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SCIENCE ADVICE ON RISK ASSESSMENT METHODS FOR GRANTING BALLAST WATER MANAGEMENT EXEMPTIONS

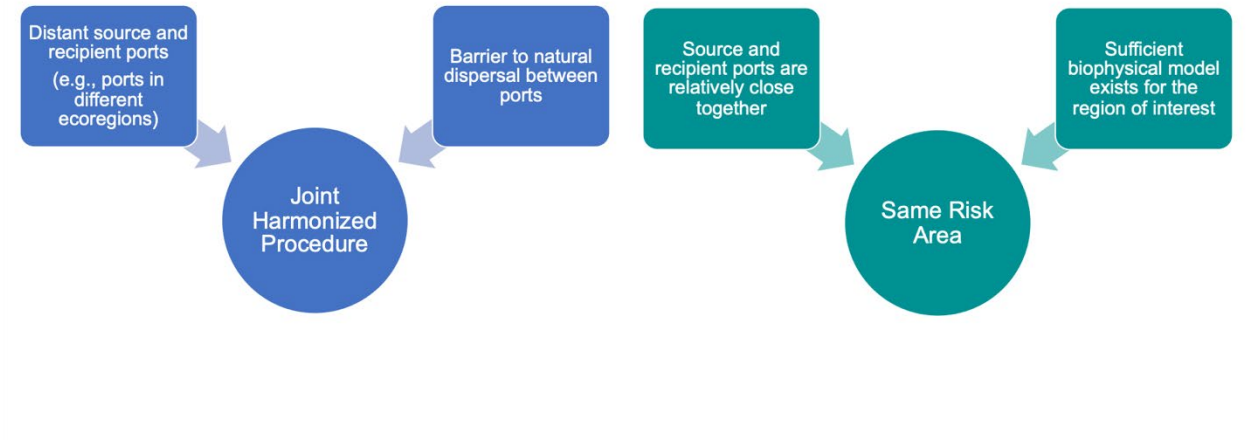

Figure 1. Suitability of each risk assessment method depending on the context of the exemption request.

Context:

Regulation D-2 of the International Maritime Organization's (IMO) Ballast Water Management Convention, to which Canada is a signatory, is intended to mitigate the introduction and spread of harmful aquatic species by setting limits on the concentration of viable organisms in discharged ballast water. Most ships are expected to comply by using onboard ballast water management systems to treat their ballast water. Regulation A-4 of the Convention allows States to grant exemptions from this ballast water management requirement to ships travelling or exclusively operating between specified ports. Exemptions must be based on a scientifically-robust risk assessment that indicates a ship's ballast water operations are unlikely to impair or damage human health, property, resources, and environment of any nation. Two existing risk assessment methods — i) Joint Harmonized Procedure and ii) Same Risk Area — that were previously considered by the IMO for granting exemptions under Regulation A-4 in other jurisdictions were evaluated by conducting a literature review and applying these risk assessments to Canadian case studies. Based on this analysis, recommendations were developed on ecological risk assessment methods to evaluate future exemption applications in Canada.

This Science Advisory Report is from the February 23–25, 2021 National Advisory Meeting on the Evaluation of Existing Risk Assessment Methods for Granting Ballast Water Management Exemptions. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- The International Maritime Organization's (IMO) Ballast Water Management Convention allows nations to grant exemptions from certain ballast water management requirements to ships travelling or exclusively operating between specified ports. Exemptions are based on robust risk assessments that indicate associated ballast water activities have low or no risk of introducing harmful aquatic organisms to the recipient port.
- Two risk assessment methods — i) Joint Harmonized Procedure and ii) Same Risk Area — previously considered by the IMO to grant exemptions from specific ballast water management requirements in Europe were evaluated to determine their suitability within Transport Canada's regime for assessing exemption applications.
- Both the Joint Harmonized Procedure and Same Risk Area are suitable methods for use in Canadian ballast water management exemption applications, provided that the assessments are conducted following the modifications and minimum requirements recommended here to address the uncertainties of each method.
- Suitability of each risk assessment method depends on the context of the exemption request, including the spatial distribution and number of ports under consideration for an exemption, ship operational profile, and availability of robust biophysical models to estimate the unassisted dispersal of planktonic organisms.
- The original Joint Harmonized Procedure uses port survey data and a decision tree to assess risk based on differences in salinity between ports and the presence of species of concern at the source port that are not at the recipient port.
- Recommended modifications and additions to the Joint Harmonized Procedure include changes to the method of selecting species of concern, nodes in the decision tree assessing potential survival of species of concern in the recipient port, and minimum requirements for the environmental data informing the assessment.
- For the Joint Harmonized Procedure, it is recommended to use a stepwise approach that initially involves a comprehensive literature review prior to conducting detailed port surveys.
- The original Same Risk Area approach evaluates whether species of concern are likely to disperse unassisted via water circulation to recipient ports, regardless of their transport in ballast water.
- Recommended modifications to the Same Risk Area approach include setting the biological inputs of the model based on species of concern identified in the source port or region (when available), otherwise a general trait-based modelling approach should be used to represent a variety of nonindigenous species. Best practices must be used when conducting biophysical modelling to ensure the results are of sufficient quality to inform the exemption decision-making process.
- It is recommended that proponents be invited to submit a notice of intent before conducting port surveys (Joint Harmonized Procedure) or port connectivity modelling (Same Risk Area assessment) and that regional Fisheries and Oceans Canada experts be engaged for input on the methodology that will be used before significant effort is expended.
- After the risk assessment is completed, an independent peer review should be undertaken through a transparent process — such as the Canadian Science Advisory Secretariat science advisory process — to ensure that the risk assessment has been conducted in a thorough and objective manner.

- Regulation A-4 may not be best suited for one-time exemption requests, where ballast water exchange, ballast water treatment, or discharge to shore are alternative approaches to manage ballast water. These alternative approaches may also be used to manage the ballast water of ships that need to temporarily deviate from the exempted route.

BACKGROUND

Ballast water is one of the primary vectors for the introduction of harmful aquatic species globally (Bailey et al. 2020). To mitigate the introduction and establishment of harmful species attributed to ballast water, the International Maritime Organization's (IMO) *International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004* (the Convention) establishes ballast water management standards and procedures for the international shipping industry (IMO 2004). As the Convention entered into force in 2017, parties are expected to transition from ballast water exchange requirements under Regulation D-1 — where ballast water is purged at sea and replaced with offshore ocean water — to the ballast water performance standard defined in Regulation D-2 (IMO 2004). The intent of Regulation D-2 is to mitigate the establishment of harmful species by setting limits on the concentration of viable organisms in discharged ballast water, for which most ships are expected to comply by utilizing onboard ballast water management systems to treat their ballast water.

Regulation A-4 of the Convention states that a nation may grant exemptions from specific ballast water management requirements in waters under its jurisdiction when the following criteria are met:

1. Ships on a voyage or voyages between specified ports/locations or ships that operate exclusively between specified ports/locations;
2. Ships do not mix ballast water or sediment other than between such specified ports;
3. Exemptions are effective for no more than a five-year period; and,
4. Exemptions are granted based on the IMO's *Guidelines for Risk Assessment under Regulation A-4 of the BWM Convention (G7)* (IMO 2004).

The G7 Guidelines state that a nation may grant exemptions under Regulation A-4 if a risk assessment indicates that unmanaged ballast water transferred between ports is unlikely to impair or damage the environment, human health, property, or resources of the granting nation or other nations (IMO 2017a). These risk assessments must be scientifically defensible, distinguishing between ballast water transfers that are likely to have negative impacts to nations, and transfers that are unlikely to have negative impacts (IMO 2017a). To date, two risk assessment methods — i) Joint Harmonized Procedure and ii) Same Risk Area — have been presented for consideration within the IMO community for granting exemptions under Regulation A-4 (IMO 2014; 2016a,b).

Canada, a signatory to the Convention, is currently undertaking regulatory updates to implement ballast water management requirements as per the Convention in Canadian waters. Canada's proposed ballast water regulations were published in the Canada Gazette in June 2019, including provisions for ballast water management exemptions under Regulation A-4 (Canada Gazette 2019). At the request of Transport Canada, Fisheries and Oceans Canada (DFO) conducted an evaluation of the two existing risk assessment methods by conducting a literature review and applying the methods to case studies in Canada. Based on this evaluation, DFO has developed recommendations on ecological risk assessment methods that can be used to support future exemption applications in Canada.

Background on the Joint Harmonized Procedure

The Joint Harmonized Procedure was developed by the Helsinki Commission (HELCOM) and the Oslo and Paris (OSPAR) Commission to help guide their contracting European nations with granting ballast water management exemptions under Regulation A-4. This risk assessment method was developed through input from multiple scientific experts (e.g., Gollasch et al. 2011, David et al. 2013) and follows the IMO's G7 Guidelines.

The Joint Harmonized Procedure uses a two-step approach to assess the risk of transferring species of concern (hereafter known as target species) from a source port to a recipient port in ballast water. See HELCOM and OSPAR (2020) for details on the Joint Harmonized Procedure.

The first step provides an initial indication of high or low risk based on port surveys to detect target species at the source and recipient ports, and an assessment of their potential introduction (via ballast water) and survival at the recipient port using a simple decision tree. Biological surveys are conducted for both source and recipient ports following a detailed port survey protocol to create robust species lists for each surveyed port (see Annex 6 in HELCOM and OSPAR 2020 for details). Ports are surveyed every five years, in alignment with the five-year renewal requirement for exemptions under Regulation A-4 (IMO 2004).

The second step includes conducting a detailed risk assessment to evaluate additional relevant factors that influence invasion risk on a case by case basis, such as the presence of target species in areas adjacent to the source port or the natural dispersal capacity of target species. For example, a high-risk outcome from the decision tree could be overruled if the target species are likely to naturally disperse (unassisted) from the source to recipient port. The method used to conduct the final detailed risk assessment is at the discretion of the governing nation.

Background on the Same Risk Area approach

The Same Risk Area approach was initially proposed by the Danish government in 2014 (Stuer-Lauridsen and Overgaard 2014) and was further developed with contributions from Belgium and Singapore (IMO 2016a,b; IMO 2017b). A Same Risk Area is a highly connected area where target species are likely to disperse naturally and establish populations throughout the area, regardless of their spread via ballast water. Thus, a Same Risk Area is a geographic area where ships may be exempted from managing their ballast water due to the high natural connectivity within the area.

The delineation of the Same Risk Area is determined using a biophysical model that simulates the natural dispersal of planktonic individuals (at any stage of development) via currents and circulation. The dispersal of individuals can be examined for each target species (species-specific approach), functional groups of target species, or general character traits that are applicable to a variety of nonindigenous species (trait-based approach). The boundaries of a Same Risk Area should be based on the target species, functional group, or trait combination having the lowest unassisted dispersal, following a precautionary approach (IMO 2016b; Stuer-Lauridsen et al. 2018).

An important factor to consider is the number of consecutive generations or years of stepping-stone dispersal to be modelled, as this influences the estimated spread of species and, in turn, the boundaries of the Same Risk Area (IMO 2016b). Evaluating the natural dispersal of species over a long period of time may reduce the importance of ballast water as an introduction vector, whereas using too short of a time period may overemphasize the importance of ballast water (IMO 2016c). There is higher uncertainty associated with modelling stepping-stone dispersal of species, due to model assumptions required to estimate the establishment success

of larvae after settlement (Hansen and Christensen 2018). Previous studies on Same Risk Area have modelled either one or five years of dispersal (Baetens et al. 2018; Hansen and Christensen 2018).

ASSESSMENT

Joint Harmonized Procedure case study and review

The Joint Harmonized Procedure method was used to assess risk of ballast water transported from Boston, MA, USA, to Saint John, NB, Canada, based on seven target species (*Agarophyton vermiculophyllum*, *Ascidiella aspersa*, *Carcinus maenas*, *Grateloupia turuturu*, *Hemigrapsus sanguineus*, *Membranipora membranacea*, and *Mytilopsis leucophaeata*). The outcome of the decision tree was high risk due to the overlap in salinity between Boston (26 – 33‰; Shiaris 1989) and Saint John (0.14 – 36‰; ACAP 2020), and the presence of target species at the source port (Boston), which were presumed absent at the recipient port (Saint John).

One outcome of the review of this case study was the recognition that creating and maintaining regional target species lists would not be feasible across the numerous biogeographic regions within Canada. Therefore, it will be necessary to select target species for assessment on a port by port basis using well-defined criteria. For example, the criteria should clearly define the requirements/assumptions used to determine the likelihood of introduction to a recipient port via ballast water transport and likelihood of impact once introduced.

Evaluating probability of establishment and severity of impact with high certainty requires considerable research effort; therefore, DFO's species-specific risk assessments should be used to assess potential target species, when available. Otherwise, relevant information (e.g., vectors of introduction, physiological tolerances, impacts) for potential target species should be obtained from extensive review of scientific literature and online databases.

Although the Joint Harmonized Procedure decision tree may adequately assess the risk of ballast water transfers in semi-enclosed seas (e.g., Baltic and North Seas) where it was developed, it may not be suitable to assess the risk of transferring ballast water longer distances where water temperature could be a limiting factor in the survival of target species. Furthermore, the Joint Harmonized Procedure decision tree does not account for potential survival of euryhaline species in a recipient port. Therefore, for use in Canada, an additional node should be added to the decision tree that compares the physiological tolerances of species against the range of environmental conditions (water temperature and salinity) at the recipient port.

In addition, environmental data used in the decision tree assessment should be comprehensive enough to adequately capture spatial, daily, and seasonal variability in temperature and salinity at coastal ports (e.g., effects of tidal cycle, spring freshets). Therefore, the environmental data should, at minimum, include monthly temperature and salinity measurements from surface and bottom depths.

Same Risk Area case study and review

The Same Risk Area method was applied to the Boston-Saint John port pair, but no individuals reached Saint John via water circulation. The model results support the high-risk outcome of the decision tree from the Joint Harmonized Procedure, as individuals would not be expected to disperse unassisted from Boston to Saint John within a single generation for the trait combinations examined.

The Same Risk Area method was also applied using a trait-based approach to a shipping route along Québec's shoreline in the Estuary and Gulf of St. Lawrence, including the ports of Rimouski, Sept-Îles, Port-Menier, Havre-Saint-Pierre, Natashquan, Kegaska, La Romaine, Harrington Harbour, Tête-à-la-Baleine, La Tabatière, Saint-Augustin, and Blanc-Sablon. Connectivity varied between these 12 ports, with some port pairs having higher connectivity for some trait combinations, though most port pairs had low connectivity. The overall connectivity across the study area was relatively low, considering all combinations of ports and life history traits.

Although species dispersal modelling is a well-established field of research, a detailed, standardized protocol does not currently exist for the Same Risk Area assessment. Selection of an appropriate biophysical model to be used in a given exemption application is likely to be case-specific, depending on the type of assessment being conducted (i.e., species-specific vs. trait-based), geographic scale (e.g., spatial resolution of the model), and the biological traits and environmental factors influencing the dispersal of organisms within the region (Stuer-Lauridsen et al. 2018).

For example, depth preference can have a substantial effect on organism dispersal. Plankton that remain in the mixed upper layer disperse longer distances since this layer typically has higher velocities than layers below the thermocline (Brennan et al. 2019). Future exemption applications using Same Risk Area modelling should consider using the depth preference that is representative of the planktonic stage of target species within the region.

There should be high natural connectivity between ports within a Same Risk Area. In general, highly connected ports would have a large number of individuals, across the target species or trait combinations examined, reaching the recipient port from the source port. It is relatively straightforward to identify ports that have either very high natural connectivity or no connectivity. However, medium and low port connectivity thresholds are not well-defined, making it difficult in certain circumstances to evaluate port connectivity relative to the likelihood of spreading harmful species to the recipient port via ballast water. When multiple ports are assessed, the delineation of the Same Risk Area should be based on the ports with the lowest connectivity as a precautionary measure.

Sources of Uncertainty

- Propagule pressure is a major determinant of the likelihood of species establishment (Colautti et al. 2006; Bailey et al. 2009) but is not considered in the HELCOM and OSPAR Joint Harmonized Procedure.
- There may be high uncertainty in the application of the Same Risk Area method due to limited scientific understanding of the relationship between propagule pressure and establishment (i.e., risk-release relationship), and the stochastic nature of small founder populations (NRC 2011).
- Any model is a simplification of complex processes and will have limitations (uncertainties) in the representation of biological factors that influence the dispersal of organisms (e.g., resolving larval mortality).
- Biophysical models may underestimate the true natural connectivity between ports, since the number of individuals seeded in simulations is typically orders of magnitude less than the true larval release reflective of a species' fecundity.

CONCLUSIONS AND ADVICE

Strengths and weaknesses of each risk assessment method

The strengths and weaknesses identified for the Joint Harmonized Procedure and Same Risk Area methods are listed in Tables 1 and 2, respectively.

Table 1. Strengths and weaknesses of the Joint Harmonized Procedure.

Strengths	Weaknesses
• The procedure is adaptable to address specific invasion risks by modifying the decision tree (based on best available science). • The assessment can be conducted as an initial screening using available species distribution data to identify high-risk routes without conducting port surveys. • The port survey protocol provides a detailed, systematic method to comprehensively sample organisms in ports. • The procedure considers a variety of taxonomic groups that may be dispersed by ballast water. • High or low risk determination using the decision tree is straightforward and easy to interpret. • Data gaps and uncertainties are addressed using precautionary principles.	• Port surveys require considerable effort and resources to comprehensively sample taxa across space (different habitats) and time (seasons). • Accurate/reliable species identification may be limited by available taxonomic expertise and molecular reference libraries. • Target species may not be detected by port surveys (i.e. false negatives may occur) or may be detected after an exemption has been granted. • Criteria to define target species can be subjective. • There can be high uncertainty when extrapolating species information from other regions, such as potential for harmful impacts.

Table 2. Strengths and weaknesses of the Same Risk Area approach.

Strengths	Weaknesses
• Dispersal modelling is a well-established field of research and comprehensive models may already exist to assess circulation and dispersal of plankton. • The method is flexible to examine dispersal of specific species, functional groups, or general traits. • The trait-based assessment does not require detailed species distribution data (no port surveys), while a species-specific assessment can be conducted when species distribution data is available.	• A detailed, standardized protocol does not currently exist for the Same Risk Area approach, and the modelling methods may need to be adjusted depending on the context of each exemption request. • Thresholds for high and low connectivity of ports are not well-defined. • The outcome of the assessment is sensitive to the assumptions and parameters used in the biophysical model.

Circumstances under which the risk assessment may not adequately assess the risk of ballast water

The HELCOM and OSPAR Joint Harmonized Procedure's decision tree may not adequately consider the survival of euryhaline species that can tolerate a wide range of salinities, nor the risk of long-distance shipping routes where temperature differences between ports could be a limiting factor in the survival of species. In addition, results may be misleading if environmental data supporting the assessment do not capture temporal and spatial variation in salinity that may occur at coastal ports (e.g., tidal cycle, spring freshets).

Method(s) of risk assessment recommended for use in ballast water management exemption applications within Transport Canada's regime for accepting and assessing exemption applications

The modifications and minimum requirements summarized in the following paragraphs are recommended to adapt the Joint Harmonized Procedure and Same Risk Area methods for use in Canada. The choice of method depends on the context of the exemption request, including the spatial distribution and number of ports, and availability of a comprehensive biophysical model to conduct the Same Risk Area assessment. For example, the adapted Joint Harmonized Procedure is best suited for long-distance trips or shipping routes that cross a barrier to natural dispersal. The Same Risk Area approach could be used when assessing source and recipient ports that are relatively close together or remote ports that would be difficult to physically survey.

Adapted Joint Harmonized Procedure recommended for use in exemption applications in Canada

The adapted Joint Harmonized Procedure should be applied as a staged approach; see Appendix 1 for details on each step and Appendix 2 for the information to be included in each exemption application. An initial pre-screening literature-based assessment is to be conducted before initiating comprehensive port surveys to determine if a Joint Harmonized Procedure-based exemption is likely to be granted based on existing species distribution data. This literature-based assessment should include data on species present in areas adjacent to the source port, since existing data may not be comprehensive within port locations and nearby species may spread (via any vector or pathway) to the source port during the exemption period. Port surveys must be conducted even if the outcome of the literature-based assessment is lower risk. The port survey-based assessment may contradict the outcome of the literature-based assessment depending on the species detected in the ports.

The method of selecting target species was changed for use on a port by port basis. In the adapted Joint Harmonized Procedure, species that meet both criteria are selected as target species:

1. Any indigenous, nonindigenous, or cryptogenic species previously detected in ballast water and/or ballast sediment or has a life stage that is likely to be transported by ballast water (planktonic life stage or sessile life stage associated with floating/ballast-able material — see Bailey et al. 2020); and,
2. Species that have a history of measurable negative impact to human health (e.g., toxin-producing), environment (e.g., impacts to ecosystem structure or function), property, or resources (e.g., fisheries, control costs) in any global location.

The decision tree was adapted to evaluate the survival of each target species in the recipient port (Appendix 3). The node comparing the salinity difference between the source and recipient

ports was removed from the decision tree, and a new node was included to determine whether the target species can tolerate the water temperature and salinity at the recipient port. Careful consideration must be given to the assessment of euryhaline species, physiological tolerances of various life stages (e.g., resting stages), and estuarine ports with temporal and spatial variation in salinity. Monthly temperature and salinity measurements from surface and bottom depths should be used in the decision tree evaluation to ensure that the full range of environmental conditions at the recipient port are being considered in the assessment.

As an optional step of the adapted Joint Harmonized Procedure, a Same Risk Area assessment can be conducted on each target species with higher risk following a port survey-based assessment. The higher risk outcome from the decision tree could be overruled if those target species are likely to disperse unassisted from the source to recipient port, regardless of their transport in ballast water.

Same Risk Area approach recommended for use in exemption applications in Canada

The Canadian Same Risk Area approach should be conducted following the steps provided in Appendix 4. See Appendix 5 for the information to be included in each Canadian Same Risk Area-based exemption application.

Biological traits used in the biophysical model should be informed by target species at the source port(s) and surrounding areas based on an extensive review of scientific literature and databases. The search for target species can be expanded to the biogeographic region of the ports to obtain a sufficient number of target species to comprehensively assess port connectivity. A general trait-based modelling approach can be used if there are insufficient biological data to inform model inputs based on regional target species.

Each target species identified at the source port must be assessed to determine whether their planktonic stage can tolerate the temperature and salinity of the waters between ports. The spatial distribution of target species can indicate their potential survival in coastal waters (e.g., species restricted to estuaries or the head of bays) if their tolerances are unknown. The Same Risk Area assessment should be abandoned if the individuals of one or more target species are unlikely to survive in the waters between ports, since the spread of these species is unlikely to be achieved by unassisted dispersal.

The recommended port connectivity metric is the cumulative number of individuals that travel from the source port and settle in the recipient port. Ports should be highly connected in the same direction as ballast water transfers. Highly connected areas would typically have a substantial number of individuals dispersing from the source port to recipient port across the target species or functional groups examined. Specific connectivity thresholds (high vs. low) have not been identified here due to limited scientific understanding of the risk-release relationship. Finally, the Same Risk Area assessment should be based on a single year of dispersal of planktonic individuals, due to high uncertainty in the application of stepping-stone dispersal modelling (e.g., uncertainties in assessing intergenerational survivorship and spawning success).

OTHER CONSIDERATIONS

It is recommended that proponents be invited to submit a notice of intent before conducting port surveys or a Same Risk Area assessment, and that regional DFO experts be engaged for input on the methodology being used in the assessment.

Once the risk assessment is completed, an independent peer review should be undertaken by scientific experts through a transparent process, such as the Canadian Science Advisory

Secretariat (CSAS) science advisory process. The independent peer review should confirm that the risk assessment has been conducted in a thorough and objective manner by evaluating the data used in the assessment, the selection of target species, the application of the decision tree, and the model used for Same Risk Area assessment.

If an exemption is granted, it is recommended to re-evaluate the grounds for the exemption if a new target species is identified at the source port during the five-year exemption period. In such a case, it is recommended to withdraw the exemption if the re-evaluation concludes that the ballast water operations of the ship(s) operating under the exemption is likely to have negative impacts to Canada or other nations.

Previous science advice from DFO indicates that the movement of ballast water by domestic and international shipping is a leading mechanism for the introduction and spread of harmful species in Canadian waters (DFO 2019; DFO 2020). Therefore, it is expected that few exemption assessments are likely to result in a low probability of introducing harmful species to the recipient port by ballast water. It is recommended to limit the granting of exemptions to ships operating exclusively between specified ports for the duration of the exemption period.

Regulation A-4 may not be best suited for one-time exemption requests, where ballast water exchange, ballast water treatment, or discharge to shore are alternative approaches to manage ballast water. These alternative approaches may also be used to manage the ballast water of ships that need to temporarily deviate from the exempted route.

Overall, conducting a risk assessment to sufficiently demonstrate a low probability of introducing harmful species from a source to recipient port by ballast water transfers requires in-depth analysis and considerable scientific effort, with potentially limited reward. It may be more productive to install and operate a ballast water management system than apply for a five-year exemption that could be withdrawn if a harmful species establishes at the source port during the exemption period.

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SOURCES OF INFORMATION

This Science Advisory Report is from the February 23–25, 2021 National Advisory Meeting on the Evaluation of Existing Risk Assessment Methods for Granting Ballast Water Management Exemptions. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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APPENDICES

Appendix 1. Steps of the adapted Joint Harmonized Procedure recommended for use in exemption applications in Canada.

Steps	Description
1. Context of the request	• Assemble information about the ship(s) and route(s) under consideration for exemption.
2. Pre-screening literature-based assessment	• Assemble species lists (nonindigenous, indigenous, and cryptogenic) for the ballast water source port(s) (and adjacent areas) and recipient port(s) based on existing scientific literature and databases. • Assess each species from source port(s) as target species using the adapted target species criteria.[(a)] ○ Seek alternate ballast water management measures (abandon exemption request) if there is an ongoing control or eradication program for any target species at the recipient port. • Assess risk of all target species for each source-recipient port pair, using adapted decision tree (Appendix 3). • If the outcome of the decision tree is lower risk for all target species, proceed to step 3. • If the outcome of the decision tree is higher risk for any target species, abandon the adapted Joint Harmonized Procedure; either conduct a stand-alone Same Risk Area assessment (all steps in Appendix 4) or seek alternate ballast water management measures (abandon exemption request).
3. Port survey-based assessment	• Submit notice of intent to proceed with the port survey-based assessment to engage regional DFO experts. The notice should include information on the context of the request, the results of the pre-screening literature-based assessment, and a detailed description of the planned port survey protocol (see Appendix 2). • Conduct port surveys in source and recipient ports following the Joint Harmonized Procedure port survey protocol (Annex 6 in HELCOM and OSPAR 2020). ○ Both morphological and molecular techniques can be used to identify organisms, provided that organisms are accurately identified to the species level. • Use the port survey data to assemble a species list for each port. • Assess species from each source port as target species using the adapted target species criteria.[(a)] • Assess risk of all target species for each source-recipient port pair, using adapted decision tree (Appendix 3). • If the outcome of the decision tree is lower risk for all target species, proceed to step 5. • If the outcome of the decision tree is higher risk for any target species, proceed to step 4 or seek alternate ballast water management measures (abandon exemption request and withdraw notice of intent).
4. Same Risk Area assessment	• A Same Risk Area assessment is conducted following the steps in Appendix 4, starting at part 2 of the pre-screening literature-based assessment (step 3 in Appendix 4). ○ This Same Risk Area assessment is an optional step of the adapted Joint Harmonized Procedure and can only be conducted if a port survey-based assessment was completed.

Steps	Description
	○ The Same Risk Area assessment is conducted on each target species from the port survey-based assessment that resulted in higher risk.
5. Independent peer review	• Submit the completed risk assessment using the checklist of required information (Appendix 2) for independent peer review to ensure the assessment has been conducted in a thorough and objective manner (e.g., CSAS science advisory process).

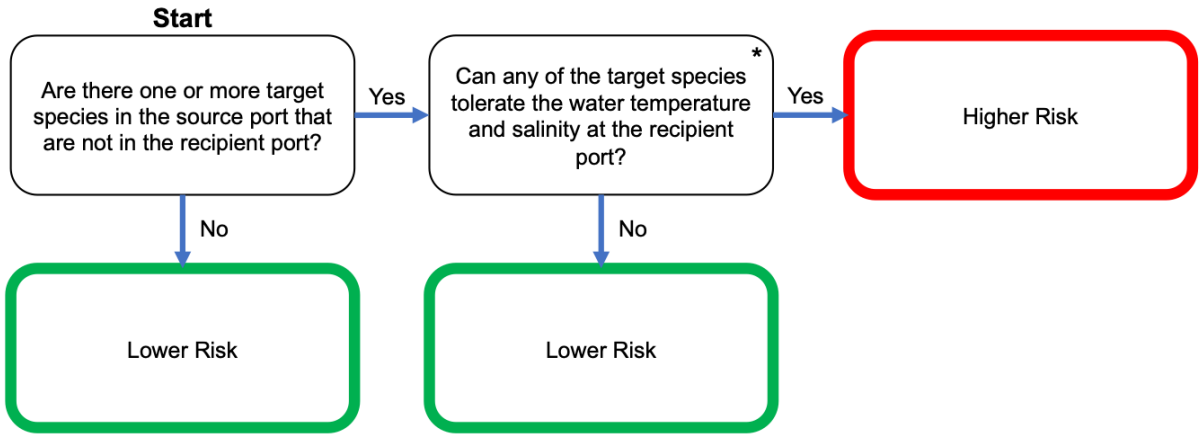
[(a)] Species that meet both criteria are selected as target species:

1. Any indigenous, nonindigenous, or cryptogenic species previously associated with transport in ballast water and/or ballast sediment or has a life stage that is likely to be transported by ballast water (planktonic life stage or sessile life stage associated with floating/ballast-able material); and,
2. Species that have a history of measurable negative impact to human health (e.g., toxin producing), environment (e.g., impacts to ecosystem structure or function), property, or resources (e.g., fisheries, control costs) in any global location.

Appendix 2. Checklist for the adapted Joint Harmonized Procedure. The following information is to be provided in an application for exemption under Regulation A-4 to support the evaluation of introduction risk by ballast water.

Section	Description of Required Information
Context of request	• Information about the ship(s) and route(s) under consideration for exemption, including the vessel type(s), a list of specified ports (latitude and longitude), berth(s) visited at each port, time period of requested exemption, ballast discharge volume(s) and frequency at each location, and directionality of ballast transfers (source and recipient ports).
Pre-screening literature-based assessment	• Full list of species reported from the source port(s), including status as indigenous, nonindigenous, or cryptogenic • Full list of species reported from the recipient port(s), including status as indigenous, nonindigenous, or cryptogenic • List of species classified as target species with supporting rationale justifying selection of target species, salinity tolerance, and temperature tolerance • Monthly water temperature and salinity at each port with supporting rationale • Results of pre-screening assessment using the adapted decision tree • List of references and databases consulted
Port surveys	• Information about general characteristics, such as typical variation of environmental conditions and patterns of port traffic, for each port sampled in accordance with Appendix 3 of Annex 6 in HELCOM and OSPAR (2020) • Description of the port survey protocol followed, including information on the number of sampling sites per port and their selection; timing of sampling; physical and biological factors; taxonomic groups sampled, sampling methods and equipment; sample processing and analysis methods • Quality assurance plan for data collection and analysis, including methods for taxonomic identification and qualifications of taxonomists • Species accumulation curve(s) indicating comprehensiveness of port surveys • Justification for any deviation of the survey protocol from that outlined in Annex 6 from HELCOM and OSPAR (2020)
Port survey-based assessment	• Full list of species sampled from the source port(s), including status as indigenous, nonindigenous, or cryptogenic • Full list of species sampled from the recipient port(s), including status as indigenous, nonindigenous, or cryptogenic • List of species classified as target species with supporting rationale justifying selection of target species, salinity tolerance, and temperature tolerance • Range of water temperature and salinity at each port with supporting rationale • Results of survey-based assessment using the adapted decision tree • List of references and databases consulted

Appendix 3. Adapted decision tree for the Canadian application of the Joint Harmonized Procedure.



*** Additional considerations:**

- Environmental data used in the decision tree must include monthly temperature and salinity measurements from surface and bottom depths;
- Temperature and salinity data can be obtained from databases;
- Careful consideration must be given to the assessment of euryhaline species, physiological tolerances of various life stages (e.g., resting stages), and estuarine ports with temporal and spatial variation in salinity;
- Tolerances of target species should be extrapolated from similar environments to the recipient port (when available);
- Assume that target species can tolerate the temperature or salinity at the recipient port if the physiological tolerance of the species is unknown.

Appendix 4. Steps for the Same Risk Area approach recommended for use in exemption applications in Canada.

Steps	Description
1. Context of the request	• Assemble information about the ship(s) and routes(s) under consideration for exemption.
2. Pre-screening literature-based assessment (part 1)	• Assemble species lists (nonindigenous, indigenous, and cryptogenic) for the ballast water source port(s) (and adjacent areas) and recipient port(s) based on existing scientific literature and databases. • Select species that are present at the source port, but not at one or more recipient ports; exclude the remaining species from the assessment. • Assess those species as target species using the adapted target species criteria.[(a)] • Select target species that can tolerate the water temperature and salinity at the recipient port(s); exclude the remaining species from the assessment.
3. Pre-screening literature-based assessment (part 2)	• Assess whether each target species has a planktonic stage, since the Same Risk Area assessment can only be conducted on species that disperse via water circulation. o If any target species do not disperse via water circulation, conduct the Joint Harmonized Procedure (Appendix 1) or seek alternate ballast water management measures (abandon exemption request). • Assess whether each target species' planktonic stage can tolerate the environmental conditions (temperature and salinity) of the waters between the source and recipient ports.[(b)] o If any target species are incapable of tolerating the waters between ports, conduct the Joint Harmonized Procedure (Appendix 1) or seek alternate ballast water management measures (abandon exemption request).
4. Port connectivity model	• Submit notice of intent to proceed with port connectivity model assessment to engage regional DFO experts. The notice should include information on the context of the request, target species selection and planned methods for the port connectivity modelling (see Appendix 5). • Assemble relevant information on the selected target species to inform the biophysical model, including but not limited to [(c,d)]: o Population density; o Reproduction period, spawning periodicity (e.g., diel, tidal timing), and fecundity (per individual or population); o Swimming behaviour of planktonic stage (vertical migratory behaviour and environmental response cues); o Swimming velocity (vertical and horizontal); o Vertical distribution of planktonic stage (e.g., constrained to surface mixed layer); o Settlement depth range of meroplankton (intertidal or 0 – 15m); o Duration of planktonic stage; and, o Physiological tolerances (temperature and salinity). • Estimate the dispersal of individuals of each target species or functional groups of target species using a validated biophysical model (see Appendix 5 for minimum requirements).

Steps	Description
	○ Measure port connectivity by recording the cumulative number of individuals that travel from the source port and settle in the recipient port for each functional group or target species.
5. Port connectivity results	• Provide a detailed analysis of the model results justifying the boundaries of the proposed Same Risk Area. ○ There must be high connectivity in the direction of ballast water transfers for each target species or functional group examined.
6. Independent peer review	• Submit the completed risk assessment using the checklist of required information (Appendix 5) for independent peer review to ensure the assessment has been conducted in a thorough and objective manner (e.g., CSAS science advisory process). ○ The completed risk assessment should also include the required information from the checklist in Appendix 2, if a Joint Harmonized Procedure assessment was conducted.

[(a)] Species that meet both criteria are selected as target species:

1. Any indigenous, nonindigenous, or cryptogenic species previously associated with transport in ballast water and/or ballast sediment or has a life stage that is likely to be transported by ballast water (planktonic life stage or sessile life stage associated with floating/ballast-able material); and,
2. Species that have a history of measurable negative impact to human health (e.g., toxin producing), environment (e.g., impacts to ecosystem structure or function), property, or resources (e.g., fisheries, control costs) in any global location.

[(b)] The spatial distribution of target species can indicate their potential survival in coastal waters (e.g., species restricted to estuaries or the head of bays) if their tolerances are unknown.

[(c)] The biological traits of some target species may be unknown and may have to be inferred from related or similar species.

[(d)] Expand the search for target species to cover the biogeographic region of the ports if an insufficient number of target species were identified to comprehensively assess port connectivity; otherwise, a general trait-based modelling approach can be used to conduct the Same Risk Area assessment.

Appendix 5. Checklist for the Same Risk Area approach recommended for use in exemption applications in Canada. The following information is to be provided in an application for exemption under Regulation A-4 to support the evaluation of introduction risk by ballast water.

Section	Description of Required Information
Context of Request	• Information about the ship(s) and routes(s) under consideration for exemption, including the vessel type(s), a list of specified ports (latitude and longitude), berth(s) visited at each port, time period of requested exemption, ballast discharge volume(s) and frequency at each location, and directionality of ballast transfers (source and recipient ports)
Pre-screening literature-based assessment	• Full list of species reported from the source port(s), including status as indigenous, nonindigenous, or cryptogenic • Full list of species reported from the recipient port(s), including status as indigenous, nonindigenous, or cryptogenic • List of species classified as target species with supporting rationale justifying selection of target species, salinity tolerance, temperature tolerance, planktonic stage, and population distribution (if salinity tolerance unknown) • Monthly water temperature and salinity at each port with description of temporal and spatial coverage and data source(s) • Monthly temperature and salinity of the waters between the ports with description of temporal and spatial coverage and data source(s) • List of references and databases consulted

Port connectivity model	• Detailed information about the model used, parameter values, species' traits assessed, number of years modelled, etc.
	• Details on model validation, including:
	  ○ Lagrangian trajectories validated with drifters
	  ○ Validated tidal current amplitudes and phases
	  ○ Validated seasonal / monthly horizontal and vertical velocity fields
	  ○ Validated seasonal / monthly horizontal and vertical temperature, salinity, and density fields (if biological traits are dependent on the model's variables)
	  ○ Validated freshwater input
	• At least two years of hydrologic data used in the assessment (one normal year and one extreme year)
	• Description of, and rationale for, assumptions and parameters used in the assessment
	• Justification for any deviation from the recommended method of conducting the assessment following initial consultation with DFO regional experts
	• List of references and databases consulted for the model (to check and assess model validation) and biological traits

Port connectivity results	• Port connectivity results for each port pair and target species or functional group assessed • Detailed analysis of the model results justifying the boundaries of the proposed Same Risk Area

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