Zebra Mussel Response Planning Guide for the Saint-François River Basin

Fisheries and Oceans Canada
Ministère des Forêts, de la Faune et des Parcs

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This guide was prepared by Fisheries and Oceans Canada and the Ministère des Forêts, de la Faune et des Parcs (Quebec Department of Forests, Wildlife and Parks), and was reviewed by a number of organizations active in controlling invasive species. It is intended to be a living document, which will be adapted according to the current situation in the field and the needs of user organizations.

Summary

The *Zebra Mussel Response Planning Guide* is a decision support tool to be used when this invasive species is detected. It outlines the steps required in deciding whether a response is possible or desirable, determining the best response option depending on the situation, and facilitating the implementation of an appropriate response. This guide was prepared by Fisheries and Oceans Canada (DFO) and the Ministère des Forêts, de la Faune et des Parcs (Quebec Department of Forests, Wildlife and Parks) (MFFP) to give governments (municipal, provincial and federal) and local Saint-François River watershed organizations the tools they need in making decisions to control the spread of the zebra mussel.

Zebra mussels cause significant changes in water quality and have impacts on all trophic levels. In Quebec, the species is found in the St. Lawrence and Richelieu rivers and, more recently, in lakes Magog, Memphremagog and Massawippi as well as in the Magog and Saint-François rivers. The species was introduced to North America in the ballast water of ocean-going vessels that travelled from Europe. Zebra mussels can spread when recreational boats carrying them are moved from one body of water to another.

Zebra mussels will colonize any available surface, including infrastructure such as water intakes, pipes supplying dams and power plants, and irrigation systems. The significant changes to the ecosystem caused by the establishment of zebra mussels affect the ecological services that this ecosystem provides.

The first stages in a response plan are aimed at ensuring that all reported sightings are processed and that the identification of the species has been confirmed. If the report is the first confirmed one in a lake, or the lake or river is known to have suitable physico-chemical conditions for the zebra mussel (or if conditions are unknown), a coordination unit will be established. The coordination unit's task will be to recommend to the decision makers in the respective organizations one or more realistic and effective response options in keeping with the organization's operational capabilities.

First, an assessment can be carried out to determine to what extent the lake or river has been invaded. A number of potential response options are available that involve either trying to eradicate the zebra mussel, limit its spread or mitigate its impacts. If the proposed recommendation is approved by the organizations that will have to invest resources in the response, the coordination unit will develop an action plan and a monitoring plan.

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1. Introduction

The zebra mussel (*Dreissena polymorpha*) is a freshwater bivalve native to the Caspian Sea and Black Sea regions. The species was introduced into the Great Lakes in the ballast water of ocean-going vessels and then spread through the St. Lawrence River and most of the navigable waterways in northeastern North America. The species was first observed in Canada in Lake St. Clair (Ontario) in 1988. It was first reported in the St. Lawrence River in 1990 and in Lake Memphremagog in 2018, and was subsequently detected in Lake Massawippi in 2021.

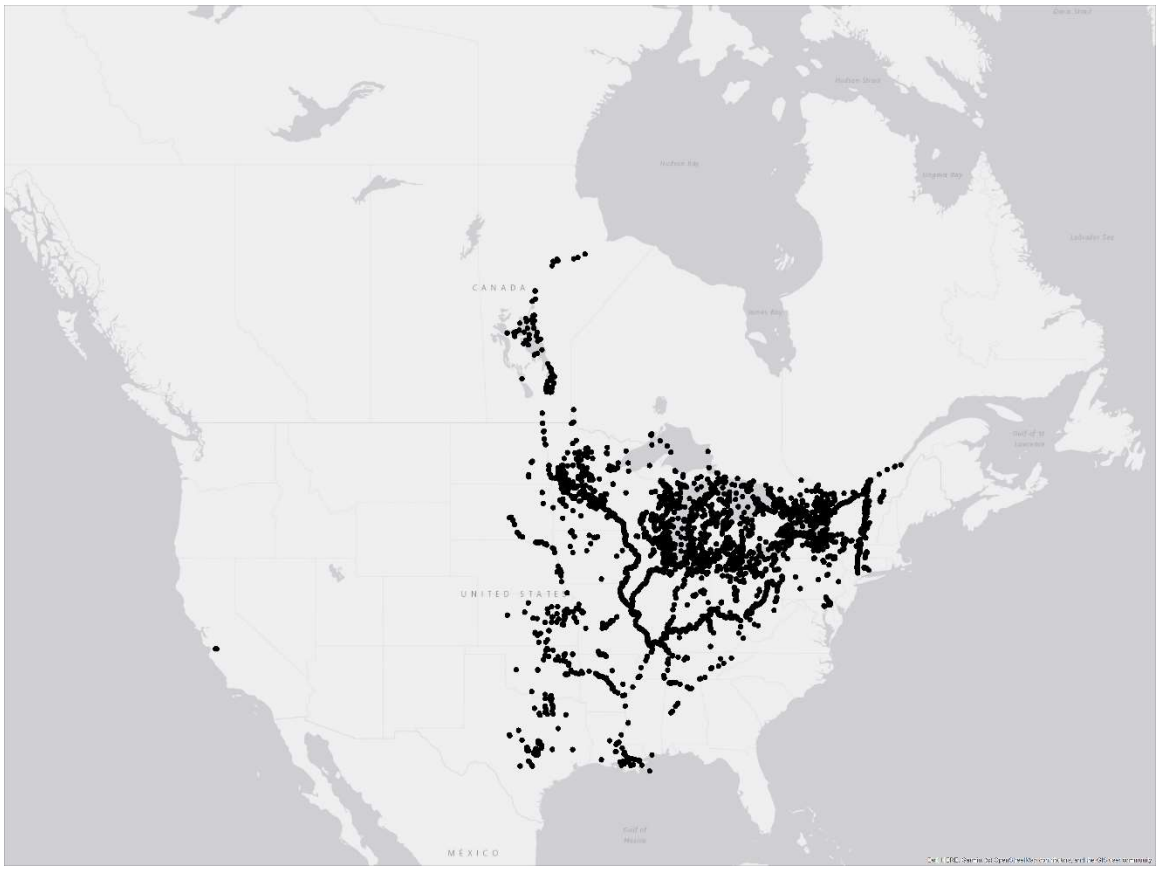

Figure 1. Distribution of the zebra mussel in North America. Source: Wilcox et al. (2022).

This response planning guide was prepared by Fisheries and Oceans Canada (DFO) and the Ministère des Forêts, de la Faune et des Parcs (Quebec Department of Forests, Wildlife and Parks) (MFFP) to give governments (municipal, provincial and federal) and local Saint-François River watershed organizations the tools they need in making decisions to control the spread of the zebra mussel. A response plan is a decision support tool used when an invasive species is detected. It outlines the steps required in deciding whether a response is possible or desirable, determining the best response option depending on the situation, and facilitating the implementation of the appropriate response.

2. Zebra mussel biology and ecology

Zebra mussels reach maturity after only two years, and a single female can produce more than one million eggs each year. The eggs and sperm are released into the water column and fertilization takes place there. The larvae, called veligers, emerge after about three to five days and are free-swimming for up to one month. During this period, they are transported with the currents until they are ready to attach to a substrate, continue their growth and develop into adult mussels.

Zebra mussels are found in lakes, rivers, canals and estuaries, typically at moderate depths. In Canada, the zebra mussel occurs in the Great Lakes and in Lake Winnipeg and Lake Manitoba. In Quebec, the species is present in the St. Lawrence River, the Richelieu River and the Ottawa River, and was recently found in Lakes Magog, Memphremagog and Massawippi as well as in the Magog and Saint-François Rivers (Figure 2).

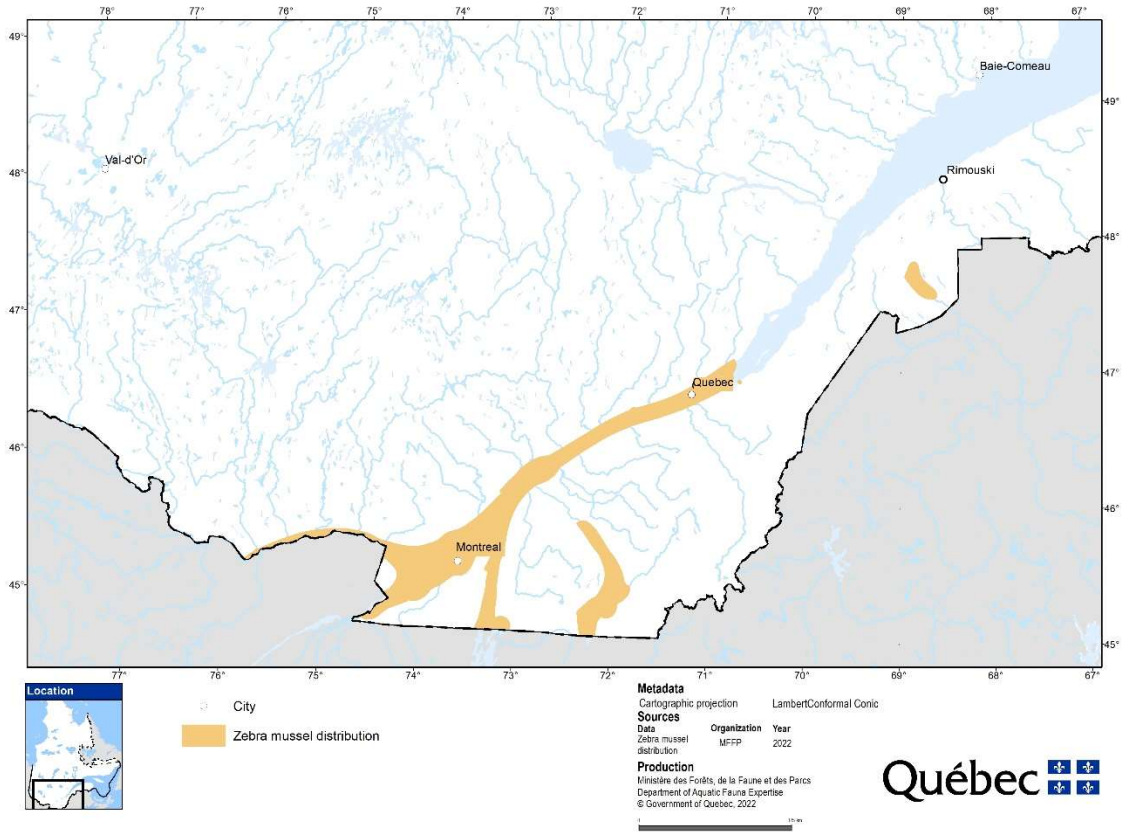

Figure 2. Distribution of the zebra mussel in Quebec (2022)

Table 1. Summary of physico-chemical parameters, optimal values and tolerance range for locations where zebra mussels have been observed. Adapted from Benson et al. (2021) and Mackie and Claudi (2010).

Parameter	Optimal Values	Tolerance Range
Temperature for growth	Larvae: 20–22°C Adults: 20–25°C	From 6–8°C, up to 30°C
Temperature for egg release	17–19°C	Lower limit of 12°C
O_2 concentration	>8 mg/L	0.1–14.4 mg/L
Calcium concentration	> 30 mg Ca^{2+}/L	> 8 mg Ca^{2+}/L
Salinity tolerance	0%	0%–10.2%
pH	Larvae: 8.4 Adults: 7.8–8.8	Larvae: 7.4–9.4 Adults: 6.6–8.5
Substrate	Hard/rocky	Any stable substrate in the benthos or the water column (rocks, macrophytes, other mussel species, other aquatic species, other zebra mussels, and artificial surfaces like cement, steel, ropes, etc.)
Depth	4–7 m	They can also settle at shallower or greater depths than this preferred zone.

2.1 Zebra mussel dispersal

2.1.1 Primary vectors

The species was introduced to North America through ballast water from ocean-going vessels that travelled from Europe. Under an international convention adopted in 2004, as well as in accordance with existing Canadian regulations, ships are now required to exchange their ballast water in the open ocean. Residual ballast water and sediments have nonetheless been found to harbour non-native species (Ricciardi 2006).

2.1.2 Secondary vectors

Natural vectors

Zebra mussel veligers drift with the current and eventually settle out of the water column and attach to a substrate in a location downstream of their source population. The presence of these mussels in the Magog and Saint-François Rivers is most likely due to the transport of veligers from Lake Memphremagog or Lake Magog.

Anthropogenic vectors

Zebra mussels can spread when a boat carrying them is moved from one lake or river to another body of water. They can attach to any equipment that has come in contact with infested waters, including trailers, hulls, propellors and ropes used on recreational boats. Veliger larvae can also be transported in residual water in the motor, bilge or livewell.

Zebra mussels have also been observed in moss balls imported as aquarium plants. Aquarium water or plants could thus be a potential vector.

2.2 Analysis of risks

2.2.1 Ecological impacts

Although the impacts that zebra mussels have on ecosystems vary from one environment to another, some clear-cut trends have emerged after a number of decades of invasion in North America (Therriault et al. 2013):

- Zebra mussels cause significant changes in water quality and have impacts on all trophic levels, from bacteria to the largest predators in the ecosystem.

- Zebra mussel establishment is likely to have irreversible ecological impacts.

- Zebra mussel establishment can have either negative or positive effects, depending on the ecological niches of the organisms involved. Organisms associated with the pelagic food web (phytoplankton and zooplankton) and the food web of deep benthic zones generally decline in abundance following zebra mussel invasion. Littoral zone organisms, such as aquatic plants and invertebrates living in shallow water, often experience an increase in abundance. Native unionid mussel species are an exception, however, because they compete with zebra mussels for food and space. Therefore, even though they inhabit the littoral zone, unionid mussel populations (many unionid species are already in decline) have been dramatically affected by the presence of zebra mussels.

- The magnitude of impacts on the food web depends on the density of the zebra mussel population, the size of the lake or river and factors that affect the mussels' filtering capacity such as water temperature and current speed. It has been observed that very small ecosystems, such as rivers and shallow non-stratified lakes, have experienced larger declines in phytoplankton than larger, deeper bodies of water. Some large ecosystems, such as the Great Lakes, have nonetheless undergone significant changes as a result of the establishment of the zebra mussel.

2.2.2 Socio-economic impacts

The major ecosystem changes that have been linked to zebra mussel establishment affect the ecological services that the ecosystem provides. Ecological services are the social and economic benefits that ecosystems provide to humans, such as potable water, fishing, harvesting and tourism. For example, in the Great Lakes, zebra mussel invasions have led to an increase in blooms of the algal species *Cladophora glomerata*, which has resulted in fouling of beaches and water intakes (Higgins and Zanden 2010). Furthermore, when it comes to food sources, the zebra mussel appears to reject certain cyanobacteria species but to ingest other types of algae. Zebra mussels are suspected to have caused blooms of cyanobacteria in a number of lakes (Raikow et al. 2004).

Zebra mussels will colonize any available surface, including infrastructure such as water intakes, pipes supplying dams and power plants, and irrigation systems. A number of studies have estimated the cost of mussel management in North America (Bossenbroek et al. 2009, Chakraborti et al. 2016, Nelson 2019), specifically the cost of zebra mussel mitigation and control related to infrastructure and the loss of income associated with

reductions in fishing activities and tourism. To this can be added property value losses and decreases in bequest (future use) value. In these studies, the economic impacts have been estimated to be tens or hundreds of million dollars. A Fisheries and Oceans Canada study on Lake Memphremagog estimated the economic impact of the zebra mussel invasion in that body of water at between $513 million and $681 million over 20 years (DFO, unpublished).

3. Response planning

3.1 Detection: reported sighting of an AIS

The first stages in a response plan are aimed at ensuring that all reported sightings are processed and that the identification of the species has been confirmed. A sighting of zebra mussels in a location where the species has not previously been detected can be reported by monitoring associations or organizations, by government departments that conduct monitoring, and even by citizens. Figure 3 below illustrates the steps that should be followed to ensure rapid and effective processing of each detection.

A sighting can be reported in several different ways: generic email from a government department, an environmental non-governmental organization, or a municipality's environment department, or an email from social media. All emails or calls to report the observation of zebra mussels should be forwarded to MFFP by email, specifically to the Direction de la gestion de la faune (DGFa, wildlife management directorate) Estrie-Montréal-Montérégie-Laval so that they can be verified (see Table 2).

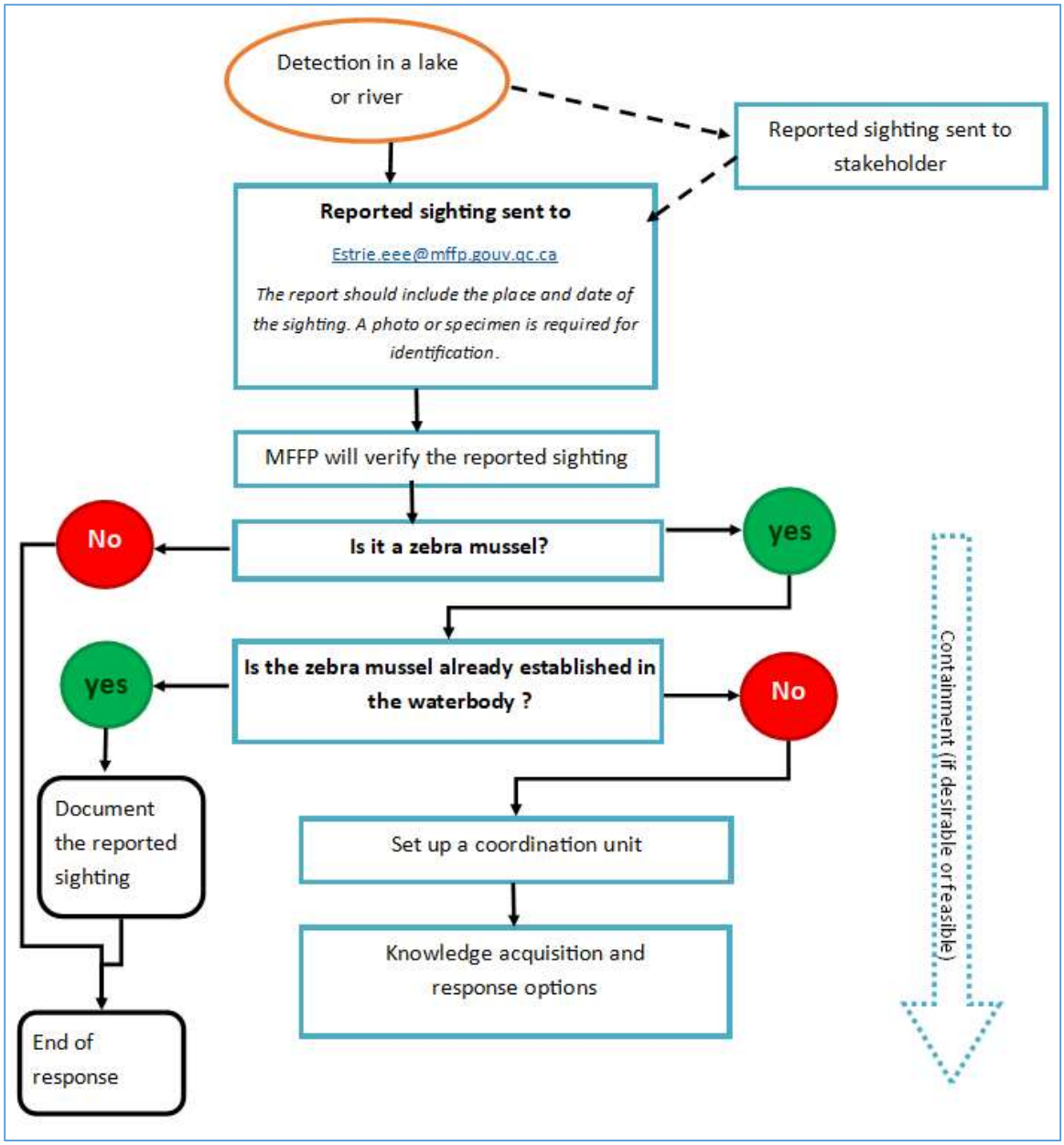

Figure 3. Steps involved in handling a reported sighting.

Table 2. How to report a zebra mussel sighting

Reporting a sighting	
Email	Estrie.eee@mffp.gouv.qc.ca
In charge of email mailbox	MFFP-DGFa Estrie-Montréal-Montérégie-Laval
By phone	1-877-346-6763
In charge of voicemail	MFFP-DGFa Estrie-Montréal-Montérégie-Laval
Application	Sentinelle
Responsible for the application	Ministère de l'Environnement et de la Lutte aux changements climatiques du Québec (Quebec Department of Environment and the Fight Against Climate Change)
Processing of report	
Responsible for processing	MFFP - DGFa- Estrie-Montréal-Montérégie-Laval
Information needed in the report	A report shall include as a minimum the following information: Name and contact of person reporting sighting Date of observation Geographic coordinates or address Name of lake/river Name of closest municipality Photo of specimen
Compilation file	Sightings should be compiled in a file to ensure follow-up.
Responsible for compiling the reports	MFFP - DGFa- Estrie-Montréal-Montérégie-Laval

Interpretation of detections using environmental DNA (eDNA)

The environmental DNA method can be used to detect the presence of DNA from target species in a water sample. However, a positive eDNA signal does not provide conclusive evidence that an established zebra mussel population is present or that the species is actually present in an ecosystem.

In fact, DNA detected in a water sample may come from 1) a dead or live individual, including mucus, feces, blood, eggs, sperm, 2) a source outside the lake or river, for example, from particles that have dispersed from a distance source and persisted, or from an improperly cleaned boat, or from 3) contamination that occurred during handling in the field or laboratory. Interpreting eDNA results therefore calls for caution, as some detections may turn out to be false positives. To ensure that the findings are valid, detection of eDNA from zebra mussels must be combined with the discovery of live individuals (veligers, recruits or adults). Zebra mussel eDNA sampling is used to guide search efforts for live individuals through conventional surveys. The procedure for forwarding an eDNA result is the same as for the detection of a zebra mussel, that is, the information must be relayed to MFFP-Estrie-Montréal-Montérégie-Laval, which will add the observation to its eDNA database.

3.2 Verification of the reported sighting

The reported sighting must be confirmed as a zebra mussel in order to move on to the next steps. While the species can be easily identified from a photo, it is preferable to have a specimen. The photo should show the flat underside which is a distinguishing feature of the zebra mussel. A specimen should ideally be kept frozen or preserved in ethanol.

Figure 4. Photo of zebra mussel shell showing its flat underside. Photo credit: Dave Brenner, Michigan Sea Grant

An expert opinion may be required if necessary. To this end, you may contact:

- MFFP-DGFa Estrie-Montréal-Montérégie-Laval (Estrie.eee@mffp.gouv.qc.ca)
- COGESAF (cogesaf@cogesaf.qc.ca)
- Fisheries and Oceans Canada (que_ais-eae_que@dfo-mpo.gc.ca)

Not all reports will trigger a response action. Circumstances in which it would not be necessary to set up a coordination unit are as follows:

1. Zebra mussel populations are already known to be present in the lake or river (the report will therefore be shared with local stakeholders for the waterbody in which the sighting was made).

2. The reported sighting does not involve a zebra mussel.

3. The lake or river has physico-chemical conditions that are not suitable for the zebra mussel (<8 mg/L calcium). Local stakeholders (municipalities, riverfront property association, marina owners, etc.) should be informed about the sighting. The detection of a zebra mussel means that vectors of introduction are present and that mitigation measures should be taken. It would be wise to set up a coordination unit to carry out a targeted response focusing on vectors, to prevent the introduction of other invasive species.

In every case, the person who reported the sighting is contacted (if necessary), to explain why no further action is being taken, using the explanations provided above.

If the report is the first confirmed one in a lake or river or if the waterbody is known to have favourable physico-chemical conditions for the zebra mussel (or if conditions are unknown), MFFP-DGFa Estrie-Montréal-Montérégie-Laval will take further action and forward the report to the coordination unit.

3.2.1 Coordination unit

In the event of a confirmed zebra mussel sighting in a lake or river, an invasive species expert at MFFP in the Estrie/Eastern Townships region (DGFa Estrie-Montréal-Montérégie-Laval) will send the report to organizations that could serve on the coordination unit. The coordination unit's task will be to recommend to the decision makers in the respective organizations one or more realistic and effective response options in keeping with the organization's operational capabilities. The decision to participate in a response action must be approved by the decision-makers of each organization concerned.

Each organization can appoint a representative and define its role within the coordination unit. The report will be shared and discussions and exchanges will take place on possible response options. The unit should have a membership that brings together scientific expertise and local stakeholder knowledge. The unit may be composed of representatives from the following:

- Ministère des Forêts, de la Faune et des Parcs de l'Estrie (DGFa Estrie-Montréal-Montérégie-Laval)
- Ministère des Forêts, de la Faune et des Parcs (DEFA)
- The municipality or municipalities in which the lake or river is located
- Any indigenous community affected by the situation in the river or lake
- The Conseil de gouvernance de l'eau des bassins versants de la rivière Saint-François (COGESAF, governance council for Saint-François River watersheds)
- The regional county municipality (RCM)
- The lake/riverfront property owners' association, as applicable, or any other local organization involved in protecting the waterbody
- Fisheries and Oceans Canada

In addition, any other organization that can provide useful expertise, such as a university, a regional environmental council, or an environmental non-governmental organization, may be invited to take part in the discussions. A template for terms of reference for the operation of the coordination unit are found in Appendix D.

3.2.2 Communication of the reported sighting

It is recommended that the different members of the coordination unit discuss the content of their respective communications (with the public and the media) and share the messages approved by their organization, to ensure consistency. Each organization can make adjustments to suit their organizational needs and circumstances.

3.3 Containment

To prevent the spread of an AIS, containment measures may be taken as soon as the identification has been validated or later during a response. Temporary measures, such restricting access to a boat launch, can be implemented to reduce the risk of dispersal until the response has been planned or a more complete analysis of the situation has been made.

3.3.1 Is containment possible or necessary?

To prevent the spread of zebra mussel and prevent further introductions to an environment, closing boat launches where there is no boat cleaning station is an approach that should be considered. Such a measure can be implemented if it is impossible to ensure proper cleaning of boats entering and exiting the lake or river. This makes it possible to reduce the risk of new introductions of zebra mussels through recreational boats while knowledge acquisition and control activities are underway. This measure will not prevent the natural spread of the zebra mussel in the lake or river and their tributaries, in the event that reproduction of the detected mussels occurs.

3.3.2 Regulatory measures

The municipality(ies) concerned can use municipal bylaws to require boat operators to clean their boats or can restrict the use of a boat launch that does not have a boat cleaning station. They can also provide a way to check that the boat has been cleaned (coupon, tag, etc.). The bylaws can also contain provisions to ensure that boat cleaning has been done before the boat enters or leaves the body of water.

Under the federal *Aquatic Invasive Species Regulations*, a DFO fishery officer or an MFFP wildlife protection officer can post signs or markers to prohibit access to a structure where zebra mussels are present (paragraph 25(1)(c)). The officer may also give a written direction requiring a recreational boater to clean their boat before putting it into the water, to prevent the spread of the zebra mussel (par. 26(1)).

3.3.3 Dissemination of information

If containment measures are implemented, it may be necessary to keep municipal residents and other people in the region informed. The municipality's communications service should be able to identify the best way to reach all those concerned.

3.4 Response

3.4.1 Information gathering

The coordination unit's first task will be to obtain all the information needed in order to provide guidance on one or more response options.

Habitat characteristics

If the calcium level in the lake or river is not known, sampling should be conducted to obtain this information.

Even if calcium data are available, sampling could be carried out at several sites at different times of year, in order to refine the existing data. Spatial variations in calcium levels may be present in a lake, depending on the inflows of water it receives, the type of soil in the lake bottom, and land use patterns in the watershed.

The lake's trophic level should also be assessed, because the dissolved oxygen level, suspended solids (organic vs. inorganic) and food availability (measured using chlorophyl *α*) will influence the zebra mussel's ability to become established in high densities.

Appendix A presents a decision support tool related to physico-chemical parameters.

Population assessment (level of invasion)

An assessment can be made to ascertain to what extent the lake or river has been invaded. The assessment can be made through:

- Sampling with plankton nets to assess the presence of veligers.
- Deployment of settlement plates to check for colonization by larvae.
- Snorkel or waterscope searches in shallow water zones.
- Scuba diving to check for colonization of substrate by adults (density per m², shell size).

Natural dispersal

Zebra mussel larvae can drift with the current and colonize other bodies of water farther downstream. The location of a lake or river in the watershed and the likelihood of it becoming a source of contamination for the rest of the watershed will influence the coordination unit's discussions. The presence of zebra mussels in other waterbodies upstream in the watershed makes recolonization by the zebra mussel more than likely.

Anthropogenic dispersal

Rapid response efforts should not be initiated to prevent zebra mussel establishment unless the risk of reintroduction can be reduced. The coordination unit must consider the vectors of introduction and mitigation measures. They should therefore obtain information on access to the water and marinas.

Ecological services

The magnitude of a response may vary depending on the estimated level of impact of zebra mussel establishment. Water intake structures and pipes supplying water to hydroelectric facilities and other infrastructure are most likely to require maintenance and additional upgrades. A lake where recreational fishing is an important economic (or social) activity could undergo changes in this activity as a result of the associated alteration of wildlife communities. Information on the estimated value of ecological services is generally fragmented or not found. However, the coordination unit should take into consideration the potential effects of zebra mussel establishment on the ecological services provided by the lake or river.

Species at risk

The possible presence of species at risk in the lake or river is an important factor that must be taken into account. Freshwater mussels are particularly vulnerable to zebra mussel invasion (Ricciardi et al. 1996, Schloesser et al. 2006). The populations of a number of freshwater mussel species are already in decline and, one of these species, the Hickorynut (*Obovaria olivaria*), is protected under the federal *Species at Risk Act*. The Hickorynut is present in the watershed of the Saint-François River (COSEWIC 2011).

3.4.2 Partnering and collaboration

The coordination unit should consider the level of interest and the capacity of the different organizations, groups, users, Indigenous communities, waterfront property owners and other citizens who are affected by the presence of zebra mussels or by the recommended response action.

Partnering and collaboration make it possible to implement response actions on a larger scale and divide the costs among the stakeholders. The coordination unit should therefore draw up a list of prospective partners who can implement a response. At the present time, a unit does not need to confirm the participation of partners, but it should consider this possibility in its reflections.

3.4.3 Response options

Burlakova et al. (2006) found that zebra mussels usually reach maximum population density in a waterbody seven to twelve years after initial introduction. They also noted that they reach maximum density about two to three years after populations are large enough to be detected. In fact, there is often a time-lag between the actual introduction of an invasive species and its detection. A detection plan (supported by local organizations and groups, for example) could help to reduce this time lag. The difficulty of detecting the zebra mussel in a waterbody points up the need to quickly determine what type of response is required.

There are a number of potential response options that involve either trying to eradicate the zebra mussel, limit its spread or mitigate the impacts. The following tables summarize the various possible options.

Table 3. Outreach campaign

Outreach campaign	
Description	Any confirmed detection in a lake with favourable characteristics for zebra mussel establishment should lead to a recommendation to mount an outreach campaign: • If eradication is not possible, the focus should be on encouraging lake or river users to clean their boats before taking them to another site. If the zebra mussel becomes established, it will be a source of contamination for surrounding bodies of water. • If the recommended option is to eradicate the zebra mussel population, recreational boaters should be encouraged to clean their boats before launching them. The goal is to maintain water access while reducing the risk of spread. • It is strongly recommended that boat cleaning be made mandatory. If new bylaws come into effect (or if they already exist), an awareness campaign should be carried out to highlight their existence and promote user compliance. Regulations should not create prohibitive conditions that restrict citizens' access to the water. Appendix C sets out an outreach strategy that is aimed at preventing the spread of the zebra mussel.
Level of effort	Low – moderate An outreach campaign can vary in intensity. It may be limited to a simple press release or may involve sending outreach officers to various locations on or around the lake or river.
Required resources	The resources and costs and may vary with the magnitude of the outreach activities: • A number of communication tools exist already which can be readily adapted by any organization interested in conducting outreach with users. • The main costs will be those associated with the personnel who are dedicated to outreach activities. • The installation and operation of one (or several) boat cleaning stations (mobile or stationary) may entail considerable expense. Ready access to a station is nonetheless essential to ensure that pleasure boaters adopt the "clean, drain, dry" approach.
Partners	A number of stakeholders may participate in the outreach effort.

Table 4. Manual removal of zebra mussels

Manual removal	
Description	Manual removal is done by divers operating with oxygen tanks but snorkeling may be sufficient in shallower waters. Scraping and suction removal of attached mussels to reduce the number of individuals can be very effective if this effort is carried out for several years (Wimbush et al. 2009, Invasive Mussel Collaborative 2018).
Response level	High: Manual removal by divers requires a sustained effort over a number of years. Only diving equipment is required because scraping can be done with simple tools. This option is more effective at the start of an invasion when the mussel population is very small or when the focus is on controlling the population in specific areas (e.g., near a water intake or a spawning ground).
Required resources	Personnel: The number of divers may vary depending on the size of the lake, substrate type and the level of invasion. Training: Divers must have the required training to carry out the requisite tasks (scientific diving) and follow health and safety instructions. Equipment: Diving equipment, scrapers, and bags or nets for collecting mussels, suction tools. Costs: Volunteer divers could help to conduct manual removal operations but they must have certification for scientific diving. Additional costs will be incurred if professional divers are hired.
Environmental impacts	Manual removal has little impact on the environment if best practices are followed to help reduce the effects on native mussel species and on aquatic habitat.
Permits	An SEG permit is required for the removal of zebra mussels. A request for this permit must be made to MFFP using the form available online.
Partners	Manual removal may be considered if a number of partners join in the effort. Scientific divers' associations could provide volunteers to participate in the operations.

Table 5. Use of tarps (benthic mats)

Tarping	
Description	This approach involves using heavy, impermeable tarps anchored to the bottom to cover zebra mussel populations (Invasive Mussel Collaborative 2018). It reduces the mussels' access to water as well as oxygen and food and can also prevent the dispersal of veliger larvae.
Response level	Moderate to high: The magnitude of the response will depend on the surface area to be covered. Most of the work is associated with installing and anchoring the tarps and removing them later on. The tarps should be kept deployed on the bottom throughout the ice-free season.
Required resources	Personnel: Divers are needed to install the tarps. The divers must be trained to carry out the tasks involved. Depending on the surface area to be covered, this work may take only a few days. Monitoring will need to be conducted throughout the summer. Obtaining the required permits and authorizations will also take time and require personnel. Equipment: Tarps and piles or weights for anchoring, diving gear. Costs: The tarps can represent a significant cost; however, they can be removed from the water in the fall and used again the following year.
Environmental impacts	Tarping destroys all the organisms that are present on the substrate that is covered. It mostly affects invertebrates and plants, along with sensitive habitat such as spawning grounds. The impacts are localized.
Permits	Installing tarps in the littoral zone may require authorizations from MFFP and MELCC. The application for authorization form is available online. The project must also be assessed by DFO to ensure it abides by the fish habitat protection provisions of the *Fisheries Act*. The request for review form is available online.

Table 6. Water drawdowns

Water drawdowns	
Description	This involves the partial or complete drawdown of a lake or river (Invasive Mussel Collaborative 2018) for a period long enough to kill zebra mussels. Zebra mussels in deeper water zones are exposed to the air, to warmer water in the summer or to colder water in winter. Water drawdown is an option that can be considered for small waterbodies or ponds that are regulated by a dam. This approach is not effective for a large body of water or one that is spring-fed.
Response level	Moderate to high: Water drawdown involves a major alteration of habitat; the research required to evaluate the feasibility, effectiveness and impacts of this method as well as to obtain the required permits and authorizations may therefore require a great deal of time and resources.
Required resources	Personnel: People are needed to apply for the necessary authorizations. Costs: the main costs are associated with personnel.
Environmental impacts	This type of response has a considerable impact on the species located in the area that undergoes drying, as well as on the ecosystem as a whole. The area of fish habitat decreases during the drawdown. Drawndown may affect water intakes (water quality and quantity) and on citizens' access to the water.
Permits	Drawing down water requires authorizations from MFFP and MELCC. The application for authorization form is available online. The project must also be assessed by DFO to ensure it abides by the fish habitat protection provisions of the *Fisheries Act*. The request for review form is available online.

Table 7. Potash

Pesticide: potash	
Description	Commercial treatment: e.g., BioBullets Salt compound enclosed in an edible shell (promoting ingestion) that interferes with the functioning of the gill epithelial cells of mussels (Aldridge et al. 2006, Invasive Mussel Collaborative 2018). Does not affect, or barely affects, species other than molluscs.
Response level	High: Owing to the costs associated with the application of this product and the regulatory process for its use, this response option requires significant human and financial resources.
Required resources	Personnel: People will be needed to obtain the necessary authorizations to apply the pest control product in the natural environment. This may be a lengthy process and may entail consultations. The product must be applied by a company with certified personnel. Costs: The costs can be split in two parts: costs associated with obtaining approval (including public consultations), and the cost of applying the product.
Environmental impacts	Potash affects filter-feeding molluscs, including native freshwater species. Some formulations can lessen the impacts on other species (Waller et al. 1993, Aldridge et al. 2006).
Permits	Potash is a registered pesticide for zebra mussel control in Canada. A permit is required under section 19 of the *Aquatic Invasive Species Regulations*. Information on obtaining the necessary permit is available online. Fisheries and Oceans Canada is responsible for issuing these permits. If there is a risk that the treatment may affect a species at risk, a permit under the *Species at Risk Act* is also required. The use of potash in a body of water may require authorizations from MFFP and MELCC. The request for authorization form is available online.
Necessary consultations – communications	Consultations must be held with waterfront property owners about the possibility of using a pest control product. Social acceptability is an important factor in this type of response.

Table 8. Copper

Pesticide: copper	
Description	Trade name: Earthtec QZ Interferes with cellular respiration and the activity of the targeted cells (Genco and Wong 2014, Albright 2017, Invasive Mussel Collaborative 2018). Shown to be effective in open waters in small lakes and non-toxic to fish.
Response level	High: Owing to the costs associated with application of the product and the regulatory process related to its use, this type of response requires considerable resources.
Required resources	Personnel: people will be needed to develop the project and obtain the necessary authorizations to apply a pesticide in the natural environment. This may be a lengthy process and may require consultations. The product must be applied by a company with certified personnel. Costs: The costs can be split in two parts; costs associated with personnel who need to obtain approval for the project (including public consultations), and the cost associated with application of the product.
Environmental impact	Concentrations that are lethal for the zebra mussel are not toxic to fish. Copper may accumulate in sediments with repeated application, and this could have impacts on benthic fauna.
Permits	Copper compounds are not registered as a pesticide for zebra mussel control in Canada. A request could be made to the Pest Management Regulatory Agency for the use of this type of product, which might be granted under certain conditions. The analysis of the file by the Agency could cause delays. A permit is required under section 19 of the *Aquatic Invasive Species Regulations.* Information on obtaining the necessary permit is available online. Fisheries and Oceans Canada is responsible for issuing these permits. The use of copper in a body of water may require authorizations from MFFP and MELCC. The request for authorization form is available online.
Necessary consultations – communications	The potential use of pesticides must be the subject of prior consultations with property owners, waterbody users and Indigenous communities. Social acceptability is an important factor in this type of response.

If eradication is not feasible, it is strongly recommended that an impact management plan be developed. Operators of water intakes, dams and other vulnerable infrastructure should be prepared to deal with zebra mussels that have clogged pipes. This may involve planning more frequent maintenance or installing antifouling systems. The table below provides some examples taken from Banerjee (2016). Owners of residential properties with water intakes used on a seasonal basis should remove these pipes in the fall to kill the attached mussels.

Table 9. Control methods for zebra mussels in water intake pipes. This list is not exhaustive. Taken from Banerjee (2016).

Method	Description	Advantages	Disadvantages
Mechanical removal	Cleaning using scrapers, high pressure water spraying, or sand blasting.	Simple and easy to administer.	Calls for personnel and must be repeated to prevent buildup.
Pseudomonas fluorescens **Trade name: Zequanox**	Causes necrosis of the digestive gland in mussels. Approved by the Pest Management Regulatory Agency (PMRA) for use in hydroelectric infrastructure in Canada.	Very few effects on non-target species.	Laboratory tests have not achieved a mortality rate of 100%. A mortality rate of about 80% is mentioned.
Chemical oxidation	A number of chemical compounds can be used to kill mussels in pipes (e.g., chlorine, bromine, potassium permanganate).	Used in many facilities in North America.	Requires injection equipment and application must be continuous. The treatment is toxic to all species.
UV light	This method mainly kills veligers, but it can also kill adults if they are subjected to treatment for a longer time period.	This method does not affect ecosystems as it is not toxic.	Not efficient if water has high turbidity
Thermal treatment	Water must be kept at a temperature above 35°C for 2 hours.	Simple, but requires energy.	The release of hot water may affect ecosystems.
Foul release coating	A silicone coating can greatly reduce the ability of veligers to attach to pipes.	Prevents an infestation and requires little maintenance.	May be expensive.
Low frequency magnetism	Low frequency magnetism is useful for preventing shell formation in zebra mussels, as it causes	Effective and low maintenance. Has no effect on the ecosystem.	Expensive and not well documented.

	disturbance and calcium loss.		
Pulse acoustics	The vibrations cause stress and immobilization of veligers; prevents them from attaching to surfaces.	Effective and not harmful to the ecosystem.	Expensive and not well documented.

3.5 Action plan

An action plan must be developed once the response has been approved. The following table, provided as an example, presents the types of information that could be included in the action plan. The action plan should be adapted to the specific situation.

Table 10. Components of an action plan

Action plan	
Roles	Indicate the roles and responsibilities of the organizations and people involved in the response.
Objectives	Indicate the objectives. Be as specific as possible and provide measurable objectives (m² treated, number of hours of diving, number of recreational boaters reached, etc.). The description of objectives should include the point (or milestone) at which the response will be considered complete.
Actions	Describe the actions to be implemented. Please be as specific as possible (diving at which site and on which date) or indicate the key milestones in order to provide operational flexibility.
Site	Describe the site (name of waterbody, municipality or county, geographic coordinates, access points, boat launches, etc.) Add a map or plan if necessary.
Human resources	Describe the personnel requirements (time/person, personnel from other organizations, overtime, etc.)
Equipment	List the required equipment and materials.
Costs	Estimate the cost of the response or present a detailed budget.
Permits	Identify the permits to be obtained and the government departments involved, as well as the numbers after they are obtained.
Health and safety	Identify the tasks that involve risks and the health and safety measures. Consider the various health and safety issues and measures to mitigate risks.

Internal communications	Each organization participating in a response should have an internal communications plan. The plan should indicate how the directors of the organization will be informed about operations and how often.
External communications	If the response includes an outreach campaign, all external communications will be an integral part of the action plan for the campaign. If the response includes field operations, it is recommended to have a communications plan with key messages for the media and citizens.
Approval	Provide the approval process for the different stages, e.g. approval of expenditures, external communications, participation of personnel.

4. Assessment and follow-up

Once an action plan has been implemented for a lake or river, it should be re-evaluated periodically based on existing knowledge, available resources and the state of the zebra mussel population. The coordination unit should develop a follow-up plan and determine how often it should meet to perform follow-up and propose further response actions as needed. The follow-up plan should identify the different types of sampling to be done, for example:

- Deployment of collectors (artificial substrates) to detect adult mussels;
- Plankton tow sampling to check for the presence of veligers;
- Diving campaigns to locate mussels on substrates;
- Monitoring by owners/operators of water intakes;
- Number of users at boat cleaning stations;
- Effort to assess the scope of the outreach: estimate the percentage of recreational boaters who are using the “Clean, Drain, Dry” method;
- Inspection of boats for adult mussels and larvae.

The frequency of the different types of sampling and the duration of follow-up should also be determined. Adjustments may be made based on the experience acquired and the results obtained. The follow-up plan should also indicate who should be informed about the results.

Conclusion

This document is intended as a tool for the different levels of government and local organizations, to support decision making if the zebra mussel is detected in a new location in the Eastern Townships (Estrie) and serve as a model for any other region of Quebec

that has to deal with this type of invasion. It must be tailored to each specific situation and it will be revised as experience is acquired over the coming years and as new scientific knowledge becomes available.

The extent of participation in a response action depends on the resources and priorities of the organizations involved.

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Appendix A
Decision support tool for the coordination unit

Since zebra mussels have invaded many regions across the world over the past several decades, there are many literature reports that describe the characteristics of the zebra mussel's preferred habitat and the stages in an infestation. The flow chart below is intended to help guide decision making by organizations involved in zebra mussel management. The physico-chemical values are taken from Mackie and Claudi (2010), who conducted an exhaustive literature review on the topic; the data can therefore be considered robust. The published literature reveals the considerable variability that characterizes each case of zebra mussel invasion. Caution should therefore be exercised, and a population monitoring plan should be established, regardless of the calcium level and the trophic level of the lake or river in which the zebra mussel was detected.

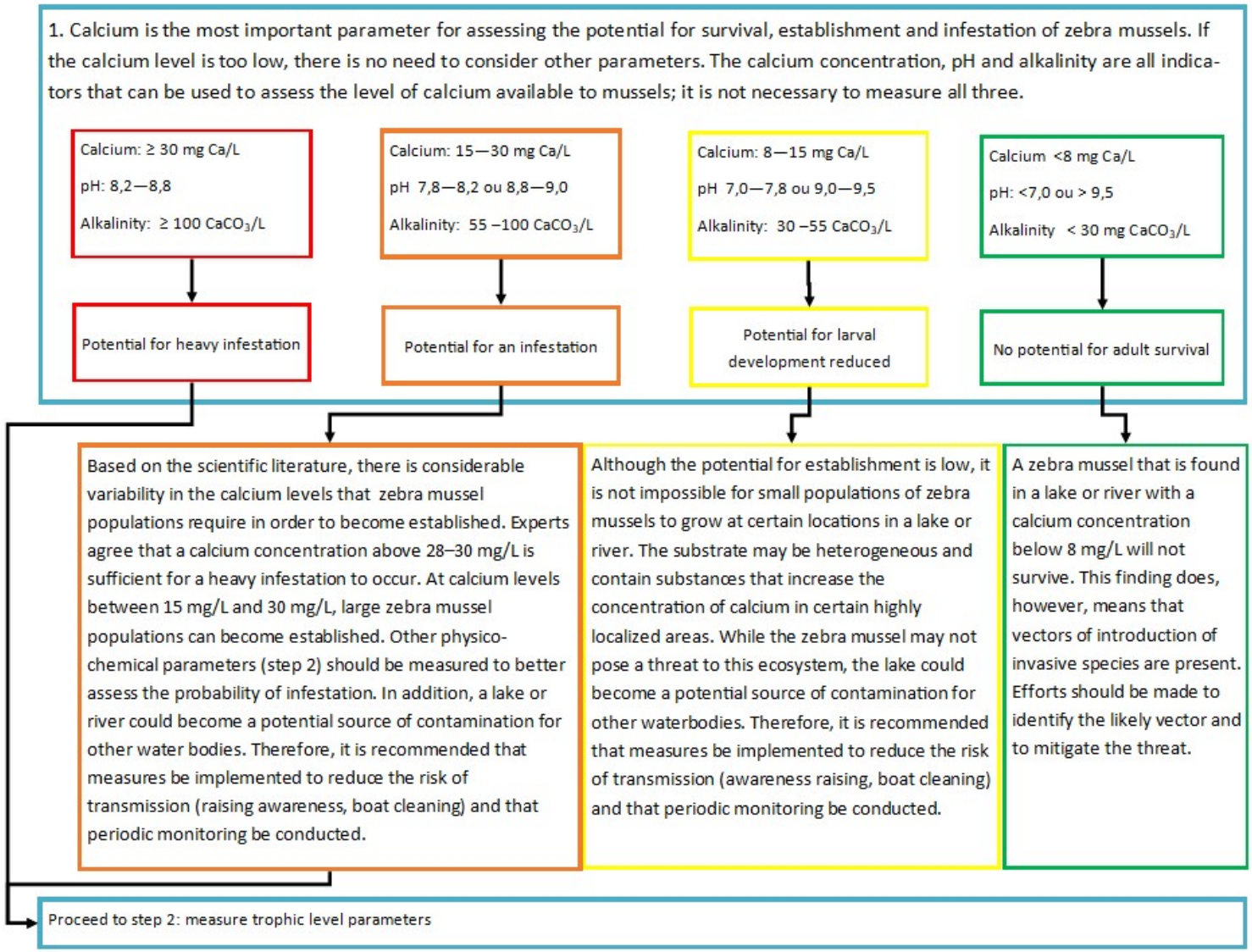
Three steps should be taken before deciding whether to recommend a response:

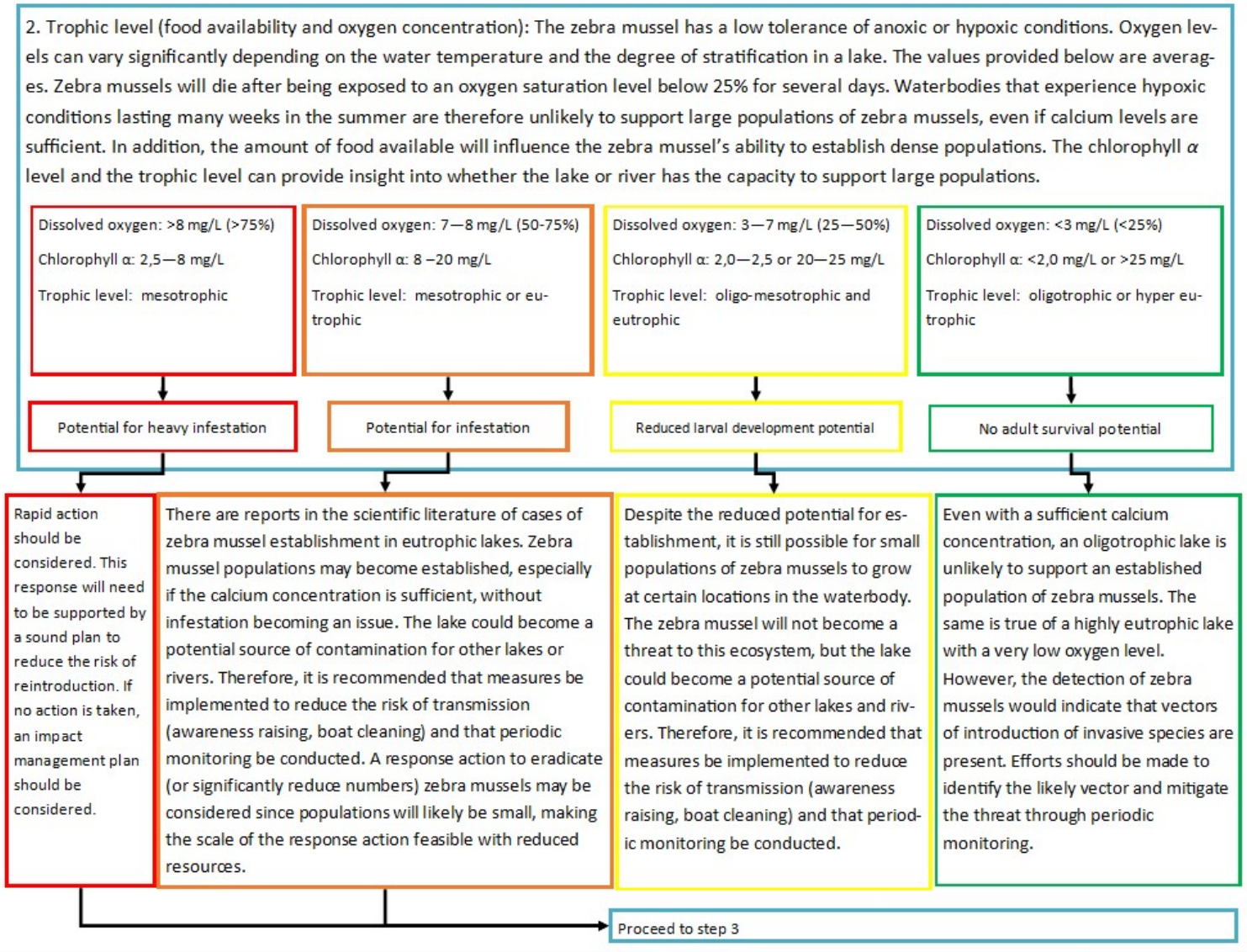
Step 1: Assess the parameters related to calcium. The calcium concentration is recognized as a limiting parameter for bivalves including the zebra mussel. The calcium level influences the species' ability to survive, establish, reproduce and reach a harmful density.

Step 2: Assess the parameters related to the trophic level. The amount of food available and the oxygen content of the water have an effect on the zebra mussel's ability to become established and reach harmful densities.

Step 3: Assess the likelihood of reintroduction. An analysis of vectors of introduction can be conducted to assess whether reintroduction of zebra mussels is likely, after the response has been implemented.

Other factors may also be considered in the decision making process—presence of species at risk, ecological services provided by the lake or river, citizen engagement—but the above three steps must be followed before actions are recommended.


1. Calcium is the most important parameter for assessing the potential for survival, establishment and infestation of zebra mussels. If the calcium level is too low, there is no need to consider other parameters. The calcium concentration, pH and alkalinity are all indicators that can be used to assess the level of calcium available to mussels; it is not necessary to measure all three.
Calcium: ≥ 30 mg Ca/L
pH: 8,2—8,8
Alkalinity: ≥ 100 CaCO3/L
Potential for heavy infestation
Calcium: 15—30 mg Ca/L
pH 7,8—8,2 ou 8,8—9,0
Alkalinity: 55 –100 CaCO3/L
Potential for an infestation
Calcium: 8—15 mg Ca/L
pH 7,0—7,8 ou 9,0—9,5
Alkalinity: 30 –55 CaCO3/L
Potential for larval development reduced
Calcium <8 mg Ca/L
pH: <7,0 ou > 9,5
Alkalinity < 30 mg CaCO3/L
No potential for adult survival
Based on the scientific literature, there is considerable variability in the calcium levels that zebra mussel populations require in order to become established. Experts agree that a calcium concentration above 28–30 mg/L is sufficient for a heavy infestation to occur. At calcium levels between 15 mg/L and 30 mg/L, large zebra mussel populations can become established. Other physico-chemical parameters (step 2) should be measured to better assess the probability of infestation. In addition, a lake or river could become a potential source of contamination for other water bodies. Therefore, it is recommended that measures be implemented to reduce the risk of transmission (raising awareness, boat cleaning) and that periodic monitoring be conducted.
Although the potential for establishment is low, it is not impossible for small populations of zebra mussels to grow at certain locations in a lake or river. The substrate may be heterogeneous and contain substances that increase the concentration of calcium in certain highly localized areas. While the zebra mussel may not pose a threat to this ecosystem, the lake could become a potential source of contamination for other waterbodies. Therefore, it is recommended that measures be implemented to reduce the risk of transmission (awareness raising, boat cleaning) and that periodic monitoring be conducted.
A zebra mussel that is found in a lake or river with a calcium concentration below 8 mg/L will not survive. This finding does, however, means that vectors of introduction of invasive species are present. Efforts should be made to identify the likely vector and to mitigate the threat.
Proceed to step 2: measure trophic level parameters


2. Trophic level (food availability and oxygen concentration): The zebra mussel has a low tolerance of anoxic or hypoxic conditions. Oxygen levels can vary significantly depending on the water temperature and the degree of stratification in a lake. The values provided below are averages. Zebra mussels will die after being exposed to an oxygen saturation level below 25% for several days. Waterbodies that experience hypoxic conditions lasting many weeks in the summer are therefore unlikely to support large populations of zebra mussels, even if calcium levels are sufficient. In addition, the amount of food available will influence the zebra mussel's ability to establish dense populations. The chlorophyll α level and the trophic level can provide insight into whether the lake or river has the capacity to support large populations.
Dissolved oxygen: >8 mg/L (>75%)
Chlorophyll α: 2,5—8 mg/L
Trophic level: mesotrophic
Dissolved oxygen: 7—8 mg/L (50-75%)
Chlorophyll α: 8 –20 mg/L
Trophic level: mesotrophic or eutrophic
Dissolved oxygen: 3—7 mg/L (25—50%)
Chlorophyll α: 2,0—2,5 or 20—25 mg/L
Trophic level: oligo-mesotrophic and eutrophic
Dissolved oxygen: <3 mg/L (<25%)
Chlorophyll α: <2,0 mg/L or >25 mg/L
Trophic level: oligotrophic or hyper eutrophic
Potential for heavy infestation
Potential for infestation
Reduced larval development potential
No adult survival potential
Rapid action should be considered. This response will need to be supported by a sound plan to reduce the risk of reintroduction. If no action is taken, an impact management plan should be considered.
There are reports in the scientific literature of cases of zebra mussel establishment in eutrophic lakes. Zebra mussel populations may become established, especially if the calcium concentration is sufficient, without infestation becoming an issue. The lake could become a potential source of contamination for other lakes or rivers. Therefore, it is recommended that measures be implemented to reduce the risk of transmission (awareness raising, boat cleaning) and that periodic monitoring be conducted. A response action to eradicate (or significantly reduce numbers) zebra mussels may be considered since populations will likely be small, making the scale of the response action feasible with reduced resources.
Despite the reduced potential for establishment, it is still possible for small populations of zebra mussels to grow at certain locations in the waterbody. The zebra mussel will not become a threat to this ecosystem, but the lake could become a potential source of contamination for other lakes and rivers. Therefore, it is recommended that measures be implemented to reduce the risk of transmission (awareness raising, boat cleaning) and that periodic monitoring be conducted.
Even with a sufficient calcium concentration, an oligotrophic lake is unlikely to support an established population of zebra mussels. The same is true of a highly eutrophic lake with a very low oxygen level. However, the detection of zebra mussels would indicate that vectors of introduction of invasive species are present. Efforts should be made to identify the likely vector and mitigate the threat through periodic monitoring.
Proceed to step 3

3. Vectors of transmission: If it is impossible to control the vector(s) that led to the zebra mussels' introduction to the lake or river, there would be no point in implementing a response, as the actions taken would be negated the next time the species is introduced. Therefore, it is important to consider the feasibility of reducing the risk of reintroduction and to include appropriate mitigation actions in the response recommendation.

Larval drift from upstream populations: Natural larval drift from source populations upstream in the lake or river is a natural vector that cannot be mitigated unless action is taken at the source population level.

Recreational boating (motorized boats): Fouled boats represent a vector of zebra mussel transmission that can be mitigated through spreading awareness, establishing cleaning stations and enforcing regulations.

Recreational boating (non-motorized watercraft): Recreational equipment such as kayaks, paddle boards and canoes are not as likely to be vectors of transmission because they store smaller amounts of contaminated water. In addition, they rarely remain in the water for more than one day and they dry naturally when removed from the water, unlike motorized boats, which are often tied to a wharf when not in use. However, there is little data in the scientific literature on this topic, and the risks associated with these activities are unclear. These risks can be mitigated through spreading awareness, establishing cleaning stations and enforcing regulations.

In the event of a regular influx of larvae from upstream (if a population is well established in an upstream lake or river) into a lake or river with suitable habitat conditions (calcium and trophic level), a mitigation plan for impacts on critical infrastructure such as drinking water intake pipes and hydroelectric dams should be considered. A monitoring plan for the zebra mussel population should also be developed to track the infestation.

An outreach campaign to encourage users to clean, drain and dry their boats and equipment before reuse is essential to reduce the risk of reintroduction.

Easy access to cleaning stations is also strongly recommended, to facilitate the adoption of positive behaviours.

Ideally, boat cleaning should be mandatory. Regulations of this type are easier to implement for motorized boats which must be launched at a boat ramp.

Appendix B
Roles and responsibilities of partners

Control of aquatic invasive species calls for the participation of a number of organizations and several levels of government. Several partners working together and pooling their resources will make it possible to implement a response. It is helpful to identify the roles and responsibilities of the different organizations in the response action. The table below presents the tasks that the different partners may be called on to fulfill in a zebra mussel response action. It does not represent a commitment by these organizations to perform all the tasks. In all cases, the participation of an organization in a response will depend on its budgets and priorities.

Table B-1: Roles and responsibilities of response stakeholders

Stakeholders	Role/mandate (general)	Roles and responsibilities for response plan implementation
Ministère des Forêts, de la Faune et des Parcs	1) Work related to wildlife conservation and enhancement, including freshwater fish and anadromous and catadromous species in provincial waters and tidal waters; 2) With a view to resource conservation, put in place an action plan to address invasive alien species, which may sometimes include control measures. 3) Ensure the enforcement of the *Act Respecting the Conservation and Development of Wildlife*, through the use of permits and required authorizations and by promoting the avoid-minimize-compensate sequence in the management of fish habitat actions.	Direction de l'expertise sur la faune aquatique (aquatic wildlife expertise directorate): • Strategic support (coordination, collaboration, communication) • Technical support (detection and follow-up) • Education and awareness (outreach material) • Analysis of requests for financial support to set up cleaning stations Direction de la gestion de la faune Estrie-Montréal-Montérégie-Laval (wildlife management directorate): • Permit issuance (if applicable) • Technical and scientific support (verification of reported sightings, characterization, detection, follow-up) • Assistance with developing an action plan • Implementation/field response • Wildlife monitoring

Stakeholders	Role/mandate (general)	Roles and responsibilities for response plan implementation
		• Regulatory enforcement (AISR and RAVP)(containment in a given area and monitoring by wildlife protection officers) • Loan of mobile boat cleaning station • Analysis of requests for financial support to establish a boat cleaning station.
Fisheries and Oceans Canada – Aquatic Invasive Species National Core Program	Control aquatic invasive species through the 4 pillars (prevention, detection, response, control). Foster consultation and collaboration. Apply the *Aquatic Invasive Species Regulations*	• Issuance of permits (as applicable) • Strategic support (coordination, collaboration, communication) • Technical support (characterization, detection, follow-up) • Regulatory enforcement (containment of an area and follow-up by fishery officers) • Outreach (outreach equipment/material including a mobile cleaning station)
COGESAF	Implement the Water Master Plan by carrying out activities to protect wildlife habitats and provide access to water.	• Implementation/field response • Awareness/communication actions
CRE (environmental regional council) of Estrie	Coordinates the Table estrienne sur les espèces exotiques envahissantes (Estrie/Eastern Townships collaborative table on alien invasive species). Foster collaboration and communication.	• Organize training sessions • Liaison offers during response activities • Stakeholder engagement
MRC		• Enforcement of municipal bylaws (containment, boat inspection, mandatory clean) • Outreach/communication • Implementation/field response

Stakeholders	Role/mandate (general)	Roles and responsibilities for response plan implementation
Municipalities		• Enforcement of municipal bylaws (containment, boat inspection, mandatory cleaning) • Outreach/communication • Implementation/field response
Lake/riverfront property owners' association	Protection of lake or river and uses by citizens.	• Outreach /communication • Implementation/field response • Follow-up
Environmental non-governmental organizations	Conservation of biodiversity, education and outreach, restoration and stewardship.	• Outreach/communication • Implementation/field response • Follow-up

Appendix C
Outreach strategy

The purpose of this section is to provide stakeholders with the tools they need to plan effective outreach activities that can be implemented quickly and easily. It outlines key points to consider when preparing an outreach campaign based on the principles of social marketing.

Set clear objectives

An outreach strategy that is aimed at preventing the spread of the zebra mussel (and other invasive species) may consist of 1) preventing the introduction of the species into rivers, lakes and other waterbodies where it is not yet present, or 2) preventing the spread of the species from a lake or river where it has become established. The goal in both cases is for users to adopt the “Clean, Drain, Dry” method when dealing with any equipment or means of transportation (boat, canoe, kayak, paddle board, etc.) that has come in contact with water. The key difference will be whether users should clean their boats before or after their boating activities.

Establishing a clear objective will help tailor the message and the means of reaching the clientele. For example, if the objective is to ensure that all boats are cleaned before being launched, a larger number of outreach/monitoring officers should be present in the morning. Conversely, if people are being urged to clean their equipment at the end of the day, more officers should be present in the afternoon.

Establishing a clear objective also helps to focus the message. It is better to avoid a proliferation of messages. A simple “Clean, Drain, Dry” sign has a greater impact than a sign with information on the biology of invasive species, the associated costs and the actions that people are expected to take.

Know your clientele

In order for an outreach strategy to be effective, it is essential to use the right means of communication to reach the intended clientele. To do this, you must know your target audience. By asking a number of questions through surveys, it is possible to target the needs of this clientele and identify the most effective means of communicating with this group.

For example, in 2021-22, DFO employees carried out a number of outreach activities by deploying the mobile cleaning station at strategic locations in Quebec. The employees surveyed the boaters they met to better understand their habits and preferences. The results showed that the preferred method of communication is in person, especially at launch sites or on the water, as well as via social media.

Knowing your target audience also helps to identify barriers to adopting the desired behaviours. These barriers may include lack of easy access to a boat cleaning station, the cost of boat cleaning and waiting times during peak traffic periods. Studying your audience also helps determine the optimal locations and ways to reach them. Boat owners are likely to be found at specific locations, the most notable being boat launch ramps. By targeting these popular locations, it is possible to increase the effectiveness and efficiency of outreach efforts. In addition, this is the easiest way to share information

with tourists who are just passing through and do not read local news bulletins. Posting information in a boaters' Facebook group may be more effective than doing so on a mainstream website. Also, a promotional item that is useful for recreational boaters, such as a cleaning cloth or a dry bag, could be transformed from a purely functional object to a visual prompt that helps get the desired message across.

Choose relevant tools

There are a number of existing outreach tools available to us. These tools have been created by various levels of government and organizations. The following table outlines the main tools that could provide relevant information for an invasive species outreach strategy.

Table C-1. Non-exhaustive list of outreach tools for the zebra mussel

Tool Owner	Target Clientele	Tool Description	Tool Format
DFO	General public	English version Identification Booklet of Freshwater Invasive Species in Quebec French version Carnet d'identification d'espèces envahissantes d'eau douce du Québec • Presentation of AIS • Identification • Habitat • Similar species • Ecological and socio-economic impacts	Web page EN/FR March 2022
DFO and RAPPEL	Divers	*Guide de retrait en plongée des moules zébrées*	PDF FR March 2022
MFFP	Fishers Recreational boaters Divers	Best practices guide and pamphlet on cleaning • A comprehensive guide to cleaning and establishing cleaning stations • Separate sheets on cleaning equipment for specific activities (fishers, boaters, divers, etc.) • Teaser version of the boat cleaning video that can be shared on social media	Guide Sheets Video FR
MFFP	Fishers Recreational boaters	French only Guide des bonnes pratiques en milieu aquatique dans le but de prévenir l'introduction et la propagation d'espèces aquatiques envahissantes	PDF 8 ½ x 11 40 pages FR

Tool Owner	Target Clientele	Tool Description	Tool Format
		• Provides recommendations/guidelines for the inspection and cleaning of boats, trailers and equipment used in aquatic environments • Purpose: to prevent the introduction and spread of AIS • Targeted activities: sport fishing, recreational boating and other water activities, as well as aquatic surveys or sampling (seaplanes and diving equipment)	
MELCC	General public	Sentinelle tool • Contains fact sheets on the highest profile species of concern (9 wildlife species and 43 plant species) • Enables reporting of these species • Provides access to reported sightings displayed on an interactive map	Mobile application Website FR
MELCC, MFFP and SLAP	General public	Attention! Évitez d'introduire des envahisseurs exotiques dans nos plans d'eau	Poster FR
MELCC	General public	Video: Espèces exotiques envahissantes : 5 étapes pour protéger son lac	Video clip FR
Memphremagog RCM (collaboration with the cities of Magog and Sherbrooke, MFFP, and the State of Vermont)	General public	Outreach campaign • Information webpages • Formulaire de déclaration des espèces envahissantes • Campagne « Bats-toi pour ton lac »	FR
Memphremagog RCM	General public	Pamphlet: La moule zébrée	PDF FR
Memphremagog RCM and REMINDER	General public	Video: Les espèces exotiques envahissantes aquatiques	YouTube FR
Organisme de bassin versant du Témiscamingue (OBVT)	Organizations	Guide pour aider les autres organismes à implanter une station de lavage de bateaux mobile	PDF FR

Identify the barriers

When planning and selecting outreach activities, it is important to identify the barriers to the adoption of desired behaviours. For example, common issues include the lack of cleaning stations, long wait times on busy days, the general public's lack of knowledge about AIS and the importance of cleaning boats and equipment, as well as the costs associated with cleaning. Therefore, providing solutions to reduce barriers allows for better adoption of positive behaviours. An example of a solution would be to have trained staff operate cleaning stations to make the process faster for boaters.

Perform follow-up

It is essential to follow up on the results obtained once the various actions have been implemented. Taking stock of the situation makes it possible to assess the effectiveness of the actions undertaken, to make any necessary changes to increase effectiveness, or to further the implementation of prevention, outreach and management measures. It could also be worthwhile to ask the public for feedback to obtain their views on the effectiveness of the measures that have been put in place. This type of input can be used to improve the measures that have been implemented and ensure that they are tailored to the target audience.

Appendix D
Template for the Terms of Reference for a coordination unit

Mandate (unit objectives)

The coordination unit's objectives are to 1) conduct a rapid assessment of the situation following a new detection and 2) provide advice to the organizations that may be called on to carry out response actions. The main organizations that participate in the response are usually members of the coordination unit.

To assess the situation, members of the coordination unit pool the available information (grey and published literature, databases, expert opinions), identify gaps and ensure that essential knowledge is obtained through field sampling.

Guidance is given to organizations that may be involved in carrying out the response actions to support their respective decision-making processes. These organizations will approve the budgets and resources allocated to the response. The information provided in the advice is intended to support decision making (e.g., feasibility, control methods, costs, communications and media, social acceptability, impacts of the species).

Composition of the coordination unit

The coordination unit is composed of:

- Make a list of members, e.g., John Doe (MFFP), Jane Doe (Saguenay-Lac-St-Jean RCM).

Roles and responsibilities

Secretariat

The secretary's duties are to convene meetings, take notes and send minutes to participants. He/she must also ensure that the documents or data required for the unit's mandate are archived and made accessible to all.

Moderator [optional, but recommended]

The moderator chairs the unit meetings. He/she ensures that the agenda is followed, that all participants have an opportunity to express their opinions, and that discussions are productive and respectful. An external moderator can be hired and paid.

Scientific expertise

Scientific experts may be invited to attend unit meetings to answer more specific questions or fill a knowledge gap. These experts are usually not members of the coordination unit. Their role should be determined by the unit.

Logistical expertise

Consultants may be invited to unit meetings to answer technical questions or prepare an action plan. These experts are usually not members of the coordination unit. Their role should be determined by the unit.

Frequency of meetings

The coordination unit meets at a frequency of [determine meeting frequency]. Meetings can be added as needed.

Funding

The costs associated with the coordination unit's participation will be assumed by each member's respective organization (e.g., travel costs).

Reporting

Members of the coordination unit will keep their organizations informed of discussions and recommendations. The members will provide advice on possible response actions to participating organizations for consideration and approval. The members will strive to reach consensus on any recommendations made, but if this is not possible, various ideas will be presented to the organizations' decision makers for their consideration.

Communications

The coordination unit will establish a communications strategy that identifies the individuals who should be informed (and when they should be informed) about the detection and updated on the situation, in the interest of transparency and efficiency. It is preferable that the unit prepare a joint communication approach and that each organization prepare its communications according to its internal decision-making process.

Pêches et Océans Canada
Fisheries and Oceans Canada

Forêts, Faune et Parcs
Québec