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Proceedings of the Regional Peer Review on Information on the Potential Harm to Fish and Mussel Species at Risk (SAR) from Bayluscide Applications

Meeting dates: February 28–March 1, 2019
Location: Burlington, ON

Chairperson: Lynn Bouvier
Editor: Olivia Sroka

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

A regional science peer-review meeting was held from February 28–March 1, 2019 in Burlington, Ontario. The purpose of the meeting was to provide research information on the potential harm to fish and mussel species at risk (SAR) from Bayluscide applications to support decision making with regards to the issuance of permits or agreements. Participants included DFO Science, Species at Risk Program, Sea Lamprey Control Program, Fisheries Protection Program, Great Lakes Fishery Commission, United States Geological Survey, and academics from Canadian universities.

The invasion of Sea Lamprey in the Great Lakes inflicted widespread and significant mortality on fish that supported Indigenous, commercial, and recreational fisheries. In response to the invasion, the Great Lakes Fishery Commission was charged with developing and implementing a program to eradicate or minimize Sea Lamprey populations in the Great Lakes. The primary method to control Sea Lampreys is the application of selective lampricides that target Sea Lamprey larvae in their nursery habitats. These include a granular formulation of Bayluscide that is used to assess and control larvae in deep-water environments. In some instances, Bayluscide has been applied in waterbodies that contain fish and mussel species currently listed under the *Species at Risk Act* (SARA). As a result of these applications, DFO's SAR Program requested Science Advice to understand the potential impacts of Bayluscide on fish and mussel SAR, and to identify best management practices and potential mitigation measures to minimize impacts.

This proceedings report summarizes the relevant discussions from the meeting and presents recommended revisions to be made to the associated Research Documents. The Proceedings, Science Advisory Report, and Research Documents resulting from this science advisory meeting are published on the DFO Canadian Science Advisory Secretariat (CSAS) website.

INTRODUCTION

The Sea Lamprey (*Petromyzon marinus*), a species native to the Atlantic Ocean, was first observed in Lake Ontario in 1835, and invaded the remaining Great Lakes between 1921 and 1937. Since their invasion, Sea Lamprey have inflicted widespread and significant mortality on fishes that support Indigenous, commercial, and recreational fisheries, including Lake Trout (*Salvelinus namaycush)*, Lake Whitefish (*Coregonus clupeaformis)*, Ciscoes (*Coregonus* spp). and numerous other species. In response, Canada and the United States established the Great Lakes Fishery Commission (GLFC) under "The Convention on Great Lakes Fisheries between Canada and the United States (1954)". The GLFC was charged with developing and implementing a program to eradicate or minimise Sea Lamprey populations in the Great Lakes. The GLFC administers the bi-national Sea Lamprey Control Program (SLCP), while the Department of Fisheries and Oceans (DFO), and the U.S Fish and Wildlife Service (USFWS) deliver its operational elements, with support from the U.S Army Corps of Engineers and the U.S. Geological Survey.

Presently, the primary method to control Sea Lamprey is the application of selective lampricides that target larvae in their nursery habitats. These include 3-trifluoromethyl-4-nitrophenol (TFM; Hubert 2003), and 2', 5-dichloro-4'-nitrosalicylanilide or niclosamide ethanolamine salt (trade name Bayluscide; Dawson 2003). Various formulations of Bayluscide are used to assess and control larval Sea Lamprey populations. In particular, the granular formulation of Bayluscide (gB) is used to assess and control larvae in deep-water environments, including estuaries, embayments, and interconnecting waterways, such as the St. Marys River, where the use of TFM would neither be effective nor economically viable.

In some instances, DFO-Sea Lamprey Control Centre (SLCC) staff conduct assessments and treatments with gB in waterbodies that contain fish and mussel species currently listed under *the Species at Risk Act* (SARA), as well as species assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The potential for lethal and sub-lethal effects to non-target fish and mussel species at risk (SAR), and the resulting potential to jeopardize their survival and recovery, is currently unknown. The lack of quantitative information about lethal and sub-lethal effects also makes it difficult to determine: 1) whether or how gB applications may alter population dynamics of these species; 2) how gB applications can be viewed in the context of other species-specific threats; and, 3) whether the investigation of potential mitigation measures is warranted.

In light of the knowledge gaps identified above, DFO's SAR Program requested Science Advice to understand the potential impacts of gB on fish and mussel SAR and to identify best management practices and potential mitigation measures to minimize impacts. Therefore, the goal of this Science Advisory Meeting was to evaluate the potential lethal and sub-lethal impacts of gB applications to fish and mussel SAR in the Great Lakes basin.

The purpose of the meeting, as described in the Terms of Reference (Appendix 1), was to understand the potential impacts of Bayluscide on fish and mussel SAR and to identify best management practices and potential mitigation measures to minimize impacts. A peer-review meeting was held from February 28–March 1, 2019 to discuss the potential impacts of Bayluscide on fish and mussel SAR. Meeting participants included DFO Science, Species at Risk Program, Sea Lamprey Control Program, Fisheries Protection Program, Great Lakes Fishery Commission, United States Geological Survey, and academics from Canadian universities (Appendix 2). The meeting followed the agenda outlined in Appendix 3.

DETAILED DISCUSSION

The meeting chair provided the participants with an introduction to the Canadian Science Advisory Secretariat (CSAS) process and explained the purpose of the meeting. This included the intent of the meeting, context on the original request for Science Advice, and how the products of the meeting might be used. Terms of Reference were outlined. Draft Research Documents (working papers) entitled “Relative Risk of Granular Bayluscide Applications for Fishes and Mussels of Conservation Concern in the Great Lakes Basin”, and “Estimating the Potential Mortality of Fishes and Mussels of Conservation Concern associated with Bayluscide Applications in the Huron-Erie Corridor” had been developed by DFO and provided to participants in advance of the meeting. The working papers were the basis for discussion, and participants were encouraged to add to or change the material, as needed, to ensure that the best and most up-to-date information was included.

Working Paper #1: Relative Risk of Granular Bayluscide Applications for Fishes and Mussels of Conservation Concern in the Great Lakes Basin

Presenter: Dr. Andrew Drake

The author presented information pertaining to the working paper titled “Relative Risk of Granular Bayluscide Applications for Fishes and Mussels of Conservation Concern in the Great Lakes Basin”. This included an introduction, methods, and results pertaining to the impacts of granular Bayluscide (gB) on fishes and mussels of conservation concern in Canadian waters of the Great Lakes basin. During this presentation, participants were asked by the Chair to refrain from asking questions until a formal review of the paper was provided by Dr. Margaret Docker. This paper dealt with objectives 1, 2, and 4 outlined in the Terms of Reference. Specifically, Dr. Drake presented information on the extent to which freshwater fish and mussels are exposed to gB in the Great Lakes and on the assessment of relative risk to gB for each species based on what is known about their toxicity to gB, habitat use, and potential exposure to gB based on past applications.

Formal Review

Presenter: Dr. Margaret Docker

The reviewer noted that the paper was clearly laid out with defined objectives and goals and that it was evident that the authors used the best available information pertaining to the four metrics used in the risk assessment calculation. She appreciated the approach used so that information could be refined without the need for additional information and without complicating matters.

Many of her comments were more questions of clarity rather than concerns with methodology. For instance, the inability to easily identify larval *Ichthyomyzon* to the species-level is problematic but there could be other ways to distinguish between these species based on their life history. She suggested that the authors try using barrier locations to identify all *Ichthyomyzon* spp. above a barrier as Northern Brook Lamprey based on the fact that Silver Lampreys largely require large lakes downstream of tributaries to fulfill their parasitic life stage. Therefore, Silver Lamprey are more likely to inhabit areas with Sea Lamprey ammocoetes which means that they are more likely to be exposed to gB in comparison to Northern Brook Lamprey. Failure to identify unknown *Ichthyomyzon* records to the species-level while including these records in each native lamprey’s relative risk assessment will likely underestimate the risk to Silver Lamprey, and like-wise, overestimate the risk to Northern Brook Lamprey. The reviewer also found it confusing how *Ichthyomyzon* records were treated throughout the paper with respect to inclusion in maps and relative risk assessments. A participant asked how identification of *Ichthyomyzon* spp. to the species-level could be reliably done and noted that the

COSEWIC status report for Silver Lamprey states that the species can in fact be found above barriers. Another participant stated that Silver Lamprey populations above barriers are relatively rare and would likely require a large inland lake above the barrier. One participant suggested that if Silver Lamprey have never been identified above a barrier then it would provide more confidence that *Ichthyomyzon* ammocoetes above such a barrier are likely Northern Brook Lamprey.

The reviewer identified issues pertaining to the use of surrogates for toxicity information and the knowledge gaps that exist. Although she stated that the authors did a good job of using surrogates in most cases, the choice of surrogates for Lake Sturgeon (*Acipenser fulvescens*), Grass Pickerel (*Esox americanus vermiculatus*), American Eel (*Anguilla rostrate*), and Spotted Gar (*Lepisosteus oculatus*) may not be appropriate given the lack of toxicity information that is available for anything closely related to these species. The reviewer asked if a range of risk scores could be given for these species depending on the surrogate used. The authors agreed that a sensitivity analysis could be done to show how different surrogates can affect the overall scores for fish species.

Questions pertaining to the intensity and habitat association scores and how the life cycle of a species may be taken into consideration were asked by the reviewer. Certain species may only use Sea Lamprey habitat for part of their life cycle, while others may be always found in Types I and II habitats, regardless of age. For this reason, the reviewer asked if authors could build this into the risk assessment. The authors replied that for most SAR, there is a paucity of knowledge on the use of habitat by different life stages of a species. This prevents the authors from incorporating life stage into their risk model.

Group Discussion

A participant asked how often an individual fish would be exposed to Bayluscide over its life cycle and if it would be expected to be in the same habitat as where mussels may be. A coauthor stated that the intensity score is more of a measure of potential repeated exposure for a population, rather than for individuals. The coauthor went on to explain that the paper does not consider the consequences of mortality in the relative risk assessment because it was meant to be broad in scope. The coauthor stated that other variables are important, but that they do not have a reliable way of including them in the model. Variables such as application frequency and response of populations are dealt with in the second working paper.

The use of circular buffers was questioned by one participant as gB applications are not expected to flow upstream of the application site. This participant suggested that the authors use elliptical buffers and go downstream rather than upstream. From a crude analysis the participant said that gB is unlikely to travel further than 600 m downstream and questioned the use of 2500 m buffers. This participant asked for clarification on where buffer sizes used in this study came from. A coauthor explained that they spent a lot of time thinking about detailed buffers versus generalized buffers and at what scale to use them. The coauthor agreed that 2500 m is large but after consideration of the pathways of effects outlined in the paper, the effects of Bayluscide at 2500 m are unknown. The coauthor explained that the use of buffers was more of a way to look at the proximity of gB applications to populations.

One participant noted that few details are given in the methods section as to how the mussel data was collected. This should be updated so that readers know the limitations of the mussel data. Another participant, in response to this comment, stated that the mussel surveys were not randomized and rather target the areas where mussels are found. The mussel program contains two types of surveys: timed search surveys and quadrat surveys. The participant re-iterated the need to know what data was used here and wondered whether the amalgamation of Type I and Type II habitats for mussels was appropriate in the analysis. Two coauthors explained that the

decision to consider Types I and II habitats equally was not an easy one but made sense given lack of substrate homogeneity that likely exists at an application site. The two coauthors defended their use of buffers as they were used to try to account for targeted small-scale sampling for fishes and mussels. Another coauthor explained that the mussel data that was used was in fact the quadrat sampling survey data and that this could be better explained in the text. The chair asked if qualitative data was considered but not included. A coauthor stated that the highest level of substrate detail was needed for the risk analysis and that the quadrat sampling data was the ideal dataset to use for this reason.

The Lake Sturgeon risk analysis results were extremely surprising to one participant who asked if Aquatic Landscape Inventory System (ALIS) segments reflected lake distributions of Lake Sturgeon. This participant noted that the authors treated Lake Sturgeon differently and suggested that based on size, life stage, and avoidance, the risk of gB will change for the species. This participant also wondered why native lamprey didn't score higher than Lake Sturgeon when Bayluscide targets lampreys in general. A coauthor stated that lake records for Lake Sturgeon are most likely not represented by ALIS segments, therefore the paper may be overestimating the risk of gB to Lake Sturgeon as its distribution is not properly represented. The authors were open to a correction factor to resolve this and agreed that Lake Sturgeon's vulnerability would change with body size, but incorporating this change in to the model would have to be done for all species which can become very complicated. Other participants echoed concerns regarding how Lake Sturgeon risk to gB was assessed. One participant in particular stated that the lack of size and life stage in the risk assessment calculation is its biggest flaw. The participant also stated that Lake Sturgeon young-of-the-year can detoxify TFM as an example and stated that life stage is also an issue for mussels as glochidia were not referenced in this risk assessment. A coauthor responded that although life stage and avoidance are factors that would affect risk to gB, the paucity of data for many SAR prevented the authors from addressing this and followed up by stating that caveats with respect to avoidance and life stage will be given in the text. In response to these concerns regarding Lake Sturgeon, the chair asked participants if they felt that Lake Sturgeon should be removed from the risk assessment or if Lake Sturgeon should be split out from the rest. The consensus amongst participants was to split out Lake Sturgeon rather than omitting it. The reviewer supported splitting out the species and stated that although caveats are presented in the text, figures illustrate that Lake Sturgeon ranks the highest and this is what readers will 'take home'. Another participant responded that due to Lake Sturgeon's life cycle and sparsity in the Great Lakes, it should be treated differently than other species and questioned the use of Rainbow Trout as its toxicity surrogate. This participant suggested that in cases where surrogates are distantly related to the species of interest, that the biology of potential surrogates be taken into consideration. A coauthor agreed that sparsity likely contributes to low absolute mortality results that will be presented in the second working paper and that this is support for splitting out Lake Sturgeon from other fish species in the risk assessment. In support of this, one participant noted that risk assessment figures should illustrate that Lake Sturgeon have been split out as to not confuse the reader. In response to the risk assessment ignoring glochidia, one participant suggested that surrogate glochidia could be used to determine toxicity to the life stage in a separate study. A coauthor stated that this cannot reliably be operationalized in the text of the working paper.

A participant asked if sampling of a rare species, including SAR, likely underestimates its abundance as in the case of this study. The participant also stated that the effect of gB on a rare species could be low given its low population size. A coauthor agreed but also stated that population level effects could be high depending on population saturation for a given area and stated that population-level effects are dealt with in the second working paper.

There is much more information on TFM and TFM/gB mixtures and how they affect aquatic organisms as opposed to just gB, as stated by one participant. This participant asked if these studies can be used to infer the impacts of gB alone on SAR. In response, another participant stated that this would be inappropriate as much of the toxicity from the TFM/gB mixtures comes from the TFM itself. Another participant explained that this would not be recommended as TFM and gB distribute in the water column differently, with gB settling on the bottom. Therefore, exposure to TFM versus gB would also relate to where species are found in the water column.

Given that gB is often applied in deep riverine habitats where wading is not possible, one participant asked how confident the SLCP is that they are applying gB in Type I and II habitats. A participant responded that the SLCP probe within an assigned plot for substrate type and are highly confident that they apply gB in Type I and II habitats.

Working Paper #2: Estimating the Potential Mortality of Fishes and Mussels of Conservation Concern associated with Bayluscide Applications in the Huron-Erie Corridor

Presenter: Eric Smyth

The author presented information pertaining to the working paper titled “Estimating the Potential Mortality of Fishes and Mussels of Conservation Concern associated with Bayluscide Applications in the Huron-Erie Corridor”. This included an introduction, methods, and results section pertaining to mortality of fishes and mussels of conservation concern in the Huron-Erie Corridor as a result of gB application. Specifically, the potential for fishes and mussels of conservation concern to be exposed to gB was quantified for the Detroit, St. Clair, Sydenham, and Thames rivers. The likelihood of individual and population-level mortality was then quantified for these species based on this exposure. Finally, the potential for altered population dynamics for select species of conservation concern was evaluated. Mitigation measures were identified that may reduce the scope for direct and indirect effects during gB applications, should risks be deemed non-negligible for fishes and mussels of conservation concern.

Formal Review

Presenter: Dr. Michael Wilkie

The reviewer first identified the strengths of the paper. This included the use of the best available information with respect to species occurrences. Also, the reviewer noted that the methodology and assumptions of the paper were clearly laid out with the description of mathematics behind the modelling easy to understand. The reviewer thought that the predictions for gB toxicity was a strength in this paper and that this information will be important for the SLCP going forward. He felt the authors were open about knowledge gaps and data limitations and did not try to oversell the conclusions.

When stating his questions and/or concerns with the research, the lack of life stage as a model parameter was firstly addressed. He thought that this was an important factor that would affect impacts of gB on a given species and that the authors should consider incorporating it into their models. He also felt that time of year was another component that should be considered for incorporation into the models as fish and mussels will not respond the same way to gB depending on the time of year. Similarly to the reviewer of the first paper, he took issue with some of the surrogate choices for toxicity. He stated that when using hierarchical taxonomic matching there is risk of a mismatch. Due to this risk, he suggested taking life cycle, physiology, and behaviours into consideration when choosing an appropriate surrogate for fishes and mussels. A coauthor suggested a sensitivity analysis for the use of surrogates to score toxicity as a possible solution. The reviewer then suggested they look at Lake Sturgeon life stage data to see which life stage is the most susceptible to gB. A participant asked if there is any ground

truthing that occurs with respect to a species toxicity to gB. Another participant responded that although they apply gB in the St. Marys River, they have never witnessed a mortality of Lake Sturgeon.

Next, the reviewer stated his concerns with how toxicity was generated for each species. He said that there could be overestimation of the concentration of gB in the field over an 8 or 9 hour period as concentrations of gB are extrapolated from acute toxicity data for surrogate species. Also, he stated that gB concentrations are not equal to Bayluscide that is applied as emulsifiable concentrate or wettable power formulations, since gB sinks to the benthos and gets released in the lower 5–10 cm of the water column. A coauthor agreed that estimating gB concentrations over time is an issue as no in situ estimates of gB concentrations have been measured.

Towards the end of the review, the reviewer stated that authors should incorporate their criticisms as best they can on a species by species basis and that the discussions of the working paper should address research needs that should be targeted by future studies. The Chair then asked the reviewer for his thoughts about avoidance as a mechanism to cope with gB in the environment. The reviewer noted that studies have been conducted on avoidance to TFM, where fishes swim to the surface to get more oxygen. A participant indicated that larval lamprey swim to the surface looking for oxygen in response to gB application and that he would assume other fishes would respond similarly. A participant stated that this vertical avoidance has been tested in the lab, but lateral avoidance has not. In response to this conversation, another participant asked the group how long gB persists in the environment. A participant responded that it is likely less than an hour for the St. Marys River, however, the reviewer then stated that it likely persists for several hours and this dissipation would be affected by factors such as water flow, current, and presence of side channels. This discussion led a participant to state that toxicity of gB is largely affected by pH (and alkalinity) and that this variable should be included in the analysis. The reviewer strongly disagreed, stating that pH is not nearly as important as the participant said it is.

The reviewer's final comment was more of a question for the group, where he wondered whether the use of Types I and II habitats in the models was causing unnecessary complications. He felt that this would relate to whether or not lamprey use both habitats equally, what the likelihood of application is in both types relative to each other, and whether nontarget fish distinguish between both types of habitat. The consensus was to keep these two habitat types in the models as they are.

Group Discussion

There was some confusion stated by one participant on the use of Silver Lamprey versus unknown *Ichthyomyzon* data for the Detroit River. A coauthor stated that they would follow up and check to see if the Silver Lamprey was an adult or if the ammocoete was identified to the species level genetically.

One participant questioned the authors about the assumption of no replacement as replacement has been observed for some species in some rivers where high mortality occurs. The participant mentioned Stonecats (*Notorus flavus*) in the Credit River and noted that populations tend not to be affected. A coauthor responded that just because recovery is observed in one species in one system it does not mean that it will occur for other species in other systems.

In the working paper, two estimates were given for Eastern Sand Darter (*Ammocrypta pellucida*) populations based on a previously published paper and one based on DFO data. A participant asked how to decide which density to choose and a coauthor stated that there is no good answer for this.

Concerns regarding the mussel data were brought up by one participant. The first issue was that the mussel toxicity was reported as a dose response; however, it was based on a paper by Newton et al. (2017) that looked at duration response. Therefore, the participant reiterated that this is a big leap that has many assumptions. Another concern raised was the fact that targeted, non-random sampling data was used to extrapolate whole river populations. The participant stated that this violates many statistical rules, making it inappropriate for use in the risk assessment and that without random standardized sampling for mussels, the mortality reported in this paper means nothing because the size of the populations to begin with is unknown. A coauthor responded that the text will be updated to explicitly state the unknown abundances for mussels in the four study systems. The participant indicated that the USGS could provide a protocol or study design to estimate mussel populations in Canadian waters of the Great Lakes.

According to one participant, the paper did not speak to mussel SAR in the Detroit and St Clair rivers and asked if any are found there. A participant responded that although the last survey of mussels in the Detroit River is from about twenty years ago, there is anecdotal evidence that populations exist and that DFO plans to sample the Detroit River this summer.

Mitigations and Alternatives

Presenter: Dr. Andrew Drake

Potential mitigations and alternatives to using gB to assess and treat Sea Lamprey habitats were presented. These mitigations and alternatives were outlined in the first working paper but many of the recommendations stemmed from models in the second working paper. The presenter outlined potential mitigation and alternative measures, focusing on potential benefits to species of conservation concern and key uncertainties.

Avoidance as an alternative was debated by participants. One person asked how important the Sydenham and Thames rivers are for Sea Lamprey production. Other participants stated that Sea Lamprey are never seen in the Sydenham while another participant indicated that Komoka Creek had a sufficient population of Sea Lamprey to drive a treatment about three to four years ago, although the participant was unsure if that creek has since been repopulated since treatment.

Reducing the concentration of gB as a mitigation measure was debated amongst the group and one participant asked if it was feasible to work towards a new benchmark for gB concentrations. This benchmark would be enough gB to flush them out of burrows and could be less than the current target of 11 mg/L. In response, another participant stated that in his experience, treating a river with a lower concentration is not necessarily better for Lake Sturgeon since it would usually require having to treat more frequently. Others stated that they would not advise lowering concentrations since this might alter the assessment which could lead to further applications of Bayluscide. Another participant suggested that experimenting with different doses would be required.

During the discussion concerning the reduction in the frequency of gB applications as a mitigation measure, one participant felt that ramifications of the mitigation measures with respect to the SLCP should not be listed in the document. They felt that this was not the forum to discuss how management decisions would impact programs. Several participants weighed in on this and most agreed that the ramifications column would be removed from the mitigations table.

Next, salvage of SAR as a management lever was debated by participants. A participant asked if it even worked, while others gave their perspectives. One participant noted that fish salvage has not worked well in studies that he had participated in. For mussels, one researcher stated that many agencies have used it as a mitigation option but that there is no data available that

speaks to its effectiveness. Another participant agreed and stated that mussel salvage could work in extreme cases, but would not be a good long-term option.

Offsetting was identified as a mitigation measure and one participant noted that this should be considered very carefully. He stated that managers should be careful as to not create new habitats that could be used by Sea Lamprey larvae in the future.

Timing windows as a mitigation measure as defined in the working paper was very fish-centric according to one participant. He stated that a window after August 1st has no impact on mussels and that any timing windows for mussels would have to be species-specific. According to one participant, finding a window for application of gB outside of mussel SAR reproductive periods (April–October) will not happen. The timing constraints for effective application were also brought up by participants. One person stated that macrophyte growth prevents the application of gB later in the season for some areas. This is because gB can stick to vegetation and may dissolve in the upper water column, which would not be beneficial for many fishes nor for the control of Sea Lamprey.

Sources of Uncertainties

Presenter: Dr. Andrew Drake

The presenter spoke at length in regards to a number of uncertainties of the effects of gB application on fishes and mussels. This included: 1) lack of knowledge about environmentally relevant concentrations of gB across habitat types; 2) lack of species-specific gB toxicity data and uncertainty about appropriate surrogates; 3) gB exposure duration for each species following application; 4) habitat preferences and species densities that are difficult to resolve through field methods; and, 5) uncertainty in population processes, including unknown population sizes for most species of conservation concern.

The uncertainty regarding environmentally relevant concentrations of gB was discussed amongst participants. One researcher questioned how much gB would be required to cause mortality over 8 hours as identified in this paper. He did a quick, simplified calculation based on an assumed flow rate of 1 m/s and said that from the rate the chemical is applied in the field, there cannot be concentrations high enough to reach the LC50 for Rainbow Trout. Another participant asked if a 1 m/s flow rate is typical for streams where gB is applied. The group discussed how water volume would affect the concentration of gB in the water column and one participant suggested that a table with differing flow rates would be useful for managers when applying gB to a river. The reviewer stated that using the time since application would be helpful in determining exposure for aquatic organisms. The original calculation that the participant used to determine the amount of gB required to get a level equal to the LC50 of Rainbow Trout will be sent around to participants for comments. The reviewer recognized that the concentrations across different sites are not known, but said that its exposure to Sea Lamprey is different from exposure to fish. He indicated that its exposure to Sea Lamprey lasts about 15 minutes in duration as they are flushed to the surface from the burrows within this timeframe, from which they have already received a lethal dose. The reviewer followed up on this calculation by stating that it is for an extreme situation and that field testing is required to assess instream concentrations of gB over time following an application.

During the discussion of population consequences as a result of gB application, one participant asked if the authors can be more explicit with respect to how changes to frequency of application can impact populations. Another participant indicated that the impacts to host fishes should be explicit in the paper since mussels are unable to complete their life cycle without their specific host organism.

DRAFTING OF SCIENCE ADVISORY REPORT SUMMARY BULLETS

The first summary bullet for the Science Advisory Report discussed the history of gB use and one participant suggested that it should reference its use in both control and assessment for Sea Lamprey.

The second summary bullet dealt with the background to the Science Advice request that led to this meeting. Multiple participants suggested that the bullet should note that gB has been applied over many years in the Great Lakes basin and not just in 2011 when concerns were raised by DFO's SAR Program.

The third summary bullet was written as a broad statement on the effects of gB to fishes and mussels. Participants argued over wording with respect to sublethal versus lethal effects. Consensus was made that the bullet should refer to the known toxicity of gB to fishes and mussels.

Generalized methods for both working papers were summarized in the fourth bullet point. The group agreed with the point and made only minor changes with respect to clarity. Similarly, only editorial style changes were made by the group to the fifth bullet which described results from the first working paper.

Concerns were raised over the sixth bullet point by participants since Lake Sturgeon was treated differently from other fishes. One participant thought that without a statement clarifying the concerns regarding Lake Sturgeon, the reader may not understand this as the bullet point was currently written. The authors agreed to revisit this bullet point once they figure out how to better deal with Lake Sturgeon data, given the problems they had with mapping its spatial proximity to past gB applications. Consensus was also made that American Brook Lamprey (*Lethenteron appendix*) would be removed from the working papers as it is not a species of conservation concern.

The seventh bullet point was reworded by participants to state that many species can experience mortality to gB within treatment areas due to the assumed toxicity of the chemical. Further details on potential mortality were provided in the eight bullet. One participant felt that absolute numbers for mortality were meaningless if the population size is unknown therefore it should be removed. However, consensus was made that these numbers were helpful and will remain in this summary bullet.

Very few changes were made to the ninth bullet point which dealt with population consequences of gB application being dependent on population size. The group moved on to the tenth summary bullet which described mitigation measures that could be used to reduce mortality from gB application. Several participants indicated that this bullet should state that mitigation measures need to be empirically tested to insure intended benefits. Another participant noted that other mitigation measures, in addition to what was already listed, should be included in this bullet. Participants agreed that a stand-alone alternatives bullet would be included before publication.

Bullets 12 to 16 all described uncertainties inherent in both working papers. One participant indicated that the suitability of some surrogates are better than others and this should be noted. Furthermore, several participants discussed the need for a bullet to address the uncertainty related to the fate of gB in the environment as most studies on this were conducted in a laboratory environment. Discussion on avoidance as an uncertainty in these studies was discussed by all participants. Most participants believed that avoidance uncertainty should be explicitly implemented here and that the act of avoidance could help or hinder individual organisms depending upon a variety of factors. A bullet pertaining to future spatial and temporal

distribution of gB application and how this distribution is unknown was removed and participants agreed that this should be included elsewhere in the text.

The Chair then went over the Terms of Reference that were developed for this meeting. There were no major issues identified by participants and consensus was made that DFO Science addressed the five objectives as best they could. It was agreed that the two working papers would be accepted as Research Documents and once all edits were made to the Research Documents and the Science Advisory Report they would get sent out to all participants for final comments prior to publication on the DFO CSAS website.

REFERENCES CITED

Dawson, V. K. 2003. Environmental fate and effects of the lampricide Bayluscide: a review. J. Great Lakes Res. 29(Suppl. 1): 475–492.

Hubert, T.D. 2003. Environmental fate and effects of the lampricide TFM: a review. J. Great Lakes Res. 29(Suppl. 1): 456–474.

Newton, T. J., Boogaard, M.A., Gray, B.R., Hubert, T.D., and Schloesser, N.A. 2017. Lethal and sub-lethal responses of native freshwater mussels exposed to granular Bayluscide®, a sea lamprey larvicide. J. Great Lake Res. 43(2): 370–378.

APPENDIX 1. TERMS OF REFERENCE

Information on the Potential Harm to Fish and Mussel Species at Risk (SAR) from Bayluscide Applications

Regional Science Peer Review – Central and Arctic Region

Date: February 28 – March 1 2019
Location: Burlington, Ontario

Chairperson: Lynn Bouvier

Context

The Sea Lamprey (*Petromyzon marinus*), a species native to the Atlantic Ocean, was first observed in Lake Ontario in 1835, and invaded the remaining Great Lakes between 1921 and 1937. Since their invasion, Sea Lamprey have inflicted widespread and significant mortality on fishes that support Indigenous, commercial, and recreational fisheries, including Lake Trout *Salvelinus namaycush,* Lake Whitefish *Coregonus clupeaformis,* Ciscoes *Coregonus spp.* and numerous other species. In response, Canada and the United States established the Great Lakes Fishery Commission (GLFC) under “The Convention on Great Lakes Fisheries between Canada and the United States (1954)”. The GLFC was charged with developing and implementing a program to eradicate or minimise Sea Lamprey populations in the Great Lakes. The GLFC administers the bi-national Sea Lamprey Control Program (SLCP), while the Department of Fisheries and Oceans (DFO), and the U.S Fish and Wildlife Service (USFWS) deliver its operational elements, with support from the U.S Army Corps of Engineers and the U.S. Geological Survey (USGS).

Presently, the primary method to control Sea Lamprey is the application of selective lampricides that target larvae in their nursery habitats. These include 3-trifluoromethyl-4-nitrophenol (TFM; Hubert 2003), and 2', 5-dichloro-4'-nitrosalicylanilide or niclosamide ethanolamine salt (trade name Bayluscide; Dawson 2003). Various formulations of Bayluscide are used to assess and control larval Sea Lamprey populations. In particular, the granular formulation of Bayluscide (gB) is used to assess and control larvae in deep-water environments, including estuaries, embayments, and interconnecting waterways, such as the St. Marys River, where the use of TFM would neither be effective nor economically viable.

In some instances, DFO-Sea Lamprey Control Centre (SLCC) staff conduct assessments and treatments with gB in waterbodies that contain fish and mussel species currently listed under the *Species at Risk Act* (SARA), as well as species assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The potential for lethal and sub-lethal effects to non-target fish and mussel species at risk (SAR), and the resulting potential to jeopardize their survival and recovery, is currently unknown. The lack of quantitative information about lethal and sub-lethal effects also makes it difficult to determine: 1) whether or how gB applications may alter population dynamics of these species; 2) how gB applications can be viewed in the context of other species-specific threats; and, 3) whether the investigation of potential mitigation measures is warranted.

In light of the knowledge gaps identified above, DFO’s SAR Program requested science advice to understand the potential impacts of gB on fish and mussel SAR, and to identify best management practices and potential mitigation measures to minimize impacts. Therefore, the goal of this Science Advisory Meeting is to evaluate the potential lethal and sub-lethal impacts of gB applications to fish and mussel SAR in the Great Lakes basin.

Objectives

The objectives of the meeting are to:

1. Summarize current knowledge of the effects of gB on fish and mussel species at risk, and estimate the scope of likely direct and indirect effects.
2. Determine the spatial extent and temporal frequency with which fish and mussel species at risk in the Canadian Great Lakes basin are exposed to gB application. The extent to which species are exposed will be based on current Sea Lamprey assessment methods, known distribution of aquatic SAR, habitat preferences of Sea Lamprey and fish and mussel SAR, and current (and proposed) critical habitat distributions.
3. Estimate direct mortality to fish SAR in the Detroit River, St. Clair River, Thames River, and Sydenham River using an allowable harm framework (Vélez-Espino and Koops 2009), based on known substrate associations of SAR, Sea Lamprey habitat classes, and resulting gB exposure.
4. Based on the information above, identify best management practices and mitigation measures that the SLCP could implement, and the potential resulting benefits to SAR.
5. Evaluate the potential impact of periodic, multi-hectare gB treatment on SAR in the St. Clair River and ascertain whether advice from Objective 4 is applicable to large-scale applications.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document(s)

Expected Participation

- Fisheries and Oceans Canada (Science, Species at Risk, and Sea Lamprey Control Program)
- U.S. Geological Survey
- Great Lakes Fishery Commission
- U.S. Fish and Wildlife Service
- Academia

References

Dawson, V. K. 2003. Environmental fate and effects of the lampricide Bayluscide: a review. J. Great Lakes Res. 29(Suppl. 1): 475–492.

Hubert, T.D. 2003. Environmental fate and effects of the lampricide TFM: a review. J. Great Lakes Res. 29(Suppl. 1): 456–474.

Vélez-Espino, L.A., and Koops, M.A. 2009. Quantifying allowable harm in species at risk: application to the Laurentian black redhorse (*Moxostoma duquesnei*). Aquat. Conserv.: Mar. Freshwat. Ecosyst. 19: 676–688.

APPENDIX 2. LIST OF PARTICIPANTS

Name	Organization
Dave Andrews	DFO – Science
Andrew Drake	DFO – Science
Eric Smyth	DFO – Science
Jason Barnucz	DFO – Science
Kelly McNichols-O'Rourke	DFO – Science
Lynn Bouvier (Chair)	DFO – Science
Olivia Sroka (Rapporteur)	DFO – Science
Todd Morris	DFO – Science
Tom Pratt	DFO – Science
Lisa Wren	DFO – Fish and Fish Habitat Protection Program
Alan Rowlinson	DFO – Sea Lamprey Control Centre
Bruce Morrison	DFO – Sea Lamprey Control Centre
Fraser Neave	DFO – Sea Lamprey Control Centre
Mike Steeves	DFO – Sea Lamprey Control Centre
Shawn Robertson	DFO – Sea Lamprey Control Centre
Tonia Van Kempen	DFO – Sea Lamprey Control Centre
Amy Boyko	DFO – Species at Risk Program
Becky Cudmore	DFO – Species at Risk Program
Shelly Dunn	DFO – Species at Risk Program
Michael Siefkes	Great Lakes Fishery Commission
Kim Fredericks	United States Geological Survey
Michael Boogaard	United States Geological Survey
Theresa Newton	United States Geological Survey
Ryan Prosser	University of Guelph
Margaret Docker	University of Manitoba
Nick Mandrak	University of Toronto

APPENDIX 3. AGENDA

Information on the Potential Harm to Fish and Mussel Species at Risk (SAR) from Bayluscide Applications

Regional Peer Review Meeting – Central and Arctic Region

Harvester North Room, Holiday Inn Burlington,
3063 South Service Rd.
Burlington, Ontario, L7N 3E9

Date: February 28th – March 1st, 2019
Chairperson: Lynn Bouvier

DAY 1 – FEBRUARY 28TH

8:30 Welcome and Introductions (L. Bouvier)

8:45 Purpose of Meeting and Terms of Reference (L. Bouvier)

9:00 Overview of Research Documents (A. Drake)

9:30 Presentation of Paper #1: "Relative Risk of Granular Bayluscide Applications for Fishes and Mussels of Conservation Concern in the Great Lakes Basin" (A. Drake)

10:30 Break

10:45 Formal Review (M. Docker)

11:15 Group Discussion

12:00 Lunch

13:00 Group Discussion

13:30 Presentation of Paper #2: "Estimating the Potential Mortality of Fishes and Mussels of Conservation Concern associated with Bayluscide Applications in the Huron-Erie Corridor" (E. Smyth)

14:45 Break

15:00 Formal Review (M. Wilkie)

15:30 Group Discussion

17:00 End of Day

DAY 2 – MARCH 1ST

8:30 Mitigations and Alternatives (A. Drake)

9:30 Sources of Uncertainty (A. Drake)

9:45 Review of Summary Bullets

10:30 Break

10:45 Review of Summary Bullets

12:00 Review of Terms of Reference (L. Bouvier)

13:00 End of Meeting