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NOVA SCOTIA AQUACULTURE REVIEW BOARD

IN THE MATTER OF: *Fisheries and Coastal Resources Act*, SNS 1996, c 25

- and -

IN THE MATTER OF: An Application by KELLY COVE SALMON LTD. for a boundary amendment and two new finfish aquaculture licenses and leases for the cultivation of Atlantic salmon (*Salmo salar*) - AQ#1205x, AQ#1432, AQ#1433, in Liverpool Bay, Queens County (the "**Application**")

Affidavit of Shawn Robinson, PhD affirmed on January 19, 2024

I affirm and give evidence as follows:

1. I am Shawn Robinson, PhD of St. Andrews, New Brunswick. I was a research scientist with the Government of Canada, Department of Fisheries and Oceans until my retirement in 2022. I am currently a senior scientist with Longline Environment, a UK research and innovation company providing services to a variety of industries, including aquaculture.

2. I have personal knowledge of the evidence affirmed in this affidavit except where otherwise stated to be based on information and belief.

3. I state, in this affidavit, the source of any information that is not based on my own personal knowledge, and I state my belief of the source.

4. I have been retained by Kelly Cove Salmon Limited ("**KCS**") to provide my independent expert opinion to the Nova Scotia Aquaculture Review Board in connection with KCS's Application to expand its Atlantic salmon operations at Coffin Island (AQ#1205X) and for two new Atlantic salmon aquaculture farms at Mersey Point (AQ#1433) and Brooklyn Point (AQ#1432).

5. In particular, I have been asked for my independent expert opinion with respect to the effect of the KCS's proposed expansion of its salmon aquaculture operations on the American lobster population in Liverpool Bay.

6. My independent opinion is set out in my report attached as **Exhibit A**.

7. My CV is attached as **Exhibit B**.

VIRTUALLY AFFIRMED before me in Halifax, Nova Scotia, on MS Teams with Mr. Robinson in St. Andrews, New Brunswick on January 19, 2024.

[redacted]

Barrister of the Supreme Court of Nova Scotia

[redacted]

Shawn Robinson, PhD

TAB A

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KCS' Application re AQ#1205X, AQ#1432, AQ#1433 in Liverpool Bay, Queens County

This is Exhibit A referred to in the Affidavit of Shawn Robinson, PhD, affirmed virtually before me on January 19, 2024.

[redacted]

Barrister of the Supreme Court of Nova Scotia

ARB Review Submission – Lobster/Farm Interactions

Shawn Robinson, Ph.D.
Longline Environment, 63 St Mary Axe, London, EC3A 8AA, United Kingdom

Introduction

1. I have been retained by Kelly Cove Salmon Limited ("**KCS**") to provide my independent expert opinion to the Nova Scotia Aquaculture Review Board in connection with KCS's Application to expand its Atlantic salmon operations at Coffin Island (AQ#1205X) and for two new Atlantic salmon aquaculture farms at Mersey Point (AQ#1433) and Brooklyn Point (AQ#1432).

2. In particular, I have been asked for my independent expert opinion with respect to the effect of the KCS's proposed expansion of its Atlantic salmon aquaculture operations in Liverpool Bay on the American lobster population in Liverpool Bay.

Historical Background

3. Canada has been a dominant player in the marine food production industry and has a long history of fishing dating back over 500 years with the activity of the early Portuguese fishers off the Grand Banks of Newfoundland[1]. To understand where we are going with marine food production, it is valuable to have some insight on where we have been. In the 1950's, Canada ranked 5th in the world for total fisheries production, but over time, that rank has diminished to the point where Canada is now 28h in the world as of 2021 and

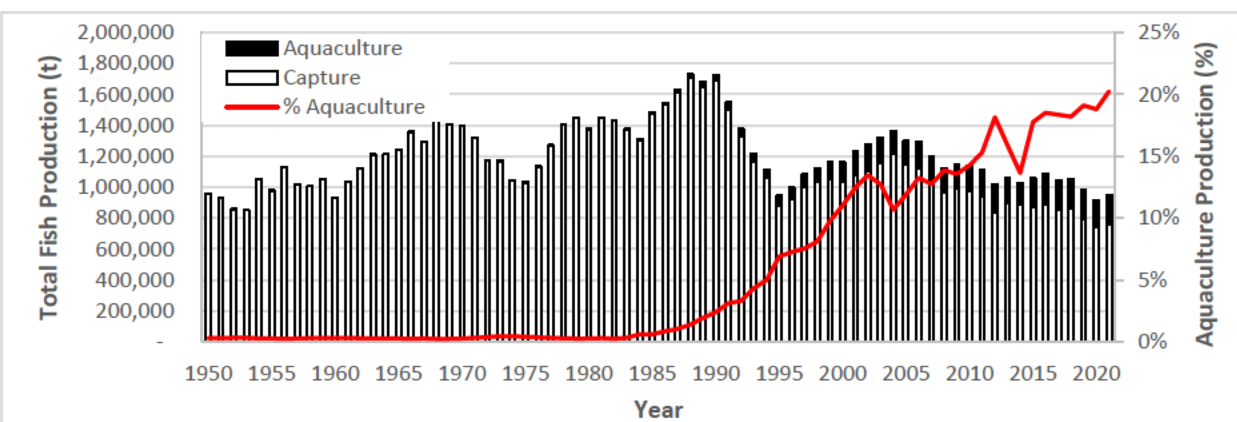

Figure 1. Time series of total Canadian aquatic production from capture fisheries and aquaculture. The line represents the annual percentage of aquaculture contribution to the total production. Data are from FAO. 2023. Fishery and Aquaculture Statistics. Global capture production 1950-2021 (FishStatJ). In: FAO Fisheries and Aquaculture Division [online]. Rome. Updated 2023. www.fao.org/fishery/en/statistics/software/fishstatj

still dropping[2]. Within Canada, the majority of the seafood production still comes from harvest fisheries (80%). Any significant aquaculture production did not occur until the early 1990s (Fig. 1), although there was some farming for trout and oysters in a few local areas. Since that time, fishery landings have continually dropped by approximately 50% and aquaculture has grown to represent 20% of the roughly 1 million tons of seafood produced in Canada in 2021[3]. The value of the entire Canadian wild fisheries in 2021 was approximately $4.6 billion[3], of which the American lobster (*Homarus americanus*) on the east coast represented 44.1% of the total value. Comparatively, the value of the Canadian aquaculture industry in 2021 was approximately $1.3 billion, of which farmed Atlantic salmon from the east coast represented 22.8% of the total value. Overall, in Canada, salmon represent approximately 75% of the value of the aquaculture industry and 63% of the volume[3].

4. The lobster fishery on the east coast of North America has experienced some dramatic increases in landings since 1990 with landings increasing over 150%, along with the associated economic benefits to the local economies (Fig. 2). The dominant fishery is in the Gulf of Maine where fishers from both the USA and Canada (primarily Nova Scotia) catch and land lobsters, but landings are also significant for New Brunswick in the Bay of Fundy and Quebec[2,3]. In New England, the recent increase in lobster landings created such a demand for lobster bait (herring primarily) that there were shortages and it was known as the “bait crisis”[4,5]. However, there are now potentially significant changes happening in the overall lobster fishery as the effects of climate change begin to show, changing distributions and challenging management strategies[5-12].

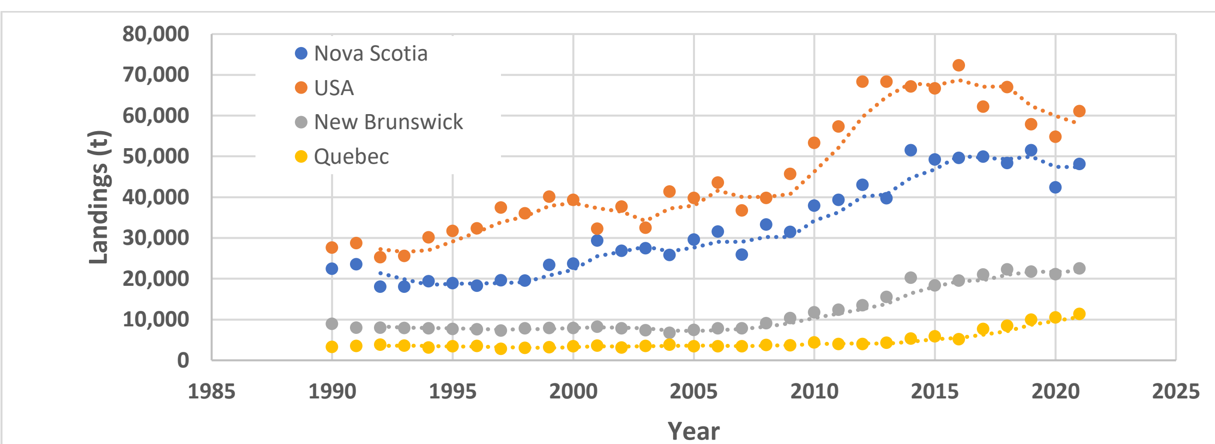

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Figure 2. Lobster landings over time from the Gulf of Maine and Gulf of St. Lawrence geographic regions. Fitted lines are 5-point running means. Data are from DFO Statistics Division (https://www.dfo-mpo.gc.ca/stats/commercial/sea-maritimes-eng.html.)

5. Lobsters have begun to move north away from the southerly warming waters and as a result, are much less available to the fishers in the southern Gulf of Maine[8]. The peaking of landings and slow decline from the USA landings are readily apparent in Figure 2. Interestingly, there also appears to be a plateauing in the Nova Scotia landings possibly indicating a potential upcoming drop similar to that experienced by fishers in the USA, although unfortunately, the data only go up to 2021 as the most recent landings have not yet been posted publicly. However, word-of-mouth from fishers in the Yarmouth area in December 2023 suggest that opening day lobster landings are down significantly from previous years (Robinson personal observation).

6. In comparison to lobsters, the Atlantic salmon aquaculture industry in Canada, and globally, is a relative newcomer to the marine food economy. Starting in the mid-1980's, the salmon aquaculture industry has grown steadily and produces about 3 million tonnes of product a year (2021)[2], which highlights the growing acceptance and demand for their product (Fig. 3).

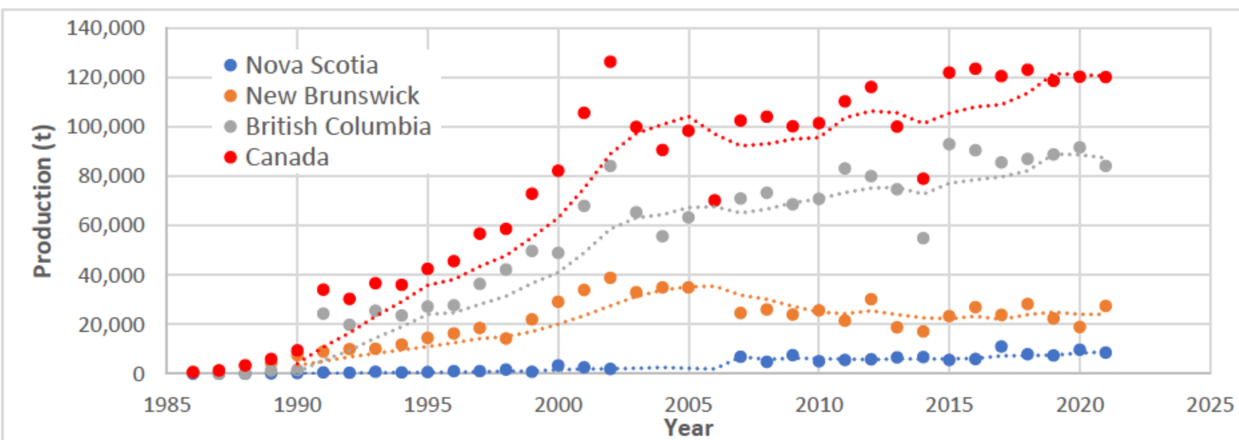

Figure 3. Salmon production over time broken down by province. Fitted lines are 5-point running means. Data are from DFO Statistics Division (https://www.dfo-mpo.gc.ca/stats/commercial/sea-maritimes-eng.html.)

7. Canada produces about 120,000 tonnes of salmon annually, as of 2021[3]. British Columbia produces the major share of the fish (70%) followed by New Brunswick (22%), and Nova Scotia (7%). In comparison to other Atlantic salmon producing areas of the world, Canada is the 4th largest grower, but only produces 4% of the farmed salmon based on records from 2021; about the same as the Faroe Islands[2]. Norway and Chile dominate the market.

8. With the overall value and employment represented by lobsters and salmon to the coastal economies of the Maritimes, it is imperative to the local communities, who derive the benefits, that both of these industries coexist with each other, ideally with no detrimental effects to either operation. Determining and managing the interactions and the effects between the two industries is complicated as the lobster fishery is more dispersed in its area of operation while the salmon farming industry is more concentrated in space; both using totally different approaches to the production of seafood. How lobsters might be impacted by these seafood-producing industries creates even more uncertainty as lobsters are notoriously difficult to study in the wild since they live in relatively deep water which affects direct observation, are long-lived, are seasonally mobile, act as refuging predators that can spend part of their time hidden under rocks and are most active at night[13].

9. The goal of my review is to further contribute to the information available on what we know about the interactions between lobsters and Atlantic salmon farming for the purpose of assessing the risk associated with the expansion of the salmon aquaculture industry in Nova Scotia for the use of industry, public managers, the other area users and the salmon farming industry itself. There have been other broader summaries compiled that review the general lobster-salmon farming interactions[14] and also assess the risk with the proposed expansion of the salmon farming infrastructure in Liverpool Bay[15]. I hope that this report will complement some of that information, based on my research experiences in the Bay of Fundy and Atlantic coast over the last 3 decades.

10. There are a number of categories of potential interactions between fish farms and lobsters. They are:

(a) Biological;

(b) Environmental;

(c) Animal health (minimal review in this report); and

(d) Genetic (not reviewed in this report).

Biological Interactions

11. Considering the value of the Maritime lobster fishery in southwest Nova Scotia, it is surprising there are not more biological/ecological studies done in this area. Within the Liverpool Bay area under discussion, there are relatively few direct observational studies done on the lobsters. The most recent studies in the near-region (Port Mouton) have collaborated with the local lobster fishers and used their catch statistics to infer some of the dynamics that may be occurring between the salmon farming and lobster fishing industries[16-18]. Some of the published papers from these studies reported the subjective observations made by lobster fishers during the development of the salmon farming industry[18] while others analyzed the catch-per-unit effort (kg of lobsters per trap haul)[16,17]. The conclusions from these studies were that salmon farms had a negative effect on lobsters and drove larger commercial-sized lobsters away from the farm area as well as reproductively mature females with eggs (berried lobsters). The authors also felt there was a weak interaction with water temperature, but the dataset used was not extensive enough to make any significant conclusions. Up until 2019, these were the best data available in Nova Scotia (11 years of catch observations) to judge the effect of salmon farming on lobster behaviour, even though the conclusions were mostly based on correlation. There was some criticism published in the literature on the conclusions from these studies[19], but most of the objections revolved around the study design and the extrapolation of trends in the dataset. Needless to say, the original authors disagreed[20].

12. In New Brunswick, in response to similar concerns about the potential negative interactions that may arise from salmon farms on lobsters, an 8-year study was initiated (2008-2015) on Grand Manan to examine changes in lobster abundance over time. Unlike the Nova Scotia studies which were based on commercial trapping records, the New Brunswick study used diver-based surveys of lobsters at the farm and reference sites during the summer months when the lobster abundance was highest and prior to their seasonal migration into deeper water during the fall and winter months[21]. The conclusions of this study were that there were no detectable interactions between the salmon farm and the local lobster populations or the associated fishery.

13. The above regional studies were both ambitious and commendable for the effort and costs that were involved in carrying them out. Working in the field is almost always exceedingly difficult to generate extensive and representative data sets, particularly when it involves

boats, people and limited financial resources and time periods. Both of these studies were based on catch-per-unit-effort (CPUE) approaches, one with lobster traps and the other visually with divers. Two analytical obstacles that both studies had to overcome were: 1) the uniform catchability (known as q in the fishery theory) of the lobsters among the different study areas and 2) the ability to detect a subtle signal within a larger external one (rapidly increasing landings). CPUE studies are known to be problematic in determining the state of fish populations as the probability of capturing an animal has to remain the same across all the sampling stations and times[22]. If the catchability is not the same, then the conclusions may not accurately reflect the reality of the changes in population densities. In lobsters in southwestern Nova Scotia, it has been shown that catchability with traps does not remain constant over the season or even with habitat (boulders vs. low relief areas)[23]. In Port Mouton and Grand Manan, the zones in the study area were different in relation to the benthic habitat, so this was an element of variability that was not accounted for. The other issue regarding the conclusions of the studies was that the work was conducted during a time when the lobster population was dramatically increasing and fishery landings continued to increase year after year setting new historical records. If the signal for the interaction between salmon farms and the lobsters was subtle, it may never have been detectable within the larger variability associated with the overall lobster population increases. For example, the lobster catch rates in the Port Mouton study were about 1 Kg/trap haul in the early spring as the lobsters were moving into shallower water[17]. This is about an order of magnitude lower than some of the landings that were achieved in 2019 during our study in Liverpool (see below). This does not mean that the Port Mouton data were flawed, but that the differences in catch rates could be related to either lobster density, catchability or a combination of both, making the subsequent interpretation difficult on top of the very strong signal of a regionally expanding lobster population.

14. Obviously, the interaction between wild species and aquaculture operations is a complex one and one that is of interest to resource managers, both domestically and internationally, as aquaculture expands. There have been several reviews done on the subject that show that there is both an attractive and a repulsive nature to farms[24]. As to be expected, the answers are not simple and depend on the magnitude of the stressor, the time frame, susceptibility of the organisms etc. Short-term predictions are much easier than longer term ones due to the complexity of the interactions and modelling is often used as a tool for assessing potential impacts and scales[25-29] with the large amounts of data to be

interpreted. However, models are only as good as the data used to create them and therefore empirical information is still required to answer management questions.

15. For lobsters, the current pressing management issue is whether salmon farms repel lobsters, based on the CPUE work (above). To answer this question, a new approach was required to generate some information. Technology has provided some interesting options as electronic miniaturization of tracking tags has permitted scientists to use them to unobtrusively follow animal movements over time and space. This is an active and growing field of research for marine animals including crustaceans[30]. Basically, a transmitter is attached to an animal that transmits a signal (e.g. a few minutes to hours) that can be detected by a grid of receivers (essentially microphones). These receivers will then triangulate the signal and determine the position, just like cell phones on a tower network. This provides a long-term record of the position of the animal from which interpretations of the behaviour can then be determined. In 2014, the DFO McKindsey team initiated tracking studies on lobsters and rock crabs in relation mussel aquaculture operations in the Gulf of St. Lawrence on the Îles de-la-Madeleine[31] and Prince Edward Island[32]. The results from these studies unequivocally demonstrated the usefulness of this approach and demonstrated that lobsters indeed used the mussel farms to forage, but remained quite mobile and therefore, were still available to the lobster fishery.

16. In 2016, this same approach was adopted to look at the interactions between lobsters and salmon aquaculture farms in southwest New Brunswick. Study sites were set up with an array of receivers in the Quoddy region at three salmon farms and lobsters were tagged and released to follow their movements through the summer and fall. Like the Gulf of St. Lawrence lobsters, the lobsters readily moved under the salmon farms with the exception of one farm in Back Bay. The time that a lobster spent under the farm seem to be related to shelter habitat since those farms with rocky bottoms had lobsters that remained in place for many weeks making regular foraging trips out and then returning to their burrow. Rock crabs were also very attracted to the areas underneath the farms, but are also prey items for the lobster[33] resulting in interesting trophic food web dynamics.

17. In 2019, the lobster tagging study was extended to Nova Scotia at the invitation the NS Dept. Fisheries and Aquaculture to look at lobster-salmon farming interactions in Liverpool Bay using the techniques developed in New Brunswick and the Gulf of St. Lawrence. A grid array of receivers was established in Liverpool Bay in 2019, 2020 and 2021. Lobsters

were tagged with transmitters and released at the existing farm as well as the two potential farm sites in Fralick Cove (also known as Brooklyn) and Mersey Point. The receivers were deployed in May and were retrieved in November for each year in order not to interfere with the lobster fishing season. The lobster movement results from this study were consistent with the previous studies in New Brunswick which demonstrated that lobsters were very mobile and would move in and around the Coffin Island salmon farming site during their movements around Liverpool Bay with no obvious aversion to the farm. The operating farm near Coffin Island was primarily a rippled sand bottom with no shelter for lobsters, so similar to the New Brunswick observations, the lobsters moved in and out of the farm area during their foraging activities. The proportion of tagged lobsters that frequented the salmon farm decreased from 2019 (fallow year) to 2021 (second year of production), but the lobsters still ventured under the farm. During the course of the 3-year study, 6 egg-bearing female lobsters (berried) were tagged with acoustic transmitters. Two of them were tagged adjacent to the salmon farm in 2020 and either made a few excursions underneath or remained in the vicinity. Crabs, on the other hand, were consistently attracted to the area under the cages during all three study years 2019-2021 and remained there for much longer periods which was similar to the observations in New Brunswick.

18. During the 2020 and 2021 September sampling trips, underwater videos were taken with a remote operated vehicle (ROV - DeepTrekker™) of the sea bottom for the three study sites in Liverpool Bay. At each site, the ROV was lowered over the side of the boat where the operator piloted it to the bottom and attempted to survey along a particular heading, depending on the drift from the wind and the tide which could override the thrust from the small propellors. Video footage was captured on an SD card in the surface controller. Results from the video footage (see attached USB of the video footage at **Tab 1**) showed that the benthic area under the cages of the active Coffin Island salmon farm was a firm rippled sand with many lobsters and crabs moving around and creating shallow depression burrows. The Fralick Cove site (Brooklyn) was mostly rock and ledge covered with seaweed (poor coverage due to entanglement with seaweed) and the Mersey Point site which was a combination of sand and boulder field with a low algal turf. These habitat observations were consistent with a previous study that had surveyed the entire bay with remote sensing technology to classify benthic habitat types for marine spatial planning for lobster management[34]. Interestingly, no lobsters were seen in the Mersey Point and

Fralick Cove (Brooklyn) reference areas from the brief video footage, although these areas are fished regularly during the fishing season and we caught lobsters easily in traps from both areas when we were sampling for the microbiome study (below). This is a good example of the "catchability" issue from an observational point of view when you are looking at complex versus simple habitats as discussed above.

19. My conclusions from the telemetered tagging studies were that lobsters were not actively repelled by salmon farms as suggested by previous studies and that lobsters likely use the areas for foraging, possibly on the crabs that seem to actively inhabit the area, although the use by tagged lobsters appeared to decline as production on the farm grows. The residence time of the lobsters under a salmon farm may be related to habitat availability as sand or mud sites showed that lobsters spent far less time there. Lobsters may not need to range as far inside the farm over the production cycle as the crab population on the lease is quite abundant.

20. The successful foraging of lobsters on food derived from salmon farms was supported by a study in Grand Manan, New Brunswick that looked at the biochemical composition of the crabs and lobsters captured under the farm[35]. That study utilized fats only found in salmon feed as a tracer to show that the lobsters and crabs were obtaining some of the nutrients from the fish food, either from direct feeding or secondarily from other prey species. These results were also confirmed in an unrelated study in Ireland looking at the European lobster on the effects of salmon farms on the local crustaceans[36].

21. As a result of the new information from the telemetered tagging work and the biochemical analysis, it became apparent that lobsters and crabs were associating with salmon aquaculture sites and also deriving a benefit from them. The next obvious question was: are the lobsters benefiting from the additional food that is becoming available to them or are there some chronic effects that might affect the lobster population in the long term, through physiological changes to growth, reproduction or survival.

22. Determining physiological changes in wild populations in nature is quite problematic as it is impossible to control all the variables affecting the organisms under study. This is similar to the problems faced with using CPUE to determine population effects of a particular stressor. The variation introduced by seasonal, interannual and other outside factors make the evaluation very difficult. For example, if we looked at fecundity of the lobster

population in relation to aquaculture, we would only generate one data point a year since the lobsters only reproduce seasonally. It would take many years to gather enough data to make any reliable assessment of the effects of the culture activities on the egg production of females. The same problem is associated with growth measurements as lobsters grow by moulting their shell and therefore only increase in size in seasonal increments.

23. Since we only had 3 years to conduct the study (2019-2021), we decided to use an integrative measure that has been shown to be indicative of an organism's health. With the development of new technology for the DNA-based study of bacteria, there has been a massive amount of research done in the last decade on the relationship between the population biodiversity of bacteria in the gut of an organism (known as the microbiome) and the organisms' overall health[37-42]. Today, there are over 24,000 papers a year being published on the role of microbiomes[43] in humans, other organisms and the environment. While the majority of publications are in the human medicine category, there is a rapidly expanding database on fish and invertebrates that are showing the same type of relationships between diet and environment on the gut microbiomes of the animal and the overall effect on the health and fitness of the animal[44]. The approach of investigating the gut microbiome in crustaceans as an indicator of overall fitness is also advancing quickly and has been used a number of different lobster species in a wide range of environments[45-53].

24. Therefore, a study was initiated in 2019 to study the gut microbiome in lobsters from Liverpool Bay at the three different study sites and at Port Mouton (2019 only). Sampling was done for 3 years (2019-2021) in the middle of September for the sake of consistency, although extra samples were also taken in July 2021 to test for any effects of seasonality. Lobsters were captured with commercial lobster traps baited with herring and were set for 24 hours. Sediment samples were also taken at each site where the trapping occurred and were frozen at -80 ^{o}C. Traps were retrieved after 24 hours and lobsters were randomly sampled, placed on ice and returned to the lab where they were euthanized and their stomachs removed and frozen immediately at -80 ^{o}C. Samples were sent to the Research Productivity Council in Fredericton, New Brunswick where all the samples were extracted for DNA, the rRNA genes amplified, sequenced and then curated to determine bacterial species diversity.

25. This approach of looking at gut microbiomes generated very large datasets and samples would contain hundreds of genera to analyze. The DNA-based taxonomic results clearly showed differences among the lobsters, crabs and the sediment (Fig. 4). Note that each group (crab, lobster and the sediment) clustered together with very little overlap. These clusters were significantly different from each other indicating that the lobsters were maintaining their own unique microbiome compared to the crabs and the environment in which they lived.

26. The data sets also showed interannual variability and indicated that each year had to be considered separately rather than lumping them all together. In the last year (2021), the comparison between samples taken in July and those in September were also different indicating that there is a seasonal succession of gut and benthic bacterial species. This is not surprising as it has been found in previous planktonic and benthic microbial studies[54-57].

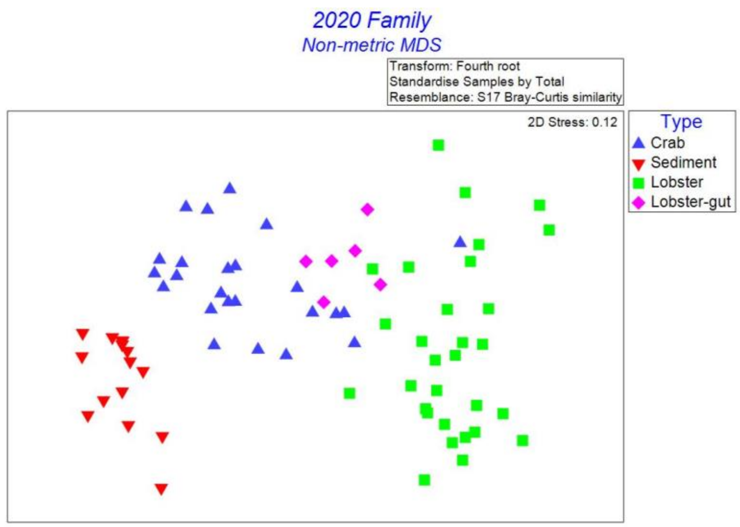

Figure 4. Plot showing the grouping of the microbiomes for crab and lobster stomachs, lobster intestine and the surficial sediment microbiome in the three study locations. Note how each of the groups tend to separate out. The data were produced using a non-metric multidimensional space analysis in the software Primer 7.

27. Most importantly, there were no significant differences in the gut microbiomes found in the lobsters from the reference areas and the lobsters from the farm site (Fig. 5) even though the microbiome of the sediment in the Coffin Island salmon farm was different than the ones in Mersey Point of Fralick Cove (Brooklyn) (not shown). These results do not mean that there were no effects on the overall condition of the lobsters from the farm site, but based on the microbiome biodiversity approach with the study of lobster stomachs, we could not detect any effect. The lack of a significant signal within the lobster stomachs would suggest that the effect is too small to detect, if it is there at all. Another approach

may be warranted, but this technique has been shown to produce results in other lobster impact studies[49-51].

28. Overall, the tagging and the microbiome studies from the Liverpool area show that there are very few detectable negative effects of the farm on the local lobster populations. Lobsters will freely range under and around fish farms and will actively consume some of the nutrients coming from them. This consumption of food items does not seem to be reflected in the microbiome of the lobster stomachs and therefore, there is no observable signal that the gut physiology of the lobsters is being affected. Interestingly, the crabs that actively remained and foraged under the salmon farm did show a change of microbiome between farm and reference sites (Fig.6). This observation would appear to support the technique to assess the impact on lobster populations.

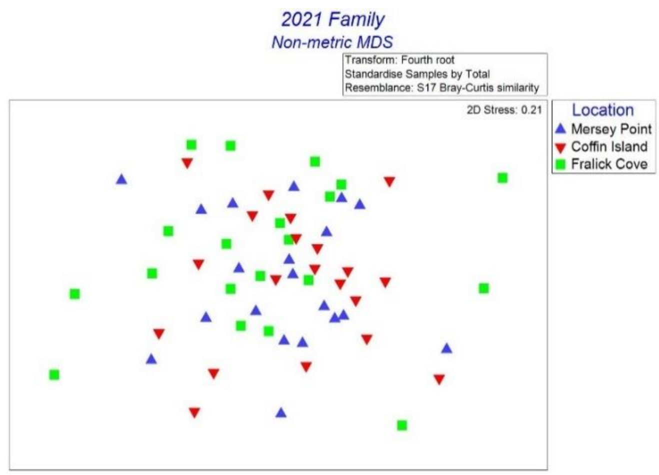

Figure 5. Plot showing the grouping of the microbiomes for lobsters found at the Coffin Island salmon farm and the other two references areas (Fralick Cove (Brooklyn) and Mersey Point). Note the lack of distinct clustering among the three sites.

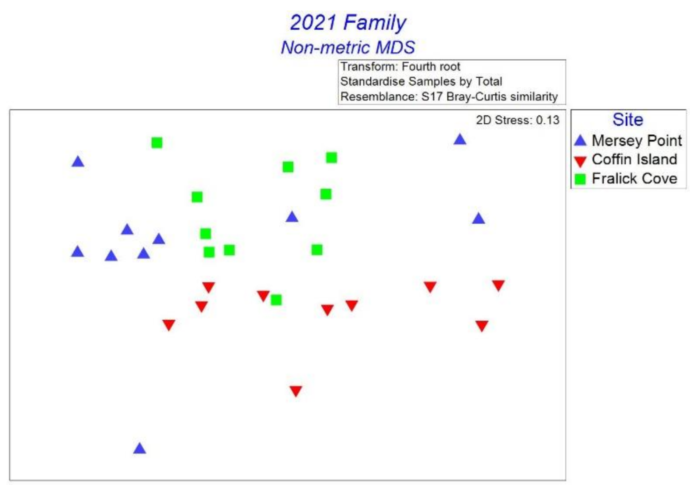

Figure 6. Plot showing the grouping of the microbiomes for rock crabs found at the Coffin Island salmon farm and the other two references areas (Fralick Cove (Brooklyn) and Mersey Point). Note the grouping of the salmon farm site.

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Environmental Interactions

29. There have been a number of reviews on the effects of salmon farming on the environment and associated species in the area[14,24,58-62] and it is reasonably well established that the addition of new organic food sources and additional 3-dimensional structures to the environment changes the dynamics of the original ecosystem. This is the same for any anthropogenic impact in the marine ecosystem, including mining, oil and gas, farming, fishing, wastewater treatment and coastal zone development. Since it is virtually impossible to reduce the impacts of industrial use to zero, management objectives have centered on monitoring the effects and creating policies that will minimize the impact to the local environment based on a risk assessment to existing resources. For aquaculture, this has led to the creation of the federal Aquaculture Activity Regulations[63] as well as policies and regulations that have been created at the provincial level, where the administration of the industry occurs, to manage aquaculture development and operations. Science at the federal, provincial and academic level contributes to the policies through direct research on issues as well as review of the literature to create summaries of interactions, such as pathways of effects[64] and better ways to incorporate local knowledge from the communities[65].

30. Monitoring of the benthic organic impacts of salmon farming in Canada are primarily done through measuring the free sulfide levels in the sediment[66] (caused by benthic loading of organic material) and the infaunal biodiversity. Sampling is done with small vessels around the farms, often by monitoring companies on the east coast and DFO staff on the west coast. Sample processing for biodiversity in the sediments is slow and can often take trained taxonomists considerable lengths of time to accomplish. Monitoring methods for sulfide levels is changing and new approaches are being adopted to increase the accuracy and speed of sampling[67,68].

31. Internationally, there are new methods for monitoring environmental changes that are increasing the resolution of management. The conditions of any habitat will determine the types of species that can exist there and this relationship exists at the macrolevel with larger organisms to the micro-level of bacteria, viruses etc. Bacterial microbiomes have been extensively studied and shown that their biodiversity and changes over time can reflect impacts to the ecosystem[69-72]. Since the reproductive time of bacteria are measured in hours or a few days, changes to the microbiome can happen reasonably

quickly and give a more sensitive estimate of environmental changes. This technique is currently being considered or being applied in New Zealand, Scotland and Norway for salmon aquaculture monitoring[73-77].

SUMMARY STATEMENT

32. My overall conclusion from a review of the literature on field-based studies on lobsters and the recently collected data from the lobster acoustic tracking and microbiome projects is that salmon farms in Liverpool Bay will have little negative effect on the behaviour and distribution of lobsters that could affect the local fishery.

33. Previous studies using the best available data at the time were hampered in their conclusions with the assumptions they had to make on the consistency of catch rates within their studies (CPUE). Our direct observational field study using acoustic tracking technology demonstrates that local rock crab populations do capitalize on the increase in organic material coming from the farms as their distribution and abundance increase in the vicinity of the salmon farms whereas lobsters are attracted, but not as intensively as crabs. Tracers such as fatty acids, and now bacterial microbiomes from the stomach, confirm that there is a pathway of effect to the crabs. Crabs are a known prey item for lobsters and the tagging and ROV video clearly show that lobsters do forage under the salmon farms, which refutes the conclusions of the previous studies. While the lobsters also show a biochemical signal (fatty acids) from the farm in our previous study, there is no sign that the organic output from the farm is changing the microbiome biodiversity in the stomachs of the lobster.

Future suggestions with respect to monitoring Liverpool Bay

Rationale

34. It is highly likely that near-future physical and biological changes will occur in the marine environment of Liverpool Bay due to climate change and these will very likely affect both commercial populations of lobsters and the salmon farming industry. The salmon farming industry is already planning on doing enhanced environmental monitoring. Warming waters, changes in hydrographic conditions and changing distributions of animals, seaweeds and microorganisms will all combine to create more variability, uncertainty and therefore more difficulty in managing the bay. As such, future studies, led by provincial

and university scientists, and supported by the industry sector, could perhaps use the Liverpool Bay farm expansion as a long-term case study area, addressing concerns. A monitoring program would have to be well-designed and implemented by the NS Dept. Fisheries and Aquaculture to detect changes within the larger upcoming climate-change signal. Long term field-based research on impacts of climate change and aquaculture activity are particularly scant in the literature.

Who should be involved?

35. The Province of Nova Scotia should be involved as they regulate the industry provincially as well as running the current environmental monitoring program. They also have significant logistic resources that can be mobilized in both people and equipment.

36. DFO and Environment Canada and Climate Change (ECCC) could be involved to provide answers to regulatory science and climate change issues since they have the national mandate for these files. They also have logistic resources that can be mobilized.

37. Academia should be involved to study the biological and physical processes that will be occurring in Liverpool Bay and around the salmon farms. For example, this could involve changes to population biology parameters such as growth, reproduction and recruitment or it may involve changes to pathogen pressures on farmed and wild fish.

38. Industry should be involved through providing logistic support for monitoring where appropriate. This could involve the use of vessels, staff etc. as appropriate.

What should be monitored?

39. I would suggest that the traditional monitoring protocols be expanded as they will likely not be enough to monitor some of the more subtle potential impacts of climate change and the more minor signal from new salmon farms on local lobster populations. What to monitor should be determined jointly by all the users of Liverpool Bay. Carefully crafted questions need to be developed that can be scientifically tested over a specific length of time, depending on the question. That could be either a few years or perhaps over a decade or more.

How can this be achieved?

40. Coordination of this monitoring program should be handled by the Province of Nova Scotia as they currently run the environmental monitoring program. Federal agencies (DFO, ECCC) have access to larger national programs for funding and have the mandate for managing commercial fishing populations and initiatives related to climate change.

41. The current suite of monitoring protocols should be continued, but newer approaches should also be employed that can be evaluated for the rest of the province and possibly the country. Examples of this would be some of the genetic technologies such as metagenomics to monitor environmental impacts and the use of environmental DNA (eDNA) to count organisms. This type of technology is already being developed in other countries so a technology transfer would be very valuable and save development time.

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Tab 1

Video footage of the sea bottom for the three study sites in Liverpool Bay taken in September 2020 and September 2021.

Secure link provided to ARB and parties under separate cover.

TAB B

KCS' Application re AQ#1205X, AQ#1432, AQ#1433 in Liverpool Bay, Queens County

This is Exhibit A referred to in the Affidavit of Shawn Robinson, PhD, affirmed virtually before me on January 19, 2024.

[redacted]

Barrister of the Supreme Court of Nova Scotia

Shawn M.C. Robinson, Senior Scientist

Longline Environment
[redacted]
London, [redacted] *United Kingdom*
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Education

Ph.D. (1984-1988) University of British Columbia, Vancouver, B.C.
MSc. (1979-1983) Simon Fraser University, Burnaby, B.C.
BSc. (Honors) (1976-1979) Acadia University, Wolfville, N.S.

Appointments

Research Scientist, Department of Fisheries and Oceans, St. Andrews, NB, 1988-2022 (retired)
Adjunct Professor, University of New Brunswick, Saint John, NB, 2002-2022
Adjunct Professor, Nova Scotia Agricultural College, Truro, NS, 2000-2004

Short Resume: Dr. Robinson worked for 34 years as a research scientist with the Dept. Fisheries and Oceans at the Biological Station in St. Andrews, New Brunswick. He was actively engaged in applied ecological research on marine shellfish species such as blue mussels, sea scallops, sea urchins, soft-shell clams, sea lice and marine bacteria. His research team studied the natural processes by which these animals interact and utilize their environment so that better and more sustainable culture techniques could be developed. One example of this research was the study of an integrated multi-trophic aquaculture (IMTA) program (sometimes known as polyculture) where shellfish and seaweeds were grown in conjunction with other fed species to recycle organic matter and produce a more sustainable and productive system. He also investigated marine microbiomes and how they related to the conversion of organic matter in the environment as a result of human activities and contributed to the fitness of marine organisms. Much of this work involved collaborative projects with industry and academic partners (nationally and internationally) and took a more holistic view of the aquaculture system combining biology, physics, economics, sociology, and government policy. He was a member of the Aquaculture Association of Canada (past president). Publications (185) are in the fields of: stock assessment, subtidal marine ecology, fishery management and aquaculture ecology; mostly associated with invertebrates.

Selected Publications and Reports:

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