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Quebec Region

ANALYSIS AND EVALUATION OF THE RESULTS OF STUDIES ON THE STRIPED BASS, CONDUCTED ON BEHALF OF THE QUÉBEC PORT AUTHORITY AS PART OF THE BEAUPORT 2020 PROJECT

Context

In 2015, the Québec Port Authority (QPA) submitted to the Fisheries Protection Program of DFO Quebec Region's Regional Ecosystems Management Branch (REMB) an application for authorization for a project to expand the Port of Québec in Beauport Bay. The REMB's analysis indicated that the project was likely to cause serious harm to a number of fish species under the *Fisheries Act* (FA) and impacts to at least one species of fish protected under the *Species at Risk Act* (SARA). Fishing carried out by firms hired by the QPA and by Quebec's Ministère des Forêts, de la Faune et des Parcs (MFFP) showed a high abundance of striped bass (*Morone saxatilis*), particularly reproductive adults, in the area targeted for the port expansion. The striped bass, St. Lawrence River population, currently in recovery, is a species protected under SARA. Subsequently, as part of the environmental assessment of the project, the QPA hired a consultant to document the occurrence of striped bass in the study area through monitoring of spawning activity (2015 to 2017), environmental DNA surveys (2016 to 2017), a simulation of egg drift in Beauport Bay, and telemetry tracking of adult striped bass tagged with acoustic transmitters (2015 to 2017). This tracking involved striped bass tagged by MFFP in projects undertaken for purposes other than assessing the species' status in Beauport Bay. In October 2017, the QPA submitted a summary report (Anonymous 2017) to the REMB. The QPA hopes that the consultant's studies will feed the analysis to more precisely identify the critical habitat of the St. Lawrence River population of striped bass.

After receiving that report, the REMB requested scientific advice from the Regional Science Branch (RSB) to determine whether the methods, analyses, results and interpretation presented allow, with reasonable certainty:

1. Confirmation of the conclusion regarding the presence of a spawning area at the mouth of the Etchemin River, based on environmental DNA (eDNA) surveys, signs of spawning activity based on the observation of striped bass jumping and splashing, and surveys of recreational fishers reporting catches of adult and juvenile striped bass during the spawning period;
2. Confirmation that the results of telemetry tracking carried out near the southwestern tip of Beauport Bay and in a section of the St. Lawrence River extending as far as Lévis could contribute to modify the area of important spawning habitat identified at the tip of the Québec Harbour peninsula (Beauport area) under the recovery strategy, taking into account that the currently designated area has already been identified as an important breeding area, as described in the recent Science Advisory Report (DFO 2017a);

3. Confirmation that the hydrodynamic model used and the assumptions of the model are adequate for simulation of the drift of striped bass eggs and incorporate all the variables specific to the St. Lawrence River.

As part of the regional science response process, representatives from the DFO Regional Science Branch and the Regional Ecosystems Management Branch, Environment and Climate Change Canada, consultants, the MFFP and universities met in Québec City on March 22-23, 2018 to review the first report (Anonymous 2017) prepared by the QPA consultant and to address the three points above. Following the March 2018 meeting, the consultant prepared a second report (Anonymous 2018) for the QPA that took into account reviewer comments on the telemetry component: it was submitted to the REMB in July 2018. The REMB once again requested that the RSB revise the second report and address the second point above.

This Science Response Report results from the Science Response Process in March and July 2018 on the evaluation and interpretation of the results of studies on striped bass, conducted on behalf of the Québec Port Authority as part of the Beauport 2020 project.

Background

Current status of the St. Lawrence River population of striped bass

In 2004, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the striped bass (*Morone saxatilis*) population of the St. Lawrence Estuary as extirpated. As a result of this assessment, the species was officially listed in Schedule 1 of SARA in 2011. In 2002, the Ministère des Forêts, de la Faune et des Parcs (MFFP) implemented a program to reintroduce the species in order to establish a new population capable of sustaining itself in the St. Lawrence River. Following these efforts, an increase in the population and its distribution, along with natural reproduction of individuals, was observed. In 2011, COSEWIC reassessed the general status of striped bass. The St. Lawrence Estuary population was renamed the “St. Lawrence River population” and was designated endangered (COSEWIC 2012). In the same year, a recovery strategy was published as required by SARA (DFO 2011). The knowledge available at that time made it possible to identify critical habitat for juvenile growth, which corresponded to the intertidal zone (0 to 5 m depth) of Anse Sainte-Anne, a bay located between Saint-Roch-des-Aulnaies and Rivière-Ouelle, on the south shore of the St. Lawrence Estuary. Since then, new areas of significance for the various life stages of the species have been discovered and documented (DFO 2017a and references). The Beauport Bay area was identified as an important habitat area for adult feeding and wintering, for the growth of larvae and young-of-the-year and for reproduction, with the likely presence of a spawning site. The other area identified as important for reproduction is the mouth of the Rivière du Sud, where the presence of a spawning site has been confirmed (Côté 2012). An update of the recovery strategy, combined with an action plan, is being prepared and should include enhanced identification of critical habitat that integrates the areas identified as important for the species, based on the 2017 Science Advisory Report (DFO 2017a and references).

Analysis and Response

The analysis of and response to the three points submitted with a view to obtaining expert advice are presented below. As mentioned above, the reviewers had to decide whether the consultant’s methods, analyses, results and interpretation allow the following, with reasonable certainty:

1. Confirmation of the conclusion regarding the presence of a spawning area at the mouth of the Etchemin River, based on environmental DNA (eDNA) surveys, signs of spawning activity based on the observation of striped bass jumping and splashing, and surveys of recreational fishers reporting catches of adult and juvenile striped bass during the spawning period;

The review of the analyses and results of the report precludes confirmation of the presence of a spawning area at the mouth of the Etchemin River with reasonable certainty. The eDNA analyses show that striped bass occur in the area. However, these results do not provide clear evidence of a spawning area at the mouth of the Etchemin River: first, there is no proven relationship between fish abundance and the amount of eDNA detected; and, second, the sampling did not have the temporal resolution required to detect spawning activity in the area. In addition, the data presented do not specify the life stage of the identified species (spawners and immature fish). With regard to signs of spawning activity, such as jumping and splashing, the observation of splashing for a few days in 2016 and 2017 did not permit formal identification of the species' presence in the area. At most one day of splashing observations, coupled with the sighting of fish with two dorsal fins, which may be characteristic of striped bass, did not allow conclusive confirmation. It should be noted that splashing is not necessarily associated with spawning activities. Also, at the mouth of the Etchemin River, the consultant found larvae of American shad (*Alosa sapidissima*), a species also known to show the same splashing behaviour as striped bass (Anonymous 2017). The absence of striped bass eggs and larvae in the samples collected does not support the presence of a spawning area at the mouth of the Etchemin River. Finally, no monitoring of spawners has been carried out by targeted fisheries in the Etchemin River area. Recreational fishers were merely surveyed without any synchronous observations of sex ratios or splashing, which limits the potential interpretation of the results.

2. Confirmation that the results of telemetry tracking carried out near the southwestern tip of Beauport Bay and in a section of the St. Lawrence River extending as far as Lévis could contribute to modifying the area of important spawning habitat identified at the tip of the Québec Harbour peninsula (Beauport area) under the recovery strategy, taking into account that the currently designated area has already been identified as an important breeding area, as described in the recently published Science Advisory Report (DFO 2017a);

The telemetry tracking data presented by the consultant (Anonymous 2018) may be used to improve the current delineation of striped bass habitat. However, considering the many errors, the general lack of methodological details, the lack of standardization of the experimental system deployed, the low scientific rigour of the Kernel analysis, the absence of solid and adequate scientific references to support the interpretation of the results limit the value of the study. Therefore, we recommend the following: the distribution ranges presented in the consultant's report should not be used to modify critical habitat for reproduction, as defined in the 2017 draft recovery strategy and action plan for striped bass (*Morone saxatilis*), St Lawrence River population.

Quality of methods and data:

Based on the review of the 2018 Anonymous report, the consultant's telemetry tracking system, despite its limitations (e.g., interannual changes in positions of receivers), appears to be suitable for the study area and for providing quality raw data. In principle, the system makes it possible to document, with certainty, the occurrence of striped bass when they are inside the grid of receivers (for STXX stations, all located in the northern portion of the study area, and excluding the Lévis stations, Lev-1 and Lev. 2, see Figure 1 below). However, no data were provided to support the consultant's assertion that its system is watertight (i.e., that all fish with transmitters were detected inside the receiver grid from entry to exit). For the positioning system, the receiver positioning rate is measured using synchronization transmitters to calibrate all receivers' clocks, calculate the receivers' positions when they are accidentally moved and estimate the position errors calculated by the system (Smith 2013). In this study, the positioning rate ranged from medium (60.6%) to high (76.6%) and the results indicate that the system was relatively stable over time during the monitoring season. Considering the hydrodynamic conditions specific to the study area and problematic factors such as port activity noise, positioning performance appears average though satisfactory for some analyses, particularly occurrence analyses. The positioning rate of striped bass in the system was low, at a value around 20%. The report does not allow an assessment of the variability in positioning rates between individuals, but we can speculate that it is high. The low positioning rate of fish can be explained by various factors specific to striped bass, including their swimming speed and the possibility that individuals may have found themselves on the periphery of the system. Hydrodynamic conditions may also be partly responsible for this poor yield. The low positioning rate of fish is a major impediment to behavioural and home range analyses for highly mobile species such as the striped bass. This drawback stems from the specific study system rather than from poor field techniques.

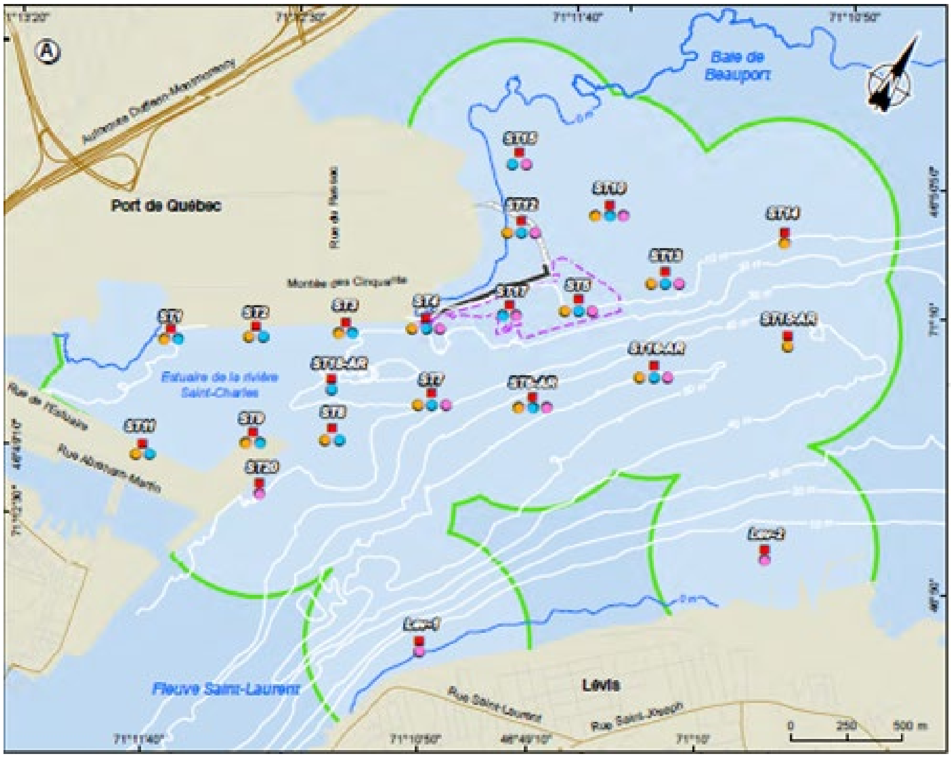

Figure 1. Map 1, p. 5, from the 2018 Anonymous report showing the position of telemetry stations in the study area.

Quality of analyses and interpretations

Although data use is appropriate for some analyses, such as occurrence analyses, several analytical issues have been identified which led to erroneous interpretations of results.

Issue 1: No assessment of signal range

Assessing and understanding the detection range of receivers and transmitters is essential for interpreting telemetry data (Kessel et al. 2014, Loher et al. 2017). For the analyses in the present study, the consultant assumed that the receivers had a theoretical range of 500 m, without factoring in the study site's configuration, environmental conditions or the type of transmitters used. The report does not define the range or provide a rationale for the 500 m value: it is assumed that the probability of fish detection is distributed evenly among transmitter types and across time and space. Yet, several factors call into question the use of a 500-m theoretical range.

First, with regard to the transmitters implanted in striped bass, the tests conducted by the manufacturer (VEMCO) show a range greater than 500 m under ideal conditions (617 m for the V16L and 520 m for the V13L). The manufacturer therefore recommends testing the signal range for each study, since this range can vary significantly from one system to another, and depending on environmental conditions. It has been demonstrated many times that signal range varies based on the systems studied and must be tested to be able to correctly interpret data (reviewed by Kessel et al. 2014, Jossart et al. 2017, Loher et al. 2017). Although the consultant states in its report that receiver range may be influenced by several factors, some of which are present in the study area (e.g., tide, ambient noise), the actual range of the receivers was not tested. Therefore, given the types of transmitters and the highly dynamic nature of the study area (reversed currents, current velocity, noise, etc.), the consultant's premise that a theoretical range of 500 m can be applied to all striped bass under all conditions is risky without field validation and is likely invalid. In a 2013 MFFP study conducted in the Île d'Orléans area, a few kilometres downstream from the Port of Québec, testing showed that signal range could exceed 2000 m, and even 3000 m (Valiquette et al. 2016). That study also noted that receivers located near transmitters sometimes had lower detection rates than did receivers farther away from transmitters. Assessing the actual signal range is therefore very important, especially when a study aims to describe small-scale movements (less than the signal range). Given the absence of testing of the signal range, and the likelihood that signals vastly exceeded the theoretical range, or were negatively affected by their proximity, applying a theoretical value of 500 m to infer small-scale movements of individuals between stations seems inappropriate.

Moreover, some of the results invalidate the use of a 500-m theoretical range. For example, Figure 2 (Map 3, p. 29 of the consultant report) shows striped bass positioning results from the VPS system stations named "STXX," all located in the northern portion of the study area. Stations Lev-1 and Lev-2, located near Lévis on the south shore, are not synchronized with the "STXX" stations and thus are not involved in calculating VPS positions. Yet, the map shows that individuals were clearly positioned on the south shore. This means that these positions would have been obtained from at least three receivers on the north shore of the river (in the VPS system) which simultaneously picked up the signals emitted by the fish on the south shore. The VPS system receivers nearest to these positions are all located more than 1,000 m away, well beyond the 500-m theoretical range (see figure below).

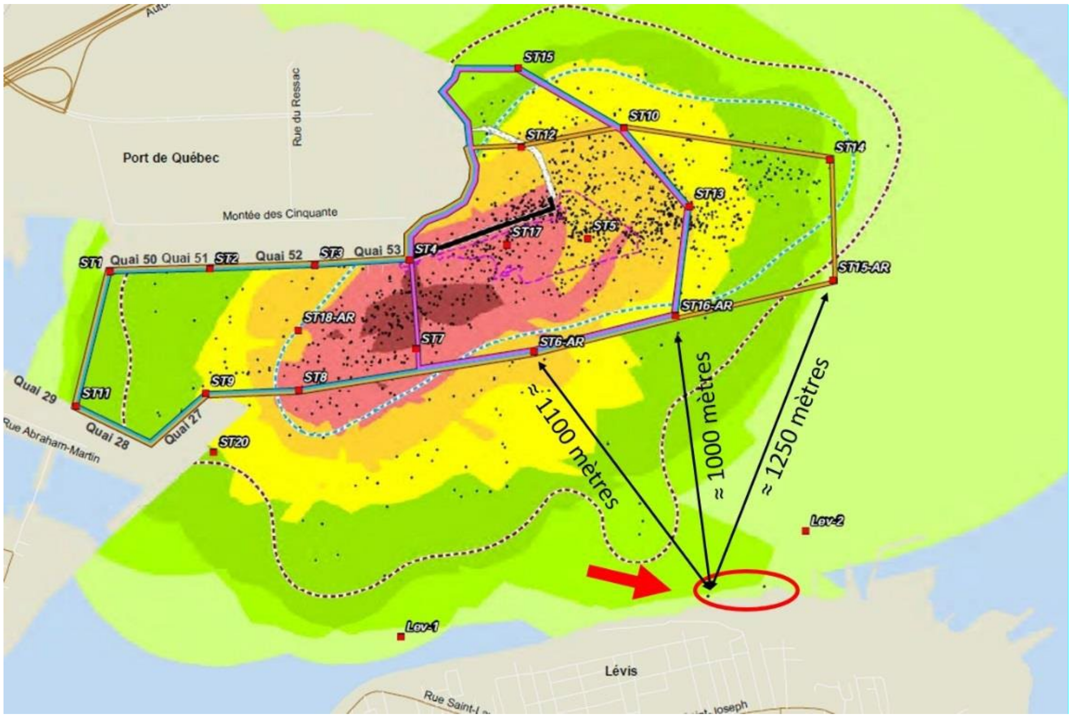

Figure 2. Map 3, p. 29, adapted from the 2018 Anonymous report. The circle and red arrow indicate the positions being considered and the approximate distances between one of these positions and the nearest stations which helped locate the fish on the south shore.

Issue 2: Incomplete definition and analysis of home ranges

As used in the report, the definition of “home range” to determine the area of occurrence per individual is incomplete. The report takes this definition from Burt’s (1943) article, in which he states, “*I would restrict the home range to that area traversed by the individual in its normal activities of food gathering, mating, and caring for young. Occasional sallies outside the area, perhaps exploratory in nature, should not be considered as in part of the home range*.” The concept of excursion (“*occasional sallies*”), and therefore of off-centre data is practically absent in the analysis presented, by using a Kernel probability threshold of 90 +/- 5% (Anderson 1982). It should be noted that the closer the Kernel probability threshold is to 100%, the wider and more inaccurate the defined area, thus increasing the probability that the animal will be considered in the targeted area (Anderson 1982).

Using a 95% probability threshold, the Kernel analysis creates a home range area that is overestimated and inaccurate, compared with what is used more intensively (core of the home range) and which could reflect a real biological attraction, such as finding partners or congregation for reproduction purposes. A 95% probability threshold is more in line with what is available to the animal in the immediate environment.

Moreover, in the analysis of home ranges per individual, the use of a very small number of VPS positions, from two positions, implies that a large bias will be present (Anderson 1982). A limited number of points implies a positive bias in terms of area, and far less accuracy in delineating the home range. As a result, the size of the home range will be overestimated and will include areas that the species does not use.

Combining all points for all individuals is a rarely used technique that is usually avoided when identifying home ranges. The technique that should be used involves delineating home ranges for each individual and then combining them. The report does not provide details on any systematic data sampling. Börger et al. (2006) note that some studies may use as few as ten positioning points by taking into account the variance associated with different sampling schemes. However, the number of days during which these positions were obtained for each individual must be standardized to properly represent the home range of a group of individuals during the study period. Otherwise, the home range analysis may be unable to discern the biological reality of space use because of poorly designed sampling (Luca Börger, Swansea University, UK, pers. comm.). The sampling effort must also be standardized in terms of the number of positions used per individual and the distribution of these positions over time. For example, a position for one, two or three days, out of the 30 days covered by the analysis, would be an acceptable temporal distribution, thus limiting the autocorrelation of the data. Resampling and a variance analysis are required to validate a Kernel approach using less than 30 positioning points (Luca Börger, Swansea University, UK, pers. comm.).

Also, treating and presenting the three years simultaneously prevents us from assessing the overlapping of home ranges from one year to the next, and from considering recurrent habitat use, which would give more weight in terms of biological importance of the site.

Another shortcoming of the analyses is the lack of comparison between the different areas. The observation of a concentration of data near the port area may be due to a system artifact: the receiving terminals are concentrated in this area and the distance between receivers prevents signals from being captured from fish outside the study area. It would have been interesting to use a reference area to obtain a more statistically valid picture of the abundance of striped bass near the wharf.

To conclude, in light of the absence of a variance analysis of sampling, the lack of accuracy and lack of standardization in the sampling regime plus the very low number of positions used, it appears that the home range analyses in the report should be considered an approximation of the area possibly used by striped bass rather than a robust analysis of the species' home range in the area.

Issue 3: Unreliable calculation of residence time

The consultant's comparisons of the residence time of striped bass observed at Beauport with the residence time of these fish observed in other systems are questionable and unreliable. The main reasons are the scale differences between the studies compared and the methods of calculating residence time.

The report (p. 36) attempts to define and compare the residence times of striped bass for different populations without taking into account the areas covered and the methods used by the different studies.

A study by Douglas et al. (2009) used geographic reference points to determine residence time when individuals were within the spawning area. When an individual passed a previously defined point and remained in a section located more than 15 km upstream of that point, it was considered to be in the spawning area until it returned to the downstream location. In terms of size of the area and residence time, the scale of analysis used in the Douglas et al. study (2009) precludes comparison with the study conducted in the Québec City area. Had the consultant considered the area as a whole, as did Douglas et al. (2009), based on the data presented in the report, the mean residence time of striped bass would have been nearly two weeks.

A study by Carmichael et al. (1998) also considered an entire area as spawning habitat. The area in question covers at least 15 linear kilometres along the Roanoke River. Similarly to Douglas et al. (2009), the authors considered the monitored fish to be in the spawning area as long as they did not return to a point downstream from this area. Residence times were therefore calculated as the difference between the dates on which the fish entered and exited the spawning area.

Also, in a study by Hocutt et al. (1990), the designated spawning areas extend along more than 40 linear kilometres of a river and include both freshwater and brackish water areas. The freshwater portion identified as a spawning area covers at least 20 linear kilometres of that river. Here again, fish were considered to be in the spawning area as long as they were not detected downstream from it. Furthermore, the authors attempted to detect several individuals, without necessarily detecting them on a daily basis, for up to the full 30 days of residence calculated. The 30-day maximum is the time between the first and last detection of an individual in the spawning area (freshwater and saltwater portions), not the sum of the days on which an individual was detected. The 30 consecutive days referred to on page 36 of the consultant's report is therefore incorrect and confusing in the context of the work conducted in the study area.

In summary, the references provided in the consultant's report, as such, do not apply to the system deployed in the Beauport area, for the following reasons:

- The area considered as a spawning area in Beauport Bay is more than five times smaller (in linear distance) than the areas studied in the cited articles; this implies that a fish is considered to be outside the spawning area much more frequently in the Beauport Bay case than in the other studies;
- The method of calculating residence time differs completely. With the system defined by the consultant, the calculation method is very accurate and consists of totalling the residence events of individuals occurring in Beauport Bay; conversely, the cited studies calculate residence times as the time between the first and last detection of an individual in a spawning area (or region).

The entire report section covering the interpretation of residence times is considered invalid as no scientific references support the following:

- A minimum residence time for a spawning activity to be effective (i.e., a female can likely arrive at a spawning site, participate in spawning and leave within the following hours/days). Since no data are available on this subject, it is impossible to interpret a one-day occurrence at a site as an individual crossing to other sites. Carmichael et al. (1998) hypothesized that females move throughout spawning areas based on eggs' degree of maturity. Hocutt et al. (1990) noted that the maturity level of eggs carried by females likely determines residence time in the spawning area. Douglas et al. (2009) noted that females, unlike males, shed their eggs all at once and then leave the spawning area. This information suggests that it would not be surprising for females that are likely mature and ready to reproduce to remain in the area for only one to a few days until egg laying. On the other hand, in terms of reproductive success, it is advantageous for males that produce large quantities of milt to remain in the area as long as possible, until their milt is expended. Considering that striped bass is highly mobile, its occurrence in one area for several hours clearly indicates that the area is biologically significant;
- Residency events in the spawning areas described in the literature, using a comparable methodology.

Issue 4: Autocorrelation of data

Since no statistical tests were conducted, using the sum of detections as a unit of comparison fails to account for the fact that consecutive detection data are not independent but are instead autocorrelated. Thus, conclusions based on a qualitative assessment of the number of detections at a given station are biased because of inadequate treatment of autocorrelated data.

This issue also arises in home range analyses (Kernel) where all positions are used in spite of the fact that they may also be autocorrelated. An alternative method, such as subsampling, can be used to overcome this problem.

Issue 5: Data representativeness and interpretation

The value of a statistic or a conclusion drawn from a sample depends on its representativeness. This representativeness is crucial, especially when a sample's characteristics can influence the conclusions sought. The authors fail to validate or discuss influential variables such as the fish tagging site, the sex of individuals or the types of behaviours.

The issue of representativeness is particularly evident in analyses of areas used (Kernel) where all positions are combined whether they are generated by transient or longer-term resident, by male or female individuals. The authors nonetheless mention that literature reports suggest that females and males have different behaviours, with males often remaining in spawning areas for longer periods than females. For example, the concentration areas identified in the report result from 2 male striped bass which alone generated 63% of the positions; however, their habitat use is taken to be representative of all observed striped bass. This is worrisome since the document states that different groups were observed (transients and residents). In addition, this generalization is based almost exclusively on male data, since little data was obtained from females. Finally, Map 3 shows that the area containing the positions generated for the other fish is almost double the size of that attributed to the 2 fish in question.

Issue 6: Lack of scientific references to support some conclusions regarding striped bass spawning behaviour in the study area

Some of the consultant's conclusions regarding striped bass behaviour in the study area are not supported by valid scientific references. The report states that the uniform hourly distribution of nine spawners indicates that no spawning activity is occurring. However, there is no scientific consensus on a specific timing for striped bass spawning (Appendix 1). Furthermore, more intense activity such as spawning cannot be inferred from the mere occurrence of striped bass in a given area. Spawners could all be present in a given area and exhibit activity peaks at specific times of the day without impacting the detection level.

With respect to the possibility that, in the study area, spawning is dependent on water temperature, the report states that the literature shows that striped bass spawning occurs in a temperature range of 12 to 22°C, whereas peak spawning activity (egg laying) occurs between 15 and 19°C (Anonymous 2018). The interpretation of the results to validate the possibility of spawning in Beauport Bay places too much emphasis on the virtual absence of tagged striped bass in the Beauport area during the period when river water temperatures fall in the species' spawning temperature range, that is 15 to 19°C according to the literature (Figures 9, 10 and 11, and Conclusion). The information available for the Miramichi River striped bass population (the population nearest to the St. Lawrence River population) (Table 1) shows interannual variations in temperature range during spawning activities, but which are in the lower values in the temperature range indicated in the report for striped bass observations at spawning sites, or directly related to spawning observations:

Table 1. Temperatures observed during spawning activities for the Miramichi River striped bass population.

Spawning activity temperatures	References
Occurrence of females at the spawning site at mean daily temperatures (spawning site) of 12 to 14°C in 2004, and 8 to 18°C in 2005	Douglas et al. (2009)
spawning at 12 to 19°C	DFO (2013)
spawning at 11 to 13°C	DFO (2014)
spawning at 14 to 17°C	DFO (2015)
spawning at 17°C	DFO (2016 and 2017b)

The report also notes that the relatively early departure of striped bass from waters that are in the spawning temperature range (15-16°C according to the consultant's data) suggests that these spawners may reproduce beyond the area covered by the receivers. The scientific literature shows that striped bass typically leave spawning areas after spawning (Wingate et al. 2011, Callihan et al. 2015). The observation that most individuals leave the area at temperatures of 15 to 16°C, likely after participating in spawning, is consistent with the literature.

3. Confirmation that the hydrodynamic model used and the assumptions of the model are adequate for simulation of the drift of striped bass eggs and incorporate all the variables specific to the St. Lawrence River.

A review of the method used does not allow confirmation, with reasonable certainty, that the hydrodynamic model and the advection-diffusion model are adequate to simulate egg drift in the study area. In the case of the hydrodynamic model, it is difficult to judge the quality of the hydrodynamic simulations because of the lack of details provided in the report. In particular, there is no information on the quality of the tidal range simulation (i.e., range error) or on the high tide phase (temporal matching error). The grid size used in the Port of Québec area for the data on currents produced by the hydrodynamic model is also considered too large (250 m x 110 m) for the size of the study area. In fact, the model used would be suitable at the regional level but not on a scale as small as that of the study area. The large grid size used in the model leads to false diffusion which expands the diffusion plume. In addition, the currents data in the model were validated using data from the atlas of tidal currents in the St. Lawrence Estuary, published by the Canadian Hydrographic Service; this constitutes circular validation, since the same basic model was used to produce the currents. To correct this bias, it is important to obtain validations of flow area velocity (depth and velocity) similar to the validation approach based on injecting particles into the system to estimate error.

The advection-diffusion model used to simulate egg dispersion is a contaminant spill model (SPILLCALC) which presents several drawbacks for the present application. In that type of model, the effect of wind is considered for surface dispersion. However, it is known that eggs do not float; instead they tend to sink to the bottom within the first few hours of being produced and subsequently reach a density similar to that of water. Therefore, the effect of wind in the model creates a false dispersion of eggs. The use of surface currents rather than the mean current over the entire water column exaggerates the spread and dispersion of eggs. Therefore, the diffusion coefficients should be calibrated and validated for the complex flow environment in the St. Lawrence River near Québec City. To do this, direct measurements of current velocity as a function of depth should be used to reflect the context of the injection zone. Furthermore, the simulations for a 72-hour cycle appear inadequate, given that the incubation time during the spawning period is 48 hours according to the literature. Finally, to obtain valid results, the modelling would have to be repeated without diffusion (advection only) over a 48-hour period using a denser hydrodynamic grid, especially in the injection zone.

Conclusions

Based on a review of the methods, analyses, results and interpretation in the consultant report, it is not possible to confirm, with reasonable certainty, the presence of a spawning area in the Etchemin River. The consultant’s conclusions concerning the eDNA analysis results are premature as they are not supported by robust evidence. First, the presence of eDNA does not provide information on the abundance of fish and it is impossible to determine whether the eDNA collected comes from spawners or immature individuals. Second, only one day of splashing observations was reported and there is no way to identify, with reasonable certainty, the species involved (the splashing could be linked to the presence of American shad). Finally, striped bass eggs and larvae were not observed during a sampling campaign conducted in 2017. Collectively, these observations fail to confirm the presence of a spawning area at the mouth of the Etchemin River.

Considering the many methodological errors, the lack of standardization of the experimental system, the low scientific rigour of the Kernel analysis, the absence of robust and adequate scientific references to support the interpretation of the results, we recommend the following: the ranges presented in the consultant’s report should not be used to modify the identification of critical habitat for reproduction. However, the results of the analyses characterizing the occurrence of striped bass concentrations add to the knowledge that was previously used to identify the Beauport Bay area as an important spawning site.

Based on the information provided on the hydrodynamic model of egg dispersion, this model must be considered inadequate for this type of analysis. The lack of details on the simulations conducted using the hydrodynamic model limits their interpretation. Furthermore, the model used for advection-diffusion (contaminant transport model) and the associated validation are unsuitable, particularly because the reliance on certain premises, such as the effects of wind, surface currents and egg floating, make the conclusions unacceptable.

In summary, none of the three points addressed can be confirmed with reasonable certainty after reviewing the information contained in both reports submitted.

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Appendix 1

Table A.1. Chronology of Striped Bass Spawning Based on the Literature

Chronology	**References**
Mainly at night	Fish, F.F., and McCoy, E.G. 1959. The River Discharges Required for Effective Spawning by Striped Bass in the Rapids of the Roanoke River of North Carolina. N.C. Wildl. Resour. Comm., Raleigh. 33 p.
No difference in the mean number of eggs/hour over 24 hours	McCoy, E. G. 1959. Quantitative sampling of striped bass, *Roccus saxatilis* (Walbaum), eggs in the Roanoke River, North Carolina. These (M.S. In Zoology). North Carolina State College, Raleigh. Kernehan, R. J., Smith, R. E., Tyler, S. L. and Brewster, M. L. 1976. Ichthyoplankton. Volume II In Ecological studies in the vicinity of the proposed Summit Power Station, January through December 1975, 669 p. Ichthyological Associates, Inc. Box 286, RD # 1, Middletown, DE 19709.
Late afternoon–early evening	Sheridan, J., Domrose B., and Wollitz B. 1960. Striped bass spawning investigations. In Virginia Dingell-Johnson Project. Commission of Game and Inland Fisheries, Warmwater Fisheries Management Investigations, Annual Progress Report for Federal Aid Project No. F-5-R-6, Richmond, Virginia. p. 32-43.
55.5% of eggs laid during the day, 45.5% at night	May, O. D., Jr., and Fuller, J. C. Jr. 1965. A study on striped bass egg production in the Congaree and Wateree Rivers. Proc. 16th Ann. Conf. Southeast. Assoc. Game Fish Comm. 1962:285-301.
Especially in the afternoon, very little at night	Dudley, R. G., Mullis, A. W. and Terrell, J. W. 1977. Movements of Adult Striped Bass (*Morone saxatilis*) in the Savannah River, Georgia. Trans. Am. Fish. Soc. 106:314-322. Hampton, K. E., Wenke, T. L., and Zamrzla, B. A. 1988. Movements of adult striped bass tracked in Wilson Reservoir, Kansas. Prairie Naturalist. 20:113-125. Henley, D. T. 1993. Seasonal movement and distribution of striped bass in the Ohio River. Proc. Ann. Conf. Southeast. Ass. Fish Wildl. Ag. 45(1991):370-384.
Late afternoon/noon–early evening, but also late night–early morning	Bain, M. B., and Bain, J.L. 1982. Habitat suitability index models: Coastal stocks of striped bass. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C. FWS/OBS-82/10.1.
A peak at night, but also at sunrise and sunset	Wilkerson, M. L., and Fisher, W. L. 1997. Striped bass distribution, movements, and site fidelity in Robert S.

Chronology	References
	Kerr Reservoir, Oklahoma. N. Am. J. Fish. Manage. 17:677–686.
A peak between 9 p.m. and 12 a.m., and another between 9 a.m. and 12 p.m.	Rulifson, R. A. and Tull, K. A. 1999. Striped Bass Spawning in a Tidal Bore River: The Shubenacadie Estuary, Atlantic Canada. Trans. Am. Fish. Soc. 128, 613-624.
69% of eggs laid between 1 p.m. and 11 p.m.	Baker W. P., Boxrucker, J. and Kuklinski, K. E. 2009. Determination of Striped Bass Spawning Locations in the Two Major Tributaries of Lake Texoma. North Am. J. Fish. Manage. 29:4, 1006-1014.

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