

Appendix IR2020-4-A
Effects to Biofilm and Migratory Birds



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Introduction

The minister's request regarding biofilm and effects to migratory birds was focused narrowly and specifically on examining how new or modified project design features and mitigation measures for fish and fish habitat, considered in other parts of the request, might alter the outcomes of the geomorphological assessment of changes in salinity and other coastal processes, including erosion and deposition, wave height, and tidal flow. The minister's request specified the approach to be used, the parameters to be considered, and the format of the response. The response prepared by the port authority provides the specific information requested as directed by the minister.

The information requested by the minister is relevant to the assessment of potential environmental effects of the new or modified project design features on biofilm and migratory birds. However, during consultation with federal agencies and Indigenous groups on the draft response, questions and comments outside the scope of the request that were previously addressed in the Federal Review Panel Report were raised. The port authority has continued to consult with Indigenous groups and federal agencies on the development of a Biofilm Habitat Creation Guidance Manual,¹ biofilm creation or enhancement project, and data collection technology trials during which these questions and comments were also raised. The port authority is committed to continuing to work with all parties on this important topic. The purpose of this appendix is to provide supplemental information to support the minister and other participants in the environmental assessment (EA) in their understanding of the relationship between the predicted geomorphological changes and the potential environmental effects of the project on biofilm and migratory birds.

The scientific empirical evidence submitted during the EA supports the key conclusions that the project will result in only a limited direct effect on biofilm habitat (2.5 ha or less than 0.1 per cent of the total habitat with biofilm available at Roberts Bank) and only minor changes in salinity; these conclusions are not in dispute. The available scientific evidence also shows that consistent high levels of fatty acids, including polyunsaturated fatty acids (PUFAs), which are considered important for biofilm quality as prey for migratory shorebirds such as western sandpiper, are maintained in all types of biofilm across variable salinity and environmental conditions at Roberts Bank. No one has disputed this finding; the independent review panel agreed that the changes in salinity from the project were minor and the port authority has demonstrated that fatty acid production does not vary across the salinity gradient currently experienced at Roberts Bank in the area where shorebirds forage during northward migration at the end of April to early May despite highly variable interannual conditions. If biofilm were not adapted to highly variable environmental conditions, it would not be a consistent component of estuarine ecosystems. In addition, biofilm composition and productivity and invertebrates, sandpiper's other primary prey, will also not be adversely affected with the project—a conclusion the review panel also reached based on an independent review of the evidence. Throughout the EA, some parties have speculated that there may be an effect, but no party has provided any empirical evidence that contradicts the scientific conclusions.

The EA process has provided for a comprehensive, precautionary, and conservative assessment of the potential effects of the project on biofilm and migratory shorebirds. That assessment demonstrates that the project is not likely to cause significant adverse effects on biofilm or the shorebirds that consume biofilm. Moreover, the port authority has proposed a robust follow-up program. That program includes proven effective mitigation measures, including offsetting, available to be implemented if an unforeseen effect on biofilm arises.

¹ CIAR Document #2001 From the Vancouver Fraser Port Authority to the Review Panel re: Updated Project Commitments (See Reference Documents #1738 and #1934). Commitment #43. <https://iaac-aeic.gc.ca/050/documents/p80054/130776E.pdf>

For these reasons, the minister can be confident that the project is not likely to cause significant adverse environmental effect on biofilm or migratory shorebirds, including western sandpiper, taking mitigation into account.

The direct effect of the project on biofilm is limited

With the recent proposed reduction in the footprint of the widened causeway (described in the response to IR2020-2.1), the direct effect of the project is limited to less than 0.1 per cent of the existing biofilm habitat within the local assessment area (LAA),² leaving more than 99.9 per cent of the existing biofilm habitat available for foraging by migratory shorebirds. The minimal direct impact to biofilm is a result of the early recognition of the importance of intertidal habitats by the port authority, which resulted in the decision to locate the proposed marine terminal in subtidal waters. Through recent further consideration of the causeway design in the reference concept, the causeway footprint was refined with direct biofilm impacts reduced by almost a quarter from 2.5 ha to approximately 1.9 ha. Consequently, the direct effect of the project on biofilm due to loss of habitat associated with the physical footprint of the project is very limited.

Indirect effects: biofilm productivity predicted to increase as a result of the project

The EA demonstrates that the project would indirectly result in an increase in biofilm productivity by producing physical conditions that are more conducive to marine vegetation growth, including biofilm.³ This predicted productivity gain would be greater than the loss of productivity as a result of the direct loss of 2.5 ha of biofilm habitat, resulting in a net gain in biofilm productivity with the project in place. The Roberts Bank ecosystem model forecasted that biofilm productivity in the LAA would increase by 1,048.6 tonnes, or 30%⁴ with the project. Despite this predicted gain, during the EA, the port authority took a conservative view and assumed that the project would not affect biofilm productivity (i.e., did not assume a gain). Additional biofilm modelling conducted to investigate potential affects to biofilm using three years of data collected after the EA was submitted found that the modest changes to salinity brought about by the project would not affect the caloric content of biofilm. Furthermore, this additional research provided evidence that fatty acid composition and abundance within biofilm were unlikely to be adversely affected by the project.⁵ This conclusion was accepted by the review panel in their recommendation report, which found that “there is sufficient certainty in the Proponent’s predictions and studies to conclude that the Project would not result in adverse effects on biofilm productivity at Roberts Bank.” In reaching this conclusion, the review panel relied on Environment and Climate Change Canada’s (ECCC) conclusion that the port authority’s studies regarding overall productivity of biofilm were technically sound.⁶

The predicted change in salinity will not alter biofilm quality or quantity

The weight of evidence from the port authority’s five-year site-specific biofilm study program indicates that biofilm within the LAA is adapted to variable estuarine conditions (including salinity) and will continue to be an abundant, high-quality food source for migrating shorebirds with the project in place. The port authority’s study program was designed with input from a Biofilm and Shorebirds Technical Advisory Group, comments and feedback received from ECCC through the EA process, and regular input from internationally recognized academic scientists. The

² CIAR Document #2062 Report of the Review Panel, Vancouver Fraser Port Authority Roberts Bank Terminal 2 Project. <https://iaac-aeic.gc.ca/050/documents/p80054/134506E.pdf>

³ CIAR Document #934, port authority response to IR3-02. <https://iaac-aeic.gc.ca/050/documents/p80054/122028E.pdf>

⁴ CIAR Document #934, port authority response to IR3-02 – Appendix A, Table A7. <https://iaac-aeic.gc.ca/050/documents/p80054/122028E.pdf>

⁵ CIAR Document #1385, 2018 Biofilm Dynamics Technical Data Report <https://iaac-aeic.gc.ca/050/documents/p80054/126516E.pdf>

⁶ CIAR Document #2062 Report of the Review Panel, Vancouver Fraser Port Authority Roberts Bank Terminal 2 Project. <https://iaac-aeic.gc.ca/050/documents/p80054/134506E.pdf>

group consisted of 12 Canadian and international scientists from academia, federal agencies, and private industry that specialized in shorebird ecology, biofilm ecology, and coastal geomorphology that met over four days. The study program demonstrated that biofilm quantity and quality, including levels of fatty acids, specifically PUFAs (recognized by the port authority as an important nutrient for foraging migratory shorebirds), were **very consistent across the salinity gradient** under highly variable conditions observed among years. Of note, biofilm at Roberts Bank is estuarine, comprised of both marine and freshwater species tolerant of daily changes in salinity ranging from 0–32 practical salinity units (psu). The biofilm community consistently produced similarly high levels of fatty acids, including PUFA, in freshwater and marine dominated areas of Roberts Bank that experienced very different salinity regimes (i.e., fluctuation in salinity levels). That is, even with the extreme variation in salinity conditions that naturally occurs across Roberts Bank, the quantity and quality of biofilm remains consistently high in both freshwater and marine-dominated areas, providing a stable and resilient food source for western sandpipers and other migratory shorebirds that stop over at Roberts Bank on their northward migration (as well as at other times of year). None of the available evidence indicates that either the quantity or quality of biofilm, including fatty acid/PUFA levels, are adversely affected by naturally variable salinity conditions at Roberts Bank.

The review panel accepted this finding, stating, in their Federal Review Panel Report, “Part of the research done by the Proponent in 2016, 2017, and 2018 also involved determining fatty acid concentrations and diatom composition across an existing salinity gradient where western sandpipers forage at Roberts Bank. The Panel finds that the Proponent demonstrated that fatty acid production did not vary across the salinity gradient currently experienced at Roberts Bank in the area where shorebirds forage during northward migration at the end of April to early May” [emphasis added].⁷ Areas where productive biofilm has been documented are exposed to very fresh (<5 psu) and saline/brackish (>20 psu) conditions in a single day due to the daily tidal cycle.⁸ Furthermore, across the three years of additional biofilm studies mentioned above, volumes of freshwater discharged by the Fraser River varied by as much as three-fold within years and more than two-fold among years during the western sandpiper migration (mid-April through early May).⁹ Under these highly variable conditions within and among years, fatty acid levels, including PUFA, remained consistent in their quantity and quality.¹⁰

Similarly, the empirical evidence submitted by the port authority during the EA also demonstrates that the consistently high quality and quantity of biofilm is unlikely to be adversely affected by the modest changes in salinity predicted to result from the project. These conclusions are not changed by recently published studies (see Review of recent scientific the literature section below). There are no empirical or published data that indicate that estuarine biofilm in the LAA will be adversely affected at Roberts Bank by the project or that fatty acid/PUFA quality or quantity in biofilm would be reduced by either the degree, the location, or the timing of the salinity changes that would result from the project.

The change in salinity is well within the natural range of variation

During the EA, the port authority presented robust empirical evidence clearly indicating that the salinity changes predicted to result in the LAA with the project in place are well within the natural range of temporal and spatial variation in salinity conditions historically experienced at Roberts Bank, including the range of salinity conditions that naturally occur during the spring, when migratory shorebirds stop over at Roberts Bank on their northward

⁷ CIAR Document #2062 Report of the Review Panel, Vancouver Fraser Port Authority Roberts Bank Terminal 2 Project. <https://iaac-aeic.gc.ca/050/documents/p80054/134506E.pdf>

⁸ CIAR Document #934, port authority response to IR12-09 <https://iaac-aeic.gc.ca/050/documents/p80054/126268E.pdf>; CIAR Document #1385, 2018 Biofilm Dynamics Technical Data Report <https://iaac-aeic.gc.ca/050/documents/p80054/126516E.pdf>

⁹ CIAR Document #1778, Vancouver Fraser Port Authority oral presentation: Coastal birds - Western sandpiper and biofilm, May 27, 2019, at Slide 10. <https://iaac-aeic.gc.ca/050/documents/p80054/129839E.pdf>

¹⁰ CIAR Document #1385, 2018 Biofilm Dynamics Technical Data Report <https://iaac-aeic.gc.ca/050/documents/p80054/126516E.pdf>; CIAR Document #1778, Vancouver Fraser Port Authority oral presentation: Coastal birds - Western sandpiper and biofilm, May 27, 2019, at Slide 13 <https://iaac-aeic.gc.ca/050/documents/p80054/129839E.pdf>

migration.¹¹ The volume of freshwater discharged by the Fraser River over Roberts Bank under existing conditions during western sandpiper northward migration can vary from approximately 500 m³/second to over 10,000 m³/second,¹² resulting in highly variable salinity conditions (i.e., from 0 to 32 psu), both temporally and spatially, across Roberts Bank. The review panel agreed with this finding:

The Panel concludes that the Project would result in minor changes in salinity in the Local Assessment Area given that the Project would cause a reduction in salinity variability, especially during freshet periods.

Further, Fisheries and Oceans Canada classified the predicted changes in salinity due to the project in the vicinity of biofilm habitat as “modest”.

There are no other adverse effect pathways

As noted by the review panel, there are no other known pathways of potential adverse effect on biofilm quantity or quality due to the project (other than the direct loss of biofilm habitat and the indirect minor changes to salinity, both addressed above).¹³ That is, there are no other mechanisms by which the project could adversely affect the quantity or quality of biofilm available for foraging migratory shorebirds, including levels of fatty acids/PUFA.

The approach to follow-up on predictions is consistent with CEEA 2012 requirements

The port authority has proposed, and the draft potential federal conditions would require, a follow-up program to verify the EA predictions pertaining to western sandpiper, which would include consideration of potential changes in salinity and effects on biofilm as a result of the project. Further, other draft potential federal conditions would require additional biofilm studies and monitoring to verify effect predictions. Results from the additional biofilm studies are anticipated to go through an independent tripartite technical review and require consultation with Indigenous groups and regulators, including ECCC. This approach to follow-up is consistent with both the requirements of the *Canadian Environmental Assessment Act (CEAA) 2012* and guidance issued by the Impact Assessment Agency of Canada (IAAC).

Adaptive management approach ensures any unforeseen effects will be addressed

As required for all follow-up program elements (see draft condition 2.6), the development, implementation, and updating of the follow-up program element for western sandpiper would include the determination of technically and economically feasible mitigation measures to be implemented by the proponent if monitoring conducted as part of the follow-up program determine that such measures are needed. Further, other draft potential federal conditions (see draft conditions 6.11.2 and 10.2) would also require the development and implementation of additional or modified measures to mitigate potential effects of the project on biofilm PUFA production, if needed. This approach to adaptive management is also consistent with the requirements of CEEA 2012, guidance issued by IAAC, and standard practice.

¹¹ CIAR Document #934, port authority response to IR12-09 (Figure 12-09-3, Figure 12-09-4, Figure IR12-09-10, Figure IR12-09-11) <https://iaac-aeic.gc.ca/050/documents/p80054/126268E.pdf>; CIAR Document #934, port authority response to IR8-04 (Figure 4-1) <https://iaac-aeic.gc.ca/050/documents/p80054/124402E.pdf>; , 2018 Biofilm Dynamics Technical Data Report <https://iaac-aeic.gc.ca/050/documents/p80054/126516E.pdf>

¹² CIAR Document #1778 – Vancouver Fraser Port Authority oral presentation: Coastal birds - Western sandpiper and biofilm, May 27, 2019, at Slide 10 <https://iaac-aeic.gc.ca/050/documents/p80054/129839E.pdf>

¹³ CIAR Document #2062 Report of the Review Panel, Vancouver Fraser Port Authority Roberts Bank Terminal 2 Project. <https://iaac-aeic.gc.ca/050/documents/p80054/134506E.pdf>

Effects on biofilm are mitigable and mitigation, including offsetting, is proven to be effective

It is important to note that proven effective mitigation for biofilm, including offsetting, is available to be implemented if monitoring reveals an unforeseen adverse effect. Biofilm is a common component of estuaries and has been and can be successfully created, including at a large scale. While the project is not anticipated to adversely affect biofilm, the port authority recognizes the concerns for its conservation by stakeholders and Indigenous groups. Thus, the port authority committed to developing a manual describing methods and techniques to construct biofilm habitat and support the expansion of knowledge of biofilm ecology. The port authority has worked with local and international technical experts and sought input from Indigenous groups to identify and document existing knowledge and known practices for developing biofilm habitat. The port authority has compiled this technical information and international examples into a Biofilm Habitat Creation Guidance Manual. The methods and techniques outlined in the manual are scalable from small projects to very large sites and can guide restoration and/or creation of biofilm habitat. One case study described in the manual where biofilm habitat was successfully created is the 320 ha Komuke Lagoon in Japan that supports biofilm and is heavily used by shorebirds. If biofilm habitat offsetting were determined to be necessary to mitigate unforeseen adverse effects on biofilm quantity or quality, there are offsetting options locally available within the Fraser River estuary.

Shorebird foraging will continue to be well supported at Roberts Bank

Shorebird prey, including biofilm, are abundant at Roberts Bank and will continue to be abundant with the project in place. Shorebird foraging modeling¹⁴ has demonstrated that biofilm in the Roberts Bank area can support over one million western sandpipers foraging on a single day with the project in place. This is more than seven times the peak daily numbers of western sandpipers documented feeding on any given day during a typical migration, based on 23 years (1991-2014) of shorebird count data collected by ECCC.¹⁵ In addition to biofilm, the Roberts Bank area also provides abundant, nutritious PUFA-rich invertebrates (i.e., infaunal and epifaunal invertebrates), which account for approximately half of the diet of western sandpiper.¹⁶ The review panel concluded “that the Project would not result in an adverse effect on infaunal and epifaunal invertebrates.” In short, even with the project in place, there will continue to be a surplus of high-quality biofilm and invertebrate prey at Roberts Bank, making it highly unlikely that the project will adversely affect western sandpipers. Western sandpiper populations are not limited by the availability or quality of foraging habitat and forage/prey at Roberts Bank, and will not be in the future with the project.

A precautionary approach was taken

From the outset of the project and throughout the EA process, the port authority has taken a precautionary approach to the assessment of potential effects on biofilm and migratory shorebirds. The decision to locate the project in subtidal waters to avoid direct footprint impacts on biofilm was made early. Recognizing the importance of understanding the ecology of biofilm and shorebirds, the port authority conducted over 20 biofilm and shorebird studies, including conducting an additional three years of biofilm studies after submission of the environmental impact statement to address concerns raised by ECCC. Those studies have examined the possible effect

¹⁴ CIAR Document #181, Environmental Impact Statement Appendix 15-B <https://iaac-aeic.gc.ca/050/documents/p80054/101358E.pdf>

¹⁵ CIAR Document #181, Environmental Impact Statement Appendix 15-B, Section 4.1.4 – Table 14 <https://iaac-aeic.gc.ca/050/documents/p80054/101358E.pdf>; CIAR Document #1778, Vancouver Fraser Port Authority oral presentation: Coastal birds - Western sandpiper and biofilm, May 27, 2019, at Slide 17 <https://iaac-aeic.gc.ca/050/documents/p80054/129839E.pdf>

¹⁶ CIAR Document #1385, 2018 Biofilm Dynamics Technical Data Report, Section 3.2 <https://iaac-aeic.gc.ca/050/documents/p80054/126516E.pdf>; CIAR Document #1778 – Vancouver Fraser Port Authority oral presentation: Coastal birds - Western sandpiper and biofilm, May 27, 2019, at Slide 8 <https://iaac-aeic.gc.ca/050/documents/p80054/129839E.pdf>

pathways for a change in biofilm quality and quantity, diatom assemblages, and fatty acids/PUFA.¹⁷ Also, the port authority has continued its work on biofilm since the public hearing, implementing a study in spring 2021 to investigate the potential to map biofilm using drone technology that could be used as a component of a follow-up monitoring program.

Further, the port authority integrated conservatism throughout the assessment, including drawing on multiple lines of evidence, using conservative and site-specific data to over-estimate potential project effects and under-estimate biofilm density, using multi-year modelling results and more than one modelling approach. In addition, even though the project is not predicted to have any serious adverse effects on biofilm, the port authority nevertheless has proposed a precautionary follow-up program element to verify the predictions and to facilitate action if an unforeseen effect on biofilm were to occur.

A science and evidence-based approach

As described above, a science and evidence-based approach was taken to assess potential project-related effects to western sandpiper and biofilm. This approach included implementing a Biofilm and Shorebirds Technical Advisory Group with involvement from local and international shorebird and biofilm experts to inform the design of baseline studies, meeting with ECCC on 10 different occasions to present and discuss baseline study designs and results prior to submitting the EA, working with academic and PhD-level industry scientists to ensure data collection and analyses were robust, conducting over 20 shorebird and biofilm studies to inform the EA, developing numerous statistical models to understand how the project would affect coastal geomorphology, the ecosystem, biofilm distribution, abundance, quality, and availability (including PUFA), and initiating an additional three-year biofilm dynamics study program after submitting the EA to address novel biofilm-fatty acid concerns raised by ECCC. During every step of the process the port authority stayed abreast of the latest findings pertaining to western sandpiper and biofilm in published scientific literature to inform study designs and assessment conclusions.

During the panel review phase, the review panel stated their confidence in results of the science-based approach that was used in important aspects of the biofilm assessment, stating the following:¹⁸

- “The Panel also heard from DFO that the modest salinity changes predicted in the vicinity of biofilm habitat were plausible.”
- “The Panel also heard from ECCC that the Proponent’s studies regarding overall productivity of biofilm were technically sound. The Panel finds there is sufficient certainty in the Proponent’s predictions and studies to conclude that the Project would not result in adverse effects on biofilm productivity at Roberts Bank.”
- “The Panel finds that the Proponent demonstrated that fatty acid production did not vary across the salinity gradient currently experienced at Roberts Bank in the area where shorebirds forage during northward migration at the end of April to early May.”

The years of study conducted by the port authority to inform the biofilm and western sandpiper effects assessments demonstrate that biofilm (including fatty acids, and specifically PUFA) quality and quantity levels are very consistent across the salinity gradient under highly variable conditions among years and provides a stable food source for western sandpipers. All evidence points to this continuing with the project in place. There is no evidence to suggest that a major impact on 558 ha of biofilm or associated adverse effects to western sandpiper due to biofilm changes (as asserted by ECCC in their comments) is plausible.

¹⁷ CIAR Document #934, Appendix IR8-04-A Shorebird and biofilm dynamics during northward migration (2016) <https://iaac-aeic.gc.ca/050/documents/p80054/124402E.pdf>; CIAR Document #934, 2017 Biofilm Dynamics Technical Data Report <https://iaac-aeic.gc.ca/050/documents/p80054/123348E.pdf>; CIAR Document #1385, 2018 Biofilm dynamics technical data report <https://iaac-aeic.gc.ca/050/documents/p80054/126516E.pdf>

¹⁸ CIAR Document #2062 Report of the Review Panel, Vancouver Fraser Port Authority Roberts Bank Terminal 2 Project. <https://iaac-aeic.gc.ca/050/documents/p80054/134506E.pdf>

Per the Federal Review Panel Report and draft conditions, the port authority has agreed to conduct additional studies to further investigate factors affecting PUFA in consultation with ECCC if the project is approved.

Review of recent scientific literature

At the public hearing, ECCC presented a new hypothesis, termed the salinity trigger hypothesis, that suggests a compression in the range of variability of salinity experienced at Roberts Bank may lead to an adverse effect on the production of PFAs by biofilm. Subsequently, ECCC has referenced several recently published papers to support the salinity trigger hypothesis; however, none provide evidence to support their theory. A summary of the papers frequently cited to support the salinity trigger are provided below:

- Schnurr, P. J., Drever, M. C., Kling, H. J., Elner, R. W., & Arts, M. T. (2019). Seasonal changes in fatty acid composition of estuarine intertidal biofilm: implications for western sandpiper migration. *Estuarine, Coastal and Shelf Science*, 224, 94-107.

Paper overview: The authors report on seasonal differences in biofilm nutritional parameters (fatty acids and chlorophyll *a*) between spring and winter at Roberts Bank. Their primary finding was that fatty acid content in biofilm was higher in spring than winter. They also report on the biofilm community composition in spring, but not winter. The authors did not study salinity, but speculate in the discussion that the Fraser River "freshet is accompanied by rapid changes in salinity and water chemistry, which may have also contributed to the observed fatty acid accumulation response in spring." [emphasis added]

Port authority response: The Schnurr et al. (2019) study was not designed to evaluate the validity of the salinity trigger hypothesis and provides no evidence in its support. The word "salinity" is mentioned twice in the entire paper, in the discussion. Using this paper to assert that fluctuations in salinity cause diatoms (biofilm) to accumulate fatty acids (including PUFA) is not valid. The finding that biofilm is more productive in spring than in winter was also reported by the port authority in the 2012-2013 RBT2 baseline studies to support the EA.¹⁹ This finding is most likely explained by the occurrence of better growing conditions for biofilm in spring compared to winter, as temperatures are much colder in winter and photosynthesis within the biofilm community is much reduced as low tides that expose biofilm to sunlight in spring are largely nocturnal during winter.

- Schnurr, P. J., Drever, M. C., Elner, R. W., Harper, J., & Arts, M. T. (2020). Peak abundance of fatty acids from intertidal biofilm in relation to the breeding migration of shorebirds. *Frontiers in Marine Science*, 7, 63.

Paper overview: The authors investigated fatty acid, total organic carbon (TOC), and chlorophyll *a* content in biofilm between spring (April-May) and summer (August-September). They also investigated the influence of physical parameters on fatty acids (e.g., median salinity and temperature over the last 24 hours, nitrogen, phosphorous, silica, mudflat elevation). They found that the amount of fatty acid per the amount of organic matter in a biofilm sample was higher in spring compared to summer. They report PUFA was negatively affected by increases in median salinity but found the opposite relationship for other fatty acid types (i.e., saturated and monounsaturated fatty acids).

Port authority response: The authors did not study fluctuations in salinity (i.e., a "salinity trigger") as a mechanism to promote fatty acid production. Therefore, referencing this paper to support the "salinity trigger" hypothesis is not valid. "Triggers" and fluctuations are discussed in the discussion section of the paper as possible mechanisms to understand the changes in fatty acid content they document, but again this is not a hypothesis that was tested in their research.

¹⁹ WorleyParsons. 2015. Roberts Bank Terminal 2 Technical Data Report Biofilm Annual Variability Study. Technical Data Report, Prepared by WorleyParsons Canada, Prepared for Port Metro Vancouver, Burnaby, B.C. <https://www.robertsbankterminal2.com/wp-content/uploads/RBT2-Biofilm-Annual-Variability-TDR-Main-Text1.pdf>

The authors also report a spring fatty acid “bloom”; however, this result should be viewed with caution. It is possible this result is an artifact of the way the data was analyzed, as they normalized (divided) the fatty acid data (within a sample) by the amount of organic content in a sample. Organic content in the Fraser River estuary is higher in summer compared to spring, so this mathematical procedure could cause results to be lower in summer compared to spring even if the same amount of fatty acids is present in a sample. The biofilm fatty acid data collected by the port authority shows no decrease in fatty acid abundance between spring and summer when expressed as the amount of fatty acids available per square meter of mudflats, indicating the same amount of fatty acids are available to foraging shorebirds in summer as in spring.

- Canham, R., Flemming, S. A., Hope, D. D., & Drever, M. C. (2021). Sandpipers go with the flow: Correlations between estuarine conditions and shorebird abundance at an important stopover on the Pacific Flyway. *Ecology and Evolution* 11: 2828-2841.

Paper overview: The authors estimated trends over time in counts of western sandpiper and Pacific dunlin during northward migration on the Fraser River estuary and examined whether counts were correlated with a suite of environmental variables related to local conditions (precipitation, temperature, wind speed and direction, solar radiation, tidal amplitude, and discharge rates from the Fraser River). The primary finding of this paper relates to a negative correlation between larger Fraser River freshet flows and lower western sandpiper usage. The authors speculate that the “results [are] from a complex interaction between the abrupt changes in salinity and the estuarine food web related to the quantity or quality of intertidal biofilm”. Similar to the above papers, fluctuations in salinity levels (i.e., a “salinity trigger”) were not investigated as part of this work. The authors cite Schnurr et al. (2019) and (2020) (see above review) as evidence to support the salinity trigger hypothesis as a mechanism to explain their findings. However, as with the above papers, fluctuations in salinity levels (i.e., a “salinity trigger”) were not investigated as part of their work.

It should be noted that port authority baseline studies documented western sandpipers foraging in high numbers in freshwater dominated areas of Roberts Banks adjacent to the Fraser River in densities equal to those observed in brackish areas within the LAA.²⁰ Biofilm nutritional data collected during this same period indicated no difference in the nutritional quality of biofilm between the areas,²¹ suggesting freshwater dominated and brackish areas within the LAA provided comparably high-quality biofilm to northward migrating sandpipers.

- Young, K. G., Vanderboor, C. M., Regnault, T. R., & Guglielmo, C. G. (2021). Species-specific metabolic responses of songbird, shorebird, and murine cultured myotubes to N-3 polyunsaturated fatty acids. *American Journal of Physiology-Regulatory, Integrative and comparative Physiology*. 320:3, R362-R376.

Paper overview: The authors conducted a laboratory study using cultured shorebird tissues to investigate how muscle cells responded to the addition of PUFA. Results from the study lend support for the hypothesis that PUFA can increase the aerobic capacity of migrant shorebird muscles, which may improve overall endurance flight performance.

Port authority response: The port authority agrees that results from Young et al. (2021) provide support for the hypothesis that PUFA may improve flight performance in migrating shorebirds.

Evidence from multiple years of site-specific research at Roberts Bank indicate that the PUFA-rich biofilm and invertebrate communities on which western sandpipers feed will continue to be abundant at Roberts Bank to support migrating sandpipers with the project in place.

²⁰ CIAR Document #388, Shorebird abundance and foraging use in the Fraser River estuary during migration – RBT2 Technical Data Report <https://iaac-aeic.gc.ca/050/documents/p80054/107622E.pdf>

²¹ WorleyParsons. 2015. Roberts Bank Terminal 2 Technical Data Report Biofilm Annual Variability Study. Technical Data Report, Prepared by WorleyParsons Canada, Prepared for Port Metro Vancouver, Burnaby, B.C. <https://www.robertsbankterminal2.com/wp-content/uploads/RBT2-Biofilm-Annual-Variability-TDR-Main-Text1.pdf>

Site-specific research at Roberts Bank indicates PUFA are consistently abundant within intertidal biofilm habitats and are available in similar quantity and quality in freshwater areas and areas dominated by saline marine waters under variable spring freshet conditions. Invertebrate communities containing 4 to 72 times more fatty acids (including PUFA) compared to biofilm are not predicted to be adversely affected by the project. This assessment prediction was supported by the review panel.

The weight of empirical evidence supports the prediction that PUFA in biofilm and invertebrates will continue to be abundant at Roberts Bank with the project in place and available to support migrating western sandpipers.

Draft potential federal conditions address biofilm and western sandpiper

IAAC has proposed several draft conditions related to biofilm and western sandpiper. These draft conditions are summarized as follows:

- Design and implement follow-up programs in consultation with ECCC and Indigenous groups to achieve the following: 1) verify effect assessment predictions on western sandpiper prey distribution and abundance (including biofilm), and 2) verify predictions of project related effects on salinity in the water column
- Conduct studies to identify potential project-related effects on PUFA production
- Document methods and best practices for creating biofilm habitat

With the implementation of the final project conditions, should the project be approved, the port authority is confident that any unforeseen effects from the project on biofilm and western sandpiper will be effectively mitigated.

Further work by the port authority

As well as the five years and over 20 biofilm and shorebird-related studies conducted to inform the effects assessment, the port authority remains committed to furthering the development of biofilm science. The port authority is trialling methods that may enhance the follow-up program. In spring 2021, the port authority implemented a program to evaluate the efficacy of using a drone and remote sensing technology to measure and monitor biofilm over large areas. The program was designed through conducting multiple meetings with experts in biofilm, shorebirds, and remote sensing that included industry and academic scientists. Prior to implementing the program, the port authority provided the study design to, and met with, ECCC and Indigenous groups to solicit their feedback. The port authority also invited ECCC scientists and Indigenous group members to observe and/or participate in the field data collection. Although ECCC scientists and Indigenous group members were unable to participate, ECCC colleagues from the University of British Columbia observed the field data collection. Initial results from the technology trial are promising and these techniques are anticipated to enhance the component of the western sandpiper prey availability follow-up program to verify effect assessment predictions and to monitor biofilm distribution, abundance, and quality for migrating sandpipers within the LAA.

The port authority is also conducting a long-term salinity monitoring program that records salinity levels at multiple locations across Roberts Banks. This program was initiated in 2016 and provides continuous salinity monitoring across the annual cycle and constitutes a robust multi-year baseline dataset on which to evaluate potential effects from the project. Data from the program has been shared with ECCC and other interested parties. This is the longest known continuous salinity monitoring program recorded at Roberts Bank.

Related to the Biofilm Habitat Creation Guidance Manual described above, the port authority intends to implement a biofilm creation or enhancement project, should RBT2 be approved. The port authority has been actively consulting with Indigenous groups and ECCC on a biofilm creation or enhancement project since March 2021 and is assessing local opportunities in the Lower Mainland to create intertidal biofilm habitat. Consultation conducted to date includes discussing the biofilm creation or enhancement project approach, site selection criteria, and discussing potential site locations. The biofilm creation or enhancement project is an opportunity to apply

techniques described in the draft Biofilm Habitat Creation Guidance Manual to provide a local project case study where biofilm creation is a primary objective. The project will focus on areas important to migratory shorebirds and will further contribute to research on biofilm habitat creation and ecological function.

In summary, the port authority continues to be a leader in biofilm science and is committed to working collaboratively with government agencies, scientists, and Indigenous groups to further the understanding of this important habitat.

Summary

The available scientific empirical evidence submitted by the port authority during the EA supports the following key conclusions:

- 1) The project will result in only a limited direct effect on biofilm habitat (1.9 ha or less than 0.1% of the total biofilm habitat available within the LAA)
- 2) Biofilm has evolved to thrive under variable salinity and environmental conditions found within the LAA
- 3) The changes to the salinity regime will be minor with the project in place and well within the natural variability that currently exists within the LAA
- 4) The dynamic estuarine conditions that support high-quality, productive biofilm within the LAA will not be affected by the project
- 5) Productive, high-quality, fatty acid-rich biofilm (including PUFA) will be available to foraging western sandpipers in similar distribution and abundance as under existing conditions
- 6) Fatty acid-rich invertebrates, sandpiper's other primary prey, will also not be adversely affected with the project (a conclusion that the review panel also reached based on an independent review of the evidence)

Based on these conclusions, the weight of evidence indicates that biofilm and invertebrate populations within the LAA will continue to support migrating shorebirds with the project in place. Throughout the EA, some parties have speculated that there may be an effect, but no party has provided any empirical evidence that contradicts the scientific conclusions.

The EA process has provided for a comprehensive, precautionary, and conservative assessment of the potential effects of the project on biofilm and migratory shorebirds. Throughout the EA, the port authority was responsive to ECC's concerns, conducting three years of additional biofilm fatty acid and PUFA studies to investigate potential project-related effects. Those results as well as the large body of studies and information that informed the assessment demonstrate that the project is not likely to cause significant adverse effects on biofilm or the shorebirds that consume biofilm. Moreover, there is a robust follow-up program. That program includes proven effective mitigation measures, including offsetting, available to be implemented if an unforeseen effect on biofilm arises.

For these reasons, the minister can be confident that the project is not likely to cause significant adverse environmental effects on biofilm or migratory shorebirds, including western sandpiper, taking mitigation into account.