & Comparative Immunology*, 104689. <https://doi.org/10.1016/j.dci.2023.104689>.*

Delphino M, Laurin E*, Patanasatienkul T, Rahardjo R, Hakim L, Zulfikar W, Burnley H, Hammell L, Thakur K (2022). Description of biosecurity practices on shrimp farms in Java, Lampung, and Banyuwangi, Indonesia. *Aquaculture.* 2022 Jul 15;556:738277. doi.org/10.1016/j.aquaculture.2022.738277*

Delphino M, O'Brien N, Laurin E*, Whelan D, Burnley H, Hammell L, Thakur K (2022). Bayesian analysis of diagnostic sensitivity and specificity for detecting infectious salmon anemia virus (ISAV) using IFAT versus qRT-PCR testing from three different laboratories in Atlantic Canada. *Aquaculture.* 2023 Jan 30;563:739006.*

Eslamloo K, Kumar S, Xue X, Parrish KS, Purcell SL, Fast MD, Rise ML (2022). Global gene expression responses of Atlantic salmon skin to

Moritella viscosa. *Scientific Reports*, Vol 12: 4622. <https://doi.org/10.1038/s41598-022-08341-7>

Kopper S*, Scott-Tibbetts S, Lavallée J, Revie C, Thakur K (2021). Fisheries dataset on moulting patterns and shell quality of American lobsters *H. americanus* in Atlantic Canada. *Scientific Data*, 9(1), 1-8

Laurin E*, Delphino M*, Burnley H, Hammell L, Thakur K (2022). Infectious disease detection associated with trends in production, environmental, and biosecurity factors for shrimp (*Litopenaeus vannamei* and *Penaeus monodon*) production systems in Banyuwangi, Indonesia. *J Fish Dis*, doi.org/10.1111/jfd.13621

Ojasanya RA*, Gardner IA, Groman D, Saksida S, Saab ME, Thakur K (2022). Antimicrobial susceptibility profiles of bacteria commonly isolated from farmed salmonids in Atlantic Canada (2000-2021). *Vet Sci*, 9(4), doi.org/10.3390/vetsci9040159

Ojasanya RA*, Gardner IA, Groman D, Saksida S, Saab ME, Thakur K (2022). Development and validation of main spectral profile for rapid identification of *Yersinia ruckeri* isolated from Atlantic salmon using matrix-assisted laser desorption ionization time-of-flight mass spectrometry. *Front Vet Sci*, DOI 10.3389/fvets.2022.1031373

Rise ML, Caballero-Solares A, Xue X, Cai W, Hall JR, Navaneethaiyer U, Eslamloo K, Kumar S, Smith NC, Taylor RG, Balder R, Andreassen R, Parrish CC, Fast MD. 2022. Aquaculture nutrigenomics and immunogenomics research: toward development of sustainable and therapeutic diets for salmon. *Aquaculture Canada and WAS North America 2022*. <https://www.was.org/Meeting/Program/PaperDetail/159458>

Robinson NA, Robledo D, Sveen L, Daniels RR, Krasnov A, Coates A, Jin YH, Barrett LT, Lillehammer M, Kettunen AH, Phillips BL, Dempster T, Doeschl-Wilson A, Samsing F, Difford G, Salisbury S, Gjerde B, Haugen J-E, Burgerhout E, Dagnachew BS, Kurian D, Fast MD, Rye M, Salazar M, Bron JE, Monaghan SJ, Jacq C, Birkett M, Browman HI, Skiftesvik AB, Fields DM, Selander E, Bui S, Sonesson A, Skugor S, Østbye T-KK, Houston RD (2023). Applying genetic technologies to combat infectious diseases in aquaculture. *Rev Aquac*. 15(2):491-535. doi:10.1111/raq.12733

Romero J*, Gardner I, Hammell L, Groman D, Whelan D, O'Brien N, Hawkins L, Burnley H, Thakur K (2022). Descriptive epidemiology of variants of infectious salmon anaemia virus in four Atlantic salmon farms in Newfoundland and Labrador, Canada. *J Fish Dis*, doi.org/10.1111/jfd.13617

Romero JF, Gardner IA, Saksida S, McKenzie P, Garver K, Price D, & Thakur K (2022). Simulated waterborne transmission of infectious hematopoietic necrosis virus among farmed salmon populations in British Columbia, Canada following a hypothetical virus incursion. *Aquaculture*, 548, 737658. doi:10.1016/j.aquaculture.2021.737658

Soto E, Fast MD, Purcell SL, Coleman DD, Yazdi Z, Kenelty K, Yun S, Camus A (2022). Expression of immune markers of white sturgeon (*Acipenser transmontanus*) during *Veronaea botryose* infection at different temperatures. *Comparative Biochemistry and Physiology Part D: Genomics and Proteomics*, Vol 41. <https://doi.org/10.1016/j.cbd.2021.100950>

b) International conferences:

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Fajei E, Cai WC, Whyte SK, Despres B, Fast MD. Implications of PACAP-38 (pituitary adenylate cyclase activating polypeptide) immunophysiology. *Veterinary Vaccine Conference, November 30, 2022. Varadero, Cuba. (Oral presentation by Fajei)*

Fajei E, Cai WC, Whyte SK, Despres B, Fast MD. Boosting tilapia (*Oreochromis niloticus*) immune responses to *Flavobacterium columnare* using PACAP (pituitary adenylate cyclase activating polypeptide) Part II. *North American Comparative Immunology Workshop, June 6-9, 2022. Banff, Alberta, Canada. (Oral presentation by Fajei)*

Fajei E, Cai WC, Whyte SK, Despres B, Fast MD. Boosting tilapia (*Oreochromis niloticus*) immune responses to *Flavobacterium columnare* using PACAP (pituitary adenylate cyclase activating polypeptide) Part II. *North American Comparative Immunology Workshop, June 6-9, 2022. Banff, Alberta, Canada. (Oral presentation by Fajei)*

Kumar S, Eslamloo K, Parrish K, Fast MD, Rise M. Identifying isoform switches in Atlantic salmon, *Salmo salar*, infected with *Moritella*

viscosa. Aquaculture Association of Canada and WAS North American Meeting, St. John's, Nfld, Canada, August 15-18, 2022. (Oral presentation by Kumar)

Groves, S.K. Whyte, S.L. Purcell, A.F. Garber, M. D. Fast. Climate change and infectious salmon anemia (ISA): How will the Atlantic salmon (*Salmo salar*) immune system defend against the ISA virus with increasing ocean temperatures? North American Comparative Immunology Workshop, June 6-9, 2022. Banff, Alberta, Canada. (Oral presentation by Groves)

Ojasanya R, Gardner I, Groman D, Saksida S, Saab M, Thakur K (2022) Antimicrobial susceptibility patterns of bacteria commonly isolated from farmed salmonids in Atlantic Canada (2000-2021), ISVEE (International Symposium of Veterinary Epidemiology and Economics) 2022 Halifax Canada

Eslamloo K, Kumar S, Caballero-Solares A, Purcell SL, Whyte SK, Lo J, Tibbetts S, Wang Y, Fast MD, Rise ML. Profiling the global gene expression response of Atlantic salmon to enteric redmouth disease. Aquaculture Association of Canada and WAS North American Meeting, St. John's, Nfld, Canada, August 15-18, 2022. (Oral presentation)

Jia BB, Saksida S, Frisch K, Whittaker P, Fast MD. Risk factors of complex gill disease in farmed Atlantic salmon in British Columbia, Canada. ISVEE, Halifax, NS, Canada, August 7-12, 2022. (Poster presentation)

Salisbury SJ, Ruiz Daniels R, Gervais O, Villamyor PR, Monaghan S, Bron JE, Sveen L, Fast MD, Houston R, Robledo D, Robinson N. Investigating the genetic underpinnings of sea lice resistance in salmonids with single nuclei RNA sequencing. 39th Annual ISG conference. (Oral presentation by Salisbury)

Caballero-Solares A, Navaneethaiyer U, Jakob E, Kumar S, Xue X, Balder R, Skugor S, Taylor RG, Fast MD, Rise ML. Dietary immunostimulation: A powerful tool against *Caligus rogercresseyi* and *Piscirickettsia salmonis* co-infection in farmed Atlantic salmon. Aquaculture Association of Canada and WAS North American Meeting, St. John's, Nfld, Canada, August 15-18, 2022. (Oral presentation by Caballero-Solares)

Navaneethaiyer U, Xue X, Caballero-Solares A, Pino J, Jakob E, Skugor S, Taylor RG, Fast MD, Rise ML. Atlantic salmon head kidney gene expression responses during single (bacterial) and co (bacterial and sea lice) infections. Aquaculture Association of Canada and WAS North American Meeting, St. John's, Nfld, Canada, August 15-18, 2022. (Oral presentation)

Michaud D, Braden LM, Weeks B, Trudel, M., Fast MD. Assessing the evolution of virulence of the salmon louse (*Lepeophtheirus salmonis*) in the Bay of Fundy. Aquaculture Association of Canada and WAS North American Meeting, St. John's, Nfld, Canada, August 15-18, 2022. (Oral presentation)

Cardé EMQ, Anenson K, Littman E, Yun S, Waldbeiser G, Fast MD, Griffin M, Brown CT, Soto E. Design and validation of a qPCR assay for diagnosis of Acipenserid Herpesvirus 2 in White sturgeon (*Acipenser transmontanus*) tissues. ISAAH (International Symposium on Aquatic Animal Health, Santiago, Chile, September 5-8, 2022. (Oral presentation by Cardé)

Cardé EMQ, Anenson K, Littman E, Yun S, Fast MD, Griffin M, Soto E. Effects of previous Acipenserid Herpesvirus 2 infection on White sturgeon (*Acipenser transmontanus*) mortality after a *Streptococcus iniae* challenge. 61st Western Fish Disease Workshop, Hood River, Oregon, USA, May 16-18, 2022. (Oral presentation by Anenson)

Cardé EMQ, Yun S, Waldbeiser G, Fast MD, Griffin M, Brown CT, Soto E. Whole-genome sequencing of Acipenserid Herpesvirus 2 and identification of potential host homologues. 61st Western Fish Disease Workshop, Hood River, Oregon, USA, May 16-18, 2022. (Oral presentation by Cardé)

Michaud D, Braden LM, Weeks B, Trudel M, Fast MD. Assessing the evolution of virulence of the salmon louse (*Lepeophtheirus salmonis*) in the Bay of Fundy. 13th International Sea Lice Conference, Faroe Islands, May 9-13, 2022. Oral presentation by Michaud)

Shartau RB, Turcotte L, Caballero-Solares A, Snyman H, McCarron P, Bradshaw JC, Rise ML, Fast MD, Johnson SC. Acute cellular changes and potential fish health biomarkers resulting from toxic cyanobacteria exposure in juvenile Atlantic salmon (*Salmo salar*). Annual Meeting of the Texas Chapter of the American Fisheries Society, Mo Ranch, Texas, USA, May 17-19, 2022. (Oral presentation by Shartau)

Ruiz Daniels R, Salisbury S, Gervais O, Villamayor PR, Monaghan SJ, Bron JE, Sveen L, Fast MD, Houston R, Robledo D, Robinson N. Using snRNA-seq to elucidate comparative resistance to sea lice in salmonids. 6th International symposium on Genomics in Aquaculture, Granada, Spain, May 4-6, 2022. (Oral presentation by Ruiz Daniels)

Thakur K. Sustainability of fisheries and aquaculture at the interface of climate change and emerging infectious diseases. Special Session on Aquatic Epidemiology in the 16th International Symposium of Veterinary Epidemiology and Economics, August 2022, Halifax, Canada

Thakur K. Sustainability of fisheries and aquaculture at the interface of climate change and emerging infectious diseases: What Aquatic Epidemiology has to offer? Aquatic Epidemiology Symposium, Japan Society of Veterinary Epidemiology Conference, Virtual, March 2022

Koepper S, Revie CW, Clark KF, Thakur K. The Shell Microbiome of American lobster *Homarus americanus* in Atlantic Canada. Poster presented (Virtual) at the at the 9th International Symposium on Aquatic Animal Health, Santiago, Chile, September 2022

Romero J, Gardner I, Valdes-Donoso P, Groman D, Thakur K. Use of Simulation Modelling for Cost-Effectiveness Analysis of Infectious Disease Management Options in Marine Salmon Aquaculture. Presented at the at the 9th International Symposium on Aquatic Animal Health, Santiago, Chile, September 2022

Jeong J, Awosile B, Thakur K, Stryhn H, Morrison D, Kamaitis M, Vanderstichel R. Longitudinal Dissolved Oxygen Patterns in Atlantic Salmon Aquaculture Sites in British Columbia, Canada. Presented at the at the 9th International Symposium on Aquatic Animal Health, Santiago, Chile, September 2022

Romero J, Gardner I, Saksida S, Price D, Garver K, Thakur K. Overview of a Simulation Framework for Evaluation of Mitigation Strategies to Reduce Waterborne Spread of Viral Diseases in Marine Aquaculture. Presented at the 9th International Symposium on Aquatic Animal Health, Santiago, Chile, September 2022

Ojasanya RA, Gardner IA, Saab ME, Thakur K. Test validation of matrix-assisted laser desorption/ionization time of flight mass spectrometry for the identification of *Yersinia ruckeri* isolated from Atlantic salmon. Poster presented at the 16th International Symposium of Veterinary Epidemiology and Economics, Halifax, NS, August 2022

O'Brien N, Whelan D, Romero J, Gardner I, Hammell L, Hawkins LJ, Thakur K. Epidemiologic description of Infectious salmon anaemia virus outbreaks at four Atlantic salmon (*Salmo salar*) marine sites in 2020, in Newfoundland and Labrador, Canada. Presented at the 16th International Symposium of Veterinary Epidemiology and Economics, Halifax, NS, August 2022

Ojasanya RA, Gardner IA, Groman D, Saksida S, Saab ME, Thakur KK. Antimicrobial susceptibility patterns of bacteria commonly isolated from farmed salmonids in Atlantic Canada (2000-2021). Presented at the 16th International Symposium of Veterinary Epidemiology and Economics (SVEE), Halifax, NS, August 2022

Romero J, Gardner I, Saksida S, Groman D, Thakur K. Simulating the economic effects of infectious salmon anaemia outbreak management in expanding salmon aquaculture operations. Presented at the 16th International Symposium of Veterinary Epidemiology and Economics (ISVEE), Halifax, NS, August 2022

Koepper S, Revie CW, Clark KF, Thakur K. The shell microbiome of American lobster *Homarus americanus* in Atlantic Canada. Presented at the 16th International Symposium of Veterinary Epidemiology and Economics, Halifax, NS, August 2022

Gautam M, Hammell L, Burnley H, O'Brien N, Whelan D, Thakur K. Spatio-temporal patterns of infectious salmon anemia virus (ISAv) outbreaks in marine salmon farms in Newfoundland and Labrador. Presented at the 16th International Symposium of Veterinary Epidemiology and Economics, Halifax, NS, August 2022

Ojasanya RA, Gardner IA, Groman D, Saksida S, Saab ME, Thakur KK. Antimicrobial susceptibility patterns of bacteria commonly isolated from farmed salmonids in Atlantic Canada (2000-2021). Presented at the Eastern Aquaculture Veterinary Association Meeting, Virtual, February 2022

c) National conferences:

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Fajei E, Cai WC, Whyte SK, Despres B, Fast MD. Assessing impacts of PACAP-38 (pituitary adenylate cyclase activating polypeptide) on infectious Nile tilapia (Oreochromis niloticus) immunophysiology. Canadian Emerging Veterinary Scholar Summit, November 4, 2022. Alberta, Calgary, Canada. (Oral presentation by Fajei)

Eslamloo K, Kumar S, Fast MD, Caballero-Solares A, Gnanagobal H, Santander J, Inkpen SM, Emam M, Bouniot C, Avendaño-Herrera R, Jakob E, Xue X, Parrish C, Purcell SL, Colombo SM, Balder R, and Rise ML. Development of Omics tools to aid in the development of novel anti-bacterial salmon diets. OFI research conference, Halifax, NS, May 18-21, 2022. (Oral presentation by Rise)

Manriquez-Hernandez JA, Tibbetts SM, Fast MD, Goldberg SR, Colombo SM. Use of astaxanthin extracted from the microalgae Haematococcus pluvialis in Atlantic salmon diets. OFI research conference, Halifax, NS, May 18-21, 2022. (Poster presentation)

Koepper S, Revie CW, Stryhn H, Clark KF, Scott-Tibbetts S, Thakur K. Spatial and temporal patterns in the sex ratio of American lobster in southwestern Nova Scotia, Canada. Poster Presented at the Ocean Frontier Institute Conference, Halifax, NS, May 2022

d) Other (Provide website address or link to appropriate information):

Saksida SM, Fast M, Garver K, Johnson S. (in press) Movement of infectious agents between wild and farmed fish (Chapter 9). Diseases and Disorders of Finfish in Cage Culture (3rd edition). Woo and Subasinghe eds.

11. What have you done in the past year to advance your area of focus, e.g. updated technology?

12. Additional comments regarding your report: