International mechanisms for the control and responsible use of alien species in aquatic ecosystems

Report of an Ad hoc Expert Consultation
27–30 August 2003,
Xishuangbanna, People's Republic of China

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Preparation of this document

This document contains the report of and papers presented at the Ad hoc Expert Consultation, International Mechanisms for the Control and Responsible Use of Alien Species in Aquatic Ecosystems, held 27-30 August 2003, in Xishuangbanna, People's Republic of China. The Consultation was sponsored by the Asian Institute of Technology (AIT), Food and Agriculture Organization of the United Nations (FAO), Mekong River Commission (MRC), Network of Aquaculture Centres in Asia and the Pacific (NACA), University of California Sea Grant College Program (UCSG), World Conservation Union (IUCN), Ministry of Agriculture of the Peoples Republic of China, the FAO Fish Code Programme and the FAO/Netherlands Partnership Programme (FNPP); it was hosted by the Yunnan Provincial Bureau of Agriculture and the Xishuangbanna Fisheries Administration and Regulation Station. The contents were compiled and edited by Devin M. Bartley (FAO), Ram C. Bhujel (AIT), Simon Funge-Smith (FAO), Paul Olin (UC SeaGrant), and Michael Phillips (NACA); Devin M. Bartley was overall editor with layout and design by Daniela Scicchigno.

Abstract

The use of alien species is a proven means to increase production and value from aquatic ecosystems. In the Mekong/Lanchang Basin, alien species such as tilapia (*Oreochromis* spp.) play an important role in providing cheap and readily available protein to rural and poor sectors. However, alien species are now recognized as one of the most significant threats to aquatic biodiversity. Members of FAO and signatories to the Convention on Biological Diversity have obligated themselves to manage and control alien species that may adversely impact ecosystems. There are a range of international mechanisms that have been established to assist countries in meeting international obligations and responsibilities. The coverage of these international instruments, the signatory countries and the degree to which they are implemented varies throughout the world. Implementation is often difficult due to lack of awareness at national level of responsibilities under the respective instruments, problems with enforcement, and lack of basic information and capacity to undertake risk assessment. Several steps are necessary for effective use and control of alien species, but one of the most important was identified to be following codes of practice similar to that developed by the International Council for the Exploration of the Sea. The development and use of indigenous species are options to the use of alien species. However, indigenous species have not received the same amount of attention, research, development and use as many alien species. Regional coordination of policies and practices on alien species is needed for effective national management. National policies need to be in place and the population needs to be aware of issues before countries can implement international mechanisms. Thus, regional coordination and national policy development are necessary actions that should go hand in hand in order to facilitate implementation of broader international agreements.

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Report of the meeting

"The use of alien species is a proven means to increase production and value from aquatic ecosystems"

The use of alien species is a proven means to increase production and value from aquatic ecosystems. However, alien species are now recognized as one of the most significant threats to aquatic biodiversity. As such, Members of FAO and signatories to the Convention on Biological Diversity (CBD) have obligated themselves to manage and control alien species that may adversely impact ecosystems. Furthermore, the movement of aquatic species has importance to international free trade, but as well as providing benefits, may concurrently incur significant risk. Members of the World Trade Organization (WTO) have duties and responsibilities to promote free-trade whilst at the same time, taking measures for protecting human and animal health.

There are a range of mechanisms that include conventions, codes of practice, agreements and guidelines that have been established to assist countries in meeting international obligations and responsibilities. Important mechanisms that relate to the introduction or movement of aquatic species are:

Code of Conduct for Responsible Fisheries (FAO), created in 1995, sets out principles and international standards of behaviour for responsible practices with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity.

Code of Practice on the Introductions and Transfers of Marine Organisms (ICES), created in 1973 and updated in 2003, gives recommended procedures and practices to reduce the risks of detrimental effects from the intentional introduction and transfer of marine (including brackish water) organisms. Endorsed by FAO Regional Fishery Bodies.

Beijing Consensus and Implementation Strategy, created in 2000, a detailed implementation strategy for the Asia Regional Technical Guidelines on health management for responsible trans-boundary movement of live aquatic animals.

Cartagena Protocol on Bio-safety, adopted in 2000 under the Convention on Biological Diversity and in force from September 2003, seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology.

Convention on Biological Diversity, adopted in 1992 and in force from 1993, its objectives are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

Convention on Wetlands, adopted in 1971 and in force from 1975, also known as the Ramsar Convention, provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

World Trade Organization (WTO), established in 1995 is the only global international organization dealing with the rules of trade between nations.

World Organisation for Animal Health (OIE), established in 1924, in association with WTO helps, *inter alia*, guarantee the sanitary safety of world trade by developing sanitary rules for international trade in animals and animal products.

The coverage of these international instruments, the signatory countries and the degree to which they are implemented varies throughout the world. Part of the problem of implementation is related to lack of awareness at national level of responsibilities under the respective instruments. Additionally problems may also relate to conflicts between national aspirations and international obligations. The practical implementation of many of these instruments is also limited by institutional, financial and human capacity in many countries. The relationship between these various instruments and their relevance to the movement and introduction of aquatic species needs to be clarified and brought to the attention of those responsible for their implementation. Importantly, the development of practical and meaningful strategies for their implementation is urgently needed.

The workshop

To address the above concerns regarding international action on alien species in aquaculture and fisheries, an international workshop, *International Mechanisms for the Control and Responsible Use of Alien Species in Aquatic Ecosystems*, was convened from 27–30 August 2003, in Xishuangbanna, People's Republic of China. The workshop was sponsored by the Asian Institute of Technology (AIT), Food and Agriculture Organization of the United Nations (FAO), Mekong River Commission (MRC), Network of Aquaculture Centres in Asia and the Pacific (NACA), University of California Sea Grant College Program (UCSG), World Conservation Union (IUCN), Ministry of Agriculture (Fishers of the Peoples Republic of China and the FAO/Netherlands Partnership Programme (FNPP)). The workshop was hosted by the Yunnan Provincial Bureau of Agriculture and the Xishuangbanna Fisheries Administration and Regulation Station. The list of participants is included in Annex I.

Purpose and objectives

The purpose the workshop was to enable policy-makers and senior resource officers in the Greater Mekong/Lancang sub-region to use international mechanisms for the control, movement and responsible use of alien species in aquatic ecosystems. The objectives of the workshop were to review the international mechanisms, to identify major constraints to their implementation in the sub-region, and to identify future actions needed to promote the control, movement and responsible use of alien species in the greater Mekong/Lancang Sub-Region.

Process of the workshop

The programme of the workshop consisted of:

- presentation and discussion on relevant international mechanisms concerning alien species and trans-boundary movements, and their practical applicability in the Greater Mekong/Lancang sub-region;
- presentation and discussion of country status analyses and case studies and review on alien species in fisheries and aquaculture, in order to facilitate debate on development of practical strategies for the sub-region;
- development of recommendations for follow-up actions that can support countries of the the Greater Mekong/Lancang sub-region to work collaboratively, or individually, to promote responsible transboundary movement and use of alien species, in the sub-region;
- development of elements of an outline that will serve as a framework for the development of Technical Guidelines on the Control and Responsible Use of Alien Species in Fisheries and Aquaculture[1].

Output of the Workshop

The workshop affirmed the fact that alien species provide valuable food and economic opportunity to rural sectors of the Mekong/Lancang River Basin. However, there are also environmental and social risks associated with their uncontrolled introduction and use. Aquaculture and fisheries in this region are composed of a mixture of native and alien species – management must acknowledge this mixture and strive to balance benefits and risks. In order to provide useful information on this issue, the workshop

- evaluated existing mechanisms dealing with alien species and their application in the Mekong/Lancang River Basin,
- identified main drivers of the practice of moving species into new areas,
- identified constraints to effective control of alien species,
- identified practical control measures, and
- identified elements of technical guidelines for the responsible use and control of alien species in fisheries and aquaculture.

Evaluation of international mechanisms and their application in the Mekong/ Lancang River Basin

A variety of international mechanisms exist to assist with the responsible use and control of alien species in fisheries and aquaculture. However, awareness of the instruments and of the obligations they entail is lacking in the region. Many general conventions such as the CBD and Ramsar Wetland Convention were thought to be less relevant to the fishery sector and harder to implement practically than those mechanisms dealing specifically with fishery issues. In general, the participants were more familiar with mechanisms that dealt with trade issues and these were seen to be extremely relevant. Once participants were familiarized

[1] In order to help implement the Code of Conduct for Responsible Fisheries, FAO et al. have produced a Technical Guideline Series including such topics as Aquaculture, Health management, Inland Fisheries, Coastal Area Management, etc. This will be another in the series

with the mechanisms dealing with alien species in the fishery and aquaculture sectors, there was general agreement that these mechanisms could be useful and should be more widely promoted.

The workshop felt that there are enough international agreements/mechanisms and that generally they were satisfactory; changing international mechanisms was thought not to be a feasible option. A summary table of the main international mechanisms, their relevance to the region, and general comments is presented in Table 1.

Major drivers of the practice of using alien species in aquaculture and fisheries

In order to control and use alien species responsibly, it is important to understand how these species are being used in the region and the reasons for their use. Alien species are primarily used in aquaculture to generate income for both the rural poor and more industrialized sectors of society. Additionally, low-cost alien species are an affordable commodity for the poorer sectors of the region that do not have access to native capture fisheries.

The workshop identified the following main drivers of the practice of moving species into new areas:

Commercial / economic drivers

- Regionally – a country/territory or business organizations benefit from starting culture of a species ahead of neighbours - early entry profits for aquaculture;
- the industrial/commercial demand for new aquaculture products to try new markets, diversify, or replace existing species that have problems e.g. white shrimp being used to replace black tiger shrimp;
- development of recreational fisheries (interest in game/sport species or bait species);
- development of ornamental fish trade, often profit oriented and moves rapidly to novel species.

Stock enhancement and genetic improvement

- Many alien species were introduced to stock into the natural water bodies to increase catches. They were also re-introduced and re-stocked assuming that it would help improve the local stock through crossbreeding.

Ready-made technologies

- Many alien species used in aquaculture have been the subject of genetic improvement, domestication, and health programmes and there has been substantial work on their farming and husbandry. Thus, culture technology is well developed for many species moved around the world for fishery/aquaculture development. There has not been a corresponding investment in research into indigenous species. Therefore their culture requirements are not well known and they are often difficult to farm. Breeding and domestication of indigenous species takes time and resources and the common perception is that alien species, already domesticated to an extent, will perform better.
- Promotion of new technologies Specific Pathogen Free and Specific Pathogen Resistant stocks) easily convince farmers and governments to import new species or strains;

Table 1. Review and evaluation of international mechanisms and their application in the Mekong/Lancang River Basin. *Descriptions of the mechanisms are found in the following section as noted.*

Mechanism (Reference in report)	Relevance to aquatic alien species in Region	Level of Awareness	Comments
Convention on Biological Diversity (Bartley & Fleischer)	Very relevant, but perceived bias towards environment ministries rather than fisheries or development ministries	Good among international organizations, but poor within the fishery sector	Convention is too general, does not provide guidance on issues and decision making, or on how to implement its articles
Cartegena Protocol (Bartley & Fleischer)	Limited relevance at present due to absence of LMO's in aquaculture	Poor awareness at present	Protocol only covers living modified organisms; may have more relevance if aquaculture begins using LMO's
Ramsar (Moore)	Has indirect relevance through protection of wetlands from alien species	Moderate awareness	Several countries have Ramsar sites, but there is an impression that the convention favours conservation over use
WTO/SPS (Moore)	Very relevant	Moderate awareness, but not on full meaning and content of articles	More relevant for trade going outside region, not used within the sub-region as much
OIE (Phillips and Subasinghe)	Very relevant	Good awareness as it relates to animal health issues	Relevant to control of pathogen spread associated with aquatic animal movements but, quarantine measures and disease reporting obligations are difficult to enforce within the sub-region
FAO Code of Conduct for Responsible Fisheries (Bartley *et al.*)	Very relevant	Good awareness of general principles, but poor awareness of specific articles on alien species	Practical application difficult and many articles are vague. Promotion of consultation with neighbours on alien species supported by group. Desire for regional adaptation of the Code
ICES/EIFAC Code (Bartley *et al.*)	Very relevant	Poor awareness at all levels	Countries have different capacities to implement. National laws/policies should be implemented before regional mechanisms can be effective. Should be adapted to Mekong/Lancang region
FAO/NACA/OIE/ Regional Disease Reporting System (Phillips and Subasinghe)	Very relevant	Low awareness	Provides a structure for sharing information on status of aquatic animal diseases and assis)t to design risk reduction measures
ASEAN/AFTA Sanitary/Phytosanitary Protocol (Phillips and Subasinghe)	Very relevant	Low awareness	
Beijing Consensus and implementation strategy (Phillips and Subasinghe)	Very relevant for health aspects	Moderate awareness	Provides a framework covering key issues. Countries need to develop practical approaches for implementing the strategy
ASEAN SEAFDEC Code of Conduct (Phillips and Subasinghe)	Relevant	Moderate awareness	Based on the CCRF, with general principles for implementation of the CCRF in the ASEAN region

- Farmers and governments do not want to invest the time in developing farming techniques for many indigenous species but want to bring the available technology to help the people as soon as possible.

Research, education and training

- Alien species serve as gateways for knowledge and skills, therefore, Government, academic and private sectors import alien species for applied and basic research to carry out on-station and on-farm, and for education and training purposes.

Food security and rural development

- Small-scale private and public organizations and large numbers of small-scale farmers use aliens as cheap food for the poor e.g. tilapia;
- Governments use and promote some alien species to meet their obligations to increase production and food availability to those lacking food security.

Cultural and religious drivers

- Religious festivals, e.g. 'fish releasing day' at temple areas are important aspects of the culture in the Mekong/Lancang Basin;
- Cultural aversion to killing ornamental fish – simply release those fish too big or unwanted.

Major constraints to the control and responsible use of alien species

The workshop identified the major constraints to the control and responsible use of alien species to be:

- general lack of clear, consistent and practical government policy;
- lack of awareness of international policies, agreements, and mechanisms that do exist;
- lack of adequate government capacity (human resources, financial and physical facilities & equipment) to regulate, enforce and monitor use of alien species;
- lengthy bureaucratic processes but ease of bypassing/influencing the government control mechanisms;
- lack of mechanisms to assign liabilities and levy fines on those causing damage or bypassing regulations;
- lack of knowledge, public awareness and perception of the risks to both environment and social/economic base;
- lack of advance planning regarding the use of alien species;
- lack of confidence in government information and expertise by private industry;
- lack of scientific evidences or research on the negative impacts of alien species in the region that could be the bases for policy formulation;
- lack of clear and easy-to-read guidelines or code of conduct specific for the region and individual countries/territories;
- lack of materials to create/ help public awareness such as brochures, internet sites and links, etc.

In addition to these policy and education constraints, there are physical and logistic constraints associated with patrolling long coastlines and international borders. Eradicating, confining and controlling alien species that have become established in the new environment is often expensive, difficult or impossible.

There are also political, social and economic constraints to enforcing existing regulations on alien species. Many rural farmers in the region use alien species for food and income generation; many rural households purchase alien species as an inexpensive alternative to more expensive wild fish or other meats. Although some of this use is illegal or unapproved, governments are reluctant to confiscate the fish without providing alternative sources of revenue or food to the rural households. Enforcement agencies often do not want to fine rural farmers with limited financial resources for infractions of alien species laws.

Information exists that relate to most of the above constraints in the form of international, regional and national legislation, guidelines and codes of practice, information sources, and databases. However, this information is often poorly organized, found in numerous locations and formats and is therefore difficult to access.

Practical control measures

There are differences between control measures at the regional and national levels. Control measures at regional level and above are not always easy to apply at national level. Therefore, a national approach should be developed within the framework of existing international/regional agreements.

Regional coordination on the use of alien species will be essential in order for national programmes to be effective. It would be counter-productive to try to manage alien species within a country, when neighbouring countries and countries sharing international or trans-boundary water systems do not also manage alien species. A regional advisory and review body could be created with representatives from all countries in the basin. Although this body would be financed by the participating countries, it need not be formal nor produce legally binding decisions, but would constitute a forum that countries could voluntarily consult. Such a regional approach is taken in Europe and North America by the countries belonging to the International Council for the Exploration of the Sea (ICES) and those Members of FAO's European Inland Fishery Advisory Committee. The ICES/EIFAC Codes offer an excellent model that could be adapted to the Mekong/Lancang River Basin.

At the National level, the following actions can lead to better control/management of alien species:

- join in, contribute to, or otherwise participate in a "Regional Review Board to advise on the use of alien species in fisheries and aquaculture, including development of a common regional policy;
- revise national policies to include a requirement that when an introduction would potentially affect one or more countries, the decision on introduction should also be referred to the regional independent review body;
- establish a "National review board" that should include representatives of all stakeholders in a watershed who would be affected by an introduction;
- develop a list of relevant criteria on which the regional and national review bodies would base decisions. Monitoring requirements should be incorporated into each proposal and if at all possible should be tied in with other ongoing activities nationally and in the region.

Enforcement of any existing policies and laws regarding alien species is difficult due to the ease at which the early life-history stages of many aquatic species can be transported, as well as the difficulty in patrolling long coastlines, numerous small islands and bays, and long borders of many countries. Thus, increased awareness and education on the risks and responsible use of alien species were judged to be a practical means of control.

Related to increased education, training programmes on alien species should be offered to fishery resource officers. Content of the training, education and awareness material is also discussed in the following section. However, a list of alien species of special concern (already introduced as well as potential to be introduced), how to identify them and the risk they pose could be drafted for the Mekong/Lancang region as a means to promote awareness.

Zonation or practice of designating specific geographic areas with defined uses of already introduced aquatic species alien species or where alien species on expressly prohibited could also be effective in the region based. One type of zoning that exists in the region are Ramsar sites, i.e. wetlands of special importance; countries are obligated to monitor and protect these areas or "zones". Zonation has been used in Europe to designate "disease free" areas where import of specific fishes with risk of specific disease-transfer is prohibited. Import consideration for zoning is the ability for animals to move among different zones, either by transboundary waterways, or through human assisted movement. Mapping and geographic information systems, well developed in some areas of the Mekong Basin would provide useful information on how to establish zones and the potential for inter-zone transfer, for example during flood periods.

Movement of alien aquatic organisms increases the probability of introducing new pathogens, which can have dire consequences on aquaculture, capture fisheries and related resources, as well as the livelihoods which depend on them. The adverse social, economic, and environmental impacts which have resulted from the irresponsible or ill-considered movement of alien species have led to global recognition of the need for health management protocols to protect aquaculture, fisheries resources and the aquatic environment. In many cases, these impacts have been a direct result of the absence of effective national and regional health management strategies. Formulation of effective quarantine measures developed as a result of risk analysis to reduce the disease risks associated with the transfer of disease agents with the trans-boundary movement of alien species includes pre-border, border and post-border health management processes. However, development of health certification and quarantine guidelines applicable on an international scale is complicated. but is important. A wide range of social, economic and environmental circumstances have to be considered, along with the range of aquatic animal species involved and their pathogens and diseases. In addition, differing reasons for moving live aquatic animals and products impose a further set of variables to the process.

Nevertheless, the serious impacts of unrestricted regional and international movement of aquatic animals merit international recognition — a fact clearly reflected in the *Aquatic Animal Health Code* and the *Manual of Diagnostic Tests for Aquatic Animals* of the Office International des Épizooties or World Organisation for Animal Health (OIE 2003a, 2003b), which provide guidelines and recommendations for reducing the risk of spreading specific pathogens considered relevant to international trade of aquatic animals. Regionally, the Asia-Pacific regional aquaculture health infrastructure support documents of FAO and the Network of Aquaculture Centres of Asia-Pacific (NACA), including a Technical Guidelines and Implementation Strategy (FAO/NACA, 2000), Manual of Procedures (FAO/NACA, 2001) and an Asia Diagnostic Guide (Bondad-Reantaso *et al*., 2001), also provide valuable guidance on reducing the risk of pathogen transfer through safe trans-

boundary movement of live aquatic animals, including alien species. All these documents take into full consideration the provisions of the World Trade Organization's Agreement on the Application of Sanitary and Phytosanitary Measures (WTO-SPS Agreement) (WTO 2002), as well as Article 9 – Aquaculture Development – of the Code of Conduct for Responsible Fisheries (CCRF) (FAO 1995).

In order to minimise or avoid the risk of pathogen transfer via alien aquatic animal species movements, concerted actions are essential, involving individuals and organisations which appreciate, and participate in, such activities taking into account the overall health management process.

Improved control of alien species may also come about through efforts of importing and exporting groups in the form of certification and provision of basic information. Importers of alien species have obligations to define the intended use of the species, for example with the use be for commercial aquaculture, recreational or ornamental use, where the species will be used and the benefits it will provide. The ICES/EIFAC codes include these obligations, plus including additional information on the species, such as harmful impacts. associated with it. Exporting groups could similarly provide basic information on the impacts of species, its disease status, e.g. disease free, specific pathogen free, specific pathogen resistance, and its reproductive status, e.g. sterile, triploid, hybrid, or fertile. This information will be useful in the risk assessment of a specific introduction.

Effective control includes wise decision making in order to prevent "bad" introductions being made in the first place. Thus pre-planning and risk assessment are vital elements that will promote good decision making. In this context, a flow diagram or decision tree could be prepared of of the national and regional review process that extracts specific information found in the ICES/EIFAC model, region-specific and country-specific adaptations of OIE list of pathogens, and other applicable models. One such example of a decision tree is the "opinionnaire" (Annex III).

Creation of a species list that designates the level of concern or potential harm from alien species in a certain area wasere identified as an effective control measure that could also help raise awareness on the issue of alien species. The workshop identified three broad levels of concern: 1) not much concern (not harmful), 2) some concerns (possibly harmful) and 3) serious concerns (probably harmful). Some lists already exist that may have some application for example in the USA, Australia and other countries, and the lists in the CITES Appendices – that could be used as examples of how to create area-specific lists of alien species that could be used to help raise awareness and guide decision making on other introductions. and elsewhere. CITES list regulates international trade and the monitoring of movement of endangered or threatened species. These specific examples of alien invasive species can illustrate general principles that will help raise awareness and guide decision making on other introductions.

Member countries of OIE are obliged to report to OIE on the occurrence of diseases listed in the *Aquatic Code*. OIE in-turn publish these reports annually thus allowing member countries to take measures to avoid incursions of those pathogens through international trade. OIE Aquatic Code provides guidelines and advice on procedures to be followed during international trade. However, the OIE Aquatic Code does not take into account the emerging pathogens and the pathogens are not considered in the OIE List.

FAO, NACA, OIE Asia-Pacific Quarterly Aquatic Animal Disease Report takes into consideration of all OIE listed pathogens as well as the pathogens of interest concern to Asia-Pacific region. Potentials of surveillance and zonation as a tool for reducing the risks of pathogen movement through trans-boundary movement of live aquatics, including aliens,

are being considered and necessary guidelines for developing countries are currently being prepared by FAO and OIE.

List of non-harmful species can also help facilitate aquaculture and fisheries development and avoid over-regulation of the sector. Lists of alien species already in use in a country and that have demonstrated that they are not causing problems would be appropriate. However, nearly all species can become harmful under specific environmental conditions or in sensitive habitats. Such a list should take into account on the potential environments available to the species and should consider areas where the species is not allowed to enter (see zoning above).

Information and materials derived from above should be aimed at various levels for different audiences, especially the introducers:

- **Farm level** – simple brochures of 2/3 pages or other material that are graphics rather than text oriented, focused on specific issues (species of concern, legislation) and written in local languages are appropriate. Brochure would stress economic gains from responsible use and economic losses from poor decisions.
- **General public level** – similar to farm level with emphasis on the role the public sector has in responsible use and control.
- **Higher level for scientist/policy-maker** – should be easily understood, with pre-analyzed information allowing decision makers easy access to principles on which to base policy.

The information could be disseminated through:

- schools,
- existing extension system,
- multi-media format, video, CD,
- TV to get messages across to a wide audience.

Manual based on the flow diagram of the national and regional review process that extracts specific information from the ICES/EIFAC model, region-specific and country-specific adaptations of OIE lists of animals and pathogens, and other applicable models would be appropriate.

Elements of Technical Guidelines on the Responsible Use and Control of Alien Species in Aquaculture and Fisheries

The workshop reaffirmed the value of the ICES/EIFAC Codes, the FAO Code of Conduct for Responsible Fisheries and the Technical Guidelines to assist in its implementation. Whilst the workshop appreciated the numerous guidelines and codes of practice on alien species that already exist, it non-the-less stressed the need for creating specific guidelines for developing countries and coalescing the variety of information on alien species into one easily accessed and understood document that could be part of the FAO Technical Guideline Series. Key elements of the Guidelines include:

- summary of agreements and other guidelines/codes of practice on alien species,
- summary of risks and benefits,
- description of an ICES like Code adapted to developing country conditions,

- the development of a set of criteria in order to establish a list of alien species of special concern in the region could further promote awareness and responsible use,
- risk assessment procedures including social and economic risks as well as environmental and ecological risks,
- decision trees (Annex III),
- recommendations for national implementation,
- recommendations for zoning areas where introductions can or can not be made, similar to OIE zoning based on disease status,
- special procedures for on-going practices, i.e. the continued use of alien species.

In addition to the Technical Guidelines, the workshop recommended the production of other videos, TV spots, posters, leaflets and pamphlets to raise awareness in general public and private industry. International aid agencies should also assist in the collection of case studies and examples of situations that have evolved that could have been avoided had this process been in place and applied. Examples should include the economic losses that have occurred to society and the aquaculture industry.

Major Conclusions

Several significant conclusions emerged from the meeting:

- Among senior policy-makers and line officers in the region, there is still little awareness of the contents of the CCRF in general, and much less awareness of codes of practice and guidelines such as the ICES/EIFAC codes of practice on introductions. Once these codes and guidelines were explained, there was general agreement that they provided a useful means to manage introductions of alien species.
- Whilst many countries in the region advocate some form of environmental risk assessment, less formal queries on potential impacts are often directed to resource managers and aid agencies. Assessments or answers to informal queries can not often be given because of a lack of readily available information on the potential impacts of alien species on the environment in general and on the specific habitats of the Mekong/Lancang specifically. Thus, many countries expressed the need for additional assistance to increase capacity in order to undertake preliminary environmental impact assessment and import risk assessment. Additionally, countries noted the difficulty in accessing relevant information for impact/risk assessment and there was a clear call to organize the various types of information on impacts of alien species into a central repository or clearing house for the region.
- Alien species, such as tilapia (*Oreochromis* spp.) play an important role in providing cheap and readily available protein to rural and poor sectors of the basin. Alien species tend to be easier to breed, are tolerant to pond condition and are therefore suitable for mass production (this is important for those areas which do not enjoy massive inland capture fishery resources).
- The development and use of indigenous species are options to the use of alien species. However, indigenous species have not received the same amount of attention, research, development and use as many alien species. Therefore, in order for indigenous species to compete the workshop recommended much more research and development be devoted to domestication and husbandry of native species. The MRC

programme on Aquaculture of Indigenous Mekong Species was highlighted as a good example of this type of development.

- There is an urgent need for and interest in the creation of sub-regional guidelines on the responsible use of alien species in fisheries. Associated with this is the desire to establish a international body or group of experts to advise on introductions of alien aquatic species. Participants felt this group could be informal and non-mandatory, and that there were several organizations operating in the region that could offer assistance; FAO and NACA were identified as lead partners in this endeavour.

- There is still the need to standardize terminology and concepts related to alien species and invasiveness. The definitions of the CBD and FAO Code of Conduct on Responsible Fisheries help in this regard, but more is needed. The workshop noted that "invasiveness" of a species, depends on the specific environment, potential disturbances to the environment and on societies perception of what "harm" is. Similarly, many genetically differentiated stocks within a species constitute alien "genotypes" yet these organisms are often not thought of as "alien".

- Much of the regulation and control of alien species is based on political boundaries and not on ecological conditions or watersheds. Thus, within a country species may be moved across natural boundaries, or into ecologically sensitive areas, and subsequently cause adverse impacts. Countries and regions should look at the distribution of species within their borders and prevent the unrestricted movement of species within a country. Zonation and GIS could assist in this regard.

- In light of the difficulty of enforcing regulations on movement of alien species and patrolling long coastlines, borders and airports, participants thought that awareness of the dangers of irresponsible movement of alien species should be improved among the general public and fishery line officers. This should be done through training courses with the assistance of international and regional organizations and popular media with the assistance of local governments.

- Several steps are necessary for effective use and control of alien species in the region. Regional coordination of policies and practices on alien species is needed for effective national management. National policies need to be in place and population needs to be aware of issues before countries can implement international mechanisms such as the CBD or CCRF. Thus, regional coordination and national policy development are necessary actions that should go hand in hand in order to facilitate implementation of broader international agreements.

References

Bondad-Reantaso, M.G., McGladdery, S.E., East, I., & Subasinghe, R.P. 2001. Asia Diagnostic Guide to Aquatic Animal Diseases. FAO Fisheries Technical Paper 402/2, FAO and NACA. 237 pp. (also available at http://www.enaca.org/NACA-Publications/ADG-complete.pdf).

FAO. 2005. Code of conduct for responsible fisheries. Rome, FAO. 1995. 41 pp.

FAO/NACA. 2000. Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals and the Beijing Consensus and Implementation Strategy. 2000. FAO Fisheries Technical Paper 402 (also available at http://www.enaca.org/NACA-Publications/AsiaRegionalTechnicalGuidelines.pdf.

FAO/NACA. 2001. Manual of Procedures for the Implementation of the Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals. 2001. FAO Fisheries Technical Paper 402/1 (also available at http://www.enaca.org/NACA-Publications/Manual-of-Procedures.pdf).

OIE. 2003a. Aquatic Animal Health Code. 2003. (Sixth Edition), 165 pp. OIE, Paris. (also available at http://www.oie.int/eng/normes/fcode/A_summry.htm).

OIE. 2003b. Manual of Diagnostic tests for Aquatic Animals. 2003. (Fourth Edition), 358 pp. OIE, Paris. (also available at http://www.oie.int/eng/normes/fmanual/A_summry.htm).

WTO. 2002. Agreement on the application of sanitary and phytosanitary measures. World Trade Organization. Geneva.

Contributed papers II

International instruments

FAO mechanisms for the control and responsible use of alien species in fisheries

Devin M. Bartley
Felix J.B. Marttin
and Matthias Halwart

"The control and responsible use of alien species in fisheries can help the implementation of FAO's strategic objectives"

Introduction

The Food and Agriculture Organization of the United Nations (FAO) has pledged to assist its Members achieve three overarching global goals: i) access of all people at all times to sufficient, nutritionally adequate and safe food, ii) continued contribution of sustainable agriculture (including fisheries and forestry) and rural development to economic and social progress and well being, and iii) the conservation, improvement and sustainable use of natural resources for food and agriculture. FAO has developed five major strategies to accomplish these goals:

- contribute to the eradication of food insecurity and rural poverty;
- promote, develop and reinforce policy and regulatory frameworks for food, agriculture, fisheries and forestry;
- create sustainable increase in the supply and availability of food and other products from the crop, livestock, fisheries and forestry sectors;
- support the conservation, improvement and sustainable use of natural resources for food and agriculture; and
- improve decision making through the provision of information and assessments and fostering of knowledge management for food and agriculture.

The control and responsible use of alien species in fisheries can help the implementation of the above strategies. Alien species have been used effectively to increase production and value from aquatic ecosystems. However, the importation of alien species for fisheries has also led to economic loss and loss of native biodiversity from disease impacts,

increased predation, competition, habitat destruction, and genetic degradation of local stocks. In order to maximize the benefits from alien species and minimize the harmful impacts of alien species, the FAO Fisheries Department has undertaken a variety of activities and partnerships that constitute a framework for the control and responsible use of alien species in fisheries. The purpose of this document is to review and promote awareness of the main mechanisms of that framework.

Framework for the control and responsible use of alien species in fisheries

The framework for the control and responsible use of alien species in fisheries consists of:

- An over-arching international agreement (the Code of Conduct for Responsible Fisheries [CCRF], [FAO, 1995]);
- technical guidelines on how to implement the articles of that agreement in relation to alien species (the International Council for the Exploration of the Sea [ICES 1995] and the Code of Practice on the Introduction and Transfer of Marine Organisms [EIFAC, 1988]);
- further technical guidelines on how to address fish health concerns (the Asia Regional Technical Guidelines and Beijing Consensus [FAO/NACA, 2000]);
- an information source to help with assessing possible positive and negative impacts (the FAO Database on Introductions of Aquatic Species [DIAS, 2003]); and
- a mechanism to deal with lack of information (i.e. uncertainty) by application of a precautionary approach to species introductions.

The CCRF and the ICES guidelines are reviewed here; the mechanisms dealing with fish health are reviewed by Subasinghe *et al.* (this volume) and DIAS is reviewed by Marttin (this volume).

Code of Conduct for Responsible Fisheries

The FAO Committee on Fisheries (COFI) in 1991 called for the development of new concepts which would lead to responsible and sustained fisheries and aquaculture. Following significant developments in international fishing, such as, *inter alia*, the International Conference on Responsible Fishing in Cancun (1992, Mexico), the 1992 UN Conference on Environment and Development (UNCED) in Brazil, and the UN Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks in New York, the FAO Governing Bodies recommended the formation of a global Code of Conduct for Responsible Fisheries which would be consistent with these instruments, and in a non-mandatory manner, establish principles and international standards of behaviour for responsible practices with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity. The CCRF was unanimously adopted on 31 October 1995 by the FAO Conference and is now the cornerstone for the work of the FAO Fisheries Department (FAO, 1995b). Although the CCRF is non-mandatory, countries, as members of FAO, are committed to its implementation to the extent possible. Certain parts of it are based on relevant rules of international law, including those reflected in the United

Nations Convention on the Law of the Sea of 10 December 1982[1]. The Code also contains provisions that may be or have already been given binding effect by means of other obligatory legal instruments amongst the parties.

The CCRF contains several articles that deal with alien species. General principles relating in a non-specific manner to alien species are in Article 2f) to promote the contribution of fisheries to food security and food quality, giving priority to the nutritional needs of local communities and in Article 2g) promote protection of living aquatic resources and their environments and coastal areas. Article 7.2.2 (d) requires that fishery management should provide that biodiversity of aquatic habitats and ecosystems is conserved and endangered species are protected. Thus, the CCRF recognizes its obligation to improve production and protect the environment.

Aquaculture was found to be the main reason that aquatic species are purposely moved outside of their native range (Welcomme, 1988; Bartley and Casal, 1998). Therefore, Article 9, Aquaculture Development, contains several sections relating to alien species.

Article 9.1.2 "States should promote responsible development and management … including an advance evaluation of the effects of aquaculture development on genetic diversity and ecosystem integrity, based on best scientific evidence.

Article 9.2 addresses responsible development of aquaculture including culture-based fisheries within transboundary aquatic ecosystems. Particularly important under this article are:

9.2.3 "States should consult with their neighbouring States, as appropriate, before introducing non-indigenous species into transboundary aquatic systems;

9.2.4 that calls on states to create mechanisms such as databases and information networks to collect and share information on aquaculture development and

9.2.5 "States should cooperate in the development of appropriate mechanisms, when required, to monitor the impacts of inputs used in aquaculture". The input here would be alien species.

- Article 9.3 summarizes much of the overall position of the CCRF in regards to alien species:

9.3.1 States should conserve genetic diversity and maintain integrity of aquatic communities and ecosystems by appropriate management. In particular, efforts should be made undertaken to minimize the harmful effects of introducing non-native species or genetically altered stocks used for aquaculture including culture-based fisheries into waters, especially where there is a significant potential for the spread of such non-native species or genetically altered stocks into waters under the jurisdiction of other States as well as waters under the jurisdiction of the State of origin. States should, whenever possible, promote steps to minimize adverse genetic, disease and other effects of escaped farmed fish on wild stocks.

[1] Full text of the United Nations Convention on the Law of the Sea of 10 December 1982 available at http://www.un.org/Depts/los/index.htm

9.3.2 calls for States to "cooperate in the elaboration, adoption and implementation of international codes of practice and procedures for introductions and transfers of aquatic organisms".

9.3.3 States should, in order to minimize risks of disease transfer and other adverse effects on wild and cultured stocks, encourage adoption of appropriate practices in the genetic improvement of broodstocks, the introduction of non-native species, and in the production, sale and transport of eggs, larvae or fry, broodstock or other live materials. States should facilitate the preparation and implementation of appropriate national codes of practice and procedures to this effect.

The CCRF acknowledges that information will never be complete and development decisions will often need to be taken with a certain degree of uncertainty as to their impacts. Article 7.5 describes a precautionary approach wherein preference is given to protecting the aquatic environment. The absence of adequate scientific information on the impacts of an activity, e.g. the use of alien species, should not be used as a reason for postponing or failing to take conservation and management measures. FAO and the Government of Sweden convened an expert consultation in order to define a precautionary approach in operational terms (FAO/Sweden, 1995). This consultation noted that due to the high probability that the impacts of an alien species in the natural environment are unpredictable and difficult, if not impossible to reverse, many species introductions are not precautionary. The consultation therefore recommended the use of codes of practice, such as the ICES/EIFAC codes described below as good precautionary measures.

In summary, the CCRF promotes the conservation of biological diversity and ecosystems through, *inter alia*, impact assessment, monitoring and evaluation, creation of useful databases and information sources, and calls on Members to cooperate in the process of using alien species through consultation and the creation of guidelines and codes of practice. Where there is uncertainty of impacts or lack of scientific information, the CCRF advocates a precautionary approach that gives preference to environmental conservation.

Codes of Practice: International Council for the Exploration of the Sea (ICES) and the European Inland Fishery Advisory Commission (EIFAC)[2].

The International Council for the Exploration of the Sea (ICES) and the European Inland Fishery Advisory Commission (EIFAC) are two inter-governmental bodies that acknowledge the necessity of international cooperation in order to conserve and use responsibly living aquatic resources. The groups noted the great success derived from the growth of marine and freshwater aquaculture and established a set of procedures (EIFAC, 1988; ICES, 1995) to be followed in the European and North Atlantic region to address three main challenges from alien species: 1) to reduce the chance of disease transfer from the movement of aquatic species; 2) to reduce impacts of alien species on native aquatic biodiversity and 3) to address the impact that genetically altered stocks may have on related natural populations. These codes and procedures have been endorsed by the CCRF and have been adopted in principle by other regional bodies of FAO.

[2] Based on Bartley, D.M., R. Subasinghe & D. Coates, 1996.

The basic code contains the requirements that:

i) the entity moving an exotic species develops a PROPOSAL, that would include location of facility, planned use, passport information, and source of the exotic species;

ii) an independent REVIEW is made that evaluates the proposal and the impacts and risk/benefits of the proposed introduction, e.g. pathogens, ecological requirements/interactions, genetic concerns, socio-economic concerns, and local species most affected;

iii) ADVICE and comments are communicated among the proposers, evaluators and decision makers and the independent review ADVISES to either accept, refine, or reject the proposal so that all parties understand the basis for any decision or action. Thus proposals can be refined and the review panel can request additional information on which to make their recommendation;

iv) if approval to introduce a species is granted QUARANTINE, CONTAINMENT, MONITORING, AND REPORTING PROGRAMMES are implemented; and

v) the ONGOING PRACTICE of importing the (formerly) exotic species becomes subject to review and inspection that check the general condition of the shipments, e.g. checking that no pathogens are present, that the correct species is being shipped, etc.

The Code is general and can be adapted to specific circumstances and resource availability, but it should not lose any of the above requirements nor should it lose the rigor at which the requirements are applied. For example, a regulatory agency may require a proposal to contain a first evaluation of the risk/benefits and this evaluation would then be forwarded to an independent review or advisory panel; or the advisory panel could make the first evaluation of a proposal. Similarly, states may require quarantine procedures to be explicitly described in the proposal before approval is granted.

"Codes" are generally perceived as being cumbersome, bureaucratic, a hindrance to development and generally not very user-friendly. Thus, they tend to be ignored by those who need them the most, the local resource managers and fisheries/aquaculture developers. In fact, application of the above, even if not completely rigorous, should help promote good decisions, avoid costly mistakes, increase community/consumer satisfaction, and help improve the standard of life for the communities concerned.

Rigorous application of these principles will be more difficult, but can be facilitated by implementation guidelines and other mechanisms. One such mechanism to help with the decision to introduce an alien species is the opinionnaire (Annex III), (Kohler and Stanley, 1984).

The absence of adequate scientific information on the impacts of alien species, should not be used as a reason for postponing or failing to take conservation and management measures

References

Bartley, D.M., Subasinghe, R. & Coates, D. 1996. Draft framework for the responsible use of introduced species. EIFAC Publication EIFAC/XXIX/96/ Inf.8. Rome.

Bartley, D.M. &. Casal, C.V. 1998. Impact of introductions on the conservation and sustainable use of aquatic biodiversity. FAO Aquaculture Newsletter No 20. Rome.

DIAS. 2003. Database on Introductions of Aquatic Species. FAO. Available at http://www.fao.org/fi/statist/fisoft/dias/index.htm.

FAO. 1995a. Code of Conduct for Responsible Fisheries. Rome.

FAO. 1995b. Report of the Twenty-first Session of the Committee on Fisheries. Rome. 10-13 March 1995. FAO Fisheries Report No, 524, paragraphs 23-29.

FAO/NACA. 2000. The Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals and The Beijing Consensus and Implementation Strategy. FAO Fisheries Technical Paper No. 402. Rome.

FAO/Sweden. 1995. Precautionary Approach to Fisheries. Part 1: Guidelines on the precautionary approach to capture fisheries and species introductions. FAO Fisheries Technical Paper 350/1. Rome.

ICES. 1995–1994. ICES Co-operative Research Report No. 204. Copenhagen.

Kohler, C.C. & Stanley, J.G. 1984. A suggested protocol for evaluating proposed exotic fish introductions in the United States. *In* W.R. Courtney, Jr. and J.R. Stauffer, Jr. eds. Distribution, biology, and management of exotic fishes, pp.387-406. Baltimore. Johns Hopkins University Press.

Welcomme, R.L. 1988. International Introductions of Inland Aquatic Species. FAO Fisheries Technical Paper No. 294. Rome.

International instruments

Mechanisms of the Convention on Biological Diversity for the control and responsible use of alien species in fisheries

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"Each Contracting Party shall, as far as possible and as appropriate: ... Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species"

Introduction

The Convention on Biological Diversity (CBD) arose from the UNCED process (the Earth Summit) in 1992 and came into force on 29 December of 1993 (CBD, 1994). It has the most signatories of any piece of international legislation and its articles are legally binding. The goals of the CBD are the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising from such use. These processes are to be facilitated by appropriate access to genetic resources and transfer of relevant technologies, taking into account all rights over those resources and technologies. Further, the international community recognized that developing countries will require assistance in implementing the articles of the CBD, and therefore a funding mechanism, the Global Environment Facility (GEF) was established. The primary governing body of the CBD is the Conference of the Parties (COP). In recognizing the need for scientific and technical advice in order to implement the CBD, the Convention established a Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA). This body is the forum for a variety of scientific and technical assessments and discussions, including those pertaining to alien species. It operates under the authority of, and reports regularly to the COP.

The CBD is often perceived as a "conservation" convention, and indeed this is a vital part of its mandate. However, it was the inclusion of the "sustainable use" of biological diversity that has also been responsible for the numbers of countries joining this process. Alien species and alien genotypes (Table 1) are a component of biodiversity and have provided the world with agriculture benefits for millennia. Following domestication, usually but not always, in centers of origin, alien species and domesticated crops and animals have been moved around the world and now form the basis of a multi-billion dollar agriculture industry. The CBD recognized the contribution that agricultural biodiversity can make to improving the human condition, and noted the unique characteristics of this component of biological diversity.

Table 1. Definitions

Alien species (also known as introduced, non-indigenous or exotic species)	A species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce (CBD)
Alien genotype	The CBD definition refers to products of selective breeding, and living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of marine and coastal biodiversity. However, hybridization and chromosome set manipulation may also produce genotypes not found in nature; we prefer a more general definition to signify any genotype produced through the intervention of humans that is not found in nature, whether or not the alien genotype adversely impacts the environment
Domestication	A species in which the evolutionary process has been influenced by humans to meet their needs (CBD)
Genetically modified organism (GMO)	Organisms (and micro-organisms) in which the genetic material (DNA) has been altered in a way that does not occur naturally by mating or natural recombination. The technology is often called "modern biotechnology" or "gene technology", sometimes also "recombinant DNA technology" or "genetic engineering". It allows selected individual genes to be transferred from one organism into another, also between non-related species (European Union)
Introduced species	Any species intentionally or accidentally transported and released by humans into an environment outside its present range (ICES 1995)
Invasive alien species	An alien species whose introduction and/or spread threaten biological diversity
Living modified organisms (LMO)	Defined in the Cartagena Protocol on Biosafety as any living organism that possesses a novel combination of genetic material obtained through the use of modern biotechnology. The Protocol also defines the terms 'living organism' and 'modern biotechnology' (see Article 3). In everyday usage LMOs are usually considered to be the same as GMOs (Genetically Modified Organisms), but definitions and interpretations of the term GMO vary widely (See for example ICES vs. EU definitions)
Living organism	Any biological entity capable of transferring or replicating genetic material, including sterile organisms, viruses and viroids
Modern biotechnology	The application of: a. In vitro nucleic acid techniques, including recombinant deoxyribonucleic acid (DNA) and direct injection of nucleic acid into cells or organelles, or b. Fusion of cells beyond the taxonomic family, that overcome natural physiological reproductive or recombination barriers and that are not techniques used in traditional breeding and selection
Transferred species	Any species intentionally or accidentally transported and released by humans into an environment within its present range (ICES 1995)

The CBD further recognized the dangers of the global movement of species and genetically altered species. The CBD especially noted the opportunities and problems associated with modern biotechnology. Thus, a specific protocol on biosafety was created in 2000 to protect biological diversity from the potential risks posed by living modified organisms (LMOs) resulting from modern biotechnology; this is known as the Cartagena Protocol on Biosafety to the Convention on Biological Diversity.

The purpose of this document is to review and raise awareness of the main articles and mechanisms of the CBD that pertain to alien species, alien genotypes and living modified organisms.

The CBD is often perceived as a "conservation" convention, and indeed this is a vital part of its mandate. However, it was the inclusion of the "sustainable use" of biological diversity that has also been responsible for the numbers of countries joining this process.

General articles

Article 1 of the CBD sets out the main objectives of the Convention, namely the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising from such use. Although not specifically mentioned, achieving these objectives is essential for the responsible use and control of alien species in fisheries. Article 3 sets out, as the guiding principle of the Convention, the sovereign rights of States to exploit their own biological diversity pursuant to national environmental policies and objectives, but that States have the responsibility not to cause environmental damage to other States beyond the limits of national jurisdiction. Thus, States are free to use responsibly alien species in national development, but should ensure that this does not adversely impact others, for example through transboundary or international water bodies.

In order to organize the work of implementing the Convention, the COP created 5 thematic areas based on ecosystem characteristics: Marine and Coastal Ecosystems, Inland Water Ecosystems, Agro-ecosystems, forests and dry and Sub-humid Lands. The programme of work for Marine and Coastal Ecosystems has been named the "Jakarta Mandate", to signify that it was adopted at the second meeting of the COP in Jakarta, Indonesia. Alien species were identified as significant cross-cutting issue that is addressed by numerous thematic areas.

The Convention acknowledges the importance of planning and Article 6 states that "Each Contracting Party shall, in accordance with its particular conditions and capabilities:

> (a) Develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programmes which shall reflect, *inter alia*, the measures set out in this Convention relevant to the Contracting Party concerned; and
>
> (b) Integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies."

Thus, under the CBD countries are preparing National Biodiversity Strategies and Action Plans (NBSAP).

Article 7 on identification and monitoring states in sections (a) and (b) that signatories should identify components of biological diversity important for sustainable use and monitor their status. In section 7(d) tates are called on to maintain and organize data derived from the above identification and monitoring. The CBD created a Clearing House Mechanism, coordinated by the Executive Secretary and overseen and guided by an Informal Advisory Committee (IAC) to promote awareness of the multiple needs and concerns facing various communities, countries and regions.

Article 14 on impact assessment and minimizing adverse impacts requires in section (a) the introduction of environmental impact assessment procedures where there is the likelihood of environmental damage from development. Article 14(c) promotes consultation and exchange of information regarding national activities that may have environmental consequences in neighbouring states through bilateral, regional or multi-lateral arrangements.

The emphasis of the CBD is on in situ conservation of biological diversity. Article 8(d) requires states to "Promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings."

The Preamble to the CBD and Principle 15 in the Rio Declaration both promote a precautionary approach to development[1]:

> "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

Specific reference to precaution and alien species is made in the Jakarta Mandate[2]:

> " (…) because of the difficulties of complete containment, introduction of alien species, products of selective breeding, and living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of marine and coastal biodiversity should be responsibly conducted using the precautionary approach."

Articles on alien species

Alien species are specially listed in Article 8(h): "Each Contracting Party shall, as far as possible and as appropriate: Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species". The COP has also identified alien species as one of five programme elements in the work programme on marine and coastal biological diversity and on inland water biodiversity. The programme of work to implement the Jakarta Mandate identified three objectives relating to alien species:

- to achieve better understanding of the causes of the introduction of alien species and genotypes and the impact of such introductions on biological diversity;
- to identify gaps in existing or proposed legal instruments, guidelines and procedures to counteract the introduction of and the adverse effects exerted by alien species and genotypes which threaten ecosystems, habitats or species, paying particular attention to transboundary effects; and to collect information on national and international actions to address these problems, with a view to prepare for the development of a scientifically-based global strategy for dealing with the prevention, control and eradication of those alien species which threaten marine and coastal ecosystems, habitats and species;
- to establish an "incident list" on introductions of alien species and genotypes through the national reporting process or any other appropriate means.

1 Report of the United Nations Conference on Environment and Development (Rio de Janeiro, 3-14 June 1992). United Nations General Assembly report A/CONF.151/26 (Vol. I). New York.

2 The Jakarta Mandate on Marine and Coastal Biological Diversity is part of the Ministerial Statement on the implementation of the Convention on Biological Diversity, as adopted at the Second Ordinary Meeting of the Conference of Parties to the Convention on Biological Diversity, 6–17 November 1995, Jakarta, Indonesia.

The CBD specifically addressed alien species in the work programme on inland water biological diversity (decision IV/4, annex I, paragraph 8 [c] [vi]), and invited states in paragraph 9 (e) (iv) to "Undertake assessments in such inland water ecosystems which may be regarded as important. Furthermore, states should undertake assessments of threatened species and conduct inventories and impact assessments of alien species within their inland water ecosystems."

Significant decisions have been taken by the COP in regards to implanting Article 8(h) and other articles of the CBD. The most recent decisions (COP VI) call for national strategies and action plans, and international action, collaboration, and funding. Relevant organizations and initiatives, as well as specific suggestions for national governments are listed in Annex 1. At its sixth meeting (COP VI), the Conference of the Parties also adopted 15 guiding principles for the prevention, introduction and mitigation of impacts of invasive alien species for the full and effective implementation of **Article 8**(h) of the CBD (Annex 2). These, "Guiding Principles For The Prevention, Introduction And Mitigation Of Impacts Of Alien Species That Threaten Ecosystems, Habitats Or Species", *inter alia*:

- urge states, other governments and relevant bodies to give priority to the development and implementation of alien invasive species strategies and action plans;
- encourage parties to develop mechanisms for transboundary cooperation and regional and multilateral cooperation in order to deal with the issue, including the exchange of best practices;
- encourage parties to develop effective education, training and public-awareness measures, as well as to inform the public about the different aspects of the issue, including the risks posed by alien invasive species.

Decision IV/4 which was again noted in COP IV, called on international groups to assist in: (a) developing standardized terminology on alien species; (b) developing criteria for assessing risks from introduction of alien species; (c) developing processes for assessing the socio-economic implications of alien invasive species, particularly the implications for indigenous and local communities; (d) furthering research on the impact of alien invasive species on biological diversity; (e) developing means to enhance the capacity of ecosystems to resist or recover from alien species invasions; (f) developing a system for reporting new invasions of alien species and the spread of alien species into new areas; (g) assessing priorities for taxonomic work.

In addition to the NBSAP called for in Article 6 (above), the CBD has also requested countries to prepare thematic reports on alien species. These reports identify responsible individuals within a country. These reports have been completed by only a few countries in the Mekong/Lancang Region and those that have been completed have not focused on aquatic alien species.

At its Fifth meeting the COP, in decision V/8, requested the Executive Secretary of the CBD in collaboration with other international agencies, including FAO, to consider, *inter alia*, further development of the guiding principles and developing an international instrument to deal with alien species. The matter of an international instrument is still pending.

Cartagena Protocol on Biosafety to the Convention on Biological Diversity

The Cartagena Protocol of the Convention on Biological Diversity, adopted on 29 January 2000 in Montreal, Canada, "seeks to protect biological diversity from the potential risks posed by LMOs resulting from modern biotechnology".[3] Thus, the scope of the Protocol is limited and does not include wild alien species, or those species genetically altered by selective breeding, hybridization, chromosome set manipulation, or sex reversal. For practical purposes at present the Protocol refers to transgenic organisms. Currently, there are no transgenic aquatic species available to the fisheries and aquaculture industry or to the consumer; genetically modified soy has been used in fish feed.

The Protocol establishes an *advance informed agreement* (AIA) procedure for ensuring that countries are provided with the information necessary to make informed decisions before agreeing to the import of LMOs into their territory. The Protocol advocates a *precautionary approach* and reaffirms the precaution language in Principle 15 of the Rio Declaration on Environment and Development. The Protocol also establishes a *Biosafety Clearing-House* to facilitate the exchange of information on LMOs and to assist countries in the implementation of the Protocol. The Protocol includes a "savings clause" that states that nothing in the agreement shall alter the rights and obligations of parties under existing international law (e.g. WTO rules).

Key Elements of the Protocol

The Advance Informed Agreement Procedure

The Protocol creates an AIA procedure that requires exporters to seek consent from importers before the first shipment of LMOs meant to be introduced into the environment (such as seeds for planting, fish for release, and for bioremediation). However, it only applies to a small percentage of traded LMOs as it excludes LMO commodities that are intended for food, feed, or processing (LMO-FFPs), LMOs in transit and LMOs destined for contained use (e.g. vials for scientific research).

The party of export is obliged to notify (or ensure notification) in writing to the party of import, before the first intentional import of any given type of LMO. The party of import then has 90 days to acknowledge receipt of the notification, and advise that it intends to proceed with the Protocol's decision procedure, or according to its domestic regulatory framework. Importers are to make decisions on the import of LMOs intended for introduction into the environment based on a scientific risk assessment and within 270 days of notification of an intent to export.

Biosafety Clearing-House

The Protocol establishes an internet-based Biosafety Clearing-House to help countries exchange scientific, technical, environmental and legal information about living modified organisms. The agreement requires governments to provide the Biosafety Clearing-House with

[3] Cartagena is the name of the city in Colombia where the Biosafety Protocol was originally scheduled to be concluded and adopted in February 1999. However, due to a number of outstanding issues, the Protocol was finalized and adopted a year later on 29 January 2000 in Montreal, Canada.

information concerning any final decisions on the domestic use of an LMO commodity within 15 days of making a decision. A pilot phase of the Clearing-House has been developed[4].

LMO– FFPs

LMO– FFPs are not subject to the AIA procedure that covers other LMOs, but are covered by a separate, less restrictive, procedure outlined in Article 11. Parties making a final decision about the domestic use of an LMO must notify the other Parties of the decision through the Biosafety Clearing-House. Thus, while the AIA procedure lays first responsibility on the *party of export* to notify its intent to export, the procedure for LMO– FFPs lays first responsibility on potential importers to develop and announce regulations proactively. The result is less onerous for the exporters, who will not have to wait for the parties of import to respond to their notifications. As well, exporters of LMO– FFPs do not face the burden of proof established for exporters of other LMOs, who may have to conduct and finance **risk assessments** in support of their notifications.

Shipments of commodities that contain, or may contain, LMO– FFPs must be identified as such in their accompanying documentation. The details of this procedure still remain to be worked out, and are supposed to be settled within two years after the Protocol enters into force. Such shipments must also be accompanied by a list of other information, including the identity and relevant traits and characteristics of the LMOs, any requirements for safe handling, storage, transport and use, and information about the importers and exporters. These requirements are helpful to countries that are enacting domestic labelling schemes for LMOs and products thereof. But they are unwelcome for exporters, who will be forced either to segregate LMO and non-LMO commodities, or to label all exports "may contain LMO– FFPs" and likely pay the penalty in lower prices.

Science and Precaution

The Protocol contains a strong version of the precautionary principle. Whether the precautionary principle can be used in deciding to prohibit or restrict import of LMOs is not clear as it is limited by the structures of the WTO Sanitary and Phytosanitary Measures (SPS) Agreement[5]. But it is indicative that the burden of risk-proof is put on the party of export and notifier, who can be required to conduct and/or finance a risk assessment.

Liability

Article 27 commits the first meeting of the parties to put in place a process to elaborate rules and procedures on liability. It sets a period of four years for completion of this task.

Trade with non-parties

The Protocol states that the "transboundary movement of LMOs between parties and non-parties shall be consistent with the objective of this Protocol."

Currently there are no LMOs available for the fisheries and aquaculture industry. However, trans-genic salmon are awaiting approval by regulatory agencies in the USA and trans-genic tilapia in Cuba are undergoing evaluation for commercial use. Thus, it will be opportune for the industry and governments to be aware of such protocols in the event LMOs become available.

4 Pilot phase of the CBD Clearing-House. September 2003. CBD. Available at http://bch.biodiv.org/ Pilot/Home.aspx

5 Agreement on the Application of Sanitary and Phytosanitary Measures, Uruguya Round Agreement (Article 1 — 11). WTO. Available at www.wto.org

References

CBD. 1994. Convention on Biological Diversity. Text and Annexes. UNEP/CBD/94/1. Switzerland.

ICES. 1995. ICES Code of Practice on the Introductions and Transfers of Marine Organisms - 1994. ICES Co-operative Research Report No. 204.

Annex 1

Excerpts from Decision VI/23[6]

ALIEN SPECIES THAT THREATEN ECOSYSTEMS, HABITATS OR SPECIES
The following are selected sections from COP Decision VI/23 that calls for national action (for complete text of the Decision see footnote 6).

II. Guiding principles for the implementation of article 8(h)

Recognizing that invasive alien species represent one of the primary threats to biodiversity, especially in geographically and evolutionary isolated ecosystems, such as small island developing States, and that risks may be increasing due to increased global trade, transport, tourism and climate change, …

Recognizing the value of international instruments under section III, the Decision recommended, *inter alia*,

"Invites the International Plant Protection Convention, the Office International des Epizooties, the Food and Agriculture Organization of the United Nations, the International Maritime Organization, the World Health Organization and other relevant international instruments and organizations, as they elaborate further standards and agreements, or revise existing standards and agreements, including for risk assessment/analysis, to consider incorporating criteria related to the threats to biological diversity posed by invasive alien species; and invites further such instruments and organizations to report on any such ongoing, planned, or potential initiatives ". Furthermore, under section IV OTHER OPTIONS the decision noted:

"Reaffirming the importance of national and regional invasive alien species strategies and action plans, and of international collaboration to address the threats to biodiversity of invasive alien species and the need for funding as a priority to implement existing strategies,

Noting the range of measures and the need to strengthen national capacities and international collaboration.

(A) NATIONAL INVASIVE ALIEN SPECIES STRATEGIES AND ACTION PLANS
Urges Parties and other Governments, in implementing the Guiding Principles, and when developing, revising and implementing national biodiversity strategies and action plans to address the threats posed by invasive alien species, to:

a. Identify national needs and priorities;

b. Create mechanisms to coordinate national programmes;

6 COP 6 - Sixth Ordinary Meeting of the Conference of the Parties to the Convention on Biological Diversity, The Hague. The Netherlands (7-19 April 2002). Decision VI/23.
http://www.biodiv.org/decisions/default.asp?lg=0&dec=VI/23)

c. Review, in the light of the Guiding Principles, relevant policies, legislation and institutions to identify gaps, inconsistencies and conflicts, and, as appropriate, adjust or develop policies, legislation and institutions;

d. Enhance cooperation between the various sectors, including the private sector that might provide pathways or vectors for the unintended transfer of invasive alien species, in order to improve prevention, early detection, eradication and/or control of invasive alien species, and in particular, ensure communication between focal points of respective relevant international instruments;

e. Promote awareness of the threats to biological diversity and related ecosystem goods and services posed by invasive alien species and of the means to address such threats, among policy makers at all levels of government, and in the private sector; quarantine, customs and other border officials; and the general public;

f. Facilitate the involvement of all stakeholder groups, including in particular indigenous and local communities, and the private sector, as well as all levels of government, in national invasive alien species strategies and action plans, and in decisions related to the use of alien species that may be invasive;

g. Collaborate with trading partners and neighbouring countries, regionally, and with other countries, as appropriate, in order to address threats of invasive alien species to biological diversity in ecosystems that cross international boundaries, to migratory species, and to address matters of common interest;

Urges existing regional organizations and networks to work cooperatively to actively support the development and implementation of invasive alien species strategies and action plans, and to develop regional strategies where appropriate.

Encourages Parties and other Governments, in undertaking this work and, in particular, when developing priority actions, to consider the need to:

a. Develop capacity to use risk assessment/analysis to address threats of invasive alien species to biological diversity, and incorporate such methodologies in environmental impact assessments, and strategic environmental assessments, as appropriate and relevant;

b. Develop financial measures, and other policies and tools, to promote activities to reduce the threat of invasive alien species;

c. When necessary, develop recommendations and strategies to take account of effects of alien species on populations and naturally occurring genetic diversity;

d. Incorporate invasive alien species considerations into national biodiversity strategies and action plans and into sectoral and cross-sectoral policies, strategies and plans, taking into account the ecosystem approach, and in order to ensure full implementation of the national invasive alien species strategies and action plans as called for in paragraph 6 of decision V/8 of the Conference of the Parties.

Notes the technical information developed by the Executive Secretary, the Subsidiary Body on Scientific, Technical and Technological Advice and the Global Invasive Species Programme and commends this information to Parties for use in national implementation of Article 8(h) and requests the Executive Secretary to ensure that the technical information developed

within the Convention on Biological Diversity is readily available to Parties in an appropriate form, including through technical publications and the clearing-house mechanism;

Urges the Global Invasive Species Programme and other relevant organizations to evaluate known and potential pathways for the introduction of invasive alien species and identify opportunities to minimize incursions and manage risks, and:

a. Provide advice to Governments and organizations on actions to be taken at national and regional levels; and

b. Provide recommendations to the Conference of the Parties at its seventh meeting on actions to be taken at the international level; " ...

Under section III (c) on assessment, information and tools the Decision, *inter alia*:

Urges Parties, Governments and relevant organizations, at the appropriate level, with the support of relevant international organizations to promote and carry out, as appropriate, research and assessments on:

The characteristics of invasive species and the vulnerability of ecosystems and habitats to invasion by alien species, and the impact of climate change on these parameters.

The impact of alien species on biological diversity;

Analysis of the importance of various pathways for the introduction of invasive alien species;

The socio-economic implications of invasive alien species particularly the implications for indigenous and local communities;

The development of environmentally benign methods to control and eradicate invasive alien species, including measures for use in quarantine and to control fouling of ship hulls;

The costs and benefits of the use of biocontrol agents to control and eradicate invasive alien species;

Means to enhance the capacity of ecosystems to resist or recover from alien species invasions;

Priorities for taxonomic work through, *inter alia*, the Global Taxonomy Initiatives.

Criteria for assessing risks from introduction of alien species to biological diversity at the genetic, species and ecosystem levels;

The use of the traditional knowledge of indigenous and local communities in the development and implementation of measures to address invasive alien species, in accordance with Article 8(j) of the Convention;

Decides that the clearing-house mechanism will be used to facilitate scientific and technical cooperation on the topics listed under paragraph 24 above, in order to enhance the ability of the clearing-house mechanism to promote and facilitate scientific and technical cooperation, and welcomes the Global Invasive Species Programme as an international thematic focal point for alien species under the clearing-house mechanism, and calls on Parties, countries

and relevant organizations to contribute to the creation and maintenance of the global information network, in particular to:

Ensure effective international cooperation and expertise sharing;

Provide information to assist countries to perform effective risk analysis;

Provide information on potential pathway of alien invasive species; and

Provide support for management and control efforts, particularly for locating technical support for rapid response activities;

“”Other sections of the Decision make suggestions to international organizations and the Secretariat of the CBD, and relate to capacity building and funding.

Annex 2

Guiding principles for the prevention, introduction and mitigation of impacts of alien species that threaten ecosystems, habitats or species

INTRODUCTION

This document provides all Governments and organizations with guidance for developing effective strategies to minimize the spread and impact of invasive alien species. While each country faces unique challenges and will need to develop context-specific solutions, the Guiding Principles give governments clear direction and a set of goals to aim toward. The extent to which these Guiding Principles can be implemented ultimately depends on available resources. Their purpose is to assist governments to combat invasive alien species as an integral component of conservation and economic development. Because these 15 principles are non-binding, they can be more readily amended and expanded through the Convention on Biological Diversity's processes as we learn more about this problem and its effective solutions.

According to Article 3 of the Convention on Biological Diversity, States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility 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.

It should be noted that in the Guiding Principles below, the terms listed in footnote are used.

Also, while applying these Guiding Principles, due consideration must be given to the fact that ecosystems are dynamic over time and so the natural distribution of species might vary without involvement of a human agent.

A. GENERAL

Guiding principle 1: Precautionary approach

Given the unpredictability of the pathways and impacts on biological diversity of invasive alien species, efforts to identify and prevent unintentional introductions as well as decisions concerning intentional introductions should be based on the precautionary approach, in particular with reference to risk analysis, in accordance with the guiding principles below. The precautionary approach is that set forth in principle 15 of the 1992 Rio Declaration on Environment and Development and in the preamble of the Convention on Biological Diversity.

The precautionary approach should also be applied when considering eradication, containment and control measures in relation to alien species that have become established. Lack of scientific certainty about the various implications of an invasion should not be used as a reason for postponing or failing to take appropriate eradication, containment and control measures.

Guiding principle 2: Three-stage hierarchical approach

Prevention is generally far more cost-effective and environmentally desirable than measures taken following introduction and establishment of an invasive alien species.

Priority should be given to preventing the introduction of invasive alien species, between and within States. If an invasive alien species has been introduced, early detection and rapid action are crucial to prevent its establishment. The preferred response is often to eradicate the organisms as soon as possible (principle 13). In the event that eradication is not feasible or resources are not available for its eradication, containment (principle 14) and long-term control measures (principle 15) should be implemented. Any examination of benefits and costs (environmental, economic and social) should be done on a long-term basis.

Guiding principle 3: Ecosystem approach

Measures to deal with invasive alien species should, as appropriate, be based on the ecosystem approach, as described in decision V/6 of the Conference of the Parties.

Guiding principle 4: The role of States

In the context of invasive alien species, States should recognize the risk that activities within their jurisdiction or control may pose to other States as a potential source of invasive alien species, and should take appropriate individual and cooperative actions to minimize that risk, including the provision of any available information on invasive behaviour or invasive potential of a species.

Examples of such activities include:

The intentional transfer of an invasive alien species to another State (even if it is harmless in the State of origin); and

The intentional introduction of an alien species into their own State if there is a risk of that species subsequently spreading (with or without a human vector) into another State and becoming invasive;

Activities that may lead to unintentional introductions, even where the introduced species is harmless in the state of origin.

To help States minimize the spread and impact of invasive alien species, States should identify, as far as possible, species that could become invasive and make such information available to other States.

Guiding principle 5: Research and monitoring

In order to develop an adequate knowledge base to address the problem, it is important that States undertake research on and monitoring of invasive alien species, as appropriate. These efforts should attempt to include a baseline taxonomic study of biodiversity. In addition to these data, monitoring is the key to early detection of new invasive alien species. Monitoring should include both targeted and general surveys, and benefit from the involvement of other sectors, including local communities. Research on an invasive alien species should include a thorough identification of the invasive species and should document: (a) the history and ecology of invasion (origin, pathways and time-period); (b) the biological characteristics of the invasive alien species; and (c) the associated impacts at the ecosystem, species and genetic level and also social and economic impacts, and how they change over time.

Guiding principle 6: Education and public awareness

Raising the public's awareness of the invasive alien species is crucial to the successful management of invasive alien species. Therefore, it is important that States should promote education and public awareness of the causes of invasion and the risks associated with the introduction of alien species. When mitigation measures are required, education and public-awareness-oriented programmes should be set in motion so as to engage local communities and appropriate sector groups in support of such measures.

B. Prevention

Guiding principle 7: Border control and quarantine measures

States should implement border controls and quarantine measures for alien species that are or could become invasive to ensure that:

Intentional introductions of alien species are subject to appropriate authorization (principle 10);

Unintentional or unauthorized introductions of alien species are minimized.

States should consider putting in place appropriate measures to control introductions of invasive alien species within the State according to national legislation and policies where they exist.

These measures should be based on a risk analysis of the threats posed by alien species and their potential pathways of entry. Existing appropriate governmental agencies or authorities should be strengthened and broadened as necessary, and staff should be properly trained to implement these measures. Early detection systems and regional and international coordination are essential to prevention.

Guiding principle 8: Exchange of information

States should assist in the development of an inventory and synthesis of relevant databases, including taxonomic and specimen databases, and the development of information systems and an interoperable distributed network of databases for compilation and dissemination of information on alien species for use in the context of any prevention, introduction, monitoring and mitigation activities. This information should include incident lists, potential threats to neighbouring countries, information on taxonomy, ecology and genetics of invasive alien species and on control methods, whenever available. The wide dissemination of this information, as well as national, regional and international guidelines, procedures and recommendations such as those being compiled by the Global Invasive Species Programme should also be facilitated through, *inter alia*, the clearing-house mechanism of the Convention on Biological Diversity.

The States should provide all relevant information on their specific import requirements for alien species, in particular those that have already been identified as invasive, and make this information available to other States.

Guiding principle 9: Cooperation, including capacity-building

Depending on the situation, a State's response might be purely internal (within the country), or may require a cooperative effort between two or more countries. Such efforts may include:

Programmes developed to share information on invasive alien species, their potential uneasiness and invasion pathways, with a particular emphasis on cooperation among neighbouring countries, between trading partners, and among countries with similar ecosystems and histories of invasion. Particular attention should be paid where trading partners have similar environments;

Agreements between countries, on a bilateral or multilateral basis, should be developed and used to regulate trade in certain alien species, with a focus on particularly damaging invasive species;

Support for capacity-building programmes for States that lack the expertise and resources, including financial, to assess and reduce the risks and to mitigate the effects when introduction and establishment of alien species has taken place. Such capacity-building may involve technology transfer and the development of training programmes;

Cooperative research efforts and funding efforts toward the identification, prevention, early detection, monitoring and control of invasive alien species.

C. Introduction of species

Guiding principle 10: Intentional introduction

No first-time intentional introduction or subsequent introductions of an alien species already invasive or potentially invasive within a country should take place without prior authorization from a competent authority of the recipient State(s). An appropriate risk analysis, which may include an environmental impact assessment, should be carried out as part of the evaluation process before coming to a decision on whether or not to authorize a proposed introduction to the country or to new ecological regions within a country. States should make all efforts to permit only those species that are unlikely to threaten biological diversity. The burden of proof that a proposed introduction is unlikely to threaten biological diversity should be with the proposer of the introduction or be assigned as appropriate by the recipient State. Authorization of an introduction may, where appropriate, be accompanied by conditions (e.g., preparation of a mitigation plan, monitoring procedures, payment for assessment and management, or containment requirements).

Decisions concerning intentional introductions should be based on the precautionary approach, including within a risk analysis framework, set forth in principle 15 of the 1992 Rio Declaration on Environment and Development, and the preamble of the Convention on Biological Diversity. Where there is a threat of reduction or loss of biological diversity, lack of sufficient scientific certainty and knowledge regarding an alien species should not prevent a competent authority from taking a decision with regard to the intentional introduction of such alien species to prevent the spread and adverse impact of invasive alien species.

Guiding principle 11: Unintentional introductions

All States should have in place provisions to address unintentional introductions (or intentional introductions that have become established and invasive). These could include statutory and regulatory measures and establishment or strengthening of institutions and agencies with appropriate responsibilities. Operational resources should be sufficient to allow for rapid and effective action.

Common pathways leading to unintentional introductions need to be identified and appropriate provisions to minimize such introductions should be in place. Sectoral activities, such as fisheries, agriculture, forestry, horticulture, shipping (including the discharge of ballast waters), ground and air transportation, construction projects, landscaping, aquaculture including ornamental aquaculture, tourism, the pet industry and game-farming, are often pathways for unintentional introductions. Environmental impact assessment of such activities should address the risk of unintentional introduction of invasive alien species. Wherever appropriate, a risk analysis of the unintentional introduction of invasive alien species should be conducted for these pathways.

D. Mitigation of impacts

Guiding principle 12: Mitigation of impacts

Once the establishment of an invasive alien species has been detected, States, individually and cooperatively, should take appropriate steps such as eradication, containment and control, to mitigate adverse effects. Techniques used for eradication, containment or control should be safe to humans, the environment and agriculture as well as ethically acceptable to stakeholders in the areas affected by the invasive alien species. Mitigation measures should take place in the earliest possible stage of invasion, on the basis of the precautionary approach. Consistent with national policy or legislation, an individual or entity responsible for the introduction of invasive alien species should bear the costs of control measures and biological diversity restoration where it is established that they failed to comply with the national laws and

regulations. Hence, early detection of new introductions of potentially or known invasive alien species is important, and needs to be combined with the capacity to take rapid follow-up action.

Guiding principle 13: Eradication

Where it is feasible, eradication is often the best course of action to deal with the introduction and establishment of invasive alien species. The best opportunity for eradicating invasive alien species is in the early stages of invasion, when populations are small and localized; hence, early detection systems focused on high-risk entry points can be critically useful while post-eradication monitoring may be necessary. Community support is often essential to achieve success in eradication work, and is particularly effective when developed through consultation. Consideration should also be given to secondary effects on biological diversity.

Guiding principle 14: Containment

When eradication is not appropriate, limiting the spread (containment) of invasive alien species is often an appropriate strategy in cases where the range of the organisms or of a population is small enough to make such efforts feasible. Regular monitoring is essential and needs to be linked with quick action to eradicate any new outbreaks.

Guiding principle 15: Control

Control measures should focus on reducing the damage caused as well as reducing the number of the invasive alien species. Effective control will often rely on a range of integrated management techniques, including mechanical control, chemical control, biological control and habitat management, implemented according to existing national regulations and international codes.

International instruments

Summary overview of health management and alien species in aquatic ecosystems

Michael Phillips
C.V. Mohan
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... aquatic animal pathogens, are trans-boundary problems with potential to impact on international trade, aquaculture and fisheries and the people whose livelihoods depend on aquatic resources

Introduction

This presentation provided an introduction to aquatic animal health aspects of trans-boundary movement and introductions of alien species, noting the relevant international and regional agreements and suggestions for practical implementation in the Mekong/Lancang region.

Trans-boundary aquatic animal diseases are a major risk and an important constraint to the growth of aquaculture. Aquatic alien species could either be pathogens, that may cause trans-boundary aquatic animal diseases, or could harbor aquatic animal pathogens that lead to diseases and epizootics in aquaculture following introduction of alien species. Aquatic alien species, and aquatic animal pathogens, are trans-boundary problems with potential to impact on international trade, aquaculture and fisheries and the people whose livelihoods depend on aquatic resources.

Aquatic species have been moved around the world for various purposes. There are many examples of positive socio-economic benefits from introductions of aquatic species, including improved livelihoods, increased production and trade. However, there are equally cases where serious negative impacts have resulted. Where introductions are necessary, they should be conducted in a responsible and transparent way using appropriate measures to assess and manage risks.

Live aquatic animals are moved actively to support subsistence and commercial aquaculture in Asia. Live aquatic animals though appearing healthy, often carry serious pathogens. Examples of introduction of pathogens to new aquatic systems and hosts leading to serious consequences in the Asia-Pacific region include Epizootic Ulcerative Syndrome (EUS) in fresh and brackishwater fishes, WSSV and TSV in cultured shrimp and VNN in grouper. Continued occurrence of koi mass mortality in Indonesia and the recent outbreak of KHV in Japan are

grim reminders of dangers associated with trans-boundary spread of pathogens. Careful examination of the history and spread of these diseases in the region indicate how irresponsible or ill-considered movements of live animals can impact aquaculture and wild fisheries resources. In many cases, these impacts are a direct result of absence of national and regional disease management strategies or non-compliance by stakeholders to such strategies.

Aquatic species are widely moved within and between countries and watersheds in the Mekong region and between the region and elsewhere. Therefore, the risk of trans-boundary aquatic animal disease problems in the region is considerable. Adaptation and adoption of relevant regional or international standards, codes or guidelines for trans-boundary movement could have far reaching positive implications for responsible development of subsistence and commercial aquaculture and fisheries in the Mekong/Lancang region.

International agreements

Various global instruments, codes of practice and guidelines (either voluntary or obligatory) exist that provide certain levels of protection, all aimed at minimizing the risks due to pathogens/diseases associated with aquatic animal movement (FAO/NACA, 2000). There are a number of international agreements that directly relate to health management and trans-boundary movement of live aquatic animals, or include provisions that consider the risks and management of risk associated with introduction of aquatic animal pathogens through trans-boundary movement. These include:

FAO Code of Conduct for Responsible Fisheries, created in 1995, sets out principles and international standards of behaviour for responsible practices with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity.

Code of Practice on the Introductions and Transfers of Marine Organisms (ICES), created in 1973 and updated in 1994, gives recommended procedures and practices to reduce the risks of detrimental effects from the intentional introduction and transfer of marine (including brackish water) organisms. Endorsed by FAO Regional Fishery Bodies.

Cartagena protocol on Bio-safety, adopted in 2000 under the Convention on Biological Diversity and in force from September 2003, seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology.

Convention on Biological Diversity, adopted in 1992 and in force from 1993, its objectives are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

World Trade Organization (WTO), established in 1995 is the only global international organization dealing with the rules of trade between nations. The Sanitary and Phyto-sanitary agreement specifically addresses the management of diseases and pathogens associated with trans-boundary movements.

World Organisation for Animal Health (OIE), established in 1924, in association with WTO helps, *inter alia*, guarantee the sanitary safety of world trade by developing sanitary rules for international trade in animals and animal products.

In many cases, these impacts are a direct result of absence of national and regional disease management strategies or non-compliance by stakeholders to such strategies

Regional Technical Guidelines

Within Asia, The Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals and their associated implementation plan, the Beijing Consensus and Implementation Strategy (BCIS), (FAO/NACA, 2000) provide expert guidance for national and regional efforts in reducing the risks of disease due to trans-boundary movement of live aquatic animals.

The preparation of Technical Guidelines and the Manual of Procedures were jointly initiated by FAO and NACA in 1998 through an FAO Technical Cooperation Programme (TCP) Project – "Assistance for the Responsible Movement of Live Aquatic Animals", with the participation of 21 countries from throughout the region. This program complemented FAO's efforts in assisting member countries to implement the relevant provisions in Article 9 - Aquaculture Development – of the Code of Conduct for Responsible Fisheries (CCRF), at both the national and regional levels. The Technical Guidelines are supported by a detailed Manual of Procedures and Asia Diagnostic Guide (FAO/NACA, 2001; Bondad-Reantaso *et al.*, 2001).

The Technical Guidelines provide valuable guidance for national and regional efforts to reduce these risks and a strong platform for mutual cooperation at the national, regional and international levels. There is strong technical and political endorsement from regional, inter-governmental and global organizations and a shared commitment from national governments to support its implementation.

Among the 21 governments adopting the Technical Guidelines include the countries of the Mekong/Lancang basin of China, Myanmar, Laos, Thailand, Cambodia and Vietnam. Further strengthening their implementation in the Mekong region, and Southeast Asia, was their adoption as a policy document by the ASEAN Fisheries Working Group in 2001. The major elements of the Technical Guidelines are provided in Box I (Part I). The framework provided by the guidelines and implementation strategy (Box I, Part II is a comprehensive one that includes all major requirements for managing risk associated with live aquatic animal movements

IMPLEMENTATION

There has been considerable progress in implementation of the Technical Guidelines in several countries in Asia, however, progress in some countries is limited. As implementation of the Technical Guidelines is a long-term process, continuous effort to motivate and support governments in initiating their health management programs is required. Regional workshops where governments come together and share knowledge and lessons learnt have proved useful in the past, and should be initiated where appropriate to facilitate the process of implementation. Such actions may be required in the Mekong/Lancang region. Governments tend to give more attention to their international obligations when trade issues start to affect them, and aquatic animal diseases are becoming a more significant international trade issue. Commitment and willingness on the part of the governments is a primary basis for

implementation of the Technical Guidelines.

Developing and implementing a regional reporting system is one of the elements contained in the Technical Guidelines. The NACA/OIE/FAO Quarterly Aquatic Animal Disease (QAAD) Reporting System is an example of such cooperation in the Asian Region. The NACA/OIE/FAO list includes all diseases listed by OIE plus diseases of concern to the region. A comprehensive surveillance program with data and reports collected in a national aquatic animal health information system can provide the basis for regional and international disease reporting.

Implementation (with special reference to the Mekong/Lancang system)

The Technical Guidelines emphasise the concept of "phased implementation" according to capacity and needs and the importance of cooperation in their implementation. The implementation strategy for the Technical Guidelines emphasizes "joint activities in risk reduction in shared watersheds" and gives specific mention of the need for cooperation in health management and responsible movement of live aquatic animals in the Mekong/Lancang river system. In some of the countries in the Mekong system, there is an urgent need to encourage governments to initiate programs to address national aquatic animal health management issues outlined in the Technical Guidelines.

Many epidemic aquatic animal diseases do not respect borders and can spread very rapidly from country to country. There is also a different capacity for health management among the countries in the Mekong/Lancang region. Neighbouring countries therefore should therefore cooperate closely in the control of these diseases. Part of this cooperation should be the rapid sharing of information on new disease occurrences and the spread of existing epidemic diseases to new areas, particularly near shared borders.

The following issues were presented for further consideration and discussion during the workshop:

- the importance of legislation and policy frameworks to support implementation;
- the need for national coordination and institutional cooperation, including between veterinary and fishery authorities, and identification of a "Competent" authority;
- the need to understand risks, and focus on key pathogens of concern for the Mekong/Lancang region;
- the importance of proper assessment of risk, and development of strategies for the region based on risk;
- building capacity for diagnostics, harmonization of approaches, and resource centres with clear responsibilities, including sharing of capacity among countries in the Mekong/Lancang region;
- disease zoning and cooperation within the Mekong/Lancang region, for example to maintain the reduce the risks of spread to watersheds with low disease incidence, or where there are particular risks to indigenous stocks;
- the importance of awareness and capacity building among stakeholders, including farmers and local extension officers;
- the need for effective communication on aquatic animal health issues and disease status among countries in the region to share knowledge on disease status, control measures, and to deal collectively with serious problems;

- the need for private sector/farmer participation and ownership;
- the need to be realistic about health management programs based on available financial resources, and make effective use of existing institutional resources;
- the importance of monitoring and evaluation of health management programs, and building systems gradually, with regular evaluation and exchange of experience.

Conclusion

Aquaculture in the Mekong/Lancang region is active, expanding and diversifying (Phillips, 2002). Increased aquaculture development in the Mekong basin will likely lead to more aquatic animaldisease outbreaks, and serious disease outbreaks and pathogens could easily spread beyond watersheds and national boundaries. Although poorly understand, risks will include socio-economic impacts on the livelihoods of small-scale aquaculture farmers, and possibly impacts on wild fish species and fisheries. Stakeholders will also consider introduction of alien species and continue to move species between countries in the region. Aquaculture has suffered enormous losses due to trans-boundary diseases, and increasing risks are expected in future as aquaculture expands in the region.

Stakeholders intending to import live aquatic animals need to adopt more effective risk management measures, based on international and regional agreements. Such agreements should be specifically adapted – and made practical to implement – in the circumstances within the region. Data gathering, analysing and sharing information on the health of aquatic animals will become increasingly important to aid decision makers in developing sound policy. Such government policies, with active awareness raising and engagement by the farming community, will not only help in disease control but also facilitate responsible movement of aquatic animals both within and between countries in the Mekong/Lancang region. Only through strong resolve and commitment among stakeholders, can responsible health management and development of aquaculture be assured. In the Mekong/Lancang region, cooperation among all the riparian countries will be an essential element of responsible aquaculture development for the region.

This workshop should provide the basis for discussing an aquaculture health management strategy for the Mekong/Lancang region as part of the discussion on responsible trans-boundary movement of live aquatic animals.

Stakeholders intending to import live aquatic animals need to adopt more effective risk management measures, based on international and regional agreements

References

FAO/NACA. 2000. Asia regional technical guidelines on health management for the responsible movement of live aquatic animals and the Beijing consensus and implementation strategy. FAO Fisheries Technical Paper. No. 402. Rome, FAO. 2000. 53 pp.

FAO/NACA. 2001. Manual of procedures for the implementation of the Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals. FAO Fisheries Technical Paper 402. Suppl. 1. Rome, FAO. 2001. 106 pp.

Bondad-Reantaso, M.G., McGladdery, S.E., East, I. and Subasinghe, R.P. (Eds.) (2001). Asia Diagnostic Guide to Aquatic Animal Diseases. FAO Fisheries Technical Paper No. 402, Supplement 2. Rome, FAO. 240 pp.

NACA/FAO. 2003. Quarterly Aquatic Animal Disease Report (Asia and Pacific Region). 2003/4, October to December 2003.

Phillips, M.J. 2002. Freshwater aquaculture in the lower Mekong basin. Mekong River Commission Technical Paper Number 7. Mekong River Commission, Phnom Penh, Cambodia. 62 pp.

Box I: Main elements of the FAO/NACA Regional Technical Guidelines for responsible movement of live aquatic animals

The Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals and their associated implementation plan, the Beijing Consensus and Implementation Strategy (BCIS) (FAO/NACA, 2000) provide expert guidance for national and regional efforts in reducing the risks of disease due to trans-boundary movement of live aquatic animals. The following highlights the main elements:

Part I - Asia regional technical guidelines

Part II - Beijing consensus and implementation strategy

International instruments

Overview of selected international agreements related to alien species in aquatic ecosystems

Patricia Moore

Treatment of alien species in aquatic ecosystems in global multilateral agreements is uneven, with marine ecosystems currently faring somewhat better than freshwater ecosystems

Abstract

Over 40 binding international agreements – not all of them yet in force – refer either directly or indirectly to alien species. Of those, less than a dozen are specifically related to aquatic environments. Treatment of alien species in aquatic ecosystems in global multilateral agreements is neither comprehensive nor entirely consistent. Marine ecosystems currently have somewhat better coverage than freshwater ecosystems. The scope of each instrument discussed in this paper is limited in some way. None of them covers all aspects of alien species regulation: intentional introductions, unintentional introductions, precaution, prevention, eradication, containment or long-term control, and restoration of ecosystems damaged by invasive alien species. It is the global trade agreements that potentially will have the greatest impact on how alien species can be managed in the future. Efforts to control transboundary movement of alien species will inevitably be caught in the trade/development/environment triangle. While the issues of the interactions of MEAs with other MEAs and with the WTO are being resolved, productive work can be done at the field and site level, setting aside political issues and focusing on concrete actions to manage invasive alien species in aquatic ecosystems.

Introduction

This paper reviews selected binding international agreements that directly or indirectly govern alien species. It does not discuss the Convention on Biological Diversity (CBD), the Cartagena Protocol on Biosafety, or river basin management agreements, nor does it address guidelines, codes of conduct, or other non-binding instruments as these are covered elsewhere in the proceedings.

International law began to address alien species more than 50 years ago. There are now over 40 binding international agreements – not all of them yet in force – that refer either directly or indirectly to alien species.[1] Of those, less than a dozen are specifically related to aquatic environments. Three of those are globally applicable instruments: the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar); the Law of the Sea; and the Convention on the Law of the Non-Navigable Uses of International Watercourses, which is not yet in force. The others are regional agreements, none of which apply in Asia. There are two Asia-specific agreements related to alien species, neither of which specifically deals with aquatic ecosystems: the 1956 Plant Protection Agreement for the Asia and Pacific Region, which is a supplementary agreement under the International Plant Protection Convention; and the 1985 ASEAN Agreement on the Conservation of Nature, which is not yet in force. There is no regional or global legal instrument that comprehensively governs alien species.

The international regime governing alien species developed over time through various processes in response to different needs. Treatment of alien species in international law is neither comprehensive nor entirely consistent. Some of the international instruments are multilateral environmental agreements (MEAs) that treat alien species in the context of their potential impact on native species and ecosystems. Others are trade-related agreements on sanitary and phytosanitary measures that address alien species as pests and potential vectors for human, plant and animal diseases. Because there are few international agreements dealing with alien species in aquatic ecosystems, there are correspondingly few tools and guidelines for managing them. Terrestrial ecosystems tend to have better coverage because of the phytosanitary, quarantine and other measures developed for agriculture and animal husbandry.[2]

The scope of each instrument discussed in this paper is limited in some way; none of them cover all aspects of alien species regulation such as: intentional introductions, unintentional introductions, precaution, prevention, eradication, containment or long-term control, and restoration of ecosystems damaged by invasive alien species. Prevention includes sanitary and phytosanitary controls for intentional introductions and pathways and vectors for unintentional introductions. Most international agreements provide generally for preventing introductions, but cover the other aspects of alien species management incompletely, if at all. [3]

The conservation treaties address alien species in the context of species and ecosystem health and function, but tend to be weak on issues such as early warning, monitoring, and transboundary cooperation. Where such provisions exist, they are general ones that are not alien-specific. Sanitary/phytosanitary agreements generally have stronger provisions for notification and monitoring, but their standards are focused on food safety and animal, plant and human health, and do not address ecosystems.[4]

[1] Shine, Clare, Nattley Williams and Lothar Gündling. 2000. A Guide to Designing Legal and Institutional Frameworks on Alien Invasive Species. IUCN: Gland, Switzerland, Cambridge, and Bonn. Available on-line as UNEP/CBD/SBSTTA/6/INF/8. http://www.biodiv.org/doc/meetings/sbstta/sbstta-06/information/sbstta-06-inf-08-en.pdf

[2] See generally, Convention on Biological Diversity. Subsidiary Body on Scientific, Technical and Technological Advice. Invasive Alien Species, Comprehensive Review on the efficiency and efficacy of existing measures for their prevention, early detection, eradication and control. 20 December 2000. pp. 1-2.UNEP/CBD/SBSTTA/6/7. http://www.biodiv.org/doc/meetings/sbstta/sbstta-06/official/sbstta-06-07-en.pdf

[3] See generally, Convention on Biological Diversity. Subsidiary Body on Scientific, Technical and Technological Advice. Invasive Alien Species, Review of the efficiency and efficacy of existing legal instruments applicable to alien species. 26 February 2001. p. 4. UNEP/CBD/SBSTTA/6/INF/5. http://www.biodiv.org/doc/meetings/sbstta/sbstta-06/information/sbstta-06-inf-05-en.pdf

[4] Ibid.

The way terms are defined varies from agreement to agreement. The earlier conservation agreements refer to "exotic" and "non-native" species. The more recent agreements refer to "alien" or "invasive alien" species, while the sanitary/phytosanitary agreements generally refer to "pests". Some agreements define a few key terms, but not others.

Agreements related to aquatic ecosystems

GLOBAL

Law of the Sea (1982)

The only global agreement in force for aquatic ecosystems with a specific provision on alien species is the Law of the Sea.[5] The Law of the Sea covers both intentional and unintentional introductions of alien species into the marine environment: States shall take all measures necessary to prevent, reduce and control pollution of the marine environment resulting from the use of technologies under their jurisdiction or control, or 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. (Article 196)

It does not provide for eradication or control of alien species, nor does it provide for restoration of damaged marine ecosystems. There is a general provision for liability under international law for non-compliance with obligations to protect and preserve the marine environment (Article 235).

The Law of the Sea provides for assessment of potential risks of activities that may cause harmful changes to the marine environment (Article 206), for monitoring (Article 204), and for immediate notification of actual or imminent damage to the marine environment. These provisions refer to "pollution" and are not alien-specific, but "pollution" is defined in such a way that it may be interpreted to include introductions of alien species.

Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar, 1971)[6]

The Ramsar Convention was the first of the biodiversity-related MEAs and is the only one that deals with one particular ecosystem – wetlands.[7] Over three decades, Ramsar has evolved from an agreement rather narrowly focused on waterfowl habitat to an organization that is contributing actively to the sustainable development agenda related to wetlands generally and has established working relationships with the other principal international organizations working in the field of wetlands conservation.[8] Ramsar remains, however, a convention that focuses on site-based action.[9]

[5] http://www.un.org/Depts/los/losconv1.htm

[6] http://www.ramsar.org/key_conv_e.htm

[7] International Institute for Sustainable Development (IISD). 2002. Earth Negotiations Bulletin (ENB). Summary of the Eighth Meeting of the Conference of the Contracting Parties to the Ramsar Convention on Wetlands: 18-26 November 2002. Vol. 17, No. 18, Friday, 29 November 2002. p. 1.

[8] Ibid. p. 15.

[9] Davidson, Nick. 2001. Case Study: invasive alien species, Multilateral Environmental Agreements and site management. Statement by Ramsar's STRP to CBD's Subsidiary Body for Scientific, Technical and Technological Advice. March. http://www.ramsar.org/speech_sbstta6_nick1.htm and IISD/ENB, supra., p. 16.

As of 19 August 2003, Ramsar has 138 Contracting Parties and 1 308 sites designated for the List of Wetlands of International Importance, with a total surface area of 110 102 681 hectares.[10] There are 14 Ramsar Contracting Parties in Asia, with 103 designated Ramsar sites among them. Of the Lower Mekong countries, Cambodia, Thailand and Viet Nam are Ramsar Contracting Parties, with 14 sites; Lao People's Democratic Republic is actively considering becoming a Party.

The Convention itself does not have a provision dealing with alien species. Ramsar Contracting Parties have an obligation to promote the wise use of wetlands in their territories (Article 3.1). The Convention has developed the concept of "wise use" over the years and in 1990 first issued *Guidelines for the Implementation of the Wise Use Concept*[11], which did not refer to alien species. In 1993, the Guidelines were revised. They now recommend that national legislation should include obligations to refrain from intentional introductions of invasive alien species, take preventive measures to minimize the risk of unintentional introductions, make efforts to eradicate introduced species, and provide for civil liability for those responsible for unlawful introductions[12]. The same year, *Guidelines on management planning for Ramsar sites and other wetlands* were adopted that have been superseded by a new version issued in 2002. Both versions of the management guidelines incorporate references to invasive alien species similar to those in the wise use guidelines.

In 1999, at its 7th Meeting, the Conference of the Contracting Parties to Ramsar adopted the first Resolution on invasive species and wetlands[13]. A background document for COP7 offered a definition of invasive alien species, described the effect of invasives on wetlands, listed organisms that can become invasive in wetlands, described methods of control, and outlined solutions[14]. The Resolution urged Contracting Parties to: address the environmental, economic and social impact of the movement and transport of alien species; inventory alien species in wetlands in their jurisdictions; target invasive alien species for eradication or control; adopt legislation to prevent the introduction and spread of invasive alien species; and build capacity to identify alien species and enforce legislation. It directed the Ramsar Bureau to give priority to addressing invasives in its cooperation with other international organizations working on wetlands, to develop a data base on invasive species that threaten wetlands, and to prepare case studies where invasives have had a negative impact on wetlands, and Ramsar sites in particular. The Scientific and Technical Review Panel (STRP) was directed to prepare guidelines for managing invasive alien species in wetlands and to collaborate on guidance for legislation and other best practice approaches. In support of this Resolution, the Ramsar Bureau produced Guidelines for reviewing laws and institutions to promote the conservation and wise use of wetlands[16] and IUCN-The World Conservation Union (IUCN) in 2000 published A Guide to Designing Legal and Institutional Frameworks on Alien Invasive Species[16].

10 http://www.ramsar.org/key_cp_e.htm

11 Ramsar Convention. 1990. Guidelines for the Implementation of the Wise Use Concept. First adopted as an annex to Recommendation 4.10 of the 4th Meeting of the Conference of the Contracting Parties. http://www.ramsar.org/key_guide_wiseuse_e.htm

12 Ramsar Convention. 1993. Additional guidance on the implementation of the wise use concept. http://www.ramsar.org/key_guide_wiseuse_add_e.htm

13 Ramsar Convention. 1999. 7th Meeting of the Conference of the Contracting Parties. Invasive species and wetlands. Resolution 7.14. http://www.ramsar.org/key_res_vii.14e.htm

14 Howard, Geoffrey. 1999. Invasive species and wetlands. Background Document. Ramsar COP7 DOC. 24.

15 Ramsar Convention. 1999. Guidelines for reviewing laws and institutions to promote the conservation and wise use of wetlands. http://www.ramsar.org/key_guide_laws_e.htm

16 Shine, Clare et al. 2000. supra. See also, Shine, Clare and Cyrille de Klemm. 1999. Wetlands, Water and the Law. Using law to advance wetland conservation and wise use. IUCN Environmental Policy and Law Paper No. 38. IUCN: Gland, Switzerland, Cambridge, UK, and Bonn.

The following Conference of the Contracting Parties, CoP8, adopted another Resolution on invasive species and wetlands[17]. Resolution VIII.18 urged Contracting Parties to identify alien species in Ramsar sites and other wetlands in their territory and carry out risk assessments. It noted that invasives can spread quickly in wetland ecosystems, that eradication in one place may not prevent future invasions, and that Contracting Parties with shared wetland ecosystems should cooperate in all aspects of managing alien species, following the *Guidelines for international cooperation under the Ramsar Convention*[18]. The Resolution reminded Contracting Parties that terrestrial invasions of alien species can affect water flows, that transfers of water between river basins can transfer alien species as well, and urged them to take measures to manage such situations. There are several references to the need for Ramsar to continue and expand collaboration with a range of international organization partners, including the CBD, the International Maritime Organization (IMO), the UNESCO Man and the Biosphere Programme (MAB), the Global Invasive Species Programme (GISP), the World Conservation Monitoring Centre (UNEP-WCMC), and IUCN.

COP8 and Resolution VIII.18 provided an example of the impact Ramsar's working relationships with other conventions and organizations can have on its own internal decision-making processes. Following the directive of Resolution 7.14 to prepare guidelines on managing invasive alien species in wetlands, the Ramsar STRP decided to prepare for Ramsar Parties a guide to each of the elements being developed under the CBD and GISP, rather than duplicating efforts. "Guidance on invasive species and wetlands: a guide for Ramsar managers" was drafted and prepared as a background document to be adopted by COP8[19]. The adoption of the CBD's Guiding Principles at its COP6 became controversial, for both substantive and procedural reasons – a Party raised a trade-related objection to an element of the contents and for procedural reasons still disputes whether the Decision containing the Guiding Principles was actually adopted. Because the Ramsar Guide was linked to the CBD Guiding Principles, a similar controversy arose at Ramsar COP8.[20] Ramsar decided not to submit its Guide for consideration by COP8, and compromise language omitting a reference to the CBD Guiding Principles was substituted in Resolution VIII.18[21].

Trade-related issues affected a Ramsar Resolution on agriculture, wetlands and water management as well. The COP agreed to include text requesting Parties to ensure that measures implementing Ramsar do not support agricultural policies that conflict with international trade obligations. Some Asian delegates and others argued that World Trade Organization (WTO) negotiations and MEA negotiations should not be mixed.[22] The final versions of Resolutions on climate change and wetlands, and on the report of the World Commission on Dams also reflected compromises related to controversies carried over from other fora[23].

17 Ramsar Convention. 2002. 8th Meeting of the Conference of the Contracting Parties. Invasive species and wetlands. Resolution VIII.18. http://www.ramsar.org/key_res_viii_18_eIAS.htm

18 Ramsar Convention. 1999. Guidelines for international cooperation under the Ramsar Convention. http://www.ramsar.org/key_guide_cooperate.htm

19 Ramsar COP8 Doc. 4: Report of the Chair of the Scientific and Technical Review Panel. paras. 59-60. http://www.ramsar.org/cop8_doc_04_e.htm

20 IISD/ENB, supra., p. 15.

21 Ramsar COP8 Doc. 4, supra, para. 61.

22 International Centre for Trade and Sustainable Development (ICTSD). 2002. Bridges. Trade Issues Spilling over into Wetland Negotiations. Vol. 2, No. 19. 11 December.

23 IISD/ENB, supra., pp. 5-6 and 16.

The Ramsar Strategic Plan 2003-2008 refers several times to invasive alien species and dedicates Operational Objective 5 to developing guidance and promoting protocols and actions to prevent, control or eradicate invasive alien species in wetland systems[24].

Ramsar and the CBD have agreed on the third in a series of joint work plans, for the period 2002-2006. The workplan includes invasive alien species as a crosscutting issue. It particularly commits Ramsar and the CBD to working with GISP, IUCN, and UNEP-WCMC to develop a programme of work focused on aquatic invasive species[25].

The World Bank and the WorldWide Fund for Nature (WWF) collaborated on a study of Ramsar's effectiveness in conserving wetlands. The report, presented at COP8, concluded that designating wetlands as Ramsar sites is likely to have improved their conservation prospects due to various factors, including increased awareness of their importance, increased conservation funding (both domestic and international), increased participation by local stakeholders in conservation, and reduction of threats[26].

Convention on the Law of the Non-navigational Uses of International Watercourses, 1997[27]

This international agreement, not yet in force, applies to the protection, preservation and management of international watercourses, which are defined as systems of surface and ground waters that constitute a unitary whole and of which parts are situated in different States (Articles 1 and 2). It recognizes a watercourse State's right equitably and reasonably to use the watercourse and the duty to cooperate to protect and preserve the ecosystems of international watercourses and to develop them sustainably (Articles 5 and 20). There is a specific provision on alien species, which addresses only prevention:

Watercourse States shall take all measures necessary to prevent the introduction of species, alien or new, into an international watercourse which may have effects detrimental to the ecosystem of the watercourse resulting in significant harm to other watercourse States (Article 22).

Watercourse States are also obliged to protect the marine environment into which the international watercourse feeds (Article 23).

The Convention does have a general obligation not to cause significant harm that requires a State causing significant harm to eliminate or mitigate the harm and to discuss compensation, where applicable (Article 7). There is a general obligation on Parties to cooperate and to exchange information (Articles 8, 9, 30 and 31). Detailed provisions cover notification for planned and emergency situations (Articles 11-19 and 28). None of these provisions are alien-specific, but apply generally to all obligations under the Convention. Risk assessment is not mentioned *per se*, but is implied in the purpose of notification – to allow potentially affected States to evaluate the possible effects of any planned measures (Article 12).

24 Ramsar Strategic Plan 2003-2008. http://www.ramsar.org/key_strat_plan_2003_e.htm

25 Third Joint Work Plan (2002-2006) of the Convention on Biological Diversity and the Convention on Wetlands (Ramsar, Iran, 1971). http://www.ramsar.org/key_cbd_jwp3_e.htm

26 Castro, Gonzalo, Kenneth Chomitz, and Timothy S. Thomas. The Ramsar Convention: Measuring its Effectiveness for Conserving Wetlands of International Importance. Ramsar COP8 DOC. 37, p. 6. http://www.ramsar.org/cop8_docs_index_e.htm

27 U.N. Doc.A/51/869. http://srch1.un.org/law/ilc/texts/nonnav.htm

Draft International Convention for the Control and Management of Ships' Ballast Water and Sediments[28]

The World Summit on Sustainable Development called for faster action to deal with invasive alien species in ballast water and urged the International Maritime Organization (IMO) to finalize this Draft Convention.[29] The IMO developed this agreement to provide globally applicable regulations for controlling "harmful aquatic organisms and pathogens". By definition, it applies to freshwater as well as marine environments (Article 1).

The main body of the Draft Convention contains general provisions on control, monitoring, inspection, notification, and cooperation. Detailed regulations are included in the Annex. They apply to ships of 400 gross tonnage and above, and do not apply to floating platforms (Regulation E-1). The regulations cover ballast water and sediment standards, and survey, certification and management (Regulations B, D, and E). Parties may designate special areas where additional measures are required to prevent, reduce or eliminate the transfer of harmful aquatic organisms and pathogens through ballast water and sediment (Regulation C).

The Draft Convention has been submitted to the International Conference on Ballast Water Management for Ships for review and adoption.

REGIONAL

Antarctica

Two of the international legal instruments governing Antarctica deal with aquatic ecosystems – the 1980 Convention on the Conservation of Antarctic Marine Living Resources[30] and the 1991 Protocol on Environmental Protection to the Antarctic Treaty[31].

The 1980 Convention is primarily concerned with harvesting marine species in the Antarctic region. It provides that harvesting may only be done in accordance with three conservation principles. One of those principles calls for preventing changes or minimizing the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades, taking into account the effect of the introduction of alien species, among other things (Article II.3.(c)).

The 1991 Protocol (also referred to as "the Madrid Protocol") prohibits the introduction of animal or plant species not native to the Antarctic Treaty area onto land or ice shelves, or into water, except in accordance with a permit (Article 4). For intentional introductions, permits must specify the precautions to be taken to prevent escape or contact with native fauna and flora, and the obligation to remove or dispose of the introduced species before the expiration of the permit (Article 4.3 and 4.4). Unintentional introductions must be removed, disposed of, or sterilized, unless it is determined that they pose no threat to native species (Article 4.4). Parties are to take precautions to prevent the introduction of micro organisms not present in the native fauna and flora (Article 4.6).

28 http://globallast.imo.org/ The IMO previously adopted non-binding technical Guidelines for the control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens. Annex to Resolution A.868(20), 20th IMO Assembly, 1997.

29 United Nations. 2002. Report of the World Summit on Sustainable Development. A/CONF.199/20*. Annex. Plan of Implementation of the World Summit on Sustainable Development. para. 34(b), p. 26.

30 http://fletcher.tufts.edu/multi/texts/BH779.txt

31 http://fletcher.tufts.edu/multi/texts/BH992.txt

Europe

European Union (EU) – Aquaculture and Integrated Coastal Zone Management (ICZM)

The revised EU Common Policy on Fisheries (CPF) took effect on 1 January 2003.[32] The CPF includes a strategy for aquaculture that notes that there is no coherent and specific EU legislation on aquaculture because many aquaculture issues are regulated by national legislation.[33] Although new legislation has yet to be enacted to implement it, the Strategy identifies escaped aquaculture species, alien species and transgenic fish as challenges to be addressed, and among the actions it proposes calls for developing instruments to tackle the impact of escapees, alien species and GMOs[34]. The Strategy also notes that the European Commission considers that all Member States should adhere to the ICES Code of Practice on the Introduction and Transfer of Marine Organisms[35]. The EU Strategy for ICZM notes that introduction of exotic species through ballast water is a problem to be tackled at the international level[36].

EU Habitats Directive[37]

The Habitats Directive by definition covers aquatic habitats (Article 1.b). EU Member States must ensure that intentional introductions of alien species are regulated so as not to cause harm to natural habitats or wild native fauna and flora, and they have the discretion to prohibit intentional introductions (Article 22.b).

United Nations Economic Commission for Europe (UNECE) Convention on the Protection and Use of Transboundary Watercourses and International Lakes (1992)

This agreement is primarily concerned with water quality and pollution control. It does not mention alien species, but does provide that "the Parties shall take all appropriate measures to prevent, control and reduce any transboundary impact" (Article 2.1). Transboundary impact is defined as meaning "any significant adverse effect on the environment resulting from a change in the conditions of transboundary waters caused by a human activity... Such effects on the environment include effects on human health and safety, flora, fauna, soil, air, water, climate, landscape and historical monuments or other physical structures or the interaction among these factors..." (Article 1.2).

Convention on Fishing in the Waters of the Danube (1958)

The Convention prohibits acclimatization and breeding of fish, animal and plant species without permission from the Commission established under the Convention (Annex Part V Article 10).

Selected Agreements from other Regions

Agreements related to aquatic ecosystems and alien species are adopted and in force in Africa, the Caribbean, Europe, the South East Pacific, and the United States and Canada. They include:[38]

32 See http://europa.eu.int/comm/fisheries/reform/index_en.htm

33 European Union 2002. Communication From The Commission To The Council And The European Parliament. A Strategy For The Sustainable Development Of European Aquaculture. COM(2002) 511 final. Brussels, 19.9.2002, p. 9. http://europa.eu.int/comm/fisheries/doc_et_publ/factsheets/legal_texts/docscom/en/com_02_511_en.pdf

34 Ibid., p. 18.

35 Ibid., p. 19.

36 Communication from the Commission to the Council and the European Parliament on Integrated Coastal Zone Management: A Strategy for Europe. COM(2000) 547 final. Brussels, 27.09.2000, p. 18.

37 European Union. 1992. COUNCIL DIRECTIVE 92/43/EEC (1) of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. http://europa.eu.int/comm/environment/nature/habdir.htm

38 Shine, Clare, supra. pp. 87-103.

Agreement on the Conservation of African-Eurasian Migratory Waterbirds (1995) – prohibit intentional introductions, take all measures to prevent unintentional introductions, and take all appropriate measures to ensure that non-native species already introduced do not become a threat to indigenous species (Article III(2)(g) and Annex 3 Action Plan 2.5);

Convention for the Establishment of the Lake Victoria Fisheries Organization (1994) – prohibit the introduction of non-indigenous species other than in accordance with a decision of the Council of Ministers (Article XII);

Agreement on the Preparation of a Tripartite Environmental Management Programme for Lake Victoria (1994) – control water hyacinth;

Protocol Concerning Specially Protected Areas and Wildlife to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (1990) – regulate or prohibit the introduction of non-indigenous species (Articles 5 and 12);

Protocol for the Conservation and Management of Protected Marine and Coastal Areas of the South East Pacific (1989) – prevent, reduce and control to the extent possible the introduction of exotic species of flora and fauna into protected areas (Article VII);

Convention on Great Lakes Fisheries Between the United States and Canada (1954) – control and eradicate the Atlantic sea lamprey (Article 1).

General Conservation Agreements

Global

Convention on the Conservation of Migratory Species of Wild Animals (CMS)

The Convention on the Conservation of Migratory Species explicitly refers to alien species. By definition the range of a migratory species means "all the areas of land or water that a migratory species inhabits, stays in temporarily, crosses or overflies at any time on its normal migration route" (Article I.1.f.). Obligations under the CMS, therefore, may apply to aquatic ecosystems.

Under CMS, Range States have a general obligation to take action to conserve migratory species, "whenever possible and appropriate" (Article II.1). Specific obligations related to alien species are in the context of endangered migratory species, which are listed in Appendix I to the Convention, and migratory species that have unfavorable conservation status and are listed in Appendix II.

For endangered migratory species listed in Appendix I, Range State Parties to CMS must endeavor to strictly control the introduction of exotic species, or to control or eliminate exotic species that have already been introduced. Parties are to do this in order to prevent, reduce or control factors that are endangering or are likely to further endanger the species.

Migratory species listed in Appendix II to CMS may be the subject of international agreements for their conservation and management (Article IV.1). CMS provides guidelines for such agreements, which should include an obligation to protect the habitats of migratory species with unfavorable conservation status "from disturbances, including strict control of the introduction of, or control of already introduced, exotic species detrimental to the migratory species" (Article V.5.e.).

Although obligations to manage alien species are limited under CMS to migratory species, any measures taken to implement them would also serve the broader purpose of controlling alien species generally.

It is the global trade agreements that potentially will have the greatest impact on how alien species can be managed in the future

Regional

Association of South East Asian Nations (ASEAN)

Agreement on the Conservation of Nature and Natural Resources, 1985

Although adopted almost 20 years ago, this ASEAN Agreement is not yet in force. This is unfortunate because the Agreement contains obligations related to alien species along with many other general obligations for transboundary cooperation that could be applied to movements of alien species. The ASEAN Agreement has a general obligation to regulate or prohibit the introduction of exotic species, in the context of conserving marine and freshwater species genetic diversity (Article 3.3.c). Introductions of exotic species are specifically prohibited in protected areas (Article 13.5(a)). There is a general requirement for prior assessment of the consequences of any activity that may significantly affect the natural environment both domestically and in other countries (Articles 14 and 20.3(a)). Parties have a general obligation to take no action that may significantly affect the environment or natural resources of other countries, particularly wildlife habitat (Article 20). Prior notification of actions likely to have significant impact beyond national boundaries and notification of emergency situations is also required (Article 20) and there is a general obligation to cooperate in monitoring activities (Article 18).

Other Regions

More than a dozen general conservation agreements with provisions related to alien species are in force in Africa, Central America, Europe, the Near East, and the South Pacific[39]. All of them provide for varying levels of preventing introductions – some strictly, some generally, some on the basis of a permit, and some only in protected areas. One requires Parties to "carefully consider" introductions. Only a few differentiate between intentional and unintentional introductions, provide for eradication, or provide for containing the spread of alien species once introduced. Fewer still provide for risk assessment either before or after introduction.

[39] Ibid. In addition, one of the objectives of the European Union's Sixth Community Environment Action Programme is to prevent and mitigate the impacts of alien species. Decision No 1600/2002/EC of the European Parliament and of the Council of 22 July 2002 laying down the Sixth Community Environment Action Programme. Article 6.

Trade Agreements

GLOBAL

World Trade Organization (WTO)

The WTO agreements deal with environmental measures indirectly – to the extent that they might affect trade – and seek to ensure that any environment-based trade measures are no more restrictive than necessary to achieve the purpose for which they are adopted.[40] Article XX of the General Agreement on Tariffs and Trade (GATT) provides two exceptions to GATT rules that could be applied in the case of alien species: Article XX(b) for the protection of human, plant or animal life or health; and Article XX(g) for the conservation of exhaustible natural resources.

To date, WTO disputes have not dealt with a situation involving alien species. The best-known environment-related case decided under the WTO, however, popularly known as the "US Shrimp/Turtle" case, dealt with conservation of endangered marine species. The 1989 Endangered Species Act (Section 609) requires the United States government to certify that all shrimp imported into the country are caught with methods that protect sea turtles from drowning in shrimp trawling nets. In 1996, the embargo was extended to all shrimp-exporting countries, approximately 40. Four Asian countries – India, Malaysia, Pakistan and Thailand – challenged the U.S. measure. The U.S. defended it on the basis of GATT Article XX(b) and (g). The WTO dispute settlement Panel ruled against the U.S. shrimp embargo, and the Appellate Body upheld the ruling. The Appellate Body decided that the GATT Article XX(g) exception applied to sea turtles, but that the United States had discriminated in implementing the shrimp embargo, partly because an alternative was available – the United States had entered into an agreement with Latin American countries to resolve the shrimp/turtle issue, but had not done so with the Asian countries.[41]

The WTO's binding dispute resolution system seeks to either remove or amend any trade-related measure that is inconsistent with WTO rules.[42] The Appellate Body's decision is read by some commentators as a narrow interpretation of WTO rules that will make it difficult for all WTO Members to defend their trade-related environmental measures through the GATT's Article XX exceptions.[43] To defend an exception for the protection of human, plant or animal life or health (Article XX(b)), a WTO Member must show that the policy objective behind its measure falls within the range of policies for that purpose, that the measure is necessary to meet the policy objective, and that there are no reasonably available alternatives

40 Mackenzie, Ruth et al. 2003. An Explanatory Guide to the Cartagena Protocol on Biosafety. IUCN: Gland, Switzerland and Cambridge, UK. p. 226.

41 See: Center for International Environmental Law. An Introduction: The Shrimp - Turtle Dispute and CIEL's Amicus Brief. http://www.ciel.org/Tae/shrimpturtle.html and International Centre for Trade and Sustainable Development (ICTSD). WTO Shrimp-Turtle Dispute. http://www.ictsd.org/html/shrimp_turtle.htm and Sakmar, Susan L. Free Trade and Sea Turtles: The International and Domestic Implications of the Shrimp-Turtles Case. Colorado Journal of International Environmental Law and Policy. http://www.colorado.edu/Law/CJIELP-10/Sakmar1.htm

42 Mackenzie, supra.

43 See, for example Wold, Chris and Glenn Fullilove. 2000. Analysis of the WTO Appellate Body's Decision in Shrimp/Turtle. http://www.lclark.edu/org/ielp/turtlebriefing.html

that are consistent with WTO rules. An exception for the conservation of exhaustible natural resources must fall within the range of related policies, be related to the conservation policy objective, and be made in conjunction with restrictions on domestic production or consumption. To qualify for either of these exemptions, a WTO Member must also show that its measure is being applied in a way that is neither arbitrary, unjustifiable, nor a disguised restriction on trade.[44]

The interpretations the WTO Appellate Body has used to resolve cases based on GATT Article XX indicate what a WTO Member would have to do to justify a measure under the 1995 Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement), which, like GATT Article XX(b), deals with human, plant and animal life and health.

WTO agreements do not address alien species per se, but the SPS Agreement covers measures to prevent or limit damage from the entry, establishment or spread of pests (Annex A, Article 1). The scope of this trade provision is substantial, given that it applies not only to measures dealing with the import/entry of pests, but also to measures to control their establishment or spread. The SPS Agreement defines "pests" only to the extent of specifying that the term includes weeds. Aquatic ecosystems are not specifically covered, but the term "animal" includes fish and "plant" includes wild flora (Annex A, fn. 4).

WTO Members have the right to take any measures to protect human, plant and animal life or health in their jurisdictions, as long as those measures are:

consistent with the SPS Agreement;

are applied only to the extent necessary to protect human, plant and animal life or health;

are based and maintained on scientific principles; and

do not constitute open or disguised restrictions on trade or discrimination against other Members with identical or similar conditions (Article 2.1-3).

Sanitary and phytosanitary measures that are consistent with the SPS Agreement are presumed to conform to the similar provision in Article XX(b) of the General Agreement on Tariffs and Trade (SPS Article 2.4).

The SPS Agreement requires WTO members to base their sanitary and phytosanitary measures on international standards and guidelines, particularly those issued by the Codex Alimentarius Commission, the International Office of Epizootics, and the international and regional organizations operating under the International Plant Protection Convention (see C.1.2, below)(Article 3).

To meet the "necessity test"[45] of the GATT and the SPS Agreement, WTO Members must determine the level of protection necessary to protect human, plant and animal life or health on the basis of risk assessment that in turn is based on scientific and economic analysis (Article 5). They must avoid arbitrary or unjustifiable differences in levels of protection that may constitute discrimination or disguised restrictions on trade. The SPS Agreement provides for a precautionary approach, allowing Members to adopt provisional measures when scientific evidence is insufficient, and requiring a risk assessment within "a reasonable period of time" (Article 5.7), usually taken in practice to be 15 months[46].

44 Mackenzie, supra, p. 235.

45 Ibid., p. 236.

46 International Centre for Trade and Sustainable Development (ICTSD). 2002. Bridges. CBD Adopts Guidelines on Access to Genetic Resources and Alien Species. Vol. 6, No. 15. 23 April. http://www.ictsd.org/weekly/02-04-03/story4.htm

Developing countries are accorded a degree of special and differential treatment under the SPS Agreement (Article 10). The WTO Committee on Sanitary and Phytosanitary Measures established by the SPS Agreement (Article 12) may grant developing country WTO Members specific and time-limited exceptions from all or some of the obligations of the Agreement.

The current WTO negotiations address the general question of the relationships between the WTO agreements and MEAs. The mandate for the "Doha Round" of negotiations and consultations to be concluded by 1 January 2005, calls for addressing the relationship between existing WTO rules and specific trade obligations in MEAs.[47] The Doha Declaration prescribes that negotiations on this point be compatible with the multilateral trading system, and that they not add to, diminish, or alter the balance of WTO Members' WTO rights and obligations.[48] The Secretariats of the CBD and five other MEAs, along with the United Nations Environment Programme (UNEP), have been invited on an *ad hoc* basis as observers at some negotiating sessions of the WTO's Committee on Trade and Environment (CTE). Their participation so far is limited to discussions on the relationship between existing WTO rules and specific trade obligations in MEAs. This situation reflects the primary restriction, as of mid-2003, on attempts to resolve the issues involved in the relationships between MEAs and the WTO. Discussions were only taking place in the context of the WTO, which limits the participation of MEA Secretariats and does not address non-specific trade measures and measures aimed at non-Parties to MEAs[49].

International Plant Protection Convention (IPPC)[50]

The IPPC came into force in 1952. Amendments adopted in 1979 came into force in 1991. Amendments adopted in 1997 substantially brought the IPPC in line with the 1995 WTO SPS Agreement but have not yet come into force. The IPPC does not explicitly apply to aquatic plants or plant pests, but neither are they excluded from coverage.

The governing body of the IPPC is one of three international organizations recognized under the WTO SPS Agreement as a standard-setting body, which gives IPPC standards effect beyond the Convention's own Parties. WTO Member States, whether IPPC Parties or not, must pattern their phytosanitary standards on those set by the IPPC[51].

The IPPC began setting International Standards for Phytosanitary Measures in the mid-1990s[52]; there are currently 19 approved standards[53]. The Interim Commission on Phytosanitary Measures (ICPM), which functions as the IPPC's governing body until the 1997 amendments come into force, in 2001 adopted new standards, including ones for pest risk analysis that provide for dealing with uncertainties[54]. Like the other two organizations recognized by the SPS Agreement, however, the IPPC focuses on human, plant and animal health and safety, rather than on ecosystem integrity.

47 World Trade Organization. 2001. Fourth Ministerial Conference. Ministerial Declaration, para. 31. Doha, Qatar, November. http://www.wto.org

48 Doha Ministerial Declaration, para. 32. (On-line). Available: http://www.wto.org

49 IUCN. 2003. Multilateral Environmental Agreements Need to Become More Proactive. (On-line). Available: http://www.iucn.org

50 http://www.ippc.int/IPP/En/default.htm

51 ICTSD. 2001. Bridges. FAO Plant Health Commission to Build Bridges between WTO and CBD. Vol. 5, No. 13. 10 April 2001. http://www.ictsd.org/html/weekly/10-04-01/story5.htm

52 http://www.nri.org/NRET/PWB/Inter.html

53i http://www.ippc.int/IPP/En/standards.htm

54 Ibid.

The Convention "applies mainly to quarantine pests involved with international trade" (1991 text, Article II.4). The 1997 amendments expand coverage to include "regulated non-quarantine pests" that an importing Party may regulate because they have an economically unacceptable collateral impact (1997 text, Article II.1). Under both the 1991 text and 1997 amendments, "pests" are any form of plant or animal life or any pathogen that could potentially harm plants. A quarantine pest is one that has not yet been introduced in a country, or is present but controlled, and that has potential economic danger if released (1991 text, Article II.2; 1997 text, Article II.1).

At the heart of the IPPC are the requirements related to imports (1991 text, Article VI; 1997 text, Article VII). The IPPC has a "necessity test" similar to the SPS Agreement – Parties may not take any measures unless they are necessary for phytosanitary reasons. The IPPC text currently in force does not require risk assessment; the text amended in 1997 does. Even though the current text of the IPPC does not require risk analysis, the ICPM has issued standards for it that must be followed by WTO Members (see above).

IPPC Parties may prohibit or restrict the import of plants and plant products and list pests whose import is prohibited or restricted. They may inspect, detain, treat, destroy or refuse entry to consignments that do not meet their prescribed requirements. These provisions are to be carried out so that they minimize interference with international trade. If ports of entry are specified, they must be selected so as not to impede international trade unnecessarily. Inspections are to be carried out promptly and certification requirements are to be kept to a minimum, particularly for plant products not intended to be planted.

The Convention provides for establishing National and Regional Plant Protection Organizations (NPPOs/RPPOs) and for supplementary agreements to facilitate implementation and cooperation among Parties. The Plant Protection Agreement for the Asia and Pacific Region[55] was adopted in 1956. Each of the Lower Mekong countries has designated a National Plant Protection Organization. The RPPO for Asia is the Asia and Pacific Plant Protection Commission, based in the FAO Regional Office in Bangkok, Thailand[56].

The 1991 text provides that notification of restrictions or prohibitions on imports is to be communicated directly (Article VI), while information on outbreaks or spread of pests, which could affect ecosystems, is to be done indirectly and periodically, rather than immediately (Article VII). This anomaly is corrected in the 1997 amendment (Article VII.6).

In contrast to the Cartagena Protocol on Biosafety to the CBD, which covers all living modified organisms (LMOs) in international trade, the IPPC covers LMOs only if they are categorized as plant pests. Collaboration between the ICPM and the CBD Secretariat will include defining when LMOs become pests to facilitate harmonizing phytosanitary and biosafety regulations[57].

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)[58]

CITES is the multilateral environmental agreement that specifically deals with international species trade. It does require reciprocal control between exporting and importing countries, but its objectives are to protect rare and endangered species against unsustainable trade,

55 http://sedac.ciesin.org/pidb/texts/plant.protection.south-east.asia.pacific.1956.html

56 http://www.ippc.int/servlet/

57 ICTSD. 2001. Bridges. supra

58 http://www.cites.org/

rather than to monitor or prevent introductions of species alien to the importing State.[59] CITES is unlikely to be applicable in cases of introductions of alien species unless a species protected in an exporting State is considered potentially invasive in the importing State.[60]

REGIONAL

ASEAN

In the early 1980s, ASEAN adopted several agreements on quarantine and phytosanitary issues[61]: These include the 1981 ASEAN Declaration on Specific Animal Disease Free Zone; 1982 ASEAN Ministerial Understanding on Plant Quarantine Ring; 1982 ASEAN Ministerial Understanding on the Standardization of Import and Quarantine Regulation on Animal and Animal Products; and the 1984 ASEAN Ministerial Understanding on Plant Pest Free Zone. None of them specifically address aquatic species or ecosystems.

In 2000, ASEAN adopted Protocol 8[62] on sanitary and phytosanitary measures to the 1998 ASEAN Framework Agreement on the Facilitation of Goods in Transit. Protocol 8 defines "goods" to include plants, plant products, and aquatic animals capable of harboring or spreading plant pests or animal diseases (Article 1.1.a). As with the WTO SPS Agreement, Protocol 8 defines sanitary and phytosanitary measures to include not only measures dealing with the import/entry of pests, but also to measures to control their establishment or spread (Article 1.1.b). Protocol 8 recognizes the same standard-setting bodies as the WTO SPS Agreement (Article 3.1) and provides for information sharing, consultation and emergency measures, which are to be immediately notified among ASEAN Member States (Article 3.2., 3., 4).

North American Free Trade Agreement (NAFTA)[63]

NAFTA's sanitary and phytosanitary provisions do not explicitly refer to aquatic ecosystems or organisms, nor are they excluded. Like the WTO SPS Agreement, NAFTA defines a phytosanitary measure to include preventing or limiting damage from the introduction, establishment or spread of a pest, in addition to protecting human, plant and animal health and safety (Article 724). NAFTA also requires that sanitary and phytosanitary measures be based on scientific principles and risk assessment to determine the appropriate level of protection (Article 712), and sets out parameters for assessing risk (Article 715). For standards, NAFTA relies on the same three international organizations specified in the WTO SPS Agreement (Article 713). NAFTA's provisions for control, inspection and notification are more detailed than similar provisions in the SPS Agreement (Articles 717, 718).

59 UNEP/CBD/SBSTTA/6/INF/5, p. 10, fn. 18.

60 Ibid., p. 15, fn. 45.

61 http://www.aseansec.org/

62 Association of South East Asian Nations (ASEAN). 2000. Protocol 8 Sanitary and Phytosanitary Measures to Implement the ASEAN Framework Agreement on the Facilitation of Goods in Transit. http://www.aseansec.org/transport/protocol_8.htm

63 http://www.nafta-sec-alena.org/english/nafta/chap-074.htm

European Union (EU)

The European Union has a Directive on protective measures against the introduction into the Community of organisms harmful to plants or plant products, and against their spread within the Community[64] whose provisions are similar to, but much broader in scope than, those of the IPPC. The Directive does not explicitly refer to aquatic species, nor does it exclude them. The Directive defines "harmful organisms" to mean plant, animal or pathogen pests of plants or of plant products (Article 2(e)). It provides for prohibiting introductions of harmful organisms listed in its Annexes (Articles 3-5), and for eradicating them or for at least containing their spread (Article 16). The phytosanitary certificate required under the IPPC is provided for (Articles 7- 9) and there are detailed provisions for inspections (Articles 13 and 21) and for notification (Articles 15-19). The Directive also provides for the possibility of a plant health control financial contribution for Member States that suffer invasions, to cover the direct costs of eradication or containment (Articles 22-25). In the past three years, the European Commission has issued several Decisions authorizing derogations from the plant health Directive and providing for temporary emergency measures to deal with infestations[65].

The EU also has a Directive that sets out animal health requirements, veterinary certification, and conditions for quarantine for the import of birds other than poultry.[66]

64 Council Directive 2000/29/EC of 8 May 2000 on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community.
Commission Directive 2002/36/EC of 29 April 2002 amending certain Annexes to Council Directive 2000/29/EC on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community.
Council Directive 2002/89/EC of 28 November 2002 amending Directive 2000/29/EC on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community. Official Journal L 355, 30/12/2002 P. 0045 – 0060.

65 2001/219/EC: Commission Decision of 12 March 2001 on temporary emergency measures in respect of wood packing comprised in whole or in part of non-manufactured coniferous wood originating in Canada, China, Japan and the United States of America (notified under document number C(2001) 694).
2001/836/EC: Commission Decision of 27 November 2001 authorizing the Member States temporarily to provide for derogations from certain provisions of Council Directive 2000/29/EC in respect of plants of Vitis L., other than fruits, originating in Switzerland (notified under document number C(2001) 3764).
2001/664/EC: Commission Decision of 16 August 2001 amending Decision 96/301/EC authorising Member States temporarily to take emergency measures against the dissemination of Pseudomonas solanacearum (Smith) Smith as regards Egypt (notified under document number C(2001) 2542).
2002/316/EC: Commission Decision of 29 April 2002 authorising derogations from certain provisions of Council Directive 2000/29/EC in respect of plants of strawberry (Fragaria L.), intended for planting, other than seeds, originating in the Republic of Chile (notified under document number C(2002) 1553).
2002/903/EC: Commission Decision of 14 November 2002 amending Decision 96/301/EC by renewing the Member States' authorisation to take emergency measures against the dissemination of Pseudomonas solanacearum (Smith) Smith as regards Egypt (notified under document number C(2002) 4416) Official Journal L 312, 15/11/2002 P. 0028 – 0029.
2002/887/EC: Commission Decision of 8 November 2002 authorising derogations from certain provisions of Council Directive 2000/29/EC in respect of naturally or artificially dwarfed plants of Chamaecyparis Spach, Juniperus L. and Pinus L., originating in Japan (notified under document number C(2002) 4348).
2002/947/EC: Commission Decision of 2 December 2002 amending Decision 93/467/EEC authorising Member States to provide for derogations from certain provisions of Council Directive 2000/29/EC, in respect of oak (Quercus L.) logs with bark attached, originating in Canada or the United States of America (notified under document number C(2002) 4761). Official Journal L 328, 05/12/2002 P. 0019 – 0020.

66 2000/666/EC: Commission Decision of 16 October 2000 laying down the animal health requirements and the veterinary certification for the import of birds, other than poultry and the conditions for quarantine (notified under document number C(2000) 3012).

For more than a decade the EU has regulated the release of genetically modified organisms (GMOs)[67] and there is currently a proposal for a Regulation on transboundary movement of GMOs.[68]

The Convention Establishing the European Free Trade Association (EFTA) provides that the WTO SPS Agreement governs sanitary and phytosanitary measures for its Parties, which are Iceland, Liechtenstein, Norway and Switzerland (Article 12, Annex G).[69] Sanitary and phytosanitary measures as provided under Annex 1 to the EFTA European Economic Area (EEA) Agreement focus only on food products and do not address pests.

Summary

Treatment of alien species in aquatic ecosystems in global multilateral agreements is uneven, with marine ecosystems currently faring somewhat better than freshwater ecosystems. The Law of the Sea provides a good framework for managing alien species in marine ecosystems – the issue is implementing it through national legislation. When the Draft International Convention for the Control and Management of Ships' Ballast Water and Sediments is adopted and comes into force, the legal basis for managing alien species in both freshwater and marine ecosystems will be further strengthened, as it provides for eradication, one of the gaps in the Law of the Sea coverage. Some States have already taken unilateral measures to protect their waters from alien species introduced through ballast water. As with the Law of the Sea, the challenge will be for all Parties to implement the future Ballast Water Convention in national legislation and enforce their measures.

Ramsar, the global MEA that deals with both freshwater and marine wetland ecosystems, contains no provision on alien species and the Convention on the Law of the Non-navigational Uses of International Watercourses, which does have a provision on preventing introduction of alien species, is not yet in force. Using its "wise use" provision as a basis, Ramsar began in the early 1990s to focus on the issue of invasive alien species in wetland ecosystems and by the end of the decade had developed several guidelines that take alien species into account. Through collaboration with the CBD and other international organizations and programmes, Ramsar will intensify its work on alien species over the coming three years, particularly in the context of freshwater ecosystems.

It is the global trade agreements that potentially will have the greatest impact on how alien species can be managed in the future. Efforts to control transboundary movement of alien species will inevitably be caught in the trade/development/environment triangle.

67 Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC - Commission Declaration.
2002/811/EC: Council Decision of 3 October 2002 establishing guidance notes supplementing Annex VII to Directive 2001/18/EC of the European Parliament and of the Council on the deliberate release into the environment of genetically modified organisms and repealing.

68 Proposal for a Regulation of the European Parliament and of the Council on the transboundary movement of genetically modified organisms/* COM/2002/0085 final - COD 2002/0046 */.
Common Position (EC) No 17/2003 of 4 March 2003 adopted by the Council, acting in accordance with the procedure referred to in Article 251 of the Treaty establishing the European Community, with a view to adopting a Regulation of the European Parliament and of the Council on transboundary movements of genetically modified organisms.

69 http://secretariat.efta.int/EFTASec/Web/EFTAConvention/EFTAConventionTexts/EFTAConvention2001.pdf.

The complex issues of the MEA/WTO relationship have yet to be clarified, but there are indications that trade may be the determining factor. In the context of the CBD's work, the issue is already being raised that a precautionary approach to managing alien invasive species could provide a cover for national protective measures inconsistent with the WTO SPS Agreement. Because Ramsar has closely linked its work on invasive alien species with that of the CBD, a procedural dispute within the CBD framework was sufficient to delay Ramsar's adopting guidance for managing invasive alien species in wetlands. At the same time, decisions of WTO dispute settlement Panels have begun to establish precedents that pose potential obstacles for countries trying to prevent introductions of alien species.

While the issues of the interactions of MEAs with other MEAs and with the WTO are being resolved, productive work can be done at the field and site level, setting aside political issues and focusing on concrete actions to manage invasive alien species in aquatic ecosystems. One example of this is the progress being made under the African-Eurasian Waterbirds Agreement under the Convention on Migratory Species. In spite of the setback in the Ramsar/CBD collaboration, the work these two MEAs have planned with each other and with other international partners has great potential for drawing international and national attention to the urgency of the issues related to invasive alien species in aquatic ecosystems, and to finding solutions.

International instruments

Information sources on alien aquatic species

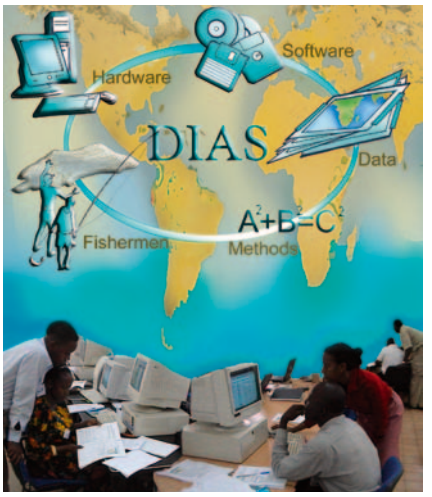
Felix Marttin

Information on species introductions is lacking, while this information is vital for risk assessments

Over centuries there have been many deliberate introductions of non-indigenous species (among others): to use in aquaculture, to provide new or additional food resources for human consumption, to increase target species available for hunting or angling, for biological control, for research, or for recreational or esthetic purposes (Welcome, 1988; IUCN, 1999). This practice can be expected to continue. Fora dealing with species introductions and or biodiversity state that information on species introductions is lacking, while this information is vital for risk assessments. The purpose of this paper is to examine which information sources can provide information needed for risk assessments and to examine in detail, what kinds of data is are available in three databases relevant to the Mekong/Lancang Basin: the Database on Introduced Aquatic Species (DIAS), the Global Invasive Species Database, and the Mekong Fish Database, and what governments can do to keep track of introductions into and within their country.

Information for risk assessment

Risk assessment will require information on a number of areas such as socio-economics, biology, ecology, genetics of the alien species, and information on the area where the alien is supposed to be transferred to. Many feel that the socio-economic aspects of an introduction are the most an especially important part of the risk assessment. It is the level of socio-economic benefits that should determine the actual need for the introduction or transfer. This need should be weighed against the risks to the environment and and the potential detrimental socio-economic impacts of the introduction. or transfer that determine the financial risk to society.



Many publications deal with introductions of species, specifically the biological, ecological, and genetic issues related to these introductions. A list of databases dealing with aquatic introduced species can be found in the text-box below. Some databases contain data on socio-economic impacts, such as like the Database on Introductions of

Aquatic Species (whether or not there was a socio-economic effect of the introduction, and if there was an effect, if this effect was positive or negative). Other databases, such as the Global Invasive Species Database, focus more on biodiversity impacts. In both cases, information is quite limited and should therefore be treated as a primer for further research.

List of selected databases dealing with introduced aquatic species issues

- Database on Introductions of Aquatic Species (DIAS)*
  http://www.fao.org/fi/figis/Introsp/index.jsp
- Global Invasive Species Database; IUCN/SSC Invasive Species Specialist Group (ISSG)
  http://www.issg.org/database/welcome/
- Mekong Fish Database
  Available at: http://www.mrcmekong.org/shopping/productsByCategory.asp?intCatalogID=2&strCatalog_NAME=Fisheries
- Nonindigenous Aquatic Species US Geological Survey*
  http://nas.er.usgs.gov/
- US State and Federal invasive species activities
  http://www.invasivespecies.gov/
- Invasive non-native species in the UK
  http://www.appliedvegetationdynamics.co.uk/IAAPwebsite/index.asp
- Regional Biological Invasions Center (RBIC) for the Baltic Region*
  http://www.zin.ru/projects/invasions/
- Baltic Sea Alien Species Database*
  http://www.ku.lt/nemo/mainnemo.htm
- Fishbase
  http://www.fishbase.org
- Aquatic Animal Pathogen and Quarantine Information Sytem (AAPQIS)
  http://www.aapqis.org

* Contains information on socio-economic impacts

The Mekong Fish Database

The Mekong Fish Database (MFD) contains information on fish species in the Lower Mekong Delta (Cambodia, Viet Nam, Laos, Thailand). Information contained in the MFD 2003 is fully referenced and was obtained both from published material and from the results from surveys coordinated by the Mekong River Commission (MRC) Fisheries Programme in collaboration with riparian line agencies. Key information for each species includes taxonomy, migration, common names, synonyms, pictures, occurrence data, maps, and biological information. Besides this information the status of the species (introduced or native) is also mentioned.

The Database on Introductions of Aquatic Species

The FAO Database on Introductions of Aquatic Species (DIAS) was initiated by R. Welcomme in the early 1980's. It considered primarily only freshwater species of fish and formed the basis for the 1988 FAO Fisheries Technical Paper no. 294. The database has been expanded to include additional taxa, such as molluscs and crustaceans, and marine species. In the

mid 1990's a questionnaire was sent to national experts to gather additional information on introductions and transfers of aquatic species in their countries. The database, which contains now more than 3200 records, can be queried either on the world wide web, or via a Microsoft Access database which is available on CD-ROM. Another way to search data from DIAS is to have a look at the records in Fishbase, which has incorporated DIAS records in 1997. FishBase is a global information system about more than 28 000 species of fish.

The database includes records of species introduced or transferred from one country to another and does not consider movements of species inside the same country. Coverage of accidental introductions of organisms (e.g., through ship ballast waters) is not complete and records on this topic have been generally entered only when important impacts on fisheries, aquaculture or the environment have been caused.

Each record in DIAS deals with the introduction of a species to a country. These records contain information on:

- which country has exported the species to the country;
- when this was done, who made the introduction;
- what was the reason for introduction, if the species is established in the wild;
- if there are socio-economic and ecological effects of the introduction, and if so, if these effects were beneficial, or adverse.
- Also the reference for the information is given (if available).

Efforts are made to use currently accepted scientific names, however, designation of subspecies taxa is often inconsistent in the literature and in the questionnaires' responses.

Users aware of other introductions of aquatic species not already included in the database or that have additional information on the records in the database are requested to report these, either through the web-site of DIAS, or through an input form of which the template is supplied with the CD-ROM version of DIAS.

The Global Invasive Species Database

The goals of the Global Invasive Species Database are to raise awareness about invasive alien species (IAS) by providing easy access to authoritative information and to facilitate effective prevention and management of invasive species problems by disseminating specialist's knowledge and experience globally.

The Global Invasive Species Database (GISD) was developed by the IUCN/SSC Invasive Species Specialist Group (ISSG) as part of the global initiative on invasive species led by the Global Invasive Species Programme (GISP). Development of the database followed extensive consultation and user analysis beginning in 1998.

The developers of the GISD are building a global picture of the invasive species issue by capturing and displaying the results of work being done by individuals and in programs all over the world. The core information elements in the GISD include:

- taxonomy, names, descriptions, images to help identify invasive species;
- distribution records describing where the species occurs;
- impacts describing what effect the species has there;

- pathways, vectors describing how and why the species was introduced;
- prevention & management information to describe how to deal with the species;
- contacts details of specialists for advice.

Each species profile in the database contains links back to local, national and regional resources where more detailed and locally specific information can be found. Users can search the database by scientific, common name or synonym, country or location, life form, habitat type or by any combination of these. A taxonomic search is also available. The GISD is being populated with species profiles and distribution records on an ongoing basis and a CD-ROM will be distributed in 2004.

Information gathering

The three above mentioned databases should be considered a start in the search for information needed for a risk assessment of an intended introduction of an aquatic species. The databases will provide 'leads' (through references for instances) of introductions in similar environments, or similar species, which need to be researched further through other information sources, e.g. like literature. DIAS can provide also an insight in the status of introductions of aquatic species and their effects (socio-economically and ecologically) in the recipiant habitat.

DIAS could be regarded as a model for national registries on species introductions. Many international fora (e.g. like for instance the Convention of Biological Diversity) call for countries to develop national databases on movements of species (Bartley and Fleischer 2004). These national registries should not only contain records on movements of species into and out of a country, but also on movements of species between ecological zones within a country. By setting up and maintaining such a national registry, countries will be able to assess impacts of introductions, and advice neighbouring countries on providing information to other interested groups or countries on the impacts, both positive and negative, of alien species.

References

Bartley D.M. and Fleischer I.J. 2005. Mechanisms of the Convention on Biological Diversity for the Control and Responsible Use of Alien Species in Fisheries. Pages 25-32 in FAO 2005.

FAO, 2000. FISHSTAT Plus: Universal software for fishing statistical time series. Version 2.3. 2000. FAO Fisheries Department, Fishery Information, Data and Statistics Unit.

ICES. 1995. ICES Code of Practice on the Introductions and Transfers of Marine Organisms 1994. This document is a slightly amended bilingual English/French version of text originally published as Annex 3 of the "Report of the Advisory Committee on the Marine Environment, 1994", ICES Cooperative Research Report No. 204.

IUCN, 1999. Wetlands, Water and the Law. Using Law to advance wetland conservation and wise use. Clare Shine and Cyrille de Klemm. IUCN Environmental Policy and Law Paer No. 38.

Welcome, R.L. 1988. International Introductions of Inland Aquatic Species. FAO Fisheries Technical paper 294. 318 pp.

Country reports

Present status of alien species in aquaculture and aquatic ecosystem in Cambodia

Sam Nuov
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and Ouk Vibol

There is currently no well documented evidence of exotic species causing environmental harm in Cambodia

Introduction

Cambodia is fortunate to have some of the most productive freshwater fisheries in the world. The Mekong, Tonle Sap and Bassac rivers, their tributaries, a number of lakes, and a vast area of floodplain are rich in aquatic resources which support these inland fisheries. An estimated 500 freshwater fish species (Rainboth, 1996) occupy various ecological niches, including plankton feeders, detritus feeders, piscivores, and omnivores. The Great Lake on the Tonle Sap is the largest lake in Southeast Asia, and supports inland fish production that provides food security and income generation for millions of people living in the country. Fish is the main source of protein for Cambodian people, with an estimated average per capita consumption of 30 to 40 kg/person/year. Recent estimates of Cambodia's freshwater capture fisheries indicate annual catches of 400 000 tons per year, having an annual retail value between US$ 250-300 million.

Increasing urbanization, industry expansion, and rapid population growth result in the alteration of natural ecosystems. These factors, coupled with conflicts in water management, overfishing, and illegal fishing activities are all contributing to observed declines in wild fish production from inland waters. Human interference with aquatic ecosystems impacts natural aquatic habitat and the biodiversity of aquatic flora and fauna. This includes freshwater fishes supporting commercial fisheries that are threatened, and several indigenous fish species that are either endangered or extinct in Cambodia.

As capture fisheries decline, aquaculture can play an important role by augmenting fish production to provide sustainable food resources for Cambodians. Aquaculture producers use seed from indigenous fish collected from the wild, and several exotic fish species that have been introduced to Cambodia. The use of alien species in aquaculture is believed to increase fish production and improve the livelihood of rural populations. However, alien species can be a significant threat to aquatic biodiversity, and they have the potential to disrupt local aquatic ecosystems.

This paper highlights the present status of introduced fish species, problems faced in fisheries and aquaculture, and mechanisms for the control and responsible use of alien fish species in aquatic ecosystems.

Status of aquaculture

Inland aquaculture is conducted using cages, fenced pens and open ponds. The utilization of cages and pens for aquaculture production is a practice thought to have originated in Cambodia. Aquaculture production, especially inland pond and cage culture, has increased from 2 000 metric tons in 1984 to 20 000 metric tons in 2002. With this as a model, it is likely that Cambodia will continue to experience similar rapid expansion in the industry.

Cage aquaculture is the most common production system and is responsible for about 80% of total inland fish production. These systems use primarily indigenous fish species collected from the wild. Two major species found in cage culture are the catfish, *Pangasianodon hypopthalmus* and *Channa micropeltes*, the red or giant snakehead. Other species are also cultured such as *Pangasius bocourti, Barbonymus gonionotus, Leptobarbus hoevenii, Ostiochilus melanopleurus*, and others. Some exotic fish are also cultured in cages, primarily *Oreochromus niloticus* and other tilapia species.

Pond culture of fish is the least developed technique in Cambodia. It contributes approximately 1 000 tons per year, or slightly less than 20% of total freshwater aquaculture production. The use of intensive culture systems is concentrated in areas around Phnom Penh and Kandal Province, while small-scale systems are in more wide spread use. The major indigenous fish species cultured intensively are *Pangasianodon hypophthalmus* and hybrid catfish. Some exotic species such as: *Clarias gariepinus* and *Hypophthalmychthys molitrix* are also cultured intensively. The Department of Fisheries, with the assistance of a variety of development organizations has actively promoted small-scale aquaculture in the upland areas for food security. Most of this production occurs in impoundments behind small dams, some of which are linked to rice paddies. This aquaculture is predominantly based on introduced species of fish and their escape may present a serious threat to local biodiversity. There are at least 15 alien species that have been introduced in Cambodia since 1970, including four Chinese major carps: silver carp (*Hypophtalmychtys molitrix*); bighead carp (*Aristichthys nobilis*); Grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*), three Indian major carps: Rohu (*Labeo rohita*); Mrigal (*Cirrhinus mrigala*) and Catla (*Catla catl*a), Java tilapia (*Oreochromis mossambicus*), Nile tilapia (*Oreochromis niloticus*), red tilapia (*O. niloticus x O. mossambicus*), African catfish (*Clarias gariepinus*), and the Giant gourami (*Osphronemus gouramy*). Most alien species can adapt well and grow very fast in pond environments.

Coastal aquaculture in Cambodia was negligible before 1988 (Nam, 1999), but is now developing along the coastal zone in three provinces, Koh Kong, Sihanouk Ville and Kampot. Penaeus monodon shrimp seed collected

from the wild or imported from Thailand and Viet Nam are commonly cultured in ponds. Shrimp farming peaked between 1994-1996 with production of 600-750 tons, after which it declined drastically amounting to only 50 tons in 2002. Seaweed (cottony II) was introduced to Cambodia in 1999 from Malaysia for coastal farming.

Introduction of alien/exotic fish

Alien species, also called exotic or non-indigenous species, are species that are not native to a specific locality or ecosystem, although they may be found elsewhere in the same country or beyond the country's borders. They represent all phyla, from microorganisms to various plants and animals, and are both terrestrial and aquatic.

Introduction of exotic fish species into Cambodia has occurred for decades. Fish have been introduced intentionally or by accident for various uses including commercial production and recreational purposes.

Although Cambodia has rich indigenous fisheries resources, many different varieties of alien fish species have been introduced for farming since 1969 to supplement the demand for fish seed from wild. The most common introduced species in Cambodia include carps, tilapia and a number of other African species. These species are desirable because they are readily reproduced in captivity, exhibit fast growth and adapt well to pond systems. Environmental concerns arise when these alien species escape the confines of the pond and spread into natural aquatic ecosystems where they compete with native species.

Some fish are intentionally released into the wild in closed reservoirs and canals to enhance the natural stocks and increase fish populations. A number of fish species were released intentionally to control aquatic weeds, while others were introduced for ornamental purposes and were subsequently intentionally or accidentally into natural water bodies.

Under heavy rainstorms or seasonal flooding, fish may escape from farms that are not properly fenced or poorly sited. Introduced plants may harbor eggs of other species that are inadvertently introduced along with them. In some cases, exotic species are knowingly introduced into native waters by private business creating the possibility that they will out compete the natives.

The decline of endemic fishes is most often reported in association with disturbed and polluted habitats

Status of alien species in the natural ecosystem

Information on exotic fish from migration studies

Since 1997, the Fisheries Program of the Mekong River Commission (MRC) has been assessing local knowledge in the Lower Mekong River Basin. The objective of the study is to provide information on the life cycles of important Mekong River fish species including the location and seasonality of migration and spawning. Databases resulting from these studies include records of exotic fish species, including many *Hypophthalmichthys molitrix, Labeo rohita, Cyprinus carpio, Oreochromis niloticus* and *Oreochromis* sp. These species have been widely recognized and recorded by local fisherman along the Mekong and it's tributaries.

The MRC surveys in the Mekong mainstream included 12 670 records documenting a total of 191 species. In Mekong tributaries 6 616 records documented 173 species. A detailed listing of the species recorded is found in Table 2.

Table 1. Information on alien species introduced in Cambodia for aquaculture

Common name	Species	Source	Year	Aquaculture Use	Established in the wild	Ecological impact	Socio-economic impact
Silver carp	*Hypophtalmychtys molitrix*	Taiwan Viet Nam	1969 1981	Widely	Few	Unknown	Beneficial
Bighead carp	*Aristichthys nobilis*	Viet Nam	1981	Widely	Few	Unknown	Beneficial
Grass carp	*Ctenopharyngodon idella*	Viet Nam	1981	Widely	Unknown	Unknown	Beneficial
Common carp	*Cyprinus carpio*	Taiwan Viet Nam	1969 1981	Widely	Few	Unknown	Beneficial
Rohu	*Labeo rohita*	Viet Nam	1986	Widely	Few	Unknown	Beneficial
Mrigal	*Cirrhinus mrigala*	Viet Nam	1980	Widely	Unknown	Unknown	Beneficial
Catla	*Catla catla*	Viet Nam	1980	Widely	Unknown	Unknown	Beneficial
Java tilapia	*Oreochromis mossambicus*	Viet Nam	1980	Widely	Yes	in reservoir	Beneficial
Nile tilapia	*Oreochromis niloticus*	Viet Nam	1980	Widely	Yes	in reservoir	Beneficial
Red tilapia	*O. niloticus x O. mossambicus*	Thailand	1991	Widely	Unknown	Unknown	Beneficial
Hybrid catfish	*Clarias gariepinus x macrocephalus*	Viet Nam	1981	Widely	Unknown	Unknown	Beneficial
African catfish	*Clarias gariepinus*	Viet Nam	1981	Widely	Unknown	Probably yes	Beneficial
Giant gourami	*Osphronemus gouramy*	Viet Nam	2000	Few	No	Unknown	Beneficial
	Pomacea canaliculata	Asia	1990 1999	Rarely	Unknown	Adverse	Adverse
Silver pacu	*Piaractus brachypomus*	Viet Nam	2003	Unknown	Unknown	Unknown	Unknown
Cuban crocodile	*Crocodilus rhombiser*	Viet Nam	1986	Widely	Unknown	Unknown	Beneficial
Golden snail	*Pomacea* sp.	Thailand Viet Nam	1985 2001	Few	Yes	Adverse	Unknown
Seaweed	*Cottony II*	Malaysia	1999	Widely	Unknown	Unknown	Beneficial

Table 2. Recorded number of exotic species in the Mekong River mainstream and its tributaries

Species Name	Total Riparian Country Records	Total Cambodian Records	Provinces	Habitats	Remarks (for Cambodia only)
Hypophthalmichthys molitrix	57	27	Kratie, Stung Treng Kompong Cham, Kandal	Mekong River	40% do not know species name. 60% call as Chinese carp, Trey linh (Thynnichthys thynnoides) and Trey Krum Sar (Osteochitus melanopleurus)
Labeo rohita	52	25	Kratie, Stung Treng Kompong Cham, Kandal	Mekong River	60% do not know species name. 40% call as Trey Krum (Osteochilus melanopleurus) , Chinese Krum, Ka Ek Tmar, Ka Ek Crahom (Morulius chrysophekadion)
Cyprinus carpio	96	27	Kratie, Stung Treng Kompong Cham, Kandal	Mekong River	63% do not know species name. 37% call as Trey Dong, Kachep, Panay, Keab Srong, Sawka keo or Trey Chen.
Oreochromis niloticus sp.	40	4	Kratie, Stung Treng Kompong Cham, Kandal	Mekong River	75% do not know species name. 25% call Tiger fish
Hypophthalmichthys molitrix	22	18	Kandal, Kompong Chhnang Stung Treng, Ratanakiri, Mondokiri	Tonle Sap and trib., Se Kong, Se San trib. Srepok trib., Srepok tributary	55% do not know species name. 40% call Trey linh Thom, linh Heu, or linh Kam 5% call silver carp
Labeo rohita	26	18	Kandal, Kompong Chhnang Stung Treng, Ratanakiri Mondokiri	Tonle Sap and trib., Se Kong, Se San trib. Srepok trib., Srepok tributary	90% do not know species name. 5% call Trey Kros (Osteochilus) 5% call silver carp
Cyprinus carpio		9	Kandal, Kompong Chhnang Stung Treng, Ratanakiri, Mondokiri	Tonle Sap, Se San, Srepok trib., Srepok tributary	88% do not know species name. 2% call Trey Pan Kov

EXOTIC FISH SPECIES IN FISHING LOT AREAS

This information on exotic species in fishing lot areas was gathered in the regions around Phnom Penh, and the provinces of Kandal, Kampong Cham, Siem Riep, and Battambang. Informal interviews were conducted with key participants including fishing lot researchers, fisherman, and fishing lot owners. The survey was focused on the annual production of exotic fish in fishing lot areas. The survey results are described below:

Phnom Penh

There is a fishing area in the outskirts of Phnom Penh City known as Chung Ek fishing lot or fishing lot number 1, which covers the area around Chung Ek Lake. The following four exotic species were caught in this area, common carp (*Cyprinus carpio*), bighead carp (*Aristichthys nobilis*), silver carp (*Hypophthalmichthys molitrix*), and tilapia (*Oreochromis* sp.)

During the fishing season of 1997-2000, the Chung Ek fishing lot reported capturing from 20-60 kg per year of these exotic species. As a result of the year 2000 fishery reform, this lot has been terminated and released to the fishing community. Recent communication with villagers fishing in this area indicate that the exotic species mix is predominately tilapia.

Kandal Province

The exotic species production from fishing lot numbers 01, 03, 04, 05, 13, 14, 16, and 17 during the 1999-2000 harvest season was around 300 kg-500 kg/year. The catch was primarily common carp (*Cyprinus carpio*), Indian carp (*Labeo rohita*), and tilapia. Individual fish were small with sizes ranging from 0.2 kg to 1 kg per fish. Fishing gear included bag and seine nets, and catches occurred from January to March.

Kampong Cham Province

In Kampong Cham province during the fishing season of 1998-1999, exotic species caught in fishing lot number 10 included common carp (*Cyprinus carpio*), Indian carp (*Labeo rohita*), and tilapia. Approximately 50 to 60 Tilapia were captured per year with a size range from 0.3-0.5 kg/fish. Average sizes for the common and Indian carps were between 2-4 kg/fish. Long, trough shaped bamboo traps are used in this fishery and the season extends from October through December.

Siem Riep Province

The quantity of exotic species caught from fishing lot numbers 04, 05, 06 and 07 in Siem Reap was approximately 1 600 kg in 1997-1998, and only 720 kg in 2000-2001. The primary exotic species was Rohu (*Labeo rohita*), referred to by local people as "Indian carp". Production statistics can be found in Table 3.

Table 3. Rohu (*labeo rohita*) production from fishing lot Numbers 4, 5, 6, 7 in Siem Reap Province 1997-2001

Fishing lot Number	1997-98		1998-99		1999-00		2000-01	
	Weight (kg/head)	Quantity (kg)	Weight (kg/head)	Quantity (kg)	Weight (kg/head)	Quantity (kg)	Weight (kg/head)	Quantity (kg)
04	1-5	105	0.8-4	29	1-5	21	0.8-2	5
05	2-5	312	2-5	175	3-6	247	2-6	140
06	2.5-5	450	2-5	225	4-8	250	2.5-8	350
07	2-5	750	2-4	300	3-6	280	2-5	225
Total		1617		729		798		720

Common ornamental fish species in Cambodia

Since the Angkor era of the 11th century the culture of ornamental fish culture has been a part of Cambodian tradition. Many famous authors in Cambodia such as Troeung Ngear and Pikho Som have written many pages about the beauty of fish in water. Some folk tales feature the wild gourami fish and many people are involved in the culture of this species. It is very popular for people to culture the Siamese fighting fish in small jars or bottles as a hobby and for competition, especially during the New Year's celebration.

Ornamental fish are mostly exotic species. Among 31 common ornamental fish species in Cambodia, there are 10 indigenous species and 21 exotic species. Exotic species are imported from Thailand, Viet Nam, Singapore and Malaysia. Some famous indigenous species like the Siamese fighting fish, or *Trey Krim* are also available in neighboring Thailand and Viet Nam. Tiger barbs (*Trey Khlar*) and the Asian bonytongue (*Trey Tapowt*) are expensive and popular

fish which can also be found in neighboring countries. Exotic species such as angelfish, koi, and gold fish which are easily bred in aquaria without hormone treatments are not imported to any significant degree.

Socioeconomics often dictates the species of fish hobbyists will enjoy. Most people, especially government staff, use inexpensive seed like goldfish which are readily available. Wealthier hobbyists possess more expensive species such as the Golden Asian Bonytongue, also known as the golden arowana or dragonfish. These fish are reknowned for their beauty and good luck. As ownership of these fish for beauty and luck becomes more widespread, many people in the cities will be encouraged to culture them as a business. Businessmen currently import some exotic ornamental species from Thailand and Viet Nam, and also engage in local breeding programs for additional species. The culture of ornamental fish has been characterized as serving three purposes: 1. beauty, 2. small-scale business and 3. medium-scale business (Vaddhna, 1996).

Table 4. Exotic species caught in fishing lot Numbers 01, 02 and 03

Species	1999-00		2000-01	
Fishing lot Number 01	**Quantity Kg/year**	**Weight Kg/head**	**Quantity Kg/year**	**Weight Kg/ head**
Indian carp *(Labeo rohita)*	150	-	300	0.3-0.6
Common carp *(Cyprinus carpio)*	no record	-	130	0.2-0.5
Silver carp *(Hypophthalmichthys molitrix)*		-	70	0.2-0.5
Total	**150**		**500**	
Fishing lot Number 02				
Indian carp *(Labeo rohita)*	12.5	2-3	-	-
Common carp *(Cyprinus carpio)*	17	-	-	-
Silver carp *(Hypophthalmichthys molitrix)*	14	-	-	-
Total	**43.5**			
Fishing lot Number 03				
Indian carp *(Labeo rohita)*	-	2.5-5	-	-
Silver carp *(Hypophthalmichthys molitrix)*	-	0.5	-	-
Total	**15***			

* Exotic carps not identified to species

Impacts of introduced exotic species of fish

There is currently no well documented evidence of exotic species causing environmental risks in Cambodia. It is likely that exotic species in Cambodia are having both positive and negative impacts on various economies in the country, while one would anticipate that impacts on aquatic ecosystems and biodiversity would be detrimental. Introduced fish may hybridize with endemic fish species, alter habitats, impact water quality, compete for food and space, prey on native fish and result in the introduction of exotic parasites and diseases (Courtenay and Stauffer, 1984; Moyle *et al.,* 1986 and Arthington, 1989).

Introduction of exotic fish species for aquaculture could improve protein supplies and create job opportunities, especially for the rural poor located far from natural water bodies in remote locations. Most exotic species introduced in Cambodia are easy to breed and grow

very fast in pond environments with minimal inputs. On the other hand, introduction or aquaculture of exotic species in natural water bodies may reduce fishery catch.

There is no study in Cambodia documenting whether introduced fish have altered aquatic habitats or had other impacts on local species and populations. However, there are reports from elsewhere indicating that exotic species can change the biological, chemical and physical characteristics of local environments to the detriment of local species. Feeding behaviors of exotic fish that uproot plants and disturb sediments can impact prey items for indigenous fish that feed on organisms in lake or streambed sediments. The disturbance of bottom substrates by European carp (*Cyprinus carpio*) during feeding has been attributed to increased turbidity (McCrimmon, 1968). This has implications for other species that visually search for food and impacts photosynthetic abilities of plants. Loss of plants further destabilizes benthic sediments, water clarity continues to decline and the whole system spirals downward. Thus, environmental degradation results from loss of aquatic vegetation, erosion of riverbanks, increased water turbidity and higher nutrient levels. This can destroy habitat for native fish, invertebrates, and waterfowl.

Some introduced species compete aggressively with native species for food and space. Although some introduced fish successfully exhibit generalist feeding habits and trophic opportunism (Taylor *et al.,* 1984; Arthington and Mitchell, 1986), considerable overlap in the diets of introduced and endemic fishes have been reported in many systems (Arthington, 1989). Aggressive feeding of some species on certain plants could reduce their availability to local species. The decline of endemic fishes is most often reported in association with disturbed and polluted habitats. High reproductive rates of introduced species such as tilapia may easily result in offspring occupying space and using resources that would otherwise be available for use by endemic species. This is a serious concern, especially during the dry season when water is normally confined to small ponds.

Introduced species may prey on all life history stages of native fish including eggs, larvae, juveniles and adults. However, whether introduced species prey on local species is undocumented in Cambodia. Introductions of fish have been implicated in the importation of parasites and disease outbreaks. Although some parasites require intermediate hosts, many are not very host specific, and others have less complex life cycles.

Existing policies on introduction of fish species

There are currently no detailed guidelines or regulations covering the importation of exotic species for culture that address environmental impact studies or environmental standards for fish farms. As a result, the development of freshwater aquaculture raises concerns about the potential negative impacts of introduced alien species on native fish stocks. Existing laws and regulations do, however, require activities undertaken be in compliance with international law including CITES, SPS, and the law of importation of goods.

The Department of Fisheries encourages culturing exotic species in earthen ponds or cages with appropriate safeguards in order to avoid the escape of these species into natural water bodies. The culture of indigenous fish species is one of the options that the Department of Fisheries is considering to further replace exotic species in aquaculture.

Table 5. The common alien ornamental fish culture in Cambodia*

No.	Common name	Scientific name	Families
1	Black Ghost Knife Fish	*Sternarchus albifrons*	Apteronotidae
2	Giant gourami	*Ophronemus gouramy*	Anabanidae
3	Pearl gourami	*Trichogaster leeri*	Anabatantidae
4	Red Finned Fish	*Metynnis* sp.	Characidae
5	Black Tetra Fish	*Gymnocorymbus* sp.	Characidae
6	Oscar	*Astronotus ocellatus*	Cichlidae
7	Angelfish	*Pterophyllum scalare*	Cichlidae
8	Discus	*Symphysodon discus*	Cichlidae
9	Jewel cichlid	*Hemichromis bimaculatus*	Cichlidae
10	Tiger Botia	*Botia macracantha*	Cobitidae
11	Koi	*Cyprinus carpio*	Cyprinidae
12	Goldfish	*Carassius auratus*	Cyprinidae
13	Bellybarred pipefish	*Hippichthys spicifer*	Indostomidae
14	Midget sucker catfish	*Hypostumus* sp.	Loricariidae
15	Guppy of million fish	*Poecilia* sp.	Loricariidae
16	Platy	*Platypoecilus maculatus*	Loricariidae
17	Badis	*Badis badis burmanicus*	Nandiae
18	Giant Arapaima	*Arapaima gigas*	Osteoglossidae
19	Swordtail	*Xiphophorus* sp.	Poeciliidae
20	Goonch	*Bagarius yarrelli*	Sisoridae
21	Malayan angel	*Monodactylus argenteus*	Toxotidae

* The source and year of introduction of these ornamental fish is undocumented

FURTHER PLAN FOR CONTROLLING ALIEN SPECIES

- Cambodia should have strict rules for importing exotic animals including fish into Cambodia.
- Only species which have no negative impacts on the environment should be imported.
- Cambodia should promote aquaculture of exotic species but not in proximity to natural water bodies.
- The Ministry of Agriculture should prepare guidelines on the management and movement of fish and fish products.
- Implementation of international and regional codes of conduct should be undertaken.
- Aquaculture should be integrated with land use planning so that certain areas can be separated for aquaculture of exotic species.
- Fish stocking programs must release only indigenous species.
- More research should be carried out on the impacts of existing exotic species on the environment.

Conclusion and Recommendations

Through surveys in fishing lots, exotic species production in five areas has been documented at approximately 1500-2000 kg per fishing season. The catch comprised primarily common carp (*Cyprinus carpio*), bighead carp (*Aristichthys nobilis*), silver carp (*Hypophthalmichthys molitrix*), and tilapia (*Oreochromis* spp.). Exotic species are present in great numbers in natural habitats of the Mekong River and it's tributaries.

Given the landscape topography and seasonal flooding in the country, it is difficult for Cambodia to control the dispersal of alien fish in natural environments. Efforts to do so should involve collaboration among all countries within the greater Mekong/Langcang Basin.

There are no research programs in Cambodia to document annual production of exotic fish species in various habitats, or identify what impacts these exotics may have on other natural resources. As a result, if exotic species abundance increases in the future, it will be difficult to ascribe any changes in other natural resources to this increased abundance of exotic fish or other causes. This will complicate natural resource management. An impact assessment of exotic fish species in Cambodia should be developed. This would identify areas of concern, increase awareness, and improve the abilities of fisheries researchers and fisherman to identify alien species. A research program to study long-term impacts of exotic fish species on the environment and fisheries resources is very important for natural resource conservation and management.

Individual countries and their peoples have a responsibility help safeguard local environments from unwanted exotic fish species. The most important guideline to prevent alien fish from entering local environments is to not allow anyone to release exotic fish into waterways.

References

Arthington, A.H. 1989. Impacts of introduced and translocation of freshwater fishes in Australia, p. 7-20. In S.S. De Silva (ed.) Exotic Aquatic Organisms in Asia. Proceedings of the Workshop on Introduction of Exotic Aquatic Organisms in Asia. Asian Fish. Soc. Spec. Publ. 3, X, Manila. Philippines. 132-173.

Arthington, A.H. & Mitchell, D.S. 1986. Aquatic invading species. In R.H. Grooves and J.J. Burdon (eds.) Ecology of Biological Invasions: an Australian Perspective,. Australian Academy of Science, Canberra. 34-52.

Courtenay, W.R. & Stauffer J.R. (eds.) 1984. Distribution, Biology and Management of Exotic Fishes. Johns Hopkins University Press, Baltimore.

Moyle, P.B., Li, H.W. & Barton, B.A. 1986. The Frankenstein effects. Impact of introduced fishes on native species in North America, In R.H. Stroud (ed.) Fish Culture in Fisheries Management. American Fisheries Society, Bethesda, MD. 1981. 415-426.

Nam, S., & Thuok, N. 1999. Cambodia Aquaculture Sector Review (1984-1999) and Outline of National Aquaculture Development Plan (2000-2020). APCU/DoF, Phnom Penh.

Rainboth, W.J. 1996. Fishes of the Cambodian Mekong. FAO Species Identification Field Guide for Fishery Purposes. FAO, Rome, 265 pp.

Taylor, J.N., Courtenay, W.R. & McCann, J.A. 1984. Known impacts of exotic fishes in the continental United States. In W.R. Courtney and J.R. Stauffer (eds.) Distribution, Biology and Management of Exotic Fishes. Johns Hopkins University Press, Baltimore. 132-173.

Vaddhna, E. 1996. Research on species of ornamental fish in Phnom Penh. Phnom Penh, Cambodia. A research study for fulfillment bachelor degree at Royal University of Agriculture.

Country reports

Introduction and management of alien aquatic species in China

Li Sifa

The benefits of introduced species are usually realized immediately, but the adverse effects of many exotic species surface after a long time

Though the major aquatic organisms used in aquaculture in China are indigenous species, the introduction of alien species and genetic selection to improve cultured strains have a significant role in the development of aquaculture, such as increasing total aquaculture production, supplying new species for aquaculture to meet market demands, and increasing farmers' income.

The benefits of introduced species are usually realized immediately, but the adverse effects of many exotic species surface after a long time. Any movement of aquatic organisms between natural ecological boundaries (e.g. watersheds) may involve risk to biodiversity. There is need for refinement and wider application of protocols, risk assessment methods, and monitoring programs for introductions of alien fish species, including genetically improved strains. Internationally accepted codes and protocols exist for reducing the risk of transboundary movement of pathogens including parasites. These cover incidental transfer associated with the movement of fish including alien species, but they need to be better promoted to increase awareness. In China, the management of introduction of alien species has been strengthened since 1991. This paper highlights the present status of introduced alien species in China, including their impacts, problems faced in fisheries and aquaculture, and related management issues.

Information on alien species introduction

Alien species and genotypes, such as tilapia, carps, rainbow trout, shrimp and prawns, are used throughout the world. The introduction or transfer of aquatic organisms in support of

aquaculture and various fishing initiatives has recently increased quite rapidly. Although China is rich in endemic aquatic genetic resources, introduction of different varieties of alien aquatic species has taken place since the 1960s. To date, introductions for aquaculture purposes have included over 50 species of fish, approximately 10 species of crustaceans, 12 species of mollusks, and 11 species of seaweed. Approximately 10% of these are important species in Chinese aquaculture (Table 1), and they comprise about 10% of national aquacultural production. The introduction of ornamental alien species is undertaken primarily by the private sector and there is no official record documenting these introductions. It is likely that more than 100 species of ornamental fish have been introduced.

Many species have been introduced illegally without pre-evaluation, quarantine, or post-evaluation. Only a few species were tested by research institutions before being released.

Table 1. Annual production of successfully introduced and cultured alien species in China

500-1000 (× 10^3 t)	100-500 (× 10^3 t)	10- 100 (× 10^3 t)	1-10 (× 10^3 t)
Tilapia *(Oreochromis niloticus niloticus)*	White shrimp *(Litopenaeus vannamei)*	Channel catfish *(Ictalurus punctatus)*	Red drum *(Sciaenops ocellatus)*
Scallop *(Argopecten irradians irradians)*	Giant freshwater prawn *(Macrobrachium rosenbergii)*	Pacu *(Colossoma brachypomum)*	Turbot *(Psetta maxima*)
Brown kelp *(Laminaria japonica)*	Tiger shrimp (Penaeus monodon)	Rainbow trout *(Oncorhynchus mykiss)*	
		Large mouth bass *(Micropterus salmoides)*	
		Africa catfish *(Clarias gariepinus)*	

Impact of introduction of alien species or genetically improved strains

Both positive and negative consequences can arise from introducing alien species. The following are a few notable examples from experiences in China:

Positive Impact

The GIFT strain of Nile tilapia (Oreochromis niloticus niloticus) has been recognized as a genetically improved fish and been introduced into many Asian countries. Its performance was evaluated on research stations and farms in China between 1994 and 1996. It was revealed that growth of the GIFT strain fish was significantly higher (7-30%), and they were 2-3 times more likely to be caught than the existing Nile tilapia strains. This strain was certified as a good breed by regulatory authorities and distributed throughout China. Since 1996, further genetic selection through seven generations has resulted in an additional 30% increase in growth in comparison to the original strain introduced in 1994.

The Chinese government will use the strongest possible measures to prevent unauthorized introductions

The bay scallop (*Argopecten irradians irradians*) was introduced in the 1980s and formed a new industry with annual production of close to 1 million tons.

The white shrimp (*Litopenaeus vannamei*) was introduced in the 1990s and now is the dominant species of shrimp produced in China.

The turbot (*Scophthalmus maximus*) was introduced in 1992 and artificially reproduced in 1998. Because of its high value, turbot culture has developed into a significant industry in Northern China.

NEGATIVE IMPACT

Disease Transfer

In 1992, there were great losses to shrimp production in China due to the outbreak of white spot viral disease. This was thought to be due to importation of virus infected shrimp post larvae from abroad.

Ecological Disturbance and Invasion

The river perch (*Perca fluviatilis*) is a carnivorous species introduced from the Ertrix River basin in the north Xiangjiang Autonomous Region to the Bosten Lake in the south Xiangjiang Autonomous Region for fishery resource enhancement. It became a dominant fish in the new environment and caused the extinction of native bighead (*Apiorhynchus laticeps*) and the decline of many other species.

The red swamp crayfish (*Procambarus clarkii*) was accidentally introduced during World War II from the USA. It appeared in catches in Shanghai suburbs in the 1960s, and then spread along the Yangtze River basin up to Chongqing City, where it reproduces in surrounding water bodies. In some areas, populations are so abundant they are consumed by people during a

Table 2. Aquatic alien species certified by NCCA

Common name	Scientific name	Certification code
Nile tilapia	*Oreochromis niloticus niloticus*	GS03001-1996
Blue tilapia	*Oreochromis aureus*	GS03002-1996
Large mouth bass	*Micropterus salmoides*	GS03003-1996
Pacu	*Colossoma brachypomum*	GS03004-1996
Channel catfish	*Ictalurus punctatus*	GS03005-1996
Rainbow trout	*Oncorhynchus mykiss*	GS03006-1996
Rainbow trout (Donaldson strain)	*Oncorhynchus mykiss*	GS03007-1996
Leather catfish	*Clarias lazera*	GS03008-1996
German mirror common carp	*Cyprinus carpio*	GS03009-1996
Russia mirror common carp	*Cyprinus carpio*	GS03010-1996
Rohu	*Labeo rohita*	GS03011-1996
Giant freshwater prawn	*Macrobrachium rosenbergii*	GS03012-1996
Bay scallop	*Argopecten irradians irradians*	GS03015-1996
Pacific oyster	*Crassostrea gigas*	GS03017-1996
Turbot	*Scophthalmus maximus*	GS03001-2000
Bigmouth buffalo	*Ictiobus cyprinellus*	GS03002-2000

special festival and also harvested and processed for export. However, burrowing activity by the crayfish has damaged dikes and drainage systems by creating burrows as deep as 1.5 meters which may weaken dikes and cause flooding.

The piranha (*Serrasalmus nattereri*) was introduced from South America as an ornamental fish. This aggressive carnivorous fish is referred to as the "eat men fish". It is easily propagated, and if released into natural waters could become established and decimate native fish populations. As a result of these concerns, this species was banned in 2003.

Genetic Introgression

Hybridization has been reported between the Nile tilapia Oreochromis niloticus niloticus and *blue tilapia Oreochromis aureus* (Li and Cai, 1995). There has also been mixed breeding between populations of the same species representing different introductions.

Formulation of Policy and Strategies to Manage Introductions of Aquatic Alien Species

Certification of Introduction of Aquatic Alien Species

Before the 1990s, China did not have any specific act to prevent the illegal introduction and spread of introduced alien species. Since 1990, a guideline and step-by-step process on exotic introductions and quarantine of aquatic animals has been prepared. The National Certification Committee of Aquatic Wild and Bred Varieties (NCCA) was established in 1991 under the Ministry of Agriculture (MOA). One of its mandates is to certify genetically improved aquatic breeds and alien species for aquaculture. Only certified genetically improved fish breeds and alien species can be released for commercial aquaculture. The current list of genetically improved fish breeds and alien species certified by the NCCA for commercial aquaculture are listed in Table 2.

Management and Regulation of Aquatic Alien Species Introductions

Recently, a proposal for national regulations to manage introduction of aquatic alien species has been developed. The regulation includes two parts: 1) the text of the rule, and 2) A list of species by category. This proposed regulation would apply to all life stages, including broodstock, gametes, embryos, larvae or young animals, spores, and other genetic materials intended for use in breeding for purposes of aquaculture and enhancement. More detailed information about this proposal can be found at: http://www.chinabiodiversity.com/etf/annual-2002-en.htm#c

- Proposals for any new introductions would be presented to the provincial and/or central government authority and should include:

Many species have been introduced illegally without pre-evaluation, quarantine, or post-evaluation. Only a few species were tested by research institutions before being released

- Application report, including proposed place of introduction and objectives, area of origin, biological data (habitat, reproduction), cultivation system, disease condition, proposed number, size and life history stage.
- Capacity of the applicants to carry out the introduction, estimated ecological (competition, predation, hybridization, pathogen transfer), social and economic impacts.
- The local fishery management authorities would grant first approval.
- Final approval is under administrative authority of the provincial or central government and depends on the category of animals proposed for introduction (see appendix II).

For new introductions, the Ministry of Agriculture will organize experts to evaluate the need and justification for the introduction. The Chinese government will use the strongest possible measures to prevent unauthorized introductions. For example, in early 2003 possession of the piranha Serrasalmus nattereri, originally imported from Brazil was prohibited throughout China.

References

Li Sifa and Cai Wanqi. 1995. Introgression in hatchery stocks of Tilapia nilotica and Tilapia aurea in China (in Chinese). J.-Fish.-China-Shuichan-Xuebao: 19(2): 105-111.

Appendix I

Category list for introduction of aquatic alien species

In this list, Class I species are forbidden to be introduced, Class II species are authorized if approved by the Ministry of Agriculture, Class III species are authorized if approved by the provincial fishery authorities. The Ministry of Agriculture has jurisdiction over species not on this list. Blank entries indicate data is unavailable or there is no English common name for the species.

Common name Chinese/English	Scientific name	Origin Area/Country	Year of first introduction
Class I			
纳氏锯脂鲤, 食人鱼,噬人鲳 Piranha	*Serrasalmus nattereri*	Brazil	1990
下口鲶, 清道夫 Suckermouth catfish	*Hypostomus plecostomus*	South America	1990
福寿螺 / Land snail	*Ampullarium insularum*	Taiwan	
Class II			
鲟形目 / Acipenseriformes			
西伯利亚鲟 Siberian sturgeon	*Acipenser baeri baeri*	Russia	1998
俄罗斯鲟 / Russian sturgeon	*A. gueldenstaedti*	Russia	1993
裸腹鲟 Fringe barbel sturgeon	*A. nudiventris*	Former USSR	1933
小体鲟 / Sterlet	*A. ruthenus*	Russia	1997
鲟鳇杂交种 Beluga sturgeon	*Huso huso* (♀)× *A. ruthenus*(♂)	Russia	1997
欧鲟	*Acipenser* sp.	Germany	1995
匙吻鲟 Mississippi paddlefish	*Polyodon spathula*	USA	1989
鳗鲡目 / Anguilliformes			
欧洲鳗 / European eel	*Anguilla anguilla*	France	1990
美洲鳗 / American eel	*Anguilla rostrata*	USA	
澳大利亚鳗 / Short fin eel	*Anguilla australis australis*	Australia	
马来西亚花鳗, 芦鳗 Giant mottled eel	*Anguilla marmarata*	Malaysia	
鲈形目 / Perciformes			
长丝鲈 / Giant gourami	*Osphronemus goramy*	Viet Nam	1996
细鳞拟松鲷, 泰国虎鱼 Siamese Tiger Fish	*Datnoides microlepis*	Thailand	

Common name Chinese/English	Scientific name	Origin Area/Country	Year of first introduction
爬行纲 / Chelonia			
巴西彩龟 / Slider turtle	*Trachemys scripta*	Brazil	1997
鳄龟 / Snapping turtle	*Chelydra serpentina*	USA	1997
草龟 / Crowned river turtle	*Hardella thurjii*	Bangladesh, Pakistan	
庙龟 Yellow-headed temple turtle	*Hieremys annandalei*	Thailand, Malaysia	
马来龟 Malayan snail-eating turtle	*Malayemys subtrijuga*	Viet Nam, Thailand, Malaysia	
彩龟 / Painted terrapin	*Callagur borneoensis*	Thailand, Malaysia	
越南石龟 / Pond turtle	*Mauremys* sp.		1997
甲壳纲 / Decapoda			
SPF对虾 / Kuruma prawn	*Penaeus japonicus*		
SPF梵纳对虾 Pacific white shrimp	*Litopenaeus vannamei*	USA	2001
澳大利亚雅比虾 Australian Cray Fish, marron	*Cherax tenuimanus*	USA	1992
贝类 / Archaeogastropoda			
美国红鲍 / Red abalone	*Haliotis rufescens*	USA	1985
美国绿鲍 / Green abalone	*H. fulgens*	USA	1985
虾夷盘鲍 / Black abalone	*H. discus discus*	Japan	1996
泥蚶 / Bloody clam	*Tegillarca granosa*	South Korea	
棘皮动物 / Echinoida			
虾夷马粪海胆 Green sea urchin	*Strongylocentrotus pulcherrimus*	Japan	1989
Class III			
鲑形目 / Salmoniformes			
大麻哈鱼 / Chum salmon	*Oncorhynchus keta*	Russia	1988
驼背大麻哈鱼 / Pink salmon	*O. gorbuscha*	Russia	1987
大鳞大麻哈鱼 Chinook salmon	*O. tshawytscha*	USA	2002
银大麻哈鱼, 银鲑 Coho salmon	*O. kisutch*	USA	1992
大西洋鲑 / Atlantic salmon	*Salmo salar*	USA	2001
马苏大麻哈鱼 / Masu salmon	*Oncorhynchus masou masou*	Japan	1996
虹鳟 / Rainbow trout	*O. mykiss*	North Korea	1959

Common name Chinese/English	Scientific name	Origin Area/Country	Year of first introduction
金鳟 / Rainbow trout	*O. mykiss*	Japan	1996
硬头鳟 / Steelhead trout	*O. mykiss*	USA	2001
美洲红点鲑 / Brook trout	*Salvelinus fontinalis*	USA	
白点鲑 / Whitespotted char	*Salvelinus leucomaenis*	Japan	1996
高白鲑 / Northern whitefish	*Coregonus peled*	Former USSR, North America	1985
楚德白鲑 Eurasian whitefish	*C. lavaretus maraenoides*	Former USSR, North America	1985
奇尔白鲑 / Broad whitefish	*C. nasus*	Former USSR	1987
白斑狗鱼 / Northern pike	*Esox lucius*	USSR	
鲤形目 Cypriniformes			
欧洲丁鳜 / Tench	*Tinca tinca*	Czech	1997
卡特拉鲃 / Catla	*Catla catla*	Bangladesh	1983
细须鲃 / Sultan fish	*Leptobarbus hoevenii*	Thailand	1988
银刺鲃 Indochina featherback	*Chitala blanci*	Thailand	1986
麦瑞加拉鲮 / Mrigal carp	*Cirrhinus mrigala*	India	1982
露斯塔野鲮 / Rohu labeo	*Labeo rohita*	Thailand	1978
德国镜鲤 / Mirror carp	*Cyprinus carpio carpio*	German	1984
乌克兰镜鲤 / Mirror carp	*Cyprinus carpio carpio*	Former USSR	1984
散鳞镜鲤 / Mirror carp	*Cyprinus carpio carpio*	Former USSR	1958
鳞鲤 / Common carp	*Cyprinus carpio*	Former USSR	1958
俄罗斯鲤 Common European carp	*Cyprinus carpio*	Russia	2000
白鲫, 大阪鲫 Crucian carp	*Carassius carassius*	Japan	1976
大口牛胭脂鱼 Bigmouth buffalo	*Ictiobus cyprinellus*	USA	1993
脂鲤目 / *Charicifformes*			
短盖巨脂鲤, 淡水白鲳 Pacu	*Colossoma brachypomum*	Brazil	1985
长盖巨脂鲤, 细鳞鲳 Black pacu	*C .macropomum*	Brazil	1998
小口脂鲤,巴西鲷，南美鲱鱼 Curimba	*Prochilodus scrofa*	Brazil	1996
鲇形目 / Silariformes			
斑点叉尾鮰 / Channel catfish	*Ictalurus punctatus*	USA	1984

Common name Chinese/English	Scientific name	Origin Area/Country	Year of first introduction
云斑鮰, 褐首鲶 Brown bullhead	*I. nebulosus*	USA	1984
革胡子鲶 North African catfish	*Clarias gariepinus*	Egypt	1981
斑点胡子鲶 Broadhead catfish	*C. macrocephalus*	Thailand	1982
蟾胡子鲶 / Walking catfish	*C. batrachus*	Thailand	1978
苏氏鱼芒鲶 . Sutchi catfish	*Pangasius hypophthalumus*	Thailand	1978
巨无齿鱼芒 / Giant catfish	*Pangasianodon gigas*	Thailand	1986
欧洲六须鲶 / Wels catfish	*Silurus glanis*	German, Hungary	1990
合鳃鱼目 / Semionotiformes			
雀鳝 /.Spotted gar	*Lepisosteus oculatus*	USA	1990
鲈形目 / Perciformes			
大眼狮鲈 / Walleye	*Sander vitreus*	Canada	1993
银鲈 / Silver perch	*Bidyanus bidyanus*	Taiwan	1998
条纹鲈(条纹石鲹) Striped bass	*Morone saxatilis*	USA	1993
白鲈 / White perch	*Morone americana*	USA	
杂交条纹鲈 (条纹鲈♂×白鲈♀)	*Morone saxatilis* ♀ *x Morone chrysops* ♂	USA	1993
金鲈 / Golden perch	*Macquaria ambigua*	Australia	1991
梭鲈 / Zander	*Sander lucioperca*	Russia	1960
纹太阳 Black spotted grenadier	*Lucigadus nigromaculatus*	USA	1989
黄金鲈 / Yellow bass	*Morone mississippiensis*	USA	
尖吻鲈 / Barramundi	*Lates calcarifer*	Thailand	1983
高体革鲷, 宝石鲈 Barcoo grunter	*Scortum barcoo*	Australia	2001
虫纹雪鲈 / Murray cod	*Maccullochella peelii peelii*	Australia	2001
美国红鱼, 红拟石首鱼 Red drum	*Sciaenops ocellatus*	USA	1991
大口黑鲈, 加洲鲈 Largemouth bass	*Micropterus salmoides*	USA	1984
兰鳃太阳鱼 / Bluegill	*Lepomis macrochirus*	USA	1987
绿色太阳鱼 / Green sunfish	*L. cyanellus*	USA	1999
莫桑比克罗非鱼 Mozambique mouthbrooder	*Oreochromis mossambicus*	Viet Nam	1957
尼罗罗非鱼 / Nile tilapia	*O. nilotica*	Sudan	1978

Common name Chinese/English	Scientific name	Origin Area/Country	Year of first introduction
齐氏罗非鱼 Red-bellied tilapia	*O. zillii*	Africa	
奥利亚罗非鱼 / Blue tilapia	*O. aurea*	USA	1981
加利略罗非鱼 / Mango tilapia	*Sarotherodon galilaca*	Africa	
黑颊罗非鱼, (萨罗罗非鱼 Black chin tilapia	*Sarotherodon melanotheron*	Ghana	2002
红罗非鱼（杂交变异种） Red tilapia	*O. mossambicus* (♀) × *O. nilotica nilotica* (♂)	Taiwan	1983
福寿鱼（杂交种） Red tilapia	*O. Mossambicus* (♀) × *O. nilotica nilotica* (♂)	Taiwan	1978
吉富品系尼罗罗非鱼 GIFT Nile tilapia	*O. nilotica nilotica*	Philippines	1994
斑纹光塘鱧 / Kawa anago	*Eleotris oxycephala*	Thailand, Viet Nam	1988, 1999
褐尖塘鱧 / Sleeper	*Oxyeleotris* sp.	Thailand	1986
云斑尖塘鱧, 笋壳鱼 Marble goby, sand goby	*Oxyeleotris marmorata*	Thailand	1987
褐塘鱧 / Dusky sleeper	*Eleotris fusca*		
巨鱧 / Snakehead	*Channa striata*	Thailand	1986
鲽形目 / Pleuronectiformes			
大菱鲆 / Turbot	*Psetta maxima (Scophthalmus maximus)*	UK	1992
漠斑牙鲆 / Southern flounder	*Paralichthys lethostigma*	USA	2002
宽牙鲆 / Broad flounder	*P. squamilentus*		
夏鲆, 大西洋牙鲆 Summer flounder	*P. dentatus*	USA	2002
鲀形目 / Tetradontiformes			
弓斑东方鲀 / Puffer	*Fugu ocellatus*	Japan	
红鳍东方鲀 / Puffer	*Fugu rubripes*		
甲壳类 / Decapoda			
日本对虾 / Kuruma shrimp	*Penaeus japonicus*		
斑节对虾 / Tiger shrimp	*P. monodon*	Thailand	1986
凡纳对虾, 南美白对虾 White shrimp	*P. vannamei*	USA	1988
南美, 墨西哥, 蓝对虾			1999
罗氏沼虾 Giant freshwater prawn	*Macrobrachium rosenbergii*	Japan	1976
红螯螯虾./ Redclaw, yabby	*Cherax quadricarinatus*	Australia	1992
贝类			

Common name Chinese/English	Scientific name	Origin Area/Country	Year of first introduction
海湾扇贝 / Bay scallop	*Argopecten irradians irradians*	USA	1981, 1982
虾夷扇贝 / Yesso scallop	*Patinopecten yessoensis*	Japan	1981
面团栉孔扇贝			
墨西哥扇贝 (南方种群) Bay, Calico scallop	*Argopecten irradians concentricus*	USA	1991
墨西哥扇贝 (北方种群) Bay, Calico scallop	*Argopecten irradians concentricus*	USA	1995
欧洲大扇贝		France	1995
太平洋牡蛎/ Pacific Oyster	*Crassostrea gigas*	Japan	1985
美国牡蛎 / Atlantic Oyster	*Crassostrea virginica*	USA	1985
魁蚶 / Blood, ark shell	*Scapharca broughtonii*		
法国蜗牛		France	
爬行类			
泰国鳖		Thailand	1987
美国鳖		USA	
绿藻门			
螺旋藻 / Spirulina	*Oscillatoriaceae spirulina*		
褐藻门			
日本真海带 / Brown algae	*Laminaria japonica*	Japan	1930
长叶海带 / Brown algae	*Laminaria japonica*	Japan	1982
红藻门			
麒麟菜 / Eucheuma	*Eucheuma muricapum*	Philippines	1985
条斑紫菜 / Nori	*Porphyra yezoensis*	Japan	1991
蓝藻门			
盐生杜氏藻 / Dunaliella	*Dunaliella* sp.	Israel	1991
拟微绿球藻	*Chlorococcum* sp.	Japan	1995
小球藻 / Chlorella	*Chlorella* sp.	Japan	1995
巨藻 / Giant kelp	*Macrocystis pyrifera*	USA	1982
卡德藻 / Tetraselmis	*Tetraselmis* sp.	Canada	1996

Country reports

Alien aquatic species in Lao People's Democratic Republic

Boonthong Saphakdy
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Aquaculture development in Lao People's Democratic Republic is a combination of traditional methods and lessons learned from the neighbouring countries, such as China, Viet Nam and Thailand

Introduction

Policy formulation and strategies in fisheries are a recent development in Lao People's Democratic Republic, emerging over the past decade. More recently, interventions in fisheries have been directed towards the conservation of natural resources and the development of fish farming by decentralizing the fisheries management functions to local authorities. These activities have included:

- awareness building on the adverse impacts on the use of illegal and destructive fishing gears;
- promoting the sustainable exploitation and use of indigenous fish species;
- the establishment of fish breeding facilities;
- the use of non-carnivorous species in aquaculture;
- the careful use of exotic species in aquaculture.

Previous fisheries management measures that have been enforced by local authorities and by communities themselves have often resulted in conflicts and problems because of the lack of scientific based information responding to the root causes of the situations. This situation started to improve through the guidance of the Prime Minister Decree No. 118 on 5 October 1989 concerning the management and conservation of aquatic animals, wild animals, the hunting and fishing.

Fisheries management in Lao People's Democratic Republic in Nam Ngum reservoir has been assisted successively by many donors such as Netherlands,

Switzerland, FAO and Denmark, through MRC since the beginning of the establishment of the Hydro-Power reservoir. mainly Netherlands, Switzerland, FAO and Denmark.

Aquaculture development in Lao People's Democratic Republic is a combination of traditional methods and lessons learned from the neighbouring countries, such as China, Viet Nam and Thailand. Fish seed farms were built in many provincial capitals during the Indochina war period, especially during 1960s with USAID assistance in Vientiane, Savannakhet, Pakse, Sayaboury and Luang Prabang. In early 1970s, hatcheries were constructed in northern provinces (Houa Phanh, Xieng Khouang and Oudomxay) with the assistance of China and Viet Nam. From 1997 onwards there were a number of external assistance projects. A FAO/ UNDP intervention assisting the Government in aquaculture development in areas such as capacity building, extension, fish seed production demonstration, fish culture techniques, information on technologies, hatchery rehabilitation. By the end of 2001 throughout the country there were fish seed hatcheries scattered throughout 18 provinces of Lao People's Democratic Republic, 30 existing hatcheries in which 17 belong to provincial Government and 13 belong to private farms. There were nine new hatcheries under construction. Altogether, these hatcheries and their production will form the basic infrastructure for the expansion of aquaculture in the near future.

Fisheries Development Program

Throughout the development of fisheries sub sector and particularly aquaculture, the promotion of the introduction of exotic species for aquaculture was problematic due to lack of supply and the inability to maintain the broodstock in sufficient numbers and quality. Several projects have also been targeted at the use and exploration of indigenous species. More than 500 species out of 1200 species in the Mekong River Basin have been identified (Fish of Lao by Maurice Kottelat 2001) with the assistance of World Bank, IUCN and WWF. This elucidated the high degree of fish species diversity, even though it is still incomplete. In the field of aquaculture, checking only the available aquatic biodiversity that is currently being utilized, it was found that there are nine exotic species and around 18 indigenous species found in subsistence farming type aquaculture. .

Indigenous species found in aquaculture comprised of: *Barbodes gonionotus* (Pa pak), Channa micropeltes (pa do), Hampala macrolepidola (pa soud), *Hemibagrus numerus* (pa kod), *Hemibagrus wyckioides* (pa kheung), *Pangassius kremfi* (pa souay), *Wallago leeri* (pa khoune), *Wallago attu* (pa khao), *Wallagodimina* (pa khop), *Osteochilus melanopleurus* (pa nock khao), *Cirrhinus molitorella* (pa keng), *Cirrhinus microlepis* (pa phone), Labeo behri (pa va), *Morulius chrysophekadion* (pa phia), *Probarbus jullieni* (pa eun), *Clarias* spp. (pa duk na), *Osphrosnemus exodon* (pa men).

Of the exotic species that are typically found (Table 1) are the: major India Carps like: *Labeo rohita, C. mrigala, Catla catla, Cyprinus carpio*, some Chinese carps: *Aristichthys nobilis, H. molitrix, Ctenopharryngadon idella* and *Oreochromis niloticaus*.

In the aquaculture of indigenous Mekong fish species project (AIMS), Lao People's Democratic Republic has chosen to study seven species among 17 namely: *Barbodes gonionotus, C. microlepis* (by Km 8 Pakse station), *C. molitorella* and *Puntioplites falcifer* (by Nah Luang station), *Clarias macrocephalus*, *Morulius chrysophekadion*, and *Osphoronemus exodon* (by Nam Huang station).

Fish farming systems and fish species

The main fish farming systems that are practiced in the country are: pond fish culture, integrated farming with livestock, rice cum fish culture and fish seed production. The above-mentioned fish farming systems are generally followed by farmers according to traditional methods that as prevail in their respective localities and according to their own experience and that of their neighbours. Other fish cultures systems are becoming increasingly popular in the country namely:

- cage culture in the main stream of rivers and reservoirs,
- hatchery and nursery farming systems,
- fish stock enhancement in small water bodies.

The indigenous species currently being bred and cultured extensively by farmers are pa pak (*Barbodes gonionotus*); While the snakehead (*Channa* sp.), and Gouramy (*Osphoronemus gourami*) are cultured by few farmers.

Other species indigenous to the Mekong and its tributaries have been imported to Lao People's Democratic Republic from adjoining Thailand. Fingerlings of *Barbodes gonionotus* were introduced to the Nong Teng fish farm in 1978 from Nongkhai fisheries station (on the opposite bank of the Mekong River Thailand) and were successfully bred for the first time in Lao People's Democratic Republic in 1980. Subsequently pa eun (*Probarbus jullieni*), pa keng (*Osteochilus prosemion*), pa phone (*Cirrhinus microlepis*), pa kaho (*Catlocarpio siamensis*), pa hou mat (*Pangassius larnaudii*), pa phia (*Morulius chrysophekadion*), pa men (*Osphoronemus gouramy*) and pa suey (*Pangassius hypothalamus*) were also subsequently introduced for culture.

Table 1. Information on alien species in Lao People's Democratic Republic

Fish Species	Date of first introduction	Origin	Reason	Ecological impact		Social economic impact	
				Positive	Negative	Positive	Negative
Catla catla	1977	Thailand/India	Aquaculture	Not destroy aquatic environment	None	Beneficial	Cannot breed in natural water bodies
Ctenopharyn-odon Idella	1977	China	Aquaculture		Probably yes		Cannot breed in natural water bodies
Cirrhinus mrigala	1977	Thailand/India	Aquaculture		Probably yes		Cannot breed in natural water bodies
Clarias gariepinus	1980	Viet Nam	Aquaculture		Yes		Low price, hybrid
Cyprinus carpio	1965	Thailand	Aquaculture		Yes	Beneficial, productive	
Laobeo rohita	1965	Thailand	Aquaculture	Not destroy aquatic environment	None	Beneficial	Cannot breed in natural water bodies
Oreochomis mossambicus	1965	Thailand/Japan	Aquaculture		Yes	Beneficial	People prefer
Oreochromis niloticus	Unknown	Thailand	Aquaculture		Yes	Beneficial	People prefer
Pomacea canaliculata	1986	Thailand	Ornamental	Unknown			Loss of money (impact on rice cultivation)

Apart from the import of indigenous species for culture, there is a long tradition of fish culture in paddy fields in northern parts of Lao People's Democratic Republic and the similarities with that practiced in surrounding countries (such as bordering provinces in Viet Nam and Yunnan, PR China) suggests that is has a long history in the region. *Carassius carassius*, known locally as "Pa fek" (or possibly *Carassius auratus*) is an exotic species that appears to be feral in northern Lao People's Democratic Republic in upland streams and paddy systems and has probably been introduced historically by the tribes in the mountains that practice rice fish culture. The common carp (*Cyprinus carpio*) is a more recent introduction to paddy filed culture, but again, may have been translocated by migrations of tribes between China, Viet Nam and Thailand and therefore its arrival in Lao People's Democratic Republic is not certain but may well extend back well over a century.

Pond fish culture

Pond culture is pursued as both polyculture and monoculture. There are 23 species of fresh water fish that are reportedly cultured in the country, of which the most popularly cultured species are: Tilapia (the strains are unknown and have been extensively mixed through serial introductions and movement), common carp (*Cyprinus carpio* as with Tilapia, this species has local coloured strains that may have along history, more recent introductions have been from development assistance activities and bilateral support form Hungary and Viet Nam), silver carp (Hypophthalmichthys molitrix), bighead carp (*Aristichthys nobilis*), grass carp (*Ctenopharyngodon idella*), Rohu (*Labeo rohita*), Mrigal (*Cirrhinus mrigala*), African catfish (*Clarias gariepinus*), Giant snake head (*Channa micropeltes*), silver barb (*Barbodes gonionotus*), *Cirrhinus microlepis, Cirrhinus molitorella, Morulius chrysophekadion, Osphoronemus exodon* and *Clarias macrocephalus*.

Integrated fish livestock farming

In addition to rice farming, livestock raising is a traditional practice in rural households. Fish culture with livestock (pig and poultry) has been introduced and is practiced by some farmers but is still relatively uncommon in the country – partly due to the tendency of small farmers to not pen livestock, limiting manure introduction directly to the pond. Fish production in demonstration areas where high levels of manure were delivered to the pond was increased from 100-500 kg/ha without integration to 1200-2500 kg/ha with integration (Gupta, 2000).

Rice cum fish culture

Traditionally Lao farmers caught wild fish from natural sources than introduced to their paddy fields. However due to declining fish supply from natural sources and given importance of rice farming, there is growing interest in recent years in integrating aquaculture with rice farming in the country. This form of aquaculture is quite common in the northern Lao People's Democratic Republic.

Cage fish culture

In recent year fish culture in cages is developed largely in the central part down to southern part of the country namely Vientiane Municipality, Vientiane province, Khammouane, Savannakhet and Champassak provinces. The farmers culture fish in cage in reservoir (Nam Ngum, Nam Houm, and Nam Xuang) and along the Mekong River, Ngum River. The most popular fingerings being raised are sex reversed Nile tilapia which are typically imported from hatcheries across the Mekong river in Thailand. The result from cage fish culture are quite encouraging so far to the farmer who do not have access to ponds.

Recommendation of the national workshop on the impact of exotic fish species in Lao People's Democratic Republic

The national workshop on the impact of exotic fish species in Lao People's Democratic Republic was conducted by the Department of Livestock and Fisheries of Lao People's Democratic Republic (DLF) and Asian Institute of Technology (AIT) with financial support from SIDA. The workshop was held in Thalat, Vientiane province from 22 to 24 November 2002.

The workshop reviewed the alien species currently cultured in Lao People's Democratic Republic (Table 1). The summary of this review is presented in Table 1.

The workshop:

- Recognized that the introduction of introduced fish has positive impact to the socio-economy of the country and also has had impacts on aquatic resources.
- Understood that grass carp, African catfish and common carp are a risk to aquatic environment. The meeting agreed that these alien species should not be released into water bodies without deep technical study.
- Recognized that the importation of aquatic animal and aquatic plants are a high risk for the introduction of fish disease into the country. Therefore the country should consider an arrangement to establish regulations for controlling aquatic animals.
- Recognized that due to the high risk of alien fish species, they should only be promoted in suitable areas that are secure enough to minimize impacts.
- Recommended publishing of technical guidelines, regulations and policy on sustainable aquaculture and fisheries in order to reduce negative impacts of alien species and promote their positive impact.
- Recommended appropriate conditions and methodologies in establishing the technical infrastructure for serving export and import services.
- Noted that there was a need to enhance public awareness on the negative impact of import introduced aquatic animals and aquatic plants into the country nationwide, in order to ensure wide participation in their monitoring and management.
- Recommended that there should be continuing studies to solve the anticipated problems of the future.
- Realized that there was a need to study new indigenous aquatic animal species in order to develop economically in the future.

Future Plans and Cooperation

Lao People's Democratic Republic lists the following as important elements of a national plan on responsible use of alien species:

National Plan

- Study on new biogenetic resources and technologies.
- Study on an appropriate environment for culture.
- Assessments on aquatic animal and aquatic plant diseases.
- Study on types of fish farming.
- Study on the fish farming and fish feeding.
- Study on the brood stock management and culture.
- Study on culture of indigenous fish and promotion of indigenous species as for the ornamental fish market.

Regional Cooperation to promote the Plan includes:

- exchange of information on health issues in aquatic animals and plants;
- establishment of Set regional guidelines on quarantine and health certification;
- immediately reporting to neighbouring countries on outbreaks of aquatic animal disease.

Country reports

Alien aquatic species in Myanmar

U Hla Win

Following increasingly good experiences with aquaculture, the Department of Fisheries has imported regionally high-demand species with the intention of increasing the income of fish farmers by producing high-price fish for local and regional markets

Introduction

Myanmar, contains 676 577 square kilometres in area with a population of over 50 million in 2000-2001 and has a varied climatic conditions. The northern part of the temperate region is the eastern part of Himalaya range and the mountain peaks are covered with snow the whole year round. In contrast, the southern part of Myanmar is close to the equator (10º N). The whole country is divided longitudinally by four big rivers which have a vast delta region before opening into the sea.

One fifth of the country is inundated during the monsoon and post monsoon period. These are the areas where Myanmar people get fish and aquatic organisms, a major source of low cost animal protein. It is reported that the per caput consumption of fish in Myanmar is 26 kg (2003), however this figure probably does not include fish caught and consumed locally and therefore may well be much higher.

Despite rich natural fisheries resources, the Myanmar Department of Fisheries established some pioneer forms of aquaculture in 1953. This started with tilapia and common carp, followed by gouramy in following years up to 1955. (Appendix A). The objectives of the Department of Fisheries were to introduce aquaculture technology and to initiate aquaculture industry which would take the vital portion of the fish production to feed people not only in the country but also in the region and international in future. The reasons of choosing these species were:

- the aquaculture of these fishes was already well established in many surrounding countries;
- these species can survive adverse water conditions;
- the all spawn readily in ponds with minimum manipulation by man;
- the taste was very similar to local fishes as indigenous carps, climbing perch and barbs.

Perception of alien species

Initially, Myanmar people were very reluctant to put these new species in the daily fish menu. This was occasionally due to similarities with local species, e.g. the common carp was named "Indonesian Nga Phane" when they were introduced due to its similarity to the native species "Inlay Nga Phane" (*Cyprinus carpio inthar*). Unfortunately, it is locally believed that these fish eat the dead bodies of human being that were traditionally buried in the water of the huge Inlay Lake and as a result, the alien common carp were rejected by Myanmar people. To overcome this first problem Department of Fisheries changed the name of the fish to "Shwewa Nga Ginn" which means "Golden Carp" after the name of very famous film actress which bore the same meaning as "Glorious yellowish gold" and like the actress, the exotic common carp started getting popular in the market and consequently in fish farms.

In the case of tilapia, Trichogaster and gouramy, the complaint of consumers was due to the small size and their colour. The Department of Fisheries had taken some time to convince the consumers that they had the same taste as local walking cat fish, *Clarias batrachus* and climbing perch *Anabas testudineus*.

Since the law enforcement is so strong and the self awareness is well developed, the illegal importation of exotic species is not practiced

Technical problems

At the same time of poor consumer perceptions, technical complaints were made by farmers regarding their ponds.

Common carp were causing embankment erosion as part of their feeding habits feeding habit of common carp.

The precocious maturation and frequent spawning habits of tilapia was leading to over population of small size groups in the ponds.

These two problems were solved by Department of Fisheries through demonstration, showing that the common carps are to be cultured in earthen pond with clay soil deep enough to keep the water level at least one and half meter deep such that it does not reach embankment base. It was also advised to keep a pave way between embankment base and the edge of the pond about one and half meter apart.

At present due to its lower market price in market than India major carp (especially Rohu) and based on farmers own experiences, the common carp is raised only in polyculture ponds and at a lesser ratio than more preferred major carp species. In this system its role is as a detritus feeder to clean the pond bottom waste. In the case of tilapia the farmers were asked to harvest the marketable size very frequently or to stock the pond with monosex fingerlings.

The impacts of common carp stocked into reservoirs and tilapia in big tanks where there are large numbers of fish seed stocked annually are unknown. and the occurrence of adverse impacts of these fishes to the local biodiversity of aquatic habitats and ecosystem has not been observed yet.

In 1967 three new species of Chinese species carp were introduced to Myanmar water with different objectives, i.e. to eradicate the aquatic weeds and to inhibit the plankton bloom in the

fish ponds. The principle role of these species is merely to maintain their pond environment. The market value of fish is rather low due to inferior taste to the consumers and therefore they are not subject to intensive propagation. So far, no negative impact has been attributed to these Chinese carp species.

Current status

Following increasingly good experience of the potential forwith aquaculture, the Department of Fisheries has imported regionally high-demand species with the intention of increasing the income of fish farmers by producing high-price fish to local and regional markets. Among these newly introduced alien species, only African catfish (*Clarias gariepinus*) imported by the private sector has shown a threat to the local fish. In this case it has caused problems with predation of smaller fish and the nibbling of the fins and body parts of bigger fish. As a result of this, the culture of African catfish is banned in Myanmar. Catfish farmers can get hybrid catfish (*Clarias gariepinus x C. macrocephalus* and *C. gariepinus x C. batrachus*) only from Department of Fisheries hatcheries.

In 2002 Department of Fisheries gave permission to import wWhite Sshrimp (*L. vannamei*) postlarvae for culture in isolated areas under thorough strict direction from Department of Fisheries as a pilot process. Though occurrence of Taura Syndrome Virus (TSV) has not been observed and high production of four tonnes/ha has been obtained, as a preventive measure the import of *Vannamei* white shrimp is still currently suspended. The case will be considered again when better information and experiences can be obtained from other countries that have imported *L. vannamei*.

Legal and policy aspects

Myanmar, though endowed with ample natural resources, has to venture to find new trends opportunities in fish trade including and aquaculture. Accordingly, exotic fish species are introduced into Myanmar aimed at diversifying aquaculture in order to feed people with new fish species, to increase income of fish farmers and to utilize fully utilize the varied favourable topographic and climatic conditions.

According to Myanmar's four fisheries laws, fish are defined as:

> *"All aquatic organisms living the whole or a part of their life cycle in the water, and their eggs, larval fry and seeds".*

This expression also includes aquatic plants, their seedlings and seeds. As a regulatory measure, it is a compulsory to get permission from Department of Fisheries under the Law Related to Aquaculture for any aquacultural activity. In section 35 of this law, it is stated that prior approval shall be obtained from the Department of Fisheries regarding import and export of live fishes into and out of the country. Severe penalties are also mentioned; to be given out to those who are convicted under this section.

To enforce this section the Department of Fisheries is the only agency and the Director-General and Deputy Director-General of the Department the two persons conferred by the State as sole competent authorities. The Department of Fisheries explains the basic concepts of the section in terms of conservation and preventive measures, to potential importers of live fishes in order to facilitate their application. In this way the importer has to be in compliance

with this section and the regulations mandated by the Department. The Department of Fisheries is taking uttermost care to safeguard imports of alien fish to Myanmar.

To induce responsibility with overriding objectives of conservation and management among stakeholder and small holder in fisheries sector the FAO Code of Conduct for Responsible Fisheries is translated into local language and distributed to the fisheries communities through department and Myanmar Fisheries Federations (NGO).

Since the law enforcement is so strong and the self awareness is well developed, the illegal importation of exotic species is not practiced. Reports from farms show that there is no adverse impact of alien species on local wild and cultured aquatic communities their habitats and eco-system. The African catfish is the only case of an alien fish species which Department of Fisheries has taken action in time. The unsuccessful stories of some alien species reveal that they are rejected not because of their ill effects on the environment, but due to poor consumer appreciation because of their colour, taste and flavour.

Stocking of open waters

With the intension of rehabilitation of natural resources and creation of the new fisheries, the Department of Fisheries has practiced culture- based capture fisheries through stocking of hatchery bred fish seed into natural and man-made water bodies. Local indigenous species such as *Labeo rohita, Cirrhina mrigala, Catla catla* are stocked into open waters, either to enhance existing fishery production or to revitalize depleted fisheries. Alien species such as catfish common carp and tilapia are stocked to create new fisheries and to increase the value and profitability of a fishery. To control the over-growth aquatic vegetation and plankton the grass carp and silver carp are commonly stocked in certain areas and farm ponds.

Stocking for recreational fishing has not been undertaken yet.

To control the over-growth aquatic vegetation and plankton the grass carp and silver carp are commonly stocked in certain areas and farm ponds.

Need for regional and international action

It is obvious that well documented information and examples of the risks related to these activities is limited and that collaboration and deliberation among the countries through regional fisheries bodies is very seldom. A number of international code and protocols are provided and developed by various institutions from different areas, but these mostly focusing on disease risks associated with introduction and transfer of live aquatic animals.

Internationally more effort and attention has focused on farming practices, feeds, economics, disease, water management and very recently genetically improvement of cultured species.

Transboundary movement and aquatic animal health

Though alien species have been introduced into Myanmar for aquaculture since 1953, the first occurrence of disease due to transboundary movement was only observed in 1984. The disease was Epizootic Ulcerative Syndrome (EUS) and it appeared that it spread from border areas adjoining Thailand (where it had already appeared) possibly through the trading of live or dead fish that were infected, across the long border. The species most severely affected

species were snake head, eel, catfish and barbs. EUS appeared to become less of a problem with time, affecting 35 townships in 1984-85 and reducing to 11 townships in 1989-90. More recent occurrences of EUS are unknown in subsequent years.

The second major transboundary disease occurred in tiger shrimp, *Penaeus monodon* and was due to White Spot Syndrome Virus (WSSV). This virus is still causing serious problems in the shrimp farming industries. The DOF has set up Disease Diagnostic Laboratories with technical assistance from regional FAO office under TCP/MYA/ 2523 project. Currently the laboratory is equipped with PCR and the technical assistance and training are provided by FAO, SEAFDEC, NACA and AAHRI.

The unsuccessful stories of some alien species reveal that they are rejected not because of their ill effects on the environment, but due to poor consumer appreciation because of their colour, taste and flavour

Present status of national animal health strategy development and implementation

PARTICIPATION IN REGIONAL ACTIVITIES

Since 1998 up to very recently Myanmar has implemented FAO Regional Technical Cooperation Programme TCP/RAS/671 and 9605 "Assistance for the Responsible Movement of Live Aquatic Animals" with close collaboration with Network of Aquaculture in Asia-Pacific.

Myanmar took part in development of Asian Regional Technical Guidelines for the Responsible Movement of Live Aquatic Animals and Beijing Consensus and Implementation Strategy. Myanmar also committed to develop National Strategies on Aquatic Animal Health Management. Mean while Myanmar took part in regional workshop in Bangkok in 1998 and 200 in Beijing and Capacity and Awareness building on Import Risk Analysis (IRA) for Aquatic Animal held in Bangkok in 2002.

To keep up with the fast developing aquaculture sector in Myanmar, a national workshop on "Developing the National Strategy Framework on Aquatic Animal Health Management" was held in Yangon from 10-11 April 2002 attended by Deputy Minister for Ministry of Livestock and Fisheries and Chaired by Director General of Department of Fisheries. The workshop was attended by over one hundred persons representing Department of Fisheries, various Universities, Myanmar Fisheries Federation, Myanmar Academy of Livestock and Fisheries, OIE and FAO. Dr M. B. Reantaso (Aquatic Animal Health Specialist – NACA) and Dr S. Chinabut (Director, Aquatic Animal Health Research Institute) were external resources expert Deliberation and preliminary assessment on the formulation of Myanmar's National Strategy Framework on Aquatic Animal Health Management were made through working group. The workshop recommended the formation of "Committee on Aquatic Animal Health Management (CAAH) by DOF, including related representatives from as many sectors as possible. CAAH will issues relating to forming and implementing of the "National Strategy". At present CAAH has already been established and development of the National Strategy framework is ongoing process base on the available resources Aquaculture Law (1998) and other international agreement. The National Strategy will be integrated into long term and short term national aquaculture development plan in the future.

As a legal framework the existing Aquaculture Law designates Director General of the DOF as the competent authority to issue relevant/ directives and notifications. Since there is no specified provision on alien species included in the law it is deemed that the law should be revised.

Under the strict regulations and efficient legislative measures coupled with expertise from various sector and collaborated activities only minor problem and constraints are expected which can be solved through responsibility and self awareness.

Present status of aquatic animal disease reporting

To enhance the technical administration processes the DOF has deployed offices in strategic areas where the fishery is intensive. The staff has to monitor the fishery activities and has to report back to head office. Normally the status and information on fisheries including fish health status in their jurisdiction are reported back to relevant section including fish health unit. DOF have good quality and eligible staff working on Health Management and data gathering activities but they are insufficient to cover the whole sector.

Since there is a significant increase in the number of species and in larger volume of production with little or no awareness of downstream consequences, Myanmar feels that harmonized principles, guidelines and sound technology are urgently needed and that the effective use of International Mechanism for the Control and Responsible use of Alien Species in Aquatic Ecosystem is very crucial for sustainable use of aquatic resources.

Recommendation

Introduction of alien aquatic species should be only made prior to consideration for safeguarding natural resources and ecosystems.

If some species, that may not cause negative impact to conservation of fishery resources and ecosystem, are decided to be introduced, studies on prior quarantine and reliable reporting should be conducted.

The culture of alien aquatic species should be facilitated through good aquaculture practice (GAP) and / or environment friendly aquaculture practices.

An introduced alien species should be genetically upgraded through high health management and screening method so as to sustain specific pathogen free (SPF) parent stock.

Introduction of *Penaeus vannamei* to Asia and the Pacific region is still questionable. Myanmar is deliberating if it should be allowed to import. In this regard, the workshop is requested to set up the solution.

Collaboration among regional and global scientists should be implemented to study cause and effect on conservation of ecosystem prior to introduction of alien aquatic species.

Appendix A

Alien Species in Myanmar according to FAO Database on Introductions of Aquatic Species

Genus	Species	Origin	Year of first introduction	Reason for introduction	Who was responsible	Ecological effect	Socio-economic effect
Oreochromis	*mossambicus*	China	1953	Culture	Government	Unknown	Beneficial
Cyprinus	*carpio*	Indonesia	1954	Culture	Government	Unknown	Beneficial
Trichogaster	*pectoralis*	Thailand	1954	Culture	Government	Unknown	Beneficial
Osphoronemus	*gouramy*	Indonesia	1955	Culture	Government	Unknown	Beneficial
Ctenopharyngodon	*idella*	China	1967	Culture	Government	Unknown	Beneficial
Aristichthys	*nobilis*	China	1967	Culture	Government	Unknown	Beneficial
Hypophthalmichthys	*molitrix*	China	1967	Culture	Government	Unknown	Beneficial
Oreochromis	*niloticus*	-	1977	Culture	Government	Unknown	Beneficial
Oreochromis	*aureus*	-	1977	Culture	Government	Unknown	Beneficial
Cyprinus	*carpio*	Israel	1978	Culture	Government	Unknown	Beneficial
Pangassius	*hypothalamus*	Thailand	1982	Culture	Government	Unknown	Beneficial
Clarias	*gariepinus*	Thailand	1990	Culture	Private	Adverse	Adverse
Clarias	*macrocephalus*	Thailand	1990	Culture	Government	Unknown	Beneficial
Barbodes	*gonionotus*	Thailand	1996	Culture	Government	Unknown	Beneficial
Notopterus	*chitala*	Thailand	1997	Culture	Government	Unknown	Beneficial
Litopenaeus	*stylirostris*	Thailand	2000	Culture	Private	Unknown	Beneficial
Piractus	*ranchypmum*	Thailand	2001	Culture	Government	Unknown	Beneficial
Litopenaeus	*vannamei*	Thailand	2002	Culture	Private	Unknown	Beneficial

Country reports

Aquatic alien species in Thailand (Part 1): Biodiversity

Chavalit Vidthayanon

Thai people consume 28.8 kg of fish per capita, of which 41.6% is exotic species

Thailand has experienced exotic aquatic animal species since the 18th Century, when goldfish were introduced to high society households for ornamental purposes. For food fish aquaculture, Chinese common carp *Cyprinus carpio* was introduced in the early 20th Century to the Bangkok area and raised by Chinese farmers; Chinese major carps were subsequently introduced. Since this time, many species of "exotic" finfishes and shellfishes have been introduced for various purposes, including for food, as ornamentals, or for mosquito control. Introduced exotic species, imported for any purpose, have mainly contributed economic or social benefit and their status can be summarized as follows:

Escapee: 11 species accidentally spread in habitats but not established.

Flourishing: 17 species have established populations in nature. Aquatic species imported mainly for the aquarium or pet trade include:

- Finfishes and rays ca. 1000 species
- Amphibian ca. 50 spp.
- Reptiles ca. 40 spp.
- Mollusc 3 spp.
- Crustacean 4 spp.

In total, 17 species have flourished in natural waters, including 11 that appear not to have become invasive (or their status is unknown) and six invasive species (see Table 1).

The means of introduction to natural waters include:

- Escapee or unintentionally release, a result of natural disasters, traffic accidents and direct escape.

Most of escapees are aquarium or pet species. Eleven taxa are frequently seen in Thailand:

Arapaima *Arapaima gigas*
Aligator gar *Lepisosteus* spp.
African lungfish *Protopterus* spp.
Bichirr *Polypterus* spp.
Japanese eel *Anguilla japonica*
Pacu *Colossoma macropomum*
Piranha *Serrasalmus* spp.
Bullfrog *Rana catesbiena*
Caiman *Caiman crocodilus*
New Guinea crocodile *Crocodylus novaguineae*
Chinese softshell *Pelodiscus sinensis*
Red cheek terrapin *Pseudemys scripta*

- Intentional release "for merit" as practiced in Thai Buddhist culture, or abandoning of some aquatic pets, sometimes to avoid legal problems.

- Official stocking, by the Department of Fisheries, for rehabilitation of inland waters and communal fishponds. This practice includes translocation of native species within their natural range.

The main reason for introducing exotic species are for social and economic benefit, especially for aquaculture. Positive or beneficial aspects of exotic species include:

Food security. Exotic species contribute more than 63% of freshwater fish production in Thailand or 160 000-170 000 mt annually, mainly from aquaculture. This statistic does not include yields from communal fishponds and natural waters. In 2001, fisheries statistics show that Thai people consume 28.8 kg of fish per capita, of which 41.6% is exotic species. Nile tilapia and its strains make the highest contribution, 8.52 kg per capita, following by hybrid walking catfish and common carp. Exotic fish aquaculture also plays an important role in the Thai rural economy, including employment, fish seed selling, polyculture with livestock and processing of fish product.

Ornamental. Up to 1 000 exotic species have been imported for the Thai aquarium trade. Many species have been bred and improved into famous breeds for the global market, such as discuss, oscar, guppy and others.

Public health. Two ornamental species were introduced for mosquito control in urban and suburban areas of Thailand; the guppy Poecilia reticulata and mosquitofish Gambusia affinis that has high tolerance to polluted water. *Sailfins, P. velifera* and *P. sphenops,* were also utilized for algae control in brackish water shrimp ponds.

Some exotic species have become invasive alien species (IAS) to Thailand, with the following negative impacts:

Predatory. Several carnivorous fishes and amphibian can cause population decline in indigenous species, through predation, including egg predation. African and hybrid catfishes are claimed to have caused predation of small fishes in some wetlands. Tilapia in some man-made wetlands have been reported through local knowledge as egg predators of larger indigenous cyprinids i.e. *Osteochilus melanopleura* and *Morulius chrysophekadion*. Larger escapees i.e. Arapaima have potential to harm small fishes and frogs as well as bullfrogs can predate smaller native amphibians.

Competitor. Most alien species have better adaptive living, an higher tolerance to habitat change and may compete with native species in foraging, niche and spawning grounds. Hybrid

walking catfish, several million of which are released annually for merit making, and escape from ponds, has been blamed for outcompeting the native species *Clarias batrachus*.

Disease, parasite transmission. Chinese major carps were suspected as carriers of anchor worm and cotton disease in Thailand; it was banned for fry importing by Fisheries Act in 1970. Many diseases and parasites have been introduced in aquarium and pet species, including protozoa and helminthes, among others. The bullfrog was found to carry virus to native frog farms and sand goby culture.

Habitat disturbance. Apple snails cause changes in wetland plant communities by foraging of soft and submerged species, leading to takeover by hard leaf species vegetation. Such vegetation change can lead to changes in fish diversity. Snails are also serious agricultural pests in paddy fields.

Agriculture and aquaculture pest. Apart from apple snails, the Mozambique tilapia has become a pest in brackish water shrimp farms throughout the Southeast Asia.

Genetic pollution or erosion. Establishment of alien taxa that are closely related to native taxa may cause genetic contamination through hybridization. Genetic examination of native walking catfish *C. macrocephalus* has found some contamination by the African species *C. gariepinus* in central Thailand.

Economic losses. Pests may cause a reduction of farming product and incur costs for eradication. There may also be secondary impacts to the ecosystem from control and eradication activities. The obvious example is apple snail eradication, where chemical agents pose hazards to all non-target species in natural waters, including humans.

Legislation relevant to alien introduction

There are three relevant legal instruments that control aquatic alien introductions in Thailand.

The Fisheries Act that prohibits imports of piranhas and sucker catfish, and regulates all imports of aquatic animals.

The National Park Act and Wildlife Conservation Act that prohibits carrying and release of any animal into National Parks and Wildlife Sanctuary areas.

The import of all living aquatic species is also controlled by the Ministry of Commerce.

Table 1. List of exotic species in Thai aquaculture

Species		From	Year	Origin	Reason	Established	Impact
Japanese eel	*Anguilla japonica*	Japan, China	1973	Japan, China	aquaculture	no	No
Chinese crucial carp	*Carassius auratus*	China	1692-1697	China	ornament	yes	No
Crucial carp	*Carassius carassius*	Japan	1980	Europe	aquaculture trial	no	No
Catla	*catla*	Bangladesh	1979	Bangladesh	aquaculture trial	no	No
Mrigal	*Cirrhinus cirrhosus*	Bangladesh	1980	Bangladesh	aquaculture	probably no	Unknown
African walking catfish	*Clarias gariepinus*	Lao PDR	Ca. 1987	Africa	aquaculture	yes	Invasive
Grass carp	*Ctenopharyngodon idella*	China, Hong Kong	1932	China	aquaculture	probably yes	Unknown
Common carp	*Cyprinus carpio*	China, Japan, Israel and Germany	1913+	China	aquaculture	yes	Unknown
Mosquitosfish	*Gambusia affinis*	Unknown	unknown	Central America	mosquito control	yes	Unknown
Silver carp	*Hypophthalmichthys molitrix*	China	1919	China	aquaculture	no	Unknown
Bighead carp	*Aristichthys nobilis*	China	1932	China	aquaculture	probably yes	Unknown
Channel catfish	*Ictalurus punctatus*	USA	1989	USA	aquaculture	no	Unknown
Sucker catfish	*Hypostomus spp.*	Unknown	Unknown	Amazonia	aquarium	yes	Invasive
Sucker catfish	*Pterygoplichthys sp.*	Unknown	Unknown	Amazonia	aquarium	yes	Invasive
Rohu	*Labeo rohita*	India	1968	India	aquaculture	possibly	Unknown
Rainbow trout	*Oncorhynchus mykiss*	Canada	1973	Canada	aquaculture trial	no	Unknown
Trout	*Oncorhynchus rhodurus*	Japan	1981	Japan	aquaculture trial	no	Unknown

Species		From	Year	Origin	Reason	Established	Impact
Tilapia	*Oreochromis aureus*	Israel	1970	Africa	aquaculture	yes	Unknown
Mossambique tilapia	*Oreochromis mossambicus*	Malaysia	1949	Africa	aquaculture	yes	Invasive
Nile tilapia	*Oreochromis niloticus*	Japan	1965	Africa	aquaculture	yes	Inobvious invasive
Grey mullet	*Mugil cephalus*	Taiwan	1998	Taiwan	aquaculture trial	no	No
Amazon apple snail	*Pomacea canaliculata*	Taiwan	1990	Amazonia	aquaculture	yes	Invasive
Giant apple snail	*Pomacea gigas*	Taiwan	Unknown	Amazonia	aquaculture	yes	Invasive
American crayfish	*Procambarus clarkii*	USA	ca 1987	USA	aquarium	no	Unknown
Yabby	*Cherax quadricarinatus*	Australia	1995	Australia	aquarium	no	Unknown
Bullfrog	*Rana catesbiena*	USA	1977	USA	aquaculture	possibly	Inobvious invasive
Redbrested tilapia	*Tilapia randalli*	Belgium	1955	Africa	aquaculture	yes	Unknown
Brineshrimps	*Artemia spp.*	USA, China	1978	USA, China	aquaculture	no	Beneficial
Whiteleg shrimp	*Penaeus vannamai*	Taiwan, Province of China	2000	USA	aquaculture	possibly	Unknown
Chinese abalone	*Haliotis diverticolor*	Taiwan, Province of China	1980	Taiwan	aquaculture trial	no	No
Sailfin	*Poecilia velifera*	Taiwan, Province of China	1960	Central America	algae contral	yes	Unknown
Chinese softshell	*Pelodiscus sinensis*	Taiwan, Province of China	1985	China	aquaculture	possibly	Inobvious invasive
Caiman	*Caiman crocodilus*	Australia	1990	Amazonia	pet, hide	no	Unknown
Red cheek terrapin	*Pseudemys scripta*	Japan	1972	USA	pet	possibly	Inobvious invasive

Country reports

Aquatic alien species in Thailand (Part 2): aquatic animal diseases

Somkiat Kanchanakhan

The awareness of aquatic animal diseases spread through international trade has been increasing since the first edition of the OIE Aquatic Animal Health Code in 1995

Trans-boundary issues concerning aquatic animal pathogens

The international trade in aquatic animals has resulted in the spread of aquatic animal diseases to many countries (Hastein, 2000). Thailand has experience with such problems, starting with introduction of Chinese carps (*Hypopthalmichys molitrix, Ctenopharyngodon idellus, Aristichthys nobilis*) for food fish culture that introduced Lerneae parasites to the aquatic ecosystem some years ago. Importation of ornamental fishes has also introduced many new pathogens such as Hexamita, Tetrahymena and iridoviruses. Epizootic ulcerative syndrome caused great losses during the 1980s and more recently, introduction of shrimp viruses has led to severe economic damage in coastal aquaculture.

Trans-boundary pathogens and management strategies

The movement of aquatic animals is generally recognized as a high risk activity for transferring diseases and pathogens from one area to another. The awareness of aquatic animal diseases spread through international trade has been increasing since the first edition of the OIE Aquatic Animal Health Code in 1995. Methods to control diseases through international trade and a development of national strategies for for addressing disease problems have been discussed in great detail among representative from 21 Asian governments during a three years (1998-2000) technical assistance program of FAO and NACA. Results of this program were a guideline called "Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals" and

Thailand has a law to control terrestrial animal diseases called the Animal Epidemic Act B.E. 2499 (1956), which is used by the Department of Livestock Development (DLD). However this Act originally did not cover aquatic animals and their diseases

a Manual of Procedures for the Implementation of the guidelines. All 21 Asian countries had accepted the guideline and agreed to implement the guidelines as part of a regional strategy to control spread of serious pathogens.

As part of this regional program, each country has prepared national aquatic animal health strategies. In Thailand, this plan has been discussed during a seminar and workshop among staff from the Department of Fisheries (DoF), Department of Livestock Development, University, Private Sectors and Farmers in Bangkok in May 2001. Nine strategic plans of the "National Strategy for Control of Aquatic Animal Diseases" have been developed from this seminar and were accepted by the DoF. The plan titles are listed as follows:

1. Law and legislation
2. Import/export regulation
3. Disease surveillance, monitoring and control systems
4. Aquatic Animal Diseases; research & development
5. Diagnosis units; capability building
6. Technology/knowledge transfer
7. Public awareness
8. Contingency plan to control disease outbreak
9. Funding support

In Thailand, aquaculture and fisheries are under the responsibility of the Department of Fisheries (DoF). The existing Fisheries Act B.E 2490 (1947) 3rd revision in B.E. 2528 (1985), Wildlife Conservation and Protection Act B.E. 2535 (1992) and Control of Importation and Exportation of Goods Act B.E. 2522 (1979) were not developed for control of aquatic animal diseases. These three Acts have small sections about movement regulations of the imported and exported aquatic animals. However Thailand has a law to control terrestrial animal diseases called the Animal Epidemic Act B.E. 2499 (1956), which is used by the Department of Livestock Development (DLD). However this Act originally did not cover aquatic animals and their diseases.

The strategic plan for law and legislation development for controlling aquatic animal diseases has been aiming to use the existing Animal Epidemic Act. There was an agreement at the Lawyer Consultation of the Parliament in September 2002 that the diseases of aquatic

animals will be controlled by using the Animal Epidemic Act. Aquatic animals are in control by this Act under Ministerial Regulation dated on June 2, 2003. A joint working group between DoF and DLD has been appointed and this group is working on the details of how to apply the law to control aquatic animals and their diseases.

A list of aquatic animal diseases proposed to be controlled under this Act should be processed in early 2004 before passed as a Ministerial Regulation are as follows:

1. Epizootic haematopoietic necrosis
2. Infectious haematopoietic necrosis
3. Oncorhynchus masou virus disease
4. Spring viraemia of carp
5. Viral haemorrhagic septicaemia
6. Epizootic ulcerative syndrome
7. Viral encephalopathy and retinopathy
8. Red sea bream iridoviral disease
9. Bacterial kidney disease
10. Bonamiosis
11. MSX disease
12. Marteiliosis
13. Mikrocytosis
14. Perkinsosis
15. Taura Syndrome
16. White spot disease
17. Yellowhead disease
18. Infectious hypodermal and haematopoietic necrosis virus
19. Tetrahedral baculovirosis
20. Crayfish plague
21. Monodon baculovirus
22. Hepatopancreatic parvovirus
23. Iridovirus disease
24. Koi herpesvirus
25. Poxvirus

NATIONAL BODIES RESPONSIBLE FOR MANAGING THE USE OF ALIEN SPECIES

Thailand has two National Bodies, the Minister of Agriculture and Cooperatives and Minister of National resources and Environment, which are responsible for managing the use of alien species. Two Acts have been drafted to protect diversity of indigenous animals, to protect against the establishment of alien species in the ecosystem and to protect the ownership of the animal type or strain. Summaries of the two drafted Acts are as follows:

Animal Diversity Protection Act

Board of Animal Diversity Protection

Chairperson: Permanent Secretariat of theMinistry of Agriculture and Cooperatives.

Committee: nine Director Generals of related Departments, 12 committees from the scientific, private sector, farming and NGO sector who are nominated by the Minister.

Responsibilities

1. Drafts Royal decrees and Ministerial Notices
2. Consideration and justification of all major conflicts between private sector and official authorization/competent authority
3. Gives suggestions to the Minister related to implementation issues
4. Gives rules for research on Animal Genetics
5. Gives rules for management of an Animal Diversity Protection Fund
6. Gives rules for promotion of Scientists who have developed new strains of cultured animals
7. Designates an Institution to inspect and evaluate any impacts on bio-security and environment
8. Board work will cover other assignments given by the Minister and Government

Animal Farming Extension and Conservation Act*

Board of Animal Farming Extension and Conservation

Chairperson: Permanent Secretariat of the Ministry of Agriculture and Cooperatives

Committee: three Director Generals; Department of Fisheries, Department of Royal Forestry and Department of Livestock Development
5-9 knowledgeable persons

Responsibilities

1. Drafts Royal Decrees and Ministerial Notices
2. Give suggestions to the Minister related to the implementation Issues
3. Give rules for researches on animal farming extension and animal conservation based on Code of Conduct and Animal Welfare
4. Give rules for management of Animal Farming Extension and Conservation Fund
5. Give a name list of the animals to be controlled under this Act
6. Designate an Institution to access any impacts on bio-security and environment
7. Board work will cover other assignments given by the Minister and Government

* There are no English names of theses two drafted Acts at time of writing. The English names of the drafted Acts appeared here are translated from the Thai by the author.

References

Håstein, T. 2000. Principals of prevention and control of aquatic animal diseases. 68th General Session of the International Committee May 22-26, 2000, Paris. Office International Des Epizooties, Paris. 31pp.

Country reports

Viet Nam national report on alien species

Le Thanh Luu
and Nguyen VanThanh

Presently, alien species are dominant in freshwater aquaculture contributing to more than 50% of the total freshwater aquaculture product in Viet Nam

A LIST OF ALIEN SPECIES AND GENOTYPES CURRENTLY IN USE IN THE COUNTRY. A REVIEW OF THE INFORMATION CURRENTLY AVAILABLE IN DIAS

Compared with the information available in the Database of Introduction of Alien Species (DIAS) of FAO, the number of alien aquatic species introduced to Viet Nam is increasing. According to our records, there are five species that are recent introductions to Viet Nam for research and aquaculture purposes (see table). They are: *Colossoma brachypomum*; tilapia *O. aureus*; red drum *Sciaenops ocellatus*; white shrimp *P. vannamei* and Pacific oyster *Crassostrea gigas*. Some species are imported by the private sector through commercial channels based on an official application (in the case of tilapia *O. aureus* and *P. vannamei*), but some are initially imported by the farmers living along the boarder with China (in case of *Colossoma brachypomum*), and latterly by research institutes for study.

KNOWN IMPACTS OF INTRODUCTIONS, MANAGEMENT STRATEGIES, CURRENT PLANS TO INTRODUCE NEW ALIEN SPECIES

Positive impacts

Aquaculture in Viet Nam is challenging with very limited numbers of domestic species being economically significant. To address this issue, for the last four decades, several alien species have been introduced in aquaculture practice. The introduced species have usually obtained good growth and high productivity. Presently, alien species are dominant in freshwater aquaculture contributing to more than 50% of the total freshwater aquaculture product in Viet Nam. For example, it is estimated that the volume of Chinese (three species) and Indian (two species) carps is sharing about 40-45% of freshwater production which is accounted approximately 600 000 MT last year. Alien species are stocked in all water bodies/ponds such as paddy fields, reservoirs, ponds and cages. In brackishwater and

marine aquaculture alien species have not had a significant role. To date, very few species have been introduced, mainly trials and experiments such as red drum, Pacific oyster through the private sector or government arrangements. *Penaeus vannamei* has also been imported.

Cases of large scale reproduction of alien species in the wild, and competition for food with local species have not been recorded so far. On the other hand, most of alien species are unable to reproduce in nature. The seed mainly is produced artificially in fish hatcheries for aquaculture purposes, or for restocking to improve the productivity of natural water bodies.

Negative impacts

To date, the research and assessment on negative impacts of introduced species have not been carried out. On the other hand, there was not any complaint from farmers about harmful or negative impacts from the introduced fish.

Transboundary issues concerning aquatic animal pathogens, impacts of transboundary pathogen issues and management strategies

Up to date, there has not been records of any serious disease among alien species or transmitted from alien species to other native species. Information on aquatic animal pathogens introduced through transboundary movement is limited, although the country has faced some serious aquatic animal disease outbreaks that may be due to introduced disease causing organisms (eg white spot syndrome virus of shrimp). There is a lack of systematic survey, however, an inadequate evidence to identify any issue concerning the aquatic animal pathogens and their affect on indigenous species.

Brief review of national legislation governing the use of alien species including health

The government of Viet Nam is not specifically strict on using alien species for culture purposes. Since 1989, the government has issued regulations on protection of aquatic resources in which it has permitted the Ministry of Fisheries to develop guidelines for use of alien species (for example, aquaculture, ornamental, gene pool exchange...). In 1990, the Ministry of Fisheries published guidelines that provide instructions on procedures for import of alien species for aquaculture or ornamental purposes. The guidelines strictly ban import of exotic species without quarantine and do not permit introduction of imported species to aquaculture practices without proper trial and risk analysis.

The initial step in this procedure is submission of an application to the Department of Aquatic Resource Protection, with a brief description about the biology of the species, distribution, aquaculture characteristics, possible risks including feed competition, diseases and pathogens. Any private sector or organization can submit an application for import of aquatic exotic species. The application is considered with advice of the concerned agencies such as the Department of Science and Technology and research institutions. Permission is given in the case when conditions are satisfied. Besides, the Ministry of Fisheries also requests research institutions to take responsibility on research and risk analysis of imported species before introduction to aquaculture practice. The testing period at least will take two-three years with all necessary research on feed, growth, diseases, aquaculture characteristics such as stocking density in different systems, survival rate in hatchery, incubation, rearing stage, and others. An annual scientific report should be prepared and presented to the committee for assessment. The committee will then make a decision to permit use of the species for aquaculture when the scientific assessment is positive.

Identification of the national agency responsible for managing the use of alien species and the name of the contact person in this agency

At this stage, the Department of Aquatic Resource Protection under the Ministry of Fisheries is responsible for managing the use of alien aquatic species. The department is responsible for looking at the justification for the application, identification and verification of biological characteristics and capacity of the applicant to testify the new species and evaluation of the potential use of introduced species to aquaculture practice. The department is responsible for issuing a permission to allow import of the alien species and verifying the quarantine process of the applicant.

Future plans and recommendations at the national level and also for regional cooperation

The Government of Viet Nam has not developed any specific plan on introduction of exotic species, however the movement and use of alien species is obvious and unavoidable as people living along the border informally exchange seed of new species with neighboring countries. As well as private sector farmers, companies are always interested in this matter. The government has collaborated with FAO to develop a "Health management strategy" for Viet Nam concerning transboundary movement of aquatic animals. The draft has been circulated for comments. Further, the government plans to give more focus on control mechanism to introduction of exotic species as well as create awareness on the possible impacts and pathogen risks from use of alien species.

The recommendations

- It is recommended that the Vietnamese government should develop a strategic plan for use of alien species. The existing technical guidelines should be further improved with a focus on control mechanism and responsible use of alien species.
- It is recommended that the exchange of information between countries should be strengthened. Technical guidelines on the control and responsible use of alien species at regional level should be developed in consultation with the participating countries.

Table 1. Information on Viet Nam from the FAO Database of Introductions of aquatic species

Genus	Species	Origin	Year of first introduction	Reason for introduction	Who was responsible	Ecological effect	Socio-economic effect
Ameiurus	*nebulosus*	USA probably	unknown	unknown	unknown	unknown	unknown
Carassius	*auratus*	China	unknown	aquaculture	unknown	unknown	unknown
Catla	*catla*	Lao PDR	1984	aquaculture	inter.	undecided	undecided
Cirrhinus	*mrigala*	Lao PDR	1984	aquaculture	inter. organization		
beneficial	*beneficial*						
Clarias	*gariepinus*	Central Africa	1974	aquaculture	private sector	beneficial	beneficial
Ctenopharyngodon	*idella*	China	1958	aquaculture	government	beneficial	beneficial
Cyprinus	*carpio*	Hungary	1969, 1975	aquaculture	government	beneficial	beneficial
Hypophthalmichthys	*molitrix*	China	1958	aquaculture	government	beneficial	beneficial
Hypophthalmichthys	*nobilis*	China	1958	aquaculture	government	beneficial	beneficial
Labeo	*rohita*	Lao PDR	1982, 1984	aquaculture	inter. organization	beneficial	beneficial
Mylopharyngodon	*piceus*	China	unknown	aquaculture	unknown	unknown	unknown
Oreochromis	*niloticus*	Taiwan islands province of China, Philippines, Thailand	1973, 1989, 1994	aquaculture	inter. organization	beneficial	beneficial
Oreochromis	*mossambicus*	Africa, Philippines	1951, 1955	aquaculture	private		
Pomacea	*canaliculata*	Asia	1988	ornamental	unknown		
Colossoma	*brachypomum*	China	1999	aquaculture	farmers/ private	unknown	unknown
Sciaenops	*ocellatus*	China	1999	research/ aquaculture	government	unknown	unknown
Crassostrea	*gigas*	China, Australia	2002	research/ aquaculture	government	unknown	unknown
Penaeus	*vannamei*	America, China	2001	aquaculture	private	unknown	unknown
Oreochromis	*aureus*	China	2002	research	government	unknown	unknown

Case studies

Aquaculture in the Mekong basin: alien or indigenous species?

Niklas S. Mattson
Naruepon Sukumasavin
Somboon
Nguyen Minh Thanh
and Ouk Vibol

Preliminary estimates of the relative profitability of alien vs. indigenous species in small-scale aquaculture indicate that some indigenous species are already economically viable despite the lack of progress in domestication

Extension of aquaculture techniques in the lower Mekong basin has in the past promoted alien species, which has led to alien species currently dominating small-scale aquaculture. The reasons for this included a general lack of knowledge on the biology of indigenous species and the associated absence of domesticated aquaculture strains. Therefore, using established alien aquaculture species was expedient since seed production and culture systems could easily be extended without the need for much additional research. By importing suitable strains the domestication process could be bypassed. Further, alien species were often perceived as more profitable for small-scale farmers.

The Mekong Basin is endowed with a rich fish fauna, estimated to consist of at least 1 200 species, and possibly as many as 1 700 (Coates, Ouch, Suntornratana, Tung, & Viravong, 2003). It is reasonable to assume that such a diverse fish fauna should include many species suitable for aquaculture. In fact, several indigenous species are already used for aquaculture, although generally at a basic level of domestication. Seed for some species groups, e.g. Pangasidae and Channa spp., are often collected from the wild (Van Zaalinge, Lieng, Bun, Kong, & Valbo-Jørgensen, 2002).

Aquaculture is one of the main reasons for introduction of alien species to aquatic ecosystems. As much as 17% of the global aquaculture production is contributed by introduced species (Bartley & Casal, 1998). Information on environmental impacts of alien aquatic species is scattered and difficult to find, but efforts are underway to improve the availability of such information, including the DIAS database maintained by FAO (http://www.fao.org/fi/statist/fisoft/dias/index.htm and http://www.fao.org/fi/figis/Introsp/index.jsp). FishBase (http://www.fishbase.org) also includes information on introductions.

Aquaculture of Indigenous Mekong Fish Species

Developing domesticated strains from wild fish for aquaculture purposes is time consuming. Current efforts to amend the situation include the MRC Fisheries Programme Component AIMS (Aquaculture of Indigenous Mekong fish

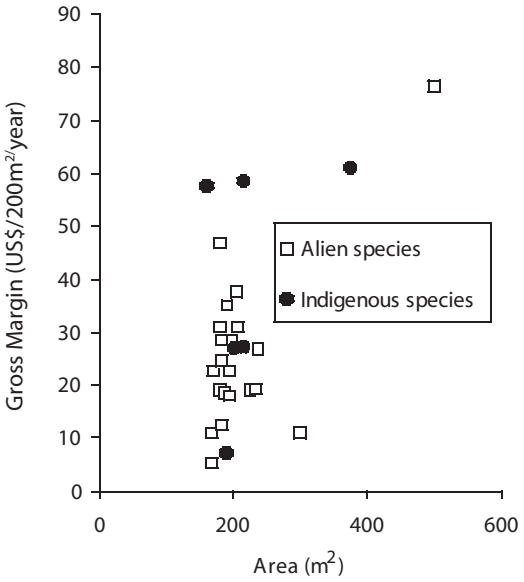
Species). The rationale for the Component is that the use of alien species will only decrease when suitable, economically viable indigenous alternatives are available. Preliminary estimates of the relative profitability of alien vs. indigenous species in small-scale aquaculture indicate that some indigenous species are already economically viable despite the lack of progress in domestication (Figure 1).

The Component supports the Fisheries Departments of Cambodia, Lao People's Democratic Republic, Thailand and Viet Nam to carry out research and development toward improved culture systems for indigenous species. AIMS cooperates with 11 aquaculture stations in the region. The current priority species are *Anabas testudineus, Barbonymus gonionotus, Cirrhinus microlepis, Cirrhinus molitorella, Leptobarbus hoevenii, Hemibagrus wyckioides, Osphronemus exodon, Pangasius bocourti* and *Pangasianodon hypophthalmus*.

Benefits from alien species

The introduction of alien fish species has brought considerable benefits to small-scale farmers. For example, tilapia culture has been successfully developed in the region, largely because it can be easily bred. This has made seed widely available, even in remote areas. Tilapia is also used in commercial aquaculture, but these operations depend on more domesticated strains with higher growth rates, which require more sophisticated propagation methods and rely on high grade, expensive feed.

Figure 1. Estimates of relative profitability of small-scale pond culture in Cambodia. Gross Margin = Revenue – Variable Costs (labour included), i.e. excluding Fixed Costs. Culture ponds were generally stocked with several species (poly-culture). Part of the data kindly provided by AIT (Cambodia) and READ (Cambodia).



Risks with alien species

One important risk with introductions of alien species is that they may be 'invasive', thus tending to spread prolifically and harmfully in the environment. Once an aquatic organism is established in a system like the Mekong, the introduction is essentially irreversible. In Cambodia, at least, there are a couple of examples where tilapia populations have almost entirely replaced the indigenous fish species (Nouv, Viseth, & Ouk, 2003). However, in recognising the obvious risks with alien species, it is equally important to consider that almost all domesticated plants and animals that humans use are actually alien to most areas, but even so they are generally not considered invasive. Import of new diseases is another major risk associated with introductions. Information on impacts of introductions of aquatic organisms in the Mekong basin is reviewed by (Welcomme & Vidthayanon in press).

NEED FOR A BALANCED APPROACH

The properties of an organism that determine whether it becomes invasive or not in a particular environment and/or at a particular time are highly complex. Adverse effects may not be immediately apparent, but may surface years or decades following the initial introduction. Further, the taxonomy and distribution of many aquatic species in the tropics are not well known, so the ability to even assess pre-introduction biodiversity is very limited. Therefore, accurate prediction of potential environmental effects from an introduction is extremely difficult. Decisions whether to introduce an organism or not are often based mainly on empirical evidence from other areas where the same or similar organisms have been introduced. Further complicating the issue is that if the environment itself comes under sufficient stress, even some indigenous species may behave as invasive nuisance organisms. Thus, there is a need for a holistic, balanced approach, which considers not only the organisms to be introduced, but also the general environmental configuration as well as temporal effects.

Risks with indigenous species

Although there is general consensus that aquaculture using indigenous species poses less risks than using aliens, release or escape of domesticated strains of indigenous species into the wild poses a threat to biodiversity. Aquaculture organisms, except perhaps in highly controlled recirculating systems, sooner or later escape to the wild. This may be due to e.g. flooding of ponds or breaking of cages. If the local wild population of the indigenous species is large and the environment is intact, limited escapes may have negligible impact. However, if the local population is small and/or the local environment is under stress, there may be considerable effects, including modification of the genetic composition of the wild population.

In his Ph.D. dissertation, Wongpathom Kamonrat showed that 75-96% of *Barbonymus gonionotus* samples from the Chao Phraya River, Thailand, were from hatchery populations (Pongthana, 2001). The main reason for this genetic contamination is an extensive fisheries enhancement programme, that every year releases large numbers of fingerlings of this species. In addition, the Chao Phraya river ecosystem is degraded due to a multitude of dams and other sources of environmental stress. Thus, it is likely that the natural recruitment is much reduced (hence the need to stock the river in the first place).

To reduce risks, there is a need to clearly distinguish between seed production for aquaculture and for fisheries enhancement. The characteristics and genetic composition of fish seed desired by aquaculture is quite different from what is required for release into the wild. The former calls for highly domesticated strains selected for e.g. growth and disease resistance, whereas the latter must be genetically as close to the local wild population as possible. For enhancement purposes, breeding should, wherever possible, be based on locally caught, wild brooders.

Management units

Many fish species in the Mekong form sub-populations, which may be separated by e.g. geographic distances or using different spawning grounds etc (Poulsen, Poeu, Viravong, Suntornratana & Tung, 2002). To enable rational management of aquaculture of indigenous species, it is recommended to establish species specific management units, which define the genetically distinct wild sub-populations of the cultured species, and thus provide a framework for determining how fish may be moved within the basin without causing undue risks to local populations.

Conclusions

Indigenous fish currently used in, or being developed for aquaculture in the Lower Mekong Basin:

- have a high market demand and value
- are usually preferred by farmers
- show variable but generally comparable growth to aliens
- are likely to have a high potential for improved strains through selection

The development of aquaculture based on indigenous species will cause fewer environmental concerns.

Good broodstock management is key to progress and to avoid potential pitfalls.

Some indigenous fish species will most likely provide viable (economically and otherwise) alternatives to alien species.

Any movement of indigenous (as well as alien) fish species must be controlled and properly considered before being carried out; such control may be facilitated by establishing management units.

Acknowledgements

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References

Bartley, D. M. & Casal, C. V. 1998. Impacts of introductions on the conservation and sustainable use of aquatic biodiversity, *FAO Aquaculture Newsletter* no. 20 (December), 15-19 pp. (also available at http://www.fao.org).

Coates, D., Ouch, P., Suntornratana, U., Tung, N. T., & Viravong, S. 2003. Biodiversity and Fisheries in the Mekong River Basin. *Mekong Development Series* no. 2, 30 pp. Phnom Penh, Mekong River Commission. (also available at http://www.mrcmekong.org)

Nouv, S., Viseth, H., & Ouk, V. [this volume]. *Country report on present status of alien species in aquaculture and aquatic ecosystem in Cambodia.*

Pongthana, N. 2001. Aquaculture genetics research in Thailand, p. 77-89. In M.V. Gupta and B.O. Acosta (eds.). Fish genetics research in member countries and institutions of the International Network on Genetics in Aquaculture. *ICLARM Conf. Proc.* 64, 179 pp. (also available at http://www.worldfishcenter.org/Pubs/Fish_Genetics/chapter%2012.PDF)

Poulsen, A., Poeu, O., Viravong, S., Suntornratana, U., & Tung, N. T. 2002. Fish migrations of the lower Mekong River basin: Implications for development, planning and environmental management. MRC Technical Paper no. 8, 63 pp. Phnom Penh, Mekong River Commission (also available at http://www.mrcmekong.org).

Van Zaalinge, N., Lieng, S., Bun, N. P., Kong, H., & Valbo-Jørgensen, J. 2002. Status of the Mekong Pangasianodon hypophthalmus resources, with special reference to the stock shared between Cambodia and Viet Nam. *MRC Technical Paper* no. 1, 29 pp. Phnom Penh, Mekong River Commission (also available at http://www.mrcmekong.org).

Welcomme, R. L. & Vidthayanon, C. in press. The impacts of introductions and stocking of exotic species in the Mekong basin and policies for their control. *MRC Technical Paper.* Phnom Penh, Mekong River Commission.

Case studies

Codes of practice for the introduction and transfer of marine and freshwater organisms

Ursula M. Kolkolo

Since the introductions nearly ten years ago, a number of species have established viable populations

Abstract

Papua New Guinea through its former organization, the Department of Fisheries and Marine Resources, and the Food and Agriculture Organization of the United Nations used the ICES/EIFAC Code of Practice to successfully introduce and transfer six exotic fish species into the Sepik River through the Stock Enhancement Program and the FISHAID Project. These fish were introduced into the Sepik-Ramu Basin, Papua New Guinea, from India, Nepal, Malaysia and Brazil. The introduced fish species have now established breeding populations and are contributing to improved fisheries. In the lowland floodplains of the Ramu and the Sepik Rivers the Java carp (*Puntius gonionotus*), Pacu (*Piaractus brachypomum* or *Colossoma bidens*), red makau (*Tilapia rendalli*) and Emily's fish (*Prochilodus margravii*) are now established. In the higher altitude streams; the snow trout (*Schizothorax richardsonii*), the golden mahseer (*Tor putitora*), now locally known as Tor and red makau (*Tilapia rendalli*) have established breeding populations and are contributing to fish production. The status of two fish species remain unknown: the chocolate mahseer (*Accrossocheilus hexagonolepis*) and the giant gouramy (*Osphronemus gouramy*). The successful use of the ICES/EIFAC Code of Practice in a developing country environment such as Papua New Guinea was because the protocols of the Code of Practice had scientific rigour and because the Government is party to a number of international conventions on biodiversity and accepts responsible management of natural resources as an operating principle. The limitations to applying the Code of Practice are the lack of technical and infrastructure facilities in countries that implement the protocols and the lack of substantial funding. Following the successful introductions, the follow-up impact assessments and fisheries survey to quantify the breeding fish populations is now necessary. The results of the follow-on assessments may be a further learning

process for the ICES/EIFAC Code of Practice in developing country situations and for Papua New Guinea policy-making for inland fisheries development.

Introduction

Fish introductions and transfers can be intentional, accidental and or through natural movements across transboundary catchments after introductions or transfers have taken place. In the Papua New Guinea (PNG) experience, the 1984-1997 fish introductions were planned as part of a government intervention to improve freshwater fish production for rural communities in the Sepik-Ramu River catchments. Previous fisheries research work done by the PNG Department of Primary Industry (DPI) in the 1970s and the early 1980s showed that the Sepik River system had low fish yields. Fisheries yield from the Sepik is less than ten percent of that achieved from similar sized tropical rivers, such as those in Asia (FAO 1997). Further to this, the most productive fish in the system was tilapia (*Oreochromis mossambicus*). The Department of Agriculture, Stock and Fisheries brought tilapia into PNG in the 1960s for aquaculture purposes in the Sepik. The tilapia got into the Sepik River when the holding facility flooded. The common carp (*Cyprinus carpio*), brought in for aquaculture purposes was also accidentally introduced into the Sepik in the 1980s. Both fish species contribute to the Sepik River subsistence fish production for food and income generation.

To place government mediated fish introductions and transfers into perspective, the PNG Government had specific policies for the fisheries sector. The developmental goals for the fisheries sector were: (i) to develop renewable fisheries resources, within the limits of long term sustainable yields; (ii) to invest public sector resources in economically viable small holder fisheries activities which are supposed to lead to expansion of exports and decrease in imports and are planned to maintain local food supplies and provide cash earning opportunities to small holders; (iii) to invest in improvements to national extension, planning, training, research and monitoring in order to improve the technical support offered to provincial departments in the implementation of fisheries projects; and (iv) to give priority to improve subsistence food production and nutrition programs as part of its strategy in improving rural welfare and self-reliance. The Australian colonial government Department of Agriculture, Stock and Fisheries (DASF) implemented these policies prior to the 1960s, then in 1975 onwards by the PNG Government Department of Primary Industry till 1983. In 1984, the newly established Ministry of Fisheries with its implementing agency, the Department of Fisheries and Marine Resources (DFMR) implemented these policies as the first step in recognizing fisheries as an economic sector. In 1994, another legislative change produced the National Fisheries Authority (NFA) as the statutory body implementing the inland fisheries policies and in 1998, the Fisheries Management Act, 1998 modified the NFA into a commercial authority for the Government of PNG, also known as NFA to focus on commercial fisheries and aquaculture.

In inland rural areas, these goals were pursued through the initiation of aquaculture as part of agriculture development and fish stock enhancement of water bodies using introduced fish. The common carp (*Cyrpinus carpio*) was brought into the country for aquaculture purposes in the 1960s. Fish ponds were constructed in Aiyura, Eastern Highlands Province where the agricultural research into coffee was being conducted by the DASF and fish farming was demonstrated for village farmers. Stocking was done with the introduction of rainbow trout (*Oncorhyncus mykiss*) also in the 1960s in the PNG highland rivers and the introduction

of the Snakeskin Gouramy (*Trichogaster pectoralis*) and the Giant Gouramy (*Osphronemus gouramy*) in the 1980s in the Central Province, a southern regional province in PNG. Aquaculture development was limited to the Highland Provinces at the time (1960s), and even then, progress was slow because fish farming was a new agricultural practice to traditional subsistence farming. The inland areas were rugged with little or no road infrastructures to allow a rural population to engage in costly aquaculture development by the government to provide fish. By the mid 1970s the aquaculture facility established by DASF still consisted of four ponds and a single scientific officer producing a small number of carp fingerlings to continue to facilitate village based fish farming. The distribution of fish to rural people through aquaculture was slow.

In the coastal areas, the development of commercial marine fish stocks for exports and government subsidized artisanal fisheries were the developmental strategies. Access to extensive marine fish resources by inland communities was limited. Poor road infrastructures and high costs of transportation and cold storage of fish made coastal fish very expensive for inland people. It was of course widely known in PNG that the distribution of the population of three and a half million people at the time (1980s) was that 84 percent of people live in inland areas and 24 percent live in coastal areas. The distribution of fish was the reverse; coastal fish stocks were abundant with a number of export based on commercial fisheries and thriving artisanal fisheries whilst freshwater fisheries was low, and limited to a few species.

From 1984 to 1997 fish were introduced and stocked in the Sepik River system since fish surveys had been previously carried out by DPI. Adjacent to the Sepik River is the Ramu River system similar in its habitat and fish species composition. These two rivers become a single system in the lower reaches during flooding seasons. Together, the Sepik-Ramu has the largest catchment in PNG of approximately 96 000 km^2. The catchment supports a substantial inland population of at least one and a half million people. Following the fish surveys of the early 1980s, and with increasing awareness of the Sepik River system's potential to be improved to promote rural fish supplies through stocking, a decision was made by DFMR in 1984 to consider introductions.

Stocking fish into rivers and lakes to initiate self-perpetuating fish stocks that are sustained by nature was attractive. Once fish populations establish after initial investment of finance, manpower and time, these fish can be managed sustainably with appropriate management strategies to sustain rural livelihoods. It was at the time, far easier technically, culturally, and financially to stock fish to meet the needs of a highly scattered rural population within the Sepik-Ramu River system.

Fish Introductions

Having made the decision to introduce fish, the next issue was to decide on the kind of species to introduce, and how to introduce them properly. There was the need to consider what species were to be introduced in order to maximise benefits for the local people but minimise any interaction with the already existing fish in the Sepik River system. It was therefore decided that the Sepik fishery would be developed through fish introductions in an environmentally responsible manner. This was so that substantial increases in fish production can be achieved within the ecological framework of the river system to sustain and maintain the new introductions. At the technical capacity level, DFMR lacked both manpower and fish rearing facilities to carry through this decision. It was decided to get help from the Food and Agriculture Organization (FAO) and the United Nations Development Program (UNDP) in 1983.

Operational strategies in the application of the Code of Practice

Through the assistance of FAO, the operational strategy on improving fish production in the Sepik basin was to apply internationally accepted precautionary approaches to fisheries development and the ICES/EIFAC Codes of Practice for the Introduction and Transfers of Aquatic Organisms. The ICES/EIFAC Codes of Practice, hereafter referred to as the Code of Practice provided the framework from which the project ideas were formulated to stock the Sepik-Ramu basin.

In short, the Code of Practice describes the activities that should be done in advance of an introduction. This involves (1) desk research of the biology and ecology of the intended introduction; (2) preparation of detailed analysis of potential environmental impacts that includes socio-economic studies; (3) examination of the biology, ecology, and disease problems in its home range; (4) the submission of the results of such an evaluation to a competent authority for evaluation and decision. PNG used these steps to recommend fish species for introduction and transfer.

Official Arrangements

In 1984, after DFMR requested assistance from FAO, an FAO mission prepared a project idea known as the Sepik River Fish Stock Enhancement Program (FI: FIRI/TRAM/2505). The project outlined the main problems and solutions to the low fish yield, high population density of the catchment, and proposed solutions. The Sepik River Fish Stock Enhancement Program (SRSEP) project was formulated to carry out the four steps of research in advance of an introduction that are described above.

The long- term objective of SRSEP was to improve inland fishery production initially in the Sepik River basin Immediately the SRSEP needed to (i) determine existing fish stocks in the catchment area, both native and already existing introduced species, and determine basic fish species inter-relationships and potential vulnerability of native species to introductions; (ii) identify fish species for introduction into the Sepik River; and (iii) establish selected fish species to be introduced through stocking into the Sepik River.

Following the need to apply a precautionary approach and establish appropriate decision making processes to the planned introductions, the work within the project was divided into two phases; (i) Phase 1: Evaluation of the potential benefits and risks of further fish species introductions and identify species suitable for introductions (years 1-3); and (ii) Phase II: Application of quarantine and stocking of suitable fish species as approved by appropriate authorities (years 4 and 5, plus an year 6 extension).

Conclusions of Phase 1

A considerable technical evaluation was completed and presented to FAO (FAO 1993). The project concluded at the end of Phase 1 that stocking the Sepik River Basin was justifiable. The research provided a basis to include the Ramu River Basin for fish stocking. Finally, the benefits of stocking in relation to government policy were becoming more apparent.

Under Phase 1, a number of key issues were resolved to allow the project to progress to Phase 2 with the guidance of the Code of Practice. The decision to stock both the Sepik and

...the introductions have allowed a large number of rural people to have more and reliable access to fish

Ramu systems was made. Secondly, it was found that existing fish stocks were negligible at altitudes higher than 800 meters whilst population density increased with altitude. This meant that the PNG Highlands where the population is highest have very little fish in their cold-water streams. This led to the decision to stock cold-water fish in higher altitude streams of the Sepik-Ramu, the northern flowing rivers of the PNG Highlands. The target area and population under Phase 2 were to include higher altitude streams of the Sepik-Ramu basin that encompasses the following PNG Provinces; West Sepik, East Sepik, Madang, Eastern Highlands, Western Highlands and Morobe. The socio-economic situations in the communities vary but all were considerably poor. However, most communities live near and or around rivers or lakes and know how to fish. Their main activities are gardening, hunting, fishing and gathering.

The target areas for stocking were identified to consist of (i) lowlands of the Sepik Ramu Basin below 100m (ii) mid-altitude rivers from lowlands to 800m (iii) and highlands, above 800m. The fish species to be introduced were proposed and in accordance to the Code of Practice assessed. An international panel of nine scientists from six different countries recommended the following fish species for introduction: 1) *Tilapia rendalli*, (2) *Puntius gonionotus* (java carp), (3) *Osphronemus gouramy* (giant gouramy), (4) *Trichogaster pectoralis* (snakeskin gouramy), (5) *Prochilodus platensis*, (6) *Colossoma bidens* (Pacu), (7) *Schizothorax richardsonii* (snow trout), (8) *Acrossocheilus hexagonolepis* (Chocolate mahseer), (9) *Labeo dero* and (10) *Tor putitora* (Tor). These fish were also scrutinised by the PNG Department of Environment and Conservation (DEC) and the Department of Agriculture and Livestock (DAL). All these fish have different habits to existing fish and previously introduced fish in the area. To cater for unseen problems with acquiring the above species, additional lists of alternate species were pre-evaluated for such a situation.

The quarantine and environmental stocking strategies were also worked out. In order to protect PNG's native fish from potential diseases, the required quarantine of the fish was to be done overseas where feasible, as PNG's facilities and expertise in quarantining fish was limited. It was also concluded that after initial tests overseas, either eggs or small fry should be transported by air to PNG. These were raised to a small size and released as the Sepik-Ramu Rivers lack any large predator fish. Further, the facility overseas could maintain breeding stocks whereas PNG at the time lacked technical expertise in this area and the project staff had very specific work with a time frame to accomplish.

Following these technical assessments, the government meetings took place to assess the reports and consider the recommendation to stock rivers in the Sepik-Ramu Basin. These were approved and in mid 1990, Phase 2 of the SRSEP went ahead.

IMPLEMENTATION OF PHASE 2 OF SRSEP, 1990

The project shifted focus from research evaluation as a primary focus to the stocking phase. The project imported, nine hundred *Tilapia rendalli* from the University of Stirling, Scotland, bred and continuously stocked this fish from November 1990 to November 1992. The tilapia were certified disease-free by the Institute of Aquaculture, at Stirling University and reared to

breeding size in Madang. *Puntius gonionotus* was imported as eggs from Malaysia in January 1993 to be placed in quarantine in the Madang hatchery. However, DAL Quarantine refused the first trial shipment in 1991 from a stock in Irian Jaya because these were not pre-certified disease free. This was good in that it led to more dialogue and process to be worked out between DFMR, DEC, DAL and the Project. It also led to the understanding that live eggs could be imported and placed in quarantine, while overseas disease testing could be done on hatchlings for a period of time, at least for three months, before the fish were stocked.

Forty feral adults of the giant gouramy were collected in Port Moresby by project staff and flown to the Madang hatchery. These were kept in the hatchery to grow to a breeding size. At the end of the project, these fish did not breed, and were later stocked in a remote lake in Middle Ramu.

These introductions and stocking brought the Sepik River Stock Enhancement Program to a close in 1990. However, at the finalisation of Phase 2 of the Sepik River Stock Enhancement Program, the next project started to complete stocking of the ten approved fish species for introduction and transfer (two of those, *Tilapia rendalli* and *Puntius gonionotus* were already in the country).

Implementation of the FISHAID Project

In 1990 and 1991 the PNG Government signed a follow-on agreement with UNDP in Port Moresby, to continue to stock fish species recommended in the Sepik River Stock Enhancement Program. This stocking was to be done in the floodplains, the mid-altitudes and higher altitude streams of the Sepik and Ramu River catchments. This was to affect a population of at least one and a half million people. The agreement was executed by UNDP and FAO through the Fisheries Improvement by Stocking at High Altitudes for Inland Development (FISHAID) project.

The PNG Government funded the field operation of the FISHAID project at a cost of approximately USD 1 million over the project period, 1993-1997 through DFMR with counter-funding from UNDP. The European Union (EU) countries also supported the project providing scientific and aquaculture technicians.

Under the FISHAID project, the source countries for the fish species to be introduced were Brazil, India, Malaysia and Nepal. For cold water species a hatchery was built in Yonki in the Eastern Highlands Province. This hatchery was at an altitude of 1 000 meters and was located away from any water body. A recirculating system using rainwater was collected and stored in aluminium tanks at the hatchery. A warm water hatchery in Madang had been built under the SRSEP project. This hatchery was at sea-level and was a re-circulating system using town water supply. The facility was in a bay on the beachfront and was near Madang airport.

The fish that were imported under Phase 2 were snow trout, Tor and chocolate mahseer for cold-water environments, and Pacu and *Prochilodus margravii* (an alternate species) for the floodplains. All the fish were imported as eyed eggs and reared either at the cold-water hatchery in Yonki or in Madang. After hatching, and over a period of three months, samples of fish were sent to overseas laboratory in Malaysia and the United States for disease testing. When the results showed that no disease problems were present, fish of about 10g were packed in plastic bags filled with water and air and were transported to the site and released directly into the river or lake.

Prior to placing an order for eyed eggs, the FISHAID Project had to request an import permit from the PNG Department of Environment and Conservation and the National Agriculture and Quarantine Inspection Service (NAQIA, formerly DAL Quarantine). The

request stated the purpose of the import, the fish species for import, the live stage of import, the potential impact to native freshwater fauna and the quarantine facilities for the import, the source country of the fish and the PNG agency doing the import. On the form, it also stated that the responsibility for future impacts was on the importer, in this case, DFMR and later, NFA.

Once an import permit was given, the EU project scientist travelled to the source country of the exotic fish species. In addition to logistical arrangements, the EU scientist had to travel to some source countries and facilities to make sure quarantine procedures were taught to source country facility staff. This was true of some countries where quarantine laws were not followed strictly. In other source countries, suppliers might lack the right types of transport equipment for live fish, or chemicals needed to apply basic quarantine procedures for eyed eggs. The project scientist supplied those facilities with what was needed to make imports easier.

RELEASE OF ALIEN FISH SPECIES

The main fish stocking phase - FISHAID project

A lack of infrastructure support in raising broodstock in PNG implicated the use of overseas facilities to maintain the broodstock for the species snow trout, pacu, chocolate mahseer, Tor and *Prochilodus*. Except for *Tilapia rendalli* the project imported eyed-eggs from source facilities overseas. At the hatchery in Madang and Yonki, eyed eggs were incubated and raised to 10g of weight before being released into selected sites. During release, fingerlings were packed in plastic bags filled with oxygenated water. These were then either driven by road or flown by helicopter to remote high altitude streams or lowland lakes and streams, and released. Hatchery water was re-circulated and escape by fish into the environment was not an issue. The Madang hatchery was at sea level and next to the beach. All and any escapees would not have survived in the salt waters of the Bismarck Sea. The Yonki hatchery was built on a hill away from the Yonki Dam. Rainwater was used for the recirculating system. Escapees from the hatchery would have died immediately as there was no river or water body nearby. At the end of the project, the recirculating water systems were treated before release into the soil at Yonki and onto the beach at Madang.

After stocking, 1997 onwards

In the Sepik River Stock Enhancement Program, monitoring and management plans for the introduced species were included. The introduction was to be monitored by the NFA, as they were the importers of the exotic species. At the time, in 1997, the NFA was undergoing another legislative change to re-create a commercial institution out of NFA for the Government of PNG. Under this change, the NFA as a commercial authority was responsible of commercial fisheries and aquaculture. The way the 1998 Fisheries Management Act was written still made the NFA the sole management body for PNG's fisheries resources. This means in effect that fisheries development includes inland fisheries matters and inland fisheries development management is still under the responsibility of the NFA. Inland fisheries by this time was the sum of all the rural fisher folks collectively fishing many of the fish species introduced in earlier years by DASF, then DPI, then DFMR then NFA.

Prior to the 1997 legislative changes, a law was ratified in 1996, giving power to the provincial governments to develop natural resources. Harmonization between the NFA legislation and the provinces are needed and can be worked out so that inland fisheries development has

clear management directions from both the NFA and the provincial governments. Until such mechanisms are organized, the mandated authority in PNG for fisheries and aquaculture management remains the NFA.

Therefore the NFA has to fulfil its legal obligations to re-assess the impacts of the FISHAID project. Its current operations make it even more possible to undertake such a basic government task. This means that NFA is still responsible for possible impacts of the fish introductions it approved from 1984 to 1997, although the resources are now growing and being fished under the legal authority of the provinces.

Results of the Fish Introductions of 1990-1997

The fish species introduced or transferred into the Sepik-Ramu are presented in Table 1. The table also shows the source countries and numbers of fish released during the FISHAID project. The introduced cold-water species were the Snow trout (*Schizothorax richardsonii*), Golden mahseer (Tor putitora) and the Chocolate mahseer (*Accrossocheilus hexagonolepis*). The cold- water species were introduced into high altitude streams of the Sepik and Ramu River sources covering the provinces Enga, Western Highlands, Simbu, Madang and Eastern Highlands. Warm-water fish species were introduced into Madang, and East Sepik Provinces. These were the Java carp (*Puntius gonionotus*), Emily's fish or Sabolo (*Prochilodus* margravii), Pacu (*Piaractus brachypomum* or *Colossoma bidens*), red Makau (*Tilapia rendalli*) and the giant gouramy (*Osphronemus gouramy*). The giant gouramy though was already introduced from Asia to PNG in previous years. From the original list of ten species, only eight were introduced or transferred. Labeo dero was not introduced and Trichogaster pectoralis was not transferred from Port Moresby to the Sepik-Ramu floodplains.

Events following the exotic fish introductions

Since the introductions nearly ten years ago, a number of species have established viable populations (Kolkolo, 2003; Mobiha, 2002). In the lowlands, the Java carp (*Puntius gonionotus*), Pacu (*Piaractus brachypomum* or *Colossoma bidens*), red makau (*Tilapia rendalli*) and Emily's fish (*Prochilodus* margravii) are growing throughout the floodplains of the Ramu and the Sepik Rivers. In the higher altitude streams, the snow trout (*Schizothorax richardsonii*), Tor putitora, now locally known as Tor and red makau (*Tilapia rendalli*) have established breeding populations. The status of two fish species remain unknown: the chocolate mahseer, *Accrossocheilus hexagonolepis* and the giant gouramy, *Osphronemus gouramy*. The six species that were confirmed to be bred are contributing to rural food and income. The magnitude and extent of their distribution is not known until a proper fish surveys are done. However, the successful introduction has fulfilled the objectives of the Government of PNG through the two stocking projects; the Sepik River Stock Enhancement Program and the FISHAID projects. This success is due to the framework outlined in the Code of Practice, the people who undertook the project and the supporting financial and administrative arrangements of the implementing and executing agencies. The two projects put into effect the Code of Practice, and successfully moved live fish eggs across countries and continents to a developing country that previously had been unprepared to undertake such a project.

Lessons learned from the SRSEP and the FISHAID projects

In the final analysis, a Code of Practice is as good as the country, organization or group of people that follow the requirements. The PNG Government is a member of the United Nations and follows the FAO Code of Conduct for Responsible Fisheries. The Government also had the other legislated authorities such as Quarantine, Department of Environment

and Conservation as well international conventions on the protection of the environment. The Government had similar procedures in place to assess introductions in agriculture and livestock. Because the Government supports responsible management of its natural resources, it was easier for DFMR to use the ICES/EIFAC Code of Practice for the 1994-1997 fish introductions.

Even within a country where international codes of practice and conventions have been signed for responsible natural resource use and management, responsible actions may not necessarily happen if funding is not there. In the SRSEP and the FISHAID projects the funding was available by the Government of PNG and UNDP to make the Code of Practice work. The use of the Code of Practice requested not only funding but also project staff or individuals who believe in and accept principles as those of the Code of Practice. Technical and administrative competence of project leadership and implementation were very important for success.

The question of whether or not these introductions were environmentally and socially successful has as yet to be answered by appropriate research. Many would argue that the 1984-1997 fish introductions were an experiment. The PNG Government has not yet carried out impact studies on the introduction and transfer of fish, The critical question is what are the environmental impacts associated with providing rural poor in the Sepik-Ramu Basin additional fish to eat daily within their subsistence means?

In 1984, fish such as *Anabas testudineus*, the climbing perch, which was not native to PNG, either naturllay dispersed across the border or was carried by Irian Jaya refugees into the PNG Morehead and Fly River system. The climbing perch has now moved as far as Port Moresby. There are aquatic invasive plants such as *Salvinia molesta* and water hyacinth that have invaded entire river systems and lakes through accidental or irresponsible introductions and transfers. Has PNG addressed these introductions and transfers by impact assessments or management measures? The 1984-1997 fish introductions have made PNG even more aware of these issues.

Since the last introduction in April 1997, there has been no monitoring of these species by the NFA. This includes actual environmental and social impact studies, fish stock surveys to determine the extent of the movements of fish, the population dynamics of the introduced species, the fishing pressures and related fisheries aspects. This was partly due to the fact that when the funding for the introduction lasted, work in the Sepik-Ramu system was possible. Since that time, no funding has been allocated to monitoring and follow-up of the work.

The FISHAID project had made specific recommendations to the PNG Government on follow-up work. A review of the recommendations of the FISHAID Project in terms of further stocking is necessary. Importantly, the overdue issue of NFA policy towards inland fisheries development with the provinces to determine responsibility and action for inland fisheries development needs to be addressed.

Through the 1984-1997 fish introductions, PNG now has the experience in using the ICES/EIFAC Code of Practice for responsible use of alien species and can build on this experience to assess future introductions and transfers or to use this experience to establish sound guidelines to manage current introduced and transferred species through appropriate legislations and policies.

RELIABILITY OF CODE OF PRACTICE IN ENSURING RESPONSIBLE USE OF ALIEN SPECIES

The protocols and guidelines of the Code of Practice are a reliable practical tool that, if followed adequately, ensures responsible introduction and transfer of alien species. The sections of the Code of Practice that made it a reliable tool include specific requirements for:

(a) the country proposing to import exotic species to assess their own receiving environment, fauna and flora prior to considering an introduction or transfer; (b) the importing country to be clear about the consequences of an introduced species to its environments and the community; (c) a complete prospectus of the proposed species for introduction to cover both environmental and socio-economic risk aspects; (d) the exporting country to know its own native aquatic fauna prior to agreeing to allow another country to import the exotic species so it can provide advise to the importing country; (e) an assessment possible impacts of the exotic species on native species; (f) notification in advance as to which life stage the exotic species will be introduced; (g) a panel of expert technical advisors from the international community to approve the introduction; (h) the right facilities in-country to raise the exotic fish prior to release; (i) options to use source country facilities if the importing country lacks technical and infrastructural support; (j) a good import quarantine and environment organization; (k) communication links between all government authorities that have legal jurisdiction over introductions and transfers; and (l) the political and governmental legal system that supports the use of such codes of practice through affiliation with international conventions on environment and sustainable resource use.

PNG did not have existing fish quarantine facilities which allowed the country to follow the guidelines of the Code of Practice. This code requests that the imported eyed eggs are raised to maturity and bred, and the first generation released in only a few selected streams. Monitoring their establishment and impacts are required before a full scale release is done. In the case of inadequate quarantine facilities the Code of Practice allows countries to use source country facilities for broodstock.

Improvement of the Code of Practice

Composition of the Expert Committee

It would be helpful for developing countries if the composition of the Expert Committee that considers introduction and transfer proposals had mechanisms that allow export and import country representation at the scientific, social and economic level. This would create, apart from the government prospectus, another independent set of discussions and recommendations on introductions and transfers within the Expert Committee.

At the social level community representation would be necessary because communities and succeeding generations in communities remain at the sites of release and continue to depend on the resources of the rivers and lakes. Although they are the ones who may face negative impacts of the introduction the communities are often not involved in the decisions taken by their governments.

At the scientific representation level, social issues should not only be evaluated by a fish biologist doing a socio-economic survey. In the PNG experience, the socio-economic survey conducted by a fish biologist resulted in the assessment of how much money a rural fisher-folk can make after an introduction. The results of a socio-economic study by a social scientist are different and important. It would serve the community if a real social scientist was a member of the independent Expert Committee.

Socio-economic impact of introductions and transfers

The socio-economic impacts of introductions and transfers are equally important as biological and ecological impacts. The Papua New Guinea experience showed that socio-economic impacts should be part of any initial assessments leading to producing the prospectus of a selected species. However, socio-economic assessments, in addition to investigating incomes

derived from fishing, should also include: (a) eating preferences of the receiving communities; (b) suitability of the introduced species to traditional preservation techniques used in receiving communities; (c) how the introduced fish species affect cultural trade systems and value system; (d) how the introduction affects gender roles and community structures; (e) what cultural roles do native species play in family relationships; and (f) economic viability of the proposed species in contrast to existing consumer species.

MONITORING AND EVALUATION AFTER AN INTRODUCTION OR TRANSFER

The prospectus of each proposed exotic fish species should also include a budget for monitoring and an evaluation plan after an introduction and transfer has been completed.. After the introduction when all the funds were spent it was nearly impossible to assess "after introduction impacts". However, at the prospectus stage of the Code of Practice, monitoring should already be planned and budgeted in order to make the Code of Practice even more effective. For poorer countries though this might be a barrier to use the Code of Practice.

INSUFFICIENT KNOWLEDGE BY IMPORTING AND SOURCE COUNTRY OF AN EXOTIC FISH

In developing countries such as PNG, basic biological, ecological, genetic or disease information hardly exists. International aid and conservation agencies can assist developing countries by maintaining genetic, disease, and impacts databases of well-known fish species that would provide information necessary for review of applications to introduce a new species. Workable tools such as these can assist the Code of Practice to be more useful for developing countries.

DISCUSSION

The efficacy of the ICES/EIFAC Code of Practice depends on the technical, political and financial capacity of the developing country. Papua New Guinea's use of the Code of Practice was a success because, the political will was there. PNG was affiliated with UNDP and signed a number of international conventions relating to sustainable resource use. The quarantine laws for PNG in livestock were in place to keep DFMR and everyone else in line. In fact, the quarantine section of DAL will only allow "certified disease free fish imports" from Australia. With a government that promotes responsible management of natural resources, and established implementing organizations that keep those policies alive, it was easy for PNG to adhere to the requirements of the Code of Practice.

Looking at the introduction now ten years down the line and having visited the PNG Highlands in 2001 and the lowlands of the Sepik-Ramu in 2002, the introductions have allowed a large number of rural people to have more and reliable access to fish (Kolkolo, 2003).

Through the project PNG now has the experience and information on introductions, transfers and imported fish species. Though the information may be lacking in certain areas, there is more information available to assess future impacts. Further, the source countries and institutions of exotic species are known, so that any follow-up work can build on those contacts.

The ICES/EIFAC Code of Practice should be broadened to include socio-economic impacts. Socio-economic studies should include cultural values and eating preferences and not just the type of socio-economics normally understood by fishery scientists, i.e. income from fishing. In addition to that, other useful instruments such as ongoing and updated databases of known fish species, biological, ecological, disease and genetic traits should be available to assist countries who wish to do an introductions or transfers.

Now that six species have been confirmed to be growing and creating new fisheries for food and income for rural people, can inland fisheries be ignored in PNG? Impact assessments and monitoring might reveal answers to some of the questions about the Sepik-Ramu Basin.

The National Fisheries Authority as the mandated authority for all fisheries and aquaculture matters in PNG can lead the way in all of this.

Conclusions

Papua New Guinea used the ICES/EIFAC Code of Practice in the Sepik River Stock Enhancement Program and the FISHAID project to improve the fish production for the people living in the Sepik-Ramu system. These projects demonstrated that the Code is reliable and can be successfully used. Six alien species of fish have become established and are contributing to food and income in rural communities of the Sepik-Ramu Basin.

The success of the Code of Practice was attributed first to the Government of Papua New Guinea's political will to to commit to international organizations, protocols, conventions and instruments that require responsible management and use of natural resources.

Further, the Codes of Practice could be used because the government had established clear policy directions for inland fisheries development within its implementing agency, the Department of Fisheries and Marine Resources.

It was also concluded that in developing countries, additional practical measures must be taken to ensure that responsible actions are being taken by both the source country of an exotic species and the importing country of the exotic species. This includes such things as basic quarantine procedures for treating live eggs for export, packaging and logistical transportation of live fish and even purchasing some of the packaging and other accessories and supplying those institutions that are supplying live fish.

In accepting the expert advice of FAO to see inland fisheries policies become a reality, the Government of PNG took a risk. The risk was to allow FAO to implement the Code of Practice within a large part of its country, in catchment areas that were not well understood with the risk of facing future implications of this decision. The Code of Practice has useful and responsible protocols that countries can use for making introductions and transfers. However, its usefulness may be limited by the technical capacity of the user country and the source country of the exotic species. In PNG the limitations were: (i) scientific manpower to implement the requirements of the Code of Practice; (ii) the baseline databases of native fish species, habitats, and the environment of the importing country to make informed and realistic assessments of biological and environmental impacts; (iii) supporting infrastructure such as quarantine and fish hatcheries capable of producing the necessary numbers of fingerlings for introduction; (iv) political will to adopt the Code of Practice and to use it in the country; and (v) funding capacity to carry out the Code of Practice in country and in supporting source country deficiencies. These limitations were overcome and PNG followed an internationally accepted protocol for the responsible use of alien species to improve livelihoods in the the Sepik and Remu Rivers.

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Explanatory Notes

The personal views and opinions expressed in this paper are the author's, and not that of the PNG Government, FAO, UNDP or the PNG National Fisheries Authority. Many of the things written outside of the Code of Practice or the FISHAID project were experiences through direct involvement as one of the DFMR scientists in the FISHAID project.

References

FAO. 1993. Papua New Guinea. Sepik River Fish Stock Enhancement Project. Project Findings and Recommendations. Terminal Report. FI:PNG/85/001 Terminal Report. FAO, Rome. 33pp.

FAO. 1995a. Precautionary approach to fisheries. Part I Guidelines on the precautionary approach to capture fisheries and species introductions. Elaborated by the Technical Consultation on the Precautionary Approach to Capture Fisheries (Including Species Introductions) Lysekil, Sweden, 6-13 June 1995. FAO Fisheries Technical Paper 350/1. FAO, Rome.

FAO. 1995b. Precautionary approach to fisheries. Part II Guidelines on the precautionary approach to capture fisheries and species introductions. Elaborated by the Technical Consultation on the Precautionary Approach to Capture Fisheries (Including Species Introductions) Lysekil, Sweden, 6-13 June 1995. FAO Fisheries Technical Paper 350/1. FAO, Rome.

FAO. 1997. Papua New Guinea. Fisheries Improvement by Stocking at Higher Altitudes (FISHAID) Project, Terminal Report. FI:PNG/93/007 Terminal Report. FAO, Rome.46pp.

Kolkolo U. 2003. *Possible Elements for a Future Project to Assess the Impact of the FISHAID Project in the Sepik and Ramu Catchments, Papua New Guinea, 2002*. A Report prepared for the Food and Agriculture Organization, Rome, Italy. FAO Unpublished Field Report.

Mobiha A. 2002. *Report on the investigation into the introduced Pacu fish (*Piaractus brachypomus*, also sometimes called* Colossoma bidens*) within the middle and upper Sepik River and Ramu River Areas*. National Fisheries Authority, Internal Report. Port Moresby, Papua New Guinea.

Table 1. Summary of stock enhancement and fish release activities undertaken by the FISHAID project (from Coates: FAO, 1997).
Fish were only released into rivers/lakes of the Sepik-Ramu River system including relevant areas of the highlands draining into these rivers (FAO 1997).

Species	Common name	Source of stock	Maximum size, diet, habits	Target	Number released	Release sites	Status as of February 1997	Notes
Tilapia rendalli	Red tilapia, "makau"	Originally from Africa via the University of Stirling U.K. Only 900 imported, grown to broodstock, all those release were reared at Madang.	1.5 kg, aquatic vegetation, habits similar to existing tilapia (Oreochormis mossambicus) but different diet.	Everywhere in catchment except fast flowing rivers. Prefers quiet backwaters with much vegetation and is quite tolerant of cold conditions.	173 111	52 widely dispersed locations throughout the catchment.	Widely established. Contributing to an improved fishery in many locations. Highly regarded as food by local communities and preferred to the already existing tilapia (Oreochromis mossambicus). Doing very well in Yonki Reservoir, lower Sepik, middle and upper Ramu in particular.	Although widely established it may take some time before the species spreads to all areas and stocks are built up to their optimum level.
Osphronemus gouramy	Giant gouramy	Originally from Asia. Obtained from Brown River, Port Moresby, PNG.	7 kg, aquatic vegetation, large air-breathing anabantid from Asia, prefers quiet waters.	Lowland swamps and lakes.	37 adult fish	Single remote lake in Middle Ramu.	Not known.	Breeding sized adults obtained from Port Moresby and breeding experiments commenced at Madang for local production. Did not breed in tanks (no ponds available) and fish released into river to make room for higher priority species.
Trichogaster pectoralis	Snakeskin gouramy	Originally from Asia. Available vicinity of Port Moresby.	0.5 kg omnivorous feeding on insects and a variety of plant, prefers quiet waters.	Lowland swamps and lakes.	-	-	No stocks released.	Efforts were devoted to higher priority and more difficult species from overseas. Supposed to be done at a later stage by DFMR.
Puntius gonionotus	Java carp	University Pertanian Malaysia.	1.5 kg omnivorous feeding on plant matter and aquatic insects etc., small Asian barb/carp, inhabits large range of habitats.	Everywhere, especially lakes and relatively slow-flowing rivers.	27 750	8 different sites especially lower Ramu at Bunapas, middle Ramu at Brahman and middle Sepik at Bunam.	Known to be established at Brahman, Bunapas and Bunam where it is already contributing to an improved fishery.	Releases of this fish were halted in 1993 in order to give priority to other species, which were more difficult to procure and stock. Broodstock were placed at the governmental fish farm at Aiyura where they were supposed to be raised and a domestic breeding programme started which would continue the necessary stocking. These fish bred in 1995/6 but no attempts were made to compensate for the necessary stocking requirements. Although established the fish will take a long time to disperse. Further stocking required, including into Yonki reservoir.

Species	Common name	Source of stock	Maximum size, diet, habits	Target	Number released	Release sites	Status as of February 1997	Notes
Prochilodus margravii	P.N.G. name "Emily's fish"	Sao Francisco River, Brazil via CEPTA/IBAMA	6kg exclusively detritus (mud), a larger S. American characin renowned for its jumping ability and long migrations along rivers, feeds on floodplain and spawns in tributary rivers, high oil content in flesh.	Lowland floodplain and lakes but migrates in large schools up tributary rivers.	160 511	Middle Sepik (especially Chambri Lake and Bunam) and middle and lower Ramu.	Not expected to breed until 1999. A few fish have been caught at least at Bunam where the fish is preferred to all others (one community report says that it was even superior to tinned mackerel).	Monitoring required to determine success. This species, if established successfully, is anticipated to become one of the most abundant species in lowlands. Biological production may exceed 50,000 tones per annum.
Colossoma bidens / Piaractus brachypomum	P.N.G. name "Pacu"	University of Pertania Malaysia, originally from Brazil	35kg exclusively vegetarian eating fruits and nuts in flooded forest, large teeth able to crack open rubber tree nuts, inhabits forested areas and migrates up rivers to spawn.	Lowland lakes and flooded forest.	14 511	Remote lakes in middle Sepik and middle and lower Ramu.	Not expected to breed until 1999.	More stocking required. This fish also has significant aquaculture potential in P.N.G. It grows very fast, is highly prized and feeds on wastes from commercial plantations (including coffee, coca palm and copra wastes). Broodstock of this species were re Madang to within one year of breed size. Most of these were dumped in Ramu River at the closure of the palm due to lack of commitment interest NFA in any follow-on activities.
Tor putitora	Golden Mahseer	Nepal and India	80 kg omnivorous – mainly aquatic insects, a large Asian cyprinid (carp) renown in its native range as a highly prized sport fish, now threatened there due to over-fishing. In addition to its food fish qualities the fish may form the basis of a tourism sportfish industry.	Fast flowing rivers at mid-altitudes including highlands.	29 827	9 different locations – chiefly Yonki Reservoir but also rivers in middle Sepik.	Not expected to breed until 1999. Doing well in Yonki reservoir where growth rates are better than expected.	It is difficult to obtain large stock numbers of this fish. Placed in the Yonki Reservoir breeders can be collected at a later date in order to start the domestic breeding programme. More stocking required.

Species	Common name	Source of stock	Maximum size, diet, habits	Target	Number released	Release sites	Status as of February 1997	Notes
Acrossocheilus hexagomolepis	Chocolate Mahseer	Nepal	5.0 kg omnivorous – mainly aquatic insects, a medium sized Asian cyprinid (carp) with similar habits to **Tor putitora.**	Fast flowing rivers at low and mid-altitudes.	11 224	9 different locations – chiefly Yonki Reservoir but also rivers in middle Sepik.	Not expected to breed until 1999.	Stocks of this fish difficult to obtain large numbers. Placed in Yonki Reservoir so breeders can be collected later date so domestic breeding programme can be started. More stocking required.
Schizothorax richardsonii	Snow trout	Nepal and India	2 kg juveniles omnivorous, adults exclusively vegetarian –feeding algae, lives in clear fast flowing streams, rivers with water temperatures from 10 to 27°C. Habits similar to ordinary trout except for feeding and improved temperature tolerance. An important species in catches in its native range.	Fast flowing rivers at higher altitudes.	70 309	40 different sites at high altitudes inc. Western Highlands, Enga, Eastern Highlands, East Sepik and Madang Province.	Not expected to breed until 1999.	This is the most important species found in highland areas. Estimated to be more suitable for P.N.G. coldwater rivers that the "normal" (salmonid) trout. More stocking required. The extent to which this species dispenses needs to be determined by future research monitoring. Due to limited supply of stock only a small part of the catchment was released near Kainantu and Bundi. Broodstocks of this species were released near Yonki within six months of breeding age. These were dumped into the Ramu River at the closure of the project; lack of interest in follow-on activities.
Labeo dero		Nepal India	2 kg vegetarian especially algae in streams, habits similar to snow trout.	Fast flowing rivers at higher altitudes.	-	Not stocked.		Proved to be difficult to obtain it from India/Nepal, species put on hold until results from snow trout introductions are available.

Case studies

The introduction of *Penaeus vannamei* and *P. stylirostris* into the Asia-Pacific region

Simon Funge-Smith
and Matthew Briggs

It is now evident that P. vannamei *is farmed and established in several countries in East, Southeast and South Asia and is playing a more significant role in shrimp aquaculture production*

Background

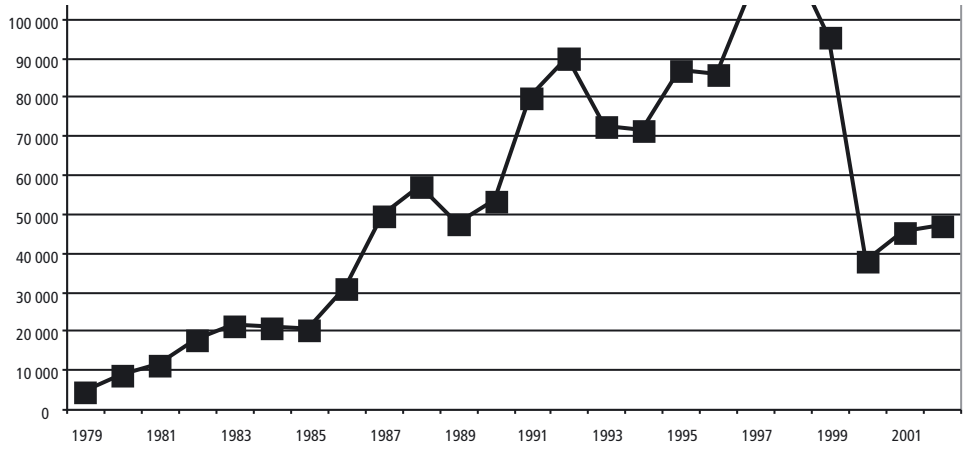
In 2000, global aquaculture production reached 45.71 million metric tonnes (mmt) with a value of US$ 56.47 thousand million. This represented an increase in production of 6.3% by weight and 4.8% by value over the previous year. Although crustaceans represented only 3.6% of total production by weight, they comprised 16.6% of total global aquaculture by value in 2000. Despite being affected by serious disease outbreaks in both Latin America and Asia, the annual percent rate of growth (APR) of the shrimp sector grew by 6.8% by weight between 1999 and 2000. These growth rates are still high relative to other food production sectors, however in terms of growth, shrimp production has decreased to more modest levels over the last decade (averaging 5%) relative to the double-digit growth rates which were observed during the 1970's (23%) and 1980's (25%).

Marine shrimp continued to dominate crustacean aquaculture, with three major species accounting for over 86% of total shrimp aquaculture production in 2000 (the giant tiger prawn, *Penaeus monodon*; the fleshy prawn, *P. chinensis*; and the whiteleg shrimp, *P. vannamei*) (Figure 1). Whilst the giant tiger prawn only ranked 20th by weight in terms of global aquaculture production by weight in 2000, it ranked first by value at US$4 047 billion.

NATURAL RANGE OF *P. VANNAMEI* AND *P. STYLIROSTRIS*

Penaeus vannamei and *P. stylirostris* both originate on the Western Pacific coast of Latin America from Peru in the South to Mexico in the North. *P. vannamei* is native to the Pacific coast of Mexico, Central and South America as far south as Peru, in areas where water temperatures are normally >20°C throughout the year (Wyban and Sweeney, 1991; Rosenberry, 2002). It is not currently known whether there is one population throughout the year

Figure 2. Exports os shrimp (mt) from Ecuador 1979–2002 and environmenta/disease events



or if isolated populations exist, although there do appear to be differences between stocks from various areas under culture conditions.

P. stylirostris is native to the Pacific coast of Central and South America from Mexico to Peru, occupying the same range as *P. vannamei*, but with higher abundance, except for in Nicaragua at the peak of the range of *P. vannamei* (Rosenberry, 2002). It has recently been demonstrated that there are at least 6 morphologically and genetically distinct populations of *P. stylirostris* in the Gulf of California, Mexico alone (Lightner *et al.*, 2002), raising the probability that there will be variations in their suitability for aquaculture.

The culture industry for *P. stylirostris* in Latin America is largely confined to Mexico, but *P. vannamei* has become the primary cultured species in Latin America from the USA to Brazil over the past 20-25 years. Total production of this species in the Americas probably amounted to some 200 000 mt, worth $1.2 billion in 2002.

P. vannamei was introduced into Asia experimentally from 1978-1979, but commercially only since 1996 into Mainland China and Taiwan province of China, followed by most of the other coastal Asian countries in 2000-2001. Experimental introductions of SPF "supershrimp" *P. stylirostris* have been made into various Asian countries since 2000, but the only country to develop an industry to date has been Brunei.

Worldwide movements and introductions

The use of exotic animal species to increase food production and income has a long history and has been an established practice since the middle of the 19th Century. Controversy over the use of exotic species arises from the many highly publicised and spectacular successes and failures.

FAO statistics show that aquaculture development has been the primary reason cited for most introductions, accounting for 40% of all cases, and that the number of introductions (65% intentional) has increased exponentially since 1940. Most of these introductions are of fish, with only 6% or 191 records being of crustaceans. Such movements have been facilitated by recent advances in transport, which have made large-scale movements of many species increasingly easy. They are also directly related to the rapid global development of the

aquaculture industry and the demand for new species to culture (FAO database of introduced aquatic species - DIAS, Fegan *et al.*, 2001).

With regard to Penaeid shrimp, the first experimental movements began in the early 1970s, when French researchers in Tahiti developed techniques for intensive breeding and rearing of various exotic Penaeid species including *P. japonicus*, *P. monodon* and later *P. vannamei* and *P. stylirostris*. Later, in the late 1970s and 1980s, *P. vannamei* and *P. stylirostris* were translocated from their natural range on the Pacific coast of Latin America from Mexico to Peru. From here, they were introduced to the North-Western Pacific coast of the Americas in the USA and Hawaii, and to the Eastern Atlantic coast from Carolina and Texas in the North through Mexico, Belize, Nicaragua, Colombia, Venezuela and on to Brazil in the South. Most of these countries now have culture industries for these species. *P. monodon* and *P. japonicus* were also experimentally introduced in the 1980s and 1990s from Asia to various Latin American countries including the USA, including Hawaii (where SPF populations have been established), and Ecuador and Brazil, where introductions were not successful.

Table 1. Importation of *P. vannamei* and *P. stylirostris* in Asian countries

Country	First introduction of *P. vannamei*	Original source	Original cultured species	Reason for importing *P. vannamei*	First introduction of *P. stylirostris*	Source of brood/PL imports	Current ban on imports	Current viral diseases
China	1988	Tx	C,M,J,P,Me	Diversification, performance	1999	Tx, Ti, Hi	No	WSSV,YHV,TSV,SMV, HPV,IHHNV,BP,MBV, BMNV,HB,LOPV,REO-III
Taiwan province of China	1995	Hi	M,J,Ma	Problems with *P. monodon*	2000	Hi, Ch	No	WSSV, YHV, IHHNV, MBV,TSV
Thailand	1998	Ti	M,Me,J	Problems with *P. monodon*	Yes	Hi, Mx, Ch, Ti	September, 2002	WSSV, MBV, BMNV, HPV, YHV, IHHNV, LOVV, TSV, MOV
Viet Nam	2000	Ch	M	Problems with *P. monodon*, cold tolerance	No	Ti, Ch, Hi	Except for 9 licensees	WSSV, YHV
Philippines	1997	Ti	M,I,Me	Problems with *P. monodon*	No	P, Ti	1993, 2001	WSSV, YHV
Indonesia	2001	Hi	M, Me	Problems with *P. monodon*	2000	Ti, Hi	Restricted to license holders	WSSV,YHV,MBV,TSV, IHHNV
Malaysia	2001	Ti	M,S	Problems with *P. monodon*	No	Ti, Th	June, 2003	WSSV, MBV, BMNV, HPV, YHV, IHHNV
India	2001	Ti	M,I,Ma	Problems with *P. monodon*	No	Ti, Hi	Except for a few trials	WSSV, MBV, HPV,YHV
Sri Lanka	None	N/A	M	N/A	No	N/A	Guidelines in force	WSSV, YHV, MBV
Pacific Islands	1972	Mx, P	M,Me,J	Experiments, cold tolerance	1972	Mx, P, Hi	Fiji has regulations	None

Notes: Cultured species: C = P. chinensis, M = P. monodon, Me = P. merguiensis, I = P. indicus, S = P. stylirostris, J = P. japonicus, P = P. penicillatus, Ma = Macrobrachium rosenbergii

Source/Broodstock Imports: Hi =Hawaii, Ti = Taiwan province of China, Ch = Mainland China, Mx = Mexico, Th = Thailand, Tx = Texas, P = Panama

More recently, experimental introductions of *P. vannamei* to Asia began in 1978/79 to the Philippines (FAO correspondent) and in 1988 to Mainland China (FAO correspondent). Of these first trials, only Mainland China maintained production and started an industry. However, beginning in 1996, *P. vannamei* was introduced into Asia on a commercial scale. This started in Mainland China and Taiwan province of China and quickly spread to the Philippines, Indonesia, Viet Nam, Thailand, Malaysia and India. A summary of the introduction of *P. vannamei* and *P. stylirostris* to Asia is presented in Table 1.

P. vannamei has been introduced and farmed in Asia since the mid 1990s, with production in Mainland China being particularly significant. There have been several reasons for the introduction and subsequent movement; apparent availability of specific pathogen free (SPF) stocks; perceived differences in susceptibility to WSSV from *P. monodon*; shortage of *P. vannamei* in the international market (mainly USA) caused by reduced production in Latin America, and the relative ease with which animals could be cultured and bred in captivity. In some countries, *P. vannamei* culture has been promoted by some private sector suppliers as being tolerant or resistant to WSSV, leading to introductions based on a mistaken belief that they are safe.

China has a large and flourishing industry for *P. vannamei*, with Mainland China producing >270 000 mt in 2002 and an estimated 300 000 mt (71% of total shrimp production) in 2003, which is higher than the current production of the whole of Latin America. Other Asian countries with developing industries for this species include Thailand (120 000 mt estimated production for 2003), Viet Nam and Indonesia (30 000 mt estimated for 2003 each), with Taiwan province of China, the Philippines, Malaysia and India also producing thousands of tonnes each.

Total production of *P. vannamei* in Asia was approximately 316 000 mt in 2002, and it has been estimated that this will increase to nearly 500 000 mt in 2003, which would be worth some $4 billion on the export market. However, not all the product is exported outside of the region and a large local demand exists in some Asian countries.

It is now evident that *P. vannamei* is farmed and established in several countries in East, Southeast and South Asia and is playing a more significant role in shrimp aquaculture production. On the other hand, it is also evident that viruses previously confined to Latin America, such as TSV are taking a toll within *P. vannamei* shrimp aquaculture in many countries in Asia and there have also been reports of "runt deformity syndrome" (RDS) caused by IHHNV, which is endemic in *P. monodon* in the region.

The overall performance of *P. vannamei* as a candidate species within shrimp aquaculture sector is still unclear. The knowledge and understanding of the social, economic, and environmental impacts of introduction of this species into Asia is far from adequate. It is uncertain how this species will behave and perform in the region, as a newly introduced species, and what impacts it will bring to the regional economy, environmental sustainability, rural livelihoods and regional biodiversity. Therefore, it is recognized that a review/study towards assessing the introduction and impacts of *P. vannamei* in the Asia-Pacific region is timely.

The overall performance of P. vannamei as a candidate species within shrimp aquaculture sector is still unclear

Table 2. Summary of advantages and disadvantages of the culture of *P. vannamei* and P. stylirostris over P. monodon in Asia

Characteristic	Advantages	Disadvantages
Growth Rate	*P. vannamei* and *P. stylirostris* can grow as fast as *P. monodon* up to 20g and typically grows faster (1-1.5g/wk) than P. monodon (1g/wk) currently in Asia; Size range on harvest generally smaller	Growth rate of *P. vannamei* slows after reaching 20g, making production of large-sized shrimp slower
Stocking Density	*P. vannamei* is easier to culture in very high densities (typically 60-150/m^2, but up to 400/m^2) than *P. monodon* and *P. stylirostris* which can be aggressive	Very high stocking densities require high control over pond/ tank management practices and are high-risk strategies
Salinity Tolerance	*P. vannamei* are tolerant of a wide range of salinities (0.5-45ppt) and more amenable to inland culture sites than P. monodon or *P. stylirostris*	None
Temperature Tolerance	*P. vannamei* and particularly *P. stylirostris* are very tolerant of low temperatures (down to 15oC) enabling them to be cultured in the cold season	None
Protein Requirements	*P. vannamei* require lower protein feed (20-35%) than *P. monodon* or *P. stylirostris* (38-40%), resulting in a reduction in operational costs and amenability for closed, heterotrophic systems; FCRs are lower at 1.2 compared to 1.6	None
Disease Resistance	Although *P. vannamei* is susceptible to WSSV, Asia is not currently experiencing problems from this virus; *P. stylirostris* is highly resistant to TSV; Both species have been selected for resistance to various diseases; Survival rates with *P. vannamei* are thus currently higher than with *P. monodon* in Asia and production is more predictable	*P. vannamei* is highly susceptible to and a carrier of TSV, WSSV, YHV, IHHNV and LOVV; P. monodon is refractory to TSV and IHHNV; There is currently no ability to select *P. monodon* for disease resistance
Ease of Breeding and Domestication	Availability of pond-reared broodstock; Ability to conduct domestication and genetic selection work; SPF and SPR lines already available; Elimination of problems associated with wild broodstock and/or PL collection; source of cheap broodstock from ponds; small sized broodstock mean faster generation times	SPF animals sometimes have high mortality in disease-laden environments; Broodstock rearing and spawning more technical and complicated than use of wild *P. monodon* spawners
Larval Rearing	Higher survival rates in hatchery of 50-60% for *P. vannamei* and *P. stylirostris* compared to *P. monodon* (20-30%)	None
Post-Harvest Characteristics	If treated with ice, *P. vannamei* are resistant to melanosis	Handling, transportation and processing of *P. monodon* easier
Marketing	White shrimp generally preferred in US market over tigers due to taste; Strong local demand for white shrimp in Asia; The meat yield is higher for *P. vannamei* (66-68%) than for *P. monodon* (62%)	*P. monodon* and *P. stylirostris* can grow to a larger size, commanding a higher price than *P. vannamei*; High competition on international markets for *P. vannamei* as production is worldwide
Origin	None	*P. vannamei* and *P. stylirostris* are exotic to Asia and their importation may cause problems with import of new viruses and contamination of local shrimp stocks
Government Support	None	No support from most countries since they remain undecided or ban imports and farming of *P. vannamei*; Supply of broodstock and seed problematic in face of bans, leading to smuggling of sub-optimal stocks and disease introduction

Table 3. Estimated Production of all shrimp and *P. vannamei* in Asian countries

Country	Total Shrimp Production (mt/yr) 2002	Total Shrimp Production (mt/yr) 2003	*P. vannamei* Production (mt/yr) 2002	*P. vannamei* Production (mt/yr) 2003	*P. vannamei* Production (% of total) 2002	*P. vannamei* Production (% of total) 2003
China	415 000	420 000	272 980	300 000	66	71
Taiwan Province of China	18 378	19 000	7 667	8 000	42	42
Thailand	260 000	300 000	10 000	120 000	4	40
Viet Nam	180 000	205 000	10 000	30 000	6	15
Philippines	36 000	38 000	3 425	5 000	10	13
Indonesia	100 000	130 000	10 000	30 000	10	23
Malaysia	23 200	27 000	1 200	3 600	5	13
India	145 000	150 000	350	1 000	0	1
Sri Lanka	3 368	3 400	0	0	0	0
Pacific Islands	2 200	2 200	0	0	0	0
Total	1 183 146	1 294 600	315 622	497 600	27	38

Note : all data for 2003 is estimated

Stocks of IHHN-resistant *P. stylirostris* based on the Tahiti strain were also introduced into the region in recent years. Although these stocks did not become as widely distributed as *P. vannamei*, some stocks of *P. stylirostris* remain and there may be some interest in this species should RDS become a limiting factor.

Advantages and disadvantages of *P. vannamei* and *P. stylirostris*

There are many reasons for the introduction of *P. vannamei* and *P. stylirostris* outside of their natural range. Despite the presence of various international, regional and country-specific regulations, the private sector (and/or government) often initiate introductions due to problems with the culture of their indigenous species and the perceived (rightly or wrongly) production benefits of the exotic species. There may also be marketing advantages and a desire to expand, intensify and/or diversify aquaculture systems. Additionally, the improved transportation efficiency available recently has removed some old limitations and encouraged international trade in exotic species. The advantages and disadvantages of *P. vannamei* and *P. stylirostris* as compared to native species, specifically *P. monodon* are shown in Table 2.

The main reason behind the importation of *P. vannamei* to Asia has been the poor performance, slow growth rate and disease susceptibility of the major indigenous cultured shrimp species, *P. chinensis* in China and *P. monodon* virtually everywhere else. Cultured shrimp production in Asia has been characterised by a series of outbreaks of disease caused by viral pathogens which have caused significant losses to the culture industries of most Asian countries over the past decade. These diseases have not been confined to single countries but have spread throughout shrimp culture regions apparently as a result of transfers of infected stock. It was not until the late 1990s, spurred by the production of the imported *P. vannamei*, that Asian (and therefore world) production levels have begun to increase again.

Despite the presence of various international, regional and country-specific regulations, the private sector (and/or government) often initiate introductions due to problems with the culture of their indigenous species and the perceived (rightly or wrongly) production benefits of the exotic species

Despite the problems with disease transfer, *P. vannamei* (and *P. stylirostris*) does offer numerous advantages over *P. monodon* for the Asian shrimp farmer. These are largely associated with the ability to close the life cycle and produce broodstock within the culture ponds. This relieves the necessity of returning to the wild for stocks of broodstock or PL and permits domestication and genetic selection for favourable traits such as growth rate, disease resistance and rapid maturation. Through these means, domesticated stocks of SPF and SPR shrimp have been developed and are currently commercially available from the USA.

Other specific advantages include, rapid growth rate, tolerance of high stocking density, tolerance of low salinities and temperatures, lower protein requirements (and therefore production costs), certain disease resistance (related to SPR stocks), and high survival during larval rearing, and some marketing advantages. However, there are also disadvantages, including their acting as a carrier of various viral pathogens new to Asia, a lack of knowledge of culture techniques (particularly for broodstock development) in Asia, smaller final size and hence lower market price than *P. monodon*, need for high technology for intensive ponds, competition with Latin America for markets, and a lack of support for farmers due to their often illegal status.

Since it is clear that *P. vannamei* culture is already established and growing fast in the Asian region (Table 3), it is important that informed decisions regarding these advantages and disadvantages and appropriate action needs to be taken. This would ideally develop with a close dialogue between government and private sector as well as other concerned organisations.

THREATS AND RISKS OF INTRODUCING EXOTIC SHRIMP SPECIES

Unregulated trans-boundary movement of aquatic animals can lead to substantial economic and environmental impacts through the transfer diseases and pathogens. Trans-boundary pathogen transfers in newly imported species often result in establishment of infection in naturally susceptible indigenous hosts and may lead to the adaptation of pathogens to a new range of hosts. Due to their inherent genetic variability, rapid rate of replication, and common occurrence as low-level latent infections in apparently healthy animals, the transfer of viral pathogens is of particular concern. However, during the past decade, powerful DNA-based molecular tools have become available to trace the origins and spread of infections in animal populations and monitor viral adaptation to new hosts. These methods have been widely applied to infections in terrestrial animals and humans (e.g. foot-and-mouth disease in Europe, West Nile virus in the USA, HIV globally) but there has been quite limited application to aquatic animals. This approach, which has become known as molecular epidemiology, uses selected genetic markers to distinguish individual viral isolates. Accumulating mutations that occur as viruses spread through animal or human populations can be used to determine the relationship between isolates and the patterns of pathogen spread.

VIRAL DISEASE

The Taura Syndrome Virus (TSV), which was initially identified on *P. vannamei* shrimp farms near the Taura River in Ecuador in early 1992, caused severe production and economic

Table 4. Hatchery and PL production for all shrimp and *P. vannamei* in Asian countries

Country	*P. vannamei* Maturations	*P. vannamei* Hatcheries	Other Shrimp Hatcheries	Total shrimp PL Production (million PL/mo)	*P. vannamei* PL Production (million PL/mo)
Mainland China	?	1 959	1 893	56 375	9 900
Taiwan province of China	20	150	250	754	644
Thailand	20	26	2 000	3 700	1 200
Viet Nam	9	9	4 800	1 600	90
Philippines	0	0	250	200	0
Indonesia	?	15	300	?	?
Malaysia	5	10	95	200	50
India	0	3	293	600	2
Sri Lanka	0	0	80	22	0
Pacific Islands	0	0	9	101	0
Total	54	2 172	9 970	63 552	11 886

Note: all data is for 2002

losses to the shrimp sector in the Americas, and remains as a major constraint to the sectoral development. Similarly, White Spot Syndrome Virus (WSSV), which was initially identified on *P. monodon* in Mainland China and Taiwan province of China, severely affected the Asian shrimp industry, and subsequently spread to Americas affecting *P. vannamei* production systems.

Although there is no reported evidence yet that TSV has spread to the major indigenous farmed shrimp species (*P. monodon* and *P. chinensis*) there has been a report of infection in wild metapenaeid shrimp in Taiwan province of China and an accompanying genetic adaptation of the virus. As a highly mutable RNA virus, TSV is particularly suitable for molecular epidemiological studies that, at this early stage of pathogen establishment, could be applied to trace the spread, adaptation and impact of the virus on indigenous farmed and wild crustaceans in the region. The methodology could also be applied to the detection and monitoring of other pathogens, particularly viruses that may be introduced with the species.

In Asia, first Yellowhead Virus (YHV) from 1992 and later White Spot Syndrome Virus (WSSV) from 1994 caused continuing direct losses of approximately $1 billion per year to the native cultured shrimp industry. In Latin America, first Taura Syndrome Virus (TSV) from 1993 and later, particularly, WSSV from 1999 caused direct losses of approximately $0.5 billion per year after WSSV (Figure 2). Ancillary losses involving supporting sectors of the industry, jobs, and market and bank confidence put the final loss much higher.

It is widely believed that these three most economically significant viral pathogens (and a host of other pathogens) have been introduced to the Asian and Latin American countries suffering these losses through the careless introduction of live shrimp stocks. Except for China, most Asian countries have legislated against the introduction of *P. vannamei* due to fears over the possibility of importing new pathogenic viruses and other diseases from Latin America to Asia.

Many governments have allowed importation of supposedly disease free stocks that are available for this species from the USA. The encouraging trial results, the industry-perceived benefits, including superior disease resistance, growth rate and other advantages, allied

with problems controlling the imports from other countries, has lead to the widespread introduction of this species to Asia, primarily by commercial farmers. Unfortunately, importation of cheaper, non-disease free stock has resulted in the introduction of serious viral pathogens (particularly TSV) into a number of Asian countries, including Mainland China, Taiwan province of China, Thailand and Indonesia, and possibly more. There are now many hatcheries established in Asia that are producing postlarvae for stocking (Table 4), although the original sources of the stock and their current health status are quite uncertain. What can be assumed is that many of the hatcheries are not able to maintain their stocks as SPF and invariably they become infected with local virus disease and quite possibly with the disease that are typical to the species when in South America (e.g. Taura). This is partly due to private sector hatcheries being unaware of the requirements for maintaining clean stocks and partly dues to corner cutting due to the rising demand for postlarval *P. vannamei*.

Biodiversity and impacts on wild stocks

Although TSV does not seem to have affected the indigenous cultured or wild shrimp populations, insufficient time and research has been conducted to prove this. TSV is also a highly mutable virus, capable of mutating into more virulent strains, which are able to infect other species. In addition, other viruses probably imported with *P. vannamei*, for example a new LOVV-like virus, have been implicated in actually causing the slow growth problems currently being encountered with the culture of the indigenous *P. monodon*. There remain many unanswered questions regarding the possible effects of introduced species on other cultured and wild shrimp populations in Asia.

At present there is still no available information regarding whether *P. vannamei* has established in the wild and if so, the effect of its interaction with existing crustacean species. For this reason there has been caution on the part of many Asian governments. However, this caution is not shared by the private sector, which has been bringing in stocks of illegal and often disease carrying *P. vannamei* into Asia from many locations. The commercial success of these introductions, despite disease problems has allowed the development of substantial culture industries for these species within Asia, so that there is effectively little ability to control the importation of *P. vannamei* and development of this new feature of the cultured shrimp sector in Asia.

International efforts and the history of import control.

The introductions of *P. vannamei* to non-native areas of the Americas and lately to Asia have had a significant positive effect on the production capacities of the countries involved. This is probably the first time that this has ever been recorded with cultured shrimp. Despite the establishment of viable shrimp culture in many countries with this species, there are potential negative impacts that are emerging.

SPF "supershrimp" *P. stylirostris* have also been experimentally introduced to many Asian countries (including Brunei, Taiwan province of China, Myanmar, Indonesia and Singapore) from secure breeding facilities in Mexico and the US. These introductions began in 2000, but have yet to make a major impact on the culture industries in those countries (with the exception of a small industry in Brunei), but without notable problems so far. *P. stylirostris* was also introduced into Thailand and Mainland China in 2000, but has yet to make much impact there either.

Although incompletely understood, it is now clear that many of the introductions of trans-boundary species have also been responsible for the introduction, establishment and spread of thousands of pathogen (viruses, bacteria and fungi) and parasite species into new geographic

areas and hosts. Once established in natural waters (and often aquaculture facilities) and hosts, such pathogens are almost impossible to eradicate. In most cases, fishery managers and governments have not properly considered pathogen transfer when contemplating trans-boundary movements of aquatic animals, or have been slow to react to such introductions directly by the private sector either with or without approval.

With proper planning, it may have been possible to avoid introduction of these pathogens and there now exist a number of international codes of practice and guidelines to assist this process. These include international efforts lead by:

- the World Trade Organization (WTO);
- the International Council for the Exploration of the Sea (ICES);
- the Office International des Epizooties (OIE);
- the Food and Agriculture Organization of the United Nations (FAO) via the Code of Conduct for Responsible Fisheries (CCRF);
- regionally through the latest initiative is the FAO/NACA Regional Technical Cooperation Program (TCP/RAS 6714(A) and 9605(A)) "Assistance for the Responsible Movement of Live Aquatic Animals", which led to the Asian Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals.

Direct, involuntary importation of new pathogens with their imported hosts has been shown to have even less quantifiable problems including transfer of new strains of established pathogens specific to the host, the potential for interbreeding with, and displacement of, native species and unknown effects on the genetic diversity and ecology of native fauna. Each of these has the potential to cause unexpected and far-ranging adverse effects on host populations and commercial and sport fisheries, with accompanying severe socio-economic impacts on human populations.

Private sector initiatives

In some countries, the private sector has adopted best management practices (BMPs), which have helped prevent on-farm disease problems. Although governments have also assisted these efforts through the development of expertise, infrastructure and capacity for health management, shrimp culture and capture fisheries in most countries remain vulnerable to further introductions of trans-boundary diseases. There is much further work that can be done however, and this report includes recommendations as to what this might comprise.

The recent publication of a number of codes of conduct and management guidelines (BMPs) for the trans-boundary importation of exotic shrimp and their subsequent culture by amongst others, the WTO, ICES, FAO, the OIE, NACA, ASEAN, SEAFDEC and the GAA have clearly defined most of the issues involved. With the availability of SPF and SPF/SPR stocks of *P. vannamei* and *P. stylirostris* from the Americas, Asia has had the opportunity to decide whether to responsibly undertake such importations for the betterment of their shrimp culture industries and national economies, whilst avoiding the potential problems with viral diseases and biodiversity issues. However, a number of factors are described to have prevented this ideal situation from manifesting. Although many of the potential problems involved with trans-boundary movements of shrimp and their viral passengers is as yet unknown, the Asian governments must take responsibility for legislating control over this industry.

World Trade Organization (WTO)

Trade issues are governed under the terms of the World Trade Organization (WTO), the legal and institutional basis for the international trading system. The main objectives for the agreement were to ensure access to markets, promote fair competition and encourage development and economic reform. Aquacultural issues are covered specifically in the "Agreement on the Application of Sanitary and Phytosanitary Measures" (SPS, 1995) and the "Agreement on Technical Barriers to Trade" (TBT).

The SPS agreement attempts to prevent non-tariff trade barriers, based on harmonized international standards, guidelines or recommendations where they exist. However, individual governments may take more stringent measures, provided they have scientific justification (i.e. following an import risk assessment), or if it is shown that international standards do not provide sufficient risk protection. Problems with harmonization of standards may arise if for example, an importing country refuses permission to import product from a country with a new or notifiable viral disease and the exporting country does not have the mechanism to ensure the product is free from the virus. Under these circumstances, the WTO has agreed to help the exporting country with its testing procedures. Settlement of disputes bilaterally is encouraged, but the WTO has its own procedures and impartial bodies are available if this is not possible (Fegan, 2000).

Office International des Epizooties (OIE)

The Committee of Sanitary and Phytosanitary Measures is linked to the Paris-based Office International des Epizooties (OIE) that sets the international standards for animal health measures. Since 1988, in the area of aquatic animal health the OIE has the Fish Disease Commission (FDC) which is responsible for informing governments of the worldwide aquatic disease situation, coordinating surveillance and control measures possible, and harmonizing regulations for trade amongst member countries. The recently introduced standards for aquaculture are currently limited by the lack of knowledge regarding aquatic disease problems. However, the OIE is continually updating two important documents for aquatic animal health: the International Aquatic Animal Health Code (2002) and the Diagnostic Manual for Aquatic Animal Diseases (2000), which are available free of charge on the OIE website at http://www.oie.int and new versions are due to appear at the end of July, 2003.

International Council for the Exploration of the Sea (ICES)

A code of practice for introductions of non-indigenous marine organisms was set by the International Council for the Exploration of the Sea (ICES) in 1973 and revised in 1994 (ICES, 1995). These codes had recommendations in the following areas: Recommended procedures for deciding on importations of new species; Recommended actions once the introduction has been approved; Encouragement for prevention of unauthorized introductions; and recommended procedures for introduced or transferred species already under commercial cultivation.

Food and Agriculture Organization of the United Nations (FAO)

FAO released a voluntary, but partly internationally legal Code of Conduct for Responsible Fisheries (CCRF) during the FAO Conference of 1995 (FAO, 1995). The CCRF was the result of four years of work following the International Conference on Responsible Fishing in Cancun, Mexico in May, 1992.

Article 9 of the code covers aquaculture development and Article 9.3.3 states that: "States should, in order to minimize risks of disease transfer and other adverse effects on wild and

cultured stocks, encourage adoption of appropriate practices in the genetic improvement of broodstock, the introduction of non-native species, and in the production, sale and transport of eggs, larvae or fry, broodstock or other live materials. States should facilitate the preparation and implementation of appropriate national codes of practice and procedures to this effect".

FAO further issued the "FAO Technical Guidelines for Responsible Fisheries No. 5: Aquaculture Development" in 1997 to provide general advice in support of Article 9 of the CCRF (FAO, 1997).

Asia Regional Initiatives (NACA & SEAFDEC/ASEAN)

Based on Article 9.3.3 of the FAO CCRF, a set of regional guidelines were issued by FAO/NACA in 2000, and called the "Asia Regional Guidelines on Health Considerations for the Responsible Movement of Live Aquatic Animals". These guidelines were developed through three years of awareness raising and consensus building and were adopted by 21 participating countries in the Asia-Pacific region in Beijing in June, 2000.

The guidelines were further adopted by ASEAN Fisheries Working Group in Bali in 2001 as an ASEAN policy document and endorsed by the ASEAN/SEAFDEC Millennium Conference on Fish for People in 2000 in Bangkok (FAO, 2000, NACA/FAO, 2001, SEAFDEC, 2001).

Country level initiatives to control or restrict importation

Despite the existence of these codes, protocols and guidelines, the government and particularly the private sector in both Asia and Latin America continue to introduce new species with little consideration of potential disease consequences. They have thus generally been caught unprepared for the recent epizootic outbreaks involved with shrimp trans-boundary movements. Additionally, their immediate responses have been largely ineffective in preventing or reducing disease losses which may exceed $1 billion/year in direct production losses worldwide, and considerably more in total. Countries which have actively enforced importation bans, with some success include:

- Brazil, Venezuela and Madagascar (who have so far managed to exclude WSSV and YHV)
- Hawaii and the continental United States, who have managed to eradicate WSSV from their culture industry
- the Philippines, who managed to delay the onset of WSSV by 4-5 years (compared to the rest of Southeast Asia), but do have non-SPF *P. vannamei* despite a ban, and
- Sri Lanka, who have still not allowed even experimental importation of *P. vannamei*, for fear of TSV.

Reasons for the lack of success of regulations

Problems with shrimp import limitations

That the numerous codes and guidelines have been largely ineffective at preventing the spread of exotic shrimp and their viral diseases throughout the world is quite apparent. The sheer scale of the cultured shrimp industry and the fact that shrimp are not usually covered by existing livestock legislation on movements gives plenty of gaps for such movements to take place. The reasons for movements are varied and include the following:

Producer driven importation

In many cases, even though governments have implemented guidelines or laws regarding the importation of trans-boundary shrimp species, the private sector has gone ahead with such imports through smuggling, non-disclosure and exploitation of a lack of government control over such importation. Thus, although there may be good reasons for limiting imports and regulations in place, these have little chance of success in limiting imports unless the private sector can be convinced of their validity and importance.

Perception of benefits of introduced species

The largely private sector-led introductions are done, whether or not official restrictions are in place, due to the perceived benefits offered by the introduced species. Thus, in the case of *P. vannamei* introductions into Asia, the current perceptions that: *P. vannamei* are more disease resistant than the indigenous species (*P. monodon* and *P. chinensis*), SPF broodstock can be purchased that are free from disease, and that they are more able to tolerate high density, often low-salinity culture, are the main driving forces behind their introduction. Whether these perceived benefits (Table 2) are true or not is often irrelevant, particularly when Asian shrimp farmers are struggling to make money using their traditional native species. In this case, as has been seen in virtually all Asian shrimp-producing countries in the past few years, the perception of the private sector is that the potential advantages outweigh the disadvantages and so the importation are made.

Whether this perception is correct or not remains unproven. On the positive side, the Asian *P. vannamei* culture industry has seen a rapid expansion in the last few years, so that production of *P. vannamei* has surpassed that of traditional native cultured species in Mainland China, is rapidly approaching that level in Taiwan province of China and Thailand, and is gaining increasing importance in Viet Nam and Indonesia (see Table 3). The generally downward trend in Asian shrimp production during the 1990s, due largely to disease problems with *P. monodon* and *P. chinensis*, has thus now been reversed with the introduction of the relatively more tolerant *P. vannamei*.

On the negative side, the introduction of *P. vannamei* into Asia has been accompanied by the importation of various viruses, including TSV (already causing losses in Mainland China, Taiwan province of China and Thailand) and LOVV (possibly responsible for the slowing growth rate of *P. monodon*) and probably others. The long term effects of these viruses is unknown, but precedents from introductions of shrimp and their viruses from Asia to Latin America (i.e. IHHNV in 1981 and WSSV in 1999) are known to have resulted in severe setbacks to the shrimp culture industry and the socio-economic status of many countries. Additionally, the associated impacts of trans-boundary introductions of shrimp have unknown, but possibly serious consequences for wild shrimp populations and genetic diversity.

RECOMMENDATIONS FOR CONTROL OF MOVEMENT AND CULTURE OF SHRIMP

Since it is clear that the majority of Asian countries have already introduced *P. vannamei* (either legally or illegally) to some extent, there is now some determination to try and ensure that any negative impacts are minimized.

Some countries are considering enforcing their official bans and destroying all stocks found within their borders (i.e. the Philippines and Malaysia). Short of this difficult (and perhaps legally unenforceable) procedure, the species, and in most cases, its attendant viruses, will remain in most countries.

A more pragmatic approach would be the investigation and elimination of all stocks infected with known pathogens, followed by an opening of the borders only to certified

disease-free stocks. This assumes that the testing of stocks for import and the necessary controls of this would be strengthened, since at the moment it is the inability to effectively control imports which has allowed the introductions so far. This approach at least offers a working solution to the reality that *P. vannamei* is already present in many countries and being cultured at significantly economic levels in several. This also allow countries to take advantage of the potential benefits offered with this exotic species and would encourage a more responsible approach to the issue of shrimp movements and disease in the region, what is certain, is that blanket bans on the importation of species (such as *P. vannamei*) which are desired by the commercial sector are ineffective at preventing their introduction, under the current conditions in Asia.

Many recommendations regarding the health implications of the importation of exotic shrimp species (and their attendant pathogens), and their sustainable culture have recently been published. The following list draws heavily from the review made on the management strategies for major diseases in shrimp culture, based on a workshop held in Cebu, Philippines in 1999 (WB/NACA/WWF/FAO, 2001). The recommendations have been modified to focus on the issues involved with the trans-boundary importations of *P. vannamei* and *P. stylirostris* in Asia:

Legislation, Policy and Planning

- Develop improved legal frameworks, monitoring systems and enforcement capabilities to control and register importation and culture of exotic shrimp species.
- Increase interaction between planners, policy makers, industry and other stakeholders to discuss strategies (and their application) for practical approaches to environmentally friendly and sustainable farming of exotic shrimp species.
- Recognise in legislation the differences between “soft laws”, codes and guidelines, and regional or international agreements and WTO “hard laws”.
- Legislate penalties for beaches of legislation or quarantine and illegal activities such as smuggling, examine the issue of liability.
- Develop and/or apply “best practices” for management of the shrimp industry based on continuous refinements of the FAO CCRF and similar guidelines on aquaculture development. This should include incorporation of quality assurance programmes (HACCP) into all aspects of the shrimp culture system.
- Develop government infrastructure and industry liaison and registration of aquaculture facilities, so that codes of practice can be developed and followed, certifications or accreditation made, expertise in disease control identified and communication and awareness raised for the benefit of both parties.
- Begin to regionally harmonize and implement Import Risk Analysis (IRA) to help prevent disease transmission. Training officials in the IRA process should be given priority.
- Implement, and if necessary, design, environmental Impact Assessments (EIA) that take account of disease transmission issues with imported species.
- Formulate national policies recognizing the importance of shrimp farming as a contributor to national development and assisting its development.

- Formulate plans for comprehensive shrimp health management strategies using existing and novel approaches to correct problems in the environment, animal and pathogen.
- Develop contingency plans and provide financial, technical and educational assistance for farmers suffering from disease outbreaks.
- Enforce coastal area management regulations of relevance to shrimp farming.
- Critical analysis of approval process for shrimp farms farming exotic species.

Regional and International Cooperation

- Member states must advise OIE of any outbreaks of notifiable pathogens.
- Link national diagnostics and disease control systems with other countries' networks to strengthen regional cooperation.
- Establish a regional disease information network/website and a timely disease reporting system.
- Organize regional annual meetings and workshops on shrimp health management for dissemination of information.
- Establish data base of facilities offering certified disease-free SPF and resistant SPR stocks.
- Give priority to collaboration between Latin American and Asian regions for cross-fertilization of ideas.
- Recognise and identify the roles and inputs of NGOs.

Disease Management Issues

- Establish national reference pathology labs to inter-calibrate with, and assure the quality of, private disease labs, and collaborate with the existing OIE reference labs.
- Initiate Quality assurance programmes, including standardization of techniques and training in disease diagnosis labs to ensure their utility in the control of disease transmission.
- Require that all facilities exporting shrimp have a minimum 2 year disease free status, are certified as such and can submit independent, qualified certification of their status.
- Submit properly collected samples of imported shrimp to certified disease diagnosis laboratories for assurance of disease-free status, whist maintaining shrimp in biosecure quarantine facilities before release into the environment.
- Conduct co-habitation trials of all imports with indigenous shrimp species to prevent the entry of unknown pathogens that pose high risks to local species.

Research and Development

- Fund programmes to investigate methods of combating disease threats (with public/private sector cooperation).

- Investigate advantages and disadvantages of exotic shrimp for the culture industry of each country to determine its suitability for import.
- Establish closed cycle breeding programmes to produce high quality SPF and SPR seed used for stocking ponds for both exotic and indigenous species.
- Identify all potential viral pathogens and develop specific and sensitive tools for their detection appropriate for both lab and farmer level.
- Research case-specific farming systems for each species so that it can be utilized optimally appropriate to local conditions.
- Establish programmes to monitor aquatic environments in and around shrimp farming areas, including effects of culturing new species on wild populations.
- Conduct routine analysis on the effects of new viruses on imported and indigenous hosts through cohabitation studies so that any effects or changes of viral pathogenicity can be monitored, and measures for its control investigated.
- Conduct routine monitoring of wild shrimp populations for all pathogenic viruses, including an assessment of which species develop the disease and which act as carriers, with attempts made to discover the source of any contamination.
- Assess the relative risk factors involved with each potential vector of shrimp pathogens to assist development of more appropriate intervention strategies for disease control.
- Evaluate viability of alternative shrimp farming systems (i.e. utilizing low-salinity and/or inland farming areas and high density, low impact culture systems).
- Investigate shrimp production and health management capabilities and practices to determine suitable codes and guidelines for culture of exotic species.
- Investigate best methods for dissemination of information pertaining to importation and management of exotic shrimp species.
- Develop epidemiological approaches to disease management.
- Evaluate water treatment methods for their ability to reduce disease risk.
- Develop simple, low-cost methods of reducing exposure to disease carriers.
- Evaluate the effectiveness of green water and shrimp/fish polyculture techniques for reducing disease outbreaks.

Infrastructure, Capacity building and Training

- Establish a network of collaborating and cross-referencing disease diagnosis laboratories with state of the art equipment and trained manpower.
- Consider reinvestment of export profits to improve health management capabilities.
- Develop biosecure high-health maturation systems and hatcheries for exotic and indigenous species with functional quarantine systems for holding imported animals whilst they are screened, and training facilities/extension for the local farmers.

- Develop a programme for the culture and genetic selection of exotic and indigenous species to aid development of improved broodstock with desirable culture characteristics, and training of farmers/extension agents in this technology.

- Allocate the necessary equipment, personnel, training and travel required for disease diagnosis, interpretation of test results, and assessment of shrimp health management practices at laboratory and farm level.

- Where required, provide overseas training or seminars from experts for government employees, trainers, extension officers and farmers on the techniques required to produce exotic species sustainably.

- Improve information dissemination and increase farmer awareness of issues involved with the importation and culture of exotic shrimp so that farmers have the facts and can clearly understand the potential risks and benefits involved. Collaboration between farmer's associations and the relevant government agencies would assist this process.

- Establish databanks on all shrimp farms, perhaps using GIS technology for effective regulation, assessment, monitoring and law enforcement.

- Promote training in the epidemiology of major shrimp diseases to improve awareness and develop practical health management schemes at farm, national and regional levels.

Industry Management and Technological Requirements

- A series of guidelines for health management in shrimp hatcheries and growout ponds were made at the Workshop on Management Strategies for Major Diseases in Shrimp Aquaculture in the Philippines in 1999 (WB/NACA/WWF/FAO, 2001).

- These were used as a basis for a subsequent Latin America/Asia inter-regional meeting on shrimp diseases funded by APEC, held in Mexico in 2000.

- Out of this meeting a report entitled "Technical Guidelines for the Management of Health and Maintenance of Biosecurity in White Shrimp *Penaeus vannamei* Hatcheries in Latin America" was produced (FAO, in press).

Industry based BMP recommendations

- The Global Aquaculture Alliance (GAA) has also produced and is distributing a set of "Codes of Practice for Responsible Shrimp Farming" and operating procedures for shrimp farming based on a 2001 survey of World shrimp farming practices.

- These guidelines were formulated to assist the development of national and regional codes of practice to help the shrimp farming industry and are available from the GAA website

- For example, the GAA Shrimp health management code of practice has, as its purpose, to promote shrimp health management as a holistic activity in which the focus is on disease prevention instead of disease treatment. They state that authorities on shrimp health management recognize that stress reduction through better handling, reasonable stocking densities, good nutrition, and optimal environmental conditions in ponds can prevent most infectious and non-infectious diseases.

- Also, treatment should be undertaken only when a specific disease has been diagnosed. In addition, effective measures must be taken to minimize the spread of diseases between farm stocks and from farm stocks to natural stocks.

References

Camera Nacional de Acuacultura (CNA) website: http://www.cna-ecuador.com

FAO 1995. FAO code of conduct for responsible fisheries. Rome, FAO. 1995. 41p.

FAO in press. Technical guidelines for the management of health and maintenance of biosecurity in white shrimp (*Penaeus vannamei*) hatcheries in Latin America. Part of the project: Assistance to Health Management of Shrimp Culture in Latin America: TCP/RLA/0071(A).

FAO/NACA 2000. Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals and the Beijing Consensus and Implementation Strategy. NACA, Bangkok and FAO, Rome.

Fegan, D., Arthur, J.R., Subasinghe, R.P., Reantaso, M.B., Alday de Graindorge, V. and Phillips, M.J. 2001. Consultant report: A review of trans-boundary aquatic animal pathogen introductions and transfers. In: Report of the Puerto Vallata Expert Consultation. APEC/FAO/NACA/SEMERNAP, 2001. pp. 132-175.

Global Aquaculture Alliance (GAA) website: http://www.gaalliance.org

ICES. 1995. ICES code of practice on the introduction and transfers of marine organisms 1994. Annex 3 of the report of the advisory committee on the marine environment, 1994. ICES Cooperative Research Report No. 204.

Lightner, D.V. *et al.* 2002. Six morphologically-distinguishable populations of *P. stylirostris*. Marine Biology 137 (5-6):875.

NACA/FAO 2001. Aquaculture in the Third Millennium. Subasinghe, R.P., Bueno, P.B., Phillips, M.J., Hough, C., McGladdery, S.E. and Arthur, J.R. (Eds). Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. 471 pp. NACA, Bangkok and FAO, Rome.

OIE (Office International des Epizooties) website: http://www.oie.int

Rosenberry, B. 2002. World shrimp farming 2002. Shrimp News International, 276 pp.

SEAFDEC 2001. Regional guidelines for responsible fisheries in Southeast Asia. Responsible aquaculture. SEAFDEC, Iloilo, Philippines, 2001. 43pp.

WB/NACA/WWF/FAO 2001. Thematic Review on Management Strategies for Major Diseases in Shrimp Aquaculture. Proceedings of a workshop held in Cebu, Philippines on 28-30 November 1999. Edited by R. Subasinghe, R. Arthur, M.J. Phillips and M. Reantaso. 135 pp.

Wyban, J.A. and Sweeney, J.N. 1991. Intensive shrimp production technology. High Health Aquaculture Inc., Hawaii. 158 pp.

Case studies

Role of exotic species in aquaculture: problems and prospects in Indochina

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The participants of four national workshops recommended that the countries should be cautious of future introductions of new exotic species and their release into natural water bodies

Abstract

National workshops were held in Cambodia, Lao People's Democratic Republic, Thailand and Viet Nam to consult local experts and users of introduced exotic aquatic organisms on the positive and negative impacts of the introduction, with a view to recommend the preparation of a regional code of conduct on the management of already introduced and new exotic species.

Exotic species have provided socio-economic benefits for a vast number of poor people in the region. There is no accurate information on their spread and negative ecological impacts as few studies have been conducted to evaluate these impacts. There is an urgent need to develop a well planned research program to assess the impacts. The governments should carefully weigh both the positive and negative impacts for each species before making any national or regional policy. After such evaluation it is necessary to develop a code of conduct for the management of alien species.

The code of conduct should address the issues of zoning, risk analysis, health certification, quarantine, development of inventory of species according to invasiveness and non-invasiveness, capacity building for monitoring and implementation of codes, and regional information exchange.

Introduction

Exotic animals are defined as "species occurring outside of its natural range". Among numerous reasons for introduction of exotic aquatic animals into countries, aquaculture development is said to be a main motive (Welcomme, 1998 and FAO DIAS). Major concerns over the introduction of exotic fish are prolific breeding, predation or competition of the introduced species affecting indigenous biodiversity. These may lead to potential dominance of the introduced species, diseases transmission or contamination of local genetic pools.

There are two levels of aquatic animal introduction in Asia: (1) new species and (2) genetic variants or 'strains' of a particular species. Review on potential impacts of exotic species in the Mekong Basin indicates that positive impacts far outweighed any negative to date. However, there is a need for developing Codes of Conduct to limit negative consequences of future introductions and regional guidelines for quarantine and health certification The Code of Conduct developed by European Inland Fisheries Advisory Commission (EIFAC) is usually taken as an example for such endeavours in Asia. Much of the recommendations made by various authors and organisations relate to present or future trans-boundary fish movements affecting genetic contamination and disease risk.

Many inland aquaculture species used in Asia are exotic. For example, with the exception of silver barb, striped catfish, and freshwater prawn, all cultured inland species in Thailand have been introduced within the last century. There are numerous unanswered questions regarding continuous use of exotic species in aquaculture such as:

- What are the existing guidelines for continuing the use of new and already introduced and established fish species in aquaculture?
- Have exotic fish established significant feral populations in Asia?
- Have they impacted adversely (ecologically as well as genetically) on local biodiversity?
- Have they introduced new diseases?
- What are the socio-economic benefits of these species?
- Does culturing these species benefit the rural poor?
- What is the trade-off between the environmental cost, if any, and the social benefits?
- Are there alternative indigenous species that can meet the needs of aquaculture production?
- What are the relative risks of spreading domesticated indigenous species on the genetic diversity of the same species within their natural range?

There is an urgent need to find answers to such questions. Environmental and poverty focused developmental organisations frequently question the ethics of using public funds for research and promotion of introduced exotic species.

The Asian Institute of Technology conducted National workshops in four countries: Cambodia, Lao People's Democratic Republic, Thailand and Viet Nam in search of answers to aforementioned questions. Key informants representing all stake holders were invited to gather and present information on impacts and to air national views on introduced species. The scope of this study was to examine the environmental and socio-economic impacts of the introduction of exotic species in South East Asia with focus on Thailand, Viet Nam, Lao People's Democratic Republic and Cambodia and consequently help develop a draft Code of Conduct and Regional Guidelines on the use of new and already introduced species in aquaculture in the region. This paper presents the major findings from the four national workshops as well as recommendations for developing Regional Guidelines to reduce/ eliminate potential negative impacts caused by exotic aquatic organisms.

Exotic species have provided socio-economic benefits for a vast number of poor people in the region

National workshop methodology

Workshops were convened in Thailand (24 Sept. 2002), Cambodia (3 – 4 Oct. 2002), Lao People's Democratic Republic (22–24 Nov 2002) and Viet Nam (20–21 May 2003); 30-40 key informants representing a wide range of expertise including fishermen, fish farmers, hatchery managers, extension workers, researchers, university lecturers, policy makers and environmentalists attended. Selected subject matter experts presented theme papers during the workshops. The participants were then divided into groups according to the profession e.g. producers, extension officers, academics and researchers. The major issues embodying the questions mentioned above were identified and discussed in the group sessions. Recommendations were then developed to alleviate negative impacts of exotic species introductions.

Current status on the introductions of aquatic organisms in Indochina.

A brief summary of aquatic animal introductions, their potential impacts, and the workshops' recommendations are presented below.

CAMBODIA

The participants identified 18 introduced aquatic species in Cambodia (Appendix A1) including, snails, crocodile and seaweeds. The purpose of introduction is said to be aquaculture development. *Clarias gariepinus* (African catfish) was the first fish species to be introduced from Viet Nam in 1982. Tilapia, silver carp, Indian carps (rohu, catla, mrigal) and common carp are found in natural water bodies in Kandal, Svey Rieng, Ta Kao, and Kampong Speu provinces. From the appearance in fishing lots, exotic species occupy less than 1% of the catch. Some of these species, e.g. Tilapia, Chinese and Indian carps, are said to be deliberately introduced by development projects or NGOs for aquaculture development. The rest of the species are believed to be either deliberately introduced or migrated by natural means from Viet Nam. No information about population size of exotic species in Cambodian waters is available, even though the first three species are widely used for aquaculture.

The participants identified following positive impacts of introduced species:

- easy to breed;
- small-scale farmers can produce seeds (seeds readily available);
- easy to culture (disease resistance, ability to use locally available feeds, and less attention to the culture system or less time spent for culturing fish);
- relatively higher production over indigenous species (faster growth and high survival);
- compatibility with agro-ecosystems (e.g. can integrated with rice farming or can grow in upland areas);
- source of alternative income (via sale of table fish or seeds);
- improves livelihood of people (poor people can either afford to buy exotic species due to relatively lower market price to culture them, improved nutrition of poor, improved income, employment opportunities);
- Golden snail has become a major protein source of animal/ fish feeds (poor people can collect 10 – 15 kg/day and sell to the feed companies).

Identified negative impacts were:

- over breeding of tilapia (cannot restrict to the culture system and escape to natural waters);
- water turbidity caused by common carp;
- potential negative environmental impacts;
- potential gene pool contamination (e.g. *Clarias* catfish);
- competition for habitats and natural food;
- potential loss of indigenous species (e.g. *Notopterus notopterus* is believed be decreasing in Angkor Borey district of Ta Kao province; some participant believe catch (including Notepterus) has been reduced by 20% after introduction of tilapia or other exotic species);
- potential for disease contaminations;
- low demand (low price);
- potential price drop of indigenous species due to cheaper price of introduced species;
- Golden snail damages rice paddy.

The Cambodian workshop recommended that:

- Cambodia should not import new exotic species;
- only indigenous species should be used in fish releasing ceremonies;
- hatchery and culture technologies for indigenous species should be developed;
- research should be conducted to evaluate the impacts of existing exotic species;
- the country should promote culture of exotic species away from natural water bodies;
- the Ministry of Agriculture should develop guidelines/ regulations for movement of existing/new exotic species within country;
- the regulation should delineate zones that exotic species can be cultured (rural areas away from natural waters).

Lao People's Democratic Republic

Exotic species introduction has long history in Lao People's Democratic Republic. However, as fish culture is new to Lao People's Democratic Republic, most introductions (Catla, Mrigal, Rohu and common carp) were brought in 1977 from India and Thailand for aquaculture development with the assistance of international organizations. Nile tilapia was introduced from Thailand in 1965. *Clarias gariepinus* was introduced from Viet Nam in 1980 for aquaculture development. Participants of the workshop pointed out that there are about 13 alien species introduced. (Appendix A2). However, only common carp and Nile tilapia have established their population in the wild through natural reproduction.

Except for the golden apple snail, no information is available on the negative impacts of introduced species. Nile tilapia and common carp are used for cage culture. In 1995, farmers accidentally have released cage cultured fish to Nam Ngum reservoir. Participants claimed

that after this incidence, there was an increase in Nile tilapia, bighead carp and common carp population in the reservoir. The participants identified that grass carp, common carp and African catfish as high risk species

The workshop recommended that:

- introduction of new exotic species should be strictly controlled and exotics already introduced should only be used for pond culture;
- high risk species such as grass carp, common carp and African catfish should not stock in the natural water bodies;
- enhance public awareness on potential negative impacts of these species
- should develop proper quarantine procedures;
- conduct research to evaluate negative impacts pf already introduced exotic species and socio-economic benefits of using native and less risk exotic species;
- develop culture techniques for indigenous species;
- should develop appropriate policies, management tools taking both positive and negative impacts into account;
- develop specific measurement for developing zones that allowed to culture exotic species and to control fish movement;
- strengthen the manpower and build the capacity for implementing policies and regulations.

VIET NAM

Participants of the workshop agreed that there have been uncontrolled introductions of 30 alien species in Viet Nam (Appendix A3). Chinese carps were introduced directly from China in 1958 by the Government of Viet Nam. Indian Major Carps were introduced from Lao People's Democratic Republic in 1984 with the help of an international organization. All these Indian and Chinese major carps are still widely used for aquaculture and have also established their population in the wild. *Oreochromis mossambicus* was brought from Africa and the Philippines by the private sector for farming in 1951 and 1955 respectively. It has established its population in the wild through its prolific reproductive nature. It is also widely cultured. Nile tilapia was imported from Taiwan, Philippines and Thailand. *Pomacea canaliculata* has been found in Viet Nam in 1988 and has most probably been introduced through the ornamental fish trade.

Alien aquatic animals are introduced to Viet Nam to diversify fish production, improve genetic materials and reduce inbreeding, improve food security, improve farmer income, creating job opportunities, use for ornamental purposes, and to use as larval/ aquarium feed e.g. Artemia. These introduced species are preferred by farmers due to well developed breeding and culture technologies, breeding potential in captivity (e.g. *P. vannamai*), high fecundity, resistance to certain diseases, higher production (fast growth and high survival), higher dress weight, ability tolerate adverse water quality, and the commercial value in both local and export markets.

There are numerous unanswered questions regarding continuous use of exotic species in aquaculture

The participants identified following benefits of introduced species:

- enhanced aquaculture production (fast growth, high survival rate, high dress weight);
- high market value;
- foreign exchange earning;
- enhanced food security of poor e.g. 35% exotic species production is used for local consumption, mainly by the poor;
- improvement in farmer income and employment opportunities;
- offer opportunity to develop hybrids that have higher growth compared to the local fish e.g. common carp and mechanism to resolve inbreeding problem of introduced species;
- can use for waste recycling/ local resources, weed control e.g. grass carp, and for mosquito control;
- some species do not breed/ survive in the natural environment e.g. introduced Artemia;
- use as live food e.g. Artemia;
- provide opportunity for in-country broodstock development;
- easy to enhance stocks;
- aesthetic and social (status) value of some ornamental species.

Since no studies have been conducted on ecological or genetic impacts, there is no scientific evidence for negative impacts. The only species that has shown clear negative impacts is the golden snail destroying rice fields. Other species that have potential for negative impacts are tilapia, grass carp, silver carp, bighead carp, Colosoma, *P. vannamei* and sucker catfish as they have established significant feral population in the natural environment. Gene pool contamination is common in some species e.g. between native and Chinese silver carp hybridization, and common carp (native and imported). Inbreeding problems of exotic species are common, e.g. African catfish originated from only one pair of fish.

Exotic species have introduced new parasites and diseases e.g. three new species of monogenea come with tilapia, and have reduced biodiversity by changing the species composition natural water bodies e.g. fishers in Thac Mo Reservoir in Binh Phuoc province believed that tilapia has eliminated or reduced some local fish species in the lake.

Import of exotic species is controlled by restricting species that can be imported e.g. there is a list of aquatic species which can be imported to Viet Nam. The Natural resources protection act, 1989, provides guidelines for methods of protection of indigenous aquatic resources. Decision paper, 2002, shows procedures to import new species i.e. should be disease free, for experiments, and how to receive permission to release to natural environment

The Vietnamese workshop recommended that:

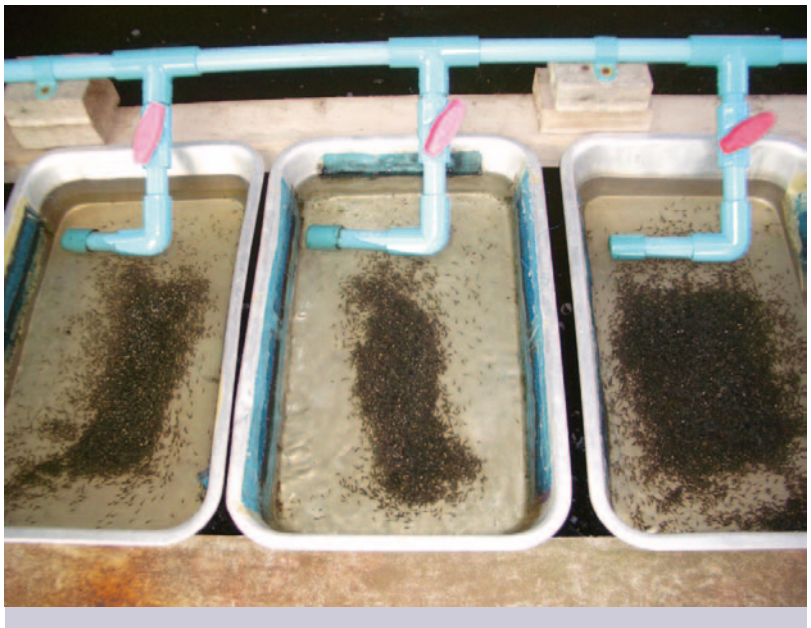
- research should be conducted to evaluate positive/negative impacts;
- methods for environmental impact assessment of exotic fish species should be developed;
- strict implementation of aquatic animal inspection procedures by the custom department;

- proper quarantine system should be developed;
- control mechanisms for controlling invasive exotic species such as golden snail should be developed;
- regulation for the stocking of fish species to natural water bodies should be developed;
- trans-boundary animal movement regulations should be developed and implemented;
- code of conduct for exotic species (import and their use) should be developed;
- capacity to implement regulations (the development of manpower) should be strengthened.

THAILAND

Altogether 163 aquatic organisms including seven species of frogs, seven crocodile species, three shrimp species, over 100 species of ornamental aquatic organisms and about 20 food fishes (Appendix A4) for the aquaculture development have been introduced into Thailand during the last century. Nile tilapia (*Oreochromis niloticus*) was introduced as a gift by the Crown Prince of Japan to the HM King of Thailand in 1965 (Pullin, 1988) then distributed to the farmers through department of fisheries after successful breeding, which has been widely used for aquaculture. This species is now widely distributed in the natural ecosystem. There is some evidence that tilapia has become a main species in Ubolratana (up to 40% catch) and Lam Ta Kong reservoirs, but no information on negative impacts are available. Although other tilapia species such as *T. rendalli*, *T. zilli*, *O. aureus* and *O. mossambicus* were also introduced into Thailand, they were not cultured. Red tilapia is found in the country but they are not separate species and thought to be the hybrids of *O. niloticus* and *O. mossambicus*. Recently, new red tilapia hybrids have been introduced from various countries e.g. Taiwan, Virgin Island, Scotland, and Malaysia. This hybrid has become commercially important species to Thailand as it has higher demand due to their attractive colour. Salinity tolerance and faster growth have made red tilapia popular in coastal areas.

A few alien species have established their populations in the natural environment through natural reproduction. Out of over 30 exotic food fish species, only carps, tilapia, hybrid catfish and white shrimp have been commercially used for aquaculture. Populations of grass and silver carps have been established through continuous re-stocking into the lakes and reservoirs for their characteristic feature of controlling excessive vegetation and plankton bloom respectively. An exotic sucker fish has been found in the rivers of Thailand which has been caught by fishermen in large numbers.



Increased freshwater fish production, provision of protein

source to rural poor, income and employment generation and enhanced export income are the major positive benefits of introduced food fish species (Boonchuwong, 2002). A fish consumption survey in 1998-1999 in seven provinces of North, Northeast and central regions has shown that Thai people on average consumed 28.8 kg fish/person/year. Exotic species accounted for 12 kg fish/person/year (41.6%) of the total fish consumption. The highest consumed exotic species is Nile tilapia which account for 8.52 kg fish/person/year for the seven provinces. Nearly 46% (13.8 kg fish/person/year) of fish consumed in rural areas are exotic species (Boonchuwong, 2002). Nile tilapia accounts for 9.84 kg fish/person/year (33%) of the total fish consumption (29.88 kg fish/person/year) in the rural areas of the seven province.

Table 1. Aquaculture production including marine species (FAO 1999, 2001)

Country	Aquaculture production		Contribution of exotic species (%)
	Total	Exotic species	
Cambodia	15 500	7 650	49
Lao People's Democratic Republic	49 840	49 480	100
Thailand	724 228	191 246	26
Vietnam	545 500	390 000	73

Very limited research has been conducted in Thailand to evaluate the negative impacts of fish introductions. Na-Nakorn *et al.* (2002) showed evidence for presumed genetic introgression of *Clarias gariepinus* genes into indigenous *C. macrocephalus* and called for making proper management plans for protecting aquatic biodiversity. They also uncovered genetic differentiation between hatchery bred stock of silver barb (*Puntius gonionotus*) and their wild counterparts and cautioned that restocking programs should not use aquaculture stocks.

National laws prohibit introduction of well known invasive fish species e.g. piranha and twelve other endangered aquatic organisms. Other control measures are restricted to avoid disease outbreaks and dangers to the consumers. Other species can be imported to Thailand taking permission from competent officials. However, the main problem of controlling the introduction of exotic species is lack of proper regulation and implementation (Chinabut, 2002).

Thai national workshop recommended:

- conduct new research to evaluate ecological and socio-economic impacts,
- develop culture technologies for indigenous species,
- develop procedures for risk assessment studies,
- risk assessment studies should be conducted before allowing the introduction of new species,
- implement existing guidelines and assign a group to oversee introduction of exotic species,
- develop guidelines and manuals for each alien species and analyse the risks.

Conclusion and recommendations

A vast number of exotic species has been introduced to SE Asia. Some introduced species (e.g. tilapia, common carp) have established significant feral populations and the local communities consider them indigenous species. There is some evidence on the alteration in genetic make-up of the indigenous species (e.g. *Clarias* sp. in Thailand), and in the catch composition (e.g. 70–80% catch from Cheng Ek lake in Phnom Penh said to be tilapia).

Exotic species have made socio-economic benefits to each country covered in this study. The exotic species have played significant roles in ensuring food security. These species accounted for about 49, 100, 26 and 73% of the total aquaculture production in Cambodia, Lao People's Democratic Republic, Thailand and Viet Nam, respectively (Table 1).

Since the culture technologies are well developed for these species, they have served as gateways of knowledge and skills for aquaculture development in the region. Hatchery and culture operation, and research into exotic species have given a large number of employment opportunities. Exotic species have served as agents for crop diversification for rural poor.

According to Dowall (1996), introduced Nile tilapia and common carp maximized the natural fertility of the paddy fields in Cambodia. Introduced trout has been reported to increase benthic phosphorous availability and stimulate the primary production (Schindler *et al.*, 2001).

There are a number of negative impacts have been attributed to exotic species. The population of *Notopterus notopterus* has been reported to be declining in Cambodia (especially in Ta Kaew) and other fish also have been reported to be declining due to exotic species such as tilapia which constitutes up to 80% of the catch in Chiang Ek Lake near Phnom Penh. In Lao People's Democratic Republic, it has been suspected that the native prawn has declined. *Hamparadispa* sp. and Pla Ka in Nam Ngum reservoir in Lao People's Democratic Republic and a local snail have disappeared most probably due to exotic fish introductions. Tilapia has also been found abundantly in the wild of all four countries studied here. In Ubonrat reservoir, tilapia can constitute up to 40% of the catch. Tilapias have also been caught in large volumes in other reservoirs of Thailand. De Iongh and Van Zon (1993) studied the impacts of the introduction of common carp, Nile tilapia, and Indian and Chinese carps into the lakes and reservoirs in northeast Thailand. According to local fishermen who caught sucker fish in large numbers from the rivers of Thailand the species might have serious impacts on indigenous species as it is a carnivorous. Participants agreed that the sucker catfish (*Hypostomus plecostomus*) has been seen in significant numbers in the natural water bodies in all the four countries, especially in the rivers.

Several diseases and parasites have been diagnosed in the exotic fish species in each of the four countries. However, it is not clear whether all these disease pathogens came with the imported fish or not. In Thailand, three fish diseases have been recorded as having entered the country along with the introduced fish (Piyakarnchana, 1989). One of the most devastating examples is white spot disease that causes virus in shrimp which was suspected to be transmitted through importation of shrimp larvae, adults, even through frozen forms and other modes (Jory *et al.*, 1999; Soto *et al.*, 2001).

There are many alternative indigenous species in the region as the Mekong River and its tributaries are rich in natural flora and fauna. There are over 1 000 indigenous species identified. However, very limited studyies have been done so far in order to bring them into culture. Silver barb has been an important species among the cyprinids. Some studies

are under way on the breeding and culture of seven Mekong indigenous species. There are indications that they can be bred and cultured in captivity but are much difficult to breed and grow slower than exotic species.

Exotic species have created socio-economic benefits for a vast number of poor people in the region. More information is needed on their spread and impacts (Welcomme and Vidthayanon, 2000) There is an urgent need to develop a well planned research program to assess the impacts. The governments should carefully weigh both the positive and negative impacts for each species before making any national or regional policies. After evaluating positive and negative effects, it is necessary to develop guide lines for management of alien species.

The participants of four national workshops recommended that the countries should be cautious of future introductions of new exotic species and their release into natural water bodies. Although there are some existing regulations in these countries, there are no specific laws or implementing agencies. All four countries suggested efforts should be made to develop common agreement of regional level cooperation.

Although there are many international conventions and agreements to address the issue e.g. for example, FAO Code of Conduct for Responsible Fisheries, ICES/IFAC code, Convention on Biological Diversity (CBD), WTO agreements of Animal health and certification, OIE aquatic animal health, Bio-safety regulations, Ramsar Convention, FAO/NACA fish health guidelines, French Rural Code, none of them adequately and appropriately addresses the issue of introductions and regulations of exotic species in the region. Therefore, participants recommended developing a suitable code of conduct taking cultural and economic situation into account. The code of conduct should also address the issues of zoning, risk analysis, health certification, quarantine, development of inventory of species according to invasiveness and non invasiveness, capacity building for monitoring and implementation of codes, and regional information exchange.

References

Boonchuwong, P. 2002. Socio-economic impacts of Introduced exotic species for consumption A National Workshop on Exotic Species use in Aquaculture, DOF/AIT, 140 pp.

Chinabut, S. 2002. Introduction of exotic species and originated new diseases. A National Workshop on Exotic Species use in Aquaculture, DOF/AIT, 140 pp.

Dowall, S. 1996. Farmer research builds capacity for small-scale integrated aquaculture development. ILEIA Newsletter: 12(2): 14-15.

FAO-DIAS www.fao.org/WAICENT/FAOINFO/FISHERY/statist/fisoft/dias/index

FAO, 1999. Aquaculture production statistics. 1988-1997, Fishery Information, Data and Statistics Unit, FAO Fisheries Department, FAO, Rome, Italy, 1999. 203 pp.

FAO, 2001. Aquaculture production statistics. 1988-1997, Fishery Information, Data and Statistics Unit, FAO Fisheries Department, FAO, Rome, Italy.

De Iongh, H.H. and Van Zon, J.C.J., 1993. Assessment of impact of the introduction of exotic fish species in north-east Thailand. Aquaculture and Fisheries Management, 1993. 24: 279-289.

Jory, D.E., and Dixon, H.M. 1999. Shrimp whitespot virus in the western hemisphere. Aquaculture Magazine 25(3).

Na-Nakorn U., W. Kamonrat and S. Poompuang 2002. The Genetic Impacts of Introduced Species and Hatchery Stocks on Aquatic Biodiversity in Thailand. A National Workshop on Exotic Species use in Aquaculture, DOF/AIT, 140 pp.

Piyakarnchana, T. 1989. Exotic aquatic species in Thailand, p. 119-124. In Proceedings of a workshop on introduction of exotic aquatic organisms in Asia, De Silva, S.S. (ed). Asian Fisheries Society.

Pullin, R.S.V. (ed). 1988. Tilapia genetic resources for aquaculture – proceedings of the workshop on tilapia genetic resources for aquaculture, 23-24 March 1987, Bangkok, Thailand. ICLARM Conference Proceedings 16. 108 pp.

Schindler, D.E., Knapp, R.A. and Leavitt, P.R. 2001. Alteration of nutrient cycles and algal production resulting from fish introductions into mountain lakes. Ecosystems 4(4): 308-321.

Soto, M.A., Shervette, V.R. and Lotz, J. 2001. Transmission of white spot syndrome virus (WSSV) to Litopenaeus vannamei from infected cephalothorax, abdomen or whole shrimp cadaver. Dis. Aquat. Organ. 45: 81-87.

Thuok, N., Korn, L. and Chenda, T. 1999. Fisheries monitoring, control and surveillance in Cambodia. Report of a regional workshop on fisheries monitoring, control and surveillance. Kuala Lumpur, Malaysia, 29 June – 3 July, 1998. FAO FISCHCODE/MCS Report, Rome, Italy, pp. 7-17.

Welcomme, R. 1998. Evaluation of stocking and introductions as management tools, pp. 397-413.In Stocking and Introduction of Fish, (ed.), Cowx, I.G. Fishing News Books, A division of Blackwell Science Ltd. 456 pp.

Welcomme, R. and C. Vidthayanon, 2000. The impacts of introductions and stocking of exotic fish species in the Mekong basin and policies for their control. Management of Reservoir Fisheries in the Mekong Basin, MRC. Vientiane. 70 pp.

Appendix A1

Some important exotic species identified by the workshop participants in Cambodia

S.N.	Common name	Scientific name	Remarks
1	Big head carp	Aristichthys nobilis	Breeds in natural water bodies itself
2	Grass carp	Ctenopharyngodon idella	Not known
3	Common carp	Cyprinus carpio	Breeds in natural water bodies itself
4	Silver carp	Hypophthalmychthys molitrix	Breeds in natural water bodies itself
5	African catfish	Clarias gariepinus	Not known
6	Rohu	Labeo rohita	Not known
7	Mrigal	Cirrhinus mrigala	Not known
8	Catla	Catla catla	Not known
9	Java Tilapia	Oreochromis mossambicus	Not known
10	Nile tilapia	Oreochromis niloticus	Not known
11	Red tilapia	O. niloticus x O. mossambicus	Not known
12	Cuban crocodile	Crocodilus rhombiser	Not known
13	Australian crocodile	-	Not known
14	Turtle	-	Not known
15	Shoft shell turtle	-	Not known
16	Golden snail	Pomacea canaliculata	Breeds in natural water bodies itself
17	Snail from Vietnam	-	Golden apple snail
18	Sea weeds	-	Not known

Appendix A2

Major exotic species and their impacts identified the workshop participants in Lao People's Democratic Republic

Fish Species	Year	Origin	Reason	Ecological impact		Social economic impact	
				Positive	Negative	Positive	Negative
Catla catla	1977	Thailand/ India	Aquaculture	Does not destroy habitat	None	Beneficial	Cannot breed in the wild
Ctenopharyng- odon idella	1977	China	Aquaculture	Unknown	Probably yes	Unknown	Cannot breed in the wild
Cirrhinus Mrigala	1977	Thailand/ India	Aquaculture	Unknown	Probably yes	Unknown	Cannot breed in the wild
Clarias gariepinus	1980, 1986	Vietnam, Thailand	Aquaculture	Unknown	Hybridization	Beneficial & People prefer	Low price, hybrid
Cyprinus carpio	1965	Thailand	Aquaculture	Unknown	Yes	Beneficial, productive	
Laobeo Rohita	1965	Thailand	Aquaculture	Does not destroy habitat	None	Beneficial	Cannot breed in the wild
Oreochomis mossambicus	1965	Thailand/ Japan	Aquaculture	Unknown	Yes	Beneficial & People prefer	Unknown
Oreochromis niloticus	Unknown	Thailand	Aquaculture	Unknown	Yes	Beneficial & People prefer	Unknown
Pomacea canaliculata	1986	Thailand	Ornamental	Unknown	Unknown	Unknown	Unknown
Red tilapia	2002	Singapore	Cage culture	Unknown	Unknown	Unknown	Unknown
Ornamental fish	various	various	Ornamental	Unknown	Unknown	Unknown	Unknown
Freshwater prawn	NA	Thailand	Aquaculture	Unknown	Unknown	Unknown	Unknown
Fresh water ray	NA	NA	Aquaculture	Unknown	Unknown	Unknown	Unknown
Soft shell turtle	NA	NA	Aquaculture	Unknown	Unknown	Unknown	Unknown
Frogs	NA	NA	Aquaculture	Unknown	Unknown	Unknown	Unknown
Elephant ear fish	NA	NA	Aquaculture	Unknown	Unknown	Unknown	Unknown
Ice fish	NA	China	Not known	Unknown	Unknown	Unknown	Unknown

Appendix A3

Major exotic fish/shrimp species introduced to Viet Nam identified by the workshop participants

Common name	Scientific name	From	Number of introductions	Year introduced
Black Tilapia Nile Tilapia Green Tilapia Red Tilapia	*O. mossambicus* *O. niloticus* *O. aureus* *O. sp*	Taiwan, Thailand Philippines Cuba, Thailand	12 1 4	1951 1973, 93, 95 1996, 2001 1996 1993, 96, 97
Grass carp	*Ctenopharyngodon idelus*	China	4	1958, 2000
Silver carp	*Hypophthalmichthys molitrix*	China	4	1964, 2000
Bighead carp	*Aristhichthys mobilis*	China	1	1957
Hungarian common carp	*Cyprinus carpio L*	Hungary	2	1971, 1996
Indonesian common carp	*Cyprinus carpio L*	Indonesia	1	Before 1975
Indian carp Rohu Mrigal Catla	 *Labeo rohita* *Cirrhinus mrigala* *Catla catla*	 Thailand, India Laos, Thailand Laos	 3 2 1	 1982, 1984, 2001 1984, 1996 1984
	Xtiobus cyprinellus	Cuba	1	1984
African catfish	*Clarias gariepinus*	Central African	1	1975
European eel	*Anguilla anguilla*	China	2	2000
Pacu	*Colossoma brachypomum*	China	6	1997, 1998, 2000, 2001
Oyster	*Crassostrea gigas*	China	1	2002
Triploid Murry cod		Australia	1	2003
Prawn	*Cherax sp*	Australia	2	1999, 2002
Cobia	*Rachrycentron canadum*	Hongkong	12	1994-1999, 2000
Red snapper	*Lutianus enrythropterus*	Hongkong, Taiwan	4	1996-1999, 2001
Grouper	*Epinephenus sp.*	Taiwan	10	1996-1999, 2001
Seabass	*Lates sp.*	Taiwan, USA, Thailand and China	9	1996-2000, 2001
Red drum	*Sciaenops ocellatis*	China	1	1999
Sturgeon	*Hisodauric sp.*	Russia	1	1997
	Setaenops ocellatus	China	1	2000
Red seabream	*Parosomus major*	China, Taiwan	2	1999, 2000
Silver pomfret	*Pampus argentenus*		2	2000
Milkfish	*Chanos chanos*	Taiwan	1	1999
Black tiger shrimp	*Penaeus monodon*	Thailand, Singapore	Many times	1998-2003
White legged shrimp	*L. vannamei*	China, USA, Taiwan	Many times	2000-2003

Appendix A4

Major exotic freshwater fish/shrimp species identified by the workshop participants in Thailand

Scientific name	Common name	From	Year	Purpose	Introduced by
1. *Anguilla japonica*	Japanese eel	Japan	1973	Aquaculture	Unknown
2. *Carassius auratus*	Gold fish	China	1692-97	Ornamental	Unknown
3. *Carassius carassius*	-	Japan	1980	Aquaculture	Unknown
4. *Catla catla*	Catla	Bangladesh	1979	Aquaculture	Unknown
5. *Cichlosoma octofasciatum*		Brazil	1950s	Ornamental	Unknown
6. *Cirrhina mrigala*	Mrigal	Japan	1980	Aquaculture	-
7. *Clarias gariepinus*	African catfish	Laos	1987	Aquaculture	-
8. *Clarias macrosephalus*	-	-		Aquaculture	-
9. *Ctenopharyngodon idella*		China & Hong Kong	1932	Aquaculture	-
10. *Cyprinus carpio*	Common carp	China, Japan, Israel & Germany	1913 & onwards	Aquaculture	-
11. *Gambusia affinis*	Mosquito fish	-		Mosquito control	Government
12. *Gymnocorymbus ternetzi*	-	Paraguay & Argentina	1950s	Ornamental	
13. *Hypophthalmychthus molitrix*	Silver carp	China	1913	Aquaculture	-
14. *Aristichthys nobilis*	Big head carp	China	1932	Aquaculture	-
15. *Ictalurus punctatus*	Channel catfish	USA	1989	Aquaculture	Private sector
16. *Labeo rohita*	Rohu	India	1968	Aquaculture	-
17. *Mylopharyngodon piceus*	-	China/HKG	1913	Aquaculture	-
18. Oncorhynchus mykiss	Rainbow trout	Canada	1973	Fisheries	-
19. *Oncorhynchus rhodurus*	-	Japan	1981	Angling/sport	-
20. *Oreochromis aureus*	Blue tilapia	Israel	1970	Aquaculture	
21. *Oreochromis mossambicus*	Java tilapia	Malaysia	1949	Aquaculture	
22. *Oreochromis niloticus*	Nile tilapia	Japan	1965	gift to HM King	Royal family
23. *Osphronemus goramy*	Gourami	-	-	-	-
24. *Pomacea canaliculata*	Golden apple snail	Asia	1990	Aquaculture & Ornamental	-
25. *Pomacea gigas*	-	-	-	-	-
26. *Procambarus clarkii*	Red swamp crawfish	-	-	Aquaculture	-
27. *Rana catesbeiana*		-	-	Aquaculture	-
28. *Tilapia rendalli*		Zaire via Belgium	1955	Aquaculture	-
29. *Pampus argenteus*	Grey pomfret	NA	NA	Aquaculture	Unknown
30. *Chanus chanos*	Milk fish	NA	NA	Aquaculture	Unknown
31. *Fluta alba*	Albino swamp eel	NA	NA	Aquaculture	Unknown
32. *Epinephelus coiodes*	Grouper	NA	NA	Aquaculture	Unknown
33. *Epinephelus bleekeri*	Grouper	NA	NA	Aquaculture	Unknown
34. *Crocodilus* sp.	5 species	NA	NA	Aquaculture	Unknown
35. *Frogs*	7 species	NA	NA	Aquaculture	Unknown
36. *Lobsters*	3 species	NA	NA	Aquaculture	Unknown
37. *Turtles/tortoise*	5 species	NA	NA	Aquaculture	Unknown

III Annexes

Annex I

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Annex II

List of organizations dealing with alien species in aquaculture and fisheries

Organization	Mandate
AIT	Education, research and out reach
APEC	Trade and economic issues
FAO	Intergovernmental forum for policy development, information collection/dissemination,and project formulation
WorldFish Center and the International Network for Genetics in Aquaculture	Sustainable use of aquatic germ plasm through research and development in developing countries. Work on alien species and genetically altered species based on the ICES/EIFAC Codes and the principles of the Convention on Biological Diversity. Material Transfer agreements for movements of aquatic germ plasm
IUCN	Research, developing management plans, developing legal and institutional responses
MRC	Intergovernmental forum for coordinated management of the lower Mekong Basin; also with breeding programme for indigenous species
NACA	Intergovernmental forum for aquaculture development in Asia and the Pacific

Annex III

Opinionnaire

A REVIEW AND DECISION MODEL FOR EVALUATING PROPOSED INTRODUCTIONS OF AQUATIC SPECIES Opinionnaire for appraisal of introductions of aquatic organisms.[1] Each member of an evaluation board or panel of experts circles the number most nearly matching his/her opinion about the probability for the occurrence of the event. If information is unavailable or too uncertain "don't know" is marked then go to Step 2.

STEP 1 Response

		No	Unlikely	Possibly	Probably	Yes	Do not know
1.	Is the need valid and are no native species available that could serve the stated need?	1	2	3	4	5	X
2.	Is the organism safe from over-exploitation in its native range?	1	2	3	4	5	X
3.	Are safeguards adequate to guard against importation of disease/parasites?	1	2	3	4	5	X
4.	Would the introduction be limited to closed system?	1	2	3	4	5	X
5.	Would the organism be unable to establish a self-sustaining population in the range of habitats that would be available?	1	2	3	4	5	X
6.	Would the organism have mostly positive ecological impacts?	1	2	3	4	5	X
7.	Would most consequences of the introduction be beneficial to humans?	1	2	3	4	5	X
8.	Is data base adequate to develop a complete species synopsis?	1	2	3	4	5	X
9.	Does data base indicate desirability for introduction?	1	2	3	4	5	X
10.	Based on all available information, do the benefits of the exotic fish introduction outweigh the risks?	1	2	3	4	5	X

[1] Kohler, C.C., Stanley, J.G. 1984. A suggested protocol for evaluating proposed exotic fish introductions in the United States. *In* W.R. Courtney, Jr. and J.R. Stauffer, Jr. eds. *Distribution, biology and management of exotic fishes pp.387-406.* Baltimore. Johns Hopkins University Press

STEP 2 Review and decision model for evaluating proposed introductions of aquatic organisms

	Review level	Opinionnaire value	Decision
	I		
1.	Is the need valid and are no native species available that could serve the stated need?	≤ 2 > 2	- reject - to next question
2.	Is the organism safe from over-exploitation in its native range?	≤ 2 > 2	- reject - to next question
3.	Are safeguards adequate to guard against importation of disease/parasites?	≤ 2 > 2	- reject - to next question
4.	Would the introduction be limited to closed system?	≥ 3 < 3	- approve - to review level II
	II		
5.	Would the organism be unable to establish a self-sustaining population in the range of habitats that would be available?	≥ 3 < 3	- approve - to review level III
	III		
6.	Would the organism have mostly positive ecological impacts?	≤ 2 < 3 > 2	- reject - to review level IV - to next question
7.	Would most consequences of the introduction be beneficial to humans?	≤ 2 < 3 > 2 ≥ 3	- reject - to review level IV - to next question
	IV		
8.	Is data base adequate to develop complete species synopsis?	< 3 ≥ 3	- conduct detailed lit. rev. 1) - to next question
9.	Does data base indicate desirability for introduction?	≤ 2 < 3 > 2 ≥ 3	- reject - conduct research 2) - approve
10.	Would benefits exceed risks?	≤ 2 ≥ 3	- reject - approve

1) Thereafter next step question 9.

2) Research focused on potential impact on indigenous species and habitats. Thereafter question 10. Value < 3 > 2 restart research.

The use of alien species is a proven means to increase production and value from aquatic ecosystems. In the Mekong/Lanchang Basin, alien species such as tilapia *(Oreochromis spp.)* play an important role in providing cheap and readily available protein to rural and poor sectors. However, alien species are now recognized as one of the most significant threats to aquatic biodiversity. Several steps are necessary for effective use and control of alien species, but one of the most important was identified to be following codes of practice similar to that developed by the International Council for the Exploration of the Sea. The development and use of indigenous species are options to the use of alien species. However, indigenous species have not received the same amount of attention, research, development and use as many alien species. Regional coordination and national policy development are necessary actions that should go hand in hand in order to facilitate implementation of broader international agreements.

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