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Alien Species in Aquaculture

Considerations for responsible use

Chad L. Hewitt, Marnie L. Campbell and Stephan Gollasch

Global Marine Programme

Fondation d'entreprise Total
Pour la biodiversité et la mer

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Alien Species in Aquaculture[1]

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Chad L.Hewitt, Marnie L. Campbell and Stephan Gollasch

Foreword by Imène Meliane

Global Marine Programme

[1] The term aquaculture in this publication primarily refers to activities occurring in the marine environment. The concepts presented herein however are likely to be readily applicable to freshwater systems.

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Foreword

Aquaculture is an important economic activity in the coastal areas of many countries. It offers opportunities to alleviate poverty, boosts employment, helps community development, reduces overexploitation of natural coastal resources, and enhances food security, particularly in tropical and sub-tropical regions. Due to the increasing worldwide demand for aquatic products, aquaculture is one of the most important and fastest growing sectors within fisheries. Currently most aquaculture facilities in the marine environment, particularly in developing countries, use non-native or alien species, mainly to reduce costs by using readily-available research and development outputs.

With the rising awareness about the ecological and economic impacts caused by alien species around the world, several international policy instruments are calling for the application of the precautionary approach and are discouraging the deliberate introduction of alien species for aquaculture purposes.

The reality faced by many developing countries is that there are few incentives for using native species; research and development costs are very high and creating markets for new native species might take a long time, besides being a risky business. Many developing economies have opted for the continued use of alien species in aquaculture in response to the strong pressure to improve livelihoods, advance societies and grow economies.

The Government of Chile recognizes the threats posed by alien invasive species, but also recognises the significant societal benefits associated with aquaculture. IUCN and the Chilean Government, through its Under-secretariat for Fisheries, joined forces in implementing a project entitled "Addressing alien species in Aquaculture systems", funded by the TOTAL Corporate Foundation for Biodiversity and the Sea. The project was an interesting experience that looked into finding pragmatic solutions to the most pressing conservation and development challenges in implementing responsible aquaculture. It aimed to reduce threats posed by alien species use in aquaculture systems by providing methodologies to assess the risk of invasions, and to control and manage escapes and invasions when they occur.

We wanted to share some of the results of this project and go beyond it, also summarising other experiences in dealing with the use of alien species in aquaculture. We have hence commissioned this publication also asking the authors to provide some "simple" sets of guidelines for use by decision makers, with consideration of the special needs of developing countries.

This publication aims to first provide decision makers and managers with information on the existing international and regional regulations that address the use of alien species in aquaculture, either directly or indirectly; and three examples of national responses to this issue.

The last section of this document provides some considerations and suggestions to be taken into account by decision makers and managers when using -or deciding on the use of- alien species for aquaculture purposes. The considerations put forward here bear in mind the challenges faced by decision makers when reconciling conservation and development needs, and aim to help them find pragmatic solutions to ensure a responsible use of alien species for aquaculture purposes, should they decide to go down that path.

The IUCN Global Marine Programme will be pleased to receive comments on this publication and hear about your experience in this domaine.

Imène Meliane

IUCN Global Marine Programme

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1. Introduction

The human population has surpassed 6 billion people (Figure 1), with increasing pressures placed on infrastructure, food security and environmental resources (McMicheal, 2001). Much of this population is found within coastal areas, 3.6 billion people, nearly 65% of the human population, lives within 150km of a coastline with an estimated growth to 75% of humanity by 2025 (Cohen, 1995; Hinrichsen, 1995). An increased reliance on ocean resources for economic growth has led to the development of intensive aquaculture in the coastal areas of many countries with stagnating yields from many wild capture fisheries and an increasing demand for fish and fishery products. Expectations for aquaculture to increase its contribution to the world's production of aquatic food are very high, and there is also hope that aquaculture will continue to strengthen its role in contributing to food security and poverty alleviation in many developing countries. Aquaculture offers opportunities to alleviate poverty, increase employment and community development, reduce overexploitation of natural coastal resources, and develop food security, specifically in developing countries.

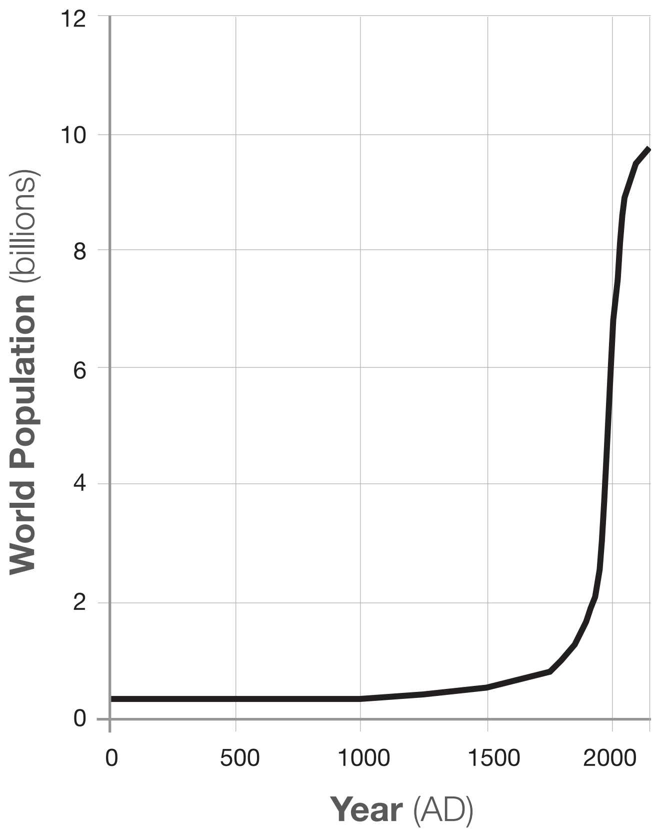

Figure 1: World population since Yr 0, including forecasted numbers to 2200 (after UN, 1999).

Due to this worldwide increasing demand for aquatic food products, aquaculture is now one of the most important and fastest growing sectors within the fisheries sector, specifically for marine aquaculture activities. Most of global aquaculture output is produced in developing countries, and, significantly, low-income food-deficit countries. However, it is also recognized that aquaculture encompasses a very wide range of different farming practices with regard to species (including seaweeds, molluscs, crustaceans, fish and other aquatic species groups), environments and systems, often with very distinct resource use patterns, offering a wide range of options for diversification of avenues for enhanced food production and income generation in many rural and peri-urban areas.

In order to rapidly and cost-effectively develop and diversify aquaculture interests, commercial enterprises in several countries have turned to pre-existing aquaculture species from other regions, such as the Japanese Oyster, Crassostrea gigas, the Atlantic Salmon, *Salmo salar*, and the California abalone, *Haliotis rufescens*. By using these species, research and development costs are minimised through use of overseas research and development outputs. Similarly, these new enterprises can utilise pre-existing markets with well established brand identity to create a more rapid profit. This use of potentially invasive Alien Species in novel locations and with farming practices that rarely provide a zero-risk of accidental release is problematic from biodiversity protection and transboundary perspectives.

A number of international, regional and national instruments exist to manage alien species use in aquaculture systems; however an analysis of the gaps in ese systems and the extent to which they are applied has yet to be undertaken. As the demand for novel aquaculture production increases, government authorities will increasingly have a key role to play in enhancing effective collaboration with and among many players, in order to promote sustainable development of aquaculture. Responsibilities for sustainable aquaculture development will need to be shared among government authorities, aquafarmers, manufacturers and suppliers of aquaculture inputs, processors and traders of aquaculture products, financing institutions, researchers, special interest groups, professional associations, non-governmental organizations, and others.

This publication aims to identify existing international, regional and national instruments, provide an evaluation of their application, specifically in the context of developing economies, and lastly provide recommendations for a 'simple' set of guidelines and principles for developing countries that can be applied at a regional or domestic level for the responsible management of Alien Species use in aquaculture development. These guidelines focus primarily on marine systems, however may equally be applied to freshwater.

2. International Instruments

Several international instruments, including agreements and 'soft regulations', have been established that account for the intentional use and transfer of alien species (Meliane and Hewitt, 2005; Shine, *et al.,* 2005; Doelle, *et al.,* in press; Hewitt, *et al*., in press). These include Conventions that place both general and binding obligations on signatory parties and have been vested as global legal agreements (UNCLOS, 1982; CBD, 1992), those focussed on specific geographic areas (World Heritage, 1972; Ramsar, 1971), and those associated with specific activities (IPPC, 1952; AFS, 2001; BWM, 2004). Here we will only deal with those treaties, agreements and codes with application to the use of Alien Species in aquaculture.

2.1 General obligations

The United Nations Convention on the Law of the Sea (UNCLOS, 1982), built on earlier agreements and created the basis for subsequent marine legal regimes and management of disputes. UNCLOS explicitly states that Parties should take measures "to prevent, reduce and control pollution of the marine environment resulting from… the intentional or accidental introduction of species alien or new, to a particular part of the marine environment, which may cause significant and harmful changes thereto" (Article 196).

The Convention on Biological Diversity (CBD, 1992) provides the only international instrument specifically oriented to the protection of biodiversity outside of exploitation (see also CITES, 1973). Three articles of the CBD can be applied to the management of Alien Species:

- Article 3: to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction;
- Article 8(h): to prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species; and,
- Article 14.1: to ensure that the environmental consequences of its programmes and policies that are likely to have significant adverse impacts on biological diversity are duly taken into account.

In addition, the Conference of the Parties of the CBD has adopted several decisions applicable to the use of marine Alien Species in aquaculture. These include Decision VI/23[2], Decision VII/5 and Decision VIII/27 that recommend Parties and other Governments use native species and subspecies in aquaculture, and express support for regional and international collaboration to address transboundary impacts of aquaculture on biodiversity, such as spread of disease and invasive alien species. In addition, recent Decisions have urged parties to implement the Code of Practice on the Introduction and Transfers of Marine Organisms of the International Council for the Exploration of the Sea, the Code of Conduct on Responsible Fisheries of the Food and Agriculture Organization of the United Nations, and Article 196 of the United Nations Convention on the Law of the Sea.

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[2] One representative entered a formal objection during the process leading to the adoption of this decision and underlined that he did not believe that the Conference of the Parties could legitimately adopt a motion or a text with a formal objection in place. A few representatives expressed reservations regarding the procedure leading to the adoption of this decision (see UNEP/CBD/COP/6/20, paras. 294-324).

2.2 Specific geographic locations

Several instruments focus on the regimes for management and protection of specific locations or environments. For example, Parties of the World Heritage Convention (UNESCO, 1972) who act to establish World Heritage Sites in the marine environment, assume obligations to protect the values for which the site has been identified (e.g. important and significant habitats for conservation of biological diversity). Some World Heritage sites are subject to multiple-use, including commercial activities such as shipping, ports, aquaculture, recreational SCUBA diving, boating and fishing (e.g., Shark Bay, Western Australia; see Wyatt, *et al*., 2005). Inaction by a Party to respond to *invasive* Alien Species, including failure to make provisions through national management plans, legislation and regulations, could impair the values of a property, possibly resulting in the removal of the property from World Heritage listing. In addition, Parties of the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar, 1971) are urged to ensure that measures are in place to prevent or control Invasive Alien Species (Resolution VIII.18).

2.3 Specific activities

Several treaties and agreements have been established in relation to specific activities that are known or have the potential to cause harm; these include vector based treaties and agreements (AFS, 2001; BWM, 2004) that have little relation to aquaculture uses of Alien Species. Various agreements can be identified under the loose banner of Quarantine and Trade (IPPC, 1951; Office International des Épizooties (http://www.oie.int); Codex Alimentarius Commission (http://www.codexalimentarius.net)). Additional agreements and treaties that relate to specific activities include the UN Convention on the Law of the Non-Navigational Uses of International Watercourses (1997) and a number of Codes for aquaculture practice that have been developed by international bodies (e.g., FAO, 1995 - Code of Conduct for Responsible Fisheries; ICES, 2005 - Code of Practice on the Introductions and Transfers of Marine Organisms).

2.3.1 Quarantine and Trade

Several international agreements have been established over the last 60 years to guarantee a standardised set of quarantine arrangements for the protection of human health, and economically important plant and animal species. These agreements include the International Plant Protection Convention (IPPC, 1952; revised 1997), the World Animal Health Organisation (Office International des Épizooties; OIE), and the Codex Alimentarius (food standards). These three agreements are recognized under the World Trade Organisation (WTO) as the only acceptable standard setting bodies within the Sanitary and Phytosanitary Standards (SPS) Agreement. Of these, the IPPC and OIE are of greatest importance to the management of Alien Species in aquaculture.

The World Trade Organization (WTO) agreement was aimed to improve developing countries opportunities to expand exports for their agricultural products to OECD countries, including goods from fisheries and aquaculture. It appears that many countries, especially developing countries, face major problems to meet food safety requirements and other standards being obligatory in several importing countries. The Genoa G8 countries and the Doha Declaration urge more attention to these needs of developing countries to meet these trade standards (Roth & Rosenthal, in press).

The IPPC was established in 1952 to prevent damage to plants of economic importance through introductions of disease, parasites or alien species. Member states have developed appropriate national quarantine systems as a direct consequence, providing for agreed standards such as the establishment of import regulations, compliance systems, surveillance systems with timely reporting to associate states, eradication and control systems, and export certification systems to meet the needs of trading partners.

The IPPC however, has a much broader scope, including protection of the natural environment from many harmful non-indigenous species (Hedley, 2004). Hedley (2004) identifies that consideration of both direct and indirect impacts to native flora (vegetation) must be considered at both international and national levels. While the IPPC has rarely been applied in a marine context, the Convention clearly identifies the obligation for Parties to consider how international trade can lead to harm to plants of economic importance. In an aquaculture context, this suggests that the IPPC places obligations on Parties to consider new aquaculture imports on the basis of potential impact to marine flora.

The OIE currently has a number of listed pathogens and disease agents of commercial aquaculture species (salmonids and molluscs) relevant to the transfer and trade of live or fresh biological material, including eggs and broodstock. The application of the OIE in marine systems is unquestionable, however its application to encompass pathogens, disease agents or parasites that affect natural systems in the absence of impacts on cultured systems will require significant efforts. There need to be a shift in the OIE philosophy and implementation through the consideration by participating nations of reporting the occurrence of listed species when detected in natural systems or wild populations and increasing the black-listed species to include those that are likely to impact on the natural environment.

The recommendations in the OIE Aquatic Code make reference only to the aquatic animal health situation in the exporting country, and assume that either the disease is not present in the importing country or is the subject of a control or eradication programme. Therefore, when determining its import measures, an importing country should do so in a way that is consistent with the principle of national treatment and the other provisions of the WTO SPS Agreement. An importing country is always free to authorise the importation of aquatic animals or aquatic animal products into its territory under conditions either more or less stringent than those recommended by the Aquatic Code, but this must be based on a scientific risk analysis and done in accordance with the country's obligations under the SPS Agreement.

2.3.2 Non-navigational uses of waterways

The UN Convention on the Law of the Non-Navigational Uses of International Watercourses (1997) obliges Parties to develop appropriate impact assessments where activities including water transfer schemes and canal projects may impinge on neighbouring countries, thus creating trans-boundary issues. This Convention explicitly identifies in Article 22 the need to minimise the introduction and ecosystem impacts of alien or new species, and within its programme of work, identifies the need to develop technical advice on methods to prevent or minimize the introduction or spread of alien or new species through canals and pipes as a matter of urgency.

There is no explicit discussion of aquaculture or mariculture uses of waterways in the Convention, however its broad application to any non-navigational use clearly encompasses both. The consequences to development of aquaculture in a waterway, such as an estuary, will require a Party to undertake appropriate impact assessments in conjunction with a potentially affected country (i.e., one that shares a border with the potentially affected waterway). In addition, a Party or Parties considering proposals that intend to develop a new waterway, must take into account the pre-existing risks posed by aquaculture in or near the affected areas.

2.3.3 Aquaculture practice

No specific conventions explicitly address aquaculture use of Alien Species. Non-binding agreements exist, however, including the Food and Agriculture Organization (FAO) voluntary Code of Conduct on Responsible Fisheries (Article 9 on Aquaculture Development; FAO CCRF, 1995). The FAO CCRF is a best-practice guide to the management and maintenance of fisheries and aquaculture facilities and has been promoted by FAO and other international instruments, resulting in numerous follow-up initiatives, specifically in relation to fisheries management. Articles 9.2 and 9.3 of the CCRF explicitly identify the introduction of Alien Species as requiring additional evaluation to minimize or prevent impacts to native ecosystems including transboundary contexts. In addition, the FAO has developed several technical guidelines aiming to provide more detailed guidance on application of the CCRF, two of which have direct relevance to the use of Alien Species in an aquaculture context.

FAO (1996 - Technical Guideline Number 2) concerns the application of the precautionary approach with respect to capture fisheries and species introductions. These guidelines highlight the use of risk evaluation and precaution in considering new introductions of Alien Species. FAO (1996) provides the ICES Code of Conduct (1995) and the IMO Ballast Water Management Guidelines (A868(20)) as appendices.

A second technical guideline, FAO (1997- Technical Guideline Number 5) is explicit to aquaculture development and discusses each CCRF Article in Section 9 in further detail. Of these articles, 9.1.2 identifies the potential genetic impacts of introduced (alien) species through introgression and competition with native stocks. Article 9.2.3 explicitly discusses the need for consultation with neighbouring states when considering the introduction of Alien Species into a transboundary system. This discussion includes the need to identify or establish a regional body for consideration of applications and the sharing of information relevant to the introduction. Article 9.3 (and all sub articles) identifies the need to minimise the adverse effects of alien species to genetic resources and ecosystem integrity and encourage the use of native species whenever possible, the application of standard quarantine procedures and the establishment (or adoption) of codes of practice for approvals and management of introduced species.

3. Regional Agreements

Several regional agreements and activities, that identify the need to develop consistent practices to restrict and minimize the impacts of invasive alien species, are in place. Numerous examples exist; here we discuss the Asia-Pacific Economic Cooperation (APEC), the Baltic and North Sea (HELCOM), and the International Council for the Exploration of the Seas (ICES). Example activities will be presented below with specific attention to the ICES Code of Practice on the Introductions and Transfers of Marine Organisms (2005).

3.1 Pacific Rim - Asian-Pacific Economic Cooperation (APEC)

The Asia-Pacific Economic Cooperation (APEC) is a key regional forum which promotes economic growth and prosperity in the region and strengthens the Asia-Pacific community. In preparation for the first Meeting of Oceans Ministers (MoM), the Fisheries Working Group and the Marine Resource Conservation Working Group (MRC WG) embarked on a joint project in 2001 to identify gaps in marine biosecurity delivery in APEC Member Economies. This project, sponsored by Australia and Chile, was designed to address the threat of introduced species that can become pests within APEC Economies. The project entailed characterization of each of the Economies' strategies to control marine pests and to draft elements of a regional risk management framework for possible use by APEC Member Economies (Williamson, *et al.,* 2002). As a direct result, the MoM (APEC, 2002) identified invasive alien species as a priority for developing coordinated management efforts and informed the development of the Seoul Oceans Declaration (2002, http://www.apecsec.org.sg).

APEC has also recently held a meeting in Beijing, China (September 2005) hosted jointly by the US State Department and China to evaluate the coordination of alien invasive species activities by APEC across all Working Groups and ecosystems (APEC, 2005).

No explicit work involving aquaculture practices has been undertaken by APEC, despite numerous examples of invasive Alien Species threats to and impacts from aquaculture practices in APEC economies (see, Bax, 1999; Campbell & Hewitt, submitted). More recently however, the APEC Bali Plan of Action (2005, http://www.apecsec.org.sg, accessed 4 August 2006) has identified the need for activities to achieve consistent approaches to sustainable fisheries and aquaculture management across the region.

3.2 North Atlantic

3.2.1 Baltic Sea – the Helsinki Commission (HELCOM)

The Helsinki Commission (HELCOM, 1974) was established in 1974 as the governing body of the "Convention on the Protection of the Marine Environment of the Baltic Sea Area" also known as Helsinki Convention. This Convention was established "to protect the marine environment of the Baltic Sea from all sources of pollution" through intergovernmental co-operation between Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia, Sweden and the European Community. HELCOM operates under the precautionary principle and has become the body under which transboundary issues relating to the improvement of the Baltic marine environment occur. Relevant to biological invasions, HELCOM undertakes work on maritime transport (including ballast water matters), environmental impacts of fishery management and practices, and protection and conservation of marine and coastal biodiversity.

3.2.2 International Council for the Exploration of the Seas (ICES)

As a fishery-oriented inter-governmental organisation, ICES has been confronted early on with issues related to the introductions of non-indigenous species, in particular diseases and parasites transferred with live transport of fish and shellfish for relaying, stocking, ranching and for fresh-fish markets. During the late 1960s and early 1970s, the need to assess the risks associated with deliberate transfers of species was primarily of concern.

While great successes have been achieved by these activities, leading to the creation of new and important fishery and aquaculture resources, three challenges have surfaced over the past several decades relative to the global translocation of species to new regions:

- The first challenge lies in the ecological and environmental impacts of introduced and transferred species, especially those that may escape the confines of cultivation and become established in the receiving environment. These new populations can have an impact on native species.
- The second challenge stems from the potential genetic impact of introduced and transferred species, relative to the mixing of farmed and wild stocks as well as to the release of genetically modified organisms.

- The third challenge is posed by the inadvertent coincident movement of harmful organisms associated with the target (host) species. The mass transfer of large numbers of animals and plants without inspection, quarantine, or other management procedures has inevitably led to the simultaneous introduction of pathogenic or parasitic agents causing harm to the development and growth of the new fishery resources and to native fisheries.

The International Council for the Exploration of the Sea, through its Working Group on Introductions and Transfers of Marine Organisms (WGITMO) and its cooperation with other ICES Working Groups and with the European Inland Fisheries Advisory Commission (EIFAC) of the Food and Agriculture Organization of the United Nations (FAO), has addressed these three levels of concern since 1973 through a series of successive Codes published by the various organisations. These Codes represent a risk management framework for operational implementation to provide surety to neighbouring coastal states that intentional introductions follow acceptable guidelines.

At its 1973 Statutory Meeting ICES adopted a "Code of Practice to Reduce the Risks of Adverse Effects Arising from Introduction of Non-indigenous Marine Species". Regulatory authorities in all ICES Member Countries were encouraged to use the strongest possible measures to prevent unauthorized or unapproved species introductions. On 10 October 1973, the Council adopted the first version of what was to become an internationally recognized "Code of Practice" on the movement and translocation of non-native species for fisheries enhancement and aquaculture purposes. The Code was set forth "to reduce the risks of adverse effects arising from introduction by non-indigenous marine species". Subsequent modifications proposed by the ICES Working Group on the Pathology and Diseases of Marine Organisms in 1978 and by the then newly reconvened ICES Working Group on the Introduction of Non-Indigenous Marine Organisms in 1979, led to the publication of a "Revised Code" adopted by ICES in October 1979 (ICES Cooperative Research Report No. 130, published in 1984). The "1979 Code" became the standard for international policy and the version of the Code most widely used, cited, and translated for the next 10 years.

Published in 1988 as ICES Cooperational Research Report 159 the ICES Working Group on Introductions and Transfers of Marine Organisms and EIFAC[3] Working Party on Introductions jointly prepared "Codes of Practice and Manual of Procedures for Consideration of Introductions and Transfers of Marine and Freshwater Organisms". Areas covered are inspection and certification, quarantine, pathology, genetics and ecology. Concerns in these areas, common to all species introductions, are outlined as are those related to species importations or other movements in commercial practice and for scientific studies or research purposes.

Minor revisions and additions over the decade have resulted in the adoption in October 1990 of a "1990 Revised Code", followed by the "1994 Code" adopted by ICES in September 1994 (ICES, 1995). The "1994 Code" took into account several updates and included issues of genetic introgression and use of genetically modifies organisms for the first time. While the ICES Code of Practice was originally developed for marine aquaculture activities, in recent years, by far the largest number of introductions has been for re-stocking or enhancement purposes but the same principles should apply.

In recent years, the release of exotic organisms via a ship's ballast water and hull fouling has become a pressing issue, with profound implications for fisheries resources, aquaculture, and other activities. These issues are dealt with separately by the ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors (WGBOSV) and are not considered within this code.

3.2.2.1 ICES Code of Practice

The most up-to-date version of the ICES Code, published in 2003, includes all concerns expressed in the 1994 Code of Practice and follows the precautionary approach adopted from the FAO principles with the goal of reducing the spread of exotic species. It accommodates the risks associated with trade in current commercial practices including ornamental trade and bait organisms, research, and the import of live species for immediate human consumption (these are not species that are intended to be released to the environment). It also includes species which are utilized to eradicate previously introduced harmful species (biocontrol agents) as well as genetically modified organisms (GMOs). It outlines a consistent, transparent process for the evaluation of a proposed new introduction, including detailed biological background information and an evaluation of risks, but does not undertake the decision making.

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3 European Inland Fisheries Advisory Commission (EIFAC)

The ICES Council and Members view the Code of Practice as a guide to recommendations and procedures. As with all Codes, the current one has evolved with experience and with changing technological developments. This latest version of the Code reflects the past 30 years of experience with the evolution of new fisheries and genetic technologies.

While initially designed for the ICES Member Countries concerned with the North Atlantic and adjacent seas, all countries across the globe have been encouraged by ICES Members, and other international conventions (e.g. CBD), to implement this Code of Practice. Public awareness of the concerns associated with introductions and transfers of marine organisms is essential to assist in the prevention of such problems. Countries are therefore encouraged to ensure widest distribution of this code.

This Code became a recognized instrument and was applied to the evaluation process for several species introductions in both ICES Member Countries and outside the ICES arena.

The ICES Code of Practice sets forth recommended procedures and practices to diminish the risks of detrimental effects from the intentional introduction and transfer of marine (including brackish water) organisms. The Code is aimed at a broad audience since it applies to both public (commercial and governmental) and private (including scientific) interests. In short, any persons engaged in activities that could lead to the intentional or accidental release of exotic species should be aware of the procedures covered by the Code of Practice.

The Code is divided into seven sections of recommendations relating to: (I) a strategy for implementation, (II) the steps to take prior to introducing a new species, (III) the steps to take after deciding to proceed with an introduction, (IV) policies for ongoing introductions or transfers which have been an established part of commercial practice, (V-IX) the steps to take prior to releasing genetically modified organisms, and (X) recommended actions to take when releasing GMOs. These sections have been revised by the ICES Working Group on the Application of Genetics in Fisheries and Mariculture. A section on "Definitions" is included with the Code.

The Code is presented in a manner that permits broad and flexible application to a wide range of circumstances and requirements in many different countries, while at the same time adhering to a set of basic scientific principles and guidelines.

ICES Member Countries contemplating new introductions are requested to present in good time to the ICES Council a detailed prospectus on the rationale and plans for any new introduction of a marine (brackish) species; the contents of the prospectus are detailed in Section II of the Code and Appendix A. The Council may then request its Working Group on Introductions and Transfers of Marine Organisms to consider the prospectus and comment on it. The Working Group, in turn, may request more information before commenting on a proposal. Guidelines to be followed are described with details in appendices on the ICES website (www.ices.dk).

If any introduction or transfer proceeds following approval, ICES requests its Member Countries to keep the Council informed both through providing details of the brood stock established and the fate of the progeny, and through submitting progress reports after a species is released into the wild. The specifics of this stage are detailed in Section III of the Code.

ICES has published two extended guides to the Code, one in 1984 as Cooperative Research Report (CRR) No. 130, entitled "Guidelines for Implementing the ICES Code of Practice Concerning Introductions and Transfers of Marine Species", and one in 1988 as Cooperative Research Report No. 159, entitled "Codes of Practice and Manual of Procedures for Consideration of Introductions and Transfers of Marine and Freshwater Organisms". These reports are available in many libraries and from the ICES Secretariat. As with all Codes, the current one has evolved with experience and with changing technological developments. The latest (2005) version of the Code reflects the past 30 years of experience with the evolution of new fisheries and genetic technologies.

The ICES CoP (2005) includes four Appendices:

Appendix A. Prospectus

This Appendix provides detailed information on suggested guidelines for the prospectus, including, but not limited to:

- potential of transfer of disease agents, parasites and non-target species;
- review of previous introductions of the candidate species.

This information is used to conduct the biological risk assessment (see Appendix B). To be scientifically valid, the information provided needs to be based on a thorough literature review.

The prospectus also needs to include a contingency plan in case immediate eradication of the introduced species needs to be carried out.

The proponent should design an appropriate monitoring programme that will document impacts in the receiving environment.

Appendix B. Risk Assessment

This Appendix provides a detailed, consistent approach for evaluating the risk of genetic, ecological, and disease impacts in the proposed receiving environment, as well as the potential for introducing non-target species. This review should be based in part on the information provided in the Prospectus (see Appendix A).

There will be an assessment of each potential hazard as to the probability of the establishment and consequences of the establishment in the receiving environment. Mitigation factors and management issues will also be reviewed.

The precautionary principle will be taken into account in the final outcome of the risk assessment.

Appendix C. Quarantine

The intention of the quarantine process is to:

- prevent the escapes of target and non-target species into the environment;
- ensure freedom from disease agents in broodstock and progeny prior to release from the quarantine system;
- protect broodstock.

The size of the facility, and the extent of the quarantine measures, will depend on the characteristics of the species being introduced. Quarantine measures may also be required for some species transfers.

The Appendix provides detailed information on suggested requirements for quarantine facilities, including, but not limited to:

- transport of broodstock;
- quarantine facilities;
- stock management in isolation;
- record keeping;
- disinfection.

Appendix D. Monitoring

The purpose of the monitoring programme is to assess the impact of the introduced organisms on the environment, ecosystem function, and biodiversity (including genetic biodiversity). The monitoring should be adjusted according to the type of organism and its potential dispersal range. The vectors responsible for further dispersal need to be identified.

Appropriate monitoring should be carried out in phases:

- initial baseline monitoring study before the introduction,
- continuing monitoring subsequent to pilot study release, and
- continuing monitoring following increases in scale of project.

The results of the monitoring may be reported to and assessed by WGITMO before the next phase is undertaken. Questions outlined in the Appendix should be addressed as far as possible.

3.2.3 European Community – Proposal for regulation of alien species in aquaculture

The European Community (EC) is considering a proposal for developing a permitting system governing marine and freshwater aquaculture practices that involve the use of non-indigenous species in the EC or the movements and transfers of species from native ranges in the EC to areas where they do not occur. The proposal is to have a sufficiently robust application process to allow an evaluation of whether the movement would be routine or non-routine. This would also allow for a decision to be made at the Member State level on whether an environmental risk assessment (ERA) is required. The screening would be carried out by an advisory committee with appropriate scientific expertise, established by the competent authority in the receiving Member State. This advisory committee would provide an assessment of the proposal, and on request by the Member State, undertake an ERA to recommend accepting or rejecting the proposed action. In situations where transboundary issues arise, and/or the impacts of a movement are likely to occur outside of the Member State, the EC procedures would apply. This proposed action draws heavily on the existing ICES (International Council for the Exploration of the Sea) and EIFAC (European Inland Fisheries Advisory Commission) Codes, given the long history and underlying principles developed by these Codes.

4. National Frameworks

Several nations have established regulatory frameworks for the prevention and management of marine bioinvasions associated with aquaculture (Williamson, *et al.,* 2002; Miller & Fabian, 2004). Most national frameworks are based on quarantine control standards, with special attention paid to import controls to prevent disease and associated parasite imports. In few instances are imports of new species for aquaculture purposes specifically assessed for impacts to native biodiversity (but see New Zealand's HSNO Act, 1996). Here we present examples from Australia, New Zealand and Chile to illustrate three similar, but different approaches to this problem.

4.1 Australia

Several significant and high profile invasions have occurred in Australia resulting in serious environmental and economic impacts (Hewitt, 2004). Several of these invasions have either been the result of, or had potential to impact on aquaculture interests.

In the 1930s, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) intentionally transported and successfully introduced the Japanese oyster, *Crassostrea gigas*, to a number of locations in southern (temperate) Australia. This species was subject to significant research efforts to determine its suitability (biologically) and viability (economically) for Australia. Subsequently, it has become a well established and viable industry in New South Wales, Tasmania, South Australia and Western Australia, however is identified as a noxious pest (or noxious fish under Tasmanian law) in Victoria and Tasmania when in feral populations and is restricted in its transport and use in New South Wales due to fears of competition with the native Sydney Rock Oyster, *Saccostrea glomerata,* another highly valued aquaculture species.

Invasive Alien Species that have caused concern to aquaculture practice include the North Pacific Seastar, *Asterias amurensis*, a voracious predator now well established in Tasmania and Port Phillip Bay (Victoria) (Hewitt, *et al.,* 1999); the Black-striped Mussel, *Mytilopsis sallei*, a fast-growing fouling species successfully eradicated from Darwin Harbour in 1999 (Bax, 1999; Campbell & Hewitt, submitted), and a number of dinoflagellates (*Gymnodinium catenatum*, and several *Alexandrium* species) toxic to humans (Hallegraeff, 1993).

Australia has developed a National System for the Prevention and Management of Marine Pest Incursions to address all potential marine pest vectors underpinned by a risk assessment framework and to specifically establish arrangements for prevention, emergency preparedness and response, and ongoing management and control. The primary piece of legislation is the Quarantine Act of 1903, with subsequent amendments that empower the control and quarantine system.

At present, aquaculture management is partitioned into quarantine associated with import standards, established by Biosecurity Australia[4] and implemented by the Australian Quarantine Inspection Service (AQIS); and operational management at the State and Territory levels. The importation of a new species for use as an aquaculture product would therefore need to be assessed and approved by Biosecurity Australia, with appropriate approvals by AQIS. Once these approvals are in place, importation could proceed once approvals from the State or Territory were provided. Under the current National System, it would be unlikely that approvals for a new importation of a species for open water culture would proceed due to the obligations to prevent and minimise impacts of non-native species in the marine environment.

If approvals were given, the operator would be required to submit and have approved an Emergency Marine Pest Plan that outlines options for action in the event of escape or other problems such as a disease outbreak. Similarly, it is likely that ongoing monitoring would be required with mandatory reporting to State and Territory authorities. Genetically Modified Organisms would be subject to similar procedures, however additional requirements have been created for Ministerial oversight for GMOs.

4.2 New Zealand

Much like Australia, New Zealand has experienced significant biodiversity and economic losses as a result of some intentional and accidental bioinvasions. While not all bioinvasions have created such losses, and in some cases form the bases of significant industries, New Zealand is one of the few countries in the world to have drafted specific pieces of legislation aimed at the comprehensive prevention and management of non-indigenous species: the Biosecurity Act (1993), and subsequent amendments, and the Hazardous Substances and New Organisms (HSNO) Act (1996). The Biosecurity Act is oriented towards the management of unintentional introductions of species and sets out the standards for creating pre-border quarantine systems as well as the post-border incursion response and continued management. The HSNO Act is oriented towards the intentional introductions of new species or genotypes and is managed by the Environmental Risk Management Authority (ERMA).

Biosecurity delivery, until recently was organised and implemented within sectoral departments (e.g. Human Health, Animals, Plants, Forests, Marine, and Conservation). Following a number of evaluations and Parliamentary reports (PCE, 2000), government established the Biosecurity Council with a mandate to develop a Biosecurity Strategy, released in 2003 (Biosecurity Strategy, 2003). As a direct consequence, biosecurity delivery has been reorganised into a new agency, Biosecurity New Zealand (BNZ), established within the Ministry of Agriculture and Forestry (MAF) in November 2004. BNZ brings together core MAF biosecurity functions and transfers responsibilities from Department of Conservation (conservation biosecurity) and the Ministry of Fisheries (marine biosecurity).

The intentional importation of novel species for aquaculture introductions would require a submission to ERMA under the HSNO Act, with supporting documentation to establish the potential risks to New Zealand's native flora and fauna, and existing economic, social and cultural values. The proposal would also be required to identify risk mitigation procedures with a clear evaluation of Emergency Response options. Once approvals were made by ERMA, Biosecurity New Zealand would undertake an evaluation for unintentional introductions associated with the approved species (e.g., pests, pathogens, parasites). This process would culminate in an Import Health Standard that sets the quarantine bounds on importation. Genetically Modified Organisms are considered New Organisms under the Act and are subject to rigorous assessments. The current stance in New Zealand is not to allow the release of GMOs from containment.

If a species and importation permit were granted, the intended use of an aquaculture leases must be approved under the local Regional Council's authority and managed under Regional Management Plans that are negotiated under agreement with a wide array of stakeholders. Regional Councils can impose monitoring and mitigation obligations on users of aquaculture leases under individual permitting and bye-laws. In addition, the Ministry of Fisheries would retain obligations for impacts on wild fisheries and the Department of Conservation for impacts on native biodiversity.

4.3 Chile

Chile is currently evaluating the establishment of an improved import model for non-native aquaculture species. This is similar to the models used by Australia and New Zealand in that it follows a science-based evaluation of risks posed by a new species importation to the economic and environmental (biodiversity) values of the country, but also incorporates an assessment of costs and benefits to society to aid in establishing an acceptable level of risk (Campbell, in press). The model is based on an importation request, with supporting documentation using standardised templates, that must include information on the target import species, the export and import facilities, and any risk mitigation procedures that the importer intends to put in place.

Based on the information provided, the Subsecretariat of Fisheries will determine whether the request involves species (or associated species) that may cause unacceptable harm to the Chilean environment and/or economy, whether the export facility is likely to have diseases, parasites or additional species living on or in the target species and whether the import facility adequately addresses the risks posed by the import. In addition, the Chilean government will identify what environmental health monitoring will be established and whether it meets the statutory requirements under law.

This process is currently under evaluation with the intent to establish a clear and transparent framework for assessing a number of applications for expanding the current aquaculture interests in Chile (Gonzales, *et al.,* in prep; Campbell, in press). For species that have been evaluated to have an acceptable risk level, an obligatory experimental evaluation of a species' survival, growth and interactions with native biota and potential control options, must occur under quarantine conditions (e.g., fully closed system) in Chile. The Chilean government is currently considering a certification scheme for approval of private provider quarantine facilities. Upon completion of the risk assessment and experimental evaluation, a decision-maker is able to determine whether to reject or accept an application. In addition to the import risk assessment, any aquaculture development project must also provide an Environmental Impact Assessment under legislation that includes a statement of risks to native biota, the management and control options and a contingency plan for escape or release.

[4] Biosecurity Australia, within the Department of Agriculture, Forestry and Fisheries, provides science based quarantine assessments and policy advice that protects Australia's favourable pest and disease status and enhances Australia's access to international animal and plant related markets.

5. Application of Current Codes

Application and uptake of the FAO CCRF and the ICES CoP are difficult to determine as explicit performance measures or formal reporting mechanisms for these voluntary Codes do not exist. From what information is available, uptake appears to be largely restricted to developed countries with significant scientific and quarantine infrastructure in place. With regard to aquaculture, the FAO CCRF has been informally applied in a number of developing countries; however this application has been restricted to the development of aquaculture interests rather than focused on the use of Alien Species.

After the initial development of the ICES CoP, the ICES WGITMO has received a diminishing number of requests for evaluations by Members over the last several years. In part this may be due to an increased awareness of the issues associated with invasive Alien Species importations and releases by the aquaculture public, or it might be due to the uptake into local legislation the assessments embodied within the ICES CoP. There is a considered concern by ICES Members however that the non-binding, voluntary nature of the ICES CoP makes some of the more onerous decisions it recommends unpalatable to many member countries.

Even in these situations however, applications of the FAO and ICES Codes may be limited or embedded within jurisdictional frameworks that restrict implementation. Consequently, adherence to these voluntary codes can be difficult to ascertain. A recent example is the State of Virginia's proposed introduction of the northeastern Pacific oyster, *Crassostrea ariakensis*, into Chesapeake Bay as a triploid to replace the depleted stocks of the native oyster, *C. virginica.* Despite a number of significant concerns by neighbouring states within the USA and requests by ICES member states for the USA to engage the ICES process, no proposal was forwarded to ICES WGITMO. A similar process to that described within the ICES CoP was followed by local authorities, however wider concerns continue to be voiced.

In part, the lack of adoption and implementation of the ICES CoP by many countries, particularly developing countries, is the perception of a complex and very comprehensive assessment process embodied in the ICES CoP. While the ICES CoP provides a good model for the biological information requirements to assess an importation proposal, it does not provide detailed guidance on the risk assessment process or methods of evaluation and does not highlight the trade-offs that decision-makers face in reconciling social, economic and environmental concerns.

In recognition of the above, a simplified suite of considerations for decision makers and managers is provided below. It aims to ensure a transparent and scientifically based decision making process in determining if a proposal for the import and use of Alien Species in aquaculture should be approved. These considerations maintain the precautionary approach supported by the FAO CCRF and the ICES CoP, but include the economic, social and cultural aspects of the decision making process.

6. Considerations for the Responsible Use of Alien Species in Aquaculture

It is now widely recognised that Alien Species represent a threat to environmental, economic, social and cultural values. Frequently, the threats posed are either unrealised or remain unobserved in the context of resource management where impacts on social use or cultural values (e.g., aesthetics) are difficult to discern and ascertain. In this context, a number of international agreements encourage national governments to restrict the intentional importation and use of Alien Species in the environment in recognition of the potential for these species to become invasive. As indicated by the FAO (1996), a precautionary approach would severely restrict the use of Alien Species in aquaculture or mariculture activities, and in preference rely on the development of native stocks.

Nonetheless, the increasing population pressures and demand for aquatic resources, coupled with the desire for many countries to engage in significant economic development of fisheries and aquaculture resources is leading to the increasing use of Alien Species in aquaculture, some of which have proven to be invasive with adverse and irreversible impacts on the native environment. In many instances, the importation and use of Alien Species in aquaculture has been and is still promoted by international aid and development agencies to reduce poverty and increase food security in developing countries. Few incentives, either in direct investment or research and development has been made to foster the use of native species for aquaculture purposes. A first step for ensuring responsible aquaculture activities would be a shift in funding strategies by these organisations to direct investment in the use of native species for aquaculture purposes, either as primary species for human consumption, or as food products for aquaculture species growth.

Recognising that the current incentives for use of Alien Species in aquaculture remain high, particularly for developing countries, the following recommendations are intended as a guideline for national governments to implement responsible use of Alien Species in aquaculture. These guidelines are largely based on the FAO Code of Conduct on Responsible Fisheries (1995) and the ICES Code of Practice on the Introductions and Transfers of Marine Organisms (2005), and aim to provide a simple, explicit and readily implementable procedure for consideration of importation and use of Alien Species. These guidelines focus primarily on marine systems, however may equally be applied to freshwater.

Governments and regulatory bodies should consider the need for use of Alien Species in aquaculture given the possible adverse and irreversible impacts to the natural environment, economic, social and cultural values. Justification for the use of Alien Species should evaluate the short-term benefits to society against the consequences of short and long-term impacts. To do this it is recommended that a clear, transparent and participative decision-making process is established based on robust scientific evidence and the application of the precautionary approach.

6.1 Roles and responsibilities:

Importations are necessarily undertaken at a national government level. It is imperative that the roles and responsibilities of government bodies for importation, regulation and subsequent management of Alien Species be identified and supported by necessary legislative, policy and regulatory frameworks. As can be seen in section 4, a wide variety of national legislation examples exist, however all share the focus on a quarantine approach to prevention of the allowed importation of species that may cause harm to specific values (environmental, economic, social and/or cultural) relying on risk assessment.

The questions in Table 1 will aid governments in deciding whether an assessment will occur and under what governmental authority. In instances where mandates are shared between two or more organisations (e.g., the Department of Fisheries and the Department of Conservation), it is recommended that a national commission be created with reporting responsibilities to the appropriate Ministerial (or equivalent) Portfolios.

The decision making authority should determine the minimum level of benefit to society for a project proposal to be considered. For example, a project that provides low employment opportunities for a region and consists of offshore investment with little local infrastructure and revenues is unlikely to provide social incentives for approval. This minimum standard will aid in screening proposals that are unlikely to succeed.

The decision making authority should also determine an Acceptable Level of Protection (ALOP) for considering the importation of Alien Species – that is, the level of risk associated with an activity that is outweighed by the possible benefits to society of the activity. For example, a society may determine that no benefits to society will outweigh the likely impacts of an Extreme Risk scenario (Table 3) and therefore, the acceptable level of protection for that society will be set at High Risk. As a consequence of this decision, any risk assessment of a proposal that results in an Extreme Risk will be rejected before a full evaluation of the societal benefits and High risk scenarios will require full consideration of risk mitigation strategies.

It should be established who is responsible for developing the import request (the proponent of the importation or a government body) and for providing the appropriate information to support the evaluation of the request. Evaluation of proposals is a costly and time-consuming process and governments should consider cost-recovery mechanisms in order to ensure appropriate and timely evaluations.

6.2 Proposal for importation:

The proposal should be the responsibility of the proponent of the importation and aquaculture development – in some instances this will be the government or a government agency.

Questions for governments	
1.	Does your government allow the importation of alien (marine) species? for aquaculture purposes?
2.	Will any new species imports be allowed for aquaculture purposes?
3.	Has an acceptable level of protection been determined for the importation of new species?
4.	Under what national regulation(s) will the import of a new species occur?
5.	Which governmental agencies/Ministries are responsible for management of these regulations?
6.	Will these new species be allowed for uncontrolled release, within controlled or quarantine facilities?
7.	Will the responsibility for managed (e.g., aquaculture species) be different from wild (e.g., feral or released species) populations?
8.	Who will be responsible for the importation (e.g., private individual, research agency/University, industry or government)?
9.	Under what legislative arrangements will release into either a managed facility or a wild fishery occur?
10.	Who will be responsible for managing the release (e.g., private individual, research agency/University, industry or government)?
11.	Are there appropriate monitoring systems in place to detect and manage accidental releases in the environment?
12.	Can neighbouring jurisdictions be potentially affected, and if so, are there communication pathways in place? Will the neighbouring country be involved in the decision-making process?
13.	Are there existing emergency response measures, including identification of the responsible authorities, in case the introduction shows unforeseen negative impacts?

Table 1: Questions to aid governments in identifying appropriate governance and management of aquaculture importation proposals.

In these instances, an independent commission should be established to guarantee equivalent rigour in the assessments. The proposal should provide sufficient information for the evaluation of importation risk to occur with a minimum of additional research. Consequently, as a minimum, the required information should include the species scientific name, population biology including the disease and parasite status of the potential source populations, the export facility and procedures to be used in guaranteeing single species export (e.g., cleaning, sterilisation, use of antibiotics, etc), the import facility including effluent treatment, location (proximity to the ocean) and emergency management plans (e.g. eradication programs and mitigation measures), and any intended risk mitigation procedures (including emergency response plans for escapes) should be identified and provided by the proponent (Campbell, in press). In addition, the proponent must identify the possible benefits to society including employment opportunities, income streams and investments. In order to facilitate the process and provide clear instructions to the proponent, a pro-forma should be provided by the government (see Annex I for an example).

6.3 Assessing the proposals:

In order to maintain consistency of approaches across multiple nations and to remove bias in scientific advice, it is recommended that an expert working group be established within the region/country for the evaluation of Alien Species importation proposals on an as needs basis. The current ICES CoP provides its Working Group on Introductions and Transfers of Marine Organisms (WGITMO) as an approval body, however this is clearly unacceptable to non-ICES member nations; this Working Group, however, may be approached for guidance and advice. It should be noted that a voluntary body would be inappropriate for this activity due to the potential for conflicts of interest and the need for consistency through time.

The process for evaluating the proposals should follow a rigorous risk assessment approach. A number of possible methods exist from fully quantitative, semi-quantitative and fully qualitative, each with a trade-off between required detail (hence cost) and accuracy. A fully quantitative risk assessment is likely to provide a highly accurate result, however may require several years of evaluation and significant investment in underlying data (Hewitt & Hayes, 2002). In contrast, a fully qualitative risk assessment can be conducted rapidly, but may not provide the accuracy required and hence not be useful for decision making. Semi-quantitative assessments have become more common, providing a balance between cost in time and resources and accuracy of outcomes.

Regardless of the type of risk assessment selected, the endpoint of the assessment process must be defined. Most quarantine endpoints are related to the entry of a species into the quarantined environment; that is the failure of a quarantined border. In risk assessments of biological invasions (e.g., ballast water: Hilliard, *et al*., 1997; Hayes & Hewitt, 1998), the endpoint of discharge or inoculation into the receiving environment has been identified as providing the greatest level of protection and meeting the requirements of precaution

Level	Descriptor	Description	Probability of Event Occurring
1.	Rare	Event will only occur in exception circumstances	<5%
2.	Unlikely	Event could occur but not expected	5 - 25%
3.	Possible	Event could occur	26 - 50%
4.	Likely	Event will probably occur in most circumstances	51 - 75%
5.	Almost Certain	Event is expected to occur in most circumstances	76 - >95%

Table 2: Likelihood matrix after Campbell (2006); event equals release of the species into an environment where it can survive.

(Hewitt & Hayes, 2002). For the purposes of aquaculture, specifically relating to the intentional import of a new species, the endpoint should be assessed as the likelihood that the species will be released into an environment where it can survive (and hence could cause harm).

Campbell (2005a, 2006, in press) provides a semi-quantitative approach to risk assessment for evaluating impacts on environmental, economic, social and cultural values. Campbell provides a suite of consequence matrices for species based evaluations (see Annex II) that, coupled with likelihood (Table 2), provide an assessment of risk (Table 3). Each consequence matrix (Annex II) should be completed in a transparent and participatory process, relying on an expert panel and explicit to the individual project proposal. For each value (environmental, economic, social, cultural) either the average or the median value should be calculated between appropriate consequence matrices in order to represent the central tendency of consequence scores for a species (see Campbell, 2006 for discussion).

Assessment of environmental, economic, social and cultural values should be undertaken individually and then as a whole in order to address the potential for differing application of national legislation. For example, environmental impacts will be managed through differing legislation than human health impacts, and are likely to have differing levels of acceptable protection.

In contrast, the ICES CoP (2005) provides a semi-quantitative approach that evaluates the likely genetic, ecological, and disease impacts of an importation using a point system, taking no account of economic or social implications. The ICES CoP requests information for a series of questions which are then scored according to likelihood by a group of experts and summed across questions to generate a final outcome. While this approach is similar to that used in many quarantine systems for the generation of black lists, it does not provide a true representation of *risk* (likelihood * consequence) but instead estimates the probability that any of a number of adverse consequences may occur.

As a first principle, uncontrolled releases into the aquatic environment will be considered to have an Almost Certain (5) likelihood. As a result, evaluations of risk are likely to result in Extreme results. Consequently, applications that propose open culture, or culture with direct and untreated release of waste water to receiving environments should be discouraged. For example, the open ocean culture of the Japanese abalone, *Haliotis discus hannae*, in Chile represents an Extreme risk due to an Almost Certain (5) likelihood ranking coupled with the potential for Major impacts (see Table 3). This may present an unacceptable risk to the environment, economy and society in Chile.

A risk mitigation strategy for managing the Japanese abalone would be to propose a self-contained, quarantine facility, where no live animal departs the facility and all waste water is heated to > 90°C prior to discharge. In this instance the likelihood of release in waste water decreases from Almost Certain (5), to Rare (1), and thus decreases the risk. However, the species in culture may still be accidentally released due to unexpected floods etc.

The outcomes of the risk assessment provide clear advice to be weighed against the Acceptable Levels of Protection and

	Consequence				
Likelihood	**Insignificant**	**Minor**	**Moderate**	**Major**	**Significant**
Rare	N	L	L	M	M
Unlikely	N	L	M	H	H
Possible	N	L	H	H	E
Likely	N	M	H	E	E
Almost certain	N	M	E	E	E

Table 3. Risk Matrix. N = negligible; L = low, M = moderate; H = high; E = extreme (after Campbell, 2006)

should be evaluated against the project specific social and economic benefits to the importing nation. It is recommended that Extreme risk scenarios be rejected automatically through the ALOP process and that High risk scenarios be rejected in all instances where no risk mitigation strategy can be identified. The primary risk mitigation strategy for consideration should be to locate the importation and grow-out facilities as far physically from suitable environments, such as the ocean, estuaries or freshwater systems (in the case of species able to survive in freshwater). Additional risk mitigation strategies may include complete quarantine facilities (complete control including recycling of water and sterilisation of effluents), use of single sex or sterile populations (mindful of possible risks associated with incomplete sterilisation, e.g., use of triploids).

Once the risk assessment has been completed, a decision making authority may wish to undertake a secondary and more explicit cost : benefit analysis to determine if the identified risk is worth taking in relation to possible benefits. Again, this evaluation may highlight projects that have marginal benefits in relation to risks, or identify high risk ventures with high benefits that require additional attention to risk mitigation strategies.

6.4 Communication, monitoring and reporting:

Once the project evaluation is complete and a decision has been made, it is imperative that feedback to the proponent be provided as soon as possible. Three scenarios present themselves: 1) the proposal is rejected and the proponent does not proceed; 2) the proposal is rejected and the proponent chooses to resubmit the proposal based on lessons from the previous attempt; or 3) the proposal is accepted with specific requirements placed on the proponent. It is advised that feedback to the proponent should include a summary of the assessment process including explicit concerns raised through the evaluation process. Throughout the evaluation, special attention should be given to transparency and appropriate process, for example explicit Terms of Reference for the expert panels, appointment processes and declaration of conflicts of interest, etc…

All successful applications should incorporate monitoring processes to determine if an accidental release has occurred, or if disease or parasite infestations exist in the facility. Explicit emergency management plans and training procedures should be provided and in place to deal with any accidental release, alternatively a levy on the industry by the government to build emergency response capacity could be considered.

Monitoring should occur at a minimum on an annual basis, but preferably on a quarterly basis and its results should be provided to the appropriate management authority. The appropriate management authority should be notified immediately in instances where: 1) detection of release occurs; 2) an infestation of a pest, parasite or pathogen is detected; 3) a significant mortality event occurs. In any of these instances, a delimitation survey as a continuation of the monitoring efforts should be undertaken to determine the necessity and opportunity to apply eradication programmes or other mitigation measures. In situations where a species is maintained in a controlled (quarantine) facility, it is advised that monthly reports of animals or plants that are maintained, suffer natural mortality, or are killed and transported outside the facility are submitted to the managing authority. National governments are advised to create mandatory reporting requirements for accidentally released species.

In order to guarantee responsible practice by industry, governments may consider the establishment of industry best practice models, with industry support for external third-party reviews appointed by government. In this circumstance, it is expected that industry groups would provide the primary motivation for this practice and governments would evaluate and approve the final products. This aspect of self-management has proven successful in numerous instances where economic benefits are linked with performance standards. The government and the industry can also join forces to look into establishing incentives such as certification schemes, or using insurance services to cover costs of remediating environmental damage. A number of examples of industry led, best practice guidelines exist such as the New Zealand Greenshell Mussel Industry Exotic Disease Response Plan (http://www.nzmic.co.nz/Assets/Content/Publications/nzmic-exoticdiseaseresponseplan.pdf), however there is no explicit model for the use and management of Alien Species in aquaculture.

Conclusions

The strong focus on food security, poverty reduction and development needs in many regions, with the projected increase in requirements for marine sources of protein coupled with decreasing wild fisheries stocks, will create pressures on many nations to increase the use and diversity of Alien Species in aquaculture operations throughout the world. As a consequence, many nations will need to determine if they have adequate legislation and policy in place to manage such activities.

No explicit international instrument to regulate the use of Alien Species for aquaculture purposes has been developed, although several international and regional guidelines and codes have been agreed. It is important that any national government considering the use of new Alien Species for aquaculture undertakes efforts to ensure that this will be conducted in a responsible manner, and where necessary, address trans-boundary issues as part of the decision-making process. In addition, governments should consider the review and management of previous Alien Species imports and releases in a fashion consistent with any new strategy. As a first step, the precautionary approach should be the foundation for the development of such a strategy.

This document was intended to provide a brief review of existing structures at international, regional and national levels that might prove useful in aiding such an evaluation, and to provide a simplified suite of considerations for undertaking an assessment, evaluation and management of Alien Species imports for aquaculture purposes. In this fashion, it is hoped that the risks of new aquaculture importations can be sufficiently decreased as to prevent the accidental introduction of Invasive Alien Species.

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ANNEX I - Prospectus Outline

Provide a hardcopy proposal for each species being proposed for import. Multiple species will not be considered.

All information fields must be addressed. State where information is unknown or not available. All information should be provided either as citations to published literature, or where supported by unpublished research, documentation of the original research provided for evaluation.

Proposals and supporting documentation should be submitted in electronic and hardcopy form to facilitate rapid evaluation.

Business Data

1. Provide the legal name of the owner and company, the aquaculture licence number and the business licence (if applicable) or the name of the sponsoring government agency or department.
2. Provide a contact name, physical and mailing address, telephone, fax and email information.
3. Provide a business plan with details of proposed employment opportunities and growth potential.
4. Describe the objectives and rationale for the proposed introduction, including an explanation as to why such an objective cannot be met through the utilization of a native species or an alien species already present in the country.
5. What is the geographic area of the proposed introduction? Indicate if the proposed area of introduction also includes contiguous waters that may have suitable habitat. Include a map.
6. Describe the numbers of organisms proposed for introduction (initially, ultimately).

Species information

1. Name of the organism(s) being proposed for introduction or transfer (common and scientific names including taxonomic group, genus and species and commonly used synonyms).
2. Identify the life cycle with explicit characterisation of life history stages and their longevities.
3. Describe the distinguishing characteristics of the organism and how it may be distinguished from similar species in its area of origin and proposed area of introduction. Include a scientific drawing or photograph.
4. Has the species previously been introduced into the proposed aquaculture region?
5. Identify where the species has previously been introduced.
6. Describe any recorded impacts in other locations
   a. ecological (predator, prey, competitor, and/or structural/functional elements of the habitat, mass occurrences)
   b. economic (infrastructure, wild fisheries, aquaculture)
   c. social and cultural (human health, recreational fishing, beach use, diving)
7. Describe the mode(s) of reproduction (including any asexual stages i.e. fission) and natural triggers and artificial means for conditioning and spawning, or other forms of reproduction. Include duration of the pelagic stages (if present).
8. Describe how the species becomes dispersed and if there is any evidence of local or larger scale seasonal or reproductive migration(s).
9. Describe the growth rate and lifespan and where possible extrapolate likely rates of growth in the introduced area based on information from its native range and where it has become introduced.
10. Describe the known pathogens and parasites of the species or stock including epibionts and endobionts. Are there specific taxonomic groups that pose a risk? Is it a known carrier of pathogens or life history stages of harmful stages? Will it act, in its new environment, as an intermediate host for unwanted species?
11. List nearest populations and indicate why the potential source population is being considered over other sources (e.g. disease-free status of source population).

Life History Information of the Species to be Introduced or Transferred (For Each Life History Stage)

1. Describe the physiological tolerances at each life history stage (from early life history stages to adult, and for reproductive development) including any resting stages:
   a. maximum and minimum LD_{90} temperature,
   b. maximum and minimum LD_{90} salinity,
   c. maximum and minimum LD_{90} water quality including turbidity, oxygen, and salinity
   d. If known, what factors limit the species in its native range?
2. Describe the habitat preferences and depth limits for each life history stage including substrate types and adaptability to different habitats.

3. Describe the feeding methods and food preferences for each life history stage. In case of algae describe the light and nutrient preferences.

Receiving Environment and Contiguous Water bodies

1. Provide information on the receiving environment and contiguous water bodies such as
   a. hydrodynamics,
   b. seasonal water temperatures,
   c. salinity,
   d. water quality including turbidity, dissolved oxygen, pH, nutrients, pollutants,
   e. substrate.
2. Have you undertaken an analysis of the proposed site of introduction?
   a. List species composition (the principal aquatic vertebrates, invertebrates and plants) of the receiving waters.
   b. What habitats are available within 1km of the introduction site?
3. For the planned site of introduction and culture, what is the likelihood of natural events that could result in the accidental release of the species into the natural environment? These events could include:
   a. floods,
   b. earthquakes,
   c. tsunamis,
   d. hurricanes, typhoons, cyclones.
4. Describe the natural and/or man-made structures relied upon to preventing or enhancing the spread of the introduced organisms to adjacent waters. Include flow rates and direction of flow that might distribute the introduced species.
5. Are there any rare, threatened or endangered species near the proposed site of introduction? If so, list the species.
6. Are there any coastal or marine protected areas (including Ramsar sites and World Heritage Sites) near the proposed site of introduction?
7. If so, what are the proposed monitoring and management plans?
8. What other existing commercial, recreational or cultural activities or areas of significance near the proposed site of introductions?

Precautions and Management Plan

1. Describe the management plan for the proposed introduction or transfer. This should include but not be restricted to the following information:
   a. details of the disease certification status of stock to be imported. Include information on stage of introduction (e.g., eggs, sperm, juveniles, etc.);
   b. disease monitoring plan proposed for the introduced stocks following introduction or transfer;
   c. precautions taken to ensure that no unnecessary associated biota accompany the shipment;
2. Precautionary measures that need to be met for each phase of development.
3. For closed contained systems describe the chemical, biophysical and management precautions being taken to prevent accidental escape of any target as well as non-target taxa to recipient ecosystems. Provide details of the water source, effluent destination, effluent treatments, local drainage and proximity to storm sewers, predator control, site security, precautions to prevent escapes.
4. Describe contingency plans to be followed in the event of an unintentional, accidental or unauthorized liberation of the species from rearing and hatchery facilities or an accidental or unexpected expansion of the range deduced at the pilot or later stages. Also, describe a contingency plan to address the finding of a disease agent of significance (e.g. exotic disease agent to the area of introduction).
5. Describe the proposed monitoring plan that will be implemented should the proposal be approved. Include the scientific rationale and expertise for the proposed plan and include site maps and procedures for sampling and specimen and data analysis. It is advised that the curriculum vitae of the primary scientific personnel involved in the proposed monitoring be included.

References

1. Provide a detailed bibliography of all references cited in the course of the preparation of the Proposal and Appendices.
2. Provide a list of names, including addresses, of scientific authorities and fisheries experts consulted and listed in the information provided.

ANNEX II - Generic Examples of Consequence Matrices for Introduced Species

(from Campbell, 2005a, 2005b; Hewitt & Campbell, 2005)

Table B1. Consequence matrix: Environment – Biodiversity

Level	Descriptor	Biodiversity Impacts
1.	Insignificant	• Biodiversity (non-commercial species, non-habitat forming species and unprotected species) reduction is minimal (<10%) compared to loss from other human-mediated activities. • Reductions in species richness and composition are not readily detectable (<10% variation). • If the introduced species was removed, recovery is expected in days; no change in species richness or composition.
2.	Minor	• Biodiversity (non-commercial species, non-habitat forming species and unprotected species) reduction is <20% compared to loss from other human-mediated activities. • Reductions in species richness and composition are not readily detectable (<20%). • Biodiversity (non-commercial species, non-habitat forming species and unprotected species) reduction and area of introduced species impact is small compared to known areas of distribution (<20%). • If the introduced species was removed, recovery is expected in days to months; no loss of species (non-commercial species, non-habitat forming species and unprotected species) populations; no local extinctions.
3.	Moderate	• Biodiversity (non-commercial species, non-habitat forming species and unprotected species) reduction is <30% compared to loss from other human-mediated activities. • Reductions in species richness and composition are <30%. • Biodiversity (non-commercial species, non-habitat forming species and unprotected species) reduction and area of introduced species impact is moderate compared to known area of distribution (<30%). • If the introduced species was removed, recovery is expected in less than a year; loss of at least one species (non-commercial species, non-habitat forming species and unprotected species) or populations; local extinction events.
4.	Major	• Biodiversity (non-commercial species, non-habitat forming species and unprotected species) reduction is <70% compared to loss from other human-mediated activities. • Reductions in species richness and composition are <70%. • Biodiversity (non-commercial species, non-habitat forming species and unprotected species) reduction and area of introduced species impact is small compared to known area of distribution (<70%); likely to cause local extinction. • If the introduced species was removed, recovery is expected in less than a decade; loss several species (non-commercial species, non-habitat forming species and unprotected species) or populations; multiple local extinction events; one regional extinction.
5.	Significant	• Biodiversity (non-commercial species, non-habitat forming species and unprotected species) reduction is >70% compared to loss from other human-mediated activities; • Reductions in species richness and composition are >70%. • Biodiversity (non-commercial species, non-habitat forming species and unprotected species) reduction and area of introduced species impact is small compared to known area of distribution (>70%); likely to cause local extinction. • If the introduced species was removed, recovery is not expected; loss of multiple species of populations of non-commercial species, non-habitat forming species and unprotected species causing significant local extinctions; global extinction of at least one species.

Table B2. Consequence matrix: Environment - Habitat

Level	Descriptor	Habitat Impact
1.	Insignificant	• No significant changes to habitat types observed; populations of habitat forming species are not affected (<1% change); introduced species impacts affecting <1% of area of each habitat type. • Changes in habitat not measurable against background variability; recovery is expected in days.
2.	Minor	• Localised affects on habitat in <10% of total habitat area; measurable changes to habitat types, measurable changes to habitat types, new habitat type observed; <10% reduction in population abundances of habitat forming species. • If the introduced species was removed, recovery is expected in days to months; no loss of habitat-forming species populations.
3.	Moderate	• <30% of habitat area affected/removed; moderate changes to habitat types, new habitat type(s) observed, possible loss of habitat type; <30% reduction in population abundances of habitat forming species. • If the introduced species was removed, recovery is expected in less than 1 year; no loss of habitat-forming species.
4.	Major	• <70% of habitat area affected/removed; major changes to habitat types, new habitat types observed, loss of most pre-existing habitat types; <70% reduction in population abundances of habitat forming species; local extinction of at least one habitat forming species. • If the introduced species was removed, recovery is expected in less than a decade; loss of habitat types and habitat-forming species; local extinction events.
5.	Significant	• >70% of habitat area affected/removed; significant changes to habitat types, no pre-existing habitat types existing; >70% reduction in population abundances of habitat forming species; local extinction of more than one habitat forming species, global extinction of one habitat forming species. • If the introduced species was removed, recovery is not expected; loss of multiple habitat types and habitat forming species populations causing significant local extinction; global extinction of at least one species.

Table B3. Consequence matrix: Environment - Protected Species

Level	Descriptor	Protected Species Impact
1.	Insignificant	• No protected species affected due to introduced species; impacts on behaviour not detectable. • In the absence of further impact, recovery is expected in days; no loss of protected species individuals.
2.	Minor	• Protected species reduction due to introduced species impacts is <1% compared to total human-mediated reduction. • Reductions in protected species population abundances are <1%. • If the introduced species was removed, recovery is expected in days to months; no loss of non-target species populations.
3.	Moderate	• Protected species reduction due to introduced species impacts is <10% compared to total human-mediated reduction. • Reductions in non-target species population abundances are <10%. • If the introduced species was removed, recovery is expected in less than a year; no loss of non-target species populations; potential loss of genetic diversity.
4.	Major	• Protected species reduction due to introduced species impacts is <20% compared to total human-mediated reduction. • Reductions in protected species population abundances are <20%. • If the introduced species was removed, recovery is expected in less than a decade; loss of protected species populations causing local extinction; measurable loss of genetic diversity.
5.	Significant	• Protected species reduction due to introduced species impacts is >20% compared total human-mediated reduction; • Reductions in protected species population abundances are significant >20%. • If the introduced species was removed, recovery is not expected; loss of protected species populations causing global extinction; local extinction of multiple protected species; significant loss of genetic diversity of multiple protected species.

Table B4. Consequence matrix: Environment - Trophic Interactions

Level	Descriptor	Trophic Interactions Impact
1.	Insignificant	• No significant changes trophic level species composition observed; no change in relative abundance of trophic levels (based on biomass). • Changes in trophic interactions not measurable against background variability; recovery is expected in days.
2.	Minor	• Minor changes (<10%) in relative abundance of trophic levels (based on biomass); <10% reduction of population abundances for top predator species. • If the introduced species was removed, recovery is expected in days to months; no loss of keystone species populations.
3.	Moderate	• Measurable changes (<30%) in relative abundance of trophic levels (based on biomass); <30% reduction of population abundances for top predator species. • If the introduced species was removed, recovery is expected in less than a year; loss of keystone species populations; no loss of primary producer populations.
4.	Major	• Major changes (<70%) in relative abundance of trophic levels (based on biomass); <70% reduction of population abundances for top predator species; <30% reduction of population abundances for primary producer species. • If the introduced species was removed, recovery is expected in less than a decade; loss of keystone species populations; changes in trophic levels; loss of primary producer populations; local extinction events.
5.	Significant	• >70% change in relative abundance of trophic levels (based on biomass); >70% reduction of population abundances for top predator species; >30% reduction of population abundances for primary producer species. • If the introduced species was removed, recovery is not expected; loss of trophic levels; potential trophic cascades resulting in significant changes to ecosystem structure, alteration of biodiversity patterns and changes to ecosystem function; significant local extinctions.

Table B5. Consequence matrix: Economic - Tourism

Level	Descriptor	Tourism Impacts
1.	Insignificant	• Reduction in national income from tourism shows no discernible change. • No discernable change in strength of tourism activities. • If the introduced species was removed, recovery is expected in days.
2.	Minor	• Reduction in national income from tourism is <1%. • Reduction of strength in individual tourism activities is <1%. • Tourism is reduced to 99% of its original area (spatial context) within *[insert country/region/port name].* • If the introduced species was removed, recovery is expected in days to months, no loss of any tourism industry.
3.	Moderate	• Reduction in national income from tourism is 1-5%. Reduction of strength in individual tourism activities is 1-5%; Tourism is reduced to less than 95% of its original area (spatial context) within • *[insert country/region/port name]*; If the introduced species was removed, recovery is expected in years with the loss of at least one tourism activities.
4.	Major	• Reduction in national income from tourism is 5-10% • Reduction of strength in individual tourism activities is 5-10%; • Tourism is reduced to less than 90% of its original area (spatial context) within *[insert country/region/port name]*; • If the introduced species was removed, recovery is expected in decades with the loss of at least one tourism activities.
5.	Significant	• Reduction in national income from tourism is >10% • Reduction of strength in individual tourism activities is >10%; • Tourism is reduced to less than 90% of its original area (spatial context) within the *[insert country/region/port name]*; • If the introduced species was removed, recovery is not expected with the loss of multiple tourism activities.

Table B6. Consequence matrix: Economic - Fishing

Level	Descriptor	Fishing Impacts
1.	Insignificant	• Reduction in national income from fishing shows no discernible change • Reduction in commercial species abundance shows no discernible change. • No discernable change in quality of product. • No discernable change in strength of fishing sectors. • No discernable change in costs of harvesting product (incl. costs of handling, damage to gear or research to mitigate impact). • If the introduced species was removed, recovery is expected in days.
2.	Minor	• Reduction in national income from fishing is <1%. • Reduction in commercial species abundance is <1% compared to loss from other human mediated activities. • Fishing is reduced to less than 99% of its original area (spatial context) within *[insert country/region/port name]*. • Reduction to quality of product <1%. • Increased costs of harvesting product (incl. costs of handling, damage to gear or research to mitigate impact) <1%. • If the introduced species was removed, recovery is expected in days to months, no loss of any fishing region.
3.	Moderate	• Reduction in national income from fishing is 1-5%. • Reduction in commercial species abundance is 1-5% compared to loss from other human mediated activities. • Fishing is reduced to less than 85% of its original area (spatial context) within *[insert country/region/port name]*. • Reduction to quality of product 1-5%. • Increased costs of harvesting product (incl. costs of handling, damage to gear or research to mitigate impact) 1-5%. • If the introduced species was removed, recovery is expected in less than a year and loss of at least one fishing region.
4.	Major	• Reduction in national income from fishing is 5-10%. • Reduction in commercial species abundance is 5-10% compared to loss from other human mediated activities. • Fishing is reduced to less than 90% of its original area (spatial context) within *[insert country/region/port name]*. • Reduction to quality of product 5-10%. • Increased costs of harvesting product (incl. costs of handling, damage to gear or research to mitigate impact) 5-10%. • If the introduced species was removed, recovery is expected in less than a decade and loss of at least two fishing regions.
5.	Significant	• Reduction in national income from fishing is >10%. • Reduction in commercial species abundance is >10% compared to loss from other human mediated activities. • Fishing is reduced to less than 90% of its original area (spatial context) within *[insert country/region/port name]*. • Reduction to quality of product >10%. • Increased costs of harvesting product (incl. costs of handling, damage to gear or research to mitigate impact) >10%. • If the introduced species was removed, recovery is not expected and loss of a number of fishing regions.

Table B7. Consequence matrix: Economic - Aquaculture

Level	Descriptor	Aquaculture Impacts
1.	Insignificant	• Reduction is national income from aquaculture shows no discernible change. • No discernable change in quality of product. • No discernable change in strength of aquaculture sectors. • No discernable change in costs of harvesting product (incl. handling costs, cost of damage to gear or research costs to mitigate impacts). • No discernable change in ability to sustain and expand aquaculture activities (incl. access to spat and/or opportunities expand an develop new and existing farms). • If the introduced species was removed, recovery is expected in days.
2.	Minor	• Reduction is national income from aquaculture is <1%. • Aquaculture is reduced to less than 99% of its original area (spatial context) within *[insert country/region/port name]*. • Reduction in quality of product <1%. • Increase in costs of harvesting product (incl. handling costs, cost of damage to gear or research costs to mitigate impact) <1%. • Reduction in ability to sustain and expand aquaculture activities (incl. access to past and/or opportunities expand an develop new and existing farms) <1%. • If the introduced species was removed, recovery is expected in days to months, no loss of any aquaculture region.
3.	Moderate	• Reduction is national income from aquaculture is 1-5%. • Aquaculture is reduced to less than 95% of its original area (spatial context) within *[insert country/region/port name].* • Reduction in quality of product 1-5%. • Increase in costs of harvesting product (incl. handling costs, cost of damage to gear or research costs to mitigate impact) 1-5%. • Reduction in ability to sustain and expand aquaculture activities (incl. access to past and/or opportunities expand an develop new and existing farms) 1-5%. • If the introduced species was removed, recovery is expected in less than 1 year and loss of at least one aquaculture region.
4.	Major	• Reduction is national income from aquaculture is 5-10%. • Aquaculture is reduced to less than 90% of its original area (spatial context) within *[insert country/region/port name]*. • Reduction in quality of product 5-10%. • Increase in costs of harvesting product (incl. handling costs, cost of damage to gear or research costs to mitigate impact) 5-10%. • Reduction in ability to sustain and expand aquaculture activities (incl. access to past and/or opportunities expand an develop new and existing farms) 5-10%. • If the introduced species was removed, recovery is expected in less than a decade and loss of less than two aquaculture regions.
5.	Significant	• Reduction is national income from aquaculture is >10%. • Aquaculture is reduced to less than 90% of its original area (spatial context) within *[insert country/region/port name]*. • Reduction in quality of product >10%. • Increase in costs of harvesting product (incl. handling costs, cost of damage to gear or research costs to mitigate impact) >10%. • Reduction in ability to sustain and expand aquaculture activities (incl. access to past and/or opportunities expand an develop new and existing farms) >10%. • If the introduced species was removed, recovery is not expected and loss of a number of aquaculture regions.

Table B8. Consequence matrix: Economic - Vessel / Moorings

Level	Descriptor	Vessel / Moorings Impacts
1.	Insignificant	• Increased costs associated with requirements to clean vessels / vectors before moving from one location to another are <1% of annual cleaning costs. • Increased costs associated with requirements to clean mooring sites are <1% of annual cleaning costs. • Increased costs associated with increased maintenance on vessels and moorings as a result of fouling are <1% of annual cleaning costs. • Lost business opportunities as a result of cleaning requirements / movement restrictions (incl. inability to access domestic / overseas ports) are <1% annual business turnover.
2.	Minor	• Increased costs associated with requirements to clean vessels / vectors before moving from one location to another are <10% of annual cleaning costs. • Increased costs associated with requirements to clean mooring sites are <10% of annual cleaning costs. • Increased costs associated with increased maintenance on vessels and moorings as a result of fouling are <10% of annual cleaning costs. • Lost business opportunities as a result of cleaning requirements / movement restrictions (incl. inability to access domestic / overseas ports) are <10% annual business turnover.
3.	Moderate	• Increased costs associated with requirements to clean vessels / vectors before moving from one location to another are <20% of annual cleaning costs. • Increased costs associated with requirements to clean mooring sites are <20% of annual cleaning costs. • Increased costs associated with increased maintenance on vessels and moorings as a result of fouling are <20% of annual cleaning costs. • Lost business opportunities as a result of cleaning requirements / movement restrictions (incl. inability to access domestic / overseas ports) are <20% annual business turnover.
4.	Major	• Increased costs associated with requirements to clean vessels / vectors before moving from one location to another are <40% of annual cleaning costs. • Increased costs associated with requirements to clean mooring sites are <40% of annual cleaning costs. • Increased costs associated with increased maintenance on vessels and moorings as a result of fouling are <40% of annual cleaning costs. • Lost business opportunities as a result of cleaning requirements / movement restrictions (incl. inability to access domestic / overseas ports) are <40% annual business turnover.
5.	Significant	• Increased costs associated with requirements to clean vessels / vectors before • moving from one location to another are >40% of annual cleaning costs. • Increased costs associated with requirements to clean mooring sites are >40% of annual cleaning costs. • Increased costs associated with increased maintenance on vessels and moorings as a result of fouling are >40% of annual cleaning costs. • Lost business opportunities as a result of cleaning requirements / movement restrictions (incl. inability to access domestic / overseas ports) are >40% annual business turnover.

Table B9. Consequence matrix: Social - Aesthetics / Diving

Level	Descriptor	Aesthetics / Diving Impacts
1.	Insignificant	• Reduction in the quality of the diving experience, in terms of access, visibility and safety, is <1%. • Reduction in the quality of the diving experience, in terms of naturalness of the surrounding habitat and the diversity of organisms, is <1%. • If the introduced species was removed, recovery is expected in days.
2.	Minor	• Reduction in the quality of the diving experience, in terms of access, visibility and safety, is <10%. • Reduction in the quality of the diving experience, in terms of naturalness of the surrounding habitat and the diversity of organisms, is <10%. • Diving is reduced to less than 90% of its original area (spatial context). • If the introduced species was removed, recovery is expected in weeks to months.
3.	Moderate	• Reduction in the quality of the diving experience, in terms of access, visibility and safety, is <20%. • Reduction in the quality of the diving experience, in terms of naturalness of the surrounding habitat and the diversity of organisms, is <20%. • Diving is reduced to less than 80% of its original area (spatial context). • If the introduced species was removed, recovery is expected in less than a year.
4.	Major	• Reduction in the quality of the diving experience, in terms of access, visibility and safety, is <40%. • Reduction in the quality of the diving experience, in terms of naturalness of the surrounding habitat and the diversity of organisms, is <40%. • Diving is reduced to less than 70% of its original area (spatial context). • If the introduced species was removed, recovery is expected in less than a decade.
5.	Significant	• Reduction in the quality of the diving experience, in terms of access, visibility and safety, is >40%. • Reduction in the quality of the diving experience, in terms of naturalness of the surrounding habitat and the diversity of organisms, is >40%. • Diving is reduced to less than 60% of its original area (spatial context). • If the introduced species was removed, recovery is not expected.

Table B10. Consequence matrix: Social - Vessel / Access

Level	Descriptor	Vessel / Access Impacts
1.	Insignificant	• Increased costs associated with requirements to clean vessels / vectors before moving from one location to another are <1% of annual cleaning costs. • Reduction in recreational enjoyment as a result of movement restrictions (incl. inability to access domestic / overseas ports) is <1%. • Increased costs associated with increased maintenance on vessels / vectors as a result of fouling are <1% of annual cleaning costs.
2.	Minor	• Increased costs associated with requirements to clean vessels / vectors before moving from one location to another are <10% of annual cleaning costs. • Reduction in recreational enjoyment as a result of movement restrictions (incl. inability to access domestic / overseas ports) is <10%. • Increased costs associated with increased maintenance on vessels / vectors as a result of fouling are <10% of annual cleaning costs.
3.	Moderate	• Increased costs associated with requirements to clean vessels / vectors before moving from one location to another are <20% of annual cleaning costs. • Reduction in recreational enjoyment as a result of movement restrictions (incl. inability to access domestic / overseas ports) is <20%. • Increased costs associated with increased maintenance on vessels / vectors as a result of fouling are <20% of annual cleaning costs.
4.	Major	• Increased costs associated with requirements to clean vessels / vectors before moving from one location to another are <40% of annual cleaning costs. • Reduction in recreational enjoyment as a result of movement restrictions (incl. inability to access domestic / overseas ports) is <40%. • Increased costs associated with increased maintenance on vessels / vectors as a result of fouling are <40% of annual cleaning costs.
5.	Significant	• Increased costs associated with requirements to clean vessels / vectors before moving from one location to another are >40% of annual cleaning costs. • Reduction in recreational enjoyment as a result of movement restrictions (incl. inability to access domestic / overseas ports) is >40%. • Increased costs associated with increased maintenance on vessels / vectors as a result of fouling are minimal (>40% of annual cleaning costs).

Table B11. Consequence matrix: Social - Recreational Harvest

Level	Descriptor	Vessel / Access Impacts
1.	Insignificant	• Increased costs associated with requirements to clean vessels / vectors before moving from one location to another are <1% of annual cleaning costs. • Reduction in recreational enjoyment as a result of movement restrictions (incl. inability to access domestic / overseas ports) is <1%. • Increased costs associated with increased maintenance on vessels / vectors as a result of fouling are <1% of annual cleaning costs.
2.	Minor	• Increased costs associated with requirements to clean vessels / vectors before moving from one location to another are <10% of annual cleaning costs. • Reduction in recreational enjoyment as a result of movement restrictions (incl. inability to access domestic / overseas ports) is <10%. • Increased costs associated with increased maintenance on vessels / vectors as a result of fouling are <10% of annual cleaning costs.
3.	Moderate	• Increased costs associated with requirements to clean vessels / vectors before moving from one location to another are <20% of annual cleaning costs. • Reduction in recreational enjoyment as a result of movement restrictions (incl. inability to access domestic / overseas ports) is <20%. • Increased costs associated with increased maintenance on vessels / vectors as a result of fouling are <20% of annual cleaning costs.
4.	Major	• Increased costs associated with requirements to clean vessels / vectors before moving from one location to another are <40% of annual cleaning costs. • Reduction in recreational enjoyment as a result of movement restrictions (incl. inability to access domestic / overseas ports) is <40%. • Increased costs associated with increased maintenance on vessels / vectors as a result of fouling are <40% of annual cleaning costs.
5.	Significant	• Increased costs associated with requirements to clean vessels / vectors before moving from one location to another are >40% of annual cleaning costs. • Reduction in recreational enjoyment as a result of movement restrictions (incl. inability to access domestic / overseas ports) is >40%. • Increased costs associated with increased maintenance on vessels / vectors as a result of fouling are minimal (>40% of annual cleaning costs).

IUCN
The World Conservation Union

Rue Mauverney 28
1196 Gland
Suiza

Tel +41 22 999 0000
Telefax +41 22 999 0002

mail@iucn.org
www.iucn.org

World Headquarters

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