UK Overseas Territories Marine Biosecurity Toolkit: Marine Invasive Species Risk Mitigation Measures and Management Strategies

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1. Introduction

This document is the result of a review of existing literature on potential risk mitigation measures and management strategies for reducing the impact and presence of marine invasive non-native species that are the focus of the UKOT's Marine Biosecurity Toolkit species ID guides (documents D). Appendix A outlines a generic framework for the entry level risk assessment of invasive non-native species through maritime routes. Within the risk assessment framework consideration is given to the role of risk mitigation and management including communication of the risks.

This document provides a synopsis of information available on the potential risk mitigation measures and management strategies shown to have some or limited success around the world. The intended use of this document is to help inform decision making (through the steps of the proposed framework in Appendix A). It should be noted that the approaches detailed may not always be appropriate or successful for implementation within the UKOTs and that there are gaps for several species.

In reality, it may not be possible to remove a species entirely once present and successful removal may depend on how well established the species may have become since first introduction or sighting. Information is presented first for species with limited information, followed by those with no known mitigation measures, finally information is provided on those species with proposed management. Table 1 below provides a quick reference summary of the management strategies for each of the priority species. Very little information exists on truly successful mitigation measures that can be applied once a species has been identified in a country's waters.

For those species with limited information available, the main pathway for introduction (entry) of these species is via hull fouling and ballast water. Due to the similarities with some of the other high-risk species with information on potential risk mitigation measures, it could be inferred that measures such as mid-ocean ballast water exchange, cleaning of vessel water systems, application of antifouling paint and cleaning of boat hulls may help reduce the introduction of these species and hence their spread. This supports the need to adequately assess the invasive entry-level risk potential for each species and adopt entry-level risk assessments, as plausible mitigation options are limited and none entirely effective. OT Governments may have limited control with regards to these issues until a vessel arrives in their waters and can be assessed. The hull fouling guidance (document A) and ballast water guidance (document B) provided within this toolkit should support rapid risk assessments to identify potential high-risk vessels.

Table 1: Summary of management strategies for the twenty-five priority marine invasive non-native species for the UK Oversea Territories

Species	Strategy
Halophila Seagrass (*Halophila stipulacea*)	• Production of a salinity barrier.
Green Sea Fingers (*Codium fragile subsp. fragile*)	• Quarantine measures. • Raising public awareness.
Asian Kelp (*Undaria pinnatifida*)	• Manually remove the sporophytes from the stipe on a monthly basis. • Exposure to air (and UV light) or high pressure, heated water (60°C for 5 seconds).
Red Algae (*Antithamnionella spirographidis*)	• Regular use of antifouling paint. • Physical removal of the algae from imported shellfish. • Heat treatment and immersion in saturated brine (not suitable to use toxic substances on shellfish produced for human consumption).

Harpoon Weed (*Asparagopsis armata*)	• No known mitigation measures.
Ruby Bryozoan (*Bugula neritina*)	• Regular use of antifouling paint. • Ballast water exchange.
Orange Cup Coral (*Tubastraea coccinea*)	• Physical removal from reefs.
Pacific Oyster (*Magallana gigas*)	• Physical removal by hand or using dredges.
Dwarf Mussel (*Semimytilus algosus*)	• In-water hull cleaning found to be effective. (See footnote [1]).
Ribbed Mussel (*Aulacomya atra*)	• Not possible to source information on potential mitigation measures. (See section 2 for details).
Asian Green Mussel (*Perna viridis*)	• Anti-fouling paints, cleaning of submerged fittings, ballast water management and inspection of boats coming from areas of risk.
Chilean Mussel (*Mytilus chilensis*)	• Not possible to source information on potential mitigation measures. (See section 2 for details)
Mediterranean Mussel (*Mytilus galloprovincialis*)	• Ballast water exchange. (See footnote [2]).
Blue Mussel (*Mytilus edulis*)	• Not possible to source information on potential mitigation measures. (See section 2 for details).
Pacific Acorn Barnacle (*Balanus glandula*)	• Not possible to source information on potential mitigation measures. (See section 2 for details).
Striped Barnacle (*Amphibalanus amphitrite*)	• Non-specific control methods: anti-fouling, ship maintenance, in-water inspection, cleaning and maintenance of ships.
Reticulated Barnacle (*Amphibalanus reticulatus*)	• Anti-fouling paints and ballast water exchange. (See footnote [1] & [2]).
Decapod (*Halicarcinus planatus*)	• Vessel hull cleaning and ballast water exchange. (See footnote [1] & [2]).
Blue Crab (*Callinectes sapidus*)	• No known mitigation measures.
European Shore Crab (*Carcinus maenas*)	• Raise public awareness, erection of physical barriers and manual removal.
Ascidian (*Microcosmus squamiger*)	• Physical removal not possible, introduction of native gastropods as predators is effective.
Star Ascidian (*Botryllus schlosseri*)	• Not possible to source information on potential mitigation measures. (See section 2 for details).
European Sea Squirt (*Ascidiella aspersa*)	• No known mitigation measures.
Sea Vase (*Ciona intestinalis*)	• Vessel hull cleaning, rotation and air-drying of submerged equipment. (See footnote [2]).
Lionfish (*Pterois miles*)	• Education, collaboration and physical removal can reduce the spread.

[1] Please refer to Document A: Hull Fouling Guidance for further information. On no account should a vessel of risk be allowed to clean hulls while in the water.
[2] Please refer to Document B: Ballast Water Guidance for further information.

2. Species with limited information

It should be noted that limited information was available on potential mitigation measures for the following species:

• **Ribbed / Cholga Mussel (*Aulacomya atra*)** - The majority of information on this species is based on reducing the impacts upon it as it is a desirable species often intentionally introduced for aquaculture purposes, as such, information on risk mitigation measures is limited.

• **Blue Mussel (*Mytilus edulis*)** - The majority of information on this species is based on reducing the impacts upon it as it is a desirable species often intentionally introduced for aquaculture purposes, as such, information on risk mitigation measures is limited.

• **Chilean Mussel (*Mytilus chilensis*)** - The majority of information on this species is based on reducing the impacts upon it as it is a desirable species often intentionally introduced for aquaculture purposes, as such, information on risk mitigation measures is limited. In addition, the close similarity between this species and native species will make it nearly impossible to tell them apart and know which individuals to target with mitigation actions.

• **Pacific Acorn Barnacle (*Balanus glandula*)** - There are no studies identifying effective mitigation strategies used against this species.

• **Star Ascidian *(Botryllus schlosseri*)** - To date no evidence has been found of attempts to control invasive populations of this species.

3. Species with no known mitigation measures

It is also recognised that there are no known mitigation measures for the following species:

• **Harpoon Weed (*Asparagopsis armata*)** - Once arrived in coastal areas, this weed is impossible to eradicate or contain. The greatest potential for controlling the spread is as soon as possible upon arrival in a non-native country [1].

• **Blue Crab *(Callinectes sapidus)*** - To date no evidence has been found of attempts to control invasive populations of the blue crab [2].

• **European Sea Squirt *(Ascidiella aspersa)*** - Copper based antifouling paints have minimal effect on this sea squirt [3].

4. Priority Invasive Species Risk Mitigation Summaries

The following text describes examples of where an effective mitigation methodology has been applied. In reality though, mitigation is a last resort, as implementation is both financially and technically challenging.

Halophila Seagrass (*Halophila stipulacea*)
There are a limited number of methods which have proven effective for the mitigation of this species. Research conducted in the Suez Canal, has suggested that the production of a salinity barrier may help to reduce the abundance of this species when it enters the Mediterranean Sea [4].

Green Sea Fingers (*Codium fragile subsp. fragile*)
This species has been identified as a high-risk invasive species which is likely to spread to uninfected bioregions by hull fouling [5]. This increased likelihood has encouraged further research that can be used to assist the development of future management and mitigation strategies. The research is currently being used to build national plans in Australia which could include options for control, eradication and long-term management.

There are currently few successful methods known to manage this species, with quarantine measures and public education being proposed as the only way of preventing the spread of this species [6]. Several strategies for mitigation have been tested but have proven to be ineffective, one example is chemical herbicides which have been found to be both expensive to use and result in further environmental harm. The use of other organisms which feed on this species of algae has also been tested and proven unsuccessful [7]. Other methods which have proven unsuccessful are mechanical removal techniques, such as trawling, as this technique has been found to only result in a temporary density reduction and manual removal, which increases the chance of fragmentation from which this species will readily reproduce from [7].

Asian Kelp (*Undaria pinnatifida*)
Eradication of this species is unlikely to succeed due to the microscopic phase of its lifecycle [8]. Manual removal of adult plants has had limited success due to the fast reproduction of this species and the wide distribution of spores. The most effective way to limit it is to manually remove the sporophytes from the stipe on a monthly basis to combat the 50 day lifespan of the sporophytes [8, 9].

Cleaning of vessels would require a large amount of infrastructure, however, treating vessels with UV light or high-pressure, heated water (60°C for 5 seconds) would kill the spores [8]. Exposure to air for 24 hours has been proven to completely kill the plant, and therefore where possible, all moorings and vessels should be exposed to air upon identifying the species on them [8].

Red Algae (*Antithamnionella spirographidis*)
The primary mode of introduction is through adult plants attached to boat hulls. As such, the best mitigation for this species is pre-emptive measures to avoid the spread of this species in the first place. Regular use of antifouling paint is the main way of limiting this introduction [10, 11].

Physical removal of the algae from imported shellfish can reduce risk of introduction greatly; heat treatment and immersion in saturated brine can effectively kill macrophytes however, it is not suitable to use toxic substances on shellfish produced for human consumption [12].

Ruby Bryozoan (*Bugula neritina*)
This species has been identified as a high-risk species which is likely to spread to uninfected bioregions through shipping [5]. This increased likelihood has encouraged further research that can be used to assist the development of future management and mitigation strategies. One potential mitigation strategy suggested is the implementation of chemical-based paints onto the hulls of vessels. The use of chemical paints on vessel hulls has exhibited a reduced density of settlement and attachment [13]. However, additional research is required to identify specific chemicals that are most efficient for the reduction in attachment and settlement [14].

It may also be transported to new regions through ship ballast water. The most traditional method of managing ballast water is ballast water exchange [15] and the use of ballast water management systems [16]. Please refer to the ballast water guidance (document B) for further guidance.

Orange Cup Coral (*Tubastraea coccinea*)
Arrives primarily through hull fouling and ballast water. Physical removal from reefs has been found to be an effective response as well as wrapping isolated colonies in plastic which prevent it from spreading [9]. Please refer to the hull fouling guidance (document A) and ballast water guidance (document B) for further guidance.

Pacific Oyster (*Magallana gigas*)
Research has identified that the abundance of this species will not decrease through natural mortality events [17] or through the eradication of established species [18] and therefore strategies should offer alternative methods to mitigating the impacts of this species. It has been identified that management strategies for this species should aim to both minimise negative environmental impacts of settlement on features of conservation interest and maximise opportunities for sustainable industry development [19]. For this reason, a number of management strategies have been proposed but most still require further research to identify their impacts. The most common method is physical removal either by hand or using a dredge [19].

One species-specific measure suggested is to establish regional management plans that govern the size of aquaculture operations and implement region licences, which take account of specific water characteristics (physical and hydrographical) [20]. An alternative mitigation strategy described in the UK is the control of oyster density in well-defined areas, such as marine protected areas (MPAs). However, so far, the results suggest that this method is not efficient due to it being time-consuming, expensive and limited to small areas [21].

Dwarf Mussel (*Semimytilus algosus*)
There are currently no species-specific control methods that have been established for this species. It has been suggested that in-water hull-cleaning practices may help reduce the likelihood of further spread of this species. However, in order to efficiently reduce spread of this species, current hull-cleaning methods should be improved, by unrestricted and legislative means [22]. It is not recommended to undertake in-water cleaning of hulls within OT waters. Please refer to the hull fouling guidance (document A) for further guidance.

Although additional research is required, it has been identified that a film-forming bacterium can inhibit byssal formation of this species and reduce its reattachment ability [23].

Asian Green Mussel (*Perna viridis*)
This species is extremely difficult to eradicate, usually spreading until it reaches its lower temperature tolerance [24]. The use of anti-fouling paints, cleaning of submerged fittings, ballast water management and inspection of boats coming from areas of risk has been proposed to limit the spread in some countries [24]. Further measures taken include cleaning propellers or submerged fittings, in an area where any removed fouling will not enter the water, and regularly flushing internal seawater systems [25]. Low levels of chlorination can detach or kill the mussels but the mortality rate is low enough that detached mussels can recover and increase in density [26]. Please refer to the hull fouling guidance (document A) and ballast water guidance (document B) for further guidance.

Mediterranean Mussel (*Mytilus galloprovincialis*)
Ballast water exchange has been shown to prevent larval spread of this species [27]. As such, the best mitigation measures for this species are pre-emptive measures to avoid the spread of this species in the first place. There are no documented mitigation measures for when species are in situ within a new location. A ban on the discharge of ballast water at the coast unless a mid-ocean exchange has occurred could be considered [28]. Please refer to the ballast water guidance (document B) for further guidance.

Striped Barnacle (*Amphibalanus amphitrite*)
There are no species-specific control methods that have been, or are currently being, developed for this species. However, there are a number of non-specific ship fouling species control methods that have been proposed for this species including: anti-fouling systems, ship maintenance and recycling facilities, in-water inspection of ships and in-water cleaning and maintenance [29]. However, these general methods do not always address all areas that fouling organisms may establish or address the proper disposal of biological debris. Research is currently being undertaken to identify new technology that can address these issues [30]. It is not recommended to undertake in-water cleaning of hulls within OT waters. Please refer to the hull fouling assessment guidance (document A) and ballast water guidance (document B) for further guidance.

Reticulated Barnacle (*Amphibalanus reticulatus*)
The primary means of introduction are biofouling of ships' hulls and the transport of the planktonic larvae within ballast water [31, 32]. As such, the best mitigation for this species is pre-emptive measures to avoid the spread of this species in the first place. There are no documented mitigation measures for when species are in situ within a new location. There is a high correlation between levels of fouling and age of antifouling paint, and thus the greatest efficacy is achieved through regular application, particularly in niche area or parts of the hulls exposed to extreme turbulence [31]. Please refer to the hull fouling guidance (document A) for further guidance.

The exchange of coastal water with oceanic water physically removes the majority of organisms from the ballast tanks and kills most of the remaining through osmotic shock; this is documented to be 80-100% effective [31, 33]. Osmotic shock and dramatic environmental changes experienced by individuals attached to the boat hull reduces their survival rate compared to those in the relative safety of the ballast tank, highlighting the importance of mid-ocean ballast water exchange as a mitigation measure [31]. Please refer to the ballast water guidance (document B) for further guidance.

Decapod (*Halicarcinus planatus*)

There are no species-specific control methods that have been, or are currently being, developed for this species. However, management measures have been proposed for a similar species, *Halicarcinus innominatus*, which include: vessel hull and internal water system cleanliness, ballast water released, all scientific equipment and operational gear which is used is thoroughly cleaned and inspected prior to storage, water sampling system should only be made operational after a depth of more than 200 metres has been reached and ship anchors should be cleaned of all sediment prior to storage [34]. Please refer to the hull fouling guidance (document A) and ballast water guidance (document B) for further guidance.

European Shore Crab (*Carcinus maenas*)

Management plans are being developed to control the spread of this species through the eradication or control of newly established populations. In general, these management plans suggest that more restrictive actions should be undertaken with the movement of invasive species. Education and outreach programmes that raise and develop public awareness should be increased and should include both the industry and the general public [35]. A species-specific prevention method which has also been suggested to mitigate the spread is to limit and assess the main anthropogenic pathways in order to reduce the translocation of this species. The construction of local physical barriers, such as fences and nets, have also been suggested to help control the spread. Further control methods proposed for this species include: manual removing, commercial harvesting and trapping [36]. The Asian shore crab, Hemigrapsus sanguineus, has shown to have a negative influence on the abundance of this species through the consuming of settling post-larvae and displacement of juveniles [37] and has also been suggested as a natural management method to reduce the spread.

Ascidian / Sea Squirt (*Microcosmus squamiger*)

The high abundance and small size of this ascidian makes physical removal impractical once it is established. Native gastropods have been known to become predators of this ascidian and profitable fisheries have been set up in zones where it has established itself [38].

Sea Vase (*Ciona intestinalis*)

Total eradication of this species would not be possible without great expense but, evidence shows that rapid response strategies have effectively reduced population sizes and minimised spread [39, 40]. Hand-scrubbing or high-pressure spraying of boats are common treatments, however removed tunicates quickly re-establish dense populations [41]. The regular rotation and air drying of submerged floats and equipment is thought to potentially reduce recruitment and spread, but more information is needed to confirm this [42]. The use of acetic acid has shown to be effective however it has biocidal impacts on non-target species and so is not recommended [40].

Lionfish (*Pterois miles*)

Total eradication of lionfish in established areas is unlikely due to their abundance, distribution and resilience [43] however, complete eradication is not necessary to allow recovery of native species, making culling a practical solution [43, 44]. Studies have shown that a 90% population reduction can be achieved by divers in less than 2.5 dive-hours per 1000 m^2, with a target density of 7 lionfish per 1000 m^2 being aimed for [43].

A management framework has been developed in the Caribbean that focusses on five objectives which could be replicated: collaborate among organisations, coordinate monitoring programmes, review and amend legislation, control existing populations of lionfish and educate the public [45].

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APPENDIX A

INVASIVE SPECIES: A SUGGESTED IMPORT RISK ANALYSIS FRAMEWORK

Introduction

The importation of goods and products and movement of people between countries involves a certain level of risk of non-native invasive species entering the importing/receiving country. This risk may be represented by one or several negative impacts on the recipient country.

The principal aim of import risk analysis is to provide importing countries with an objective and defensible method of assessing the invasive risks associated with the importation of goods, animals, animal products, feedstuffs, biological products, other products associated with the import (e.g. untreated wooden pallets etc.) and migration of people. The analysis should be transparent. Transparency means the comprehensive documentation and communication of all data, information, assumptions, methods, results, discussion and conclusions used in the risk analysis should be available. This is necessary so that the exporting country and all interested parties are provided with clear reasons for the imposition of import conditions or refusal to import.

Transparency is also essential because data are often uncertain or incomplete and, without full documentation, the distinction between facts and value judgements may blur.

This section provides recommendations and principles for conducting a transparent, objective and defensible risk analysis considering international maritime trade as a route of entry of invasive species. The key elements of the risk analysis are *hazard* identification, *risk assessment*, *risk management* and *risk communication* (Figure 1).

Figure 1. The four components of invasive species entry risk analysis
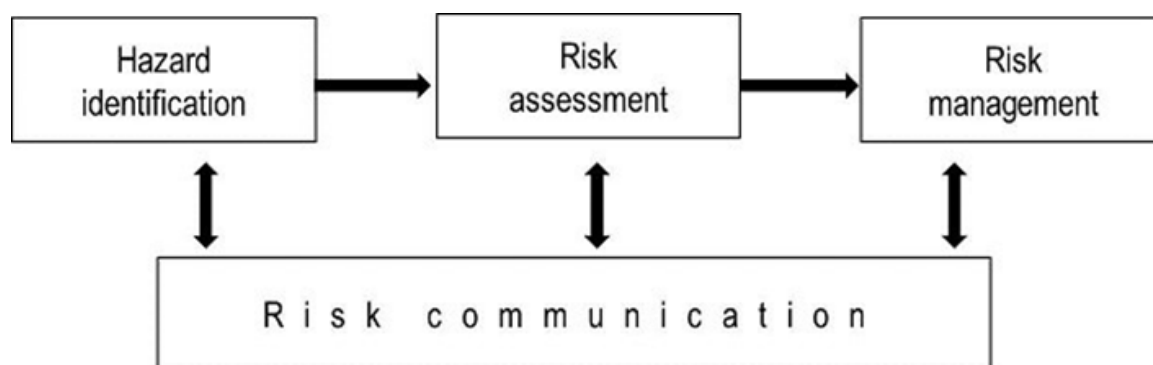
The risk assessment is the component of the analysis which estimates the risks associated with a particular hazard. Risk assessments may be qualitative or quantitative. For many identified hazards (invasive species), there is increasing agreement concerning the likely risk presented by certain species but less certainty in the route of entry. In such cases it is more likely that a qualitative assessment is all that is required. Qualitative assessment does not require mathematical modelling skills and is thus often the type of assessment used for routine decision making.

The process of import risk analysis usually needs to take into consideration the results of an evaluation of the likely routes / pathways of entry.

Hazard identification

The hazard identification involves identifying the invasive species which could potentially produce adverse consequences associated with their importation into a country.

The hazards identified would be those appropriate to the species likely to be imported, or from which the commodity is derived, and which may be present in the exporting country. It is then necessary to identify whether each hazard is already present in the importing country, and whether it is subject to control or eradication in that country and to ensure that import measures are not overly trade restrictive.

Hazard identification is a categorisation step, identifying species as hazards or not. The risk assessment may be concluded if the hazard identification fails to identify hazards associated with the species route of entry.

Principles of risk assessment

1) Risk assessment should be flexible to deal with the complexity of real-life situations. No single method is applicable in all cases. Risk assessment should be able to accommodate the variety of likely routes of import/ entry for invasive species, the multiple hazards that may be identified with an importation and the specificity of each species, including detection and monitoring.

2) Both qualitative risk assessment and quantitative risk assessment methods are valid.

3) The risk assessment should be based on the best available information that is in accord with current scientific thinking. The assessment should be well-documented and supported with references to the scientific literature and other sources, including expert opinion.

4) Consistency in risk assessment methods should be encouraged and transparency is essential in order to ensure fairness and rationality, consistency in decision making and ease of understanding by all interested parties.

5) Risk assessments should document the uncertainties, the assumptions made, and the effect of these on the final risk estimate.

6) Risk increases with increasing likelihood of the species being imported.

7) The risk assessment should be amenable to updating when additional information becomes available.

Invasive species risk assessment steps

1. Entry assessment

Entry assessment consists of describing the biological pathways necessary for an importation activity to introduce an invasive species into a particular environment, and estimating the probability of that complete process occurring, either qualitatively (in words) or quantitatively (as a numerical estimate). The entry assessment describes the probability of the 'entry' of each of the hazards (the invasive species) under each specified set of conditions with respect to amounts and timing, and how these might change as a result of various actions, events or measures. Examples of the kind of inputs that may be required in the entry assessment are:

a) Biological factors
  – The invasive species
  – Survival rates of larvae, juveniles etc.
  – Routes of entry – treatments and "quarantine"

b) Country factors
  – Likelihood of survival in receiving environment
  – Pre-existing species established
  – Evaluation of use of monitoring, surveillance and control programmes of the importing and of the exporting country.

c) Commodity factors
  – Quantity of commodity that may be associated with a specific invasive species
  – Ease of establishment in country
  – Effectiveness of any treatments

If the entry assessment demonstrates no significant risk, the *risk assessment* does not need to continue.

2. Exposure assessment

Exposure assessment consists of describing the biological pathways through which the invasive species (the hazard) can enter the importing country from a given risk source, and estimating the probability of the exposures occurring, either qualitatively (in words) or quantitatively (as a numerical estimate).

The probability of exposure to the identified hazard is estimated for specified exposure conditions with respect to amounts, timing, frequency, duration of exposure, routes of exposure, the number of species and other characteristics of the species and likely consequences for the environment or human populations exposed. Examples of the kind of inputs that may be required in the exposure assessment are:

a) Biological factors
   – Properties of the species.

b) Country factors
   – Presence of potential onward pathways
   – Suitability of habitats
   – Animal demographics
   – Customs and cultural practices
   – Geographical and environmental characteristics.

c) Commodity factors
   – Quantity of species introduced/ imported
   – Intended use of the imported products
   – Disposal practices.

If the exposure assessment demonstrates no significant pathway, the risk assessment may conclude at this step.

3. Consequence assessment

Consequence assessment consists of describing the relationship between specified exposures to a biological agent and the consequences of those exposures. A causal process should exist by which exposures produce adverse health or environmental consequences, which may in turn lead to socio-economic consequences. The consequence assessment describes the potential consequences of a given exposure and estimates the probability of them occurring. This estimate may be either qualitative (in words) or quantitative (a numerical estimate). Examples of consequences include:

a) Direct consequences - invasive species becomes established and results in habitat and production losses, with potential public health consequences.
b) Indirect consequences
   – Monitoring and control costs
   – Compensation costs
   – Potential trade losses
   – Adverse consequences to the environment.

4. Risk estimation

Risk estimation consists of integrating the results from the entry assessment, exposure assessment, and consequence assessment to produce overall measures of risks associated with the hazards identified at the outset. Thus, risk estimation considers the whole of the risk pathway from any hazard identified to subsequent unwanted outcome(s) or consequences. For a quantitative assessment, the final outputs may include:

– estimated numbers of likely economic or environmental damage likely to result in various degrees of severity over time;

– probability distributions, confidence intervals, and other means for expressing the uncertainties in these estimates;

– portrayal of the variance of all model inputs;

– a sensitivity analysis to rank the inputs as to their contribution to the variance of the risk estimation output;

– analysis of the dependence and correlation between model inputs.

Principles of risk mitigation

1) Risk mitigation is the process of deciding upon and implementing measures to address the risks identified in the risk assessment, whilst at the same time ensuring that negative effects are minimised. The objective is to manage the risk appropriately to ensure that a balance is achieved between a country's desire to minimise the likelihood or frequency of an invasive species gaining a purchase in a country and their consequences and its desire to import commodities and fulfil its obligations under international trade agreements.

Risk mitigation components – the following steps comprise the elements of the risk management considerations

1) Risk evaluation - the process of comparing the risk estimated in the risk assessment with the reduction in risk expected from the proposed risk management and mitigation measures.

2) Option evaluation - the process of identifying, evaluating the efficacy and feasibility of, and selecting measures to reduce the risk associated with a particular species. The efficacy is the degree to which an option reduces the likelihood or magnitude of adverse environmental and economic consequences. Evaluating the efficacy of the options selected is an iterative process that involves their incorporation into the risk assessment and then comparing the resulting level of risk with that considered acceptable. The evaluation for feasibility normally focuses on technical, operational and economic factors affecting the implementation of the risk management and mitigation options.

3) Implementation - the process of following through with the risk management decision and ensuring that the risk management or mitigation measures are in place.

4) Monitoring and review - the ongoing process by which the risk management/ mitigation measures are continuously audited to ensure that they are achieving the results intended.

The final stage in the risk assessment process is then effective communication.

The following summarises the key principles of risk communication

1. *Risk communication* is the process by which information and opinions regarding hazards and risks are gathered from potentially affected and interested parties during a risk analysis, and by which the results of the risk assessment and proposed risk management measures are communicated to the decision-makers and interested parties in the importing and exporting countries. It is a multidimensional and iterative process and should ideally begin at the start of the risk analysis process and continue throughout.

2. The *communication* of the risk should be an open, interactive, iterative and transparent exchange of information that may continue after the decision on importation.

3. The principal participants in risk communication include all the involved stakeholders.

4. The assumptions and uncertainty in any risk model, model inputs and the risk estimates of the risk assessment should be communicated.