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Research article

Rapid response to non-indigenous species. 3. A proposed framework

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Abstract

The ability to conduct an effective rapid response to the detection of a novel non-indigenous species is greatly enhanced by the development of appropriate protocols and action plans before the arrival of species for which rapid response may be required. Worldwide, much effort has been expended on the development of such plans. Rapid response in Canadian waters is in its infancy and in Atlantic Canada, at least, rapid response against invasive tunicates has been carried out on an *ad hoc* basis in the absence of formal rapid response plans. Even so, many of the essential elements of a rapid response plan were implemented in the management of recent colonization of estuaries of Prince Edward Island (PEI) by non-indigenous tunicates. This paper proposes a framework that can be used to develop rapid response plans against future colonization of Canadian waters by non-indigenous species. The framework builds on principles derived from the preceding two papers that reviewed case histories of marine rapid response internationally and of four non-indigenous tunicates that have recently become pests in PEI estuaries. The status of non-indigenous tunicate management in PEI will be discussed with reference to the proposed framework in order to highlight areas where rapid response planning in Canada may benefit from further development.

Key words: rapid response, invasive species management, tunicates

Introduction

Rapid response is a key component of the management programs for marine invasive species being developed in many countries, e.g., Australia, New Zealand, and the USA (McEnnulty et al. 2001; NEANS 2003; NISC 2003; WANS 2003; Wotton and Hewitt 2004). Indeed, Australia has developed an internet-based "Rapid Response Toolbox" for marine species (McEnnulty et al. 2001).

In contrast, Canada lacks a formal rapid response procedure for non-indigenous aquatic species. In this paper, we propose a framework for the planning and execution of rapid responses to species invasions, which could be used as a "methods manual". While we have specifically examined marine rapid responses in the development of the framework, the principles and approach are applicable to any ecosystem or taxon.

A proposed framework for rapid response

Wotton and Hewitt (2004) identify three main components of an effective rapid response system: (1) processes and plans to guide response actions; (2) tools with which to respond; (3) the capability and resources to carry out the response. Our proposed framework explicitly addresses the first component, the development of processes and plans. Inevitably, the development of such processes and plans interacts with the other two components, as it must take into account the availability of tools, and the capability and resources to undertake a response. The overall structure we propose for a model rapid response (RR) plan for aquatic invasive species (AIS) was inspired by the Northeastern Aquatic Nuisance Species Panel (NEANS) workshop, "Rapid response to aquatic nuisance species in the Northeast", which the senior author attended in May 2003 (NEANS 2003).

The NEANS framework was modified with elements drawn from other rapid response planning literature (e.g., Myers et al. 2000; USGS 2000; McEnnulty et al. 2001; NISC 2003; GLC 2004; Wotton and Hewitt 2004; NEANS 2006), international marine responses (Locke and Hanson 2009) and our experience in AIS management in Atlantic Canada – especially in Prince Edward Island (PEI) (Locke et al. 2009a). The proposed framework also benefited from the suggestions of participants at a tunicate risk assessment and rapid response workshop held in Charlottetown, PEI, in March 2007. The framework consists of a series of pre- and post-invasion actions, which are explained below and presented in the form of a checklist in Annex 1.

Pre-invasion planning steps

General preparation:

Understand all relevant laws, regulations, policies and guidelines that may affect the ability to undertake a rapid response. Legal and management tools that enhance or hinder the ability to undertake a rapid response must be identified. If regulatory or legal hurdles are likely to delay or prevent a rapid response, pre-approvals or exemptions should be sought, or other management alternatives considered. Legal powers may need to be established at the federal or provincial level (Annex 2).

Identify who is responsible overall, and for each step in the rapid response. The roles and responsibilities of all participants should be clearly understood. The agency responsible for enforcing laws that support the goals of rapid response would logically be the appropriate entity to lead the rapid response team. For example, in New Zealand (NZ), the Biosecurity Act 1993 provides the legal basis for incursion response and the Chief Technical Officer for Marine Biosecurity is responsible for managing any response (Wotton and Hewitt 2004). A coordinator representing the lead agency should oversee all steps in the rapid response process in order to avoid confusion in implementing the plan. Personnel from participating agencies should be able to function as a team, which may require formalization through Memoranda of Understanding or other agreements.

Identify a primary point of contact at each local, provincial, and federal agency involved, and at major stakeholder organizations as appropriate. In the Great Lakes Commission rapid response plan (GLC 2004), "Invasive Species Response Coordinators" are primary points of contact and form the core of the team that would implement rapid response. The contact person or coordinator from each agency should have the authority to make commitments on behalf of the agency.

Identify the source of funding. Funding is perhaps the largest obstacle to implementation of rapid response (GLC 2004). A funding plan should be developed to identify potential resources from federal, provincial and local government agencies as well as other public and private entities. It is important to recognize that funds may be required for several fiscal years. Explicit strategies should be developed to secure long term funding (perhaps a dedicated Trust Fund for rapid response). Advocacy and education to develop the political and societal will to commit funds for rapid response may be necessary.

Identify existing frameworks, networks, etc., that may be useful in developing or implementing a rapid response plan. Potential linkages to international, national and regional frameworks or to existing response plans for pollution events or other emergencies should be considered.

Develop a communications structure. A clearly defined communication structure is essential. A network of communication among members of the rapid response team should be established to expedite information flow in the event of an invasion. Upon confirmation of the AIS, a communications officer should be designated to ensure that the media and public as well as primary contacts (agencies and stakeholder organizations) are informed and then kept up to date.

Detection phase:

Develop criteria for listing "species of concern". The NZ Biosecurity Act 1993 defines "species of concern" or Unwanted Organisms as those that "the Chief Technical Officer believes are capable or potentially capable of causing unwanted harm to any natural and physical resources or human health". One could argue that, in theory, any AIS has the potential to cause harm. In practice, this step involves a form of risk analysis of the species in the context of the receiving environment. Currently, the characteristics usually attributed to "species of concern" include some

combination of: previously documented invasions elsewhere, links to a potential invasion vector, serious potential impacts, suitable environmental conditions for survival in the receiving environment, and life history traits associated with rapid spread (NEANS 2003; Wotton and Hewitt 2004).

Develop a list of "species of concern". It would be preferable that the list, and justification for listing, be a living document, publicly available at an Internet site maintained by the legally responsible agency.

Make provision for dealing with "species of concern". The discovery of organisms suspected of being "species of concern" should trigger the rapid response process.

Make provision for dealing with species not on the list. It is likely that AIS not included on the "species of concern" list will be detected. In NZ, upon receiving a report of a suspected non-indigenous species which is not an Unwanted Organism, the Chief Technical Officer undertakes a preliminary risk assessment based on the available information, and determines if the incursion warrants a technical advisory committee to provide independent advice on scientific, operational and community issues. This may result in the designation of the species as an Unwanted Organism (Wotton and Hewitt 2004). However, errors in assumptions with regards to, for instance, likelihood of over-winter survival may occur (Locke et al. 2009b) and follow-up investigations should be the rule even for species that appear relatively innocuous.

Develop monitoring networks:

- *Develop monitoring network coordination.* Each local, provincial and federal agency, industry stakeholder organization, or volunteer monitoring group concerned with AIS should designate a contact (most likely, but not necessarily, their Invasive Species Response Coordinator) to be responsible for coordinating monitoring activities of that entity and conveying AIS reports to the overall network coordinator.
- *Develop a monitoring protocol*. The monitoring protocol requires decisions to be made about the monitoring approach, and the handling of specimens.

The monitoring approach may consist of passive or active detection networks, syndromic surveillance, or some combination of these. Passive detection refers to "serendipitous" detection by professionals or volunteers engaged in other activities. Existing environmental monitoring programs may cost-effectively contribute to AIS monitoring if the participants receive basic training in recognizing AIS. Gaps in existing programs may be filled using active detection networks, which specifically target the detection of AIS by professionals or volunteers. Active detection is typically focused on high-priority targets, including high-risk locations, high-value resources, important vectors, or species of particular concern; e.g., targeted surveys by professionals for taxonomically challenging yet high-priority species. The NZ marine biosecurity surveillance program uses such an approach to monitor for Unwanted Organisms in eight harbours that have a high risk of incursions (Wotton and Hewitt 2004). NISC (2003) emphasizes the need to select high-risk targets for monitoring, based on research into the environmental or social factors that may contribute to invasions or affect monitoring priorities (e.g., climatic conditions, ecosystem disturbance patterns, land use changes, or changes in pathways). The third general category of monitoring approaches, syndromic surveillance, detects anomalies that may indicate an invasion before any causative species or agents are identified (NISC 2003). This monitoring approach will be useful for a limited group of potential invaders (most often, pathogens or parasites). Common to all these approaches is the need to develop quantitative monitoring techniques for AIS that ensure acceptable levels of uncertainty. In particular, knowing the error associated with non-detection of a species at a given level of effort is important for informed management.

Professional and volunteer monitoring network members must be trained in the preservation of specimens, and in collection of relevant location and environmental data. Voucher specimens and high-quality digital photographs of confirmed AIS for morphological and genetic purposes, and a reference collection and photographs of species native to the area, should be retained in a permanent location that is accessible to individuals seeking taxonomic training. The voucher collection should be housed permanently in a museum or government institution where it will be curated and maintained. Secure chain of custody is required for any specimens to be used as evidence for legal or insurance purposes.

If necessary, conduct ecological inventories to establish baseline information on native and AIS populations. It is impossible to determine if a species has newly arrived in a location without knowing what was previously present. Existing biodiversity inventories may have major gaps, especially for non-commercially fished taxa and habitats. Monitoring surveys should include a component designed to provide several years of baseline information for poorly studied areas or taxa.

Develop protocols for identification of invaders. A lack of readily available taxonomic expertise is one of the major impediments to addressing AIS in the marine environment (Meliane and Hewitt 2005). In other words, "If you can't identify it, you can't detect it".

At the very least, a contact list of taxonomic experts should be developed. A better approach is taken by the NZ government, which maintains contracts with taxonomists for the rapid diagnosis of suspected new organisms (Wotton and Hewitt 2004). Indeed, we think that the need for government support of fundamental studies in taxonomy is one of the most important recommendations of Wotton and Hewitt's (2004) evaluation of biosecurity research.

There have been numerous examples where misidentification has hindered rapid response. The northern Pacific sea star, *Asterias amurensis* Lütken, 1871, considered Australia's most damaging marine pest, was thought to be a native species for almost a decade. By the time this mistake was corrected, the sea star was so abundant that any chance of eradication had passed (Goggin 1998). The misidentification of northern snakehead, *Channa argus* (Cantor, 1842), as the less damaging giant snakehead (*C. micropeltes* Cuvier, 1831) by Maryland Department of Natural Resources staff delayed rapid response activities (Early 2003) and the species is now well-established in US waters (Odenkirk and Owens 2007). Reports to the Chief Technical Officer of NZ of the fouling tunicate eventually identified as *Didemnum vexillum* Kott, 2002 were delayed by several months because field biologists were unfamiliar with the organism (Coutts and Forrest 2007).

Develop a database of regional AIS sightings and established AIS populations. Like the voucher specimen collection, the AIS database should be a centralized and long-term repository of data. Regional AIS coordinators should update the database with verified new AIS records or range extensions. Unverified observations should not be included. This database can be made available through the internet to all stakeholders and agencies, should have mapping capabilities including the ability to track changes in distribution over time, and may benefit from an ability to link to international AIS sites (e.g., for studies of worldwide distribution and international vectors, biogeographic trends, species literature, risk assessments, etc.).

Communications planning for the detection phase:

- *List the stakeholders and agencies that should be notified in the event of detection.* The list of entities or individuals to be notified may change at different stages of the rapid response process. For example, a smaller group will probably be notified at the detection stage than at later stages.
- *Develop educational materials.* Educational materials that could be prepared in advance of an invasion include:
  (1) Materials for the public and politicians about the dangers of AIS in general, e.g., characteristics of AIS and the risks of invasion; the benefits of rapid response versus the risks of not taking action; what situation will trigger a rapid response.
  (2) Materials for specific interest groups with a vested interest in the effects of AIS invasion, e.g., commercial and recreational water users, angling groups, environmental groups. Fact sheets should target specific pathways associated with the group's activities. If informed and aware of AIS issues, water users may be willing to voluntarily modify their activities to reduce the risk of introductions, and their support may help to gain the political will needed for approval of implementation of rapid response.
  (3) Identification materials for high-priority species. High-resolution images of typical and atypical specimens with key identification characters to differentiate from native species are a minimal requirement.
- *Develop a dedicated website and a toll-free telephone number to report sightings or access information on invasions.* The site, updated regularly, can be used to post reports on the range of the invasion, the status of current efforts and provide links to the appropriate source(s) for further infor-

mation (e.g., the AIS database). Distribution maps and photographs should be included.

- *Prepare generic press release statements*. Generic documents can be prepared for later customization to a specific situation, e.g., announcement of AIS detection, rapid response options and planning, rapid response implementation, and post-response outcome. Upon verification of an invasion, the stakeholders most directly affected by invasion and/or rapid response should be targeted with the message that any local impacts potentially caused by rapid response management are being made for the greater environmental, social and economic health of the region.

Demarkation phase

Identify who will conduct biological surveys for various environments/species, and collect data for risk assessment. This entity will be responsible for conducting field surveys to determine the spatial extent and abundance of the AIS. While it may seem superfluous to repeat the need for funding, surveys will not likely be conducted in its absence.

Determine what data would be required for risk assessment of species and vectors, and develop sampling protocols to collect these data during the surveys. Train survey personnel and ensure that equipment will be available. Data requirements for risk assessment will be site- and species-specific, depending on what information is needed in the Containment and Risk Assessment steps.

Determine the likely composition of potential scientific assessment committees for various kinds of AIS. This group should have the capability to undertake risk assessment and evaluate the seriousness of an infestation, and whether rapid response is warranted and feasible. The federal, provincial and academic scientific community, specialists in invasive species biology and in the taxa under consideration, and local stakeholders should be included.

Develop a strategy for stakeholder consultation and communication of information. Depending on the circumstances, it is likely that consultation will be needed with stakeholders engaged in specific resource-based industries, along with consultation or communication with the general public, shoreline landowners environmental organizations, or resource users other than those directly affected.

Containment phase

Develop criteria for determining the need for containment or restriction of use of an infested water body. Containment may be needed in the long term, but is more likely to be employed as an interim strategy while decisions are being made on further actions. Pre-invasion risk assessments of high priority species should identify whether there would be a need for containment. The criteria for containment or restriction decisions based on data collected during post-invasion delimitation should also be developed in the event of rapid responses for species lacking a pre-invasion risk assessment.

Determine whether legal authorities will allow containment or restriction of use of the water body. Evaluating the appropriate legal authorities for containment, before these are needed, should minimize challenges that could delay an effective response (NISC 2003).

Identify who is responsible for the enforcement of restrictions of specific systems, *what enforcement resources may be required, and how to obtain additional resources or funding if needed.* Restriction of access to or from the water body, or to facilities adjacent to that water body, may be necessary for the containment of an infestation. In the case of aquaculture, complete product and infrastructure removal may be required.

Identify the communications needs associated with containment or restriction of use.

Risk Assessment phase

Identify who will conduct the risk assessment. Presumably the risk assessment will be conducted by members of the scientific advisory committee, but there must be provision for non-scientific input to the decision (so long as it does not unduly delay the rapid response**)**.

Identify the information needs for risk assessment, develop the required protocols, ensure appropriate equipment and personnel will be available, and provide training to personnel. The protocols required will be determined by the needs of data gathering for the risk assessment to be conducted post-invasion. Environmental, vectors, and resource usage data may need to be collected on the affected area.

Identify control options for "species of concern". The range of possible management options includes: providing stakeholders with information and monitoring the event; commencing a full-scale containment, management, or eradication program; management options such as slowing the spread of the organism; or actively managing established populations to keep abundance below a threshold of effect (Wotton and Hewitt 2004). In this step, the tools available to support these management options are identified and evaluated for feasibility. An assessment matrix to aid in comparing and choosing among control options is provided in Annex 3.

Control options may be considered from several categories: physical/mechanical (e.g., removal of species by hand or machinery, trap nets, water drawdown, exposure to heat, barriers), chemical (herbicides, insecticides), biological (natural enemies), and habitat management (GLC 2004). In practice, physical/mechanical and chemical options are most likely to be considered for the marine environment. Biological control has yet to be proven as a viable approach to controlling marine pests, and is more likely to be effective in population reduction than eradication (GAO 2001). Habitat management mainly occurs in the terrestrial environment (e.g., burning, grazing) (GLC 2004). Removal of all man-made objects (e.g., aquaculture structures, docks, buoys) from a marine site and allowing it to sit fallow for at least one generation time of a non-indigenous tunicate is an example of habitat management that could be used in the marine environment. Optimally, the method should be highly selective for the target pest, cost-effective, easy to use, and have no long-term negative effects on the environment or non-target species (WANS 2003).

Identifying environmentally sound control methods for marine species is a challenge that requires a level of knowledge of the physiology, habitats, and ecology of the target AIS, which is rarely available (McEnnulty et al. 2001). To this we add a lack of the same information for non-target native species and habitats, and the consequences in the marine environment of control techniques that are standard practices in fresh water (e.g., poorly understood chemical reactions of pesticides in salt water). Control methods in aquatic, especially marine, areas are generally much less developed than in terrestrial systems because (1) awareness of the need for aquatic control methods is relatively recent, and (2) there have been few commercial applications, thus industry has little incentive to develop control methods for aquatic areas (GAO 2001).

Formalize the decision support system for risk assessment and provide training. The decision-making tools to be used must weigh the factors (biological/ecological, technical, economic, and social) that will determine the decision for rapid response. A decision should not be solely based on scientific assessment, but requires consultation from the non-scientific community. The actual level of response will depend on: the potential impacts of the organism on the environment, economy, and people; the technical feasibility of response options; the ability to target the invasive species; risks associated with treatment; the degree of public concern or interest; and the likelihood of the organism being eradicated or effectively managed (Wotton and Hewitt 2004). A series of questions to be considered before attempting eradication is presented in Annex 4.

Some special considerations may apply to a decision to undertake eradication. An eradication program is based on an intentional trade-off of short-term localized impacts for long-term wide-area benefits. As such, it may require accepting higher levels of non-target damage than a pest management program that aims to maintain a pest at low abundance. Eradication technologies perhaps need not be highly specific if impacts on non-target species are limited to a restricted area (McEnnulty et al. 2001). Once a pest has become widespread, control techniques need to have higher specificity. If eradication is not feasible, long-term control to reduce and maintain the population to an economically or ecologically acceptable level may be the only option (McEnnulty et al. 2001). The existence of Species at Risk within an affected waterbody presents a special problem as the requirement to take action is high yet the tolerable level of collateral damage is very low.

Implementation phase

Identify who is responsible for implementation of the rapid response. Decisions ahead of time as to who is responsible for the cost of the response, and who will obtain the required permits, will prevent delays in implementation.

Develop protocols for the control methods that may be used. Protocols must be developed to protect the environment and the personnel who

will be carrying out the response. These may need to be provided as part of the permitting process.

Provide training to rapid response group members with simulations and field trials. Depending on the methodology chosen, training may be needed. At a minimum, personnel should receive a thorough briefing before undertaking the response. Formal training, e.g., licensing to apply pesticides, may be required.

Identify the communications needs associated with implementation. Users of the location (including all water users, and landowners with waterfront property) should not be surprised when implementation begins.

Follow-up phase

Identify who is responsible for post-treatment monitoring. As in the earlier steps, it is necessary to know who will carry out post-treatment monitoring and who will fund it.

Identify protocols to be used in post-treatment monitoring to assess the effectiveness of the selected response. Criteria to be used to determine if the response is complete must be identified. For example, at what point would a formerly infested water body be considered "clean"? We suggest a "risk managed approach" to this step, analogous to that used in medicine, e.g., for cancer patients.

The necessary duration of monitoring will depend on the life cycle of the AIS. The NZ Ministry of Fisheries recently completed a response to *Undaria pinnatifida* (Harvey, 1873) in which monitoring was undertaken every 30 days for three years. This requirement was based on a conservative interpretation of the species' life history, with maturity of sporophytes after 40 days, and maximum known gametophyte dormancy of two years (Wotton and Hewitt 2004).

The NZ Biosecurity Council considers a response to be complete when one or more of the following applies:

- organism is non-indigenous but unwanted-organism status is not warranted; and an environmental survey has been completed to confirm the current and potential distribution and abundance of organism
- no further response action is required or practicable
- the organism is eradicated
- initial actions were ineffective but no practical alternative remains
- no suitable response options are available
- sufficient arrangements are in place to sustain an appropriate level of response until decisions about a longer-term response are made (Wotton and Hewitt 2004).

Identify protocols to evaluate the effectiveness of communication. Assess if outreach efforts were successful in notifying and educating a broad range of stakeholder groups about the initial invasion, subsequent response efforts, and response outcomes. Measure both the public's awareness and acceptance of the rapid response effort by asking, for example, "are you aware that a response was implemented?", "do you support how the response was conducted?", "are you satisfied with the outcome of the response?".

Post-invasion process

After a suspected AIS is detected, the following actions follow as a check list.

Detection phase

Report the suspected AIS. The organism should be reported by the discoverer to the identified authority who then undertakes the following steps.

Confirm the identity of the specimen.

Deposit voucher specimens at the appropriate permanent archive.

Update the database and webpages.

Mobilize the communications officer and scientific advisory team.

Demarkation phase

Determine the distribution of the invader and other relevant data needed for risk assessment, including vectors and options for containment.

Convene scientific assessment committee and review preliminary data.

Continue communicating with stakeholders as new information becomes available.

Begin stakeholder consultation to determine the need (or legal requirement) for management.

Containment phase

Scientific advisory committee evaluates need for containment or restriction and continues to assess risk as more data become available.

Communicate the decision. Commence containment or restriction of use of the infested water body or facility, if necessary.

Continue stakeholder consultation.

Monitor the infestation.

Risk Assessment phase

Continue to assemble data on the affected area.

Review the control options.

Identify risks and benefits associated with various controls, including no control.

Consult stakeholders. Institutional, mandated responsibilities may override the wishes of local stakeholders, for example when a Species at Risk is involved.

Select the preferred control option.

Set schedule for implementation. Different species and invasion scenarios will require differing schedules of response, depending on the likelihood of establishment, the rate of spread, life cycles, climate, weather, and other factors (NISC 2003).

Communicate the decision.

Implementation phase

Begin experimental or full-scale management effort.

Follow-up phase

Monitor for long enough to ensure the response was effective (e.g., all individuals have been eradicated, or abundance has been suppressed).

Determine if response is complete.

Take measures to prevent reinvasion (may not be necessary unless eradication was undertaken).

Evaluate the effectiveness of communication.

Debrief the process and record ALL steps. Very good record-keeping is an essential learning tool. ALL responses, including failures, must be published in the permanent scientific literature, otherwise the lesson is lost.

Discussion

While a formal planning procedure for rapid response to aquatic non-indigenous species does not exist in Canada, numerous elements of our proposed framework are already in place. Prince Edward Island may have more experience in marine rapid responses than any other jurisdiction in Canada after a decade of management of non-indigenous tunicates (Locke et al., 2009a). The federal government (Department of Fisheries and Oceans Canada, or DFO) is responsible for the management of fishery and aquaculture resources in marine waters in Canada, and has been the nominal lead in rapid response activities in the province of PEI; however, provincial, academic, and industry institutions have played major roles and an excellent working relationship prevails despite a lack of formal arrangements. These groups have collaborated since the initial discovery of non-indigenous tunicates and form a "PEI AIS Steering Committee" (AISSC), which meets weekly. Members are effectively Invasive Species Response Coordinators, and form the core of a *de facto* scientific assessment committee.

The chair of the AISSC committee is DFO's AIS coordinator in PEI and is the central point of contact for AIS reports in PEI. Reports are also received by the PEI Department of Agriculture, Fisheries and Aquaculture (DAFA), and a research laboratory at the regional DFO headquarters in Moncton NB (receiving reports from the region, not just PEI). These three sites communicate regularly through the weekly AISSC meeting. In addition, reports of possible AIS have been received at other locations, including Parks Canada and DFO field offices. In some cases, this led to considerable delays in receipt of the information at the three main reporting points and, on occasion, release of erroneous information to the public.

Passive detection, mainly by mussel growers, has been responsible for many of the tunicate observations in PEI although there is also an active detection monitoring program for high-risk sites. To date, only qualitative monitoring has been attempted for tunicates in PEI – essentially presence/absence data that lacks any determination of error rate (false negatives). Researchers from several universities are currently engaged in studies that may contribute to the development of quantitative monitoring.

There exist no criteria in Canada for listing non-indigenous species of concern. Given past experiences of tunicate invasions in PEI, any unrecognized tunicate or tunicate-like organism is now treated as a species of concern by the AISSC. Species for which risk assessments have been undertaken through the Centre of Expertise

for Aquatic Risk Assessments may be considered as *de facto* species of concern, proposed by regional DFO scientists and selected as worthy of assessment by the Centre's steering committee. Assessments of the risks of colonization and of ecological impacts at the national level in Canadian waters have been completed for seven marine species - five species of tunicates, the European green crab *Carcinus maenas* (Linnaeus, 1758), and the Chinese mitten crab *Eriocheir sinensis* H. Milne Edwards, 1853 (Therriault and Herborg 2007; Therriault et al. 2008a, b). Locke (2009) has attempted a more general screening procedure for potential invaders of Atlantic Canada, which to date has been completed only for tunicates.

Formal protocols for the identification of AIS in Canada do not exist and there is no centralized facility for identification, although through an informal arrangement questionable tunicate specimens found in Atlantic Canada are sent to a DFO laboratory in Moncton, NB, for confirmation. At present, there is no protocol for preservation of voucher specimens of tunicates from PEI or any other province. Increasingly, researchers are beginning to preserve specimens in ethanol for use in genetic studies instead of, or in addition to, specimens in formaldehyde for traditional taxonomy. The Atlantic Veterinary College (Charlottetown, PEI) has recently offered to serve as an international repository for extracted genetic material of tunicates but there is no equivalent collection of specimens for morphological study, although provincial or national museums are available for this purpose. There is, however, a centralized location for AIS distribution data in the National AIS database recently developed by DFO.

Communications about AIS in PEI are assisted by a communications officer working at the DFO PEI Area Office. There is no formal list of groups to be notified in the event of AIS detection in PEI. Informally, the members of the AISSC are probably aware of most of the appropriate groups. There is a formal mechanism to notify stakeholders in the bivalve aquaculture and processing industries through representatives on the PEI Introductions and Transfers (I&T) Tunicate Sub-committee. Historically, groups associated with aquaculture have been most likely to be notified because this industry has been most affected by both the pests and the subsequent management measures. Brochures and posters about AIS, especially tunicates, have been distributed in PEI for the past decade along with reporting information and best practices for vector control (Locke et al. 2009a). Recently, educational activities such as hands-on demonstrations of AIS removal from boat hulls and gear have been targeted at specific interest groups.

Formal criteria for determining the need for containment or restriction of use exist in Atlantic Canada only for fish disease (e.g., McGladdery and Stephenson 2005). The relationship of federal and provincial legal instruments to AIS rapid response in PEI has not been thoroughly reviewed although a review of federal instruments is being undertaken by the Policy branch of DFO. A Canadian document equivalent to EPA (2006), outlining the relevant authorities and instruments, would be a useful tool to facilitate rapid response in this country. Most management of AIS on PEI has been undertaken under the sections of the Canadian Fisheries Act concerned with the deliberate transfer of species, specifically using the provincial Introductions and Transfers process to limit the spread of pests of aquaculture in PEI. Methods for the eradication of AIS are only now being evaluated relative to requirements under the Canadian Pest Regulatory Management Act (Locke et al. 2009b).

Tunicate management in PEI began without a formal risk assessment, although the I&T committee sought expert advice following each new incursion (Locke et al. 2009a). In PEI, tunicate management has typically been initiated only after the demonstration of nuisance status of each tunicate, which typically occurred 2-3 years after each incursion (Locke et al. 2009a). Management of *Ciona intestinalis*, the most recent arrival, was undertaken without delay because aquaculturists in PEI were aware of the adverse effects of this species on mussel aquaculture in Nova Scotia (Carver et al. 2003). It is not our intention to propose formal risk assessment methodologies for Canadian aquatic invasive species because such methodology is under development by DFO's Centre of Expertise for Aquatic Risk Assessment (Mandrak et al. 2007).

However, the assessments conducted under the auspices of this Centre of Expertise assess risk only at the national level, and do not take into account the differences in risk that may be associated with regional ecosystem types, resource utilization, or vectors. Therefore, the risk assessment is not at the level required for management at the regional or local scale. The

national risk assessments also explicitly exclude consideration of socio-economic impacts and the feasibility of management or eradication; and these essential components of the rapid response risk assessment process therefore have to be carried out by scientific committees for their local incursion.

In PEI, "no control" has not been considered a viable option, due to the serious consequences of tunicate invasions to date for the aquaculture industry. Eradication would have been the preferred response to any of these invasions, but to date has been unsuccessful in PEI. At present, eradication of existing invasive tunicates is generally assumed to be infeasible (but see Edwards and Leung (2009) for an alternative view). The aquaculture industry has settled for management to reduce abundance and limit dispersal to new estuaries. Two levels of response to non-indigenous tunicates in PEI have been undertaken. The first, permitting transfers or harvests of aquacultured bivalves only between infested estuaries, is a containment strategy under the control of the I&T committee. The second is management to reduce the abundance of tunicates and their economic impacts on mussel aquaculture facilities. This has been funded and undertaken by the aquaculture operators, except for a small project that was funded by DFO and DAFA in 2005 as an eradication experiment (Locke et al. 2009a).

There has been no formal evaluation of the efficacy of rapid response efforts in PEI, but annual monitoring has been carried out by DFO and DAFA in estuaries managed for tunicates. Post-invasion followup protocols have primarily involved surveys by divers using SCUBA, and settlement plate monitoring of sites where tunicates were reported. Currently, the AISSC has agreed that PEI estuaries would be considered "clean" (not requiring management) after two years without detection of a given tunicate.

In PEI, the main gap in rapid response is the third component that was identified by Wotton and Hewitt (2004): the capability and resources to carry out the response. There has been no dedicated funding to respond to an emergency AIS situation in PEI. Federal and provincial funding has been available only on a case-by-case basis, and the lack of ongoing resources has affected the ability to enforce regulations or to mount a response beyond the low-cost (to government) I&T restrictions. Rapid response is also restricted by the absence of legislative tools that would allow management of known vectors (e.g., recreational and commercial boat hulls) outside the scope of I&T.

It is probably correct to say that rapid response to tunicates in PEI is incomplete. While monitoring and management are ongoing, sufficient arrangements are *not* in place to sustain the response because management at its present level requires a high level of effort (weekly committee meetings). The absence of long-term funding for this program is also evident, as the AISSC chair and the communications officer in PEI are both temporary employees of DFO. The situation for the other four provinces in Atlantic Canada is even less advanced despite the presence of invasive tunicates and other nuisance AIS in their waters.

The next step towards effective rapid response for tunicate infestations in Atlantic Canada, or, for that matter, any Canadian aquatic incursion, will be to fully develop the infrastructure to support such a plan. Otherwise, the situation will be similar to that described by Anderson (2005) for most rapid response proposals in the United States: "with very few exceptions…the plans at this time are analogous to having a conceptual design for a fire department, but with no fire station, no on-call fire fighters, no pool of effective fire-fighting equipment, no mandate or authorization to fight fires, and no hands-on training for fire-fighters…[The plans] all have public education/outreach components, but realistically, creating an awareness similar to that for fire prevention and fire-hazards will probably take a generation." Now is a good time to start the process.

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Annex 1

Checklist of steps in developing a rapid response plan.

A. Before the invasion

General preparation

Understand all relevant laws, regulations, policies and guidelines that may affect the ability to undertake a rapid response.
Identify who is responsible overall, and for each step in the rapid response.
Identify a primary point of contact at each local, provincial, and federal agency involved, and at major stakeholder organizations as appropriate.
Identify the source of funding.
Identify existing frameworks, networks, etc., that may be useful in developing or implementing a rapid response plan.
Develop a communication structure.

Detection

Develop criteria for listing "species of concern".
Develop a list of "species of concern".
Make provision for dealing with "species of concern".
Make provision for dealing with species not on the list.
Develop monitoring networks:

- *Develop monitoring network coordination.*
- *Develop a monitoring protocol.*

If necessary, conduct ecological inventories to establish baseline information on native and AIS populations.
Develop protocols for identification of invaders.
Develop a database of regional AIS sightings and established AIS populations.
Communications:

- *List the stakeholders and agencies that should be notified in the event of detection.*
- *Develop educational materials.*
- *Develop a dedicated website and a toll-free telephone number to report sightings or access information on invasions.*
- *Prepare generic press release statements.*

Demarkation

Identify who will conduct biological surveys for various environments/species, and collect data for risk assessment.
Determine the likely composition of potential scientific assessment committees for various kinds of AIS.
Communications: Develop a strategy for stakeholder consultation and communication of information.

Containment

Develop criteria for determining the need for containment or restriction of use of an infested water body.
Evaluate legal authority that will allow containment or restriction of use of the water body.
Identify who is responsible for the enforcement of restrictions of specific systems, what enforcement resources may be required, and how to obtain additional resources or funding if needed.
Communications: Identify the communications needs associated with containment or restriction of use.

Risk Assessment

Identify who will conduct the risk assessment.
Identify the information needs for risk assessment, develop the required protocols, ensure appropriate equipment and personnel will be available, and provide training to personnel.
Identify control options for "species of concern".
Formalize the decision support system for risk assessment and provide training.

Annex 1 (continued)

Implementation
Identify who is responsible for implementation of the rapid response.
Develop protocols for the control methods that may be used.
Provide training to rapid response group members with simulations and field trials.
Communications: Identify the communications needs associated with implementation.

Follow-up
Identify who is responsible for post-treatment monitoring.
Identify protocols to be used in post-treatment monitoring to assess the effectiveness of the selected response.
Identify protocols to evaluate the effectiveness of communication.

B. Post-invasion

Detection
Report the suspected AIS.
Confirm the identity of the specimen.
Deposit voucher specimens at the appropriate permanent archive.
Update the database and webpages.
Mobilize the communications officer and scientific advisory team..

Demarkation
Determine distribution of invader and other relevant data needed for risk assessment, including vectors and options for containment.
Convene scientific assessment committee and review preliminary data.
Continue communicating with stakeholders as new information becomes available.
Begin stakeholder consultation to determine the need (or legal requirement) for management.

Containment
Scientific advisory committee evaluates need for containment or restriction and continues to assess risk as more data become available.
Communicate the decision. Commence containment or restriction of use of the infested water body or facility, if necessary.
Continue stakeholder consultation.
Monitor the infestation.

Risk Assessment
Continue to assemble data on the affected area.
Review the control options.
Identify risks and benefits associated with various controls, including no control.
Consult stakeholders.
Select the preferred control option.
Set schedule for implementation.
Communicate the decision.

Implementation
Begin experimental or full-scale management effort.

Evaluating effectiveness (follow-up)
Monitor for long enough to ensure the response was effective.
Determine if response is complete.
Take measures to prevent reinvasion.
Evaluate the effectiveness of communication.
Debrief the process.

Annex 2

Some legal powers that may be needed to manage non-indigenous species (modified after GLC 2004).

- Prohibition on further releases
- Regulation of quarantine, containment, possession, transport, or trade
- Notification requirement (e.g., for individuals engaged in specific activities) to report detection
- Authority for domestic officials to coordinate management programs with counterparts in neighbouring countries
- Authority to use cost recovery mechanisms (polluter pays) and/or revenues from national or regional environmental funds
- Inspections, confiscations, disinfection of equipment, destruction of infested material
- Access to private property for management
- Authority to use selected management techniques (e.g., exemptions to chemical permitting under specific conditions)
- Closure of contaminated areas to navigation
- Restrictions on transfers of living material from contaminated to "clean" areas
- Ban on anchorage and provision of alternative moorings
- Establishment of compliance program based on enforcement and economic incentives

Annex 3.

An "assessment matrix" that may be used to rank management options in a rapid response (modified after GLC 2004).

Consideration	Management option	
	A	B
Timeline to apply treatment		
Specificity of treatment to invading species		
Authority to access invaded habitat		
Required federal permits for application		
Required provincial permits for application		
Required training needed to apply treatment		
Safety concerns for applying treatment		
Costs of treatment		
Effectiveness of treatment		
Appropriateness to the habitat under consideration		
Long term ecological impacts (potential for restoration)		
Quality of existing guidance on use / impact		
Detoxification time		
Effects on threatened and endangered species		
Public acceptance of approach		

Annex 4.

Questions to be considered before attempting eradication (adapted from WANS, 2003).

A. Is the risk of re-introduction low enough to justify eradication?

B. Can controls be initiated rapidly?

1. Was there early detection?
2. Was there accurate and rapid identification?
3. Is there information on species biology and management?
4. Are treatment methods available?
5. Will environmental issues or regulatory hurdles delay or increase cost?
6. If permits needed, are they available quickly?
7. Is the species prioritized for response? Does it have an existing plan?

C. Is there a will to act?

1. Do decision-making structures have power to determine whether eradication should proceed, how, and who should fund?
2. Are technical, field, administrative, funding and legal resources available for an eradication campaign?
3. Is there acceptance of the need to proceed on best information available?
4. Is there acceptance of short term local impacts as trade-off for long term wide area benefits?
5. Is there acceptance that "do nothing" response has serious impacts and is a poor option?
6. Do most agencies and their staff feel they have a clear responsibility to act, or that one agency has clear mandate and authority to act?
7. Is there acceptance that the eradication effort may be long-term?

D. Is organization adequate?

1. Is there the ability to quarantine or control the infested area?
2. Is there capacity to survey/determine whether pest is restricted to controlled area?
3. Do program staff have experience in pest management and eradication?
4. Is funding adequate and for sufficient duration?
5. Is there effective collaboration between parties?
6. Is there good regional collaboration when species cross jurisdictions?
7. Are there provisions for monitoring to support decisions to modify, expand or end the eradication campaign?

E. Other

1. Is there support by affected parties, including public?
2. Is there effective education for the public, and government decision makers?