T his report contains the papers presented and outcomes from the workshop "Building capacity to combat impacts of aquatic invasive alien species and associated trans-boundary pathogens in ASEAN countries, hosted by the Department of Fisheries, Government of Malaysia, on 12th-16th July 2004. The workshop was generously supported through a US State Department grant, and co-sponsored by several other agencies. The reference for the report is:

NACA. 2005. The Way Forward: Building capacity to combat impacts of aquatic invasive alien species and associated trans-boundary pathogens in ASEAN countries. Final report of the regional workshop, hosted by the Department of Fisheries, Government of Malaysia, on 12th-16th July 2004. Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand.

The Way Forward: Building Capacity to Combat Impacts of Aquatic Invasive Alien Species and Associated Trans-Boundary Pathogens in ASEAN Countries

Final Report of a workshop hosted by the
Department of Fisheries, Government of Malaysia,
Penang, Malaysia, 12th-16th July 2004

March 2005
Network of Aquaculture Centres in Asia-Paficic

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Workshop Summary and Way Forward

Workshop Summary and Way Forward

Background

The workshop on "Building capacity to combat impacts of aquatic invasive alien species and associated trans-boundary pathogens in ASEAN countries" was held in Penang, Malaysia, on the 12th-16th July 2004. The workshop was hosted by the Department of Fisheries of the Government of Malaysia and organized by the Network of Aquaculture Centres of Asia-Pacific (NACA) in collaboration with ASEAN, FAO, the WorldFish Center and the United States Department of State.

The 75 participants included delegates from each ASEAN[1] member country, resource persons with experience in aquatic invasive alien species (IAS) and aquatic animal pathogens and representatives of regional and international organizations, research institutes, universities and private sector entities[2].

The workshop supports the ASEAN 2020 Vision of enhancing "food security and international competitiveness of food, agricultural and forest products and to make ASEAN a leading producer of these products…." It was convened specifically to better understand the relationship of aquatic IAS and pathogens and their impacts (both positive and negative), and to identify management and capacity building needs to reduce risks.

The workshop built on the recommendations from a 2002 Bangkok workshop organized by the Global Invasive Species Program (GISP[3]) and a 2003 workshop of countries sharing the Mekong watershed[4], particularly in promoting awareness, establishing coordination mechanisms and information exchange systems and identifying management strategies and risk mitigation measures for aquatic IAS.

Findings

The participants concluded that aquatic IAS and invasive aquatic animal pathogens significantly impact the aquaculture industry in ASEAN, and can have negative implications for aquatic biodiversity, and the social and economic well being of people in the ASEAN region. Participants also recognized the positive social and economic benefits that have come from the introduction and farming of some alien aquatic species in the region. Participants agreed that the way forward is to minimize the risks and costs associated with negative impacts of aquatic IAS and aquatic animal pathogens whilst capturing the social and economic benefits possible through responsible aquaculture of alien species.

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[1] Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam

[2] AIT, APEC, ASEAN Secretariat, AusVet Australia, CAB International, Deakin University, FAO, IUCN, MRC, Multimedia Asia, NACA, OIE, PhilRice, SakNIRO-Russia, SEAFDEC-AQD, Universiti Putra Malaysia, World Fish Centre and the US Department of State, US Dept of Commerce and Interior and the MD Dept of Natural Resources.

[3] http://www.usa.or.th/embassy/reo/reo-wrkshp.htm. GISP (2003) "*Prevention and Management of Invasive Alien Species: Forging Cooperation throughout South and Southeast Asia*". Global Invasive Species Program.

[4] Workshop on *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.

Recommendations

Four working groups prepared detailed action plans to assess and manage the impacts and risks from aquatic IAS and associated animal pathogens. The following bullets highlight the main recommendations agreed upon by the workshop participants as the Way Forward:

- Management of aquatic IAS and associated pathogens is imperative and should be encouraged and implemented in all ASEAN countries.
- National strategies should be developed consistent with obligations under existing international treaties and instruments[1] and in harmony with strategies for other IAS, including aquatic plants and ornamental fish. National strategies, coordinated through national focal points, should be based on impact assessment and management of alien species, where they are already established, and use of ecological and environmental risk analysis for proposed new introductions.
- National strategies should be implemented within a legitimate regional framework supported and endorsed by ASEAN. The recommendations in this Way Forward summary should be presented to the ASEAN Secretariat as a starting point for coordinated regional action, through the ASEAN Sectoral Working Group on Fisheries and other appropriate bodies.
- ASEAN member countries should have the necessary institutional and human resources to adopt a harmonized regional strategy. Bridging development gaps and capacity building across member countries is therefore necessary. Special attention should be given to capacity building among the Mekong basin countries of Cambodia, Lao PDR, Myanmar and Vietnam.
- In-country IAS impact assessment and risk analysis training should be promoted and implemented to establish core expertise in these practices in all ASEAN countries. Experiences in risk analysis and impact assessment should be shared among ASEAN countries.
- Networking, information exchange and cooperation among concerned agencies, industry, trading partners and countries sharing common watersheds or waterways is recommended for cost-effective use of resources in support of ASEAN in achieving the goal of effective management of aquatic IAS and associated aquatic animal pathogens.
- Assistance should be sought from regional and international organizations to implement the workshop recommendations, including from the organizers and participants of this workshop and other regional and international organizations. Progress in implementing the workshop recommendations should be assessed in three years.

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[1] These include the Convention on Biological Diversity (CBD), International Maritime Organisation (IMO), World Trade Organisation (WTO), World Animal Health Organisation (OIE) and Food and Agriculture Organisation of the United Nations (FAO).

Workshop Background

Workshop Background

Background

The workshop "Building capacity to combat impacts of aquatic invasive alien species and associated trans-boundary pathogens in ASEAN countries" was held in Penang, Malaysia, on the 12th-16th July 2004. The workshop was generously supported through a US State Department grant.

The workshop was intended to assist ASEAN countries build their national capacities to combat the impacts of aquatic invasive alien species (IAS) and associated trans-boundary pathogens in aquaculture. Invasive alien species (IAS) are defined as plants, animals or disease agents that are non-native to an ecosystem, and which may cause economic or environmental harm or harm to human health. IAS can have a negative impact on sustainable development, significant in many ASEAN countries that depend on agricultural, fishery, and forestry resources for economic prosperity.

Aquatic invasive alien species – animals, plants, pathogens – are of increasing concern in ASEAN because of the social and economic importance of the fishery and aquaculture sectors. Trans-boundary diseases caused by spread of aquatic animal pathogens have caused significant damage in recent years, and are now recognised as a major risk and a primary constraint to the growth of the aquaculture sector, an important constraints for economic and socio-economic development through aquaculture in many ASEAN countries. The aquaculture industries alone provide several billion dollars of export earnings to ASEAN economies, so the economic and social risks are substantial.

Aquatic invasive alien species do not respect geopolitical borders and have the potential to cause significant negative impacts on international trade and transport of aquaculture products. Therefore cooperation between countries in addressing the issue is essential. ASEAN countries are committed to building national capacities to improve their abilities to combat aquatic invasive alien species. It is in the interest of the international community to assist building regional cooperation among trading partners, so that the issue could be effectively addressed.

The Penang workshop responds to the recommendations of the 2002 Bangkok workshop, "*Prevention and Management of Invasive Alien Species: Forging Cooperation throughout South and Southeast Asia*" [1] and supports the ASEAN Cooperation Plan goal of assisting ASEAN in addressing trans-national issues, as well as the ASEAN 2020 Vision of enhancing "food security and international competitiveness of food, agricultural and forest products and to make ASEAN a leading producer of these products…." It further builds on experiences from the workshop on *International Mechanisms for the Control and Responsible Use of Alien Species in Aquatic Ecosystems,* held 27-30 August 2003, in Xishuangbanna, People's

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[1] Recommendations from the Regional Workshop on "Prevention and Management of Invasive Alien Species: Forging Cooperation throughout South and Southeast Asia", 14-16 August 2002, Bangkok, Thailand. www.usa.or.th/embassy/reo/reo-wrkshp.htm.

Republic of China, involving countries sharing the Mekong/Lancang watershed[1] .

The Penang workshop also supports existing efforts by national governments and regional and international organizations in addressing issues related to food security and reduction of poverty and social inequity through improved benefits from aquaculture and fisheries by safeguarding the sector from disease incursions and invasive alien species. Raising awareness of this problem and its remedies throughout the ASEAN region, and building regional capacity to assess risks, share information and strengthen networks, are critical to protect aquaculture and other production systems and the natural ecosystems on which they depend.

Workshop Objectives

The workshop was organized to provide a regional platform for ASEAN nations to address aquatic alien species, and to carry out the recommendations of the regional Global Invasive Species Program Workshop, "Prevention and Management of Invasive Alien Species: Forging Cooperation throughout South and Southeast Asia," held in Bangkok, Thailand in August 2002[2] . It was expected to assist ASEAN countries further strengthen capacities and cooperation to address aquatic invasive animal species and aquatic animal pathogens in the region.

The specific objectives of the workshop were to:

1) Review recommendations of the regional Global Invasive Species Program Workshop "Prevention and Management of Invasive Alien Species: Forging Cooperation throughout South and Southeast Asia" and other relevant regional and international initiatives on aquatic invasive species and identify specific actions for their implementation in ASEAN.

2) Review progress in implementation of the FAO/NACA, "Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals and Beijing Consensus and Implementation Strategy[3] ' that has been adopted as an ASEAN policy document, and identify further actions to support their implementation in ASEAN.

3) Examine relationships between trans-boundary aquatic animal pathogens and aquatic invasive alien species in the ASEAN region, including long-term impacts of alien diseases in the region.

4) Review national policies and legislation as well as compliance to international treaties and conventions dealing with aquatic IAS, and identify specific actions for their implementation in ASEAN.

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[1]Workshop on *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.

[2] Recommendations from the Regional Workshop on "Prevention and Management of Invasive Alien Species: Forging Cooperation throughout South and Southeast Asia", 14-16 August 2002, Bangkok, Thailand. www.usa.or.th/embassy/reo/reo-wrkshp.htm.

[3] www.fao.org/DOCREP/005/X8485E/X8485E00.HTM

5) Identify current gaps in knowledge and information for dealing with aquatic IAS and aquatic animal pathogens, and develop national and regional decision support to focusing on design and incorporation of information and other communication media pertaining to invasive species and the risks of their introduction to ASEAN. Special attention will be given to initiating the evelopment of a comprehensive knowledge base on aquatic IAS and pathogens in ASEAN region[1], thus supporting the further development of AAPQIS (Aquatic Animal Pathogen and Quarantine Information System – http://www.aapqis.org) and complementing previous regional projects on risk analysis.

6) Support national and regional awareness and capacity building for aquatic species at various levels, focusing on risk analysis measures, improving information sharing, surveillance and reporting and networking.

Report Organisation

This report describes the activities of the workshop and major outcomes. It is organized into three parts as follows:

Part 1: The Proceedings

Part 2: The Resource Papers and Case Studies

Part 3: The Country Papers

The final statement of the workshop "The Way Forward" as adopted by workshop participants is provided at the beginning of the report showing the main workshop findings and agreed recommendations.

[1] This knowledge base benefited from discussions and outputs from the Global Invasive Species Information Network (GISIN) Experts Meeting Planning in April 2004.

Part One

The Proceedings

The Proceedings

The workshop on "Building capacity to combat impacts of aquatic invasive alien species and associated trans-boundary pathogens in ASEAN countries" was held at the Hotel Grand Plaza Parkroyal Penang, Malaysia, on the 12th-16th July 2004.

The workshop was hosted by the Department of Fisheries of the Government of Malaysia and organized by the Network of Aquaculture Centres of Asia-Pacific (NACA) in collaboration with ASEAN, FAO, the WorldFish Center and the United States Department of State. The 75 participants included delegates from each ASEAN[1] member country, resource persons with experience in aquatic invasive alien species (IAS) and aquatic animal pathogens and representatives of, regional and international organizations, research institutes, universities and private sector entities[2] . The list of participants is provided in Annex A. The workshop program is given as Annex B.

The workshop supports the ASEAN 2020 Vision of enhancing "food security and international competitiveness of food, agricultural and forest products and to make ASEAN a leading producer of these products…." It was convened to better understand the relationship of aquatic IAS and pathogens and their impacts (both positive and negative), and to identify management and capacity building needs to reduce risks. The workshop built on the recommendations from a 2002 Bangkok workshop organized by the Global Invasive Species Program (GISP[3]) and a 2003 workshop of countries sharing the Mekong watershed[4], particularly in promoting awareness, establishing coordination mechanisms and information exchange systems and identifying management strategies and risk mitigation measures for aquatic IAS.

Session 1: Opening ceremony

The workshop was opened with a Doa Recital followed by welcome remarks, statements of collaborating organizations and the keynote and inaugural address by the Director-General of the Department of Fisheries Malaysia.

Welcome remarks

Ms Thalathiah Saidin, Director of Fish Health Management and Quality Assurance Division, Department of Fisheries Malaysia welcomed participants to the workshop.

Introductory statements

Introductory statements were made by Mr Pedro Bueno, NACA, Mr David Muniz, US State Department, Dr Rohana Subasinghe, Food and Agriculture Organisation of the United

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[1] Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam

[2] AIT, APEC, ASEAN Secretariat, AusVet Australia, CAB International, Deakin University, FAO, IUCN, MRC, Multimedia Asia, NACA, OIE, PhilRice, SakNIRO-Russia, SEAFDEC-AQD, Universiti Putra Malaysia, World Fish Centre and the US Department of State, US Dept of Commerce and Interior and the MD Dept of Natural Resources.

[3] http://www.usa.or.th/embassy/reo/reo-wrkshp.htm. GISP (2003) "*Prevention and Management of Invasive Alien Species: Forging Cooperation throughout South and Southeast Asia*". Global Invasive Species Program.

[4] Workshop on *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.

Nations (FAO), Mr Rony Soerakoesoemah, ASEAN Secretariat, Dr Yoshiyuki Oketani, OIE Regional Representation and Dr M.V. Gupta of the World Fish Centre.

Keynote and Inaugural Address

The keynote and inaugural address of Y. Bhg. Dato' Junaidi Che Ayub, Director General of Department of Fisheries Malaysia was read by Bpk Hj Ibrahim Salleh, Deputy Director General of the Department of Fisheries. The keynote address is provided in Annex C.

The address referred to several global and regional agreements influencing aquaculture and fisheries, including the FAO Code of Conduct for Responsible Fisheries, Sanitary and Phytosanitary (SPS) agreement and the Convention for Biological Diversity. The Director-General noted the duties of ASEAN countries as to "prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species" and "to conserve genetic diversity and maintain integrity of aquatic communities and ecosystems". He emphasized the importance of these issues in relation to ASEAN and trade, their current status, and plans to improve processes such as quarantine measures and observe transfer protocols to prevent entry or introduction of harmful organisms. The speech also discussed previous introductions experienced within Malaysia, problems associated with them and the difficulty in eradicating them, and emphasized the need for international cooperation in their prevention and mitigation. The importance of improving databases, sharing of information on biosecurity, as well as capacity building on risk analysis and management were emphasized.

The full text of the keynote and inaugural address is given in Annex C.

Session 2: Workshop objectives, and selected technical overviews of invasive alien species and associated trans-boundary pathogens

The purpose of Session 2 was to introduce the workshop objectives, expected outputs and activities; and provide overviews, from an ASEAN and global perspective, on issues concerning aquatic alien invasive species and associated trans-boundary pathogens. The following provides a brief summary of the presentations. The full papers from this session are provided in Part 2 of this report.

"Introductory remarks on objectives and organization of the workshop"- Michael Phillips, NACA

The presentation provided the workshop objectives and information to participants concerning the organization of the workshop.

"CBD COP-7 Decisions on alien species that threaten ecosystems, habitats or species" - Chan Han Hee, Department of Agriculture, Malaysia

The presentation provided information on the Convention of Biological Diversity COP-7 meeting (particularly decision VII/13 and article 8) and issues concerning invasive alien species as a significant area that needs international, regional and national commitment and cooperation. In Decision VII/13 (although all are relevant), the most important point with concern to the workshop is that it "Recognizes need to strengthen institutional coordination at international, regional and national levels on IAS as a trade-related issue."

"An overview of international initiatives, treaties, agreements and management actions addressing invasive alien species" –
Jeffrey P. Fisher, US State Department
The presentation detailed the negative impacts that invasive species (including non-aquatics) impose, particularly on the environment and the main international agreements and initiatives in operation to address the problems of IAS, emphasizing the WTO-Sanitary and Phytosanitary Agreement, CBD, OIE and IMO. The presentation emphasized the importance of building on previous experience, recognising potential synergies, acknowledging past mistakes and implementing future actions together.

"Place of trans-boundary aquatic animal pathogens (TAAPs) within the invasive alien species (IAS) category: a review" –
Rohana Subasinghe, FAO and Melba Reantaso, USA
The presentation provided an overview of many of the issues concerning aquatic IAS and associated pathogens. Summaries of many of the leading sources of information on IAS were provided, including the CBD and internet based tools such as The National Invasive Species Council (USA) and ISSG. The presentation also introduced a number of relevant codes and guidelines from IUCN/SSC, FAO, WTO,CCRF and the OIE, with an emphasis on aquatic animal pathogens and parasites. The presentation emphasized the need for clear definitions of aquatic IAS, particularly in relation to pathogens and parasites, and clarification in order to define the place of TAAPs in the IAS issue.

"Current knowledge of aquatic invasive alien species in ASEAN and their management in the context of aquaculture development" –
A.G. Ponniah and Norainy Mohd Husin, World Fish Centre
The presentation discussed invasive alien species and associated pathogens within the context of aquaculture development. It emphasised the development of effective invasive alien species programs through the use of programmes such as FishBase, linked to well designed scientific studies. An overview of an ideal national institutional, policy and legal framework was provided.

"Trans-boundary aquatic animal pathogens in ASEAN and their management"
CV Mohan, Brett Edgerton and Michael Phillips, NACA
The presentation described the major pathogens of concern to ASEAN countries, and development of the Asia regional technical guidelines for responsible movement of live aquatic animals. It noted the importance of ASEAN continuing to implement the guidelines and emphasized the importance of further collaboration, including sharing of data, international cooperation and increased stakeholder responsibility.

"Aquatic alien species and their contribution to aquatic production, food security and poverty alleviation" –
Devin Bartley, Valerio Crespi, Isabel Fleischer and Rohana Subasinghe, FAO
The presentation outlined FAO's position on introductions and described the different negative and positive aspects of non-native species introductions for aquaculture. The negative aspects

concern habitat, genetic and disease impacts, whereas the positive impacts are generally social and economic gain. Major agreements on aquatic animal transfers (EIFAC/ICES Codes of Practice on the Introductions and Transfers of Marine Organisms 1994, and FAO Codes of Conduct for Responsible Fisheries) were described.

Discussion points

The discussions around these presentations emphasized the need for better understanding of the status and impacts of aquatic IAS in ASEAN. Participants noted the importance of identifying knowledge gaps, and research to fill these gaps.

Session 3: Country status paper presentations

The purpose of Session 3 was to allow country participants to make presentations concerning the present knowledge, impacts, risks and management of aquatic invasive alien species; and associated trans-boundary aquatic animal pathogens; and (3) to recommend follow up actions to strengthen national and regional capacity to deal with IAS and associated trans-boundary pathogen issues. The following provides a brief summary of the presentations. The full papers from this session are provided in Part 3.

Brunei - Hajah Laila Haji Hamid

The presentation emphasized non native shrimp introductions. The new Shrimp Broodstock Development Unit (SBDC) in Brunei was provided as a good example of non-native species aquaculture management. The unit was developed to reduce dependency on importation of broodstock, to meet the high demand from farmers.

Cambodia –Bun Racy and Hav Viseth

The presentations listed the aquatic IAS species in Cambodia. They discussed the reasons behind species introductions, and circumstances in which they are released or escape to the wild in Cambodia. Impacts of introduced exotic fishes species, existing policies and current management strategies were covered, as well as details of Cambodia's future plans for controlling IAS. The presentations also covered the history of major disease outbreaks, the current status of trans-boundary aquatic animal pathogens, aquatic animal health and quarantine legislation and regulation and their current management strategies. Recommendations were provided for strengthening national and regional capacity in addressing risks from trans-boundary aquatic animal pathogens.

Indonesia –Hardjono

The presentation described the background to IAS, and relevant government policy (Environment Law and the Ministry of Agriculture) in Indonesia. It also gave an overview of present and future plans in Indonesia to improve the prevention and control of IAS. The paper highlighted also the many issues complicating the mitigation process and gave some recommendations for follow up actions.

Laos - Nivath Phanaphet

The presentation noted the classic issue of lack of national policy on IAS due to perceived more important issues. It notes that until recently IAS issues were not considered important enough to result in the restriction of species which were important for aquaculture, though the government was promoting the sustainable utilization and use of indigenous fish species. The presentation discussed current management for IAS through the Ministry of Agriculture and Forestry and the Department of Livestock and Fisheries, and provided recommendations for strengthening national and regional capacity to address risks from invasive alien species. The need for strengthening of capacity to manage IAS in Laos was emphasized.

Malaysia - V. Palanisamy and Thalathiah Saidin
The presentation of Mr Palanisamy provided a background to IAS and discussed the current status of trans-boundary aquatic animal pathogens in Malaysia, their current management strategies and progress in implementing recommendations for managing trans-boundary aquatic animal pathogens. It also provided a comprehensive check-list of the procedures that should be followed when implementing recommendations and quarantine procedures, and recommendations to strengthen national and regional capacity for addressing risks from transboundary aquatic animal pathogens. The presentation of Ms Thalathiah Saidin discussed legislation on the control of live fish trade and an overview of Fisheries Regulations. The presentation described the impacts of invasive alien species in Malaysia and commented on capacity building to formulate a Malaysian national strategy and action plan to address risks and mitigate impacts.

Myanmar - Minn Thame and Myat Myat Htwe
The presentation provided a background to introduced aquaculture species in Myanmar and their associated pathogens. It also talked about Myanmar's Committee on Aquatic Animal Health (CAAH) as part of the national strategy for increasing capacity to mitigate IAS issues and presented recommendations to strengthen national and regional capacity to address risks from IAS.

Philippines - Simeona E. Regidor and Joselito R. Somga
The presentation gave the background to Philippine Fisheries policy, particularly relating to the initial 1975, Presidential Decree 704, concerning accelerating and promoting the integrated development of the fishery industry. It noted the most recent and relevant documents for implementation of the movement of live aquatic animals. Also discussed was the current status and knowledge, management strategies, quarantine and inspection services and procedures and requirements for importation of non-native species. Recommendations to strengthen national and regional capacity to address risks from invasive alien species were also given.

Singapore - Loo, J. J
The presentation provided background on Singapore in relation to high trade figures and aquatic invasives. A summary of the role of the Agri-Food and Veterinary Authority (AVA) in combating IAS and to "ensure a resilient supply of safe food, safeguard the health of animals and plants and facilitate agri-trade for Singapore" was provided. The importance of aquaculture in Singapore, particularly of ornamental fish species, and the potential disease infiltration associated with the large seed importation necessary for the industry was noted. The presentation also reported on the national management strategy for mitigation of IAS and the implementation of the FAO/NACA Asia regional technical guidelines.

Thailand - Supranee Chinabut and Somkiat Kanchanakhan
The presentation provided an account of the history of IAS and aquatic trade in Thailand and lists the common aliens and invasive aliens in Thai aquaculture and waters. The presentation discussed the impacts of IAS on the environment and economy, and mentions the genetic risk imposed by IAS. The role of the Department of Fisheries (DoF), National Biosafety Committee (NBC) and the Institutional Biosafety Committee (IBC) in managing the spread and introductions of IAS was explained.

Vietnam - Phan Thi Van
The presentation provided information on introductions and the impacts associated withthese introductions of aquatic alien species in Vietnam. It described the associated management strategies that are in place, and those that are planned such as government guidelines for importing live species (based on import risk analysis). The aquatic pathogen status in Vietnam was presented, together with information on management systems in place, such as quarantine regulations and procedures, to mitigate potential problems.

Discussion points

The discussions around the country presentations further emphasized the need for better understanding of the status and impacts of aquatic IAS in ASEAN, and collaboration between ASEAN nations in understanding and managing impacts of IAS.

Session 4: Case studies

The purpose of Session 4 was to provide learning experiences concerning the management of: (1) aquatic invasive alien species and; (2) associated transboundary aquatic animal pathogens. The selected case studies were intended to illustrate key lessons for management and policy actions to inform discussions and working group deliberations. Resource speakers were requested to give special attention to management and capacity building requirements. The following provides a brief summary of the presentations. The full papers from this session are provided in Part 2 of this report.

Chair: Supranee Chinabut
Rapporteur: Le Ann Southwood

"Case study on the invasive Golden Apple Snail in ASEAN"–
Ravindra C. Joshi, A.G. Ponniah, Christine Casal and Norainy Mohd Husin
This presentation introduces GAS as a pest and highlights problems associated with its spread in Asia. It gave a historical record of its initial introduction and proliferation throughout SE Asia. Advice on methods of containing spread and limiting its impact, as well as methods of utilising the pest once it has become established were described.

"Tilapias are alien to Asia: But are they friend or foe" –
Sena De Silva, Australia
The presentation evaluated the contribution of tilapia to aquaculture production in the ASEAN region (as a food fish resource and by providing livelihood opportunities) and assessed its

potential negative environmental impacts (i.e. as a vector for introducing pathogens through translocation or by decreasing biodiversity through competition/ habitat degradation). The author concluded that tilapias are very "physiologically robust", and invasions always occur in degraded environments, suggesting they are opportunistic invaders in environments already degraded by human actions. It was noted that the balance of evidence suggests that tilapias have been beneficial to Asia.

"Movements of economically important Penaeid shrimp in Asia and the Pacific" – Simon Funge-Smith and Rohana Subasinghe, FAO, and Michael Phillips, NACA

The presentation provided a summary of the history of *Penaeus vannamei* and *P. stylirostris* in aquaculture from Latin America to Asia in the early 1970's, and throughout Asia until today. The advantages and disadvantages of Penaeid species introductions, particularly the associated transfer of pathogens versus the increase in productivity (due to rapid growth rate, tolerance of high stocking density), tolerance of low salinities and temperatures, lower protein requirements and non-reliance on wild broodstock or postlarvae were discussed. The importance of Asian governments taking actions in legislating control over the shrimp industry, and in particular, adopting guidelines and codes of conduct formulated by, for example, FAO, the OIE, NACA, ASEAN, SEAFDEC and the GAA, was emphasized.

"The special danger of viral infections in crustaceans" - Tim Flegel, Mahidol University, Thailand

The presentation gave a background on risks from shrimp viral infections and highlighted the difficulties involved in diagnosing 'cryptic' viruses, issues related to not testing 'healthy' shrimp, and the problems associated with dual, triple and quadruple infections of shrimp. The main viral infections affecting the shrimp trade, and the pathways in which the viruses have spread between boundaries and continents, were described. The importance of trans-boundary movements strictly following ICES quarantine guidelines and including mandatory co-habitation tests with economically or ecologically important local crustaceans was emphasised.

"Key freshwater crustacean pathogens of concern to ASEAN" - Brett Edgerton and CV Mohan, NACA

The presentations emphasized the potential for freshwater crustacean farming (crayfish, prawns and crabs) Due to the increasing occurrence of marine shrimp disease, the paper highlighted the prospective opportunity to farm more freshwater crustaceans. It also acknowledged the fact that freshwater crustacean farming is not disease-free, and our knowledge of it lags far behind that of marine species. Because of this lack of knowledge, and due to limited available data, it was emphasized that extreme caution should be taken when introducing any freshwater species into a non-native area, and that health certification practices should be utilised.

"Mollusc pathogens of concern to ASEAN" - Melba Bondad-Reantaso, USA and Franck C.J. Berthe, IFREMER, France

The benefits from and and great potential of mollusc farming were emphasized. The following were noted: a) the importance of rigorous quarantine and risk assessments when introducing species across boundaries and into non-native territories, and b) the difficulties associated with controlling pathogen transfer when translocating molluscs. Increasing the expertise for diagnostics and surveillance was cited as the best measure to improve risk management.

"Key aquatic animal pathogens of concern to ASEAN: marine and freshwater finfish" -
Mohamed Shariff, Universiti Putra Malaysia

The presentation noted freshwater and marine finfish pathogens of concern to ASEAN and describes current knowledge of these pathogens. It emphasized the importance of capacity building (specifically increasing trained manpower, using a holistic research approach and improving facilities) for preventing or mitigating negative impacts of future disease introductions.

"Need for an Institutional Network for managing aquatic exotic species in Indochina"
Amara Yakuptiyage, AIT, Thailand

The presentation summarizes the reasons why an Institutional Network is essential for the management of exotics in Indochina. It used the major findings of national workshops to support proposals of building an institutional network consisting of both regional and local institutions. The aim of the network is to enhance capacity and public participation in managing alien species and to reduce/eliminate potential negative impacts caused by exotic aquatic organisms. Associated with this network, it also called for the development of a Code of Conduct and Regional Guidelines on the use of new and already introduced species.

"Risk Analysis as a Tool for the Management of Alien Aquatic Animal Diseases"
Kevin Amos, USA

The presentation provided a detailed background to risk management, highlighting the major questions that should be asked and components that should be included when carrying out a risk assessment. An historic overview of the advantages and disadvantages of species introductions was also provided. The presentation emphasized that it is in the interest of all countries to promote import risk assessment in the national strategy for the prevention and control of aquatic diseases.

"Risk Analysis for determining invasive potential, risks, and appropriate management for non-native aquatic species" -
Jeffrey Fisher, US State Department

The presentation described the theries behind risk assessments, their advantages and necessity in the trade of aquatic animals. It described the methods used to determine whether the risk is greater than the potential positive outcomes, and explained the set of protocols that should be used in the case of uncertainty, i.e. the precautionary principle. It concluded with the notion that a perfect risk analysis does not exist, and that a good imperfect one is better than none at all. The lack of empirical data to base risk analyses on is a constraint to making informed predictions of possible consequences of introductions.

"Risk analysis frameworks and tools for management of aquatic invasive alien species and associated trans-boundary pathogens. Infrastructure and capacity requirements" –
Chris Baldock, Australia

The presentation provided an overview of the risk analysis framework for aquatic animal diseases. The main recommendations for infrastructure and capacity building were surveillance (providing reliable information and early warnings of species invasions), risk analysis (a scientific basis to make decisions on detrimental effects of trade versus no trade) and response (in the event of invasion, is there the capacity to effectively control the spread?). It gave a list of the essential resources required to allow development of a country's infrastructure and capacity.

Discussion points

- Impacts of tilapias are controversial, with some reports that their introduction may have been responsible for negative effects on biodiversity and have features typical of an invasive alien species.On the other hand, it was noted that in Asia tilapia does not influence genetic diversity of indigenous stocks and that invasiveness has been limited to habitats already degraded by human activity. If there is evidence anywhere in the region of tilapias being invasive this information should be reported to NACA and/or FAO.
- Regarding *P.vannamei*, can we identify critical points that can be effectively controlled? It was suggested that hatcheries would be a good place to start with effective control measures.
- Participants reiterated the need to put national and regional policy into lay terms to educate indigenous and grass roots people.
- The importance of raising the IAS and aquatic animal pathogen issues to high-level officials so that they get attention and are actually implemented. Participants considered that IAS should become a priority for ASEAN countries and members of this workshop can take information from this workshop back to their countries to raise awareness among higher-level managers.

Session 5: Working group sessions

Following the presentations by country participants and resource persons, the workshop divided into four working groups. The purpose of Session 5 was to allow participants in four working groups to discuss and agree on key issues and the actions required, and to formulate recommendations, including regional capacity-building tools for risk analysis. The four working groups were:

Working group 1: Aquatic invasive alien species
Working group 2: Trans-boundary pathogens and aquatic animal health
Working group 3: Recent activities on aquatic invasive alien species
Working group 4: Information needs and tools

Guidelines for the working groups are provided in Annex D. Outcomes from the working groups are presented in Annex E.

Session 6: Building information systems to support ASEAN in assessment and management of alien aquatic species and associated aquatic animal pathogens

Chair: Dr A.G. Ponniah
Rapporteur: Dr Jeffrey Fisher

The purpose of Session 6 was to discuss the development of information systems and tools to support ASEAN members in assessment and management of aquatic invasive alien species and associated aquatic animal pathogens. The session was organized as an evening session with presentations by three resource persons, and a morning session that reviewed a draft web site.

The resource presentations are summarized in the following pages, with full papers provided in Part 2.

Golden Apple Snail -
Ravi Joshi, PhilRice
This presentation noted that the internet is an excellent information source for Golden Apple Snail management in ASEAN. Information available on GAS management on the following web sites was described: http://www.openacademy.ph/elearning/goldenkohol/ and http://pestalert.applesnail.net/main.php.

Towards building a tool to assess species invasiveness -
Christine Casal, FishBase, Philippines
The presentation described the many and various ways in which the FishBase website can be utilised to aid IAS management and prevention, such as providing lists of species introduced to Asia (or elsewhere in the world), their biological characteristics, food requirements and adverse ecological impacts. It also discussed the essential components for building a risk assessment tool, and the opportunities for collaboration with FAO's DIAS tool (available on the internet).

Tracking pathogens through species introductions: a database mapping approach -
Christine Casal, FishBase, Philippines
The presentation provides an in-depth methodology to species tracking using databases and information sources from different organizations to predict probable presence and sources of aquatic animal pathogens in a country.

The Global Invasive Species Information Network (GISIN) International Meeting – summary and path forward –
Dr Soetikno, CAB International
The presentation provided an history and overview of GISIN, described the theory behind the program and database infrastructure. The main recommendations of the international meeting were also provided. The GISIN online community can be consulted for more information (http://my.nbii.gov).

Aquatic IAS web site and plenary discussion session

The draft aquatic IAS web site was presented by John Molloy, Multimedia Asia, in the morning session on the 15th July. The web site provides information on aquatic IAS, with a special emphasis on risk assessment.

Following the presentation of the draft web site, a plenary discussion session on building of information systems was facilitated by Rohana Subasinghe. The following summarises the main discussion points:

- The web site will provide a source of information on IAS, and access to decision making tools, but should not do any analysis. Links will be provided to FishBase, FAO DIAS, GISIN, and other relevant sites. The web site will provide a portal for people eho are searching for information on IAS relevant to ASEAN.
- NACA has committed to provide an institutional "home" for the web site, and will continue to operate the system. Continued input frompeople and institutions across the region will be essential to make the site useful and current. Involvement of national institutes will be important in making the site sustainable.
- The site should include practical extension materials that can be downloaded and used for raising awareness of aquatic invasive alien species.
- There is need to inform policy makers on aquatic IAS issues. It was suggested for each ASEAN country to nominate a focal point for communication and sharing information on aquatic IAS between countries.
- Thelanguage of the web site should be English, and countries could then translate relevant material into local languages. Original documents in local languages could be made available.
- The web site should be linked with AAPQIS as an important tool for aquatic animal pathogen information.
- Opportunities were mentioned for collaboration with relevant national web sites, such as NAFRI in Laos, and national and regional institutions, including Cambodia's new fisheries research institute and the MRC secretariat which is working on a Fish Base of Mekong species. Links with STREAM communication hubs should also be encouraged.
- OIE emphasized the importance of using official information.
- Risk assessment is a key feature of the web site. There is a need to include descriptors of habitat, environment, pathways and other information on the site. Databases should be organized in categories of pathogens, habitat, environment etc. There is a need for this sort of organization to be able to enable good risk assessment.
- Include good case studies from other sectors, such as the livestock sector.
- The web site might be linked with educational tools, such as the on line education course Aquahealth organized by SEAFDEC, that provides training in health management principles and practices in aquaculture.

Session 7: Final session

The final session involved presentation and discussion of the working group reports, discussion and adoption of a final wothe rkshop statement and the closing ceremony.

Chair: Pedro Bueno, NACA
Rapporteur: Devin Bartley, FAO

Working group reports

The following are the discussion points following the presentation of the Working Groups comments from plenary discussions. The final reports from each Working Group are provided in Annex E.

Working group 1: Invasive alien species

The participants of this working group were asked to draft a national and regional action plan to increase the capacity to assess and manage risks. The plan was based on present knowledge on the status of aquatic invasive alien species in ASEAN, impacts and risks and include recommendations for implementation. The following points were raised in discussions of the report from working group 1.

- Need to be clear about definition of invasiveness (use CBD definitions).
- Better guidance is needed on how the term IAS can be used to characterize invasiveness.
- Invasiveness and non-invasiveness often depend on habitat requirements
- CBD has already formulated biodiversity action plans, there is a need to look at them and decide how they can be adapted to aquatic IAS.
- Some countries are reluctant to impose on resource poor farmers using the alien species. ("Do not make their situation worse by enforcement!")
- The need for development of technical guidelines that will assist governments in interpreting the provisions in international treaties.
- Participants should go back to their own country, organize a workshop, and prepare national strategies. In Malaysia, this was organized at the request of the Ministry of Agriculture. All national institutions were invited, and worked together to develop recommendations.

Working group 2: Transboundary pathogens

The participants were asked to address the issues relating to implementation of the Asia Regional Technical Guidelines to minimize the risks associated with trans-boundary pathogens in ASEAN. The following points were raised in discussions of the report from working group 2.

- The necessity to raise the profile of the sector in order to obtain more resources to manage aquatic animal pathogens. In order to influence policy makers and politicians, the trade advantages and economic/environmental gains of having health management systems should be clearly presented to them.
- Senior policy makers need to be informed of their role and encouraged to pay more attention to issues concerning IAS and associated pathogens.
- Increase awareness of neighboring countries and the need to share responsibility to help neighbors.
- The importance of continuing current work, and acknowledgement of previous findings related to transboundary pathogens is essential to sustain the progress of their initiative.

- IAS issues need to be introduced into educational systems and included in school curricula.
- The SEAFDEC funding and Japanese trust fund are facilitating the shift to on-line training. Those who pass the computer based examination go to SEAFDEC for hands on training.

Working group 3: Regional and international initiatives
A discussion on recent activities on aquatic invasive alien species with relevance to the ASEAN region. The following points were raised in discussions of the report from working group 3.

- Ornamental fish and their contribution to economies – potential for development and potential problems. The issue of encouraging the development of ornamental fish culture has not been properly addressed within the aquatic resources discussion. Is this the right forum to say we need to look further at this issue?
- NACA GC had asked to develop a regional program on ornamental fish.
- Approaching the issue of aquatic invasive alien species within the context of the ecosystem i.e. not only in aquaculture, but also their effects in the natural environment.
- The effect of ornamental fish on disease transmission as well as on ecosystems has been under-estimated. A large number of imported ornamental species have escaped, established in natural waters and become invasive.
- Increase awareness of neighboring countries and the need to share responsibility to help their fellow neighbors.
- The importance of continuation of current work, and acknowledgement of previous findings related to transboundary pathogens is essential for the sustainability of progress.

Working group 4: Information
The working group was asked to discuss the information needs and tools necessary for building capacity to address risks and manage impacts of aquatic IAS and associated pathogens. The following points were raised in discussions of the report from working group 4.

- Need to bring the information down to the farmers. Include those recommendations in discussions — NACA would welcome hosting.
- Accessibility to risk assessment for alien species? Is there one available? What can we place on the internet to allow easy access to information/resources.
- Web based information services such as FishBase should receive more funding to include other phyla such as crustaceans as well as mapping and geo-referenced information.
- The OIE - international standard setting organization by WTO. Encourage adoption of OIE guidelines as international guidelines. Make governments adherence to international standards a top priority.
- Examine how the OIE guidelines can be applied to ecological impacts.

The Way Forward

The following statement on "The Way Forward" was discussed and adopted by the workshop participants during the final session.

Background

The workshop on "Building capacity to combat impacts of aquatic invasive alien species and associated trans-boundary pathogens in ASEAN countries" was held in Penang, Malaysia, on the 12th-16th July 2004. The workshop was hosted by the Department of Fisheries of the Government of Malaysia and organized by the Network of Aquaculture Centres of Asia-Pacific (NACA) in collaboration with ASEAN, FAO, the WorldFish Center and the United States Department of State. The 75 participants included delegates from each ASEAN[1] member country, resource persons with experience in aquatic invasive alien species (IAS) and aquatic animal pathogens and representatives of, regional and international organizations, research institutes, universities and private sector entities[2] .

The workshop supports the ASEAN 2020 Vision of enhancing "food security and international competitiveness of food, agricultural and forest products and to make ASEAN a leading producer of these products…" It was convened to better understand the relationship of aquatic IAS and pathogens and their impacts (both positive and negative), and to identify management and capacity building needs to reduce risks. The workshop built on the recommendations from a 2002 Bangkok workshop organized by the Global Invasive Species Program (GISP[3]) and a 2003 workshop of countries sharing the Mekong watershed[4] , particularly in promoting awareness, establishing coordination mechanisms and information exchange systems and identifying management strategies and risk mitigation measures for aquatic IASFindings.

Findings

The participants concluded that aquatic IAS and invasive aquatic animal pathogens significantly impact the aquaculture industry in ASEAN, and can have negative implications for aquatic biodiversity, and the social and economic well being of people in the ASEAN region. Participants also recognized the positive social and economic benefits that have come from the introduction and farming of some alien aquatic species in the region. Participants agreed that the way forward is to minimize the risks and costs associated with negative impacts of aquatic IAS and aquatic animal pathogens whilst capturing the social and economic benefits possible through responsible aquaculture of alien species.

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[1]Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam.

[2] AIT, APEC, ASEAN Secretariat, AusVet Australia, CAB International, Deakin University, FAO, IUCN, MRC, Multimedia Asia, NACA, OIE, PhilRice, SakNIRO-Russia, SEAFDEC-AQD, Universiti Putra Malaysia, World Fish Centre and the US Department of State, US Dept of Commerce and Interior and the MD Dept of Natural Resources.

[3] http://www.usa.or.th/embassy/reo/reo-wrkshp.htm. GISP (2003) "*Prevention and Management of Invasive Alien Species: Forging Cooperation throughout South and Southeast Asia*". Global Invasive Species Program.

[4] Workshop on *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.

Recommendations

Four working groups prepared detailed action plans to assess and manage the impacts and risks from aquatic IAS and associated animal pathogens. The following bullets highlight the main recommendations agreed upon by the workshop participants as the Way Forward:

- Management of aquatic IAS and associated pathogens is imperative and should be encouraged and implemented in all ASEAN countries.
- National strategies should be developed consistent with obligations under existing international treaties and instruments[1] and in harmony with strategies for other IAS, including aquatic plants and ornamental fish. National strategies, coordinated through national focal points, should be based on impact assessment and management of alien species, where they are already established, and use of ecological and environmental risk analysis for proposed new introductions.
- National strategies should be implemented within a legitimate regional framework supported and endorsed by ASEAN. The recommendations in this Way Forward summary should be presented to the ASEAN Secretariat as a starting point for coordinated regional action, through the ASEAN Sectoral Working Group on Fisheries and other appropriate bodies.
- ASEAN member countries should have the necessary institutional and human resources to adopt a harmonized regional strategy. Bridging development gaps and capacity building across member countries is therefore necessary. Special attention should be given to capacity building among the Mekong basin countries of Cambodia, Lao PDR, Myanmar and Vietnam.
- In-country IAS impact assessment and risk analysis training should be promoted and implemented to establish core expertise in these practices in all ASEAN countries. Experiences in risk analysis and impact assessment should be shared among ASEAN countries.
- Networking, information exchange and cooperation among concerned agencies, industry, trading partners and countries sharing common watersheds or waterways is recommended for cost-effective use of resources in support of ASEAN in achieving the goal of effective management of aquatic IAS and associated aquatic animal pathogens.
- Assistance should be sought from regional and international organizations to implement the workshop recommendations, including from the organizers and participants of this workshop and other regional and international organizations. Progress in implementing the workshop recommendations should be assessed in three years.

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[1] These include the Convention on Biological Diversity (CBD), International Maritime Organisation (IMO), World Trade Organisation (WTO), World Animal Health Organisation (OIE) and Food and Agriculture Organisation of the United Nations (FAO).

Closing remarks

Ms Thalathiah Saidin of the Department of Fisheries Malaysia congratulated the workshop participants for their productive work over the past three days and coming up with important final statement and a way forward in management of IAS in ASEAN. On behalf of the Department of Fisheries, she thanked the organizers for organizing the workshop in Malaysia, which had been very useful to Malaysia. Ms Thalathiah noted that the workshop had provided a better understanding of aquatic IAS, and that now it was important to take the recommendations forward. She appreciated the spirit of cooperation among the participants during the workshop and emphasized the importance of further networking and communication in helping ASEAN understand and manage aquatic invasive alien species.

Dr Devin Bartley of FAO thanked all the participants for their cooperation and looked forward to future collaboration. He confirmed FAO's willingness to support ASEAN in building capacity for management of IAS and associated pathogens.

Dr Oketani of OIE thanked the participants for their interest in OIE's work and the code and manual. He said that the OIE web site (www.oie.int) provided more information that should be of interest to participants. He thanked the Department of Fisheries Malaysia and organizers for a successful workshop, and looked forward to future cooperation.

Dr A.G. Ponniah of the World Fish Centre thanked the participants for their good collaboration in the workshop. He said that the WFC would be willing to continue supporting ASEAN on aquatic IAS, and looked forward to development of joint actions with the workshop participants and organizers to support implementation of the recommendations.

Dr Jeffrey Fisher thanked the participants on behalf of the US State Department. He mentioned the importance of building the web site, working closely with other ongoing regional and international initiatives on IAS, including ASEANNET, that will provide some taxonomic information. He noted the challenges ahead and the need to improve communications on IAS, develop national strategies and continue to build capacity for assessment and management of IAS. He said that the US State Department would continue to assist and collaborate with ASEAN on this issue. Dr Fisher thanked the participants for their active participation in the workshop, and wished them a safe journey home.

The Chairman of the final session, Pedro Bueno, Director General of NACA, thanked everyone for his/her valuable contributions to a successful workshop, reiterated the words of appreciation to the Government of Malaysia, and declared the workshop closed.

Annexes

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Annex B / Workshop Program

Tuesday, 13th July

0800h	Registration of Participants
0830h	Doa Recital
	Session 1: Opening ceremony
0835h	*Welcome Remarks* by Ms Thalathiah Saidin, Director of Fish Health Management and Quality Assurance Division, Department of Fisheries Malaysia
0840h	*Introductory Statements* Mr Pedro Bueno, Director-General, NACA Mr David Munoz, US State Department Dr Rohana Subasinghe, FAO Mr Rony Soerakoesoemah, ASEAN Secretariat Dr Yoshiyuki Oketani, OIE Regional Representation Dr M.V.Gupta, World Fish Centre
0910h	*Keynote and Inaugural Address* by Bpk Hj Ibrahim Salleh, Deputy Director General on behalf of the Y. Bhg. Dato' Junaidi Che Ayub, Director-General, Department of Fisheries Malaysia
0930h	Coffee
1000h-1245h	***Session 2: Workshop objectives, and selected technical overviews of invasive alien species and associated trans-boundary pathogens***
	Introductory remarks on objectives and organisation of the workshop – Michael Phillips, NACA
	CBD COP-7 Decisions on alien species that threaten ecosystems, habitats or species - Mr Chan Han Hee, Department of Agriculture, Malaysia
	An overview of international initiatives, treaties, agreements and management actions addressing invasive alien species – Jeffrey P. Fisher, USState Department
	Place of trans-boundary aquatic animal pathogens (TAAPs) within the invasive alien species (IAS) category: a review" – Rohana Subasinghe, FAO and Melba Reantaso, USA

Current knowledge of aquatic invasive alien species in ASEAN and their management in the context of aquaculture development" – A.G. Ponniah and Norainy Mohd Husin, World Fish Centre

Trans-boundary aquatic animal pathogens in ASEAN and their management" – CV Mohan, NACA , Brett Edgerton, NACA and Michael Phillips

Aquatic alien species and their contribution to aquatic production, food security and poverty alleviation" –Devin Bartley, Valerio Crespi, Isabel Fleischer and Rohana Subasinghe, FAO

1230h-1400h: Lunch break

1400h-1800h: ***Session 3: Country status paper presentations***

Brunei -	Hajah Laila Haji Hamid
Cambodia -	Bun Racy and Hav Viseth
Indonesia -	Hardjono
Laos -	Nivath Phanaphet
Malaysia -	V. Palanisamy and Thalathiah Saidin
Myanmar -	Minn Thame and Myat Myat Htwe
Philippines -	Simeona E. Regidor and Joselito R. Somga
Singapore -	Loo, J. J
Thailand -	Supranee Chinabut and Somkiat Kanchanakhan
Vietnam -	Phan Thi Van

1900h: Evening dinner hosted by Department of Fisheries, Malaysia

Wednesday, 14th July

0830h-1500h ***Session 4: Case studies***

Chair: Supranee Chinabut
Rapporteur: Le Ann Southwood

Case study on the invasive Golden Apple snail in ASEAN– Ravindra C. Joshi, A.G. Ponniah, Christine Casal and Norainy Mohd Husin, World Fish Centre

Tilapias are alien to Asia: But are they friend or foe – Sena De Silva, Australia

Movements of economically important Penaeid shrimp in Asia and the Pacific – Simon Funge-Smith and Rohana Subasinghe, FAO, and Michael Phillips, NACA

The special danger of viral infections in crustaceans - Tim Flegel, Mahidol University, Thailand

Key freshwater crustacean pathogens of concern to ASEAN - Brett Edgerton and CV Mohan, NACA

Mollusc pathogens of concern to ASEAN - Melba Bondad-Reantaso, USA and Franck C.J. Berthe, IFREMER, France

Marine and freshwater finfish pathogens of concern - Mohamed Shariff, Malaysia

Need for an institutional network for managing aquatic exotic species in Indochina - Amara Yakuptiyage, AIT, Thailand

1200h-1330: Lunch break

Risk Analysis as a Tool for the Management of Alien Aquatic Animal Diseases - Kevin Amos, USA

Risk Analysis for determining invasive potential, risks, and appropriate management for non-native aquatic species – Jeffrey Fisher, US State Department

Risk analysis frameworks and tools for management of aquatic invasive alien species and associated trans-boundary pathogens - Infrastructure and Capacity Requirements – Chris Baldock, Australia

1500h-1800h: ***Session 5: Working group sessions***

Working group 1: Invasive alien species [Lawang room]

Working group 2: Transboundary pathogens [Plenary room]

Working group 3: Regional and international initiatives [Pala room]

Working group 4: Information [Jintan room]

1830h-2000h: ***Cocktail Showcase:***

Showcase of posters and the work of the various countries and organisations involved in the workshop.

Special presentations:

Tracking pathogens through species introductions: a database mapping approach - Christine Marie V. Casal, Allan N. Palacio, Melba Reantaso, A.G. Ponniah, Norainy Mohd Husin, Boris Fabres and Rainer Froese

CAB International: its activities related to information on invasive alien species - S.S. Sastroutomo, K.Y. Lum and W.H. Loke

FishBase: towards building a tool to assess species invasiveness - Christine Marie V. Casal.

The Global Invasives Species Information Network (GISIN), expert meeting *summary and the way forward* - Annie Simpson and Soetikno S. Sastroutomo

Thursday, 15th July 2004

0830h-1030h: ***Session 5: Working group sessions (continued)***

1030h-1100h: Coffee break

1100h-1230h: ***Session 6: Building information systems to support ASEAN in assessment and management of alien aquatic species and associated aquatic animal pathogens***

Chair: A.G. Ponniah, World Fish Centre
Rapporteur: Jeffrey Fisher, US-State Department

Presentation of draft web site for aquatic IAS by John Molloy, followed by discussion session on building of information systems facilitated by Rohana Subasinghe

1300h-1400h: Lunch break

1400h-1730h: Field trip to local aquaculture site

Friday, 16th July 2004

0830h-1200h: ***Session 7: Final session***

Chair: Pedro Bueno, Director-General, NACA
Rapporteur: Devin Bartley, FAO

Working group 1: presentation by Thalathiah Saidin

Working group 2: presentation by CV Mohan

Working group 3: presentation by Richard Arthur

Working group 4: presentation by Devin Bartley

1045h-1100h: Coffee break

1045h-1145h: The Way Forward

1145h-1200h: Closing remarks

Annex C / Keynote and Inaugural Address

Y. Bhg. Dato' Junaidi Che Ayub
Director General of Department of Fisheries
Malaysia

It is an honor to deliver a keynote and officiate this auspicious event "Building Capacity to Combat Impacts of Aquatic Invasive Alien Species and Associated Trans-Boundary Pathogens in ASEAN Countries". I welcome you to Malaysia and hope that your deliberations will be inspired by the beauty of the island.

Rather than talking at length on a subject that you all know very well, I would like to view this issue from the standpoint of a government decision maker. I will place this in the context of some global and regional agreements.

The issue of alien species was prominently raised during the UNCED process which culminated in the creation of the Convention of Biological Diversity (CBD). The principal objectives of the Convention are the conservation and sustainable use of biological diversity, and the fair and equitable sharing of benefits arising from its utilization. Article 8 of the Convention says that "Each Contracting Party shall Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species".

The Conference of the Parties of the Convention has considered that the subject of alien species is a cross-cutting issue within the Convention, and recognized the particular importance of geographically and evolutionary isolated ecosystems. It has identified alien species as an important concern in the work program on marine, coastal biological and inland water biological diversity. Another important issue addressed by the Convention is biosafety. The second Conference of the Parties in1995 established a working group to develop a draft protocol on biosafety, which has since become known as the Cartagena Protocol on Biosafety, focusing specifically on trans-boundary movement of living modified organisms resulting from modern biotechnology.

Very recently the seventh meeting of the COP, held in February 2004 in Kuala Lumpur, deliberated on guidelines with respect to "Alien Species That Threaten Ecosystems, Habitats or Species".

Complementary to the CBD, the FAO Code of Conduct for Responsible Fisheries also recognizes the importance of alien species: Article 9.3.1 calls on States to conserve genetic diversity and maintain integrity of aquatic communities and ecosystems by appropriate management of *inter alia* alien species. The FAO Code provides guidelines to minimize the risks from alien species and calls on States to cooperate in managing alien species by

- Consulting and notifying neighboring States when an introduction is being planned;
- Complying with relevant international agreements;
- Adopting measures to reduce the risk of spread of disease.

To help implement the above articles, FAO has created a Database on Introductions of Aquatic Species, that now contains approximately 3800 records of international introductions.

In ASEAN, the ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security in the New Millennium: "Fish for the People" in 2001, issued the Resolutions on Sustainable Fisheries for Food Security for the ASEAN Region. The Resolution calls on member countries to cooperate to identify constraints and enhance collaboration among government agencies to harmonize policies, plans and activities to mitigate potential impacts on the environment and biodiversity, including the spread of diseases caused by uncontrolled introduction, trans-boundary movement and transfer of non-indigenous and exotic or alien aquatic species through international and regional trade of live fish.

Concurrently, a Plan of Action for sustainable aquaculture development and fish trade was formulated. The Plan of Action emphasizes the importance of reducing the risk of negative environmental impacts, loss of biodiversity, disease transfer by regulating the introduction, trans-boundary movement and transfer of aquatic organisms in accordance with the wider-scoped Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals. This guideline was referred to by the Director General of NACA as a result of a wide-ranging consultation and cooperative work among NACA, FAO, The World Animal Health Organization, other regional and national organizations, and 21 governments in Asia-Pacific. I would like to say that it has been a valuable document to ASEAN and to governments. The ASEAN Fisheries Working Group adopted it, and it has been an important practical guide to national health management policies and programs. It gives substance to codes of conducts and gives substantial operational basis for government programs. I would not be surprised if many of you have been involved in its development.

In fish trade, the Plan calls for a concerted effort to strengthen ASEAN trade policy on fish and fishery products through regional collaboration, by harmonizing product standards and sanitary measures with international standards wherever possible, working towards harmonized guidelines for fish inspection and quality control systems among ASEAN member countries with regards to food safety.

One of major setbacks to live fish trade and aquaculture in the region are the disease outbreaks, which can result in massive loss of production and thereby loss of trade. Disease control also adds significantly to production costs making the products uncompetitive.

The live fish trade among ASEAN member countries is more than US$100 million annually. But it is a trade through which invasives – animals or the pathogens they bring with them – can be transferred. We have endeavoured to install adequate quarantine measures and observe transfer protocols to prevent entry or introduction of harmful organisms. These have included fish inspection, quality control and certification systems in all ASEAN member countries. The weakness of the systems however stem from the different levels or degree of implementation of the prescribed international standards, owing to a number of factors that include varying levels of competence and capacity of national authorities.

To refer again to the "Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals and Beijing Consensus and Implementation Strategy," its objective is to assist countries to undertake responsible movement of live aquatic animals to minimize the disease risks associated with pathogen transfer and disease spread, both within and across boundaries. As I said, a number of constraints – some technical, some resource-based — prevent full adherence to the guidelines. On the other hand, I must also say that legislation and complementary management measures to enforce quarantine measures and control disease outbreak, are sometimes lacking or adequate in its enforcement. There is also need to complement regulations with multi-stakeholder action so that rules are widely accepted, and codes – which are voluntary — are observed.

There is also – at the regional level – increasing need for a harmonized inspection, monitoring and quarantine procedures among ASEAN member countries to support responsible trade among our countries, and to ensure that efforts are in line with the Asia Technical Guidelines on the Responsible Trans-boundary Movement of Live Animals and the Beijing Consensus and Implementation Strategy.

On another impact, biodiversity, CITES has also addressed trade in alien species and has called on Parties to consider the problems of invasive species when developing national legislation and regulations that deal with the trade in live animals or plants. The call also urges consulting the Management Authority of a proposed country of import when considering exports of potentially invasive species, to determine if there are domestic measures regulating such imports. We are also urged to consider the opportunities for synergy between CITES and CBD and explore appropriate collaboration between the two Conventions on the issue of introduction of invasive alien species. I am sure these are now being addressed in various follow up forums.

FAO reports that aquaculture continues to be the world's fastest growing food production sector, registering an overall growth rate of over 11.0% annually since 1984, compared with 3.1 % for terrestrial farm animal meat production, and 0.8% for production from capture fisheries. Aquaculture's contribution to world fisheries production has increased three-fold since 1984, from 10.15 million mt or 11.4 % of total fisheries production to 42.0 million mt, or 33% of total fisheries production in the year 2000. ASEAN countries make a substantial contribution to the global total.

In Malaysia, the total trade of live fish in 2003 was about RM100 million (or US$26 million), comprising mainly ornamental fish, valued at RM85 million (US$22 million). The rest were of fish seed as well as some live food fish.

With the advent of aquaculture and international trade in live aquatic species, trans-boundary movement of species within the country, between countries and regions becomes inevitable.

A significant number of aquatic species that are alien to the native environment have been transferred, introduced and traded in the pursuit of aquaculture development including the ornamental fish industry. Some of the impacts that we have felt in Malaysia, of introduction of aquatic invasive alien species include displacement of indigenous species and habitat destruction. I will describe some cases: first is the introduction of the flat head fish popularly known as the municipal fish. It was brought into the country sometime in the 1950's as an ornamental fish. The fish eventually became established, especially in shallow rivers. The presence of this fish is indicator of a polluted river. Consequently, efforts to restore the ecological status of these rivers have become an exercise in futility as the nature of this fish is to persistently rake and scour the river bed, thus increasing water turbidity and making it an extremely un-livable environment for indigenous species.

A second example, which I am sure is not unique to Malaysia, is white spot syndrome viral disease in marine shrimp. It has resulted in an estimated loss in global revenue of about US $ 2 billion in 1999 alone, and caused additional economic losses as well as social disruption with the displacement of labor due to closures of farms, hatcheries and adverse effects on support and ancillary industries. In Malaysia, the loss that could be attributed to white spot disease outbreaks in shrimp aquaculture was estimated at US$25 million.

In view of the devastating impact of the invasive aquatic alien species to livelihoods, national economies, and to environments including local biodiversity, and the threats they pose on wild fisheries, in the ASEAN region, a concerted effort is urgently needed to minimize these impacts and to curb the invasive nature of these alien species to the environment at large. The CBD has explicitly specified outlined the need to prevent the introduction of, control or eradicate those alien species that threaten ecosystems, habitats or species.

This would indeed be considerably enhanced by a broad and close cooperation among regional and international organizations and their appropriate assistance to improving the capacities of Governments. Perhaps rehabilitation and restoration of the degraded ecosystems and habitats to promote the recovery of threatened species. The development and implementation of plans or other management strategies can be collectively implemented at the regional level.

Capacity building on risk analysis, risk management, risk assessment and environmental impact assessment, improved information, for example by the setting up of a biosafety and /or biosecurity clearing-house and by further use and upgrading of databases such as the FAO Database on Introductions of Aquatic Species and the Global Invasive Species Database, liability and redress from damage resulting from aquatic invasive alien species and associated trans-boundary movements of pathogens, is highly desirable to enhance the capacity of the ASEAN member countries to implement these initiatives. On this point, the APEC/FAO/NACA/OIE/DOF-Thailand workshop on Capacity and Awareness Building on Import Risk Analysis for Aquatic Animals held in Bangkok (and in Mexico) during 2002 has produced the Manual on Risk Analysis for the Safe Movement of Aquatic Animals. From government's point of view, this is an exemplary guide in that it provides a simplified and easy to follow, practical guide to risk analysis. I should think that it can also be applied to the trans-boundary pathogens resulting from the trans-boundary movement of invasive aquatic alien species.

This current initiative will further enhance protection of the aquatic environment and biodiversity, for the aquaculture and capture fisheries industry. This workshop is very timely in view of the increasing threat posed by aquatic invasive alien species on the aquaculture industry, which is the mainstay of most of the ASEAN countries. I would like to see the workshop come up with some good practical recommendations for follow up action that will benefit all our countries. As present Chairman of the ASEAN Fisheries Working Group, I will be pleased to take the recommendations to the next working group meeting, for further discussion and development of collective regional action.

This congregation of international experts to work with regional and national experts in a collegial atmosphere – a trademark of NACA-executed activities – is a welcome sight to governments. Another source of re-assurance to national fishery managers like me is that NACA ensures that practical follow up actions are recommended and, most important, taken up in national and regional programs.

Speaking as a former Chairman of its Governing Council, uptake of recommendations is assured by the nature of the Organization, which is intergovernmental; the way its programs are developed, which is through extensive consultation; and the manner in which its projects are designed, which is to add value to rather than duplicate existing programs. In short, its programs are owned by governments and the principal stakeholders, and they are developed to make use of, at the same time improve national institutions and capacities. I am confident that the objectives of this regional workshop will be achieved.

I convey my appreciation to government representatives, experts from various institutions, and advisers to this activity, for your time and inputs to this workshop. I congratulate and appreciate the efforts of the organizations and agencies that have conceived and developed this initiative — NACA, FAO and the US-State Department, and the World Fish Center and ASEAN Secretariat.

In closing, on behalf of the Government of Malaysia I express my sincere gratitude for the collaborative assistance of the US- State Department, NACA, FAO, World Fish Center, ASEAN Secretariat and World Animal Health Organization in making this workshop a success.

It is my pleasure to declare the workshop open.

Annex D / Working Group Guidelines

The following guidelines were distributed to the working groups to facilitate discussion for each of the following four working groups.

Working group 1: Aquatic invasive alien species in ASEAN
Working group 2: Trans-boundary pathogens and aquatic animal health
Working group 3: Recent activities on aquatic invasive alien species
Working group 4: Information needs and tools

Each group will appoint a Chair, Vice Chair and Rapporteur. The group should refer carefully to the objectives and expected outputs of the workshop (see background papers) and country status paper and resource papers to focus their discussions. Keep outputs clear and focused as much as possible, and identify practical follow up activities, and prioritize them.

The following provides specific guidance for each working group.

Working group 1: Aquatic invasive alien species

Expected output from Working Group 1

Working group 1 should draft a national and regional action plan to increase the capacity to assess and manage risks. The plan should be based on present knowledge on the status of aquatic invasive alien species in ASEAN, impacts and risks and include recommendations for implementation.

More specifically the output should cover the following points:

1. Review the current knowledge and impacts of already established invasive aquatic alien species in ASEAN (an understanding of which species are considered as invasive, negative impacts, the ambiguities in determining these and trade-offs between negative and positive impacts.)
2. Identify country approach / criteria for risk analysis of potential aquatic invasive alien species in ASEAN.
3. Review the status of existing national strategies, legal, policy and institutional mechanism in ASEAN to address risks due to invasive alien species. Identify gaps in existing mechanisms and constraints that limit implementation.
4. Identify practical actions to build capacity for addressing risks of invasive alien species in ASEAN, at national level and for initiating regional collaborative programs in the area of legislation and policies and the development of information tools. Identify supporting/collaborating agencies.
5. Identify key elements in a national and regional risk management framework and actions required to build the framework.

Working Group 2 - Trans-boundary pathogens and aquatic animal health

This group will consider implementation of the Asia Regional Technical Guidelines to minimize the risks associated with trans-boundary pathogens in ASEAN.

The main elements contained in the Asia Regional Technical Guidelines (TG) are:

- Disease diagnosis
- Health certification and quarantine measures
- Disease zoning
- Disease surveillance and reporting
- Contingency planning
- Import risk analysis
- National strategies and policy frameworks
- Regional capacity building

Discuss the progress of implementation of the above aspects of the TG with the view to minimize the risks associated with trans-boundary pathogens in ASEAN region.

Discuss the linkages between IAS and associated pathogens and the opportunities for reducing the risk of introductions and spread of such pathogens through implementation of the TG.

Identify key actions to address the above concerns.

Some further background

Trans-boundary aquatic animal diseases are a major risk and a primary constraint to the growth of the aquaculture sector and are now severely impeding the socio-economic development of aquaculture in many ASEAN countries. Aquatic IAS could either be pathogens, which could cause trans-boundary aquatic animal diseases, or could harbour aquatic animal pathogens that lead to diseases and epizootics in aquaculture. Aquatic invasive alien species, and aquatic animal pathogens, could be a trans-boundary problem and there is potential to cause negative impacts on international trade, travel and transport.

Trans-boundary movement of live aquatic animals in the region is one of the principal reasons for increased occurrence and spread of several serious diseases (Subasinghe *et al*, 2001). The spread of aquatic animal pathogens has directly led to serious disease outbreaks in Asia, impacting on aquaculture productivity, livelihoods, trade and national economies. Such problems have also indirectly impacted on trade of aquatic animal products within Asia and between Asia and major trading partners. 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 ASEAN 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 would have far reaching positive implications for the development of subsistence and commercial aquaculture and fisheries in the ASEAN region.

Since defining a framework for disease control in the region, NACA, FAO and OIE with various partners have worked towards support in implementation. Supporting documents have been prepared that provide further guidance to Asian countries, including the Asia Regional Technical Guidelines (FAO/NACA 2000, the Manual of Procedures (FAO/NACA 2001) and an Asia Diagnostic Guide (Bondad-Reantaso *et al.* 2001). All 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 1994), as well as Article 9 - Aquaculture Development - of the Code of Conduct for Responsible Fisheries (CCRF) (FAO 1995).

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.

To ensure effective implementation at the national level, competent national authorities have designated **National Coordinators (NC)** for each of the participating governments The National Coordinators are the focal persons in participating countries for coordinating national aquatic animal health management initiatives, and a focal point for coordination with NACA on aquatic animal health issues. The specific responsibilities of the National Coordinator are:

- To coordinate implementation of aquatic animal health management strategies at the national level
- To promote the Technical Guidelines and their implementation at national levels.
- To organize a disease reporting system for reportable diseases and prepare quarterly aquatic animal disease reports for the NACA/OIE/FAO regional reporting system
- To initiate programs to develop national aquatic animal health strategies to implement the Technical guidelines in a phased manner.
- To oversee implementation of quarantine and health certification in consultation with aquatic animal health expertise in the country
- To participate in the regional aquatic animal health programs of NACA
- To initiate actions to address disease emergencies

The 21 governments adopting the Technical Guidelines include the countries of the ASEAN. Further strengthening their implementation in the ASEAN was their adoption as a policy document by the ASEAN Fisheries Working Group in 2001. The main elements of the Technical Guidelines are as follows:

- Scope, purpose, and background
- Definitions and guiding principles
- Pathogens to be considered
- Disease diagnosis
- Health certification and quarantine measures

- Disease zoning
- Disease surveillance and reporting
- Contingency planning
- Import risk analysis
- National strategies and policy frameworks
- Regional capacity building
- Implementation of the technical guidelines
- The Beijing Consensus and the implementation strategy

Information presented during the first two days of the workshop would provide an opportunity for the NCs from ASEAN to better understand common regional problems on disease and pathogen aspects of aquatic invasive alien species, and think of ways to act in a unified way through improved human capacities, improved policies, standardized approaches and networking that will facilitate exchange of information, experiences and expertise.

While developing the working group recommendations, the groups are urged to keep the following issues in mind. There are differences between regional and national contexts. Guidelines at regional level are not always easy to apply at national level. The way forward is to develop a national approach within the framework of the guidelines. Within the ASEAN, between countries, there are social and political differences, differences in capacity and availability of resources, and differences in priorities. Common borders and shared watersheds can facilitate or hamper implementation. The following issues are presented for further consideration and discussion at the working group sessions:

- The importance of legislation and policy frameworks to support implementation.
- The need for national coordination and institutional cooperation, including between veterinary and fishery authorities
- The need to understand risks and to focus on key pathogens of concern for the ASEAN 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 ASEAN countries. Disease zoning and cooperation within the region, for example to 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 evaluating health management programs, and building systems gradually, with regular evaluation and exchange of experience.

Questionnaire to Aquatic Animal Health National Coordinators.

Name of the Country:

Questions	Yes/no	Comments if any
Does your country have a comprehensive national strategy to deal with trans-boundary aquatic animal diseases?		
Is your country implementing the TG in a phased manner?		
Have institutions been identified with defined responsibilities for TG implementation in your country?		
Does your country have list of diseases of national concern?		
Does your country have adequate diagnostic capability (level I, II and III)?		
Does your country have adequate trained technical personnel?		
Does your country follow quarantine and health certification protocols for import/export?		
Does your country take decisions on introductions based on formal/informal risk assessments?		
Does your country undertake active targeted surveillance for any specific pathogen?		
Does your country have a framework for gathering disease data for regional disease reporting?		
Does your country have contingency plan for dealing with disease emergencies?		
Has your country initiated any work on zoning?		
Does your country have capacity for IRA?		
Has networking of aquatic animal health experts and laboratories initiated/established in your country?		
Does your country have the necessary policy framework to support TG implementation?		
Does your country have the necessary legal framework to enforce TG implementation?		
Does your country allocate sufficient resources for national strategy development and implementation?		

Working Group 3 - Recent activities on aquatic invasive alien species

This working group will consider recent activities on aquatic invasive alien species with relevance to the ASEAN region.

As we go through the recent IAS activities we must continue to refer to the desired objectives and outcomes of this workshop. Although each one is relevant, the following objective relates specifically to this working group:

4) **Review national policies and legislation as well as compliance to international treaties and conventions dealing with aquatic IAS, and identify specific actions for their implementation in ASEAN.**

Expected output from Working Group 3

We expect working group 3 to consider outcomes of current meetings, workshops, international decisions, etc. that have addressed the issue of aquatic invasive alien species and associated trans-boundary pathogens in the ASEAN region. Special attention should be paid to impacts, risks, and recommended national and regional actions aimed to increase capacity to assess and manage risks. In particular the discussions should review and build on:

- the recommendations of the 2002 Bangkok workshop, "*Prevention and Management of Invasive Alien Species: Forging Cooperation throughout South and Southeast Asia*".
- the Yunnan workshop on international mechanisms to address alien species held in August 2003, whose recommendations are provided, with special reference to Mekong cooperation for policy development and capacity building;
- the APEC workshop on marine pests held in Chile in April 2004 (see below);
- the Conference of the Parties of the Convention on Biological Diversity held in Malaysia 2004;
- USAID project on IAS and development assistance; and
- Other activities as identified by the group.

The outputs, conclusions and recommendations from the above activities should be reviewed and evaluated as to their application to the ASEAN region. More specifically we expect the output should cover the following:

- List and categorize recommendations, decisions, plans of actions, strategies according to related issues.
- Describe the status of their implementation.
- Prioritize into short, medium and long term implementation.
- Major gaps not covered by above, e.g. are socio-economic issues associated with biodiversity impacts well addressed?
- Suggest how to move forward in implementing the decisions or address gaps.
  What are the major constraints in implementation, with emphasis on legal, policy and institutional capacity?
- Identify practical actions to build capacity for addressing risks of invasive alien species, within the context of ASEAN cooperation, at national and regional (collaborative) levels,

including possibly legislation and policies, knowledge and information (information tools), and capacity building and cooperation at, regional and international levels. The outcome should include key elements in a national and regional risk management framework.

- Recommend measures to support ASEAN countries individually and collectively build capacity to address aquatic alien invasive species, including potential supporting/collaborating agencies.

A management framework for pests in APEC: Workshop statement

APEC member economies are united by the Pacific Ocean. Its marine resources are vital to trade, economic development and the health and well being of APEC member economies and their people. These resources are, however, under increasing pressure from human induced spread of marine pests. Introduced Marine Pests (IMPs) are estimated by some member economies to have cost them billions of dollars in lost economic activity, increased pressure on food safety, and costs for control measures, as well as trade and socio-economic implications. As marine based activity grows in the region, the economic, environmental and health costs to APEC member economies will increase unless action is taken to limit the spread of these pest and pathogen's species.

A workshop to develop options for regional action to address this growing threat was co-hosted by Australia and Chile in Puerto Varas, Chile from 3-5 May 2004. The workshop was attended by representatives from 17 Economies, the Lead Shepherds of the Marine Resource Conservation Working Group and the Fisheries Working Group, the International Maritime Organisation, the World Conservation Union, the Permanent Commission for the South Pacific, the workshop consultants, and scientific experts.

The workshop builds on previous APEC work and responds to the APEC Oceans Ministers call in the Seoul Oceans Declaration to "*Contribute to further international effort for the control and management of ships' ballast water and sediments"* and to *"Accelerate efforts to address the threats posed by introduced marine pests, destructive fishing practices, and sea- and land-based sources of pollution".*

A shared awareness and understanding of the risks that IMPs pose to regional growth and sustainability is urgently needed, given the cross-sectoral nature and complexity of the problem. Due to the way marine pests are transferred, co-ordinated regional action is essential and can help reduce the costs of addressing pest problems to individual economies. Some key areas for further work include: coordination of management of IMPs within and between economies; capacity building; information sharing; targeted research; and education and training. Further integration of the work of MRCWG with other APEC working groups, regional and international organisations, will demonstrate APEC's commitment to integrated oceans management and regional action based on agreed principles and practices.

Given the direction that Chile, the APEC host for 2004, has given to its related activities and particularly its explicit commitment to sustainable growth, the workshop requests that the MRCWG ask Senior Officials to bring this matter to the attention of APEC Leaders. This would help promote a shared understanding of the problems and a shared commitment to the sorts of actions identified at the workshop in Puerto Varas..

Working Group 4 - Information needs and tools

The working group will consider information needs and tools to support ASEAN countries build capacity to address risks and manage impacts of aquatic invasive alien species and associated pathogens.

The group will discuss matters pertaining to the availability and accessibility of information essential to assist governments, policy makers, scientists and other stakeholders in dealing with aquatic IAS and associated trans-boundary pathogens.

Expected output from Working Group 4

1. The Working Group will examine sources of information on aquatic IAS, identify subjects where access to information is lacking, and recommend how access to information for these critical areas can be improved. Special attention should focus on identifying current gaps in knowledge and information for dealing with aquatic IAS and aquatic animal pathogens in ASEAN. Consideration should be given to additional information, e.g. on socio-economics, habitats and environment, that may be necessary for risk assessment of alien species.
2. Review existing national and regional decision support tools, focusing on design and incorporation of information and other communication media pertaining to invasive species and the risks of their introduction to ASEAN countries and the region. The group should identify what format, e.g. database, pdf files, interactive systems, etc. for this information is appropriate for ASEAN.
3. In particular, the Working Group will review the concept, framework and progress made towards establishing the pilot website on aquatic IAS in ASEAN, and recommend ways to improve its usefulness, scope and content. Special attention should be given to existing information on aquatic IAS and pathogens in ASEAN region.
4. The Working Group will advise on organisation of the information session (session 5) and prepare a presentation of a draft of the above system for Session 6 in plenary.

AnnexE / Working Group Reports

Working Group 1 - Aquatic invasive alien species in ASEAN

Represented - Malaysia, Lao PDR, Myanmar, Philippines, Viet Nam, Thailand, Cambodia, Indonesia. **Not represented** - Brunei, Singapore

1. Invasive species

Species lists – no specific lists exist for *alien* aquatic invasives.

Invasive species impact assessments

- Myanmar has for *C. Gariepinus* (non scientific assessment).
- Philippines (apple snail?).
- *Eichornia*, *Pistia* plant species may be done by departments other than Fisheries in some ASEAN countries.
- Singapore - appears to have a list.
- Not all the assessments have been done by National DOF but may been done by other agencies.

There is a need for a common view regarding invasive species – in particular the viewpoint of "invasive pathogens" and "invasive species" (i.e. larger organisms such as animals and plants etc.). An additional consideration is invasive organisms that are typically planktonic (or larval) in nature and may arrive in ballast waters.

The group agrees to the specification regarding pathogens i.e. that the pathogen is an 'alien pathogen' (its degree of invasiveness would be a subsequent consideration). For aquatic species there are some criteria for 'invasiveness' (this is not internationally agreed) but no such list exists for pathogens.

Therefore the lack of common definition for invasiveness prevents the development of specific lists. The question is how does a country assess "invasiveness" – The group feels that there is a need to elaborate some practical criteria for evaluating invasiveness in the context of aquatic species and aquatic environments. The general description that is used by CBD probably requires more specific elaboration to deal with alien invasive aquatic organisms and pathogens.

There are lists of species (freshwater species, invertebrates, marine species etc.) that have been prepared by many countries. These may not be exhaustive but at least indicate indigenous species and in some cases, the commonly utilized alien species. These lists could be screened and the species so far listed could be categorized into 'indigenous' and alien (or possibly include 'native' in the case of species that are considered feral or have a long history within the country) as well as those considered high risk with respect to invasiveness.

2. Risk assessment

2.1 Approach and criteria for assessment

Is risk assessment a standard 'tool' for making decisions or evaluating species invasiveness/ infectiousness?

There is a need to establish risk assessment of invasive species as a priority in ASEAN countries. Some species have been assessed (or considered) by countries but the use of IRA as a tool has not necessarily been used or is not in place. It follows that assessments are made on available information (e.g., fish base) or based on communication of information on the experiences or concerns of others (i.e. a formal risk assessment is not made, but a judgement is taken). Information is rarely taken from the field but mostly from the desktop. Unfortunately, in most cases, invasiveness is decided after the impact has been assessed and the organism has become established.

The examples below illustrate why fundamental "in-country" capacity building on risk assessment is needed. For some species, the risks may be easy to determine, e.g. piranha., and there is already some information in some countries. But generic guidelines for risk assessment of IAS are needed, or guidelines already available elsewhere could be adopted and modified for ASEAN applicability. The guidelines should provide clarity on the definition of 'impact', including positive and negative impacts and their socio-economic aspects. Sharing and easy access to information (e.g. biological information); completed risk assessment studies etc., would be very helpful to this end. Mitigation measures will be dependent on criteria of risk.

Thailand, Philippines and Malaysia have undertaken an assessment of *P. vannamei* and two other species only. The assessments have been primarily targeted at health related issues but in the case of the Philippines was also extended to potential environmental impact. There are also model impact studies available from Australia.

Examples:

- Philippines - An expert panel makes an evaluation (the panel composition will include a national expert on the species. Associated supporting information is taken from resources such as Fishbase. The decision to ban *P .vannamei* was based on the perceived risk of TSV infection of the local *P. monodon* industry and wild stocks. The invasiveness was not assessed but a ban was put in place as a precautionary approach.
- Indonesia – long term assessment for Clupeicthys introduction. Risk assessment is undertaken on insect species but not for aquatic species, therefore some capacity exists in IRA.
- Thailand has a system that includes a committee for evaluating species for introduction. Any individual wishing to introduce a species must submit a request to the committee, which would consult relevant scientific agencies e.g.AAHRI for health or another department regarding potential environmental impact. In the case of *P. vannamei*, a university was commissioned to conduct the survey, whichconcluded that in the interest of enabling greater control over introduction, introductions should be allowed under license.

Ecological impact assessments were not undertaken.
- Malaysia has a committee on exotic species (this undertakes assessments similar to the Thai system). I.e. would also have import risk analysis.
- Lao PDR has no risk assessment process, but requires certification from the exporting country regarding the origin and health status of the animal.

2.2 List of prohibited species

Species lists need to be completed in all countries in the region, and consider all alien aquatic animals, pathogens and plants to address the issue comprehensively.

- Thailand has a list of prohibited species (a long list maybe more than 20 species)
- Malaysia (Piranha/ Pacu/Silver dollar/ total seven genera)
- Indonesia (7 aquatic species)
- Philippines (Piranha and 'all shrimp')
- Myanmar (Piranha, African catfish, *P. vannamei*)
- Lao PDR does not have a list but in the case of a new species it would use information from neighbouring countries. Mostly in a case by case basis.
- Viet Nam has a 'permitted list' of species, but not a 'prohibited list'.
- Cambodia (Piranha)

The CITES lists apply to signatory countries regarding species transportations.

3. National strategies

Within health guidelines, there is a need for a common strategy for integrated guidelines that cover all aquatic IAS. National strategies need to be developed by countries. ASEAN would declare it as a policy to encourage all countries in the region to build their national strategies. Such strategies should be based on needs and priorities of each country and will be dependent upon resources.

There is currently no mechanism in place for developing such strategy or components of the strategy. There is a need for some simple templates of existing strategies e.g. the recommendations of the ASEAN Fisheries Society meeting.

The coverage of such a strategy should also be clear. For instance, should aquatic plants be included?

3.1 Institutional mechanisms

- Lao PDR has a national 'policy' for indigenous species (MRC AIMS project), but this is not yet a full management strategy.
- Thailand – Institutional Biosafety Committee (DOF) Alien species GMO, (NBC – National Biosafety Committee under Biotech). Expertise from the directors of bureaus and from research institutes.
- Malaysia – Fisheries/aquatic issues are discussed at *ad hoc* committee of the DOF (exotics are covered under the fisheries act).

- Philippines – Has an import risk assessment panel which can approve an important introduction. However if the panel cannot decide it would refer the case to the National Committee on Biosafety of the Philippines (NCBP) under the Department of Science and Technology covering both plants, animals and aquatic animals (e.g importation of BT corn).
- Indonesia – has a committee under the Minister of Empowerment. Headed by the Ministry of Environment, with members from Fisheries, Forestry and Agriculture and Indonesian Institute of Science.
- VietNam – NAFIQAVED (veterinary agency) is the competent agency covering all aspects (heath and environment).
- Myanmar – has the Committee on Aquatic Animal Health. There is one aquaculture law. Import and export of live fish can only be authorized by the DG of Fisheries. Institutional linkages to veterinary institutions and universities.
- Cambodia has no specific mechanism but would probably come under DOF jurisdiction.
- In Thailand, aquatic plants are managed under Fisheries (import/export); control of established problem plants is covered by the agriculture department. In Indonesia and Myanmar if there is part of its life cycle in water, it is managed by Fisheries. Same with Philippines—covered under aquatic 'animal' .
- In Vietnam, aquatic vascular plant import/exports are covered by the agriculture department, just as they are if they were considered a nuisance plant in-country. Seaweed trade, however, is covered by the Fisheries department.

3.2 Elements of a National Strategy

The following elements were considered necessary for developing national strategies that could be integrated into a broader regional ASEAN strategy. These are not listed in any priority:

- National frameworks should be harmonized with regional frameworks, in turn supported with top-level regional policy endorsement and national legislation.
- Standardized analysis tools for risks and impacts. This would include the development of evaluation criteria for invasiveness as well as some environmental criteria for habitats (to identify habitats at risk from invasiveness from a particular species and to assist with developing criteria for zoning).
- Identification guides. An indicative list of potentially invasive aquatic species of common concern among all countries.
- Communication platform and media—both for national and regional level . (There is a hot line for disease outbreaks in Vietnam, but there is also the need for a mechanism that allows for input from the public.
- Surveillance mechanisms—need to recognize that the public/stakeholders are the first line of surveillance and should be engaged accordingly.
- Early warning systems can be more effective if a surveillance system is in place.
- Need focal points for information. Need web site for communication amongst experts.
- Rapid response—for health component, if there is an outbreak of disease, there is relatively rapid response. There is a similar need for an emergency response mechanism for cases of invasions of IAS (that are not pathogens) or of introductions.

- Control points identified and if possible strengthened (custom inspection, licensing, national database, etc.) .
- Eradication component—involves local communities and stakeholders. There is a need to look into how communities can be mobilized to undertake such action.

How can existing mechanisms be improved?

Importations are often driven by the private sector. Market forces during importations or introductions inevitably means that introductions occur before assessment can be undertaken. As long as there is a demand, a ban is unlikely to have an effect and weak control mechanisms can be easily bypassed.

3.3 Legislation, enforcement implementation

Even though restrictions exist, cross border transfers are difficult to enforce due to:

- Inspection difficulties (cannot open all boxes, inspection authorities do not recognize the species or animals).
- Sampling may not be done properly.
- Opening of sealed bags or packed animals is unacceptable since no repacking facilities (Malaysia is considering x-raying).
- Philippines - needs a similar approach as found in the implementation guidelines for transboundary pathogens. At the border/customs level the inspection process is similarly constrained to Malaysia.
- Customs officers have requested a simple pictorial manual of species for easy identification (even for fisheries staff).
- Focus on monitoring of effectiveness of controls coupled to strong penalties to offenders (i.e. disposal of illicit shipments and/or banning of operators following seizure).
- Legally, the penalties are relatively light and do not act as effective deterrents. Fines levied are relatively low and in some cases the office is not closed for repeat offenders.
- This approach will require considerable regional cooperation; otherwise loopholes between countries will continue to exist.
- Public education is a second level of awareness that is required to reinforce the message. For instance, visual materials (on airlines and at border crossings)would be useful.

What help is needed on legislation?

It should be recognized that fishery people are not legal experts. Existing laws that may address IAS should be summarized by country to determine if they are adequate. Using existing law is better, as enacting new legislation can take time and may even be more problematic. Assistance may be needed to enact legislation.

- In Indonesia the government considers IAS an important issue, asks minister to prepare law that involves consulting with experts, followed by lawyers drafting the legislation.
- Malaysia: Enforcement is where the problem is. Can have new legislation, but without teeth, what's the point; strategy/policy is needed before legislation.

The participants have responsibility to prepare a statement to bring it up the chain of command if new legislation is recognized as a need.

There is a need to evaluate existing legislation to assessif they cover invasive species and to determine whether existing laws could be used or new legislation required.

Need to integrate new legislation on invasives that is not confined to IAS in the aquatic sector, but recognizes that the problem may be viewed bigger encompassing aquatic plants and terrestrial animal health issues.

4.1 Capacity building

How do you communicate issues to decision makers and policy makers? Help the government make an assessment of thepositive and negative impacts of alien species, e.g. development of technical guidelines/criteria, capacity building on implementation of the guidelines. Need a national, regional or sub-regional level, mechanism, with support from regional/international funding mechanisms

- Impact assessment of those already in the country.
- Risk assessment for potential 'invasive alien' species.
- Technical Guidelines for RA for aquatic invasives. The criteria for invasiveness is based on available information.
- Definition of 'impact', positive/negative impacts, socio-economic aspects. Invasiveness is decided after impact is assessed.
- Model impact studies available, i.e. Australia's.

In reference to species lists, there is need for capacityin these areas:

- Make a list of alien species, do the impact studies, and then decide on potential invasiveness.
- Guidelines or criteria for making a list of 'invasiveness'.
- Guidelines in assessing the impacts and risks of invasive species.

Country examples:

Lao PDR recognises positive and negative impacts of introduced species, e.g. grass carp, African catfish. Common carp is traditionally farmed and managed in some upland farming systems (and has been done so for hundreds of years).

4.2 Collaborative programmes of legislation and policies

Review of existing legal instruments and their adequacy for dealing with the issues of invasive/ alien species.

Other issues

The GISP meeting in Bangkok 2002 is a valuable resource but can also provide some lessons.

- It was concerned mainly with agriculture and was represented by departments/ministries pther than those in fisheries.
- There are good lessons that can be taken from the proceedings (available at URL http://www.gisp.org or contact to: gisp@nbi.ac.za.

- This highlights a significant issue relating to connections between institutions – the GISP meeting probably invited the competent national agency that deals with issues of biodiversity/ CBD (ministry of environment). There is often a poor linkage (or inadequate communication) between these agencies and Ministry of Agriculture/Department of Fisheries and the decision making process relating to biodiversity (and hence invasive species)

Recommendations

- There are comprehensive species lists (freshwater species, invertebrates, marine species etc.) for all countries. These lists could be screened to and the species so far listed could be categorized into 'indigenous' and alien (or possibly include 'native' in the case of species that are considered feral or that have a long history within the country) as well as those considered high risk with respect to invasiveness.
- The lack of common definition for invasiveness prevents the development of specific lists. To be able to assess "invasiveness" there is need to elaborate criteria for invasiveness. The general description in CBD probably requires more specific elaboration to effectively develop lists for alien aquatic organisms and pathogens.
- There is a significant issue relating to relations between institutions. There is often a poor linkage (or inadequate communication) among agencies and the decision making process relating to biodiversity (and hence invasive species). Therefore it is essential that focal points for each country are identified and the composition of the committees responsible for decision making are clearly established (list of agency, specific function/competence of the agency are elaborated).
- There is an important point here regarding the manner in which consequent meetings are organized. invitations that are made to different departments on matters of mutual interest (e.g. ministries of of agricultureand environment) would create discontinuity in process as well as inevitably leading to the exclusion of fisheries issues (these are generally given a lower priority than agriculture/livestock issues). Ministries of Environment may not adequately represent the interests of agriculture/forestry and fisheries.
- Customs officers need simple pictorial manuals of species for easy identification (even for DOF staff). Public education is needed to reinforce the message.
- Focus on monitoring of effectiveness of controls coupled with strong penalties for offenders. This approach will require considerable regional cooperation.
- National strategies are needed that will combine efforts dealing with IAS health pathogens to aquaculture, with a framework for addressing IAS aquatic plants and animals impacting other areas (biodiversity, etc.). These strategies should be harmonized with a regional (ASEAN) strategy, which should in turn recognize related initiatives on IAS in other regions outside ASEAN.
- Risk analysis training to facilitate decision making is needed in the countries. This shpuld be hands-on and implemented country-by-country to create a critical mass of trained experts in each country. One possibility is to have the national focal points organize the focus teams, with training provided by development organizations and NGOs (e.g., FAO, CABI, IUCN, SEAFDEC, etc.).

- Legislative review is needed in most countries to examine where IAS are, or could be covered under existing legislation, and where new legislative mechanisms may need to be developed.
- Communicating with decision makers will be required to enact any new legislation, and in so doing, economic tools and the capacity building needs to create them must be addressed. To attract better the attention and undersatanding of the decision makers of the problem, there is need to speak in economic terms (costs/benefits, etc.). Linking with agriculture departments that already address IAS in this manner will be helpful, as they are more powerful.

Working Group 2 – Trans-boundary pathogens and aquatic animal health

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The working group discussed the progress made in implementation of TG in the ASEAN member countries and identified region and country specific limitations and constraints in implementing the various elements of the TG. The group also discussed the linkages between IAS and associated pathogens and the opportunities for reducing risks of introductions and spread of such pathogens through implementation of TG.

The aquatic animal health National Coordinators (NC) from the 10 ASEAN countries informed the working group of the progress made in implementation of different elements contained in the TG, highlighted country specific limitations and constraints, and suggested approaches to improve TG implementation in their respective countries.

The working group members agreed that significant progress has been made in the region to address trans-boundary aquatic animal pathogen issues. Members expressed the need for strong commitment by the national governments, to sustain the excellent momentum generated in the region to deal with trans-boundary pathogens.

The generic summary of the progress made in the implementation of the TG in the region based on the information given by the aquatic animal health NCs is provided below:

Elements in the TG	Progress made (Number of Countries)		
	Good	Moderate	Low
Disease diagnosis	3	4	3
Health certification and quarantine measures	5	2	3
Disease zoning	0	2	8
Disease surveillance and reporting	4	2	4
Contingency planning	0	2	8
Import risk analysis	0	5	5
National strategies and policy frameworks	4	2	4

Issues highlighted by the working group

All ASEAN countries, except Brunei Darussalam, have adopted the Technical Guidelines and Beijing Consensus and Implementation Strategy.

Most of the countries in the ASEAN have made rapid progress in the implementation of the TG elements, specially, in the establishment of diagnostic and disease reporting systems. Others (e.g., Cambodia, Laos, Myanmar) are progressing much more slowly, owing to lack of adequate financial resources and human capacity.

Most of the countries in the ASEAN have established level III (PCR) diagnostic capability to deal with shrimp viral diseases.

Implementation of some of the TG elements, specially, IRA, surveillance, zoning and contingency planning is progressing slowly in the region compared to the rapid progress made in disease diagnosis, reporting and health certification and quarantine.

Targeted surveillance is being initiated in some of the countries (Thailand, Singapore) for diseases like KHV, while disease reporting from most of the countries is largely based on the information collected from diagnostic laboratories and passive surveillance .

Some of the countries (Thailand, Indonesia, Malaysia) have established National Fish Health Committees to oversee the implementation of various elements contained in the TG.

Approaches to reducing the spread of trans-boundary pathogens vary considerably in the region. Some countries (Indonesia, Philippines, Malaysia) have relied heavily on legislation, quarantine and enforcement. Others (Thailand) are beginning to apply risk analysis to determine effective risk reduction measures.

The group noted that the approach in the region for dealing with disease emergencies, has been largely reactive (crisis management) rather than proactive.

Existing legislation covering livestock is being used in some of the countries (Thailand, Vietnam) to enforce the required policy decisions to deal with aquatic animal health issues.

While many ASEAN countries have made good progress towards addressing trans-boundary pathogen issues, most countries have not adequately considered the issues associated with invasive alien species.

Use of *Penaeus vannaemi* and *P.stylirostris* for aquaculture development remains controversial in ASEAN, some countries have facilitated importation (Brunei, Thailand), while others have banned [or provisionally] them (Myanmar, Malaysia, Philippines). Concerns expressed about these species include potential disease transmission and their unknown invasiveness potential.

There was general agreement in the group that effective implementation of the existing regional and international codes and agreements, including the Asia Regional TG, would offer significant opportunities to reduce risk of introductions and spread of pathogens associated with IAS.

Recommendations and key actions

Recommendation 1
Lack of supporting legislation and inadequate allocation of financial and human resources by national governments remain as the major constraints to the implementation of the TG in most of the ASEAN countries. To sustain the progress made in these countries, **national governments should allocate adequate resources**.

Actions:

1. Policy makers should be encouraged to learn from other countries' success stories
2. Organization of regional/international meetings for joint participation of policy makers and technical experts.
3. Actions should also be initiated to raise the profile of aquaculture/fisheries at the national level (e.g. highlighting economic value of aquaculture and losses due to disease).

Recommendation 2
To maximize the resources within countries, wherever possible, governments should **encourage better utilization of resources already existing within the country**

Actions:

1. Promote closer cooperation between fisheries and livestock authorities.
2. Promote collaboration between public and private sectors (Thai experience).

Recommendation 3
Although resources to deal with trans-boundary pathogens and IAS issues are already available in the region, there is still a need to **improve the organization and networking of** these **resources** for the implementation of the TG.

Actions:

1. Formally recognize and support regional resource centers to offer technical and expert guidance.
2. Implement within broader regional initiatives (e.g. NACA, FAO, others).

Recommendation 4

To properly implement the TG and reduce translocations of trans-boundary pathogens associated with IAS, **additional resources should be established** both at the national and regional levels.

Actions:

1. Improve the expertise on IRA, zoning, surveillance and contingency planning.
2. Support appropriate research (e.g. role of ballast water).

Recommendation 5

Lack of awareness of the risks associated with translocation of trans-boundary pathogens and invasive alien aquatic species at different stakeholder levels has been a major impediment. Efforts should be devoted to **increase awareness especially at farmer and hatchery levels**.

Actions:

1. Communication of risk.
2. Development and dissemination of extension materials.

Recommendation 6

There is a strong need to **initiate a sub-regional program** using existing ASEAN or other regional/international initiatives **to support countries which have made limited progress** in the implementation of the TG, namely Cambodia, Laos PDR and Myanmar.

Action:

1. Provide support at every level: financial, technical, human and infrastructure development.

Working Group 3 – Recent activities on aquatic invasive alien species

Chairperson: Sam Nuov
Vice Chair: Wattana Leelapatra
Rapporteur: LeAnn Southward

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Khamthanh Vatthanatham
Arthur Besther Sujang

The focus of working group 3 was to consider outcomes of current meetings, workshops, international decisions, etc. that have addressed the issue of aquatic invasive alien species and associated trans-boundary pathogens in the ASEAN region. The following meeting recommendations were reviewed:

- The recommendations of the 2002 Bangkok workshop, "*Prevention and Management of Invasive Alien Species: Forging Cooperation throughout South and Southeast Asia*".

- The recommendations of the 2002 Bangkok workshop, "*Prevention and Management of Invasive Alien Species: Forging Cooperation throughout South and Southeast Asia*".
- The Yunnan workshop on international mechanisms to address alien species held in August 2003.
- The APEC workshop on marine pests held in Chile April 2004 (to be distributed).
- the Conference of the Parties of the Convention on Biological Diversity held in Malaysia 2004.
- Other activities identified by the group.

One of the most important recommendations that came from these meetings was the need for coordination and information sharing on a regional level. The group discussed this and brainstormed ideas on how this could be improved in the ASEAN region. Sub-regional, regional, local governments and private sector stakeholders that could potentially assist ASEAN in achieving this goal were identified and their roles discussed. Examples are the MRC, AIT, Mekong Wetland, Programme, APEC, FAO, OIE, IUCN, SEAFDEC and NACA. The group also discussed the need for national focal points that would be the go to points in each ASEAN country for all IAS issues. Each focal point could then form an Experts Working Group who could meet to discuss and share IAS information, problems, and success stories in the region. It was pointed out that at the Yunnan workshop there were focal points identified in participating countries and that ASEAN could use this list and build on it.

Another important recommendation from these meetings was the need to identify partners to fund IAS activities, such as research, in the ASEAN region. The identified potential international, regional and national partners included: FAO, GEF, World Bank, US State Department, USAID, Asian Development Bank, SIDA, CIDA, APEC, and bilateral agreements.

There was also discussion on the type of management and research needed in the ASEAN region that would warrant the necessity for funds from these potential partners. These were: 1) impacts of invasive alien species on indigenous species, 2) education and outreach, 3) production of tools, i.e. laboratories, 4) development and implementation of management strategies. Also discussed was the need for a strategic plan that would include IAS goals and priorities within ASEAN region to help guide research and management. APEC has just developed a strategic framework that prioritizes the research needs of the Fisheries Working Group and will provide a guide for research. The group recommended using the APEC strategic framework as a model for a framework in the ASEAN region.

The next recommendation was that the 10 ASEAN countries agree that this should be a regional priority. After IAS is identified as an ASEAN priority it should be taken to the Chairman of the Working Group on Fisheries so that it can be presented at the SOM-AMAF level. Raising the profile of the IAS issue in ASEAN would help resource managers in each country raise the profile of the issue to their national governments.

Finally the group agreed on four reasons why ASEAN is the appropriate forum to deal with IAS issues in the region.

1) ASEAN is a policy making body that is already established; therefore it can be used to coordinate regional and national efforts.

2) Aquaculture and aquarium fish trade are economically important to the region.
3) There is no one monitoring the exportation of tropical fish in the region.
4) The indigenous species in the region are abundant and diverse and need to be conserved.

Working Group 4 - Information needs and tools

Chair: Chris Baldock
Rapporteur: Devin Bartley

Where is information lacking?
Fishbase needs molluscs, crustaceans, other invertebrates, and plants. Ornamental fish are poorly covered in many databases, although there should be some information available elsewhere. Although FishBase is widely used, 11 million hits/month, it has a narrow and insecure funding base. Efforts should be made to secure funding and broaden support for the system. The MRC maintains an information source similar to FishBase on species relevant to the Mekong Basin which includes mollusks, amphibians, crustaceans, etc. Mapping and geo-referenced information, good examples exist in USA, but inadequate coverage for ASEAN . Could be expensive and data-intensive and difficult to use. Examine how to make EMPRES and the new biosecurity portal useful, i.e. incorporate aquatic sector into it?

Basic information on risk assessment is difficult to obtain and is often incomplete or contradictory. Focus on risk assessment, management and communication would make this web site unique and more useful.

Decision support tools
Generally lacking in ASEAN.
Examples: USDA site on GMOs; AFS opinionnaire. ICES codes of practice
Need standards similar to that for pests (IPPC), but how to do this for aliens. Evaluation system for aliens (e.g. Canada reference, New Zealand standardized protocols). What to standardize?

- monitoring and surveillance ?
- protocols ?
- list of good or bad species?

If international standard (e.g. OIE standards) does not exist – then undertake risk analysis. Can we follow the same model for alien species? Some things are applicable, some are more difficult to apply to alien species. Also look at examples from the Livestock sector.

Note: Fisbase and DIAS do not track secondary introductions and translocations within a country following the 1st introduction.

Web site review
The group reviewed the draft web site, and made the following suggestions for its further development.

Site map and instructions for use need to be included on home page.

Users

- National resource managers. Decision makers. General public.
- Pass relevant information to " hubs" that can then spread the word, e.g. to STREAM coordinators.
- Farmers via mass media? No, it will be someone else's responsibility to reproduce material for them. Some material may be contained in the site.
- What languages are covered/needed?

Content

- In addition to what is contained, PDF on extension materials, posters, flyers that others can download. Country specific page and a country specific "white paper" on aliens.

Include search engine

- Simple – search every word on a page.
- More complex - meta-data on information.
- Keep it simple for now and see how use develops.

Databases

- Keep only top 40–50 key databases for now.
- Organize database by pathogen, alien species, environment, hosts, production/value.
- Participants to send key databases.

Recent events box or news item,

- Need some kind of moderator/editor**.** NACA has mechanism for administering requests and postings – content management database.

Include interactive forum on specific topics for a specific period of time

- Those proposing a forum must moderate the session. Could go in the recent event box. Do not duplicate existing fora. Link to existing fora or websites. Do not repeat general listservers, but directed participants.

Include a box on " Relevant actions from non-aquatic sectors" e.g. livestock, plants, agriculture, etc.

- Good examples exist in other sectors such as livestock in the Philippines and summarized case-studies should be included in this web-site.

List of experts to be included

- Accessed via NACA system.

Link where possible

- e.g. to GAS, FishBase, and FAO glossary. Avoid duplication.

Main recommendations

1. A broader-based and more secure funding source is required for FishBase with the eventual addition of crustaceans, molluscs, ornamental fish and other relevant aquatic animal and plant species.
2. The IAS web site is an excellent initiative and should be maintained under NACA's care and further developed based on user needs.

3. Specific improvements for the next version of the IAS website are to:
    a. widen the range of links to relevant web sites and to group these under topic headings such as host, pathogen, invasive species, habitats/environment, production and value, sites which might provide ideas;
    b. include a search engine;
    c. add a news and events section;
    d. add a discussion forum facility;
    e. add a list of relevant experts;
    f. include country-specific pages if required;
    g. add a page to give easy access to extension materials that may be available through other web sites eg pdf files of posters in local languages

    The wider group supported the use of English for the web site and advised that the site needs to be clearly identified as relevant to aquatic species.

4. Further investigation of decision-support tools is required for the region. The group did not make specific recommendations but noted there were no recognised international standards for international movement of potential IAS along the lines of the OIE Codes for animals and IPPC for plants. Look at OIE philosophy and how it can be applied to alien species in general.

In view of Article 8 of the Convention on Biological Diversity, that requires States, "to collect information on national and international actions ... 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"; and to establish an "incident list" on introductions of alien species and genotypes through the national reporting process or any other appropriate means, and to "create mechanisms such as databases and information networks to collect and share information on aquaculture development" and Article 9 of the FAO Code of Conduct for Responsible Fisheries that asks Members to, "cooperate in the development of appropriate mechanisms, when required, to monitor the impacts of inputs used in aquaculture", the Workshop recommended the creation of a web site on Invasive Alien Aquatic Species, with special attention to the area served by ASEAN.

The Workshop recommended that the Web site should feature prominently a Decision Support System in order to facilitate risk assessment, risk management and risk communication, as well to conduct cost-benefit analyses. Realizing that accurate and up-to-date information is crucial for informed decisions, the Workshop recommended that information systems such as FishBase should be created for additional non-fish taxa such as crustaceans, molluscs, and echinoderms.

Part 2

The Resource Papers and Case Studies

The Convention on Biological Diversity: Decisions of the 7th Meeting of the Conference of Parties on Alien Species that Threaten Ecosystems, Habitats or Species

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Introduction

Invasive alien species (IAS) are species introduced deliberately or unintentionally outside their natural habitats that may cause environmental and/or economic harm in the environment to which they have been introduced. In their new environments, IAS' properties enable them to establish reproducing (naturalized) populations, invade and out-compete native species, and often take over the environments. IAS are widespread throughout the world and are found in all categories of living organisms and all types of ecosystems.

With the advent of globalization and trade liberalization, rapid accelerating trade, tourism, transport and travel, biological invasions operate now on a global scale and their impacts will likely increase in the coming years as alien species surmount natural geographical barriers and spread dramatically. After habitat loss, the threat from IAS is now considered the next most important and leading threat to the biological diversity of the world. As such, they are a serious impediment to the conservation and sustainable utilization of local, regional and global biological diversity. If they are not managed efficiently and effectively, they can cause significant undesirabl impacts on goods and services provided by ecosystems, besides causing irreversible environmental impact at the genetic, species and ecosystem levels. Hence IAS can have adverse negative impacts on sustainable development, especially in developing countries that depend on agricultural, fishery, and forestry resources for socio-economic prosperity.

Addressing the invasive alien species issue in the Convention on Biological Diversity

The Convention on Biological Diversity (CBD) recognizes invasive alien species as a significant area that needs international, regional and national commitment and cooperation to address their impact. Parties to the CBD see the urgent need to highlight the IAS issue so that appropriate eradication, control and mitigation measures can be put into place. In this respect, the IAS issue has been put into the text of the Convention under Article 8 (h), which reads as follows:

"Each contracting party shall, as far as possible and appropriate: (h) Prevent the introduction of, control or eradicate those alien species that threaten ecosystems, habitats or species."

It is not surprising therefore that Meetings of the Conference of Parties (COP) to the CBD, as well as Meetings of the Subsidiary Body on Scientific, Technical and implementation of the above party obligations to ensure that IAS negative impacts can be minimized or mitigated. Amongst the most important decisions prior to the COP-7 meeting were Decision IV/1, Decision V/8 and Decision VI/23 made at COP-4, COP-5 and COP-6, respectively. SBSTTA also considered alien species at both its fourth and fifth meetings, resulting in a set of interim guiding principles on the introduction of alien species.

In Decision IV/1, the COP decided that alien species were a cross-cutting issue within the Convention with impact on all seven thematic areas, namely marine and coastal biodiversity, agricultural biodiversity, forest biodiversity, island biodiversity, biodiversity of inland waters, biodiversity of dry and sub-humid lands, and mountain biodiversity. In the same decision, the COP recognized the particular importance and vulnerability of geographically and evolutionary isolated eco-systems such as small island states. In Decision V/8, the parties outlined the 15 Interim Guiding Principles proposed by SBSTTA. At COP-6 where IAS was one of the three priority issues discussed, Parties to the CBD adopted the 15 guiding principles for the prevention, introduction and mitigation of impacts of IAS and a number of decisions for the full and effective implementation of Article 8(h) of the CBD, that included collaboration with the Global Invasive Species Programme (GISP), development and dissemination of technical tools and related information, integration of IAS considerations into thematic work programmes of the Convention, notification to parties and other governments on relevant COP decisions on IAS, and identification of gaps and inconsistencies in the international regulatory framework.

CBD COP-7 Decisions on Invasive Alien Species

The 7th Meeting of COP to the CBD was held in Kuala Lumpur, Malaysia from 9-20 February 2004. IAS was discussed as one of the items under the agenda on Cross-Cutting Issues: Progress Reports on Implementation. COP-7 decisions related to the IAS issue were reported as Decision VII/13. Amongst the points contained in this decision are the following:

(i) Addressing the IAS Issue

COP-7 reiterated the importance of mainstreaming activities relating to IAS management, particularly to poverty and inequity. It welcomed collaboration between CBD and other conventions and organizations to address threats posed by IAS. It called upon parties to ratify the recently adopted International Convention for the Control and Management of Ballast Water and Sediments.

(ii) Strengthening Further Institutional Coordination

COP-7 recognized the need to strengthen further institutional coordination, including:

a. Promotion of IAS issues at other international forums (e.g., United Nations' Framework Convention on Climate Change [UNFCCC], Convention to Combat Desertification [UNCCD], and Forum on Forests [UNFF].
b. Collaboration with other relevant organizations, initiatives and conventions (e.g., Food and Agriculture Organization of the UN [FAO],

World Health Organization [WHO], International Maritime Organization [IMO], Convention on International Trade in Threatened and Endangered Species [CITES], World Animal Health Organization [OIE], International Civil Aviation Organization [ICAO], International Plant Protection Convention [IPPC], etc.)

c. Supporting closer coordination between national focal points of relevant international instruments, regional institutions and international convention and programmes

d. Cooperation with relevant site-based conventions and other organizations to develop biome-specific practices for guidance to site managers.

(iii) Strengthening Institutional Coordination On IAS As A Trade-Related Issue

Having noted the existing international, regional and national frameworks, and also recognizing the need to strengthen institutional coordination at international, regional and national levels on IAS as a trade-related issue, COP-7 requested that:

a. the World Trade Organization (WTO) and its relevant bodies give consideration to risks from IAS in their deliberations,

b. the CBD collaborate with WTO in training, capacity building and information sharing activities to raise awareness related to IAS and enhance cooperation on this issue,

c. the CBD have observer status in the WTO Sanitary Phytosanitary SPS Committee to enhance exchange of information and developments on IAS,

d. the Parties and other governments consider IAS aspects during development of international, bilateral or regional trade arrangements.

(iv) Enhancing Coordination Between Governments and Organizations

COP-7 called upon parties and other governments as well as national, regional and international organizations to:

a. Improve coordination of regional measures to address transboundary issues through the development and implementation of regional standards, regional support for risk analysis and regional cooperation mechanisms.

b. Support national and regional decision-making and rapid response through the further development of risk analysis, which includes environmental risk assessments, as well as alert lists, diagnostic tools and capacity development.

c. Incorporate IAS considerations, including monitoring, reporting and notification of threats into regional agreements, and make information on IAS status and trends available through the Clearing House Mechanism (CHM) and other regional information systems.

d. Allocate adequate financial resources to developing countries, in particular the least developing countries and small island developing states, and countries with economies in transition, and to build capacity in effective mitigation, border control and quarantine measures, with a view to improve synergies with policies relating to trade, food security, human health and environment protection, scientific research and exchange of information.

e. Strengthen cooperation between biodiversity, agriculture, forestry, land and water agencies in the application of standards and guidance.
f. Consider introducing positive incentive measures for the prevention, mitigation, eradication or control of IAS and the use of native species.
g. Proactively engage relevant stakeholders, indigenous and local communities in IAS plans, including awareness raising and training as well as through the design and implementation of appropriate incentive measures.

(v) Gaps in the International Regulatory Frameworks

COP-7 noted specific gaps in the international regulatory frameworks at global, regional and national levels persist, notably in relation to species that are invasive but do not qualify as plants pests under the regulations of the IPPC and other international agreements, or animal diseases under the regulations of the OIE and other international agreements. The following potential pathways were identified:

a. use of non-native organisms in aquaculture and the restocking of marine and inland water systems for commercial and recreational fisheries,
b. the unintentional or opportunistic introductions (e.g., hitchhiker organisms), including hull-fouling, packaging material, import consignments, vehicular transport and other means,
c. the unintentional introduction of IAS through international assistance and humanitarian programmes, tourism, military, scientific research, cultural activities and other activities,
d. the intentional introductions of alien species for non-food purposes, including certain aspects of horticulture and trade of pets and aquarium species,
e. the intentional introduction of alien species as bio-control agents for control or eradication of IAS or weeds,
f. the trans-national and national *ex-situ* breeding projects with alien species as sources for intentional or unintentional introduction,
g. the intentional introduction of alien species through international assistance programmes for conservation and development projects,
h. the introduction of alien species through aquaculture escapes, bait and pet releases, and water transfer schemes.

(vi) Application of Existing Risk Assessment Methodologies

COP-7 noted that there is potential for the application of existing methodologies for risk assessment and risk analysis established in the context of plant and animal health, to a wider range of issues related to IAS.

(vii) Establishment of an Ad Hoc Technical Expert Group (AHTEG) on IAS

COP-7 requested SBSTTA to establish an ad hoc technical expert group to address gaps and inconsistencies in the international regulatory framework at global and regional levels and to report at the next COP Meeting its findings together with practical options to address these gaps and inconsistencies to facilitate the full and effective implementation of Article 8 (h) of the Convention. The Government of New Zealand offered to fund the AHTEG Meeting.

(viii) Requests to CBD, Parties, Other Institutions and Agencies

COP-7 requested CBD together with GISP and its participating organizations and other relevant organizations to address the priorities for practical action. The Meeting further requested CBD to facilitate parties to share practice and lessons learned, and to cooperate in the development of new technology, scientific understanding and beneficial practice. COP-7 made a plea to funding institutions and development agencies to provide for financial support to developing countries, in particular the least developing countries and small island developing states among them, and countries with economies in transition, to assist in the improved prevention, rapid response and management measures to address threats of invasive alien species.

Conclusion

The decisions on Invasive Alien Species made in the 7th Meeting of the Conference of Parties to the Convention on Biological Diversity represent another step towards the realization of international and regional cooperation and collaboration to address the issue of IAS and mitigate their impacts. The nature of these organisms and their pathways for potential spread make international and regional cooperation and collaboration as essential prerequisites for effective prevention, control, eradication or management. Likewise COP-7 has reemphasised the need for commitment of parties and stakeholders at all levels. The findings of the AHTEG on IAS and recommendations for practical options will be very useful for full and effective implementation of Article 8(h) by parties to the Convention.

Acknowledgement

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An Overview of International Initiatives, Treaties, Agreements, and Management Actions Addressing Alien Invasive Species

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Abstract

Invasive alien species (IAS) issues infiltrate virtually every trade and environment element of the international environmental policy arena. Sustainable biodiversity, global warming, threatened and endangered species preservation, watershed management, living modified organisms, global plant, animal and human health - the issues associated with species' invasiveness are addressed in all of these policy discussions. Of course, good policy is informed by good science, and good science is informed by communication amongst experts, a primary impetus for this workshop.

This workshop primarily addresses one aspect of the broad IAS subject, developing capacity to manage the transboundary risks from aquatic invasive species and pathogens associated with the acquaculture sector and the trade in aquatic species. Although this meeting focuses on the aquaculture sector in the ASEAN group of nations, the invasive species challenges faced by the industry here are similar across the globe. Yet, the global linkages between the actions taken to address a specific problem such as IAS may not be immediately obvious to parties of a regional trading block such s ASEAN. This paper therefore attempts to provide an overview of some of the other global and regional activities that are ongoing to address the impacts of IAS, so that potential synergies for addressing capacity needs that might not be immediately recognizable can be brought to light. It is admittedly a "broad brush" approach to a subject for which a book on the topic would be necessary to capture the many actions that have been initiated amongst the nations of the world combating invasive species.

International Conventions and Activities on a Multi-Lateral Scale

Multilateral agreements and treaties are particularly useful at addressing problems caused by invasive species when the impacts from them can be viewed as potentially affecting resources shared by the international community. Some of the multi-lateral activities addressing invasive species include the Convention on Biological Diversity (CBD), the International Plant Protection Convention (IPPC), the Ramsar Convention on Wetlands, the International Maritime Organization (IMO), the World Organization for Animal Health (OIE), the Food and Agriculture Organization (FAO), the World Health Organization (WHO), and Codex Alimentarius Commission created in 1963 by the FAO and WHO to develop food standards and guidelines to protect human health and ensure fair trade. Agreements in trade bodies such as the World Trade Organization (WTO) and in environmental consultative mechanisms of free trade agreements are also providing effective at raising awareness of the IAS problem and developing cooperative solutions (Fisher 2004).

Convention on Biological Diversity

Article 8(h) of the Convention on Biological Diversity (CBD) commits Parties to the Convention to, “prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species.” The CBD engenders efforts to sustain biodiversity, and the recognition of IAS by the Convention as a primary reason for the loss of biodiversity was a critical step in generating international recognition of the link between IAS and sustainable biodiversity.

The programme of work to implement Article 8(h) of the CBD has developed since the convention went in to force in 1993, and several key decisions have been made. The Subsidiary Body on Scientific Technical and Technological Advice of the CBD introduced common definitions for IAS and developed 15 guiding principles for implementing Article 8(h). They also identified a roster of experts, promoted the Global Invasive Species Programme (GISP) as the focal point and clearing-house mechanism for scientific and technical matters related to invasive species under the Convention, and proposed the development of the Global Taxonomy Initiative (GTI)—a critical tool for building the capacity to recognize new invaders. The CBD has been a strong supporter of national and regional plans for IAS control, collaboration with other relevant international instruments, and research and the development of new assessment and information tools for addressing IAS impacts and species identification (e.g., GTI). Sweden, Australia, the United Kingdom, the United States, and New Zealand amongst others continue to be significant contributors to the GTI.

The CBD has designated substantial funds from mandatory and voluntary contributions to further the development of a global invasive species information network, or “GISIN” (http://www.gisinetwork.org). The GISIN, funded initially by the U.S. and eventually expected to be linked to GISP’s web site, is envisioned to provide a portal to all existing invasive species databases once on-line (Sellers et al. 2004). It is noteworthy that in Seller’s review she identifies over 150 databases on invasive species that already exist, and an ongoing Heinz Foundation study has found approximately 100 more. A central portal such as that provided by the GISIN is clearly necessary to streamline data searches.

The World Animal Health Organization (OIE)

The OIE’s principal objectives are to: (1) to ensure transparency in the global animal disease and zoonosis situation, (2) to collect, analyze and disseminate scientific veterinary information, (3) to provide expertise and encourage international solidarity in the control of animal diseases, (4) to safeguard world trade by publishing health standards for inernational trade in animals and animal products, (5) to improve the legal framework of national veterinary services, and (6) to provide a better guarantee of the safety of food of animal origin and promote animal welfare. The publications of the OIE, “Disease Information” and “World Animal Health”, serve to communicate the most recent findings of animal health disease and zoonosis findings. Contributions of particular relevance to the objectives of this meeting include, the

2004 International Aquatic Animal Health Code, and the 2003 Manual of Diagnostic Tests for Aquatic Animals, and the recently released Handbook on Risk Analysis for Imports of Animals and Animal Products available through their web site (www.oie.int).

The OIE Certifies Disease Free Status of Member Countries for 35 listed aquatic pathogens of which there are no List 'A' aquatic animal pathogens and currently 13 List 'B' aquatic animal diseases recognized by the OIE, approximately half of which are problematic in the ASEAN region. Member Countries can also declare themselves free of diseases for which there is, as yet, no specific procedure for obtaining Official OIE recognition. In this case, they must provide the relevant epidemiological information to importing countries in proof of their position. The data provided must conform to the standard measures contained in the International Animal Health Code, which is recognized under the SPS Agreement of the WTO.

International Plant Protection Convention (IPPC)

Approximately half of the 50,000 non-indigenous species in the U.S. are invasive weeds, and these yield the majority of the estimated $137 billion/year economic and environmental costs to the U.S. from invasive species (Pimental 2002). The International Plant Protection Convention (IPPC) is the international treaty whose purpose is to secure actions to prevent the introduction and spread of such problem plants, as well as pests of beneficial plants and native flora. The provisions of the Convention extend to cover conveyances, containers, storage places, soil and other objects or material capable of harbouring plant pests. In all, the IPPC has produced 19 international standards for phytosanitary measures (ISPM), which address, in part, the invasive issues. For example, ISPM 11 specifically addresses guidelines for conducting pest risk analyses, including genetically modified organisms. The recently published ISPM 15 contains information on the requirements for treating wood packaging material to prevent its potential as a vector for harboring plant pests. The IPPC has also recently produced a phytosanitary capacity evaluation (PCE) tool, whose function is to aid NPPO diagnoses at gauging the capacity gap between the current situation and what is needed to meet the requirements of international standards.

International Civil Aviation Organization (ICAO)

The International Civil Aviation Organization (ICAO) has recently begun to recognize the potential for invasive species spread via air travel, and adopted resolution A33-18 on "Preventing the introduction of invasive alien species," at their 33rd annual assembly in 2000. This resolution urged States to collectively support and cooperate on efforts to prevent the spread of IAS via international civil aviation. Microorganisms in discarded aircraft food, insects in packing material, passenger goods containing plants and weeds, animals "hitchhiking" in the aircraft structure, all of these vectors are possible through civil aviation pathways. The introduction of the brown tree snake, responsible for the extinction of numerous bird species on Guam, is a classic example of an introduction via this vector (Enbring and Fritts 1988). Seaplanes may pose a particular hazard for the introduction of invasive aquatic plants and animals given the difficulty of conducting thorough inspections prior to flight for these types of aircraft, and the direct relationships to the aquatic environment inherent to these planes. ICAO recently published the results of a survey of member States' programs to address the issue (ICAO 2004). Thirty-eight of the 49 States that responded to the survey indicated they had IAS problems in their countries, and provided examples of IAS invasions via aircraft, air cargo, or passengers. ICAO has been particularly active in addressing aircraft disinsection measures required for preventing the spread of contagious disease pathogens—some of which may also be invasive, such as the SARS virus. The United States recently proposed a working paper in ICAO to consider non-pesiticidal means for disinsection, such as air curtains, that is now being evaluated by member States of the organization.

World Trade Organization (WTO) – Sanitary and Phytosanitary Standards (SPS)

The WTO Sanitary Phytosanitary Agreement obligates countries to consider the impacts of invasive species possible through trade, and commits them to following international sanitary and phytosanitary standards set by the IPPC and OIE. These standards can result in bans on countries with known invasive species impacts on a trade commodity, or specify more stringent actions for treatment, inspection and certification to mitigate risks. The WTO-SPS agreement outlines 15 core principles that are intended to encourage responsible trade to minimize invasive species risk. The most notable of these principles include: harmonization of actions based on international standards, risk analysis as the means to underlie protection measures, notification of exporters by importers when an IAS is discovered, non-discrimination (in trade) between countries with similar invasive species situations, and recognition of and respect for IAS-free areas based on surveillance. In essence, the WTO-SPS is intended to outline measures by which trade can continue by controlling IAS risks, without implementing trade tariffs.

International Maritime Organization (IMO)

Roughly 10 billion tons of ballast water are discharged globally each year (IMO 2003), and carried along with this ballast are potentially invasive species that cause millions of dollars of environmental harm. Classic examples of invasive species introduced by ballast water include the zebra mussel, green crab, and comb jellyfish, amongst many others (Carlton 1999). In recognition of this problematic vector, the International Convention for the Control of Ships' Ballast Water and Sediments was adopted by diplomatic conference in February 2004, and was open for signature beginning this June. The Convention will enter into force 12 months after ratification by 30 States, representing 35 per cent of world merchant shipping tonnage (see Article 18, *Entry into force*).

The objective of the Ballast Water Convention is to minimize and ultimately eliminate the transfer of aquatic IAS through ships' ballast water and sediments, and the meeting was effective at establishing the first standard for ships' ballast, that will replace the current IMO voluntary guidelines for ballast water exchange. All fishing boats that carry ballast water are subject to IMO requirements and would be required under the London convention to exchange their ballast water and meet standards the same as other commercial vessels. Signatories to the Convention will be required to implement a ballast water management plant that ensures that ballast water management practices and discharges meet the prescribed ballast discharge standard developed at the meeting of no more than 10 viable organisms per cubic meter of ballast water that are greater than or equal to 50 micrometers in size, and fewer than 10 viable organisms per milliliter of ballast water that are between 10 and 50 micrometers in size. This standard was not as stringent as many delegations thought necessary and exemptions and exclusions for its implementation raise the possibility for weakening the intent of the treaty in practice. Notwithstanding, the Convention does not preclude countries from applying more stringent measures, and the establishment of the Convention should be seen as a hallmark for international cooperation, as it represents the first time that international shipping standards for aquatic invasive species have been developed. The UNEP/GEF funded GloBallast program serves to support the implementation of these IMO standards in developing countries.

The 2001 IMO Convention on anti-fouling systems phased out the use of harmful tributylin anti-fouling paints by 2008, so alternatives must be sought to prevent invasive hull fouling organisms from being transported. New Zealand has been experimenting with the use of "skirts" around vessels to this end.

International Council for the Exploration of the Sea (ICES)

The International Council of the Sea (ICES) recently developed a protocol consistent with the topical nature of this meeting, in that it was initially written in response to problems of aquatic invasive pathogens associated with the transfer of fish and shellfish in the aquaculture industry. Although the movement of live aquatic animals and their products is necessary for aquaculture development, it is now widely recognized that the introduction and spread of transboundary pathogens due to the imprudent movement of live aquatic animals have resulted in serious adverse consequences to national socio-economic and environmental well being in many regions throughout the world.

Regional and Bilateral Initiatives and Agreements

Regional collaborative programs to exclude invasive species provide some of the most tangible measures for implementing actions that address IAS. A good example has been the very high degree of cooperation in developing and testing biological control methods to address new invaders. In particular, Australia, the U.K. and the U.S. operate overseas biological control laboratories, from which explorations for natural enemies of invaders are conducted. The U.S. currently operates six such laboratories, in Beijing, China; Brisbane, Australia; Hurlingham, Argentina; Montpellier, France; Rome, Italy; and Thessaloniki, Greece. A good example from the ASEAN region is how the Australian Centre for International Agricultural Research has worked with local governments to eradicate *Mimosa pigra*. The U.S. Government, has also helped to sponsor seven regional workshops on IAS around the globe (GISP 2003a, b, c). With increasing awareness in Southeast Asia, the number of projects has grown and is likely to continue to grow. Below I highlight just a few of the more relevant regional actions.

South and SE Asia Evaluation of Invasive Species Risks from Development Aid

Development assistance projects have contributed to the introduction of IAS, as well as being adversely impacted by them. However, there is increasing sensitivity to the negative impacts caused by IAS, and several development agencies have begun addressing specific IAS and are working to educate regional governments on the prevention and management IAS. In 2002, the US Agency for International Development (USAID) commissioned GISP to conduct an assessment on the linkages between development assistance and invasive alien species IAS in freshwater systems in Southeast Asia (Gutierrez and Reaser 2004). The assessment explored three linkages between development assistance projects: (1) as intentional/ unintentional pathways, (2) as adversely impacted by IAS and (3) as working to address IAS. The assessment and the detailed recommendations can be found at www.gisp.org.

Three USAID development assistance programs that promoted freshwater fish aquaculture were surveyed, the Pond Dynamics/ Aquaculture Collaborative Research Support Program (PD/A CRSP), the Mekong River Commission (MRC) and the World Fish Center. From this survey, it became evident that in freshwater systems in Southeast Asia, aquaculture projects are the most significant pathway of intentional/unintentional introduction of IAS. This is largely the result of the use of non-native species for aquaculture, such as tilapia (*Oreochromis spp.*). While the assessment revealed that there are benefits derived from non-native aquaculture such as employment and food security, it also demonstrated that the risks from the aquaculture of non-native species as potentially invasive if released, and as vectors for diseases that could affect native stocks were not always considered. The PD/A CRSP and MRC have now begun to explore ways to promote the aquaculture of native species.

Established IAS were also found to adversely impact development assistance projects. The Golden apple snail (*Pomacea canaliculata*) is the best-documented example. GAS was introduced into Southeast Asia in the early 1980s for culture as a high-protein food source for domestic consumption, as well as for export. However, local and foreign consumers failed to acquire a taste for GAS and the snails were quickly discarded into irrigation ditches and public waterways (Halwart 1994). The species soon made its way to rice fields, where the animals voraciously consumed young rice plants. Naylor (1996) estimated that by 1990 the costs of snail invasion in the Philippines alone were between US$425-1,200 million, excluding non-market damages to human health and ecosystems.

Great Lakes Fishery Commission

The Great Lakes Fishery Commission (GLFC) was established by the Convention on Great Lakes Fisheries between Canada and the United States in 1955. The GLFC offers a good example of how regional cooperative actions can be successful. The Commission has been fighting for more than 50 years to prevent and manage invasive species that enter the Great Lakes through ballast water, trade of live organisms and aquaculture. The Commission receives federal funding of approximately $12 million a year from both the U.S. and Canada for this task. One of the responsibilities of the Commission is to coordinate the implementation of the invasive sea lamprey control program for the Great Lakes, with the Fisheries and Oceans Canada, the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers. This control program uses several techniques to attack sea lamprey such as sea lamprey assessment, lampricide control, barriers, traps and sterile male release techniques. The sea lamprey control program has been tremendously successful. Ongoing efforts by the Commission have resulted in a 90% reduction of sea lamprey populations in most areas of the Great Lakes. The Great Lakes Fishery Commission is also involved in a project that will restore the existing electrical barrier and provide for the building of a second barrier to be placed in the Chicago Shipping and Sanitary Canal, preventing the movement of the Asian Carp from the Mississippi River into the Great Lakes Basin.

Managing Invasive Marine Pests in APEC Economies

The APEC Marine Resources Conservation Working Group (MRCWG) held a second workshop on the "Development of a Regional Management Framework for APEC Economies for Use in the Control and Prevention of Introduced Marine Pests (IMP)" on May 3-5, 2004 in Puerto Varas, Chile, co-hosted by Chile and Australia. Delegates from 17 APEC economies attended the workshop, along with representatives from the IMO, Permanent Commission for the South Pacific, World Conservation Union, workshop consultants, and invited IMP experts. The workshop focused on defining risks, sharing information, capacity building, and funding for work on introduced marine pests. IMP vectors identified included ballast water discharge, hull fouling, the movement of oil and gas infrastructure, and recreational vessels; fishing activities; aquaculture; and the release of aquaria fish. Comprehensively addressing risks of introductions posed by hull fouling organisms and aquaculture imports was identified as an important mission for future APEC cooperation.

Regional Fishery Management Organizations and bilateral agreements were proposed as the most appropriate means to address fishing vessels as vectors of IAS. However, fishermen in general are dealing with a large volume of regulatory requirements, and the desire to avoiding burdening them further was expressed. The use of ports and harbors, positive incentives, and providing services to minimize the risk from these vectors should be explored. Ship captains do not desire hull fouling for fuel efficiency reasons, so they have an inherent incentive to control this vector. In closing, the IMP workshop participants produced a negotiated statement and risk management framework underscoring the need for APEC action on introduced marine pests because of their potential economic, environmental and health costs (APEC 2004).

In addition, the APEC Fisheries Working Group, in cooperation with NACA, FAO, WHO and the OIE recently published a manual on "Risk Analysis for the Safe Movement of Aquatic Animals". The manual arose from the initial workshop, "Capacity and Awareness Building on Import Risk Analysis (IRA) for Aquatic Animals," (APEC Project FWG/01/2002), and provides a simplified overview of the risk analysis process to assist responsible individuals to formulate national policies and develop approaches to conducting risk analyses for pathogens.

Risk analysis for aquatic animal pathogens has become a major component of global strategies aimed at providing appropriate health management protocols and biosecurity measures that protect national biological, social and economic resources and support economically and environmentally sustainable aquaculture development while, at the same time, facilitating trade. Like the ICES protocol for minimizing the risks from the movement of aquatic animals, both the Risk Management Framework produced by the APEC-MRCWG and the FWG manual on Risk Analysis for the Safe Movement of Aquatic Animals, are highly relevant documents with potential application to the current ASEAN efforts (particularly considering that 7 of the 10 ASEAN nations are also members of APEC). The mere presence of these manuals and methods recognizes that trade cannot persist without an acceptance of some level of risk. APEC, NACA and their partners have therefore initiated these projects in order to improve aquatic animal health policies and practices that will contribute to reducing the risks of disease incursions and promote the development of better strategies to prevent such incursions, for higher productivity and smoother trade.

Free Trade Agreements

Environmental consultative mechanisms (ECMs) associated with free trade agreements (FTA's) are a relatively new tool that can be applied at the regional level to address collaborative invasive species prevention and management. The North American Free Trade Agreement established the Commission on Environmental Cooperation (CEC), under which the U.S., Canada and Mexico are undertaking cooperative actions addressing invasive species. One study that has been proposed through the CEC will address the vectors for aquatic introductions via the aquarium fish industry. Invasive species are also being addressed in the U.S./Chile FTA, and language to address invasive species has been accepted in the ECM of the Central American Free Trade Agreement. One advantage to raising the issue in these venues is that the audience differs, allowing the message to be conveyed to different ministries than might otherwise be aware.

NGO Activities

The non-governmental organization (NGO) community often represents the front-line of defense in addressing the ecological risks from invasive species and for implementing control actions. Through teaming with NGO's, governments and intergovernmental bodies like ASEAN, have the opportunity to ensure that efforts are leveraged with other NGO programs for maximum effectiveness. Collaboration with other ongoing IAS initiatives (e.g., ISSG, Cooperative Islands Initiative, GISP, Learning Network) is essential to maximize coordination and learn from past experience. Actions by the NGO community are numerous, and it is beyond the scope of this article to highlight all actions but a few of those spearheaded by the international NGO community in particular.

The Nature Conservancy

The Nature Conservancy (TNC, www.tnc.org) has been very active in promoting trade practices that minimize the spread of invasive species, through their "Clean Trade" program. This program is supporting a variety of initiatives that promote dialogue, policy tools and other mechanisms to improve understanding of current political, scientific, economic, and cultural factors that influence efforts to address invasive species issues. Current projects and/or proposals in their focus include: (1) the development of an economic took-kit to facilitate local decision making in small island developing states (SIDS) on IAS prevention and control options, (2) a resource guide summarizing available funding sources for global projects, and (3) private sector outreach to develop voluntary compliance actions and guidelines to prevent IAS introduction.

The Pacific Islands Invasives Learning Network (PIILN), a project recently initiated by the TNC with start-up funds from the U.S. State Department, may have particular applicability to the ASEAN region. In essence, this program will bring peers from different locations in the Pacific to the table to share their experiences in combating IAS problems in SIDS. This program, initiated in Micronesia, will eventually expand to establish learning networks throughout Melanesia and Polynesia under the oversight of the South Pacific Regional Environment Program (SPREP). The learning network model recognizes that conservation success requires complementary action by a variety of actors from all sectors—action based on a shared understanding of how natural systems function and a common vision of their improvement for today and future generations. Multi-disciplinary project teams will work together on strategies with critical input from other teams and experts, resulting in the creation of a common vision and plan for effective action on-the-ground.

CAB-International Compendium Programs and the Global Invasive Species Program

CAB-International *(www.cabi.org)* has produced four compendium documents that summarize expert knowledge on topics such as crop protection, forestry, and animal health and production (http://www.cabi.org/compendia/ahpc/index.htm). These are on-line, or cd-rom based encyclopedic sources of knowledge on topical subject matter, much of which is of particular relevance to sustainable agriculture in developing countries. An aquaculture compendium will be released in 2005. A 2001-02 feasibility study for the development of an invasive species compendium initiated by the USDA-Agricultural Research Service, a Consortium member of the Crop Protection Compendium, recommended the National Invasive Species Council (USA) take the lead in developing this compendium. Until this is completed, the other compendia should be consulted, as these already provide a substantial amount of IAS information. CABI has also been active in organizing capacity building efforts for addressing IAS—most recently in Ghana for the West Africa Region. Proceedings from this meeting are now available on the GISP website *(www.gisp.org)*, along with proceedings from 3 other regional IAS workshops convened directly by GISP with U.S. funding in southern Africa, the Austral-Pacific, and South-SE Asia (GISP 2003 a,b,c). The S-SE Asia workshop provided a foundation for the subject matter focus of this workshop organized by the Network of Aquaculture Centres of Asia (NACA).

IUCN-ISSG

The World Conservation Union (IUCN, *www.iucn.org*) Invasive Species Specialist Group (ISSG) shares many of the goals of the TNC and CAB-International in addressing the problems created by invasive species, and in building capacity amongst local communities to combat them. The ISSG developed the Global Invasive Species Database (GISD, www.issg.org/database) as part of the global initiative led by GISP, and also publishes the Aliens newsletter. In 2002, the ISSG launched the Cooperative Initiative on Invasive Species on Islands (CII) *(a.saunders@auckland.ac.nz)*. The initiative focuses on building cooperative efforts to address impacts to island biodiversity principally, and is not focused on impacts to agriculture.

South Pacific Regional Environment Program (SPREP)

The SPREP has been highly active in developing systems to address IAS in SIDS of the Pacific. They drafted the initial Invasive Species Strategy for the Pacific Islands Regions in 1999. In that report SPREP noted the following limitations: (1) shortage and inaccessibility of scientific information on basic biology for assessment of risks and risk management of IAS, (2) lack of awareness of the impacts of invasive species on biodiversity, (3) insufficient networking mechanisms for the dissemination of information, (4) poorly developed coordination within the region on IAS management, (5) inadequate cross-sectoral policies and legislation in the Pacific island countries, and (6) inadequate enforcement of existing legislative instruments due to a shortage of technically trained personnel and a limited supply of adequate quarantine and risk assessment facilities. Most recently, they have been working actively with the U.S. Fish and Wildlife Service to address at least some of the above limitations. Specifically, SPREP is training border inspection and control agents, and helping to build capacity on surveillance methods for the identification of founder IAS populations. Many of the limitations recognized by SPREP (whose member countries include several ASEAN nations) could also be applied to ASEAN.

Other NGO and Government Regional Activities

The above discussion does not give due credit to other NGO and government actions ongoing in the ASEAN region and elsewhere in the adjacent Asia-Pacific, Austral-Pacific and Indo-Pacific regions. For example, other projects such as the Pacific Islands Ecosystems at Risk Project (PIER), and projects conducted by the South Pacific Commission, Aus-AID, SEAFDEC, and the World Wildlife Fund's efforts in the biocontrol of aquatic invasive plants, amongst others, have been highly effective at raising local awareness on IAS prevention and control and will certainly be addressed.

Conclusion

The brief summary outlined here represents a small fraction of the global activities that are ongoing to address the IAS problem and the capacity building needs for improved cooperation worldwide. Here in the Asia-Pacific region, aquaculture production and capture fisheries for food, income and employment, has suffered perhaps disproportionately from the consequences of exotic aquatic animal disease. The degree to which the ASEAN nations can reverse this trend will largely depend on how effective they can implement the actions called for here over the next few days, or, as appropriate and practicable, co-opt those strategies and methods previously developed under the OIE, APEC, ICES, and the S-SE Asia regional plan. Like all regions of the world where we struggle with the IAS problem, we must seek to move beyond the architecture of the tabletop plan, towards the implementation of what the plans actually call for if we are to look back in five years time and see tangible outcomes of our efforts here. No nation can do it alone. Trading blocks such as ASEAN have the opportunity, through their economies of scale, to address the IAS problem together, one industry at a time that single nations simply cannot support.

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Current Knowledge of Aquatic Invasive Alien Species in ASEAN and their Management in the Context of Aquaculture Development

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Introduction

Global aquaculture production now supplies one-third of seafood consumed worldwide and has more than doubled in volume and value during the past decade (Naylor *et al.* 2001). Aquaculture has expanded rapidly and grown consistently at the rate of over 11% per annum since 1985. Demand for fish is expected to further increase with rising global per capita incomes and populations. Over 80% of total aquaculture production comes from developing countries, and in some large developing countries, aquaculture accounts for 30% to 60% of total fish production. In many countries a significant portion of aquaculture production is based on alien species. With the leveling of capture fisheries production, the increasing demand for fish will be met from aquaculture. The Association of Southeast Asian Nations (ASEAN) comprises ten member countries: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam. In the ASEAN region 20.2 % of aquaculture production is based on alien species (Bartley *et al,* 2004) indicating the crucial role of alien species in sustaining the growth of aquaculture in this region. One of the main strategies to increase aquaculture production would be the use of faster growing strains, most of which would be alien to many countries.

Globalization and increased trade have led to increases in the establishment and naturalization of alien pathogens and invasive aquatic organisms. The ASEAN countries have ambitious plans to increase aquaculture production and trade in ornamental fishes. Due to economic losses caused by diseases, significant efforts have been initiated in ASEAN countries to tackle alien pathogens through NACA and FAO initiatives. For example, NACA and the FAO published the "Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals" in 2000 (FAO/NACA 2001). This document provides valuable guidance for national and regional efforts in reducing risks of disease due to the transboundary movement of live aquatic animals. However, there has been no regional initiative for non-pathogenic invasive alien species.

International and regional consultations in past workshops have identified a number of issues that need to be tackled with respect to invasive alien species. For example, the Global Invasive Species Program (GISP), with funding from the U.S. Department of State organized a regional workshop, Prevention and Management of Invasive Alien Species: Forging Cooperation throughout South and Southeast Asia' in August 2002 in Bangkok, Thailand (GISP

2003a). While this GISP-organized workshop supported the broader ASEAN Cooperation Plan goal of addressing transnational issues, and the ASEAN 2020 vision of enhancing food security and international competitiveness of food, agricultural and forest products, it focused more on terrestrial alien species, as reflected in the participants from agricultural and environmental ministries and organizations. However, there have been two international meetings focusing on aquatic alien species and stocks of relevance to this region. An international workshop on, "International Mechanisms for the Control and Responsible Use of Alien Species in Aquatic Ecosystems" was held in Xishuangbanna, People's Republic of China in August 2003. the workshop's goal was to assist countries in the Greater Mekong/Lancang sub-region by increasing familiarity with, and making effective use of international mechanisms for the control and responsible use of alien species in aquatic ecosystems. This current workshop, 'Building capacity to combat impacts of invasive alien species and associated transboundary pathogens in ASEAN countries' held in July 2004 in Penang, and the proposed regional workshop on "Preparedness and Response to Aquatic Animal Health Emergencies' to be held in Jakarta, Indonesia, during September 2004 by FAO will help to bring greater awareness and clarity on the issues concerning invasive alien species affecting aquatic environments and aquaculture. Finally, the 'Expert Consultation on Ecological Risk Assessment of Genetically Improved Fish' convened in Bangladesh in August 2003 (WorldFish Center 2003) examined how to determine the risks of invasiveness of aquatic organisms that may be altered genetically to increase their aquaculture potential (e.g., growth, disease resistance, etc.).

These international and regional consultations have clearly highlighted the link between aquaculture and invasive alien species. In order to sustain the growth in the aquaculture and ornamental sectors, the aquaculture programs that use new strains of alien species must explore methods to minimize the negative environmental and biodiversity impacts that can occur should the new species or strain become invasive outside the controlled aquaculture environment. The present paper examines this topic in relation to the three following areas:

- *(i) The present status of introduced aquatic species and their impact.*
- *(ii) The gap between the required and existing institutional, policy and legal mechanisms to tackle invasive alien species.*
- *(iii) The potential for growth in the aquaculture and ornamental sectors through the use of faster growing alien strains.*

Introduced Aquatic Species and Their Impact in ASEAN Countries

The introduced aquatic species in ASEAN countries consists of both fin and shellfishes as well other groups like the aquatic weeds.

Invasive Aquatic Fishes

To have a better understanding of the present status of introduced fish species and their impact, the Database of Introduced Aquatic Species (DIAS 2004) and FishBase (FishBase 2004) were examined with respect to information on ASEAN countries. Similar to the global picture, the main reasons for aquatic alien introductions in the ASEAN region are aquaculture and the ornamental (aquarium) trade. FishBase has records of 610 fish species introduced worldwide and out of these, 79 species were introduced to ASEAN countries. Country-wise introduction of alien fish species in all ASEAN countries is listed in Table 1.

All introductions have not led to the establishment of naturalized (feral) populations. Only twelve of the introduced alien fish species have been reported to become invasive in one or more countries. These fishes have established breeding populations and have been reported to have adverse effects. Even for the twelve invasive alien species, negative impacts have not been reported from all countries where they have been introduced. For example, *Aristichthys nobilis*,big head carp, is found in all ASEAN countries; however, only Vietnam has reported established populations with negative ecological effects. Scientific management of invasive alien species would be enhanced if we could understand the reasons why only 12 of the 79 introduced species have become invasive and only in a few of the countries where they have been introduced. What constitutes 'invasiveness' has not been defined or accepted by consensus among the scientific community. Most of the reported findings of invasiveness have been based on observations and not on specific studies to quantify the alleged impacts of the introduced species. The methodology adopted has not been uniform or standardized. The methodology adopted has not been uniform or standardized. There has been no reported instance of attempts to control these invasive fish species.

Evaluation of the 79 introductions indicates that we have more information on food fishes than ornamental fishes. For example, *Hypotomus plecostomus*, the ornamental sucker catfish has established in Philippines causing negative impacts to capture fisheries. It is probably also established in other ASEAN countries but surveillance efforts have not reported it. In Malaysia it has become a dominant fish species in the Gombak-Kelang River. Taking into consideration the volume of introductions through ornamental trade and minimal regulatory oversight of the trade, it can be inferred that the potential for introduction of alien species through the ornamental sector is much more than food fishes. Therefore, greater efforts to consider the role of the aquarium trade in the introduction of alien fish species are required.

Examining available information on invasive alien species in this region indicates the need for increased efforts to document their impacts. The Nature Conservancy (1996) notes that alien invasive species are responsible for the decline of 42 percent of those species listed as threatened or endangered by the U.S. Fish & Wildlife Service, and that invasive alien species have contributed to the extinction of 40 North American freshwater fishes over the past century. No similar analysis exists for invasive alien fish species from the ASEAN region. For most of the ASEAN member countries and other developing countries, organized data on invasive of alien species is very sketchy, limited to what is found in global databases like FishBase or DIAS. Many developed countries like the United States, Canada, New Zealand, Australia, and some European countries have better data documentation of alien invasions and possible management options. Setting up information systems for the ASEAN region linked to well-designed scientific studies would help in formulating better management measures.

The question of tradeoffs between the benefits of introductions and their likely impact on biodiversity should be addressed. Many invasive fish species cause ecological harm while still conferring distinct economic advantages. Common carp which has caused much ecological damage where released into foreign waters contributed over 2.8 million tons to global aquaculture production in 2002. This species highlights the need for capacity to make decisions based on evaluating both negative and positive impacts of species before they are introduced.

Table 1: Introduced fish in the ten ASEAN countries (Modified from FishBase, 2004).

Fish Species	Singapore	Philippines	Thailand	Malaysia	Myanmar	Indonesia	Laos	Vietnam	Cambodia	Brunei
Abbottina rivularis			+				+			
Aequidens latifrons						+				
Aequidens pulcher						+				
Anguilla japonica			+						+	
Aristichthys nobilis **	+	#	+	+	+	+	#	*	+	+
Aspidoparia morar								+		
Astronotus ocellatus	+									
Austrolebias nigripinnis		+								
Barbonymus gonionotus		+		+						
Betta imbellis	+									
Betta splendens	+			+						
Carassius auratus auratus **	*	#	#	+		*		+		
Carassius carassius		+	+							
Catla catla		+	+	+			+	+		
Channa micropeltes	+									
Cichlasoma octofasciatum			+							
Cirrhinus chinensis	+		+	+		+				
Cirrhinus cirrhosus		+	+	+			+	+	+	
*Clarias batrachus***		*				*				
Clarias gariepinus		+				+	+	+	+	
Clarias macrocephalus				+						
Colisa lalia	+									
Colossoma macropomum		+								
Ctenopharyngodon idella **	+	+	+	+	+	+	+	*	+	
*Cyprinus carpio carpio***		#	#	#	+	#	+	*	+	+
Devario malabaricus					+					
Esomus metallicus	+									
Etroplus suratensis				+		+				
Fundulus heteroclitus heteroclitus		+								
*Gambusia affinis*** o		*	*	#	+		#			
Gambusia holbrooki	+									
Gymnocorymbus ternetzi			+							
Helostoma temminckii	+	+								
Hemibarbus labeo							+			
Hemibarbus maculatus							+			
*Hypophthalmichthys molitrix***	+	+	+	+		+	#	*		
Hypostomus plecostomus		+								
Ictalurus punctatus		+								
Labeo rohita		+	+	+			+	+		
Lepomis cyanellus		+								
Lepomis macrochirus		#								

Micropterus dolomieu								+		
Micropterus salmoides		#		+						
Misgurnus anguillicaudatus		+								
Oncorhynchus mykiss			+	+						
Oreochromis aureus	+	+	+							
*Oreochromis mossambicus***	#	+	+	#		*	#	*	+	
*Oreochromis niloticus niloticus***	*	*	*	#		#	*	*	+	+
Oreochromis urolepis hornorum				+						
Osphronemus goramy	+	+								
Pangasius hypophthalmus	+	+								
Pangasius pangasius			+	+				+	+	
Paracheirodon innesi	+									
Parambassis siamensis	+									
*Poecilia latipinna**o*	*	*				+				
*Poecilia reticulata**o*	+*	*		#		*				
Poecilia sphenops	+	+								
Poecilia velifera	+									
Pseudorasbora parva							#			
Puntius conchonius	+									
Puntius partipentazona	+									
Puntius semifasciolatus	+									
Puntius tetrazona	+									
Rasbora borapetensis	+									
Rasborinus lineatus							+			
Rasborinus macrolepis	+									
Sciaenops ocellatus	+									
Scleropages formosus	+									
Thorichthys meeki	+									
Tilapia rendalli			+							
Tilapia zillii		+		+						
Tinca tinca						+				
Trichogaster leerii		+								
Trichogaster microlepis	+									
Trichogaster pectoralis	+	+				+				
Trichogaster trichopterus		+								
*Xiphophorus hellerii**o*	*					+				
Xiphophorus maculatus	+					+				
Xiphophorus variatus	+									

+ alien species; # established alien species; * negative impact recorded; *o* introduced through ornamental trade; ** adverse effect in more than one country.

Other Aquatic Invasive Organisms

There are many introduced aquatic organisms other than fish in ASEAN countries that have become invasive. Some of the species are riparian while others are fully aquatic. A list of such species not normally considered by fishery organizations is given in Table 2 along with their effect on the aquatic environment. Their impacts to fisheries are provided in Table 3. Most of the information has been compiled from GISP (2003b). The listed species are common across different countries and a regional program would be more effective.

Unlike invasive fish species, efforts have been directed at addressing invasive aquatic weeds. Specific guidelines to address invasive weeds are widely available and initiatives to control the spread of these aquatic weeds have been implemented (Table 3).

Table 2: Introduced species other than fish that may impact aquatic ecosystems in ASEAN countries.

Country	Species
Cambodia	*Acacia farnesiana* sweet acacia, *Chromolaena odorata* siam weed, *Eichornia crassipes* water hyacinth, *Pomacea canaliculata* golden apple snail, *Pistia stratiotes* water lettuce
Indonesia	*Acacia farnesiana, Chromolaena odorata, Eichornia crassipes, Mimosa pigra* black mimosa, *Myriophyllum aquaticum parrot feather, Pomacea canaliculata, Pistia stratiotes*
Laos	*Pomacea* sp., *Echinochloa colonum* jungle rice, *E. crusgalli* barnyard grass, *Mimosa invisa* giant sensitive plant, *Mimosa pigra*.
Malaysia	*Acacia farnesiana, Chromolaena odorata, Eichornia crassipes, Mimosa pigra, Pomacea canaliculata, Pistia stratiotes*
Myanmar	*Chromolaena odorata, Eichornia crassipes*
Philippines	*Acacia farnesiana, Chromolaena odorata, Eichornia crassipes*, *Litopenaeus vannamei* Pacific white shrimp, *Ipomoea aquatica* water spinach, *Pomacea canaliculata, Pistia stratiotes*
Singapore	*Chromolaena odorata, Eichhornia crassipes, Salvinia molesta, Trachemys script red-eared terrapin, Cuora amboinensis Malayan box turtle, Siebenrockiella crassicollis black marsh turtle, Macrobrachium lanchesteri Riceland prawn, M. nipponense oriental river shrimp, Mytilopsis sallei Carib-bean bivalve, Pomacea canaliculatA, Siebenrockiella crassicollis, Macrobrachium lanchesteri, M. nipponense, Mytilopsis sallei Caribbean bi-valve*
Thailand	*Acacia farnesiana, Cherax quadricarinatus Red claw, Chromolaena odorata, Eichornia crassipes, Pomacea canaliculata golden apple snail, Pomacea gi-gas apple snail, Pistia stratiotes water lettuce, Trachemys scripta elegans, turtles 2 spp, Litopenaeus vannamei Pacific white shrimp*
Vietnam	*Annona glabra pond apple, Chromolaena odorata, Eichornia crassipes, Pomacea canaliculata, Pistia stratiotes*

Table 3: Changes in aquatic environment, impact on fisheries and other sectors, and initiatives to control invasive alien species in ASEAN countries (Modified from GISP2003b; Global Invasive Species Database).

Species	Country	Effect on aquatic environment	Impact on Fisheries and other sectors	Some examples of control
Pomacea canaliculata (mollusk)	Cambodia, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, Vietnam	Eats water plants leading to potential habitat modification and competition with native species.	Causes serious damage to crops.	The Department of Agriculture,Malaysia launched a control operation in Keningau in 1992..
Eichornia crassipes *(aquatic plant)*	Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam	Reduces light and oxygen due to formation of dense mats, loss of water due to high evaporation rate and, overall reduced biological diversity	Reduced access to fishing and decline in fish catch.	The Department of Irrigation and Drainage (DID) spends about US$50,000 for clearing these weeds at the Likas Wetlands project, an urban wetland project in Kota Kinabalu of Sabah (North Borneo), Malaysia.
Pistia stratiotes (Aquatic plant)	Cambodia, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, Vietnam	Reduces light and oxygen due to formation of dense mats.	May reduce fish availability.	Bio-control using noctuid *E. pectinicornisin* Thailand.
Mimosa pigra (Riparian shrub)	Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam	Infests wetlands and paddy field and reduces the water availability in aquatic bodies.	Reduced access to fishing, dries up floodplain and wetlands and reduced fish a vailability. Interferes with irrigation and recreational use of waterways.	Reduced access to fishing, dries up floodplain and wetlands and reduced fish availability. Interferes with irrigation and recreational use of waterways.

In most ASEAN countries, the fisheries department is not involved in the monitoring and control of aquatic invasive weeds and species like the golden apple snail. This management schema raises questions of which agency is to monitor the impact and control of such aquatic invasive alien species. Many new aquatic weeds are being introduced through the aquarium trade without risk assessment and there is a possibility that some could become invasive. Though fisheries departments are not involved in managing invasive aquatic weeds, considerable expertise is available within the fishery scientific community on aquatic weeds like the expertise available on aquatic weeds within the Fisheries Research Institute of Malaysia. Fishery departments need to examine the issue of alien species other than fin and shellfishes and be proactive in controlling them.

Institutional, Policy and Legal Mechanisms

Effective management of invasive alien organisms requires strong institutional, policy and legal mechanisms. Ideally a single unified mechanism should handle this. Globally there are many imiportant international instruments to address the issue of introduced species. Most ASEAN countries like Malaysia have also adopted the Code of Conduct for Responsible Fisheries, a voluntary code that has sections on management of introduced species (FAO 1995).

Table 4: Adoption of international treaties by ASEAN countries.

Country	Conventional on Biological Diversity (CBD)		Biosafety Protocol		
	Signed	Party	Signed	Ratification	Party
Brunei Darussalam					
Cambodia		9/2/1995 a		17/9/2003 a	16/12/2003
Indonesia	5/6/1992	23/8/1994 r	24/5/2000		
Lao PDR		20/9/1996 a			
Malaysia	12/6/1992	24/6/1994 r	24/5/2000	3/9/2003 r	2/12/2003
Myanmar	11/6/1992	25/11/1994 r	11/5/2001		
Philippines	12/6/1992	8/10/1993 r	24/5/2000		
Singapore	12/6/1992	21/12/1995 r			
Thailand	12/6/1992	29/1/2004 r			
Vietnam	28/5/1993	16/11/1994 r		21/1/2004 a	20/4/2004

Note: a: accession r: ratification

Source: Convention on Biodiversity (CBD), 2004.

ASEAN countries have some legislation that addresses the management of invasive alien species either directly or indirectly (Table 5). Most of the legal instruments resulting from the CBD do not effectively address the problem of aquatic alien species since they have been framed for terrestrial plants. They do not cover all aspects of aquatic alien species adequately. Especially how to balance the negative biodiversity impacts with the positive economic impacts in aquaculture and the ornamental sectors. Involvement of fisheries sector in formulating these legal instruments will ensure a better balance.

Table 5: Existing national legislation and frameworks available in some ASEAN countries relevant to alien species management. (Modified from GISP, 2003b and NACA, 2005)

Country	Legislation/ Initiative
Brunei Darussalam Alien related legislation:	Plant Protection Unit of the Department of Agriculture. The unit is responsible for the prevention of the introduction of dangerous pests and diseases which are harmful, and takes action under the "Agricultural Pest and Noxious Plants Act" of Brunei Darussalam
Cambodia Alien related legislation:	Currently there are no specific guidelines or regulations related to the importation of exotic species for culture. The existing law and regulation will use the international law: The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Law of importation of goods (Racy, 2004).
Indonesia Alien related legislation:	Ministerial Decree no. 411, 1995 issued by Ministry of Agriculture concerning the Importation into the Territory the Republic of Indonesia of Biological Agents which provides a comprehensive measure to deal with the introduction of living organisms intended for biological control as well as for various other purposes. Decree No. 412/1995 issued by Ministry of Agriculture concerning the formation of Biological Agent Commission. Fish quarantine measures operated by Centre for Fish Quarantine under the Ministry of Marine Affairs and Fisheries.
Aquatic related initiatives:	Alien invasive species assessment was done by ad-hoc committee coordinated by Ministry of the Environment, Ministry of Agriculture; Ministry of Forestry; Ministry of Marine Affairs and Fisheries (Hardjono, 2004). National seminar on Biodiversity and control of alien invasive species.
Lao PDR Alien related legislation:	Decree on Prohibition of Wildlife Trade (1986), Decree on the Management and Protection of Wild Animals, and on Hunting and Fishing (1989) Decree on the establishment of National Protected Areas (1993),

Lao PDR Alien related legislation:	Quarantine legislation (1994) Forest Law (1996) Water Resources Management Law (1996) Plant Application legislation (1996) Land Law (1997), Mining and Mineral Resources Law (1997), Environment Protection Law (1999) including biological resources conservation, and Pesticide Law (2000). The Science, Technology and Environment Agency (STEA), created in 1993 under the Prime Minister's Office, is in charge of overall management and control of environment activities at the national level.
Aquatic related initiatives:	The National Agriculture Research Center, in cooperation with the Lao-International rice Research Institute (IRRI) project has initiated research experiments testing the efficiency of several biological controls against GAS. The bio-access draft legislation, which contains measures related to legal and illegal exportation of indigenous species, and introduction (legal and illegal) of alien species, is still being discussed at the central level of the government and will be promulgated in the near future.
Malaysia Alien related legislation:	The Plant Quarantine Act of 1976 and the Plant Quarantine Regulations of 1981 under The Crop Protection and Plant Quarantine Division of the Department of Agriculture (DOA). This act provides the legal framework for dealing with dangerous alien pests of plants and aquatic plants. Custom Act 1967.
Legislation related to fisheries:	Regulations made under Fisheries Act 1985 Fisheries (Maritime) Regulations 1967 Fisheries (Maritime) Regulations (Sarawak) 976 The Fisheries Regulations (1964) Establishment of Marine Parks & Marine Reserves Order 1994 Fisheries (Conservation & culture of Cockles) Regulations 1964 Fisheries (Prohibition of Methods of Fishing) Regulations 1980 Fisheries (Licensing of Local Fishing vessels) Regulations 1996 Fisheries (Prohibited Fishing Methods For The Catching of Grouper Fries) Regulations 1996

	Fisheries (Prohibited Areas) Rantau Abang Regulations 1991 Fisheries (Prohibited Areas) Regulations 1994 Fisheries (Marine Culture System) Regulations 1990 Fisheries (Prohibition of Import etc. of Fish) Regulations 1990
Aquatic related initiatives:	Containment and eradication of the golden apple snail (*Pomacea* spp.) by Department of Agriculture. Eradication of water hyacinth (*Eichornia crassipes*) using mechanical removal by Department of Irrigation and Drainage in a few infested water bodies across the country.
Philippines Alien related legislation:	Quarantine regulations Philippine Policy on Biodiversity; Guidelines on Planned Release to the Environment of Genetically Modified Organisms and Potentially Harmful Exotic Species. Wildlife Act.
Legislation related to fisheries:	Fisheries Administrative Order No. 220, Series of 2001. Operation of the Fish Health Laboratories and collection of fees and charges therefore; Fisheries Administrative Order No. 207, series of 2001. Prohibiting the importation and culture of imported live shrimp and prawn of all stages. Fisheries Administrative Order no. 221, Series of 2003. Further regulating the importation of live fish and fishery/aquatic products under FAO no. 135 s. 1981 to include microorganisms and bio-molecules Fisheries Office Order No. 211,Series of 2003 – Amendment to Fisheries Office Order No. 147-01, series of 2001: Designation of Regional Fish Health Officers (RFHOs) of BFAR. Fisheries Memorandum Order No. 240, series of 2003- Regulations on Transboundary movement of Shrimp Post-larvae; Fisheries Memorandum Order No. 078, series of 2003 Restriction on entry of live fish species importation from Taiwan and China Fisheries General Memorandum Order No. 014, series of 2004. Guidelines for the implementation of Fisheries Memorandum Order 240: Regulation on transboundary movement of shrimp post-larvae Fisheries Memorandum Order No. 013, series of 2004- Imposition of active surveillance mechanism for all shrimp hatcheries nationwide as part of the strict implementation of the National Action Program to Control White Spot Syndrome Virus (WSSV) in shrimp.

Aquatic related initiatives:	Exhibition on Biodiversity Management of Alien IAS, May 22-23, 2001. The Maritime and Ocean Affairs of the Department of Foreign Affairs (MOAC-DFA) formulated country's position on the control and management of ships' ballast water and sediment to prevent, minimize and ultimately eliminate the transfer of Harmful Aquatic Organisms and pathogens. A consultation workshop was held to determine management and control strategies to remedy Hypostomus plecostomus problem. Strict implementation of the law and issue of several memorandum orders and the apprehension and detention of the white shrimp operator as well as confiscation of smuggled live fry into the country.
Singapore Alien related legislation	Fisheries Act (Chapter 111) Animals and Birds Act (Chapter 7) Wholesome Meat and Fish Act (Chapter 349A) National Genetic Modification Advisory Committee (GMAC) approval needed for Genetically Modified Organisms (GMO) National Parks Act under Singapore National Parks Board
Aquatic related initiatives:	Fish Health Certification Program Accredited Ornamental Fish Exporter Scheme-voluntary Surveillance and Monitoring Programs for Aquatic Animal Pathogens Farm and Export Premises Survey Specific Import and Quarantine Requirements Development of Good Management Practice for Aquaculture-voluntary
Thailand Alien related legislation	National Biosafety Committee implement control of invasive alien species with the help of Institutional Biosafety Committee (IBC).

Getting legislation passed in developing countries takes a long period and needs expertise and manpower often beyond the capacity of fishery departments. One way forward would be to evaluate the existing legislation to identify gaps in the context of aquatic alien species and to work out mechanisms for how to best address them in collaboration with the ministry responsible for environment, the key ministry responsible for alien species legislation in many countries.

One of the key issues that should to be addressed in building effective institutional mechanisms to tackle invasive alien species is the lack of clarity about the roles of existing agencies with stakes in managing alien species. This issue is further hampered in many countries by conflicting jurisdictions over specific water bodies between national government bodies. Aquatic weeds are another gray area with respect to institutional mandates. The departments may not be aware of their similar program of work on alien species being undertaken in other agencies.For example,many organizations in Malaysia are in one manner or another involve in different aspects of alien species (Table 6). However there is no institutional mechanism for coordination or sharing of best practices across different sectors involved in alien species.

Table 6: List of major ministries, governmetn agencis and non-governmental organizations involved in IAS management in Malaysia (Modified from GISP 2003b).

Ministry	Agency or department	Areas of responsibility
Ministry of Agriculture	Department of Agriculture Peninsular Malaysia (Plant Protection and Quarantine Division)	Crop production and plant protection, including plant quarantine services (regulation and extension)
	Department of Fisheries, Peninsular Malaysia	Fisheries and other aquatic life, incl. related quarantine services (regulation, and extension) and research through Fisheries Research Institute. CITES National Management authorities for policy matters
	Department of Veterinary Services	Animals and animal husbandry incl. Animal quarantine services (regulation, research and extension)
	Malaysia Agricultural Research and Development Institute (MARDI)	Agricultural research and development
Ministry of Science, Technology and Environment	Conservation and Environment Management Division	CBD primary National Focal Point and National Focal Point for Body on Scientific, Technical and Technological Advice (SBSTTA).
	Department of Wildlife and National Parks, Peninsular Malaysia	CITES National Contact-Management Authorities Regulations and research in wildlife

Ministry of Agriculture and Fisheries, Sabah	Department of Agriculture, Sabah	Regulations and extension - crops, agriculture, animal husbandry and veterinary services, marine and fresh water fisheries, drainage and irrigation (also quarantine services)
	Department of Fisheries, Sabah	Research, development and extension services in fishing industry Competent to issue export and import permits for all marine species (including corals) except otters, dugongs and turtles under CITES
	Department of Veterinary Services and Livestock Industry, Sabah	Research, development and extension in animal husbandry and veterinary services, including animal quarantine
Ministry for Tourism Development, Environment and Technology	Sabah Wildlife Department	CITES National contact for Sabah
Ministry of Agriculture, of Sarawak	Department of Agriculture	Agricultural research and extension – crop, livestock, inland fisheries and farmers institution, including plant quarantine services

Ministry of Primary Industry, Ministry of Health, Ministry of International Trade and Industry, Ministry of Education Malaysia and Non-governmental Organizations are also involved in addressing alien species either directly or indirectly. It is clear that there are no specific agencies working solely on alien species in most of the ASEAN countries. Cooperation within the department, inter-department, non-governmental organizations and universities is needed to address the issue effectively. An interorganizational coordinating body with the mandate to cover alien species would be capable of addressing the issue. Thailand has a working group on alien species consisting of representatives from National Biological Control Research Center, Royal Forest Department, Department of Fisheries, Department of Livestock Development, Department of Agriculture, Department of Agriculture Extension, Office of the Cane and Sugar Board, Natural Science Museum, dean of Faculty of Veterinary Science and Office of Environmental Policy and Planning as the secretariat. The group has prepared the Thailand Thematic Report on Alien and Invasive. According to the report the country has developed national policies for addressing issues related to alien species as a separate strategy.

Aquaculture Development and Introduction of Improved Strains

Aquaculture is a $60 billion a year industry (FAO 2002) and the aquarium industry is estimated to be valued at US$250 million per year (Dawes 2003). Many ASEAN countries have plans to further increase their share in these sectors. To achieve this end, these countries have developed or are in the process of developing master plans. A brief country wise evaluation of the importance of aquaculture and the plans being put in place would help programs aimed at integrating these plans with the use of improved strains while concurrently addressing theinvasive alien species problem.

Brunei

Freshwater aquaculture production for the 1997 was only 30 tones (Earth Trends 2003). The country is expanding its aquaculture industry, particularly ornamental fish culture due to internal market demand and strong government support.

Cambodia

Aquaculture is largely practiced using captured fry from the wild. As per FAO (FAO 1999a), since development of marine capture fisheries is very costly and the inland capture industry does not seem to have a further margin for development, the aquaculture industry represents a potential venue that needs to be explored.

Indonesia

Aquaculture contributed 69% of the total 1997 inland fisheries and culture fisheries with culture production of 662,547 tones (FAO 2000a). Alien species constitute more than 72% of the total aquaculture production in the country for the year 2000 (FishSTAT 2004).

Malaysia

Aquaculture from both freshwater and brackish water provides about 10 percent of the total fish production in the country. In 1998 aquaculture production was 129 thousands tones which was valued at RM 726.5 million. Malaysia produced 309 million fingerlings of ornamental fish, which fetched an export price of US$ 21.8 million (FAO 2001).

The Malaysian National Agricultural Policy (1992-2010) indicates that deep sea fishing, aquaculture and inland fisheries will be encouraged and supported with adequate incentives, infrastructure and programs and that it will cater for the expanding of local and foreign markets. The policy document also has placed emphasis on establishing Malaysia as the global centre for aquarium and floricultural products. It calls for further research and development to produce new species and varieties, and to develop cost-effective production and post-harvest handling technologies. It calls for the doubling of aquaculture production using high market value species and one of the key species promoted to achieve this is tilapia.

Thailand

The aquaculture industry in Thailand expanded rapidly in the 1980s. By 1996 its marine and freshwater aquaculture were valued at US$1,050.73 million and US $171.89 million respectively (FAO 2000c). Alien species constitute 46% of the total aquaculture production in the country for the year 2000 (FishSTAT 2004). The national directive aims at increasing production by 5 percent per annum to provide at least 30 kg per person per year of food fish. Through rapid expansion of aquaculture, Thailand has become a major exporter of shrimp. There is also intensification of fish restocking in public water bodies.

Philippines

The Government policies in fisheries have called for full utilization of the country's fisheries resources by encouraging the private sector to invest in commercial fishing and aquaculture. With the intention of maintaining self-sufficiency in fish supplies, improving handling and distribution, strengthening small-scale fisheries, and increasing earnings of foreign exchange from exports, the country is focusing on a production-oriented fisheries development strategies (Baluyut, 1989). Philippines ranks ninth in world aquaculture production and in 1998 the aquaculture industry was worth US$640 million, which is 31 percent of the country's fisheries total value (FAO 2000b). Alien species constitute more than 77% of the total aquaculture production in the country for the year 2000 (FishSTAT 2004).

Vietnam

The Government of Vietnam is giving importance to fish and shrimp farming as an integral part of agriculture. Recent analysis indicates that subsistence and small scale enterprise of freshwater aquaculture as having potential for further development (FAO 2000). The Government is particularly interested in the introduction of modern technology to its traditional fish culture for earning foreign exchange (Baluyut 1989). Aquaculture contributed about 270,000 tones in 1996 and almost 75% of it was through improved varieties of carp species introduced into the country.

The increasing importance of aquaculture in ASEAN countries and the growth of the aquaculture sector in these countries is evident. Alien species and improved strains have contributed to this increase in production indicating the need to integrate the management of alien species with aquaculture development

Conclusion

The introduction of alien species and improved strains of species already in production is essential for the growth of aquaculture and the ornamental fish sector. However, the planning in these sectors is not proactive in this aspect. Most of the introductions are driven by the industry with the focus on shrimp. However, the bulk of aquaculture production, especially those involving the poor, is based on fishes like carps. This paper has analyzed the existing limited information on the present status of introduced aquatic species and their impact, existing institutional, policy and legal mechanisms to tackle invasive alien species and the potential for growth in aquaculture and the ornamental sectors through the use of faster growing alien strains. Based on the analysis, it recommends that action should be focused on the following three areas in order to sustain and enhance the growth in aquaculture and ornamental sectors:

i) Building scientific information and expertise on the impact of invasive alien species, risk assessment methods and proven mitigation mechanisms
ii) Strengthening existing institutional, policy and legal framework to tackle the issue of alien species
iii) Developing a strategy to utilize alien aquatic species aquaculture and ornamental programs in an environmentally sustainable and socially equitable manner

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Trans-boundary Aquatic Animal Pathogens in ASEAN and their Management

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Abstract

This presentation provides information on some of the serious and emerging transboundary aquatic animal pathogens impacting the ASEAN aquaculture sector, noting some past and current regional and international efforts at minimising the risk of the international spread of pathogens. The present status of national aquatic animal health strategy development and implementation in the ASEAN is discussed. This presentation will provide the basis for discussing health management strategies for the ASEAN region as part of the discussion on the responsible transboundary movement of live aquatic animals

Introduction

Transboundary animal diseases (TADs) are defined as epidemic diseases that are highly infectious or transmissible, with the potential for very rapid spread irrespective of national borders, and serious socioeconomic consequences (Baldock 2002). Transboundary aquatic animal diseases are a major risk and an important constraint to the growth of aquaculture. Aquatic alien species could either be pathogens that cause transboundary aquatic animal diseases, or they could harbour aquatic animal pathogens that lead to diseases and epizootics in aquaculture following introduction. Aquatic alien species, and aquatic animal pathogens, are transboundary problems with the potential to impact 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 (Arthur 2004). Many of these introductions have provided positive socio-economic benefits, including improved livelihoods, increased production and trade. However, there are also many cases where serious negative impacts have resulted. Live aquatic animals are moved actively to support subsistence and commercial aquaculture. 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, white spot syndrome virus (WSSV) and taura syndrome virus (TSV) in cultured shrimp and viral nervous necrosis (VNN) in grouper (Bondad-Reantaso 2004). Continued occurrence of koi mass mortality in Indonesia since June 2002 and the recent outbreak of koi herpes virus (KHV) in Japan (NACA/FAO, 2003) are grim reminders of the danger associated with the transboundary spread of pathogens.

The transboundary movement of live aquatic animals in Asia is one of the principal reasons for the increased occurrence and spread of several serious diseases (Subasinghe *et al*, 2001). The spread of aquatic animal pathogens has directly led to serious disease outbreaks, impacting aquaculture production, livelihoods, trade and national economies. Such problems have also indirectly impacted the trade of aquatic animal products within Asia, and among Asian countries and their major trading partners outside of the region. 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 the absence of national and regional disease management strategies or the non-compliance by stakeholders to strategies that are already in place.

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

This presentation provides a brief look at the transboundary pathogens and emerging diseases in the ASEAN region, the regional responses to combat them, and the needs for effective surveillance and emergency preparedness programs. We also discuss the importance of implementing structured health management programs based on the agreed regional frameworks of the “Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals”(FAO/NACA, 2000).

Serious Transboundary Pathogens in the ASEAN Region

Despite the vast body of information on transboundary pathogens in the Asia-Pacific region in several regional documents and publications (Subasinghe et al. 2001, Bondad-Reantaso et al. 2001, Bondad-Reantaso 2004), it is still the most widely debated and discussed topic in various workshops, expert consultations and meetings. This signifies the importance attached to this serious issue. Important transboundary pathogens recorded in the ASEAN, based on the information available in 22 (from 1998 second quarter to 2003 fourth quarter) quarterly aquatic animal disease (QAAD) reports published from the Asia-Pacific region through the FAO/NACA/OIE joint regional disease reporting system, are provided in Table 1 on the next page.

Epizootic Ulcerative Syndrome (EUS)

Since its first appearance in early 1980’s in Asia, EUS has spread throughout much of the Asia-Pacific region and continues to be a serious problem in the region. EUS has been reported from 8 countries within the ASEAN and continues to be associated with large scale mortalities in natural water bodies. In affected natural water bodies, EUS could produce up to 80% mortality in susceptible species (e.g. snakeheads). In some of the affected countries there is a widely held belief that the population of susceptible species has come down significantly, possibly having an impact on aquatic biodiversity. EUS is known by different names, such as

Table 1: Important transboundary pathogens in the ASEAN region

Country	EUS	VNN	Iridoviral diseases	KHV	WSSV	TSV	YHV	IHHNV
Cambodia	+				+			
Indonesia	+	+	+	+	+	+		+
Lao PDR	+							
Malaysia	+	?			+	?		
Myanmar	+				+			+
Philippines	+	+			+			
Singapore		+	+		+			
Thailand	+	+			+	+	+	+
Vietnam	+	+			+	+	+	

possibly having an impact on aquatic biodiversity. EUS is known by different names, such as mycotic granulomatosis (MG) in Japan, red spot disease (RSD) in Australia and ulcerative mycosis (UM) in the United States. The disease is now largely believed to have a single causative agent - *Aphanomyces (Aphanomyces invadans/piscicida*). The literature and our knowledge of EUS have been reviewed a number of times and the technical handbook on epizootic ulcerative syndrome (Lilley *et al.* 1998) provides the most comprehensive coverage of this syndrome.

Viral Nervous Necrosis (VNN)

The marine finfish farming industry is not free from disease problems. VNN causes serious problems to grouper culture in the Asia-Pacific. It was first reported from Japan in 1991. At present, within the ASEAN it is reported from 5 countries. VNN affects the nervous system and mortalities range from 10-100%. The occurrence of VNN is generally accepted as being widespread, but not being officially reported. In recent years, grouper iridoviral diseases have been recognized as increasingly important for the region. These are not currently considered by the OIE for international listing. In view of the increasing importance of marine finfish farming in ASEAN, and extensive movement of fry, fingerlings and adult fish, countries with active marine finfish farming should strengthen surveillance and reporting of viral diseases in marine finfish in the region.

Mass Mortalities of Koi And Common Carp/Koi Herpes Virus (KHV)

Mass mortalities of koi and common carp first occurred in the Asia-Pacific region in Indonesia in June 2002 and continued to cause serious losses in 2003 (NACA/FAO, 2003). Although the precise etiology of Indonesian outbreaks is still uncertain, the evidence (NACA, 2003) suggests possible involvement of koi herpes virus (KHV). In October 2003, confirmed KHV outbreaks caused mass mortalities in cultured carp for the first time in two lakes in Ibaraki Prefecture of Japan and since then spread to large parts of the country affecting cultured and wild populations of carp (FAO/NACA, 2003). The virus was first detected in 1997 in Israel and since then has spread globally. According to Gilad et al (2003) a single strain of koi herpes virus had spread worldwide by the unregulated trade in ornamental fish. KHV has now been reported from many countries in the world, and could become a considerable problem to ornamental koi carp as well as common carps, both cultured and wild. The spread of this virus into common carp populations represents a significant concern to food security – going well beyond its traditional threat to the ornamental fish industry. KHV is not currently considered by the OIE for international listing, but it is of serious concern to the region.

White Spot Syndrome Virus (WSSV)

White spot syndrome virus (WSSV) was first reported in Taipei China and China PR between 1991-1992. This major viral disease now affects almost all the shrimp producing countries in Asia and is officially reported from 8 ASEAN countries. WSSV continues to cause serious disease outbreaks in *P. monodon* in many countries of the region (FAO/NACA, 2003). WSD outbreaks are often characterized by high and rapid mortality of infected populations. The pathogen can produce upto 80-100% mortalities in affected ponds. WSD outbreaks usually take place between 40-60 days of culture, and farmers resort to emergency harvest. This practice prevents full-blown WSD outbreaks, but lead to significant economic loss. Recent reports of WSSV causing mortalities in cultured *P. vannamei* in China PR and Indonesia is a cause for serious concern as some of the leading shrimp producing countries in the ASEAN are farming *P.vannamei*.

Taura Syndrome Virus (TSV)

Taura syndrome virus (TSV) is a new addition to the growing list of shrimp viruses in the region. Introduction of *P. vannamei* based on perceived/projected advantages is largely believed to be responsible for TSV introduction to the Asia-Pacific (Smith and Briggs, 2003). In 2003, TSV has been reported in *P. vannamei* from China PR, Indonesia and Thailand. Reports of TSV in native P. *monodon* from Indonesia and China PR are also a cause for concern. The acute phase of infection in *P.vannamei* may result in high mortalities (40-90%). Co-habitation of *P. monodon* and *P. vannamei* in hatcheries and farms has been suggested as responsible for movement of pathogens between species and such pathogen transfers between species may have serious consequences. It is still early to estimate the economic impact of TSV in the region, but is certainly an additional problem to the already disease hit industry. TSV may be under-reported due to existing government restrictions on *P. vannamei* introductions and limited screening. The spread of TSV may be greater than indicated by QAAD reports and there is a need for improved reporting of TSV in the region. There is lot of concern about TSV in the region especially because the pathogen is spreading and changing genetically. This could conceivably lead to changes in the virulence, not only to *P.vannamei* but also to local crustacean species.

Other Emerging Disease Problems

There are several other emerging diseases that are worth mentioning. The slow growth syndrome in *P. monodon*, mourilyan virus (MoV) in shrimp, peripheral neuropathy and retinopathy in *P. monodon*, white tail/body disease in *Macrobrachium rosenbergii* and red spot disease in grass carp are concerns to the region. Epidemiological studies, effective disease outbreak investigations, and clear case definitions are required to better understand these problems and their impacts.

Key Regional Responses for Managing Transboundary Pathogens

a. Guiding Principles

Since defining a framework for disease control in the region, NACA, FAO and OIE, with various partners, have worked towards support in implementation. Supporting documents have been prepared that provide further guidance to Asian countries, including the Asia Regional Technical Guidelines (FAO/NACA 2000), the Manual of Procedures (FAO/NACA 2001) and an Asia Diagnostic Guide (Bondad-Reantaso *et al.* 2001). All 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 1994), as well as Article 9 - Aquaculture Development - of the Code of Conduct for Responsible Fisheries (CCRF) (FAO 1995).

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) provide expert guidance for national and regional efforts in reducing the risks of disease due to the transboundary movement of live aquatic animals (FAO/NACA, 2000).

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.

b. Response to Disease Emergencies

In the wake of massive mortalities of common carp and koi carp, and responding to an urgent request from the Government of Indonesia, NACA, with the timely support of Australia and FAO, constituted an emergency task force in 2002 to investigate the problem and advise the government on control measures. This task force provided significant insight to the problem and recommended a series of control measures. The task force studies set the stage for a follow up project assistance from FAO through its Technical Cooperation Programme (TCP) in 2003. This project provides assistance to improve national aquatic animal health capacity including establishment of a virology laboratory; evaluation of legislation on aquatic animal health; finalization of Indonesia's National Strategy on Aquatic Animal Health; training of field extension workers and farmers on aquaculture health management; technical training of project staff on virology and health management; epidemiological investigations on KHV; and establishment of surveillance and reporting systems for KHV.

c. Changes to the Regional (FAO/NACA/OIE) QAAD Reporting List

KHV outbreaks in the region have significant trade implications for the high value ornamental koi carp industry, and the important food fish common carp. Active trade in ornamental fish poses a potential risk for spread of KHV. In recognition of this risk, "mass mortalities of koi carp" was listed under the "unknown diseases of serious nature" category in the FAO/NACA/OIE regional QAAD reporting list effective from 2003.

Since the listing of koi mass mortality in QAAD, Singapore and Thailand introduced active surveillance and quarantine programs in 2003 aimed at preventing introduction and spread of KHV. In response to recent confirmed KHV outbreaks in Japan, 'infection with koi herpes virus" has now been added to the list of "diseases prevalent in the region" in the QAAD, to become effective for reporting from 2004.

Recognising the importance of iridoviral disease, in terms of its potential to spread and cause economic loss, "grouper iridoviral disease" was included for listing in the QAAD under "any other diseases of importance" effective from January 2003. Since the listing came into effect, Hong Kong China and Indonesia have reported grouper iridoviral disease while Singapore has reported the occurrence of mullet iridoviral diseases**.**

d. *Capacity Building in Import Risk Analysis (IRA)*

Recognizing the increasingly serious socio-economic, environmental and possible international trade consequences arising from disease incursions related to the introduction and spread of transboundary pathogens/diseases through irresponsible movement of live aquatic animals, an APEC and FAO supported project to build capacity in import risk analysis (IRA) was successfully implemented by NACA during 2002 and 2003. The first training workshop was completed from 1-6 April 2002 in Bangkok, Thailand, and a second training workshop was held from 12-17 August 2002 in Mazatlan, Mexico. The two training workshops brought together regulatory authorities and administrators responsible for trade of live aquatic animals and aquatic animal health specialists to share experience, raise awareness, build capacity and contribute to the development of a practical manual for risk analysis to support responsible aquatic animal movements. From the ASEAN region, 8 countries participated in the program. Important outputs include technical proceedings[1] of the workshops and a practical manual on IRA[2] for aquatic animals (Arthur and Bondad-Reantaso 2004; Arthur 2004). These documents provide further support to Asian governments developing health management measures based on scientifically sound risk analysis, a key element of the World Trade Organization's Sanitary and Phytosanitary Agreement (WTO-SPS) and the Asia Regional Technical Guidelines.

e. *Cooperation within ASEAN*

Within ASEAN, there have also been much welcomed efforts at promoting closer collaboration among ASEAN members in aquatic animal disease control. The Department of Fisheries, Malaysia, in collaboration with NACA, organised a regional Seminar "Harmonization of Quarantine Procedures for Live Fish among ASEAN Member Countries" in February 2003, in Penang, Malaysia. The seminar succeeded in developing "Draft Guidelines for harmonization of quarantine procedures of live fish among ASEAN member countries". The ASEAN Sectoral Working Group on Fisheries is now working towards further development of the document and comprehensive procedures for implementation of the guidelines at the operational level. Further collaboration within ASEAN is evidenced by this workshop, where the Department of Fisheries, Malaysia, in collaboration with NACA and FAO, and with support from the United States Department of State, have organized this workshop on "Building capacity to combat invasive alien species and associated transboundary pathogens in ASEAN countries". The workshop is expected to help ASEAN countries build their national capacities to combat the impacts of aquatic invasive alien species (IAS) and associated transboundary pathogens in aquaculture.

The importance of cooperation among countries of the same watershed was highlighted in the Asia Regional Technical Guidelines. Within the Mekong/Lancang basin, an international workshop, *International Mechanisms for the Control and Responsible Use of Alien Species in Aquatic Ecosystems,* was convened during August 2003, in Xishuangbanna, People's Republic of China, to promote cooperation in the Mekong/ Lancang in responsible movement of aquatic animals, including both disease and exotic species issues. The workshop involved cooperation between 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-Pacific (NACA), University of California Sea Grant College Program (UCSG), World Conservation Union (IUCN), Ministry of Agriculture of the Peoples Republic of China and the FAO/Netherlands Partnership Programme (FNPP). The outcome, as agreed among the senior policy makers and scientists present, provides a strong basis for further cooperation among the six Mekong/Lancang basin in control and responsible movement of aquatic animals.

f. Advisory Group

A Regional Advisory Group was established at the request of the member governments of the Network of Aquaculture Centres (NACA) in 2001 to provide advice in the Asia-Pacific region on aquatic animal health management, through the following activities: (a) Review and evaluation of regional aquatic animal disease reporting; (b) Review and evaluation of implementation of the *Technical Guidelines*; (c) Advise on identification and designation of regional aquatic animal health resources, including specialist advisers, Regional Reference Laboratories and Resource Centres; (d) Revision of the *Technical Guidelines* (FAO/NACA 2000), *Manual of Procedures* (FAO/NACA 2001) and *Asia Diagnostic Guide for Aquatic Animal Diseases* (Bondad-Reantaso and McGladdery 2001) as required; and (e) Development of procedures for advising on dealing with aquatic animal health emergencies. Members of the Advisory Group include invited aquatic animal disease experts, and representatives from the World Animal Health Organisation (OIE), Food and Agricultural Organisation of the United Nations (FAO) and other collaborating regional organizations. The AG meets annually and through its meeting reports provides specialist advice to governments in the region (NACA 2004).

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[1] J.R.Arthur and M.G.Bondad-Reantaso (eds.). Capacity and awareness building on import risk analysis (IRA) for aquatic animals. Proceedings of the workshops held 1-6 April 2002 in Bangkok, Thailand and 12-17 August 2002 in Mazatlan, Mexico. APEC FWG 01/2002, NACA, Bangkok. 203p.

[2] Arthur et al.,2004. Manual on risk analysis for the safe movement of aquatic animals (FWG/01/2002). APEC/DoF/ NACA/FAO, 59 p.

g. *Information Sharing*

In response to the introduction of KHV into Asia, an international conference on KHV was organized in Japan in March 2004, by the Fisheries Agency of Japan in collaboration with OIE and SEAFDEC. This has provided useful guidance to the region in dealing with this problem. FAO, NACA and the World Fish Centre, in collaboration with the Government of Indonesia, will hold a workshop on “Emergency preparedness and response to aquatic animal diseases in Asia” in Indonesia in September 2004. These activities will provide a platform for countries to share information and experience and facilitate development and implementation of practical and comprehensive emergency contingency plans as part of their national aquatic animal health strategies.

h. *Regional Resources*

Identification and establishment of the Regional Aquatic Animal Health Resource Base was one of the key recommendations of the first regional advisory group (AG) meeting in 2002. It was proposed that the resource base in aquatic animal health be identified at three levels; regional resource experts (RRE), regional resource centres (RRC) and regional reference laboratories (RRL). A cohesive networking among RRE, RRC and RRL in aquatic animal health is a requirement in the region to provide diagnostic support and to build capacity for implementation of the Asia Regional Technical Guidelines. Work has started on this resource base during 2003, and it is hoped that in the coming years an effective network of resource centers will provide valuable support within the Asia-Pacific region to national agencies with assistance in the diagnosis of key regional diseases, assistance in responding to disease emergencies, and as contact points for advice and capacity building in close cooperation with FAO, NACA and OIE.

Implementation of the Asia Regional Technical Guidelines in the ASEAN

The Asia Regional Technical Guidelines (FAO/NACA 2000, 2001) 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.

The ASEAN countries were among the 21 governments adopting the Technical Guidelines. In addition, the ASEAN Fisheries Working Group adopted the policy document in 2001, further strengthening their implementation within the ASEAN. The main elements of the Technical Guidelines are as follows:

1. Scope, purpose, and background
2. Definitions and guiding principles
3. Pathogens to be considered
4. Disease diagnosis
5. Health certification and quarantine measures
6. Disease zoning
7. Disease surveillance and reporting

8. Contingency planning
9. Import risk analysis
10. National strategies and policy frameworks
11. Regional capacity building
12. Implementation of the technical guidelines
13. The Beijing consensus and the implementation strategy

The comprehensive framework summarized above considers the major requirements for managing risk associated with live aquatic animal movements and transboundary pathogens (Bondad-Reantaso 2004).

There has been considerable progress in implementing the Technical Guidelines in several countries in ASEAN (Table 2). 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 ASEAN. 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.

Table 2: Status of national strategy development for implementing the elements contained in the Asia regional Technical Guidelines*

Present Status of TG implementation in the ASEAN	No of Countries
National aquatic animal health strategies in place. Key elements of TG being implemented under various policies, programs and regulations.	5
Work towards National strategy development under different programs initiated. National Strategy Documents developed and approved by the Ministry	1
National Strategy framework developed.	1
Specific programs yet to be initiated towards development of National Strategies	2

*information provided from national health coordinators

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. Until now, 22 quarterly aquatic animal disease reports have been published and widely disseminated in the 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.

Countries where governments and policy makers have realized the trade benefits/ advantages that can come with compliance to international obligations and requirements (such as international and regional disease reporting) have been quick to establish well formulated and practical national aquatic animal health strategies with defined responsibilities for institutions and individuals. Willingness and commitment of the governments, availability of technical expertise and diagnostic capabilities and allocation of adequate resources appear to be most important for well established disease reporting systems in some of the countries in the region.

Despite the significant progress in regional disease reporting, concerns remain in some of the following issues:

- ineffective disease data gathering (surveillance) at the country level
- lack of compliance by some of the member countries
- poor quality of disease reports
- wrong/under reporting of diseases of concern

The Technical Guidelines emphasize 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 some of the countries in the ASEAN, 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. Neighbouring countries therefore should cooperate closely in the control of these diseases. Part of this cooperation should be the rapid sharing of information on the occurrence of new diseases and the spread of existing epidemic diseases to new areas, particularly near shared borders.

The following issues are presented for further consideration and discussion during the workshop and specifically during the working group discussions:

- The importance of legislation and policy frameworks to support implementation.
- The need for national coordination and institutional cooperation, including between veterinary and fishery authorities
- The need to understand risks, and focus on key pathogens of concern for the ASEAN 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 ASEAN region.
- Disease zoning and cooperation within the region, for example to 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 has suffered significant losses due to transboundary diseases, and increasing risks are foreseen in the future as aquaculture expands in the region. Enabling government policies, coupled with strong resolve and commitment among stakeholders, will not only help in disease control but also facilitate responsible movement of aquatic animals and contribute to development of sustainable aquaculture in the region, and responsible trade with major trading partners.

Various global instruments and voluntary or obligatory codes of practice and guidelines are aimed at minimizing the risks due to pathogens and diseases associated with aquatic animal movements. Within Asia, The Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals and their associated implementation plan, and the Beijing Consensus and Implementation Strategy (BCIS), (FAO/ NACA, 2000) provide the basic framework and guidance for national and regional efforts in reducing the risks of disease from the transboundary movement of live aquatic animals. Many regional, inter-governmental and global organizations strongly endorse the implementation of the guidelines and support the shared commitment from national governments that is required for their success. It is the responsibility of the governments to act now, and make provisions within their development plans to implement the technical guidelines.

Most countries face significant challenges in the practical implementation of health management strategies, specifically in the areas of diagnosis, surveillance, risk analysis, emergency preparedness, and quarantine and certification programs. These challenges are mainly due to inadequate national capacity. There is, therefore, a need to continue the strong regional cooperation in aquatic animal health in the Asia-Pacific region. What is required now is the strong political will that would bring the implementation process forward. This is the only way to protect the regional aquaculture industry from serious transboundary pathogens.

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Aquatic Alien Species and Their Contribution to Aquatic Production, Food Security and Poverty Alleviation: An Overview of Data from ASEAN Countries

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Introduction

Alien species have been used to improve production and value from fisheries and aquaculture systems for thousands of years: early Romans introduced the common carp to some areas of Europe and the practice was continued by clerical workers, lay persons and monks during the middle ages (Balon 1995). In the 19th and 20th centuries many European colonists brought native species of salmon and trout with them to establish fisheries as they settled in Latin America and Africa (Welcomme 1988). With the development of aquaculture, fish farmers have transferred species around the globe in hopes of improving production and creating new markets (Welcomme 1988, Bartley & Casal 1998).

Although the introduction of exotic species has provided a significant economic boost to some economic sectors and communities, the use of such alien species has also generated controversy in that they are now recognized as one of the most significant threats to native aquatic biodiversity (Bartley and Casal 1998; Williams et al. 1989). The Convention on Biological Diversity (CBD) (CBD 1994) contains numerous references to alien species (Bartley and Fleischer 2004) and importantly Article 8(h) requires, "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 CBD recognizes the contribution that alien species have made to agriculture in the formof agro-biodiversity. The Food and Agriculture Organization of the United Nations (FAO) also addresses alien species in the Code of Conduct for Responsible Fisheries (Bartley et al. 2004). Thus, in managing alien species in fisheries and aquaculture, there is a clear need to balance the benefits of their use, versus the adverse impacts they may have on local biodiversity.

A key consideration in this balance will be to determine who derives benefits and who incurs the risk. For international aid agencies such as FAO, primary beneficiaries of fishery development should be the poorer sectors of society in developing countries. Thus, for FAO, the needs of rural and less developed communities must be met in an environmentally and socially acceptable manner.

In this paper we report on the fishery production derived from the use of alien aquatic species in ASEAN countries. This information provides one view of the balance sheet in managing alien species. We have used official information on fishery production submitted by member states, and also unofficial information from a variety of sources on records of alien species in the region. The dataset is far from complete, but does allow a general analysis of the contribution that alien species can make to fishery production.

Sources of Information

Continuously up to date information will be crucial in determining the benefits and risks of alien species. International mechanisms have recognized this and have called for the establishment of information systems. For example, the CBD in Article 8h requests member States:

- to collect information on national and international actions ... 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; and
- to establish an "incident list" on introductions of alien species and genotypes through the national reporting process or any other appropriate means.

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 "conduct inventories and impact assessments of alien species within their inland water ecosystems."

The FAO Code of Conduct for Responsible Fisheries under Article 9 on Responsible Aquaculture Development recommends, that member States:

- "create mechanisms such as databases and information networks to collect and share information on aquaculture development" and
- "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.

In order to assist its member States responding to the above requirements for an information system, FAO has updated the information on introductions of inland fish compiled by Robin Welcomme (Welcomme 1988) to include additional taxa and species from marine environments. This expanded Database on Introductions of Aquatic Species (DIAS) (DIAS 1997; Garibaldi and Bartley 1998) now (June 2004) contains approximately 3,880 records on alien species and provides socio-economic and ecological information on the positive and negative impacts of the introductions.

In order to get a more precise assessment on the socio-economic benefit of alien species production figures for species listed in DIAS for ASEAN countries were derived from FAO fishery statistics (FAO FishStat+ 2004).

Both of these data sources are incomplete, but represent the best available information on the subject and allow analysis of the reasons for the introduction of alien species and a rough estimate of their productivity.

Production from Aquatic Alien Species

Alien species contributed to overall fishery production to varying degrees in ASEAN countries (Table 1). A complete listing of the information contained in DIAS and fishery production from FAO FishStat+ is listed in Annex 1. Lao PDR had the highest percent production from alien species, whereas absolute production was highest from China (Table 1).

The alien species accounting for the highest production were common carp (*Cyprinus carpio*), and Japanese kelp, *Laminaria japonica*, in China with production of over 4 million teach in 2002, molluscs, tilapia species, and walking catfish (*Clarias batrachus*) were the other most productive groups (Table 2). There were several important aquaculture

Table 1. Production from aquatic alien species in ASEAN countries (2002 data)*

Country	Production from alien species (mt)	Total production (mt)	Percent of total aquaculture production from alien species
Brunei	52	2,215	2.35
Cambodia	7,193	424,382	1.69
China	13,522,012	53,426,645	25.23
Indonesia	491,775	5,679,391	8.66
Lao PDR	49,731	93,156	53.38
Malaysia	18,308	1,463,625	1.25
Myanmar	2,200	1,433,908	0.15
Philippines	208,164	3,371,874	6.17
Singapore	1,205	7,796	15.46
Thailand	179,630	3,566,106	5.04
Viet Nam	No data	2,042,500	-
Country Average	1,448,027	6,501,054	11.9%
Total	**14,480,270**	**71,511,598**	**Percent total production from alien species in ASEAN by mt = 20.2%**

**Data Source: FAO FishStat+ 2004 and DIAS*

species introduced into Vietnam and we have seen culture of Pirapitinga (*Colossoma brachypomum*) near Hanoi (DMB personal obs.), however no production from these species is listed in official reports from Vietnam to FAO. Therefore, actual production from alien species is undoubtedly higher than zero. In Singapore alien species are used in the ornamental fish industry (Table 3) – therefore absolute weight is small, however value can be substantial.

As is the global trend (Welcomme 1988, Bartley and Casal 1998), aquaculture was the most common reason for the deliberate introduction of alien species (Figure 1; Table 3). The development of fisheries (commercial and recreational) and biological control, as well as the development of ornamental fish trade, were the other main reasons.

Table 2. Most productive alien species introduced into the ASEAN region*

Species	Production (mt) in region	Country
Kelp	4,207,700	China
Common carp	4,377,184	Thailand, Vietnam, Philippines, Malaysia, Lao PDR, Indonesia, China, Cambodia, Brunei
Pacific oyster	3,625,548	China
Scallop	935,585	
Tilapias	3,177,882	Thailand, Vietnam, Philippines, Malaysia, Myanmar, Lao PDR, Indonesia, China, Cambodia, Brunei
Walking catfishes	87,797	Thailand, Philippines, Malaysia, Indonesia

**Data source: FAO FishStat+ 2004 and DIAS*

Table 3. Summary information on reasons for introductions of aquatic species*

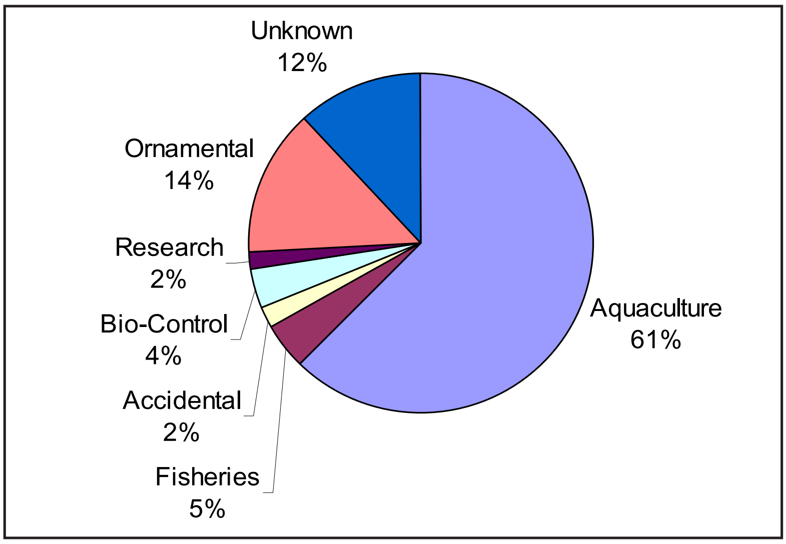
REASON	COUNTRY									
	Cambodia	China	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Vietnam
Accidental		2	1				2	1		
Aquaculture	4	32	25	11	17	18	37	14	21	20
Fisheries/Angling		1	1		3		6	25	2	
Ornamental		2	3	2	1		5	2	6	1
Biological control		1	2		2		5		1	
Research			2				1			2
Unknown			14				6	2	2	1
No data		63								

**numbers in body of table refer to number of records in DIAS*

Conclusion

Aquaculture is by far the dominant reason for the deliberate introduction of alien species. Yakupitiyage and Bhujel (2004) reported that alien species contribution to aquaculture production in Cambodia, Lao PDR, Thailand and Viet Nam were 49, 100, 26

Figure 1: Reasons for the introduction of alien invasive species



**Data source: DIAS*

and 73 percent, respectively. The most commonly used alien species in the region are generally those that feed low on the food chain, e.g. tilapia, or are omnivorous, e.g. common carp and walking catfishes. The culture of these species requires little input from farmers, or at least inexpensive input in the form of waste, fertilizer or plant material. Therefore, they are often farmed by low-income people with minimal resources to devote to aquaculture. In this respect alien species play an important role in the food security and livelihoods of many rural communities in developing countries of the region. This was further confirmed by workers at the Asian Institute of Technology who conducted a series of workshops to assess the economic value of alien species in IndoChina (Yakupitiyage and Bhujel 2004). For example, in Thailand alien 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 seven Thai provinces. Nearly 46% (13.8 kg fish/person/year) of fish consumed in rural areas are exotic species (Boonchuwong, 2002).

Research for this report confirms that improved information is needed on fishery production in general, and on alien species specifically. Inland fishery and aquaculture production contributes substantially to the economic development of many countries in the region and alien species contribute substantially to this production. However, without accurate information, development decisions will be taken that may adversely impact the sector and the countries' indigenous aquatic biodiversity.

FAO's DIAS is in continuous evolution to facilitate member States efforts to update their country's species-specific data and at the same time use the information they receive through DIAS in deciding on how to manage alien species. The present workshop will provide additional valuable information on alien species in ASEAN countries and a similar workshop is planned for October 2004 at the 13th meeting of the Commission on Inland Fisheries of Africa. Countries are encouraged to continue to work with NGOs, the international development community, scientific institutions and the private sector to continue to improve the quantity and quality of data that are collected at the national level and that are reported to FAO. Significant progress has been made in this area through the work of the Mekong River Commission, WorldFish Center, Network of Aquaculture Centres in Asia and the Pacific, and FAO, but more is still needed.

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Annex 1

Information on Aquatic Alien Species
(Data on introductions from DIAS and production from FishStat+ 2004)

SPECIES	YEAR	REASON	PRODUCTION (MT) OF INTRODUCED SPECIES IN ASEAN REGION
VIETNAM			
Ameiurus nebulosus	Unknown	Unknown	*
Carassius auratus	Unknown	Aquaculture	*
Catla catla	1984	Aquaculture	*
Cirrhinus mrigala	1984	Aquaculture	*
Clarias gariepinus	1974	Aquaculture	*
Colossoma brachypomum	1999	Aquaculture	*
Crassostrea gigas	2002	Research, Aquaculture	*
Ctenopharyngodon idella	1958	Aquaculture	*
Cyprinus carpio	1975	Aquaculture	*
Cyprinus carpio	1969	Aquaculture	*
Hypophthalmichthys molitrix	1958	Aquaculture	*
Hypophthalmichthys nobilis	1958	Aquaculture	*
Labeo rohita	1984	Aquaculture	*
Labeo rohita	1982	Aquaculture	*
Mylopharyngodon piceus	Unknown	Aquaculture	*
Oreochromis aureus	2002	Research	*
Oreochromis mossambicus	1955	Aquaculture	*
Oreochromis mossambicus	1951	Aquaculture	*
Oreochromis niloticus	1994	Aquaculture	*
Oreochromis niloticus	1973, 1989	Aquaculture	*
Penaeus vannamei	2001	Aquaculture	*
Pomacea canaliculata	1988	Ornamental	*
Sciaenops ocellatus	1999	Research, Aquaculture	*
TOTAL VIETNAM			**2,042,500****

SPECIES	YEAR	REASON	PRODUCTION (MT) OF INTRODUCED SPECIES IN ASEAN REGION
THAILAND			
Anguilla japonica	1973	Aquaculture	*
Aristichthys nobilis	1932	Aquaculture	*
Carassius auratus	1692-1697	Ornamental	*
Carassius carassius	1980	Aquaculture	*
Catla catla	1979	Aquaculture	*
Cichlasoma octofasciatum	1950s	Ornamental	*
Cirrhinus mrigala	1980	Aquaculture	1,455
Clarias gariepinus	about 1987	Aquaculture	14,300
Clarias macrocephalus	Unknown	Aquaculture	*
Ctenopharyngodon idella	1932	Aquaculture	*
Cyprinus carpio	1913 onwards	Aquaculture	14,268
Gambusia affinis affinis	Unknown	Mosquito control	*
Gymnocorymbus ternetzi	1950s	Ornamental	*
Hypophthalmichthys molitrix	1919	Aquaculture	401
Hypophthalmichthys nobilis	1932	Aquaculture	*
Hypostomus spp	Unknown	Ornamental	*
Ictalurus punctatus	1989	Aquaculture	*
Labeo rohita	1968	Aquaculture	1,830
Mylopharyngodon piceus	1913	Aquaculture	*
Oncorhynchus mykiss	1973	Fisheries	*
Oncorhynchus rhodurus	1981	Angling/sport	*
Oreochromis aureus	1970	Aquaculture	*
Oreochromis mossambicus	1949	Aquaculture	98
Oreochromis niloticus	1965	Aquaculture	145,178
Osphronemus goramy	Unknown	Unknown	2,100
Pomacea canaliculata	1990	Aquaculture	*
Pomacea canaliculata	1990	Ornamental	*
Pomacea gigas	Unknown	Unknown	*
Procambarus clarkii	Unknown	Aquaculture	*
Pterygoplichthys sp. (which one?)	Unknown	Ornamental	*
Rana catesbeiana	Unknown	Aquaculture	*
Tilapia rendalli	1955	Aquaculture	*
TOTAL THAILAND			**179,630 (5.04%) of 3,566,106****

SPECIES	YEAR	REASON	PRODUCTION (MT) OF INTRODUCED SPECIES IN ASEAN REGION
SINGAPORE			
Barbodes spp.	1960s	Ornamental	*
Betta splendens	Unknown	Ornamental	*
Carassius auratus	1900s	Ornamental	*
Cichlasoma spp	1970s	Ornamental	*
Cirrhinus chinensis	1900s	Aquaculture	*
Colisa spp.	1970s	Ornamental	*
Corydoras spp.	1970s	Ornamental	*
Crassostrea gigas	Unknown	Aquaculture	*
Crocodylus porosus	Unknown	Aquaculture	1,058
Ctenopharyngodon idellus	1900s	Aquaculture	*
Cyprinus carpio	1915	Aquaculture	*
Helostoma spp.	1950s	Ornamental	*
Hemigrammus spp.	1960s	Ornamental	*
Hyphessobrycon spp.	1960s	Ornamental	*
Hypophthalmichthys molitrix	1900s	Aquaculture	*
Hypophthalmichthys nobilis	1900s	Aquaculture	5
Lutjanus argentimaculatus	1990	Aquaculture	*
Moenkhausia oligolepis	1960s	Ornamental	*
Oreochromis aureus	Unknown	Unknown	*
Oreochromis mossambicus	1943	Unknown	*
Oreochromis niloticus	1970s	Aquaculture	142
Oreochromis niloticus	1973	Aquaculture	*
Paracheirodon innesi	1960s	Ornamental	*
Pelvicachromis pulcher	1960s	Ornamental	*
Penaeus japonicus	Unknown	Aquaculture	*
Poecilia latipinna	1960s	Ornamental	*
Poecilia reticulata	1900s	Ornamental, Mosquito control	*
Poecilia reticulata	1937	Ornamental, Mosquito control	*
Poecilia sphenops	Unknown	Ornamental	*
Poecilia velifera	1960s	Ornamental	*
Pterophyllum spp.	1960s	Ornamental	*
Puntius semifasciolatus	Unknown	Accidental	*
Puntius spp	1960s	Ornamental	*
Rasbora spp.	1960	Ornamental	*
Symphysodon spp.	1960s	Ornamental	*
Thayeria obliquus	1960s	Ornamental	*
Tomistoma schlegelii	Unknown	Aquaculture	*
Trachinotus falcatus	1992	Aquaculture	*
Trichogaster pectoralis	Unknown	Ornamental	*
Trionyx sinensis	Early 1970s	Aquaculture	*
Xiphophorus hellerii	1960s	Ornamental	*
Xiphophorus maculatus	1960s	Ornamental	*
TOTAL SINGAPORE			**1,205 (15.46%) of 7,796**

SPECIES	YEAR	REASON	PRODUCTION (MT) OF INTRODUCED SPECIES IN ASEAN REGION
PHILIPPINES			
Ameiurus catus	1935	Aquaculture	*
Anabas testudineus	Unknown	Aquaculture	*
Carassius carassius	1964	Aquaculture	*
Catla catla	1964	Aquaculture	*
Channa striata	1908	Aquaculture	8,732
Cirrhinus mrigala	1967	Aquaculture	*
Clarias batrachus	1972	Aquaculture	5,235
Clarias gariepinus	1987	Aquaculture	*
Clarias gariepinus	1985	Unknown	*
Clarias gariepinus	1985	Unknown	*
Colossoma macropomum	Unknown	Ornamental	*
Crassostrea gigas	Unknown	Aquaculture	*
Cristaria plicata	1970	Accidental	*
Ctenopharyngodon idellus	1964	Aquaculture	*
Cyprinus carpio	1915	Aquaculture	27,278
Cyprinus carpio	1910	Aquaculture	*
Fundulus heteroclitus	1905	Mosquito control	*
Gambusia affinis	1913	Mosquito control	*
Gambusia affinis	1920	Mosquito control	*
Helostoma temminckii	1948	Unknown	*
Hypophthalmichthys molitrix	1964	Aquaculture	*
Hypophthalmichthys molitrix	1968	Aquaculture	*
Hypophthalmichthys nobilis	1982	Fisheries	*
Ictalurus punctatus	1974	Aquaculture, Ornamental	*
Labeo rohita	1964	Unknown	*
Lepomis cyanellus	1950	Aquaculture	*
Lepomis macrochirus	1950	Aquaculture	*
Megalobrama amblycephala	1944	Aquaculture weed control	*
Micropterus salmoides	1907	Aquaculture	*
Misgurnus anguillicaudatus	1942	Aquaculture	*
Oreochromis aureus	1977	Aquaculture	48,624
Oreochromis mossambicus	1950	Aquaculture	*
Oreochromis niloticus	1970	Aquaculture	104,352
Oreochromis niloticus	1973	Aquaculture	*
Oreochromis spilurus	1985	Aquaculture	*
Oreochromis spp.	1979	Aquaculture, Fisheries	*
Osphronemus goramy	1927	Aquaculture	41
Pangasius hypophthalmus	1978	Ornamental, Fisheries	*
Pangasius hypophthalmus	1982	Ornamental, Fisheries	*
Penaeus stylirostris	1980	Unknown	13,902
Penaeus vannamei	1980	Unknown	*
Poecilia latipinnna	1914	Unknown	*

Poecilia latipinna	Unknown	Mosquito control	*
Poecilia reticulata	1905	Accidental, Ornamental, Mosquito control	*
Pomacea canaliculata	1980	Aquaculture, Ornamental	*
Pomacea canaliculata	1980	Aquaculture	*
Pomacea gigas	1980	Aquaculture	*
Puntius gonionotus	1956	Research	*
Puntius javanicus	1956	Aquaculture	*
Tilapia zillii	1970	Aquaculture, Fisheries	*
Tilapia zillii	1977	Aquaculture, Fisheries	*
Trichogaster leerii	1938	Aquaculture	*
Trichogaster pectoralis	1938	Aquaculture	*
Trichogaster trichopterus	1938	Aquaculture	*
TOTAL PHILIPPINES			**208,164 (6.17%) of 3,371,874****

SPECIES	YEAR	REASON	PRODUCTION (MT) OF INTRODUCED SPECIES IN ASEAN REGION
MYANMAR			
Aristichthys nobilis	1967	Aquaculture	*
Barbodes gonionotus	1996	Aquaculture	*
Clarias gariepinus	1990	Aquaculture	*
Clarias macrocephalus	1990	Aquaculture	*
Ctenopharyngodon idella	1967	Aquaculture	500
Cyprinus carpio	1954	Aquaculture	*
Cyprinus carpio	1978	Aquaculture	*
Hypophthalmichthys molitrix	1967	Aquaculture	100
Litopenaeus stylirostris	2000	Aquaculture	*
Litopenaeus vannamei	2002	Aquaculture	*
Notopterus chitala	1997	Aquaculture	*
Oreochromis aureus	1977	Aquaculture	1,000
Oreochromis mossambicus	1993	Aquaculture	*
Oreochromis niloticus	1977	Aquaculture	*
Osphronemus gouramy	1955	Aquaculture	100
Pangasius hypophthalmus	1982	Aquaculture	500
Piaractus brachypomum	2001	Aquaculture	*
Trichogaster pectoralis	1954	Aquaculture	*
TOTAL MYANMAR			**2,200 (0.15%) of 1,433,908****

SPECIES	YEAR	REASON	PRODUCTION (MT) OF INTRODUCED SPECIES IN ASEAN REGION
MALAYSIA			
Catla catla	1960	Aquaculture	*
Cirrhinus mrigala	1960	Aquaculture	*
Clarias gariepinus	late 1980s	Aquaculture	11,686
Clarias macrocephalus	1950	Aquaculture	*
Crassostrea gigas	1980-1990s	Aquaculture	249
Ctenopharyngodon idellus	1800s	Aquaculture	1,031
Cyprinus carpio	1800s	Aquaculture	670
Etroplus suratensis	1975	Aquaculture	*
Gambusia affinis affinis	Unknown	Mosquito control	*
Hypophthalmichthys molitrix	1800s	Aquaculture	*
Hypophthalmichthys nobilis	1800s	Aquaculture	991
Labeo rohita	1960	Aquaculture	*
Micropterus salmoides	1984	Angling/sport	*
Oncorhynchus mykiss	1935	Angling/sport	*
Oncorhynchus mykiss	1968	Angling/sport	*
Oreochromis mossambicus	1943 - 1945	Aquaculture	2,710
Oreochromis niloticus	1979	Aquaculture	*
Piaractus brachypomus	1984	Aquaculture	*
Poecilia reticulata	Unknown	Mosquito control	*
Pomacea canaliculata	1987	Aquaculture	*
Pomacea canaliculata	1987	Ornamental	*
Puntius gonionotus	1958	Aquaculture	971
Trichogaster pectoralis	1921	Aquaculture	*
TOTAL MALAYSIA			**18,308 (1.25%) of 1,463,625****

SPECIES	YEAR	REASON	PRODUCTION (MT) OF INTRODUCED SPECIES IN ASEAN REGION
LAO PDR			
Catla catla	1977	Aquaculture	972
Cirrhinus mrigala	1977	Ornamental	2,500
Clarias gariepinus	1980	Aquaculture	*
Ctenopharynodon idella	1977	Aquaculture	1,957
Cyprinus carpio	1965	Aquaculture	14,929
Cyprinus carpio	1977	Aquaculture	*
Labeo rohita	1965	Aquaculture	2,500
Labeo rohita	1977	Aquaculture	*
Oreochromis mossambicus	1955	Ornamental	*
Oreochromis mossambicus	1965	Aquaculture	*
Oreochromis niloticus	Unknown	Aquaculture	26,872
Pomacea canaliculata	1986	Aquaculture	*
Pomacea canaliculata	1992	Aquaculture	*
TOTAL LAO PDR			**18,308 (1.25%) of 1,463,625****

SPECIES	YEAR	REASON	PRODUCTION (MT) OF INTRODUCED SPECIES IN ASEAN REGION
INDONESIA			
Anabas testudineus	1980	Aquaculture	*
Anguilla anguilla	Unknown	Aquaculture	4,715
Anodonta woodiana	1992	Aquaculture	*
Aplocheilus panchax	1986	Aquaculture	*
Carassius auratus	1986	Ornamental	*
Cirrhinus chinensis	1984	Aquaculture	*
Clarias batrachus	1984	Ornamental	56,567
Clarias gariepinus	1969	Aquaculture	*
Clarias gariepinus	1980 onwards	Aquaculture	*
Clarias gariepinus	1985	Aquaculture	*
Clarias gariepinus	1985	Research	*
Colossoma macropomum	1985	Fisheries	*
Colossoma macropomum	1937	Unknown	*
Ctenopharyngodon idellus	1963	Unknown	*
Ctenopharyngodon idellus	1963	Unknown	*
Ctenopharyngodon idellus	1983	Unknown	*

Cyprinus carpio	1971	Unknown	208,362
Etroplus suratensis	1937	Unknown	*
Eucheuma cottonii	Unknown	Aquaculture	*
Gambusia affinis affinis	Unknown	Unknown	*
Helostoma temminckii	1937	Unknown	23,934
Helostoma temminckii	1986	Research	*
Helostoma temminckii	1929	Ornamental	*
Hypophthalmichthys molitrix	1927	Unknown	*
Hypophthalmichthys molitrix	Unknown	Mosquito control	*
Hypophthalmichthys nobilis	1979	Unknown	*
Ictalurus punctatus	1969	Aquaculture	*
Oncorhynchus mykiss	1969	Aquaculture	*
Oncorhynchus mykiss	1939	Aquaculture	*
Oreochromis mossambicus	1985	Aquaculture	70,311
Oreochromis niloticus	1964	Aquaculture	60,437
Oreochromis niloticus	1969	Aquaculture	*
Oreochromis niloticus	1920	Mosquito control	*
Oreochromis spp. *Osphronemus goramy*	1929 1972	Aquaculture Unknown	* 16,438
Osteochilus hasselti	1929	Fill ecological niche	14,694
Pangasius hypophthalmus	1929	Unknown	*
Piaractus brachypomus	1915	Aquaculture	*
Poecilia reticulata	1949	Aquaculture	*
Pomacea spp.	1964	Aquaculture	*
Pomacea spp.	Unknown	Accidental	*
Puntius gonionotus	mid 1980s	Aquaculture	11,840
Puntius orphoides	Unknown	Aquaculture	*
Rana catesbeiana	prior to 1900	Aquaculture	1,180
Salmo salar	1930	Aquaculture	*
Salmo trutta fario	Unknown	Aquaculture	*
Tinca tinca	1937	Unknown	*
Trichogaster pectoralis	Unknown	Unknown	23,297
Trichogaster pectoralis	1939	Aquaculture	*
TOTAL INDONESIA			**491,775 (8.66%) of 5,679,391****

SPECIES	YEAR	REASON	PRODUCTION (MT) OF INTRODUCED SPECIES IN ASEAN REGION
PEOPLES REPUBLIC OF CHINA			
Acipenser baerii	1998	*	*
Acipenser gueldenstaedtii	1993	*	*
Acipenser ruthenus	1997	*	*
Acipenser spp.	1995	*	*
Ameiurus nebulosus	1984	Aquaculture	*
Anguilla anguilla	1990	*	*
Anguilla australis	Uknown	*	*
Anguilla rostrata	Uknown	*	*
Argopecten irradians	1981-1982	Aquaculture	*
Bidyanus bidyanus	1998	*	*
Carassius auratus	1976	Aquaculture	*
Carassius carassius	1976	*	1,697,217
Catla catla	1973, 1983	Aquaculture	*
Channa striata	1986	*	*
Cherax quadricarinatus	1992	*	*
Cherax tenuimanus	1983	Aquaculture	*
Cherax tenuimanus	1992	*	*
Cirrhinus mrigala	1982	*	*
Clarias batrachus	1978	Aquaculture	*
Clarias gariepinus	1981	Aquaculture	*
Clarias gariepinus	1981	*	*
Clarias macrocephalus	1982	Aquaculture	*
Colossoma macropomum	Uknown	Aquaculture	*
Colossoma macropomum	1998	*	*
Coregonus lavaretus	1985	*	*
Coregonus nasus	1987	*	*
Coregonus peled	1985	Aquaculture	*
Coregonus peled	1985	Aquaculture	*
Crassostrea gigas	1979-80,1985	Aquaculture	3,625,548
Crassostrea virginica	1985	*	*
Cyprinus carpio	1958	*	2,235,634
Cyprinus carpio	2000	*	*
Cyprinus carpio	1984	*	*
Cyprinus carpio	1984	*	*
Esox lucius	No data	*	*
Gambusia affinis affinis	Unknown	Mosquito control	*
Haliotis fulgens	1985	Aquaculture	*
Haliotis rufescens	1985	Aquaculture	*
Huso huso X *Acipenser ruthenus*	1997	No data	*

Hyriopsis schlegerii	1982	Aquaculture	*
Ictalurus punctatus	1984	Accidental	*
Ictiobus cyprinellus	1993	*	*
Labeo rohita	1978	Aquaculture	*
Laminaria japonica	1927,1930, 1982	Accidental	4,207,700
Lates calcarifer	1983	*	*
Lepomis cyanellus	1999	*	*
Lepomis macrochirus	1987	*	*
Leptobarbus hoevenii	1988	*	*
Macquaria ambigua	1991	*	*
Macrobrachium rosenbergii	1976	Aquaculture	113,743
Macrocystis pyrifera	1978, 1982, 1984	Aquaculture	*
Micropterus salmoides	1983	Aquaculture	*
Micropterus salmoides	1984	*	*
Morone americana		*	*
Morone saxatilis	1993	*	*
Morone saxatilis X *chrysops*	1993	*	*
Oncorhynchus gorbuscha	1987	*	*
Oncorhynchus keta	1988	*	*
Oncorhynchus kisutch	1992	*	*
Oncorhynchus masou masou	1996	*	*
Oncorhynchus mykiss	1959	Aquaculture	*
Oncorhynchus mykiss	1996	*	*
Oncorhynchus mykiss	2001	*	*
Oncorhynchus tshawytscha	2002	*	*
Oreochromis aureus	1981	Aquaculture	*
Oreochromis aureus	1981	*	*
Oreochromis mossambicus	1957	Aquaculture	*
Oreochromis niloticus	1978	Aquaculture	*
Oreochromis niloticus	1994	*	*
Oreochromis niloticus X *Oreochromis mossambicus*	1983	*	*
Oreochromis niloticus X *Oreochromis mossambicus*	1978	*	*
Orthodon microlepidotus	1982	Aquaculture	*
Osphronemus goramy	1996	*	*
Pangasius hypophthalmus	1978	Aquaculture	*

Patinopecten yessoensis	1981	*	*
Penaeus japonicus		*	*
Penaeus monodon	1986	*	*
Penaeus vannamei	1988, 2001	*	*
Perca fluviatilis	Unknown	*	*
Piaractus brachypomus	1985	Aquaculture	*
Piaractus brachypomus	1985	*	*
Polyodon spathula	1989	*	*
Pomacea canaliculata	1985	Ornamental	*
Pomacea gigas	1982	Aquaculture	*
Porphyra yezoensis	1991	*	*
Procambarus clarkii	1940s	Fisheries	*
Psetta maxima	1992	Aquaculture	*
Puntius gonionotus	1986	Aquaculture	*
Pygocentrus nattereri	1990	Ornamental	*
Rana catesbeiana	1982	Aquaculture	*
Salmo salar	2001	*	*
Salvelinus fontinalis		*	*
Salvelinus leucomaenis pluvius	1996	*	*
Sarotherodon galilaeus galilaeus	1981	Aquaculture	*
Sarotherodon melanotheron	2002	*	*
Schilbe mystus	1976	Unknown	*
Sciaenops ocellatus	1991	*	*
Silurus glanis	1990	*	*
Stizostedion vitreum	1993	*	*
*Tilapia zillii**	1981	Aquaculture	*
Tinca tinca	1997	*	*
Trachemys scripta	1997	*	*
TOTAL PEOPLES REPUBLIC OF CHINA			**13,522,012 (25.23%) of 53,602,237****

SPECIES	YEAR	REASON	PRODUCTION (MT) OF INTRODUCED SPECIES IN ASEAN REGION
CAMBODIA			
Aristichthys nobilis	1981	*	461
Catla catla	1980	*	*
Cirrhinus mrigala	1980	*	*
Clarias gariepinus	1982	Aquaculture	*
Clarias gariepinus X *macrocephalus*	1981	*	*
Cottony II (please check this name again)	1999	*	*
Crocodilus rhombiser	1986	*	*
Ctenopharyngodon idella	1981	*	903
Cyprinus carpio	1969, 1981	*	4,043
Hypopthalmichthys molitrix	1969, 1981	*	1,410
Labeo rohita	1986	No data	*
Oreochromis mossambicus	Unknown	Aquaculture	273
Oreochromis niloticus	Unknown	Aquaculture	103
Oreochromis niloticus X *Oreochromis mossambicus*	1991	*	*
Osphronemus gouramy	2000	*	*
Piaractus brachypomus	2003	*	*
Pomacea canaliculata	1990s	Aquaculture	*
Pomacea sp.	1985, 2001	*	*
TOTAL CAMBODIA			**7,193 (1.69%) of 424,382****

BRUNEI			
Oreochromis niloticus	Unknown	Aquaculture	52
TOTAL BRUNEI			**52 (2.35%) of 2,215****

* No data

**Cumulative total production of alien and non-alien aquaculture production

Case Study on the Invasive Golden Apple Snail in ASEAN

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Abstract

The golden apple snail (GAS), Pomacea canaliculata (Lamarck), a freshwater ampulariid, is one of the world's worst invasive alien species. It is distributed primarily in Asia, North America and South America; the later being its home of origin. The unique morphological and biological traits make them survive in diverse and harsh environments. In this case study, we highlight what makes GAS invasive and show the mechanisms and pathways of their spread over time and space. An overview of the cost of GAS invasion from the loss of aquatic native biodiversity and impacts on social, environmental and economic levels are presented. New knowledge-based information and tools to manage GAS in future are crucial for its early detection and containment in risk-prone countries. Such knowledge is derived from lessons learnt from the Philippine experience on GAS invasion.

See complete paper on p. 353.

Tilapias are Alien to Asia: But are they Friend or Foe?

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Abstract

Tilapias are alien to Asia, but have been a significant component of some inland fisheries and aquaculture, in the region, for over half a century. Tilapias have continued to contribute increasingly to aquaculture production and over the last 20 years this group has recorded the highest rate of growth in production of any species group, globally. In the present context of development success of a species is determined not only by its contribution to production *per se*, but also on its impacts on the environment and social milieux.

In this paper the contribution of tilapia to aquaculture production in the ASEAN region and its purported negative environmental impacts are evaluated. It is concluded that tilapias are "physiologically" very robust, enabling them to adapt to varying environmental conditions, often those not suitable for indigenous fish species, and that indeed, they exhibit features expected of "invasive" species. It is pointed out that tilapias, however, become invasive when environmental degradation occurs due to other human activities, and that there are no records of its invasiveness of pristine habitats.

Introduction

Although the tilapias have been synonymous for more than half a century with Asian fisheries and aquaculture, tilapias are not a natural component of the Asian biota. Indeed, there are only two species of cichlids that occur naturally in Asia, the chromids, belonging to the genus Etroplus that are found along the east coast of India to Sri Lanka. Members of the genus Tilapia, Oreochromis and Sarotherodon, originally all known as Tilapia, on the other hand, are known to have been introduced into Asia about the 1940s, and spread across the tropical regions of the continent from Indonesia (Pullin et al., 1988). The first tilapia species to have come to Asia is the Mozambique tilapia or Tilapia mossambicus (=*Oreochromis mossambicus*). The Mossambique tilapia fell into disrepute rather quickly because of its prolific breeding potential and the consequent tendency to stunt in relatively unmanaged aquaculture situations. Mozambique tilapia is being gradually replaced by the Nile tilapia, O. niloticus over the years, and its introduction into the region was hailed as a potential solution to the increasing demand for fish supplies and was referred to as the "aquatic chicken' (Smith and Pullin, 1984). The former species is no longer used in aquaculture in the region, and elsewhere, and is found in some self-recruiting fisheries for example in lakes and reservoirs in Indonesia (Sarnita, 1999), the Philippines (Guerrero, 1999), Thailand (Chookajorn et al., 1999) and Sri Lanka (De Silva, 1999; Amarasinghe and De Silva, 1999), etc.

The purpose of this paper is to evaluate the role tilapias have and are playing in the ASEAN region/ countries, and to address the question whether this group of fishes that are alien to the region have impacted positively or negatively on the livelihood of people and on the biodiversity in the region directly and/or indirectly. In our approach we will endeavour to consider aspects of tilapia production as a fish food source and its social impacts, and those on the biota and aquatic ecosystems in the region. The objective of this paper is to highlight the lessons learned, and attempt to provide relevant recommendations for managing these species in the future in the ASEAN, particularly in relatively pristine watersheds.

Tilapia as a Food Fish Resource

Tilapia production in the ASEAN

The current global tilapia production is about 2
since 1980, and also the contribution from tilap
the last 10 years or so at around $0.5x10^6$ mt, wh
increasing steadily over the years (Figure 1). Wh
the annual increase of cultured tilapia over the las
of other major cultured groups of fishes such a
importance of tilapias as an aquaculturally impor

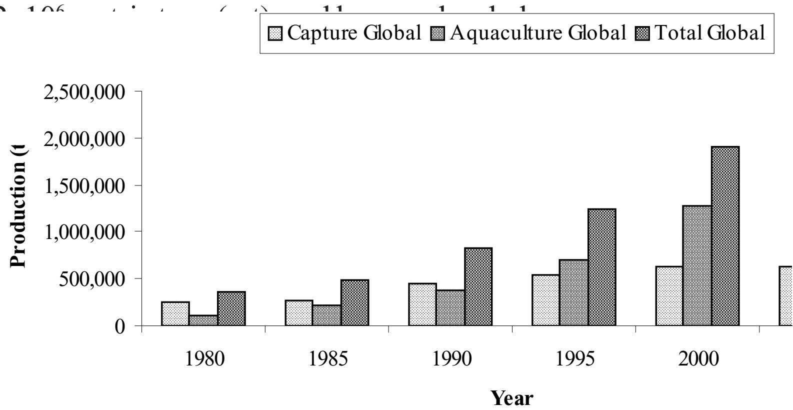
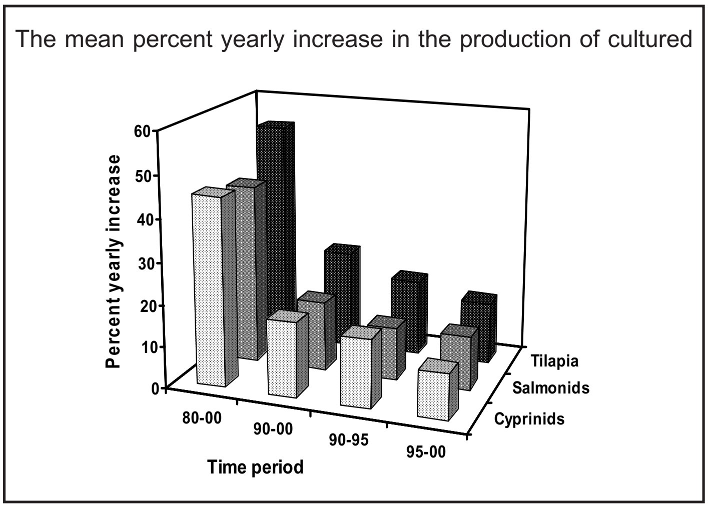


Figure 1. Changes in global c
duction over the period 1980

Figure 2. The mean percent yearly increase in the production (global) of cultured cyprinids, salmonids and tilapias in different time periods.



The importance of tilapia production in aquaculture has grown over the last two decades and cultured tilapias contribute over 70% to global tilapia production currently. The global aquaculture production of tilapias is dominated by Asia, and in turn in Asia the ASEAN countries together with PR China are the predominant contributors; these countries together contribute over 80% to the global aquaculture production of tilapias (Figure 3). It is important to note that the tilapia production in the ASEAN is essentially through aquaculture, with capture fisheries contributing less than 10% to the ASEAN production (Figure 4). Over the last ten to fifteen years there have been major shifts in the production in ASEAN countries, brought about as a result of PR China gaining dominance in tilapia production in the recent years (Figure 5).

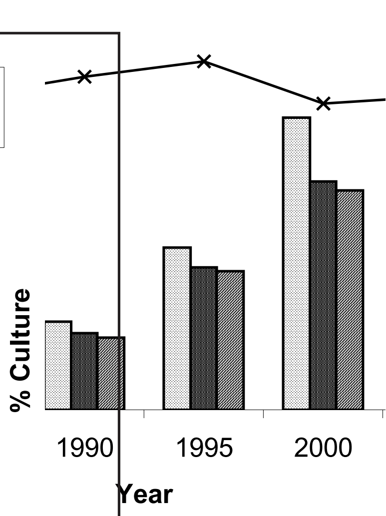
Why are Tilapias so Successful in Aquaculture?

As the great bulk of tilapia production in Asia is based on aquaculture it is relevant to consider, briefly, the reasons for the success of tilapias as cultured species in a region that is very much further from its natural distribution range. Indeed, from an aquaculture production viewpoint, there is no equivalent group of fish species in the world that has performed better, beyond its natural distribution range like the tilapias, although admittedly salmon culture in Chile and *Penaeus vannamei* culture in Asia are nearing very close to the tilapias in this regard.

In evaluating the success of a cultured species/ species group, particularly in the current context of sustainable development and environmental integrity, consideration of production levels *per se* are inadequate, and indeed are not acceptable to many groups. High production levels achieved at the expense of social and environmental damage/ perturbations, as well as at the expense of a net loss of natural fishery resources are no longer acceptable to the community. As such in assessing the success of an alien species amore holistic approach is needed. In the present paper the production aspects are dealt with in this section and later on other impacts of tilapias in the region are considered.

Figure 3. Changes in global, Asian and ASEAN and PR China cultured tilapia production and the percent contribution of ASEAN and PR China production to the global cultured tilapia production.

Figure 4. The contribution of capture and cultured tilapia production to the total tilapia production in the ASEAN and PR China, and the percent contribution of cultured production to the total over the period 1980 to 2001.



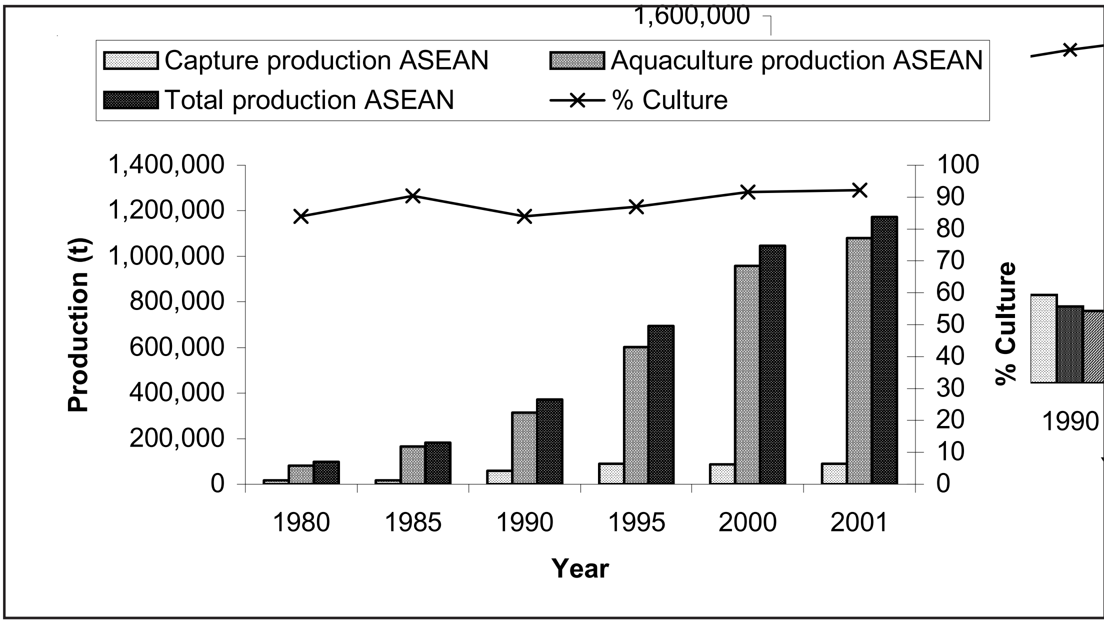
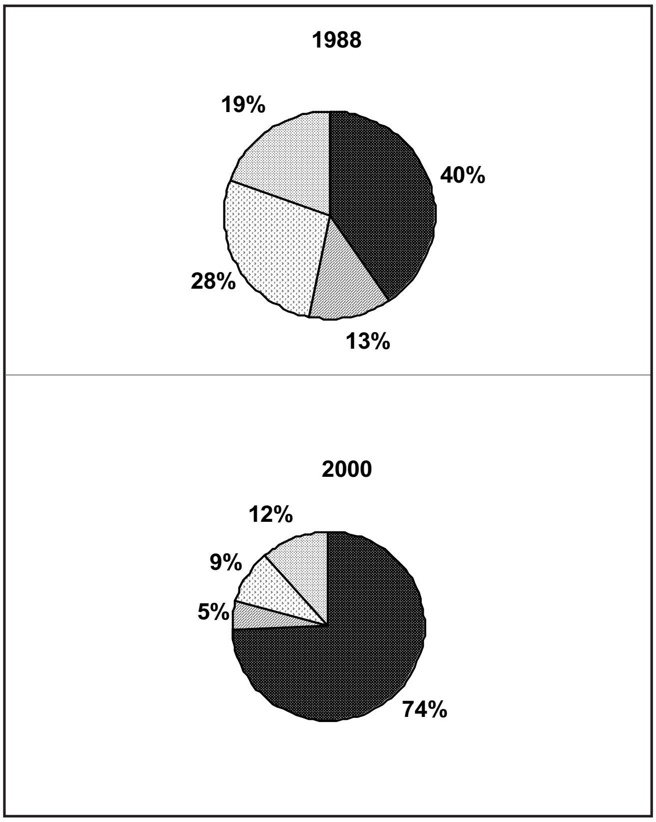


Figure 5. Changes in percent contribution to the total cultured tilapia production in 1988 and 2001 in the selected countries in Asia.



The predominant tilapia species cultured in the East and South East Asia is the Nile tilapia or the hybrid varieties (*O. niloticus* x *O. mossambicus*) commonly referred to as "red tilapia". Tilapia, in particular Nile tilapia has the attributes that are suitable for aquaculture, such as fast rate of growth, plasticity in food habits, easiness to wean to artificial feeds, high food conversion rates, relatively high resistance to disease, wide range of tolerance to temperature (18 to 30ºC), salinity (0-30 ppt), dissolved oxygen levels etc, and relatively direct hatchery young production, very low larval and juvenile mortality, relatively high dress weight ratio, good storage qualities and acceptable flesh quality.

The "physiological robustness' of tilapias makes them amenable to culture in a variety of environments and under different ecological conditions. They can be cultured in ponds, raceways, closed systems, cages, in ponds under chicken pens with no supplementary feeding, etc. and even in sewage-fed ponds (Nandeesha, 2002; though not in the ASEAN) very successfully. They can be cultured intensively at very high densities, semi-intensively with minimal supplementary feeding and or extensively such as in culture-based fisheries. They require relatively less intensive husbandry and management skills, thus such labour costs are summarily reduced in intensive operations.

In modern aquaculture the trait that male tilapia grow faster is commonly utilised through all male culture. All male aquaculture not only results in higher production but also eliminates and or minimises unwanted reproduction in grow-out stages. All males being produced through sex reversal by hormonal treatment in the fry stages, a technique that can be applied routinely and successfully even by backyard or small-scale hatchery operators. Alternately, and probably more acceptable to consumers in the future, is the production of genetically all-male tilapia commonly referred to as YY/GMT (Scott et al., 1989: Mair et al., 1991).

On the negative side is its low fecundity, which necessitates the maintenance of a large number of broodfish. On the other hand, this negative is countered by its short reproductive cycle and low larval mortality.

The great bulk of the above features make tilapias, in particular the Nile tilapia an excellent species for aquaculture, as well as a good commodity species. Equally, these features in most ways make the tilapias invasive also. However, it will be apparent later on that though the tilapias, in particular the popular Nile tilapia exhibit invasive features, its invasiveness thus far has been restricted to waters that are mostly unsuitable for indigenous fish species, and the instances in which it has displaced indigenous species from their habitats are hardly known.

It is also important to note that tilapias have another very desirable characteristic, especially from an aquaculture viewpoint. It is a group that can be extensively as well as intensively cultured, but in the latter instance it requires a feed that is considerably less in protein content (De Silva et al., 1989) than that of many of the other species cultured ntensively. Furthermore, a significant proportion of the protein could be met from suitably processed agricultural by-products. This trait makes the group less dependent on fish meal supplies, an already limited resource which other intensively cultured species such as salmonids require disproportionately.

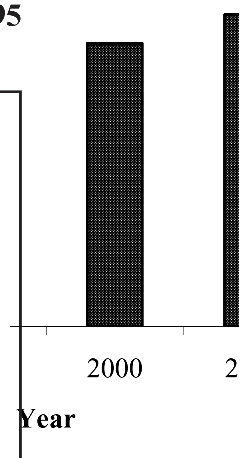
Tilapia Markets

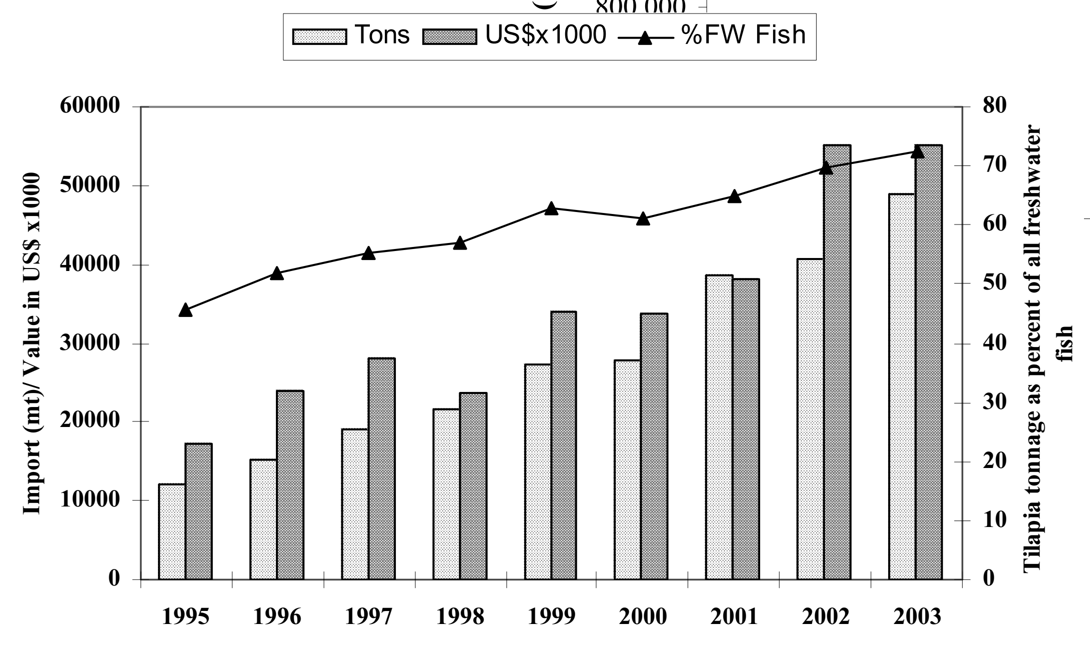
There are only a handful of fish species that have made a rapid impact on markets in the developing and developed world as the tilapias have done—essentially within a decade or so. In the very early days tilapia was essentially a "poor mans fish"; fetching low prices and often looked down as a very low quality fish. It never or rarely reached urban markets. The situation has changed completely in all of Asia and particularly so in some ASEAN countries. Tilapia is a mainstay in the urban markets in the Philippines for example, and fetches a higher price than the traditionally favoured milkfish, *Chanos chanos*. It is a readily accepted component of the cuisine in PR China, Indonesia, Malaysia, The Philippines, Thailand, Taiwan and Vietnam, and consequently tilapia has become a much sought after commodity across all sectors of the population.

Currently, the total annual value of cultured tilapia production exceeds US$1.2 billion and as such it is an important fishery activity to the region (Fig. 6). In Taiwan tilapias are a major cultured species, accounting for 25% of the total aquaculture produce valued at US$81 million in 2002 (TTA, 2003). The great bulk of cultured tilapia in ASEAN countries and in East Asia is exported to the US. Tilapia exports to the US have been growing over the last ten years currently valued at US$67.6 million (Fig. 7). Moreover, tilapias have come to dominate the freshwater imports to the US, accounting for 72.5% of all freshwater fish imports (all data obtained from the US Department of Commerce Web Site; *http://www.st.nmfs.noaa.gov/st1/trade/trade*...). However, the Asian nations are encountering increasing competition in the US tilapia market from producers in South America and elsewhere (Table 1), and also the production in the US itself is increasing. On the other hand, the immediate future for tilapia in the US does not look gloomy because of the increasing consumer preference for tilapia, which appears to satisfy the "American palate".

Figure 6. The value of cultured tilapias in the ASEAN nations and PR China.

Figure 7. Changes in the imports of tilapia (in quantity and value) and the quantity of tilapia imported as a percent of the total freshwater fish imports to the US from 1995 to 2003.





The world tilapia market is not confined to the US. For example Taiwan exported 44,344 MT of tilapia into countries such as Saudi Arabia (11%), UK (6%), Canada (5%), Kuwait (4%) and France (4%) (TTA 2003). In fact Taiwan has been proactive in a manner that the decreasing exports to the US have been compensated by exports to new markets, and it sets a good strategy for ASEAN nations to adopt.

Table 1. The top ten cultured tilapia producing nations/territories in the world in selected years. The amount produced (t) and the percent contribution to the worlds total by each nation are given in parentheses (from De Silva et al., 2004).

1980	1990	1995	2000
Taiwan (31489; 27%)	China (106071; 25.9%)	China (314903; 25.9%)	China (629182; 46.1%)
Philippines (13214; 11.3%)	Philippines (76142; 18.6%)	Philippines (81954; 10.4%)	Egypt (157425; 11.5%)
Indonesia (11249; 9.7%)	Indonesia (53768; 13.1%)	Thailand (76054; 9.7%)	Thailand (97790; 7.2%)
ChinaPR (9000; 7.7%)	Taiwan (52047; 12.7%)	Indonesia (74125; 9.4%)	Philippines (92333; 6.8%)
Thailand (8419; 7.2%)	Thailand (22895; 5.6%)	Taiwan (46473; 5.9%)	Indonesia (85179; 6.2%)
Egypt (8100; 6.9%)	Japan (5825; 1.4%)	Egypt (21969; 2.7%)	Taiwanv (44322; 3.3%)
Mexico (6907; 5.9%)	Mexico (5000; 1.2%)	Colombia (12310; 1.6%)	Brazil (28819; 2.1%)
Nigeria (2866; 2.5%)	Egypt (4916; 1.2%)	Brazil (12014; 1.5%)	Colombia (22870; 1.7%)
Israel (2512; 2.2%)	Israel (4795; 1,2%)	Malaysia (8798; 1.1%)	Malaysia (15363; 1.1%)
Japan (2392; 2.0%)	Sri Lanka (4500; 1.1%)	USA (6838; 0.9%)	Ecuador (9201; 0.7%)

Has the Translocation of Tilapias Into the Region Resulted in any Negative Impacts?

Impacts resulting from introductions and translocations can be immediate or long-term, and equally these could be obvious and/or visible, or not very apparent for a long period of time.

Immediate impacts

There are two concerns here. One is the most obvious immediate impacts is the transmission of diseases/ parasites associated with the translocation. Such impacts could be devastating and one of the best examples is the disappearance of the European crayfish largely thought the result from the introduction of the N. American crayfish that carries an infectious fungus to which the former has no resistance (Reynolds, 1988). In the case of tilapia translocations into the region there is no documentation on transfer of any disease and or parasite that have harmed or affected any indigenous species. However, this is no reason for complacency, especially in view of the fact there are considerable movements of tilapia stocks/strains, such as GIFT (Genetically Improved Farmed Tilapia), intra-regionally, often with scant attention to accepted protocols and quarantine regulations.

The other concern is the possible and or direct impacts on biodiversity. Instances of immediate and noticeable impacts on biodiversity brought about by introductions are not common. One of the best-documented cases in this regard is that of the impacts of the Nile perch, *Lates niloticus* introduction on the haplochromid species in Lake Victoria, Africa. It is somewhat comforting that no such direct impacts on biodiversity have been reported as resulting from tilapia introductions/ translocations in the region, and those instances that have purported to have had an influence on biodiversity will be dealt with later.

Long term impacts

The above impacts could be ecological, affecting the indigenous flora and fauna, or genetic, resulting in hybridisation with native species and or bringing about a loss in genetic diversity of related indigenous species. In the latter regard tilapias are unlikely to have a negative impact as the region has no indigenous species of the same genus/genera. On the other hand, indirect effects on the genetic diversity of indigenous stocks resulting from the dominance of an introduced species is a possibility, but there is no evidence in this regard, to date, on such influences of the tilapias in the region. Equally, there could be a reduction of the genetic diversity either through hybridisation and/or inbreeding of the already translocated tilapia stocks, resulting in adverse affects on the established aquaculture industries or in some of the self-recruiting fisheries based on tilapia in the region. For example it has been suggested that in self-recruiting tilapia fisheries in the region *O. niloticus* x *O. mossambicus* hybrids have a lower fecundity, and that this could in the long term reduce the reproductive potential and thereby affect the existing fisheries (Amarasinghe and De Silva, 1996).

Having ruled out possible genetic interactions with indigenous species one needs to consider the ecological impacts, including those on the indigenous flora and fauna. Ecological impacts could be brought about in a number of ways, for example, through competition for common resources such as food, ecological niches, breeding grounds, etc. It is also not always easy to discern cause and affect relationships in evaluating ecological impacts, as more often than not other factors such as human influences may also come into play.

The most obvious and destructive impacts are those affecting species in the following ways:

- accelerate/exacerbate the disappearance of an indigenous species, already on the decline and/or endangered due to other reasons such as depletion of its habitat as a result of development activities, deforestation, etc.;
- occupy niches of indigenous species, especially the more vulnerable ones with specialized habitats, and thereby bring about a decline in indigenous populations to a critical level; and
- selective predation on more vulnerable indigenous populations causing a decline in their populations to a critical level as has been suggested in the case of the introduction of Nile perch into Lake Victoria, Africa (Ogutu-Ohwaya, 1992).

The alleged negative ecological impacts arising from the translocation of tilapias into the region are summarised in Table 2. Each of these alleged negative influences from the translocations are considered in some detail below, and a final objective assessment is made in each case. The information provided in the above regard is essentially a synthesis of a recent more detailed treatise on the subject of the influence of exotic tilapias in the Asia-Pacific region (De Silva et al., 2004).

Table 2. The alleged detrimental influences reported in Asia arising from the introduction of Tilapias.

Country/ habitat	Purported negative affect	Effected by	Authority
Philippines; Lake Buhi	Near extinction of the endemic goby, sinarapan, *Mistichthys luzonensis*	*O.mossambicus*	Baluyt, 1983; Aypa, 1993
Indonesia; Lake Toba	Decline of indigenous cyprinid *Lissochilus* spp.		Balayut, 1999
Bangladesh; Kaptai Lake	Decline in indigenous major carp catches	*O. niloticus*	Hussain, 1996
Sri Lanka; reservoirs	Decline in freshwater turtles *Lissemys punctata*, *Melanochelys trijuga*	High fishing pressure on tilapias	Pethiyagoda, 1994

Case of Near Extinction of Sinarapan in Lake Buhi, Philippines

The most targeted detrimental affects due to tilapias in the region have been alleged in the case of the near extinction of the small endemic goby, sinarapan, *Mistichthys luzonensis* in Lake Buhi, in the Philippines (Baluyt 1983), and Aypa (1993) re-endorsed the above view. The only direct evidence that the decline and/ or near extinction of sinarapan was brought about due to the introduction of *O. mossambicus* was a laboratory study which indicated that the cichlid feeds on sinarapan, and the increase in landings of the cichlid which happened to coincide with the decline of the former. Apart from the fact that the laboratory study was inconclusive, other factors such as damming of the river flowing from the Lake, intensification of the fishing effort, and more importantly the introduction of destructive gear such as motorized push nets, which in turn destroyed the beds of the aquatic macrophyte, *Vallisneria*, the breeding grounds of sinarapan (Gindelberger, 1983) received little consideration in the analysis of the issue.

The balance of evidence seems to suggest that the decline of sinarapan was probably a result of a number of factors, the least influential of these being the presence of the exotic cichlid. It is heartening that with better management of the fishery activities in Lake Buhi, sinarapan is staging a recovery.

Lake Toba, Indonesia, the Decline of the Indigenous Cyprinid Species Lissochilus

It has also been suggested that in Lake Toba, Indonesia, the decline of the indigenous cyprinid species *Lissochilus*, which is considered to have cultural importance, has been due to the introduction of *O. mossambicus* in to the lake (Baluyut, 1999). The latter is estimated to account for 86 % of the fish landings in the Lake. More explicit evidence has not been forthcoming with regard to this observation, however.

Reduction in Catches Of Indian Major Carps, Kaptai Lake, Bangladesh

Reduction in commercial catches of Indian major carps in Kaptai Lake, a large reservoir in Bangladesh (Haldar et al., 2002), has been attributed to an increase in *O. niloticus* landings. *O. niloticus* landings account for less than 1% of the total fish yield in the reservoir, however. In this instance a thorough study has not been undertaken, including the increased use of disruptive gear, landing of indigenous carps during their spawning migration etc. Admittedly, there have been isolated instances that cichlid introductions have been implicated in certain faunal changes; perhaps in these instances the introduced cichlids happen to be present at the site but in all probability were not the primary cause of the changes.

Reduction in Freshwater Turtle Populations in Sri Lankan Reservoirs

Pethiyagoda (1994) suggested that the decline of freshwater turtles, *Lissemys punctata* and *Melanochelys trijuga* in reservoirs have been brought about as a result of high fishing pressure for *O. mossambicus* in the reservoirs. This suggestion may be true. But then on the other hand, reservoirs are man-made and it is not the natural habitat of these turtles. In the same vein, there has been a significant increase in the bird fauna, which primarily feeds on the young of the tilapias (Winkler, 1983), a fact often ignored by conservationists.

General Considerations

Tilapias are very opportunistic and a generalised group of fishes with a capability of adapting to a variety of environmental conditions, particularly lacustrine habitats. The species translocated into the region have relatively non-catholic feeding habits and their requirements for nest building and other requirements for reproducing successfully are easily fulfilled. On the other hand, some indigenous/ endemic species/ species flocks may occupy rather specialised ecological niches with specific habitat requirements. Major disturbances to such habitats could make such species more vulnerable than other generalised species. Disturbances do not necessarily have to be physical; could be even biological as exemplified by the case in Lake Victoria, East Africa where it is purported that the introduction of Nile perch, *Lates niloticus* was responsible for disappearance of a number of haplochromid species (Barel et al., 1985). However, this view is being increasingly refuted currently, and there are indications of the re-emergence of some of the haplochromid species that were purported have been extinct (Cowx, personal communication).

There are considerable watershed development activities taking place in the region, often at an accelerated pace. Foremost amongst such activities are dam building and deforestation, all of which singly and or collectively have major ecological influences on aquatic habitats. The overall impact of tilapias in the region can also be considered to have both positive and negative consequences in the following general ways: (a) they provide livelihoods- through cage culture- for displaced persons from reservoir construction, such as in Indonesia and Malaysia (b) their perceived impact as a group of exotics that have become an integral component of the current ichthyo-fauna of the region; (c) their potential impacts that tilapias might have on biodiversity as technological advances (e.g. genetic) are introduced.

The positive outcomes of introduced tilapias in the region are:

- establishment and sustenance of capture fisheries in certain countries in the region;
- contribution to other inland waters capture fisheries;
- an important aquaculture species group in most countries in the region, catering to small-scale, large-scale and/or extensive, semi-intensive and/or intensive aquaculture operations; and
- successful contribution to integrated aquaculture operations.

The above have, undoubtedly and significantly, impacted the socio-economic milieu of various sectors of the communities involved. There have been direct and indirect beneficiaries from these impacts; the former being those involved in the production, both capture and culture of the tilapias as well as aspects of marketing of the produce; the latter being the general populace through the access to an affordable animal protein source. The benefits in exact economic terms, considering the value of the produce, are difficult, if not impossible, to estimate. Thesame will be true of the impact of tilapias on the overall nutritional status of rural communities, which in turn could have a profound influence on their well-being. Of course in some nations with the general increase in the standard of living occuring (e.g., Philippines) tilapias are becoming expensive, as it is in Malaysia.. These changes are unavoidable to a great extent, and the same scenario would have occurred with any other fish species in this regard.

Except for tilapia, there is no other exotic aquatic species or a species group in the tropics that currently makes a contribution of such high magnitude to fish food production. The significance of tilapias as food fish is doubly important because, by and large, it is an affordable animal protein source to most poor communities in developing countries. For example, in Bangladesh, tilapias are regularly stocked and maintained in the home-garden ponds together with major carps. More often than not, these small-scale aquaculture operations produce tilapias for household consumption and carps for generating cash income (Barman *et al.,* 2002). On the other hand, tilapia capture fisheries in lakes and reservoirs, which in most instances happened to be located in rural areas (e.g. in Sri Lanka and Indonesia), tend to provide an accessible and an affordable animal protein source to communities living in the vicinity of these water bodies.

Freshwater fish are considered to be among the most threatened groups of vertebrates with regard to the numbers threatened, endangered or extinct (Bruton, 1995; Moyle and Leidy, 1992). In general, exotic piscine introductions are cited as contributing to the threatened and endangered status of indigenous species (Moyle and Leidy, 1992). Nevertheless, there have been instances where the latter has caused considerable negative impacts and concerns. In this regard, tilapias in Asia are not an exception.

Influences of tilapias on biodiversity were discussed earlier. The balance of currently available evidence in the Asia-Pacific suggests that, as far as we are aware, tilapias have had no negative impact on biodiversity *per se*. However, in some instances it could take longer than 50 to 60 years for influences on biodiversity to take place, as was the case with the sea lamprey in the Great Lakes of North America. Therefore, there is a need for vigilance. With increasing emphasis on biodiversity issues (see for example Holdgate, 1996; Maclean and Jones 1995; Beveridge *et al.,* 1994), it is understandable that there are schools of thoughts emerging and indeed gaining momentum, expressing the view for a shift in emphasis of culturing exotics (i.e. the tilapias) to indigenous species (Jensen, 1999; Bakos, 1997). This may not be the complete solution to the hypothetical problem of tilapias impacting biodiversity with time.

Tilapias are already present in most of the major watersheds in the region and it would be difficult, if not impossible, to remove them completely from natural and quasi-natural water bodies in which they are already established. Previous attempts to remove established exotic fish species (e.g. common carp in Australia) provides compelling evidence of the inherent difficulties that are encountered in such an exercise (Roberts and Tilzey, 1997). Evidence has been presented that tilapias are not, by any means, unwanted in the Asia-Pacific region nor in the Americas. Tilapias will continue to contribute to the world's animal protein supplies as well as have significant societal impacts in developing countries. It will be difficult, if not impossible, to eradicate them.

In the context of increasing but often unsubstantiated views on tilapia introductions and in addition to increasing concerns on biodiversity issues, a pragmatic strategy would be to limit the spread of tilapias to new and major watersheds, primarily, by preventing direct translocations to such water bodies. This strategy, however, will not be a complete solution since major watersheds in most nations in Asia are interconnected. Such a strategy should go in parallel with the prevention of the further deterioration of the immediate environments and their catchments. A good example to be considered is the Great Lake, also known as the Tonle Sap, in Cambodia with its unique hydrology and a very rich and diverse piscine fauna. To date, tilapias have not been reported to inhabit this lake. The fishing commune inhabitants of this lake increased from 0.36 to 1.20 M, and catches surged from 125,000 to 235,000 tonnes, a 1.9 fold increase from 1940 to 1995-1996, respectively, with an overall 44 percent decrease of catch per fishing commune inhabitant (Sverdrup-Jensen, 2002). Considering these increasing human impacts on the lake and its watershed, as well as the mounting fishing pressure on the indigenous stocks, if tilapia, with its great adaptive resourcefulness, were to get established in Tonle Sap, are we justified in pinpointing tilapias as the causative factor? The answer is no! More often than not, exotics get introduced and established in undesired waters when the environment is already degraded or overexploited and its diversity and complexity are reduced as a consequence (Maclean and Jones, 1995; Moyle and Leidy, 1992).

Pillay (1977) expressed the view that the haphazard introduction of species between nations, watersheds and continents, for all intents and purposes, is over and future introductions will need more consideration from an ecological viewpoint. The general concerns on introductions led to the development of guidelines for introductions (ICES, 1985; EIFAC, 1984), and culminated in the development of codes of practices for aquatic organisms (EIFAC, 1988). As far as the authors are aware of the tilapia introductions only translocations across watersheds have been the subject of rigorous requirements set out in the FAO Code of Practice for Introductions (Coates,1987). This is true of other species introductions and translocations. In this regard, ecological and biological evaluations as well as feasibility studies were conducted in connection with the introduction of the Thai river sprat, *Clupeichthys aesarnensis* to Indonesian reservoirs (Cost- Pierce and Soemarwoto, 1990). On the other hand, it is common knowledge that currently many introductions and translocations of fish, crustaceans and newly developed strains have and are being made without any consideration of these accepted guidelines. Needless to say, most of these are driven by perceived potential economic gains resulting from globalization and trade liberalization. One does not have to look far for adverse economic effects of such trans-boundary movements as exemplified by the shrimp culture industry in recent years. The long-term biological and adverse ecological effects of these introductions will not be known for a few more decades. It is therefore important to, at this late stage, pay attention to the Code of Practice for Introductions and limit impulsive and irresponsible introductions and translocations.

It is evident that tilapias exhibit features that are to be expected of invasive species. However, its invasive characteristics are very different to that of such as the Nile perch. Tilapias invasiveness overall lies in its abilities to occupy niches and habitats that are generally unsuitable for indigenous species, or habitats that are human-created and are alien to native species. The balance of evidence suggests that tilapias have been beneficial to Asia, and that it has until now not been responsible for negative impacts on biodiversity. However, this is no reason for complacency, and as such continuous monitoring and vigilance will be required if pristine waters are to be safeguarded from alien species such as the tilapias.

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Movements of Economically Important Penaeid Shrimp in Asia and the Pacific

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Abstract

Both *Penaeus vannamei*[1] and *P. stylirostris* originated on the Western Pacific coast of Latin America from Peru in the south to Mexico in the north. They were introduced from the early 1970s to the Pacific Islands, where research was conducted into breeding and their potential for aquaculture. During the late 1970s and early 1980s they were introduced to Hawaii and the Eastern Atlantic Coast of the Americas from South Carolina and Texas in the North to Central America and as far south as Brazil.

The culture industry for *P. stylirostris* in Latin America is largely confined to Mexico, but *P. vannamei* has become the primary cultured species in the Americas from the USA to Brazil over the past 20-25 years. Total production of this species in the American region probably amounted to some 213 800 metric tonnes, worth US$ 1.1 billion[2] in 2002.

P. vannamei was introduced into Asia experimentally from 1978-79, but commercially only since 1996 into Mainland China and Taiwan Province of China, followed by most of the other coastal Asian countries in 2000-01. Experimental introductions of specific pathogen free (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.

Beginning in 1996, *P. vannamei* was introduced into Asia on a commercial scale. This started in Mainland China and Taiwan Province of China and subsequently spread to the Philippines, Indonesia, Viet Nam, Thailand, Malaysia and India. These introductions, their

[1] In 1997, the majority of cultured Penaeid shrimp were renamed according to the book "Penaeid and Sergestid shrimps and Prawns of the World" by Dr. Isabel Perez Farfante and Dr. Brian Kensley. Most scientists and journal editors have adopted these changes. Whilst the names *Litopenaeus vannamei* and *L. stylirostris* are technically now considered correct, the majority of the readers of this report will probably be more familiar with the original name *Penaeus vannamei* and *Penaeus stylirostris*. For the purposes of this presentation, therefore, the genus name *Penaeus* will still be used throughout.

advantages and disadvantages and potential problems are the covered in the presentation.

China now has a large and flourishing industry for *P. vannamei*, with Mainland China producing more than 270 000 metric tonnes in 2002 and an estimated 300 000 metric tonnes (71 percent of the country's total shrimp production) in 2003, which is higher than the current production of the whole of the Americas.

Other Asian countries with developing industries for this species include Thailand (120 000 metric tonnes estimated production for 2003), Viet Nam and Indonesia (30 000 metric tonnes estimated for 2003 each), with Taiwan Province of China, the Philippines, Malaysia and India together producing several thousand tonnes.

Total production of *P. vannamei* in Asia was approximately 316 000 metric tonnes in 2002, and it has been estimated that this has increased to nearly 500 000 metric tonnes in 2003, which is worth approximately US$ 4 billion in terms of export income. However, not all the product is exported and a large local demand exists in some Asian countries.

The main reason behind the importation of *P. vannamei* to Asia has been the perceived 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. Shrimp production in Asia has been characterized by serious viral pathogens causing significant losses to the culture industries of most Asian countries over the past decade and slowing down of growth in production. 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 rapidly increase again. By comparison, *P. vannamei* production has greatly reduced in Latin America also as a result of disease problems, however, there has so far been little sign of recovery.

In Asia, first Yellowhead Virus (YHV) from 1992 and later White Spot Syndrome Virus (WSSV) from 1994 caused continuing direct losses of approximately US$ 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 US$0.5 billion per year after WSSV. 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. Most Asian countries have legislated against the introduction of *P. vannamei* due to fears over the possibility of introducing 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 in controlling the imports from other countries, have led 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 maybe more.

Although TSV is not reported to have affected indigenous cultured or wild shrimp populations, insufficient time and research have been conducted on this issue and there is a need for caution. TSV is 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 and associated pathogens on other cultured and wild shrimp populations in Asia.

For such reasons there has been caution on the part of many Asian governments. However, this caution has not been demonstrated by the private sector, which has been bringing stocks of illegal and often disease carrying *P. vannamei* into Asia from many locations, as well as moving infected stocks within Asia. The commercial success of these introductions, despite disease problems, has allowed the development of substantial culture industries for these alien Penaeids within Asia and in China and Thailand in particular. One effect of this is that it is rapidly becoming difficult to control the importation and development of this new industry.

Despite the problems with disease transfer, *P. vannamei* (and *P. stylirostris*) does offer a number of 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 postlarvae (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 specific pathogen resistant (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 (if SPR stocks are used), and high survival during larval rearing. 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. Informed decisions regarding these pros and cons need to be taken, with close cooperation between governments, the private sector and NGOs to decide on the best course of action to take. Unfortunately, due to the rapid rise of *P. vannamei*, there has been little time for such considered actions concerning shrimp imports and movements.

The recent publication of a number of codes of conduct and management guidelines (BMPs) for the transboundary importation of alien shrimp and their subsequent culture by, amongst others, 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 related to transboundary movements of shrimp and their viral passengers are as yet unknown, it is important that Asian governments take action in legislating control over this industry.

Examples of countries that have managed to legislate for and enforce codes of conduct and management practices (as outlined in this report), and develop successful industries for the culture of imported *P. vannamei*, include the USA (and especially Hawaii), Venezuela and Brazil. These countries have succeeded despite early failures and disease episodes, demonstrating that such measures can and do work if rigorously applied.

This report has attempted to gather all of the currently available data on the extent of *P. vannamei* and *P. stylirostris* importation and culture in Asia, its potential problems and benefits, and in this way serve as a source document from which to investigate further the means by which control over this issue might be re-established.

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Key Freshwater Crustacean Pathogens of Concern to ASEAN

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Introduction

There is commercial interest in the Asian region in the production of three groups of freshwater crustaceans – shrimp (prawns), crayfish and crabs. Production of all of these groups significantly lags that of marine shrimp. However, the disease losses and other factors in shrimp aquaculture have led to renewed and/or new interest in the aquaculture of these species. Very approximate estimates suggest that production of each freshwater crustacean group is relatively even at around 200,000 MT (FAO 2000, Yang and Huang 2003, Edgerton 2004a).

A common feature of growth of farming each species has been the premise that they are relatively disease-free. This contention was usually made in comparison to the much more commercially significant, and more comprehensively studied, marine shrimp. Not surprisingly, this premise has been proven incorrect and important diseases have begun to emerge as the freshwater species are more widely farmed, and as intensity of farming increases. Nonetheless, it is critical to recognise that the general understanding of diseases in freshwater crustaceans remains well behind that for marine shrimp.

Key Freshwater Crustacean Pathogens

Freshwater Crayfish and Crayfish Plague

Freshwater crayfish are farmed on most continents. China is the largest producer followed by the U.S. (Edgerton 2004a). Until 20 years ago most interest was in American species and a number of species have been widely introduced, both intentionally and unintentionally. Most significant has been the spread of the redswamp crayfish, *Procambarus clarkii*, which has also been introduced to the Asian region (Huner 2002). Over the last 20 years there has been much interest shown in semi-intensive culture of Australian species, particularly the tropical redclaw, *Cherax quadricarinatus*. Redclaw has been introduced widely throughout the world, including Asia. As they are farmed semi-intensively, the broadest knowledge of disease is of Australian freshwater crayfish and some pathogens are known to have been cotranslocated to South Africa, South America and the U.S. (Evans and Edgerton 2002). However, thorough study would almost certainly confirm that more pathogens have been spread, and more widely, than has been reported.

Crayfish plague, caused by the water mould *Aphanomyces astaci*, is the only disease of freshwater crayfish – and the only specific freshwater crustacean disease listed by the World Organisation for Animal Health (OIE). Crayfish plague has long been the classic textbook case of an aquatic animal disease incursion from a non-native species as it has caused immense damage to native freshwater crayfish populations in Europe (Alderman 1986), where the crustacean is of major historical economic and cultural significance. Ironically, in many European countries the spread of crayfish plague was assisted by restocking of natural waterbodies with resistant American species that were subsequently shown to be the natural carriers of the causative agent. Of significance in the Asian region, *P. clarkii* is known to carry a warm-adapted strain of *A. astaci* (Dieguez-Uribeondo et al. 1993). One stream of thought in the field considers that virtually all populations of American freshwater crayfish carry *A. astaci*. However, widespread surveys have never been undertaken to confirm this, and there are no reports of surveys for *A. astaci* outside of Europe.

Freshwater Prawns and White Tail Disease

Interest in farming freshwater shrimp was subdued over the last three decades by the growth of marine shrimp aquaculture. The advent of massive disease-related losses in marine shrimp aquaculture, and the resistance of freshwater shrimp, and especially *Macrobrachium rosenbergii*, to white spot syndrome virus (WSSV), has been a major factor in the recent strong growth in this industry. Perhaps recent interest has been strongest in India. China, Vietnam, Bangladesh and Thailand are other major producers (FAO 2000).

White tail disease (WTD), also known as whitish muscle disease and other similar names, has been associated with losses of 50-70% in freshwater shrimp aquaculture in Taiwan commencing in 1992 (Tung et al. 1999), followed by Martinique in 1995, and then China and India (Sri Widada et al. 2004). The disease most frequently affects postlarvae whilst in the hatchery or soon after relocation to growout ponds. At present little is known about the disease and a clear case definition is yet to be developed. WTD has been associated with infection by two viruses, Macrobrachium rosenbergii nodavirus (MrNV) and extra small virus (XSV), and diagnostic tests involving PCR and ELISA have been developed (Romestand and Bonami 2003, Sri Widada et al. 2004). However, these diagnostic tests have not been used on a wide-scale basis to determine the geographic range of the viruses. Moreover, modes of transmission and other potential hosts are unknown. This information is clearly required for development of management strategies for the disease. Yang and Huang (2003) considered that WTD was introduced to China from Thailand. However, WTD has not been reported from Thailand and the authors did not identify the causative agent. WTD has been identified as an emerging disease of significance in the Asian region.

Freshwater Crabs and Trembling Crab Disease

The freshwater Chinese mitten-handed crab, *Eriocheir sinensis*, is primarily farmed in China. Again, there was a "honeymoon" period for cultivation of the species where there were no serious disease problems. However, in the late 90s widespread serious mortality associated with the striking clinical sign of limb tremor seriously impacted on production of *E. sinensis* in China (Wen and Zhifeng 2002). The aetiological agent of the disease has not been conclusively determined. However, a spiroplasma is commonly associated with the disease, and bacteria and several viruses have also been found in association with affected crabs (Wen and Zhifeng 2002, Yang and Huang 2003).

White Spot Syndrome Virus in Freshwater Crustaceans

White spot syndrome virus (WSSV) is best known as a pathogen of marine shrimp. However, WSSV is capable of infecting virtually all crustacean species, including freshwater crustaceans, and has caused mortality in captive and experimental stocks of freshwater crayfish (Richman et al. 1997, Edgerton 2004b). The fact that WSSV can infect virtually all crustaceans necessitates extreme vigilance in the introduction and transfer of all crustaceans, including freshwater crustaceans, from areas where WSSV is endemic. Certainly this risk is reflected in OIE recommendations. It should be noted that the natural host of WSSV remains unknown, and there is no evidence available which would implicate any particular species or crustacean group over another.

Humans Pathogens

Transboundary pathogens that may cotranslocate with aquatic animals include human pathogens. The trematode *Paragonimus* is a human pathogen that uses freshwater crustaceans as intermediate hosts. Paragonimiasis has been considered a serious public health issue in Asia. Humans contract the disease by eating raw or partially cooked freshwater crabs or crayfish (Blair et al. 1999). *Paragonimus westermani* is endemic in freshwater crustaceans in Asia, whilst *P. kellecoti* is endemic in freshwater crustaceans in North America. This example highlights the public health issues involved with aquatic animal introductions and transfers .

Conclusions

Clearly no aquatic animal species should be considered free from disease. In the case of these freshwater crustaceans, absence of evidence was confused for evidence of absence. To this date, introductions of freshwater crustaceans have occurred with limited knowledge of the health status of the original stocks and there are now documented cases of pathogen cotranslocation. However, the actual number of pathogens cotranslocated, and their breadth, is no doubt much greater than what is reported.

The emergence of several important diseases of freshwater crustaceans, and the interest in introducing various freshwater crustaceans in the region, highlights the need for extreme vigilance to prevent the transboundary spread of pathogens that may be deleterious to cultured and wild crustaceans. Where local gastronomic customs involve consumption of uncooked or partially cooked crustaceans, there may also be risks to human health. The current lack of published data on diseases affecting freshwater crustaceans may hamper establishment of monitoring and surveillance schemes. Nonetheless these should be implemented to build a picture of the range and occurrence of pathogens in freshwater crustaceans. Whilst sensitive diagnostic tests for described pathogens should be included, especially for WSSV and WTD, it is important to note that broad spectrum diagnostic tests, and in particular, histopathology, must be employed to reduce the likelihood of the transboundary spread of freshwater crustacean pathogens (Edgerton and Jussila 2004).

The lack of skilled freshwater crustacean pathologists is likely to be a major impediment to improving understanding in this field. Moreover, risk analysis on freshwater crayfish and freshwater shrimp is massively hampered by the limited data on health status on a regional and global basis (Edgerton 2002, J.R Arthur pers. comm.). To address these deficiencies, the region must invest in improving capacity in freshwater crustacean pathology.

While it will take time to develop capacity and knowledge in freshwater crustacean pathology, general strategies should be employed to manage the spread and impact of disease in freshwater crustacean aquaculture. Many freshwater crustaceans have biological attributes that are advantageous for diseases management. As freshwater crustaceans often have reduced free-living larval stages – they are totally absent in freshwater crayfish – the possibility for development of specific pathogen-free (SPF) stocks is greatly enhanced over marine species that typically hatch in the same water that they were spawned. Stripping of eggs from brooding females, surface disinfection, and hatching in clean water has been shown to be effective in producing juveniles free from pathogens transmitted horizontally and vertically outside of the egg (Edgerton and Owens 1997). Introduction of stock produced in this manner, accompanied by health certification, will significantly reduce the likelihood of pathogen cotranslocations. It is also important to note that in some regions it is common practice to produce freshwater crustaceans postlarvae (e.g. freshwater shrimp) in hatcheries also used for production of marine shrimp. In such cases, extra hygiene and biosecurity practices must be employed to lessen the threat of pathogen cross-infections occurring and the consequent emergence of new and serious disease problems in the naive crustacean species.

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Marine and Freshwater Finfish Pathogens of Concern

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Introduction

The rapid development of aquaculture in the ASEAN region has increased movement of aquatic animals amongst the different countries as well as introduced new species from the Asian region and from other continents. The movement of aquatic animals has also introduced alien pathogens and combined with the existing diseases, caused severe economic losses to the industry. Disease is now recognised as a major constraint in aquaculture.

The introduction of alien pathogens aggravates the issues for the small number of fish health researchers already burdened trying to solve current disease mortalities. The introduction of new pathogens disrupts the ongoing investigations due to the limited expertise, manpower and facilities. As a result, new diseases are left unchecked resulting in heavy losses to the industry. The rapidly expanding aquaculture industry requires further attention from the policy makers to ensure sufficient trained manpower and expertise are provided for the sustainable development of the industry. There is also a need for a paradigm shift for a holistic approach in capacity building to minimise losses to the aquaculture industry. This paper briefly reports on freshwater and marine finfish pathogens of concern to ASEAN with lessons learned and emphasis on capacity building.

Pathogens of Concern

Five categories of pathogens of concern to the ASEAN region are discussed below.

Pathogens that cause diseases listed in the OIE Aquatic Animal Health Code 2004

The OIE criteria used for listing an aquatic animal disease are given in Table 1.

A. Consequences	B. Spread	C. Diagnosis
1. The disease has been shown to cause significant production losses at a national or multinational (zonal or regional) level. or 2. The disease has been shown to or scientific evidence indicates that it is likely to negatively affect wild aquatic animal populations that are an asset worth protecting for economic or ecological reasons. or 3. The agent is of public health concern.	4. Infectious aetiology of the disease is proven. or 5. An infectious agent is strongly associated with the disease, but the aetiology is not yet known. and 6. Potential for international spread, including via live animals, their products and inanimate objects. and 7. Several countries or countries with *zones* may be *declared free* of the disease based on the general surveillance principles outlined in Chapter 1.1.4 as well as the relevant disease chapter of the *Aquatic Manual*.	8. A repeatable, robust means of detection/ diagnosis exists.

Diseases proposed for listing must meet all of the relevant parameters set for each of the criteria, namely A. Consequences, B. Spread and C. Diagnosis. Therefore, to be listed, a disease must have the following characteristics: 1 or 2 or 3; and 4 or 5; and 6; and 7; and 8.

Table 1. Criteria for listing an aquatic animal disease

The following diseases of fish are listed in the 2004 OIE Aquatic Animal Health Code.

Epizootic haematopoietic necrosis
Infectious haematopoietic necrosis
Oncorhynchus masou virus disease
Spring viraemia of carp
Viral haemorrhagic septicaemia
Channel catfish virus disease
Viral encephalopathy and retinopathy*
Infectious pancreatic necrosis
Infectious salmon anaemia
Epizootic ulcerative syndrome*
Bacterial kidney disease (*Renibacterium salmoninarum*)
Enteric septicaemia of catfish (*Edwardsiella ictaluri*)
Piscirickettsiosis (*Piscirickettsia salmonis*)
Gyrodactylosis (*Gyrodactylus salaris*)
Red sea bream iridoviral disease
White Sturgeon iridoviral disease

** Diseases reported in the ASEAN region.*

The ASEAN region is fortunate that only two of the diseases in the OIE list have been reported in the region. Although the other diseases have not been reported in the region, the ASEAN countries have to look out for these diseases in their quarantine protocols to ensure that these are not brought into the region. Since many of these diseases are caused by viruses, facilities and expertise should be developed to screen fish for viruses.

Pathogens Causing Diseases that are not listed by OIE but are Identified in the NACA/FAO/OIE Quarterly Reporting List.

The following pathogens causing diseases that are not listed by OIE but are identified as important for the Asia-Pacific region in the NACA/FAO/OIE Quarterly Reporting List.

- Epizootic haematopoietic necrosis.
- Koi mass mortality.

Both OIE and NACA/FAO/OIE list should be reviewed to determine whether the diseases listed meet the established criteria. For example epizootic ulcerative syndrome (EUS) which was a serious problem 15 years ago is now no longer considered a threat. On the other hand, koi mass mortality should be further studied to determine the primary cause of the disease as koi fish dealers have been suffering sever losses. According to Dr Hassan Mohd Daud (UPM) there are two major diseases of koi in Malaysia.

1) ***Sleepy Disease:*** Fish is anorexic, emaciated, lethargic and gradually drifts with the current. Histopathology of brain shows vacuolative degeneration in the molecular layer of the cerebellum. Mortalities can range from 30 to 50 %.
2) ***Koi ulcerative syndrome:*** Deep ulcers on the body and the head or mouth region with hyperaemia border. *Aeromonas hydrophila, Shewanella putrefaciens* and *Vibrio cholerae* were some of the bacteria isolated in these cases. These cases are usually

seen after handling and do not respond to antibiotic treatment. Mortality is 100%. Under TEM corona-like virus was seen in the ulcer lesion.

New Emerging Pathogens

It is now confirmed that besides the mass mortality of koi due to complex aetiologies seen in the region, Indonesia has reported the occurrence of Koi herpesvirus (KHV) which caused severe losses to the aquaculture industry. Although KHV was suspected to be introduced by illegal imports of koi ornamental fish from the Far east, the disease caused heavier losses in common carp which is extensively cultured food species (per comm. Agus Sunarto, Jakarta). The Directorate of Fisheries and Environment Indonesia estimated losses for 2001 and 2002 were in the region of US$15. Since the KHV is a viral disease that is highly contagious causing severe economic losses (Hedrick et al. 2000, Gray et al 2002) it should be included into the OIE list and the NACA/FAO/OIE list as well. The labs in the ASEAN countries should establish the capability for rapid diagnosis of KHV.

Due to lack of facilities for fish virus studies, it took almost 6 months to confirm that mortality was due to KHV. Special funds and assistance for international experts to help investigate the disease also took sometime to materialise. Meanwhile the disease that was first diagnosed in Java spread to other islands in Indonesia.

It is important that capacity building should be in parallel with the development of the industry. Although strategic planning and guidelines for fish health are in place the lack of manpower and facilities prevented the guidelines from being implemented. Scientists have to generate enough support from the policy makers for capacity building and facilities. The early warning system in place with the quarterly reporting needs further improvement for rapid dissemination of information.

Pathogens Associated With Zoonosis

Mycobacteriosis reported in snakehead *Channa striata* (Fowler), and Siamese fighting fish, *Betta splendens* (Regan), cultured in Thailand is caused by *Mycobacterium fortuitum and M. marinum* (Puttinaowarat et al. 2002). *Mycobacterium* spp. of fishes can infect humans. In most cases, the infections are confined to the extremities, and though not usually life-threatening may require aggressive antibiotic treatments to resolve (Kern et al. 1989). However, these infections may be lethal to immune compromised individuals (Lessing et al. 1993).

Another example of zoonotic concern is *Streptococcus iniae causes* which causes meningoencephalitis in tilapia. In humans it was reported to cause four cases of a bacteremic illness (three accompanied by cellulitis and the fourth with infective endocarditis, meningitis, and probable septic arthritis) (MMWR 1996). All four patients had a history of preparing fresh, whole fish purchased locally. This suggests that *S. iniae* may be an emerging pathogen associated with injury while preparing fresh aquacultured fish. (Weinstein et al. 1997)**.**

Although *S. iniae* is present in the ASEAN region, it is difficult to trace published records on the case. Many such findings or observations are not published or published in grey literature which is difficult to access. The fish health group need to work closely with the medical doctors to get reliable zoonotic data on fish pathogens.

Other pathogens

Several other alien species of parasites have been implicated in significant fish mortalities. The protozoan parasites such as *Ichthyophthirius multifiliis,* Trichodnids., *Myxobolus* sp. monogeneans group especially *Neobenedenia girallae, Sanguinicola armata,* crustaceans *Lernaea spp*, *Argulus spp* can all cause significant economic losses to the aquaculture industry. Fish mortality is severe during the early (parasitic) stages of these pathogens life cycles and mortality can wipe out stocks within a week. Severe mortality is also seen in adults ifstressed by poor husbandrypractices.

Similarly bacterial diseases have also been reported to cause severe losses to the aquaculture industry. Groups such as Vibrios and Aeromonads; *Streptococcus iniae* especially in Tilapia, *Tenacibaculum maritimus* Cytophaga-like bacteria in seabass can all cause severe losses to the crop.

Losses due to this category of pathogens aregenerally due to poor farm/pond management resulting in the stressed animals that succumb to infection. Although there are reports on occurrence of these pathogens, very few of these reports quantify the losses to the aquaculture industry. Policy makers need facts on the economic losses to the industry before they can be convinced that the matter is serious and requires action. Scientists reporting the identification and occurrence of pathogens/diseases must attempt to highlight the economic implication to the industry.

Capacity Building

Many of the causes of fish mortality can be traced to new introductions or poor farm management practices. The authorities concerned should be proactive in the prevention of introductions and ensure that aquaculture practices are sustainable. Although quarantine measures are in place in various countries, however due to lack of trained manpower and insufficient facilities the quarantine system is not implemented effectively. Fish at quarantine centres is still examined visually for its health status.

During the outbreak of significant diseases, the ASEAN region has to rely heavily on foreign expertise to help diagnose or confirm the case. This involves having to go through bureaucratic protocols that delay the arrival of expertise. Meanwhile the disease spreads and economic losses are severe. In Thailand losses due to EUS were estimated to be US$8.7 million in the 1982-1983 outbreak, whilst KHV caused losses amounting to US$15 million in 2000 and 2001. Thus regional capacity building is imperative to enable effective implementation of fish health control measures.

Capacity building in the ASEAN region for fish health has long been felt by the concerned authorities especially since the outbreak of EUS. However, due to the structural organization under the Department of Fisheries, fish health has not been accorded the priority it deserves compared to the veterinary services. Progress for capacity building has been slow and hence the poor technical backup for the aquaculture industry. The lack of manpower, appropriate expertise or facilities has hampered the growth of the aquaculture industry.

Capacity building should take a holistic approach rather than compartmentalization into different areas, such as parasitology, bacteriology and the other typical fish health areas. This "old fashion" approach is no longer applicable and furthermore hampers progress in fish health research. Fish health is a new field that requires enormous input for research and development. In addition to the little regional knowledge on fish health, and the fact that it is closely associated with the environment, the subject deserves special treatment.

A holistic research approach must encompass all aspects of the medical field related to fish health. This would include identification of the organism, its habitat, growth requirements, epidemiology, pathogenesis, immunity, genetics, diagnosis (using rapid and non lethal techniques), treatment (environment friendly), prophylaxis including good management practices and the use of immune enhancers, probiotics, vaccination and quarantine. In addition emphasis should also be given to environmental issues, (e.g., water quality). This means that besides mastering subjects such as pure parasitology, virology, bacteriology or mycology, basic knowledge should also be imparted in all the medical subjects. This holistic approach is not aimed to make the fish health personnel experts in all these fields, but they should be knowledgeable enough to appreciate the subject and use fundamental knowledge from their basic findings to spearhead its application to strategise prevention of losses to the aquaculture industry. The holistic approach will ensure correct diagnosis, followed by appropriate and correct measures taken to prevent losses, and avoid or minimise future disease occurrences.

It would be ideal to have the expertise in all fields related to fish health but due to manpower and budgetary constraints this may not be possible. In addition to imparting basic knowledge on a holistic approach, a limited number of sufficiently strong experts covering different fields distributed in the region should be the target to ensure self reliance on fish health in the region.

Capacity building will be more effective if it is implemented through higher degree programmes at Masters and Doctorate levels. This training should be provided in one of the universities in the region. Students undertaking the programme must do all courses related to medical sciences. Completing a degree program in a local university will ensure that the research project is done on current diseases of local relevance. Masters and Doctorate programmes through research and without structured courses will narrow the scope of expertise in the particularly field of research studies.

The laboratory attachment is another approach for capacity building. Personnel seeking expertise in a specific field should be funded for attachment either in a regional lab or international lab. Similarly, international or regional expertise can also be based for an appropriate duration in a regional lab to upgrade the skills and knowledge of the personnel.

The distance learning approach can also be adopted for capacity building. Personnel that cannot be spared from their routine work can register for distance learning programmes. Such programmes in other fields have been successfully implemented through the Internet. Students are given regular exercises that are graded. This sandwich programme includes a short-term visit to the expert's lab to sharpen their practical skills and theoretical knowledge.

Capacity building should include technical writing skills. Many valuable observations and research findings are not published or are published as grey literature that is not accessible even within the region.

A strong network is important to provide and maintain close links among the scientists in the region and at the international level. A strong internationally recognised network will also serve as a reliable platform that will reap appropriate benefits in the pursuance of fish health issues. Email networking should be established with participants attending this workshop. The networking should also cover a wider circle involving international experts or selected fish health labs to monitor the situation and provide input whenever required. The Fish Health Section of the Asian Fisheries Society and/or NACA, should coordinate the networking activities.

The ASEAN fish health capacity building should be considered as a long-term investment by donor agencies. The expertise trained within ASEAN can be tapped to assist the lesser developed neighbouring countries in the region that will most likely face similar fish health problems.

Capacity building should also be extended to all levels of stakeholders. This could be done through seminars, short courses, posters, media and websites.

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Molluscan Pathogens of Concern to ASEAN

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Abstract

Molluscan aquaculture production contributes 26.9 percent to the global aquaculture production valued at US$10 500 million. The positive environmental impacts (e.g., absence of biological/ chemical pollution, filter-feeding properties) have generated interest in molluscan culture. The growing industry has a huge trade potential, contributes significantly to food availability, and an important source of employment. Increasing species diversification for aquaculture, as well as hatchery production to enhance natural seed collection is putting increased pressure for international movements and transfers of live molluscs. This paper provides examples of pathogen movement and their impacts resulting from the translocation of molluscan hosts. Information on important molluscan pathogens of concern to ASEAN as well as ongoing regional efforts to address issues related to molluscan health management in Asia-Pacific region are provided.

Molluscan Production Trends

World aquaculture production of molluscs including freshwater molluscs, abalone, winkles, oysters, mussels, scallops, clams, cockles, arkshells and other marine molluscs was estimated at 11 784 073 tonnes in 2002 with a value of US$10 500 million (FAO, 2002). This represents 29.6 percent of global aquaculture production (excluding aquatic plants). Three molluscan species are among the top ten aquaculture producers for 2002. These are Pacific oyster (*Crassostrea gigas*), Manila clam (*Ruditapes philippinarum*) and Yesso scallop (*Patinopecten yessoensis*). Blue mussel (*Mytilus edulis*) and blood cockle (*Anadara granosa*) adds to the list to make the top five molluscan species cultured in 2002. Molluscan contribution to capture fisheries trails behind at 8.0 percent (= 7 433 845 tonnes) of world's total production. When considering capture fisheries, the top five groups of molluscs are: (1) squids, cuttlefish, octopuses; (2) miscellaneous marine molluscs; (3) clams, cockles, arkshells; (4) scallops; and (5) freshwater molluscs (FAO, 2002).

Mollusc culture provides several positive environmental impacts relative to other forms of aquaculture. There is no biological/chemical pollution which is commonly associated with finfish and crustacean aquaculture and the natural filter-feeding process of bivalves generally improves the water quality where they are cultured. These positive impacts on the aquatic environment have generated a growing interest in mollusc culture. Molluscs are sensitive and susceptible to many anthropogenic pollutants and require pristine environment for optimum growth; they are thus good sentinels of environmental quality.

The industry has enormous trade potential and contributes significantly to food availability. Furthermore, it offers a good employment alternative for the coastal farming communities in lieu of shrimp farming, which has suffered significant setbacks due to disease problems, and illegal operations such as cyanide and dynamite fishing which are major problems in many countries of Southeast Asia. Mollusc culture will continue to be a source of growth in aquaculture production and an important source of income and hard currency for most developing economies of the region.

Increasing species diversification for aquaculture, as well as hatchery production to enhance natural seed collection is putting increased pressure for international movements and transfers of live molluscs. In order to ensure that mollusc production can contribute to food availability and poverty alleviation, it has to grow in a responsible and well-managed direction.

Species Movement, Movements of Pathogens and Impacts of Molluscan Diseases

The global movement of the Pacific oyster, *Crassostrea gigas,* is a classical example of the spread of infection facilitated by host movement. Pacific oysters were introduced from Matsushima Bay in Japan to the west coast of the United States, and from there moved to the east coast. These western US stocks are infected at low levels with a *Haplosporidium* sp. identical to *H. nelsoni*, which has caused massive mortalities among eastern oysters (*Crassostrea virginica*) along the eastern US coast. A highly specific and sensitive DNA probe, developed to detect *H. nelsoni* by *in situ* hybridization, also detects the *Haplosporidium* sp. described in Pacific oysters of the western US and Matsushima Bay (Burreson and Stokes, 2000). It is now known that *H. nelsoni* is present in *C. gigas* in Japan (Kamaishi and Yoshinaga, 2002) and Korea (Kern, 1976). It appears that *H. nelsoni* does not cause serious disease in Pacific oysters, and it is speculated that *Haplosporidium nelsoni* was introduced into the Pacific US by apparently healthy, but infected, *C. gigas*. Infected Pacific oysters were then introduced onto the east coast of the US, where the parasite shifted virulence into a new host (Burreson and Stokes, 2000), infecting eastern oysters, and causing mass mortalities. This example demonstrates the possible dramatic consequences of transferring infected stocks.

Another mollusc parasite, *Bonamia ostreae*, was introduced into Europe by means of imports of infected juveniles of flat oyster, *Ostrea edulis*, from California (Grizel, 1997; Cigarría and Elston, 1997). The pathogen rapidly spread to almost all of the oyster farming areas in Europe.

In southern hemisphere, bonamiosis caused by *Bonamia exitiosa* was more probably transferred via movements of infected oysters, *Ostrea chilensis*, intended for human consumption from New Zealand into Tasmania (Dartnall, 1969).

Currently, the role of ballast waters and hull attachment in the transfer of mollusc pathogen is increasingly drawing scientist community attention. For example, although *Ostrea angasi* is the only large native flat oyster species in southern Australian waters, DNA markers identified *Ostrea edulis* at a 30 percent occurrence with *O. angasi* in Oyster Harbour, Albany (Morton *et al*., 2003). European oyster has apparently been introduced in this harbour by means of ballast waters. Such introductions could also be a possible route of pathogen transfers. Several cases strongly suggest hull attachments or ballast waters as potential source of long distance spread of pathogens of molluscs. These incluse *Haplosporidium nelsoni* in Cape Breton, Canada (REF), *Marteilia* sp. in Florida USA (Moyer *et al*., 1993), *Bonamia exitiosa* in North Carolina USA (Burreson *et al*., 2004), *Marteilioides chungmuensis* in Darwin Harbour Australia (Hine and Thorne, 2000).

Molecular studies based on the sequence of the ITS1 (internal transcribed spacers) region of the rRNA genes suggest that *Perkinsus olseni* is closely related to *P. atlanticus* described in Europe from the carpet clams *Ruditapes philippinarum* and *R. decussatus* (Goggin, 1994; Murrel *et al*., 2002). One interpretation of the close relationship of *P. olseni* and *P. atlanticus*, is that *P. olseni* was moved from Asia to Europe with movement of *R. philippinarum*. This is supported by the report of a *Perkinsus* sp. in *R. philippinarum* in Japan with nucleotide sequences which resemble those of *P. olseni* and *P. atlanticus* (Hamaguchi *et al.*,1998). Also, *P. atlanticus* does not cause disease in *R. philippinarum* in Europe, except under crowded aquaculture conditions and during the marketing process, but it does cause disease in cultured and wild stocks of the native *R. decussatus.* This suggests a shorter history of association with the latter clam species. Therefore, *P. olseni/P . atlanticus* occurs in New Zealand, eastern Australia, throughout the tropical Pacific, Asia, and the coasts of Italy, France, Spain and Portugal as well as in Tunisia. However, *P. olseni* has not been reported from the Pacific or Atlantic coasts of North or South America. In a recent study, clams destined for importation into Mexico from Korea were found to be heavily infected with a *Perkinsus*, likely *P. olseni*, and importation stopped because of the potential for spread (Elston *et al*., 2003).

Some of the most serious economic losses resulting from molluscan disease epizootics have been reported from the Asian region (see **Table 1**).

Perkinsus olseni caused mass mortalities among abalone (*Haliotis ruber, H. laevigata* and *H. cyclobates*) around South Australia in 1972, and continues to have an economic impact due to the yellow pustules it causes in the meat, making many abalone unmarketable.

Marteilia sydneyi causes greater than 90% mortality among farmed Sydney rock oysters (*Saccostrea commercialis = glomerata*), with losses of about 40 percent of total production, in Australia (New South Wales, Queensland and Western Australia).

Bonamia exitiosa destroyed 90 percent of the wild stocks of flat oysters (*Ostrea chilensis*) around New Zealand between 1986 and 1992, resulting in closure of the fishery and the loss of work for ~1000 people. In New Zealand and Australia, the presence of the parasite has prevented the development of flat oyster (*O. chilensis, Ostrea angasi*) farming. Winter mortality, caused by *Mikrocytos (Bonamia) roughleyi*, originally caused significant losses among Sydney rock oyster farmers in New South Wales.

The Akoya pearl oyster mortalities in Japan, which occurred 10 years ago, reportedly resulted to losses (mortalities and decreased quality of pearls produced) exceeding 30 000 million Japanese yen (approximately US$276 million at current exchange rate) during the 1996-1997 outbreak (Miyazaki *et al.* 1999). Pearl oyster is an important commodity in the Asia-Pacific Region, with established industries in Australia, China, Japan, India, Indonesia, French Polynesia and the Philippines.

Mass mortalities of scallops (*Chlamys farreri)*in North China in 1998, caused an estimated loss of US$180 million (Wang *et al*., 2002; Chongming, personal communication, 2002).

In March 2003, mass mortalities of small abalone (*Haliotis diversicolor*) in Taiwan, Province of China caused the domestic abalone industry losses equivalent to 400 million TW$ (US$11.5 million) (Pro-Med, 13 March 2003). Some of the largest abalone industries are located in Australia, China, Japan, Korea R.O., New Zealand, Taiwan, Province of China. China and Taiwan Province of China are the world's biggest abalone-farming countries. Abalone is one of the fastest growing mollusc aquaculture sector and will become an important resource for ASEAN.

Molluscan Pathogens of Concern to ASEAN

Of the 35 pathogens currently listed by the Office International des Epizooties (World Organisation for Animal Health), 11 are pathogens of molluscs (see **Table 2**). These pathogens fit the criteria of being of socio-economic and/or public health importance and significant in the international trade of aquatic animals and aquatic animal products (OIE, 2003). Although most of these pathogens have not been reported in ASEAN, some of them are known to occur in neighbouring Korea, Japan, Australia and New Zealand. Absence of report does not necessarily mean absence of pathogen unless a surveillance program is in place that will support freedom from pathogen/disease occurrence.

Most of the knowledge of bivalve mollusc diseases in the region is derived from studies from Australia and New Zealand. These studies have reported the presence of several serious pathogens of bivalves, including fiveof the 11 OIE-listed disease agents of molluscs (i.e. *Haplosporidium nelsoni*, *Marteilia sydneyi*, *Bonamia exitiosa*, *Mikrocytos (= Bonamia) roughleyi*, *Perkinsus olseni*). Another seven organisms, closely related to the OIE-listed pathogens, are known to occur in the region (*Marteilia lengehi*, *Marteilia* sp., *Marteilioides branchialis*, *Marteilioides chungmuensis*, *Haplosporidium* sp. and *Perkinsus* sp.).

Two other protozoans, not listed by the OIE, may also have a significant impact on bivalve culture in Asia. *Marteilioides chungmuensis* infects the ova of oysters (*Saccostrea echinata, Crassostrea gigas*) in Darwin Harbour, northern Australia, and in Korea and Japan (Comps *et al*., 1986; Itoh *et al*., 2003). Infection can so reduce fecundity that there are spawning failures (Ngo *et al*., 2003). The parasite may be spread by both aquaculture operations and by shipping, as the parasite is restricted to ports in Australia and the western United States (Hine, 1996). It has recently been reported from another oyster species, *Crassostrea nippona* (Itoh *et al*., 2004). Another ovarian parasite, *Steinhausia mytilovum,* infects the eggs of mussels (*Mytilus* spp.) in Korea and Japan, and again affects fecundity of the host.

Apart from the significant diseases listed by the OIE and those described above, some countries of the Asian region are faced with increasing molluscan epizootics during the last few years. These include mortalities of zhikong scallops (*Chlamys farreri*) in China (Wei, 2002; Wang *et al*., 2002) and diseases affecting seabed-cultured scallop (*Patinopecten yessoensis*), abalone (*Nordotis discus discus*) and Akoya pearl oyster (*Pinctada fucata martensii*) in Japan (Kosaka and Yoshimizu, 1999; Miyazaki *et al.,* 1999; Morizane *et al.,* 2001; Nakajima, 1999; Nakatsugawa *et al.,*1999; Sorimachi, 2000; Muroga, 2002). The mass mortality of Akoya pearl oyster in 1994 in southwestern Japan that killed 400 million oysters, with similar mortalities widely observed in other districts of western Japan since 1996 (Muroga, 2002), is the most controversial because of uncertainties as to the nature of the causative agent. Muroga *et al.* (1999) reported the results of a workshop on "Emerging Diseases of Cultured Marine Molluscs in Japan" that presented various suspected agents, including the toxic dinoflagellate *Heterocapsa circularisquama*, perkinsosis, a virus or filterable agent and environmental factors. However, the causative agent is still unknown. Although an uncharacterized virus was isolated and grown in a fish cell line (Miyazaki *et al.,* 1999), there was no ultrastructural evidence of replication in pearl oyster cells.

In a review of significant diseases of molluscs in Asia-Pacific, Hine (2002) noted that although there have been relatively few reports, new diseases of regional importance will become evident once molluscan health studies become firmly established in Asia, **Table 3** shows a list of parasites and microbial agents reported from Asian bivalves.

Molluscan Health Management in Asia-Pacific

With respect to molluscan diseases, Europe, North America as well as Australia and New Zealand in the Asia-Pacific have pioneered support programmes and infrastructures for molluscan health based on historical experience with significant diseases. The lack of or inadequate legislative framework or national policy protection of aquatic animal health make countries vulnerable to:

- trade barriers, due to lack of health information on their stocks comparable with that of potential trade partners; and
- imports certified as free of specific pathogens, but which have little relevance to the mollusc health profiles in the waters to which imported molluscs are to be introduced.

While health infrastructure and expert support for crustaceans and finfish are significantly in place in Asia-Pacific, those for molluscs are still lacking region wide. In view of this NACA and FAO, in 1999, initiated a program on Molluscan Health Management Program which is described below.

NACA/FAO Molluscan Health Program

Increasing species diversification for aquaculture, as well as hatchery production to enhance natural seed collection is putting increased pressure for international movements and transfers of live molluscs. The disease risks inherent in international trade are clearly recognised by international organisations for marine development such as ICES (International Council for the Exploration of the Seas – Pacific and Atlantic) and the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS) with the OIE as the relevant organisation designated by the World Trade Organization (WTO) responsible on matters relating to fish health and disease. The Code of Conduct for Responsible Fisheries of FAO also recognises that the transboundary movement of live aquatic animals must be conducted in a responsible manner using appropriate health measures. Health considerations have become thus a significant factor in international trade.

The Asia-Pacific Regional Programme on Mollusc Health Management was initiated by NACA and FAO in response to the recommendations arising from the Second Workshop (February 1999) of the FAO/NACA Regional TCP on "Assistance to Safe Transboundary Movement of Live aquatic Animals in Asia". The workshop considered the shortage of information and knowledge about molluscan diseases in the region, the absence of general health monitoring programs as well as expertise, facilities and infrastructures for molluscs for most countries of the region which have commercially significant mollusc production. The need to establish baseline expertise that will provide the foundation for national programmes for molluscan health monitoring, disease risk analysis and control of losses was also recognized. The programme, consisting of three Phases, has the following objectives and expected outcomes:

Objectives:

- To train national staff on techniques used in molluscan disease investigation, diagnosis and management
- To build up expertise in molluscan disease diagnosis and research in the Asian region
- Through country-specific mollusc health survey/assessment - to identify molluscan diseases existing in, and of concern to the Asian region; and
- To establish a network of people with expertise in molluscan disease diagnosis throughout the Asia-Pacific region.

Expected outcomes:

- Baseline data on the health profile of economically important mollusc species in the region
- Identification of molluscan diseases of concern to the Asian region
- Uniform standards of mollusc disease diagnosis and pathogen detection throughout the region, comparable to those acceptable to countries outside the region
- Enhanced national and regional capability on molluscan health management and good husbandry practices
- Asia-Pacific network of people with expertise in molluscan health
- Manual on molluscan health based on actual Asian examples
- Reference collection of important mollusc diseases in the Asian region

Specific outcome/activities for each Phase are outlined below:

Phase 1: Baseline Training – November 29-December 3rd 1999 (SEAFDEC-AQD, Tigbauan, Iloilo, Philippines) to:

1.1. Establish the concept principles of the OIE and the Asia Regional Guidelines on Health Considerations for the Responsible Movement of Live Aquatic Animals to prevent the risk of transferring diseases in mollusc aquaculture (listed diseases/zones/transfers)
1.2. Establish ability to screen healthy and diseased molluscs
1.3. Ensure optimum sample collection, handling and preservation for subsequent diagnostic examinations
1.4. Establish networking and provide links to specialised diagnostic advisors and laboratories
1.5. Establish capability to undertake gross examination of molluscs and field conditions (Tier 1 health management)
1.6. Establish capability to collect and examine at light microscope level mollusc tissues collected for disease diagnosis and pathogen screening (Tier II)
1.7. Establish country-specific mollusc health survey programs to determine **normal** conditions, as well as **abnormal** conditions in commercially important molluscs.
1.8. Provision of selected reference materials

2. Phase II: Follow-up Training, Evaluation of Results from Country-Specific Surveys (November 29-3 December 2002, University of Queensland, Brisbane, Australia):
   2.1. Discussion of country-specific data collection issues. Infrastructure and accessibility of sample sites, industry diversity, live transfer exchange practices (traditional and developing).
   2.2. Examination of country-specific histology and other preserved materials.
   2.3. Provision of updated international reference materials from support laboratories within and outside the Region.
   2.4. Discussion of needs and national/international links to Tier III health management capability (electron microscopy, immunodiagnostics, nucleic acid assays).

3. Phase III: Tier II/III Follow-up Training, Evaluation of Support & Results (2005, Pusan Korea)
   3.1. Discussion of disease issues:
      3.1.1. Introductions and transfers
      3.1.2. Unknown aetiologic agents/environmental factors
      3.1.3. New or emerging disease issues
   3.2. Examination of new country-specific histology and other preserved materials
   3.3. Discussion of developments in national and regional molluscan health programs (e.g. diagnostic and research needs, activities to establish national and regional molluscan health programmes, molluscan health surveys, molluscan disease collection and reporting system, risk analyses and surveillance program, molluscan health manual, institutional capacity building, etc.)
   3.4. Provision of updated international reference materials from support laboratories within and outside the Region.

This NACA/FAO programme on Molluscan Health is being implemented in cooperation with a number of regional and international organisations and centres of excellence for molluscan and aquatic animal health.

The Way Forward

Molluscan diseases pose great problems with regard to international movements because of the following: (a) molluscs are often traded live; (b) after translocation they are often laid in seawater to recover from transport until needed; (c) it is difficult to determine whether an individual is dead, moribund or alive; (d) absence of or limited clinical signs means that diagnosis of infection bears on pathogen; (e) no cell lines are available as a support to diagnostic; (f) demonstration fouling organisms on the shell also pose a threat; (g) no vaccines are available; (h) disease epidemiology is usually poorly understood; (i) large numbers of very small animals may be involved; (j) nearly impossible to apply any treatment; and (k) a frequent strong interaction between wild populations and cultured stocks.

Some efforts are in place to address the issues pertaining to lack of infrastructure and support program for molluscan health in Asia-Pacific. Pro-active support to the Asia-Pacific Molluscan Health Program and to the Regional Programme on Aquatic Animal Health Management, both of FAO/NACA, should be provided particularly in implementing the various components, such as National Strategies, Disease Surveillance and Reporting, Risk Analysis, etc. Research will form a significant part of the global effort in addressing molluscan pathogen invasions. Assessments through systematic surveys to better understand disease epidemiology are necessary. As it is difficult to make sound and informed policy decisions based on qualitative and anecdotal data, systematic collection of information is essential in order to support effective policies for prevention and control.

Sharing of information is critical, particularly with respect to information available in several languages (e.g. Chinese, Korean, Japanese). There are also a number of e-mail discussion groups and internet-based information systems which can be utilised (**Box 1**).

More capacity building towards practical application of risk analysis for safe movement of aquatic animals should be planned. Inventory of diseases through national and regional databases is essential to support risk analysis. There should be a mechanism for easy access and sharing of information and resources. As histopathology is the gold standard for diagnosis of many molluscan disease, depository of histological specimens is highly desirable in a regional reference centre. With intensification of mollusc aquaculture, special focus on hatchery diseases should be taken. Hatcheries are a high risk segment of the molluscan aquaculture sector, but specific control measures can be established in hatcheries which make hatchery based production safer. Studies on the economic estimates of impacts and management costs should be initiated. Last but not least, public and government awareness and education and outreach activities should be carried out.

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Box 1. List of e-mail discussion groups and other world wide web resources for molluscan health information.

- Invertebrate pathologist group: E-mail Administrator at administrator@pathology-registry.org
- Abalone Health Interest Group: E-mail: Judith.Handlinger@dpiwe.tas.gov.au)
- Marine Pathology: E-mail: majordomo@back.vims.edu)
- *Perkinsus* Identification: Email: perkid@ifremer.fr)
- National Shellfisheries Association: http://shellfish.org/pubs/qnl.htm
- The Crest (VIMS Newsletter): http://www.vims.edu/vimsnews/
- Laboratoire de Genetique et Pathologie Home Page: http://www.ifremer.fr/latremblade/
- The University of Maryland Aquatic Pathobiology Center: http://www.som1.ab.umd/aquaticpath/
- Synopsis of Shellfish Diseases DFO-Canada: http://www.pac.dfo-mpo.gc.ca/sci/shelldis/toc_e.htm
- Oxford Marine Library: http://mrl.cofc.edu/oxford/
- Aquatic Animal Health Subprogram (Australia's FRDC): http://www.frdc.com.au/research/programs/aah/
- National Shellfisheries Association: http://shellfish.org/
- Fish Disease Net: http://www.fishdisease.net/
- Haskin's Shellfish Research Laboratory: http://vertigo.hsrl.rutgers.edu/
- Western Australia Pearl Oyster: http://www.fish.wa.gov.au/aqua/broc/species/pearls/index.html
- Abalone Network: http://web.uct.ac.za/depts/zoology/abnet/index.html
- Maryland Sea Grant Oyster Disease Research Program:

Table 1. Some examples of economic impacts of diseases on representative molluscan species.

Species	Pathogen/ Disease	Country/ Year	Impacts *(losses, mortality, rates, etc.)*	Reference
Eastern oyster *Crassostrea virginica*	MSX *Haplosporidium nelsoni*	Chesapeake Bay, USA, since 1959	>90% of oysters grown in the Bay	Andrews (1968)
	MSX *Haplosporidium nelsoni*	Canada 2002	80% mortalities	OIE report October 2002
Japanese pearl oyster (Akoya oyster) *Pinctada fucata martensii*	Mass mortalities associated with a virus disease	Japan since 1994	1996-1997 - annual mortality in all of western regions>400 million oysters equivalent to 50% of oyster production in Japan Total economic loss: >30,000 million Japanese yen (mortalities and decreased quality of pearls produced) (approximately US$276 million at current exchange rate) May also be responsible for black-lip oyster mortalities in Polynesia	Miyazaki *et al.* (1999) Jones (2002)
Rock oyster *Saccostrea glomerulata (=commercialis)*	Marteiliosis (QX Disease), *Marteilia sydneyi*	Australia	>90% prevalence single most important pathogen of rock oyster US$30 million worth of production in NSW Australia	Adlard and Weshe (2002) Kleeman and Adlard (2000)
Pacific oyster *C. gigas* (larvae and spat in hatchery and natural beds)	Herpes type virus disease		80-90% mortalities	Berthe (2002)
Pacific oyster *Crassostrea gigas*	*Marteilioides chungmuensis*	Japan	60% prevalence during harvest period	Itoh *et al.* (2002)
Scallop *Chlamys farreri*	Possible virus-like aetiology Scallop acute viral necrotic disease	North China 1998	Mass mortality in 1998 caused US$180 million	Chong-ming (personal communication, 2002)
Abalone *Haliotis diversicolor*	Unidentified virus	North east coast of Taiwan Province of China, 2003	400 million TWD (US$11.5 million) loss to the domestic abalone industry. Annual product value of Taiwan abalone exceeds 7,000 million TWD (US$200 million), including 2,000 million TWD (US$58.8 million) from those raised in farms along the northeast coast. Dropped to 400 NTD from 600 NTD per kilogram.	Taipei Times 13 Mar 2003 Pro-Med, 13 March 2003 Remarks: similar epidemics occurred in South China which caused high mortalities (Dr. Choi and Dr. Wang, personal communication, 2003)

Black abalone *H. cracherodii*	Withering syndrome of abalone	California	Cumulative mortality over 99%	OIE (2003)
Manila clam *Ruditapes philippinarum*	*Perkinsus olseni*	West and south coast of Korea since 1997	Dramatic decrease in clam landings since 1993; clam landings in 1997 was 14,000 tonnes, 1/5 of the total landings in 1990	Park and Choi (2001)
Hard clam *Meretrix meretrix*	Mass mortality of unidentified cause	Coast of southern Jiansu, China	US$6 million in 1989 alone	

Table 2. Diseases of Molluscs listed by OIE (OIE, 2003).

Pathogens		Distribution in ASEAN and other regions	Host
Bonamiosis	*Bonamia exitiosa*	New Zealand, Australia	*Ostrea angasi, O. chilensis*
	Bonamia ostreae	Pacific coast of USA: California and Washington states	*Ostrea edulis, O. conchaphila, Can also infect O. puelchana, O. angasi, O. chilensis*
	Mikrocytos (Bonamia) roughleyi	Australia	*Saccostrea glomerata*
MSX disease	*Haplosporidium nelsoni*	Korea, Japan, East coast of North America from Florida, USA to Nova Scotia, Canada	*Crassostrea virginica, C. gigas*
Marteliliosis	*Marteilia regfringens* (Aber disease)	not reported from the region; occurs in Europe	*Ostrea edulis*
	Marteilia sydneyi (QX disease)	Australia: New South Wales, Queensland and Western Australia	*Saccostrea glomerulata, S. echinata*
Mikrocytosis	*Mikrocytos mackini*	Pacific coast of Canada	*C. gigas, O. edulis, O. conchaphila Experimentally infects C. virginica*
Perkinsosis	*Perkinsus marinus (Dermo disease)*	not reported from the region; occurs on the East coast of the USA	*C. virginica*
	Perkinsus olseni	Eastern and southern Australia, New Zealand, Korea, Japan	*Haliotis rubber, H. cyclobates, H. scalaris, H. laevigata, Anadara trapezia, Austovenus stutchburyi Ruditapes decussatus, R. philippinarum*
SSO disease	*Haplosporidium costale*	not reported from the region; occurs on the East coast of the USA	
Withering syndrome of abalone	*Xenohaliotis californiensis*	not reported from the region; occurs in Chile, California (USA), Israel and Iceland	*Haliotis cracherodii (black abalone), H. rufescens (red abalone), H. corrugata (pink abalone), H. fulgens (green abalone), H. sorenseni (white abalone)*

Table 3. Parasites and Other Microbial Agents Reported from Asian Molluscs

Pathogens	Host Species	Distribution	Reference
Haplosporidium nelsoni	*Crassostrea gigas*	Japan, Korea	OIE (2003)
Haplosporidium sp.	*Pinctada maxima*	North western Australia	Hine and Thorne (2000)
Haplosporidium sp.	*Haliotis iris (Paua)*	New Zealand	Diggles and Oliver (2002); Diggles *et al.* (2002)
Unidentified haplosporidian	*Argopecten irradians*	China	Chu *et al.* (1996)
Marteilia sydneyi	*Saccostrea glomerata*	Australia	Perkins and Wolf (1976)
Marteilia lengehi	*Saccostrea cucculata*	North western Australia	Hine (1996), Hine and Thorne (2000)
Marteilioides chungmuensis	*Crassostrea gigas*	Korea, Japan	Comps et al. (1986)
Marteilioides branchialis	*Saccostrea glomerata*	Queensland, Australia	Anderson and Lester (1992)
Mikrocytos roughleyi	*Saccostrea glomerata*	Eastern Australia	Farley et al. (1988)
Bonamia exitiosa	*Ostrea angasi, O. chilensis*	Southern mainland Australia, Tasmania and New Zealand	Hine (1996), Hine and Thorned (2000)
Perkinsus olseni/atlanticus	*Tapes philippinarum and many other bivalves and abalone*	Pacific Islands, mainland Australia, Korea, Japan, Spain	Lester and Davis (1981)
Perkinsus sp.	*R. philippinarum*	Korea, Japan, China, Viet Nam	Choi (2002), Maeno et al. (1999), Itoh (personal communication, 2002)
Perkinsus sp. *(possibly P. olseni)*	*Clam Paphia undulata*	China	Choi (2002)
Perkinsus olseni	*Abalone, giant clam, pearl oyster*	Australia, New Zealand	Choi (2002)
Ostrincola koe	*Meretrix meretrix*	China	Ho and Zheng (1994)
Nematopsis sp.	*Blood cockles (Anadara granosa) and tropical oyster (Crassostrea iredalei)*	Malaysia	Beng-chu (personal communication, 2002)
Unidentified trematode	*Blood cockles (Anadara granosa) and tropical oyster (Crassostrea iredalei)*	Malaysia	Beng-chu (personal communication, 2002)

Birnavirus (IPNV Ab)	*Meretrix lusoria*	Taiwan Province of China Worldwide (?)	Lo *et al.* (1988)
Unidentified virus	*Pinctada maxima martensii*	Japan, China	Miyazaki *et al.* (1999)
Unidentified virus	*Nordotis discus discus*	Japan	Nakatsugawa *et al.* (1999)
Unidentified virus	*Hyriopsis cumingii*	China	Shao *et al.* (1995)
Rickettsiales-like organisms	*Hippopus hippopus*	Philippines, Micronesia	Norton *et al.* (1993)
Rickettsiales-like organisms	*Meretrix lusoria*	Taiwan Province of China	Chen *et al.* (1994)
Rickettsiales-like organisms	*Pinctada maxima*	Philippines	McGladdery and Bondad-Reantaso (unpublished data, 1996)
Vibrio alginolyticus	*Meretrix meretrix*	China	Yu et al. (1990)
Viral gametocytic hypertrophy (Papilloma-like virus)	*Crassostrea* spp., *Ostrea* spp., *Pinctada maxima*	Korea, Japan	Berthe (2002)
Herpes type virus disease	*Crassostrea spp., Ostrea* spp.	Korea	Berthe (2002)

Need for an Institutional Network for Managing Aquatic Exotic Species in Indochina

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Abstract

The Aqua Outreach Programme of the Asian Institute of Technology (AIT) conducted four national workshops to examine the environmental and socio-economic impacts from the introduction of exotic species in Southeast Asia, with a focus on Thailand, Vietnam, Laos and Cambodia. The principal purpose of the workshops was to help to develop a Code of Conduct and Regional Guidelines on the use of new and already introduced species in aquaculture in the region. Key informants representing all stakeholders were invited to present information on both positive and negative impacts of introduced species. The major constraints to managing introduced species and preventing new introductions identified by all four countries' delegates were: weak institutional capacities, a paucity of well-conducted impact studies, and a lack of educational programs to enhance public awareness. To alleviate these shortcomings, an institutional network consisting of both regional and local institutions was proposed to provide much needed expertise to strengthen local partners, and to enhance capacity and public participation in managing alien species to reduce and/or eliminate their potential negative impacts.

Introduction

There are two opposing arguments on the effects of exotic aquatic species on indigenous aquatic biota. One argument is that most exotic species are invasive. The other is that some exotic species such as tilapia are beneficial and become invasive only when-made environmental changes such as aquatic pollution provide an opportunity for them to thrive. Despite this difference of opinion, a call for developing a Code of Conduct and Regional Guidelines on the use of new and already introduced species in aquaculture in the ASEAN region is getting the attention of many development agencies.

Exotic species in aquaculture have created socio-economic benefits for a vast number of poor people in the region but development of a code of conduct is imperative to maintain the sustainability of such benefits. Therefore, AIT Aqua Outreach Programme conducted four National workshops to examine the status of both positive and negative impacts of the introduction of exotic species in Thailand, Vietnam, Laos and Cambodia, with a view to recommending the preparation of a regional code of conduct on the management of exotic aquatic species in aquaculture for the region. Delegates representing all stakeholders were invited to gather and present information on exotic species impacts, and to air national views on introduced species. This paper summarizes the major findings of national workshops 24 and proposes to build an institutional network consisting of both regional and local institutions to enhance capacity and public participation in managing alien species to reduce or ideally eliminate their potential negative impacts.

National Workshop Methodology

Workshops were convened in Thailand (24 Sept. 2002), Cambodia (3 – 4 Oct. 2002), Lao PDR (22 – 24 Nov 2002) and Vietnam (20 – 21 May 2003) with delegates representing a wide range of expertise including fishermen, fish farmers, hatchery managers, extension workers, researchers, university lecturers, policy makers and environmentalists. Experts presented theme papers during the workshops and participants were then divided into groups according to general professional categories (e.g. producers, extension officers, academics and researchers). The major issues embodying the bulleted questions below were identified and discussed in the group sessions:

- 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?
- 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 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?

Recommendations were then developed to alleviate negative impacts of exotic species introductions.

Current Status of Exotic Fish Species In Indochina

Cambodia

The participants identified 18 introduced aquatic species in Cambodia including snails, crocodile and seaweeds (Table 1). Some of the species were clearly introduced for aquaculture development, while the remainder were believed to be either deliberately introduced for ornamental or wild stock enhancement purposes, or they migrated naturally from Vietnam. 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. Exotic species occupy less than 1% of the commercial catch, suggesting they are not extensively established in the wild. However, no information about the population size of exotic species in Cambodian waters is available and there are no regulations for controlling new introductions.

Table 1. Major exotic species in Cambodia*

S.N.	Common Name	Specific 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. mossmbicus*	Not known
12	Cuban crocodile	*Crocodilurhombiser*	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

** Identified by country expert participants in national workshop in Cambodia, 3 – 4 Oct. 2002.*

Lao PDR

Catla, mrigal, rohu, common carp, Nile tilapia (*Oreochromis niloticus)*, and African catfish (*Clarias gariepinus*) have been introduced to Lao PDR for aquaculture development with the assistance of international organizations. Participants of the workshop identified 13 introduced species (Table 2). However, only common carp and Nile tilapia are thought to have established naturalized populations in the wild.

Except for the golden apple snail, no information is available on the negative impacts of introduced species. The participants identified the grass carp, common carp and African catfish as high risk species. Needs to develop appropriate policies, specific measurement on zoning, and controlling movement of exotic high risk species were emphasized by the workshop participants.

Thailand

Approximately 163 species of aquatic organisms, including seven species of frogs, seven crocodile species, 3 shrimp species, over 100 species of ornamental aquatic organisms and about 20 food fishes for aquaculture have been introduced into Thailand during the last century. Some important species are shown in Table 3. Populations of grass and silver carps have been established through continuous re-stocking into the lakes and rivers. An exotic sucker catfish, *Hypostomus plecostomus,* has been caught by fishermen in the rivers of Thailand in large numbers. Nile tilapia , which has been widely used for aquaculture, is now widely distributed in the natural ecosystem. There is some evidence that

Table 2. Major exotic species and their impacts in Lao PDR*

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	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	Un-known	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	

**Identified by country expert participants in national workshop in Lao PDR, 22 – 24 Nov 2002.*

tilapia has become a main species in the Ubolratana (up to 40 percent of the commercial catch) and Lam Ta Kong reservoirs, but no information on negative impacts are available. New red tilapia, a hybrid of *O. niloticus* and *O. mossambicus*, has also been introduced from various countries. This hybrid has become a commercially important species to Thailand as it has higher demand due to its attractive colour. Salinity tolerance and faster growth have also made red tilapia popular in coastal areas.

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 be used for aquaculture stocks.

National laws prohibit the introduction of well-known invasive fish species (e.g. piranha) and twelve other endangered aquatic organisms. Other species can be imported to Thailand with permission from competent officials. The control measures are mainly designed to avoid disease outbreaks and dangers to the consumers. However, the main problem of controlling the introduction of exotic species is the lack of proper implementation of enforcement provisions in the regulations (Chinabut, 2002).

Vietnam

Participants identified 30 alien species introduced into Vietnam (Table 4) The Indian/ Chinese major carps, Nile tilapia and Mozambique Tilapia (*Oreochromis mossambicus*) are still widely used for aquaculture and have also established their population in the wild. Apple or golden snail *Pomacea canaliculata* was first found in Vietnam in 1988 and was most probably introduced through the ornamental fish trade or food production purposes.

Since no studies have been conducted, there is no scientific evidence for negative ecological or genetic impacts. The only species that has shown clear negative impacts is the golden apple snails' destruction of rice fields. Other species that have potential for negative impacts are the tilapia, grass carp, silver carp, bighead carp, *Colosoma*, *P. vannamei* and sucker catfish as they have established significant feral populations in the natural environment. Tilapia is said to have reduced biodiversity by changing the species composition in natural water bodies. For example, fishers in Thac Mo Reservoir in Binh Phuoc province believe that tilapia has eliminated or reduced some local fish species in the lake. Gene pool contamination is common in some species (e.g. between local and imported Chinese silver carpand common carp). Inbreeding problems of exotic species are also common. For example, the African catfish lineage in Thailand is thought to have originated from only one pair of fish. Exotic species have also introduced new parasites and diseases, and at least three new species of *monogenea* are thought to have been introduced with tilapia.

The importation of exotic aquatic species in Vietnam is controlled by restricting species to an approved list. The Natural Resources Protection Act of 1989 provides guidelines for protecting indigenous aquatic resources. Decision paper, 2002, details the procedures for importing a new species: it should be disease free, for experimental use only, and must not be released to the natural environment without permission. The Vietnamese participants emphasized that there was a significant need for developing a code of conduct and strengthening the capacity to implement the existing regulations.

Table 3. Major exotic freshwater fish/shrimp species 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	1997	Fisheries	-
19. *Oncorhynchus rhodurus*	-	Japan	1981	Angling/sport	-
20. *Oreochromisaureus*	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

**Identified by country expert participants in national workshop in Thailand, 24 Sept. 2002.*

Table 4: Major exotic fish/shrimp species introduced to Vietnam*

Common name	Scientific name	From	Number of introductions	Year introduced
Black Tilapia	*O. mossambicus*	Taiwan, Thailand	12	1951
Nile Tilapia	*O. niloticus*	Philippines		1973, 93, 95
		Cuba, Thailand	1	1996, 2001
Green Tilapia	*O. aureus*		4	1996
Red Tilapia	*O.* sp			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	*Labeo rohita*	Thailand, India	3	1982, 1984, 2001
Mrigal	*Cirrhinus mrigala*	Laos, Thailand	2	1984, 1996
Catla	*Catla catla*	Laos	1	1984
	Xtiobus cyprinellus	Cuba	1	1984
African catfish	*Clarias gariepinus*	Central African	1	1975
European ell	*Anguilla anguilla*	China	2	2000
	Colossoma brachiomun	China	6	1997, 1998
				2000, 2001
	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
		China		

** Identified by country expert participants in national workshop in Vietnam, 20 – 21 May 2003.*

Costs and Benefits

Positive Impacts

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. Exotic species have provided socio-economic benefits to each country addressed 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 PDR, Thailand and Vietnam, respectively (Table 5).

Table 5. Contribution of Exotic Aquatic Species to National Aquaculture Production, Including Marine Species*

Country	Aquaculture Production		Contribution of exotic species (%)
	Total	Exotic Species	
Cambodia	15,500	7,650	49
Lao PDR	49,840	49,480	100
Thailand	724,228	191,246	26
Vietnam	545,500	390,000	73

* *Source: FAO, 1999; 2001.*

Increased freshwater fish production, provision of a protein source to rural poor, local income and employment, and enhanced export income are the major positive benefits of introduced food fish species (Boonchuwong, 2002). A fish consumption survey in 1998-99 in seven provinces of the North, Northeast and central regions in Thailand 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 the Nile tilapia, which account for 8.52 kg fish/person/year for the seven provinces in urban and rural areas combined. 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 provinces.

The National workshop in Vietnam concluded that exotic species have assisted the country by diversifying its fish production, improving genetic materials and reducing inbreeding (via importing broodstock), improving food security, farmer incomes, and job opportunities, and providing uses for ornamental purposes and as larval/ aquarium feed (e.g. Artemia). The introduced species are often preferred by farmers due to their high commercial value to local and export markets, their well-developed breeding and culture technologies, and a multitude of other characteristics such as:

- Ease of breeding in captivity by small-scale farmers
- Ease of culture (e.g., disease resistance, ability to use locally available feeds, and ability to use less intensive and demanding production systems)
- Relatively higher production over indigenous species (faster growth and high survival)
- Compatibility with agro-ecosystems (e.g. can integrate with rice farming)
- Source of alternative or supplemental income and employment (e.g., via sale of table fish or seeds)
- Enhanced food security for the poor (e.g. 35% of exotic species production is used for local consumption, mainly by the poor)
- Opportunities to develop hybrids that have higher growth compared to the local fish
- Potential use for waste recycling of local resources (e.g. grass carp for weed control, Gambusia for mosquito control)
- Low risk of (some) exotic species surviving in the natural environment were

they to escape (e.g. introduced *Artemia*)

- Use as live food (e.g. Artemia)
- Opportunity for in-country broodstock development
- Easy to enhance stocks
- Aesthetic and social (status) value of some ornamental species

Negative impacts

Besides the positive economic impacts that exotic species can provide, there are also a number of negative impacts that have been attributed to them. For example, 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 PDR, it has been suspected that the native prawn has declined. *Hamparadispa* sp. and Pla Ka in Nam Ngum reservoir in Lao PDR 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. Local fishermen have caught sucker catfish (*Hypostomus plecostomus*) in large numbers from the rivers of Thailand and claimed this species might have serious impacts on indigenous speciesas it is carnivorous. Participants agreed that the sucker catfish has been seen in significant numbers in the natural water bodies in all of the four countries, especially in the rivers. Na-Nakorn *et al* (2002) showed evidence of the alteration in the genetic make-up of 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).

Several diseases and parasites have been diagnosed in the exotic fish species in each of the four countries. However, it is not clear whether 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, caused by a virus in shrimp that was thoughttransmitted through the importation of shrimp larvae, adults, or even through frozen forms (Jory et al., 1999; Soto et al., 2001).

Other negative impacts of introduced aquatic species identified by the workshop participants include:

- Excessive breeding and escape of tilapia from culture facilities
- 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* in the Angkor Borey district of Ta Kao province; some participants believe the catch,including *Notopterus*, has been reduced by 20% after the introduction of tilapia and other exotic species)

- Potential for disease contamination
- Low demand (low price)
- Potential price drop of indigenous species due to cheaper price of introduced species
- Golden snail damages rice paddy farms

Workshop Recommendations

Workshop participants recommended the following measures to better manage exotic species already introduced, and control the risks from new potential introductions:

i) ***Control of New Introductions***

- Exotic species not already established should not be imported, or should be strictly assessed through thorough risk analysis prior to importation
- Develop codes of conduct for the importation and use of exotic species
- Proper quarantine systems should be developed (especially Lao PDR and Cambodia)
- Strict implementation of aquatic animal inspection procedures by the customs department

ii) ***Management of Already Introduced Species:***

- Countries should develop appropriate policies, guidelines, regulations, and management tools for the movement/management of existing and new exotic species within their borders, taking both positive and negative impacts into account.
- Transboundary animal movement regulations should be developed and implemented
- Regulations should delineate zones that exotic species can be cultured and transported (e.g., promote culture of exotic species away from natural water bodies)
- Regulations for the stocking of fish species to natural water bodies should be developed.
- High risk species such as Grass carp, Common carp and African catfish should not be stocked in the natural water bodies
- Only indigenous species should be used in fish releasing ceremonies
- Exotics should only be used for pond culture (not for cage or pen culture) and these ponds should be away from natural water bodies
- Control mechanisms for controlling particularly invasive exotic species such as the golden snail should be developed.
- Implement existing guidelines (e.g. Thailand and Vietnam) and assign a group to oversee the introduction of exotic species
- Enhance public awareness on potential negative impacts of these species
- Strengthen capacity to implement policies/regulations (the development of manpower).

iii) ***Promotion of Aquaculture for Indigenous Species***

- Hatchery and culture technologies for indigenous species should be promoted and developed

iv) ***Impact Assessments Issues***

- Develop procedures for environmental impact and risk assessment of exotic fish species.
- Conduct risk assessment studies before allowing the introduction of new species.
- After analysing risks, develop guidelines and manuals for each alien species

v) ***Research Needs***

- Conduct research to evaluate negative impacts of already introduced exotic species
- Evaluate socio-economic benefits of native and low risk exotic species

The participants of the four national workshops recommended that the countries should be cautious about releasing new exotic species into natural water bodies. Although there are some existing regulations in these countries, there are no specific laws or implementing (enforcing) agencies. All the four countries suggested efforts should be made to develop common agreement on regional level cooperation.

Development of Codes of Conduct

Culture technologies for exotic species have served as gateways of knowledge and skill for overall aquaculture development in the region. Hatchery and culture operations, and research into exotic species have provided a large number of employment opportunities. Exotic species have served as agents for crop diversification for the rural poor. On the other hand, increased food production through aquaculture has provided a gateway for introducing new exotic species (Naylor *et al*, 2001) into the region. Therefore, workshop participants suggested the following approaches and tools for managing already introduced species.

For Managing Already Introduced Species

i) ***Development of Inventory Of Species***

There is a need for the preparation of an inventory of all the introduced exotic species and their distribution in each country. Since there are no published research documents on the impacts of introduced exotic species, the inventory should also include the reported (anecdotal) negative and positive impacts. The inventory should be able to determine whether these species should be restricted to some areas (e.g., species that breed in natural environment), or introduced widely (e.g. species that propagate naturally).

ii). ***Zoning***

Based on the characteristics of the species in the inventory, zones for movement of species to one habitat to other should be considered, based on the habitat preferences of the species introduced. The major concern here is the introduction of prolific breeding species to the greater Mekong region and its tributaries.

iii) Stocking and Transportation Permits

There is a need for each country to develop stocking and transportation permits for moving exotics to different zones/ establishing exotic species aquaculture.

For Controlling New Introductions

i) Risk Analysis

Simple procedures for the assessment of invasiveness or non-invasiveness of species are urgently needed. The practicality of the assessment procedures (i.e. cost and time) should be emphasized during their development.

ii) Health Certification & Quarantine

All four countries have some quarantine regulations but there is no specific unit or department responsible for monitoring aquatic animal exports or checking whether health certificates have been submitted. Thus, there is a need for developing strict quarantine regulations and appointing an implementation authority.

iii) National Policies

National policies and laws for management of exotic species are non-existent in all four countries. Development of such policies is urgently required.

The Process of Policy Development

It is doubtful that development of policies on exotic species, enforcement of regulations, and monitoring negative impacts using top-down approaches would be successful. These activities are compartmentalized into different ministries or institutions that usually work independently. Therefore, there is a need to develop participatory approaches and tools, building capacity and confidence and changing attitudes for managing exotic species, taking both positive benefits and negative impacts into account. A need for developing primary, secondary and tertiary educational and training curricula to train local people with a holistic view of the aquatic environment and to enhance public participation in exotic species management should be emphasized.

The AIT's Aqua Outreach Program experience over the past 12 years has found that influence through local level demonstrations is one of the best ways to develop new policies with the ownership secured with the local people. AOP learned that promoting better participation of stakeholders in the development process is the key to solving problems. Since exotic species have created socio-economic benefits for a vast number of poor people in the region, developing codes of conduct and regional guidelines should involve participatory approaches, and both positive benefits and negative impacts should be taken into account. The suggested steps are:

1. *Detailed Stakeholder Analysis*: It is necessary to identify all stakeholders (i.e., implementing partners and beneficiaries) and their participation in the process of development of the code of conduct.

2. *Problem/ Objective Analysis:* Each country has different problems and different aspirations and demands. It is necessary to guarantee all the stakeholders' participation in the problem/ objective analysis that lead to developing the code of conduct.
3. *Alternatives Analysis:* There are ranges of viable alternatives available in each country such as zoning for already introduced species, developing risk assessment procedures for new introductions *etc.* These alternatives should be analyzed taking cultural and regional context into account
4. *Development of a Management Process:* implementation of a code of conduct or regional guidelines is complex as there are many stakeholders with different aspirations. The implementation of any code of conduct is going to be difficult and costly, at least initially. Therefore, there is a need for developing an innovative process taking step-by-step approach. The process should take following into consideration.

Managing Exotics - A Need for Networking

National management groups consisting of several representatives from related disciplines (e.g. socio-economics, health, environment, etc.) should be formed to submit and review the proposals for new introduction/movement from one area to another in each country. The national management committee, working together with a regional management group, should develop the guidelines for the approval process. Procedures for forwarding information on new introductions to other national committees, and regional approval processes will have to be developed.

The capacity to undertake impact assessments, and monitor and implement regulations are weak in the four countries. Therefore, the management network should include regional partners who have activities at the field level (e.g. AIT, IUCN, MRC, Wetland International, World Fish Center, WWF, SEAFDEC). While inter-governmental organizations such as FAO, NACA and MRC can have a major influence on governmental policy at the central level, regional partners in the network who work with local level aquatic resources and management institutions can assist to develop management tools, build the capacity of local people, develop educational and training programs, and provide much needed research information for policy changes. A well-formed regional alliance with all interested partners would provide much needed expertise to develop management tools and strengthen local institutions. Developing a code of conduct without a basis on sound impact studies, and implementation procedures, and a well-designed capacity building program may not be effective in controlling and managing exotic species introductions.

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Risk Analysis as a Tool for the Management of Alien Aquatic Animal Diseases

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Introduction

Alien aquatic animal species have historically been important in the development of aquaculture, harvest fisheries and recreational fisheries throughout the world. In the Americas, Atlantic salmon (*Salmo salar),* rainbow trout (*Oncorhynchus mykiss*), and white shrimp (*Litopenaeus vannamei*) have been instrumental in the development of aquaculture industries. Rainbow trout are the mainstay for recreational fisheries managed by government agencies throughout North America. With few exceptions, all of these programs have been implemented with alien aquatic species or species native to the country but transplanted outside their historic environs to another region in the country - essentially becoming introduced alien species.

The economic value of transplanted alien species is demonstrated by the recreational trout fishery in the United States, which has an estimated value of approximately US $21 billion (USFWS, 2002). The majority of this trout fishery is the result of cultured rainbow trout being introduced into non-native watersheds. The $21 billion spent on this fishery represents more than money spent by fishing enthusiasts enjoying their favorite hobby. It also represents economic stability for tens of thousands of people who manufacture and sell fishing equipment, operate hotels and restaurants, and raise and stock the trout initially. This example manifests itself again and again throughout the world with a multitude of species.

One might conclude that the introduction of alien aquatic animals has been the savior of aquaculture, recreational, and commercial fisheries. Since much of this transplanting activity has taken place over many decades, if not hundreds of years, it is hard to turn back the clock and imagine how things might have evolved if aquaculturists had only used local stocks in their ventures. There is little value in speculating about what might have happened if we had managed differently. What we do know, however, is that many negative impacts have resulted due to these trans-boundary movements and consequent introductions of alien aquatic animals. These imports directly compete with native species and are vessels for diseases that have resulted in catastrophic losses to wild and cultured animals, alike. For example, in the Americas, the losses to shrimp aquaculture due to introduced viral diseases are estimated to be $ 5-10 billion U.S. dollars (D. Lightner, personal communication 2004).

Comparable losses have occurred in the shrimp aquaculture industries in Asia due to White Spot and Taura Syndrome viral diseases (M.G. Bondad-Reantaso 2004). The losses due to one outbreak of spring viremia of carp (SVC) in one farm in the U.S. is estimated to be over US $15 million (J. Rolland, personal communication, 2004) and the total impact of Koi Herpes Virus on Asian carps is yet to be calculated, but is likely to be in the billions of US dollars. Even within the United States, the transplantation of native species carrying diseases from one region to another has resulted in the introduction of diseases with significant impact. It is likely that Whirling disease (*Myxobolus cerebralis*) was spread in the United States as a result of intra-national movement of infected rainbow trout stocks (Bartholomew, J.L and P.W. Reno 2002).

Perhaps more important than asking the question "What would have transpired if we had not introduced the alien aquatic animals", is asking "What can we do to minimize the risk of introducing exotic diseases when we decide to import aquatic animals into our country, region, or farm?" This paper examines the utility of a tool designed for minimizing risk - Risk Analysis (RA). This tool has produced significant benefits for both cultured and wild aquatic animals.

Risk Analysis as a Tool

Virtually every daily human activity involves risk to our health and well-being. Will our breakfast give us food poisoning? Will we be run over in a crosswalk as we walk to our office? Will we be attacked by a poisonous snake while walking around our fish ponds? All these possibilities are real and many of us face these negative outcomes every single day. Is the likelihood of these events occurring high? Probably not. Yet many factors, intrinsic and extrinsic, determine whether these events will affect our lives. Likewise, when a farmer or government agency contemplates introducing aquatic animals into their ponds or country, consideration must be given to factors that may enhance the possibility of introducing alien invasive aquatic animal diseases.

The formal process by which we consider, evaluate, and manage the risk of disease introduction is called *Risk Analysis* (RA). RA is a valuable tool that attempts, in an objective and scientific way, to measure the likelihood or "risk" that an exotic disease will be introduced via the commerce of live animals or their products. Each country is afforded the ability to protect itself from alien diseases *vis-à-vis* the Agreement on Sanitary and Phytosanitary Measures (i.e., the SPS Agreement) of the World Trade Organization (WTO, 1994). This ability to protect oneself in the SPS Agreement is called the "appropriate level of protection" (ALOP). In other words, a country may establish regulations to keep out diseases known not to occur in that country. It may be very challenging for a country to define its ALOP, as much information must be known of the disease status of aquatic animals within that country. Conducting disease surveillance and reporting the results to the country's authorities is the only method that can reliably provide this disease information. Consequently, much effort must be expended within a country before looking beyond its borders in contemplation of importing new species and evaluating that import with an RA. As we can see, RA becomes an integral component of a national aquatic animal health management program (Arthur et al, 2004; and, Arthur and Bonidad-Reantaso 2004).

The process of Risk Analysis can be broken down into roughly five components (MacDiarmid 2000; OIE 2003). The following discussion provides an overview of these components in the general sequence that they would be considered in the risk analysis process. As demonstrated, each component begins with a straightforward 'big-picture' question. The challenge lies in addressing the additional considerations these big picture questions generate.

Hazard Identification

What alien disease might be introduced?

Considerations:

- Species to be introduced?
- Host susceptibility?
- Intermediate hosts?
- Occurrence in source country?

Exposure/Risk of Release Assessment

How likely is it that the alien disease will be introduced?

Considerations:

- Quantity and frequency of introduction?
- Type of product - live, fresh, frozen, processed?
- Distribution and prevalence of disease in source country?
- Type of surveillance program in source country?
- Preventative sanitary procedures in place at source and in transit?
- Sanitary measures effective at life stage of product introduced?
- Health management program in place at destination?
- Other, perhaps more susceptible species at destination?
- Environmental factors (water temperature, quality, climate) favoring the disease and/ or compromising the host?

Consequence Assessment

What are the consequences if the alien disease is introduced?

Considerations:

- How are watersheds/farms managed in receiving country?
- Can live products move easily from one area to another, exposing wild aquatic animals to disease?
- What social and economic impacts would result if the disease were to occur and spread within the wild or cultured animals in the destination country?
- Does the government have an indemnification program to reimburse farmers for their losses if eradication becomes necessary?
- Is the social or economic gain from introducing the new species and, potentially, new diseases outweigh the social and economic value of existing aquaculture programs and natural resources?

Risk Management

What can be done to reduce the likelihood of introduction of alien disease or reduce/prevent consequences should it be introduced?

Considerations:

- Are bio-security measures in place at both national and farm level?
- Are inspection procedures and health certificates issued by competent authority at country of origin?
- Are strict sanitary measures required, such as product disinfections upon entry to country/farm?
- Are surveillance programs in place to identify in a timely fashion the occurrence of an alien disease?
- Are emergency eradication programs in place that can quickly eliminate an alien disease?

Risk Communication

Has all critical information about the disease event been shared with interested stakeholders, aquatic animal health specialists, and government officials?

Considerations:

- Have channels of communication between necessary parties been established?
- Has a central repository for critical data been created?
- Can the critical data be retrieved as necessary?
- Is a notification process in place to ensure that all necessary parties promptly receive information about the disease outbreak?

When these issues have been addressed and the questions have been considered and answered, the elements of an RA have been completed; i.e., identification of the hazard, in this case an infectious disease, conduct of risk and consequence assessments, and development of a strategy to manage the risk. It sounds simple, and indeed, RA can be a very simple process. On the other hand, depending on the data available or the nature of the disease and its distribution, the RA process can become quite costly and complex. Regardless of whether the process is simple or complex, it is essential that such a process be utilized when conducting commerce with aquatic animals.

Pathways

Before proceeding with development of an RA for an aquatic animal disease, it is important to remember that there are many pathways by which an alien invasive disease may invade your country. First and foremost, the highest risk lies in the import of live, diseased aquatic animals. Unfortunately, infected animals often do not readily show clinical signs of disease and only upon stress, such as transport, does the disease exhibit itself in the form of lesions or mortality. Aquatic animals which serve as reservoirs for alien diseases may be alien species which are legally or illegally introduced, native species which are legally or illegally transported from another region within a country, or alien species entering via ballast water. The risk is highest in live animals because many pathogens can only survive for a brief period, if at all, outside a live host. Therefore, the ability of a disease-causing pathogen to exist, amplify, and spread to other organisms is highest in a live aquatic animal. It is this area that should receive the greatest consideration in contemplating, developing and implementing a RA, although all reasonable and scientifically supportable modes for disease introduction should obviously be considered.

Development

How does one prepare an RA? In the "Manual on Risk Analysis" (Arthur et al, 2004), an excellent example is provided for developing a hypothetical IRA. The suggested steps are as follows:

- Establish the IRA Team within the Responsible/Competent Authority.
- Define the scope of the project. Is this a routine, simple RA or does the situation require the RA to be complex and comprehensive?
- Conduct a preliminary hazard identification search and develop a list of possible diseases of concern.
- Identify stakeholders to be involved in or aware of the RA process and seek input from them.
- Conduct a detailed investigation into the diseases of concern that have a reasonable possibility of being present in the imported commodity based on knowledge obtained from records, oral reports from farmers or health specialists, OIE reports, and scientific literature.
- Conduct the risk assessment. Determine how the disease might enter, transfer to other organisms, spread in the region or country, and determine anticipated economic, social and biological impacts from best case to worse case scenarios.
- Conduct a risk management evaluation. Determine if and how entry of the disease might be prevented, how it might be managed or eradicated should it appear, and consider several management options.
- Conduct internal and external scientific review of the RA draft.
- Share the draft RA with stakeholders and invite their comments.
- Implement the RA policy and regulation at the appropriate local, regional, or national level.

Application

Risk analysis used to prevent introduction of alien aquatic animal diseases has a multitude of applications within and beyond traditional aquaculture considerations. Some applications for RA might be as follows:

- Evaluate live aquatic animals being imported from another country, region, or zone for the first time.
- Evaluate the import of live animals from a country with which there has been a traditional pattern of trade, but after a report from the source country of a new disease thought previously exotic in both the importing and exporting country.
- Assess the risk of intra-national commerce of live animals from a region where a serious disease is known to occur to another region where it has yet to be identified.
- Determine the risk of importing unpasteurized or unprocessed aquatic animal products from a country or region that has diseases thought to be exotic to the

country/region/farm under your jurisdiction.

- Re-evaluate traditional trading programs which previously an RA had not scrutinized.
- Assess the risk of importing ornamental species intended for home aquarium or pond use.

These are some of the ways that RA can be used. Already, many of these types of RAs have been conducted by various countries and could potentially be used as models. Notably, Australia has conducted excellent RAs for aquatic animals and two of these are listed in the bibliography section (Kahn et al, 1999a; Kahn et al, 1999b).

Limitations

The cornerstone for a robust and scientifically supported RA is a solid, ongoing surveillance program accompanied by an effective communication and reporting system to convey information to the farmer and relevant officials in a timely fashion. How can we assess the disease risk via the import of aquatic animals if the status and prevalence of diseases in the source country are unknown? With great difficulty! Having reliable surveillance programs for aquatic diseases of concern is a great challenge for <u>all</u> countries. Disease surveillance relies on trained individuals pond-side to observe and report suspected outbreaks. Accurate diagnoses require trained specialists accompanied by support from laboratories with the equipment necessary to conduct the tests. Finally, a communication system must be in place that quickly and accurately provides this information to the farmer and to the competent authority that administers the disease control program. The competent authority must maintain this information in some sort of database which is readily available when inquiries are made as to the status of diseases in a given region or country.

While specialized equipment may assist in diagnosing diseases, this equipment can be expensive and often is not available to many farms or regions. All information is valuable when conducting surveillance for potential use in a RA. It is for this reason that diagnostic programs with varying levels of sophistication exist as described in *Asi*a *Diagnostic Guide to Aquatic Animal Diseases* (FAO/NACA, 2001). Level 1 diagnostics involve pond-side observations and record keeping. This aspect is very important and typically is the first place where a problem is identified. The farmers themselves can conduct these observations and record keeping. The next level of diagnostics is Level II and it requires knowledge of parasitology and bacteriology and the use of light microscopy. This capability may be available at the farm site or a visiting aquatic animal health specialist might provide it. Finally, Level III diagnostics requires the use of expensive and sophisticated tools such as tissue culture, electron microscopy and other bio-molecular diagnostic tools. Level III capability is often not available within a country or region. However, the availability of Level II and Level III tools are growing every day and it is important that all countries or groups of countries invest in developing capacity not only in capital equipment but also in training their valuable human resources. Again, though all levels of disease diagnoses are important, diagnostics that are conducted on the most regular basis, daily by the farmer, will likely be the first point of detection. It is at this level that observations must be stressed and local personnel trained accordingly.

National Health Plans as a Vehicle to Implement Risk Analysis

Risk Analysis is but one formal portion, albeit critical, of a larger health management program that should be implemented in order to prevent the introduction of alien aquatic diseases. Having focused primarily on the use of RA to prevent the introduction or manage the spread of invasive species, it is also instructive to list the additional components of a national aquatic health program that are necessary to achieve critical objectives of disease management. Interestingly, the RA process can stand by itself as an element within a national program, and can also be woven into the threads of a national program.

Below, I provide the outline of the national aquatic animal health program in the process of being developed in the United States. After each element of the U.S. plan, in italics, is the portion of the RA that relates to that part of the plan (NAAHTF, 2003).

1. Rationale (*problem formulation*)
2. Definitions *(problem formulation and risk communication)*
3. Roles and Responsibilities (*risk assessment, risk management, risk communication,)*
4. Diseases of Concern (*hazard identification*)
5. Surveillance (*risk assessment, risk management*)
6. Disease Prevention, Control, and Management (*risk assessment, risk management*)
7. Research and Development (*hazard identification, risk assessment, risk management*)
8. Education and Training (*hazard identification, risk assessment, risk management*)
9. Outreach and awareness (*risk communication*)

A national aquatic animal health plan is the logical place to implement RA for the purposes of preventing the introduction of alien diseases to your respective countries and to also address other aquatic animal health issues. While national animal health plans are not novel approaches for terrestrial animals, these plans are relatively new for both developed and developing countries. The United States and Canada are both working diligently on their plans and likely will not have full implementation for years to come. Australia, as indicated in their *Aquaplan* (AFFA 1999), has taken remarkable strides in developing and implementing a national strategy. I would highly recommend Australia as a model for countries starting to develop their own plans. While developing a national plan and the infrastructure to support it may seem like a daunting task, there are many models available to consider and institutions such as NACA to provide assistance. If you do not have a national strategy for the prevention and control of aquatic diseases, consider starting one today!

Conclusion

Risk analysis is a powerful tool to assist all conducting commerce in aquatic animals to prevent or reduce the risk of the introduction of unwanted pests and diseases. These analyses may be simple or complex, but all have the consequence of providing improved protection for cultured and wild fishery resources. A logical place to use RA is in the context of a national health program. I would offer encouragement to all who are embarking on developing national plans and remind them there are many avenues for support, whether it is from within their own country, NACA, FAO, or APEC. The time is now to join your partners from throughout your country and the world to take the steps necessary to protect your resources and provide aquaculture and fishing opportunities for the generations to come.

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Risk Analysis Frameworks and Tools for Management of Aquatic Invasive Alien Species and Associated Trans-Boundary Pathogens: Infrastructure and Capacity Requirements

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Introduction

To effectively address the problem of the transboundary movement of invasive alien species and pathogens, the infrastructure and capacity must be in place for a number of components. These components are principally surveillance, risk analysis and response.

A country must have an effective surveillance system designed for two purposes: 1) provide reliable information on the species present and current health status of aquatic animal populations, and 2) provide early warning of an incursion so that response measures will be effective. Risk analysis is now used to provide a scientific basis to decisions on trade in aquatic animal commodities and the process is described in the *International Aquatic Animal Health Code*. In the event of an incursion, a country must be in the position to mount an appropriate and effective response and this requires planning before the event.

Together, these three components underpin what has become known as national biosecurity arrangements.

Surveillance information is used in risk analyses and also provides early warning of incursions so that responses can be implemented quickly to give a greater chance of success. On the other hand, risk analysis assists in deciding on what surveillance is required both for early warning and informing the risk analysis process as well as identifying priority pathogens and alien species for which response capabilities should be in place.

Because these three components are so closely linked, a country must have capabilities in all of them. This requires that resources be invested in people, planning, infrastructure and activities. The following table is a very brief checklist of all the major items that need to be considered in developing infrastructure and capacity:

1. Legal powers
2. Financial provisions
3. National Coordination Committees
4. National Planning Officers
5. National Centres
6. Chain of command
7. Expert advisors
8. Competent and trained personnel
9. Standard operating procedures or "How To" manuals
10. Equipment and facilities (laboratory and field) such as diagnostic laboratories
11. Training and field exercises
12. Awareness programs

Each of these three components will now be considered in turn to provide a basis for some of the issues relevant to the specific component.

Surveillance

Investigations of suspected disease occurrences that eventually result in meaningful surveillance information require:

- appropriately trained and motivated personnel;
- standardized field and laboratory methods supported by quality control;
- access to manuals and training opportunities.

Thus, the basis of all good surveillance programmes are observant and skilled people with appropriate support resources who understand what constitutes the "normal" condition of the animals under examination, are alert to changes and can describe the abnormalities they see. The precise design and structure of a surveillance program depends on its purpose. However, all surveillance programmes have some basic common features, including:

- clearly stated objectives;
- a list of diseases of concern;
- the capability and capacity to undertake investigations to the required level of diagnostic certainty;
- specifications for methods of collection of the information required;
- a system to collect, record and collate data, as well as report findings.

Expanding on the above, a capability for early detection depends on:

- farmer and public awareness of important alien species and exotic diseases;
- field officers trained in alien species recognition as well as the clinical signs and gross pathology of important exotic diseases;
- sustained general and targeted surveillance activities at a level that will meet objectives with close collaboration between field and laboratory agencies;
- establishment of systems to identify farms and trace commodities;

- effective and reliable reporting and information systems;
- laboratory capability for the diagnosis of important diseases and capacity to support field surveillance activities;
- linkages with regional and wider international organizations including participation in laboratory quality assurance programs;
- sound epidemiological capabilities.

Response

Having the capacity to mount an early response is critical to the effective management of incursions whether these be alien species or unwanted pathogens. Effective emergency preparedness planning is central to success in this area. A strong national approach is required to ensure the necessary operational capability is in place so that effective responses are efficiently achieved. Recovery from an emergency response is followed by measures to ensure that freedom from the particular alien species or disease is again maintained.

In order to have emergency preparedness planning recognized as an important core function of government services, and to have adequate funding and other resources allocated to these activities, the responsible authority should enlist the support of all interested parties. These will include the relevant minister and senior ministry officials, other government departments and agencies including national economic development planning authorities, farming and fishing communities and organizations, seafood marketing authorities, processors, traders and exporters.

Of these, the most important target groups are the government and the farming and fishing communities. In presenting a strong case for support for emergency preparedness planning, the identified disease risks should be described together with the potential socio-economic consequences of an incursion of the disease. Additionally, the benefits that will result from a more rapid response to incursions through well-planned preparedness should be forcefully presented. The case should preferably be supplemented by a formal socio-economic cost-benefit analysis.

Having an effective response capacity in place requires:

- development of national emergency plans, both generic and specific for high-risk alien species and diseases, which should be regularly reviewed and tested through simulation exercises;
- establishment of a system for national planning, consultation and implementation of response plans;
- preparation of legislative and administrative frameworks to facilitate activities during an emergency response;
- establishment of funding arrangements so that emergency responses can be implemented without delay;
- maintenance and regular evaluation of a diagnostic capability for high-risk exotic diseases;
- establishment of mechanisms to involve farmers;
- inclusion of emergency aquatic animal responses in more general national disaster

plans so that other agencies such as the police, army and other services can be engaged if required;
- organization of fisheries and aquatic animal health services in such a way as to facilitate disease reporting and national coordination of a response;
- appropriate training of key personnel;
- access to appropriate information management systems;
- preparation of compensation arrangements for farmers if required;
- access to vaccines for identified high-risk diseases;
- harmonization of arrangements with neighbouring countries to provide a regional approach if required;
- development of wider international linkages to ensure prompt assistance if required for extensive emergencies which are difficult to manage.

Risk Analysis

Risk analysis for trade in aquatic animal commodities is a relatively new concept and few countries have experience in this area. However, the OIE *International Aquatic Animal Health Code* does provide some guidance and the recently published manual on *Risk Analysis for the Safe Movement of Aquatic Animals* provides more detailed information with examples. Having an ability to undertake risk analysis essentially requires appropriately trained personnel with access to relevant information.

Tracking Pathogens Through Species Introductions: A Database Mapping Approach

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Background

The introduction of species may be a vehicle for the entry of pathogens and diseases into countries. It has been estimated that every introduced species brings with it three associated species (Torchin et al., 2003). Aquaculture species that have been moved around Asia are not exempt, with 118 documented introduced aquaculture species presenting a significant threat as hosts of pathogens (FishBase, 2004). This extended abstract summarizes preliminary evaluations of a databasing method for predicting the prevalence of two of the most problematic fish pathogens to the ASEAN region, White Spot and *Myxobolud koi,* by tracking the movements of their piscine hosts.

Overview of White Spot (Ich) and *Myxobolus* Disease Agents

The White Spot Disease caused by the protozoan *Ichthyophthirius multifilis*, 'Ich', is one of the most common pathogens of freshwater fish held in aquaria and aquaculture facilities. Highly contagious, it can spread rapidly, moreso in crowded aquaculture facilities. It can thrive in 2-33°C, completing its life cycle in only four days when temperatures are at or above 25°C, to more than five weeks when temperatures are lower than 7°C. Pathological changes include frayed fins, thickened mucus coat, skin erosion with associated scale loss, hyperplasia, necrosis, and loss of gill function, all of which lead to disruptions in osmoregulation. The disease agent can cause mortality of fishes up to 100 percent in aquaculture facilities. It affects several species of importance to the aquaculture industry in Asia, including *Aristichthys nobilis*, *Carassius auratus auratus, Catla catla, Cirrhinus cirrhosus, Cyprinus carpio* and *Pangasius hypophthalmus* (AAPQIS, 2004).

Myxobolus koi, is a small unicelled parasite, infecting the connective tissue of gill filaments, subcutaneous tissue, swim bladder, spinal column, and internal organs of the host. The spores are extremely resistant and can withstand freezing. It causes hyperplasia in the gill filament resulting in inefficient oxygen uptake. Gills start to disintegrate which causes respiratory failure in affected animals. The disease was originally recorded from carp (*Cyprinus carpio*) in Japan and apparently spread to Korea, China, the former USSR, Indonesia, Sri Lanka, the Philippines, Vietnam, the USA and England through transboundary movements of aquacultured species. It has been reported to cause mortalities of young common carp cultured in China, Japan and Indonesia. It has also affected *Acanthorhodeus asmussi, Barbus gonionotus, Cyprinus carpio haematopterus, Hypophthalmichthys molithrix*, *Leuciscus cephalus*.and *Squalibarbus curriculus* (AAPQIS, 2004).

Species Movement

Cyprinus carpio (carp) is known from Western Europe throughout Eurasia to China, and South-East Asia, Siberia and India. Widely cultivated and important for many communities, it has been introduced to 121 countries for aquaculture with an estimated global production of 2.85M tons in 2001 (*see* http://www.fishbase.org/report/FAO/FAOAquacultureList.cfm?scientific=Cyprinus%20carpio). However, this species is also susceptible to several diseases, including the White Spot Disease and Myxobolus koi. The movement of this species may have expanded the range of some diseases and pathogens. For countries sharing common waters and moving live fish among themselves, this is a significant problem.

Cirrhinus cirrhosus (mrigal) is native to large rivers in the Indian subcontinent but has been recorded in several countries in Asia. It has been introduced to 12 Asian countries for aquaculture (FishBase 2004) with an estimated global production of 590,000 tons in 2001 from Bangladesh, India, Laos, Myanmar, and Thailand alone (http://www.fishbase.org/report/FAO/FAOAquacultureList.cfm?scientific=Cirrhinus%20mrigala). The species is also susceptible to the white spot disease (AAPQIS, 2004).

Methodology for Tracking Species Movements

The movement of fish species within Asia was reanalyzed using both the Database of Introduced Aquatic Species (DIAS) (http://www.fao.org/figis/servlet/static?dom=root&xml=Introsp/introsp_s.xml) and FishBase (http://www.fishbase.org/search.cfm). This exercise was done to illustrate the possibility of using databases and information sources from different organizations to predict probable presence and sources of parasites in the country. The introduction records were utilized to create a "flow chart" of source and destination of carp and mrigal movement. Dates of introduction were placed in between countries to show initial entry of species into the country. Reports of disease outbreaks within Asia retrieved from the Aquatic Animal Pathogen and Quarantine Information System (AAPQIS) (http://www.aapqis.org/main/main.asp) and FishBase, (http://www.fishbase.org/search.cfm) were then overlaid to the *Cyprinus carpio* (carp) and *Cirrhinus cirrhosus* (mrigal) "flow charts". Dates of the outbreaks were also incorporated in the chart. The diseases and fishes used as examples were dependent on data availability in the databases and importance of the species in the region.

Preliminary Results, Implications and Future Considerations

Preliminary results indicate that tracking the probable pathway of the diseases provide simple [1] to complex [2] paths. A simple path means that a link can easily be shown from a probable source to a disease outbreak in the country where introduction records from the source country to the recipient country exists.

[1] Country A (probable source) —— Country B (disease outbreak reported)

A complex pathway is one wherein a disease may have traversed several country introductions before disease outbreak in a country is reported.

[2] Country A (probable source) — Country B —— Country C —— Country D (disease outbreak reported)

Presence of the disease (e.g. Ich) outbreaks (in other species) in other countries within the probable pathway of the disease in mrigal served as a validation of the more complex disease pathways. Not all species movement nor disease outbreaks have been documented or reported (Reantaso, pers. comm.), hence it is difficult to ascertain the probable presence or absence of a parasite or pathogen. Additionally, a particular pathogen or disease may be introduced by one or more species. Nevertheless, the above approach of mapping species introductions and disease outbreaks can provide clues as to the probable presence of the pathogens in countries where disease outbreaks have not been reported as well as locate the probable source/s of the pathogens when the disease has erupted in a country using databases and other information sources.

Knowing the probability of parasite presence in any country will enable countries, agencies and industry to take precautionary measures to ensure that the pathogen can either be monitored, kept in check or eradicated prior to becoming a major problem.

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Fishbase: Towards Building a Tool to Assess Species Invasiveness

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Introduction

The precautionary approach to species introductions has been espoused by several organizations like the Food and Agriculture Organization of the United Nations (FAO), the International Council for the Exploration of the Seas (ICES) and the World Conservation Union (IUCN). This approach is promoted partly to address the uncertainty of a species becoming established in the environment into which it has been imported, as well as to address the potential irreversible ecological impacts alien species may bring. At present, risk screening protocols for introduced species are largely based on qualitative categorizations or expert opinions, however, quantitative, repeatable and transparent assessments are being promoted by the National Research Council of the United States as the next generation of risk assessments (Kolar and Lodge, 2002). This entails having biological information about the species proposed for introduction as well as impacts of the species where they have been introduced available in electronic format and freely accessible to users.

FishBase

FishBase, an information system that contains biological, ecosystem and country data on finfishes has also been developing and incorporating global information on introduction of fish species. This database is being developed by FAO, which initially provided Fishbase with information from their Database of Introduced Aquatic Species. FAO gather introduction data from their member countries through questionnaires. FishBase introductions data come from published information sources including books, journal articles and project reports (Casal and Bartley, 2000). Together, these data sets become powerful tools to show the magnitude and breadth of the movement of fish species as well as the impacts of species introductions.

Importance of alien species in the ASEAN

There are over 3,300 records of species introductions globally as recorded in the database, roughly 60% of which have established in the wild. In the ASEAN region comprising of 10 member countries (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam), 348 introduction records have been logged, 39% of which have been reported as established in the wild (FishBase, 2004). This is by no means complete, as there has been no exhaustive assessment of fish species that have been introduced to the different countries to date. The importance of aquaculture in the ASEAN region cannot be overemphasized in these introductions. Indonesia, the Philippines and Thailand rely heavily on introduced species for aquaculture, with 72%, 77% and 46% of aquaculture production from non-native species in 2000 respectively (FishSTAT, 2003). Increased trade and tourism have also exacerbated the movement of alien species. The aquarium industry has been identified as the probable source of marine introductions like the Indo-Pacific lionfish *Pterois volitans* in the Western Atlantic.

Several reports related to alien fish species are accessible on CD-ROMs, DVD and web interfaces of FishBase (www.fishbase.org). These include the following:

1. The matrix of species introductions provides the overall view of global introductions. It provides two report interfaces - one shows the number of introduction records while the other shows the number of species which have been introduced from one FAO area to another (e.g. introductions from Africa inland waters to Asian inland waters and so on).

2. List of species introduced into particular countries. For most of the countries, the list is not complete, several species which have entered the countries have not been documented, particularly those which came in through the ornamental industry.

3. List of species that have reported adverse introductions where they have been introduced. From this list one can get into the specific introduction record and check on impacts the species had on the particular country (e.g. what species it competed with, preyed on, displaced, etc.). This is available in the global, regional as well as local scale. Since all information within the database is referenced, the user can go back to the original source of the data.

4. The species summary pages provide information on the taxonomy, distribution, biological characteristics and environmental characteristics among others on one page; another page reports the availability of information on over 28,500 fish species in the database. From this page, the user can jump to other information related to the fish within and outside the database (on a species to species linkage). These include characteristics that have been identified as important to assess invasiveness of a species such as reproduction, growth, resilience, salinity ranges, food ranges or trophic status.

The biological characteristics of the species and its environmental requirements play a major role in species establishment (Pullin et al., 1997). Species introduced for aquaculture almost always escape aquaculture facilities and make their way to natural waters (Welcomme, 1988), others released from aquaria are also able to thrive in natural waters (Lever, 1996).

In the near future, a customized species summary page from FishBase (on species invasiveness) will be available and it will show only characteristics that are useful to assess species invasiveness, where the species have been introduced and their impacts. It will also provide linkage to other databases that have similar information to allow users ease of access to related sources. Field assessments to better gauge the probability of species becoming established after introduction are badly needed, but for several countries this is simply not possible. Developing countries cannot afford field assessments while other countries may not be willing to spend for the exercise.

Developing an information system and decision making tool which provides biological data to assess species behavior prior to introduction is of vital importance. This approach would provide a cost-effective way of getting information on the risk of species being proposed for introduction into a specific country. This desktop decision-making tool could provide a system to better plan and manage natural resources. Organizations can work towards this pooling resources and institutional strengths for a risk assessment tool which can warn managers and decision makers of species which are likely to establish and become invasive in their proposed ecosystems (Casal, 2003).

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Pilot Project on the Linkages Between Development Assistance and Invasive Alien Species in Freshwater Systems in Southeast Asia: A Report to the U.S. Agency for International Development

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Introduction

For decades development projects have worked to improve the social, economic, and political reality of those in the developing world through agriculture, fisheries, and water security projects. Until recently, these projects have typically been conducted without much consideration for their impacts on the surrounding ecosystems that ultimately sustain local communities. At times, project managers and donor agencies have failed to recognize or acknowledge that cultured organisms can have significant impacts on ecosystems and human health when they are released or escape into natural systems (Msiska et al. 1991, Welcomme 1988). As a result, species originating in one part of world have been intentionally or unintentionally introduced into other regions of the world. In some cases, these alien species have proven invasive, causing harm to ecosystems, economies, or human health, and thus threatening the very development activities they were introduced to support. Collectively, these introductions have contributed to a long-term problem of global scale; invasive alien species (IAS) are now among the top drivers of biodiversity loss and environmental change globally (Sala et al. 2000).

As awareness of IAS has grown, efforts to safeguard against their spread have begun to emerge. Forward-looking development agencies, which may have in the past been responsible for IAS introductions, are now educating their officers and partners about the risks posed by IAS. Recognizing the significant impacts that IAS have on the environment, economy, and human health, the U.S. Agency for International Development (USAID), in cooperation with the Global Invasive Species Programme (GISP), sponsored a preliminary assessment to investigate the linkages between IAS and development assistance in the freshwater systems of Southeast Asia. This report details the findings of the assessment, which focused on three areas – (1) development assistance as pathway of introduction, (2) development assistance projects adversely impacted by IAS, and (3) development assistance projects working to address IAS.

The assessment findings indicate that some development agencies are engaged in aquaculture projects that use alien species in Southeast Asia's freshwater systems in order to further food security and economic development (WorldFish 2003c). On occasion, the cultivation of local species has been suppressed in order to use species that international experts better understood (Msiska et al. 1991). Traditional aquaculture species like carps and tilapias, which have been documented to be extremely invasive in some parts of the world, are still commonly used outside their native ranges. In Southeast Asia, these species are sometimes used in open water systems, often absent even a basic assessment of their potential impacts, and certainly without long-term monitoring programs in place. In recent years, a few development agencies have begun to evaluate the introduction, use, and distribution of alien species that have a significant potential for becoming invasive and thus undermine their projects (MRC 2002a). Some development agencies have begun to develop alternatives to alien species. For instance, there are efforts underway to establish an indigenous aquaculture program in the Mekong region of Southeast Asia. Increased financial and technical support is necessary, however, to expand these activities and make them sustainable throughout the region. Yet, there still remains a significant need for greater education on the risks of IAS within the development assistance sector, as well as further evaluation following the introduction of alien species.

For all programs involving alien species, regional governments need to increase their capacities to conduct adequate risk assessments and environmental impact assessments. Given the progression of regional and global trade integration, coupled with the increasing freshwater aquaculture production, the countries of Southeast Asia will undoubtedly face escalating risks from IAS. In order to ensure sustainable development, development agencies must continue to raise awareness of IAS, as well as provide means for the Association of Southeast Asian Nations (ASEAN) countries to protect both their economies and their ecosystems from the impacts of IAS. A summary of recommendations arising from this assessment is listed in the following section. The authors hope that these recommendations will help ensure that the sustainable development opportunities for Southeast Asia are not diminished by the economic and ecological impacts of IAS.

Summary of Recommendations

Based on the findings of this assessment, the authors recommend that USAID and other relevant donor agencies take the following actions to support responsible and sustainable development practices in Southeast Asia. In order to be effective, the specific means by which the recommendations are addressed will need to reflect the socio-economic and ecological contexts unique to each ASEAN country.

USAID Internal Action

- Policy
    - Improve coordination among USAID offices regarding species introduction and the implications of IAS.

USAID Interagency Action

- Policy
    - Use the findings of this assessment, to inform the revision of the U.S. National Management Plan on IAS, especially the international section.

- Coordinate between USAID and other development agencies on activities that are relevant to the prevention, management, control and eradication of IAS.

USAID External Action

- Policy
  - Promote acknowledgement and enforcement of existing instruments governing sustainable management of fisheries, including protection of biodiversity.
  - Encourage and support a study to identify gaps in international and national policies that enable resource managers to introduce and propagate alien species without adequate consideration and prevention of potential ecological and socio-economic impacts. As a result of the study, projects should be developed to help countries design new policies to rectify these gaps.
  - Identify and promote use of 1) incentives for resource managers to apply "best management practices" for native and alien species and 2) penalties for resource managers whose practices lead to the introduction and spread of IAS.
  - Work with the Mekong River Commission (MRC), WorldFish Center, USAID Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP) and UN Food and Agriculture Organization (FAO) in addition to engaging managers, policy makers, industry and other stakeholders to help developing countries implement the Code of Conduct on Responsible Fisheries.

- Management and Monitoring
  - Assist governments, industries and local communities within the region to improve management and monitoring infrastructures, including the development of best management practices.
  - Encourage the continued development and expansion of indigenous aquaculture programs coupled with sustainable capture fisheries management.
  - Promote a holistic approach to the management that considers genetic diversity (especially with respect to indigenous aquaculture), pathogens and parasites associated with fisheries, as well as native biodiversity at all levels.

- Research
  - Encourage and support studies, such as the WorldFish Center's and the USAID PD/A CRSP's work to develop techniques for the management of alien aquatic species that significantly reduce the potential impact on native biodiversity (e.g., minimizes escapes, disease-transfer).
  - Encourage and support research to identify environmentally-sound methods of eradicating and controlling aquatic IAS (including pathogens and parasites) within the region.
  - Encourage and support programs, such as the MRC's Aquaculture of Indigenous Mekong Species program and the USAID PD/A CRSP program, to investigate and promote, where appropriate, the use of native fish species for aquaculture.

- Information Sharing
  - ➢ Strengthen technical capacity in risk assessment and environmental impact assessment by sharing relevant information from U.S. National Invasive Species Council and providing training and financial support where feasible.
  - ➢ Provide governments with copies of relevant IAS publications (e.g., U.S. National Invasive Species Management Plan) as well as encourage the development of national and regional plans to prevent and manage aquatic IAS.
  - ➢ Encourage the governments of the region to report the occurrence of aquatic IAS (including pathogens and parasites) through the Network of Aquaculture Centres of Asia-Pacific (NACA) and other relevant mechanisms and support them in the development of regional network of national databases on aquatic IAS.

- Education & Training
  - ➢ Further develop environmental education programs for industry, policy makers and local non-governmental organizations (NGOs) and communities about the importance of native biodiversity and the potential risks associated with alien species, like those PD/A CRSP has developed.
  - ➢ Support the development of a field guide/website on aquatic IAS present in Southeast Asia, that includes information on emerging IAS, that is IAS that are already established in neighboring regions or the countries of trading partners with similar environments.
  - ➢ Where necessary, provide training on the aforementioned issues using local/regional training centers and experts in conjunction with relevant U.S. agencies or multi-national organizations such as the World Conservation Union (IUCN) or CAB International (CABI).

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The Global Invasive Species Information Network (GISIN): Expert Meeting Summary and the Way Forward

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Background

The first major meeting to consider the global character of the IAS threat was held in Trondheim, Norway in 1996, convened by the Norwegian government and various United Nations (UN) organizations. Participants recommended development of a global strategy and mechanism for addressing invasive species. As a result of this meeting, the Global Invasive Species Programme (GISP) was formed in 1997.

In 2001, the GISP issued a 'Call to Action' at the 6th meeting of the Subsidiary Body on Science, Technology and Technical Advice (SBSTTA) of the Convention on Biological Diversity (CBD), held in Montreal, Canada. This Call to Action described the effects of IAS as a global problem and challenged governments, inter-governmental organizations, non-government organizations, the private sector and all other interested parties to take steps to implement the Global Strategy on Invasive Alien Species.

In 2002, the CBD designated GISP as the International Thematic Focal Point on IAS under the Clearing House Mechanism and directed GISP to identify standards & protocols for implementation of a Global Invasive Species Information Network (GISIN).

After issuing the Call to Action in 2001, the GISP initiated and coordinated seven regional workshops to assess the global IAS threat, impact, and needs. These and other related workshops resulted in several declarations (e.g. the Kirstenbosch declaration from South Africa and the US in 2000; the Copenhagen declaration from the nations of the Nordic/Baltic region and the Brasilia declaration from South American nations in 2001; the Davis Declaration from the North American Invasives Hub meeting in 2002). Reports delivered by the nations involved in these workshops identified the need for information sharing, capacity building, financial support, research, expertise and other resources for addressing the IAS threat.

During a re-organizational phase within the GISP in 2003, the NBII was approached by the U.S. Department of State and asked to coordinate a workshop or gathering of experts to explore the implementation of a GISIN. A global planning committee was established with 24 members.

Pre-Expert Meeting Activities

Over a period of two months prior to the meeting, a list of about 150 online IAS databases and general biodiversity databases containing IAS information was distributed via the GISIN online Community prior to the meeting (Sellers 2004). An accompanying document "Databasing Invasions: A Review in the Context of the Global Invasive Species Information Network (GISIN)" reviewed this list of databases and provided background information on the development of the GISIN concept (Sellers 2004).

A straw-man document presenting a possible organizational framework was also created and presented to participants prior to the meeting. An electronic pre-meeting discussion among members of the IAS community also took place, to refine the meeting's agenda and share database standards and schemas.

The GISIN online community was created and launched in February 2004, is hosted by the NBII, and consists of over 170 international members and is accessed via the Internet, through a login mechanism. It provides members with the ability to conduct online discussions, share and edit documents and other information resources, and generally keep track of the progress of the GISIN concept. As the GISIN grows, this online forum will grow with it. Different project areas can be created for each working group involved in implementing the GISIN. It is hoped that the working groups on content, infrastructure, capacity building, and organizational framework will use this community to achieve further development of the GISIN.

Expert Meeting on The Implementation of GISIN

An 'Experts Meeting' was convened from April 6th to the 8th in 2004, in Baltimore, Maryland, USA. Five goals for the meeting were established, including:

1) Creation of an online community to support global collaboration,
2) Identification and agreement on common data types for global database cross-searching and interoperability,
3) Creation of a proposal funding toolkit containing such things as example proposals, proposal-writing guidance, suggested funding sources and other related information, as a capacity-building task,
4) A review and listing of existing online IAS databases, and
5) Production of workshop proceedings.

The Experts Meeting was attended by 76 participants representing 26 countries. Thirty-four of the participants were from outside the U.S. These included information managers, IAS managers, database developers, programmers, biologists, professors, students, consultants, contractors, and others that all shared a common desire to combat the IAS threat on a global scale through the creation of a GISIN.

The interests of government, non-government, academic, and private organizations as well as individuals were presented by these participants through formal and information discussions during the meeting.

Presentations on eleven different databases or information systems were given, and grouped into sets of three with each presentation demonstrating a theoretical, centralized, or distributed approach to serving IAS information on the Internet.

Participants learned about the technology, standards and protocols behind each type of system, and considered the components that might be incorporated into a GISIN. These presentations included global examples (GBIF and FISHbase), as well as regional ones from Europe, Asia, and the Americas.

Four formal breakout groups gathered each day to discuss organizational issues, database infrastructure, content, and capacity building.

A fifth breakout group was also formed on the second day and dealt with aquatic systems and how they might connect to NISbase, a distributed database system created by US Geological Survey and the Smithsonian Institution.

Each breakout group provided summaries of their discussions at the end of each day, which were published in the proceedings of the workshop (Sellers et al. 2004, see http://www.gisinetwork.org/meeting04.html).

Immediate Outcomes of The Meeting

The meeting participants agreed to create an Interim Steering Committee (ISC) consisting of 6 members from different countries: Brazil, China, Denmark, Malaysia, Morocco, and USA.

The objectives of the ISC are to:

- Develop a plan of work
- Finalize and distribute the Baltimore Declaration
- Determine the group's affiliations and financial support
  Options under consideration — GISP, GBIF, IUCN-ISSG, US DOS, World Bank/GEF
- Acquire a domain name, **http://www.gisinetwork.org** (will be maintained by NBII, in the medium term)
- Distribute the *Databasing Invasions* document (available on the Web)
- Catalog online IAS information systems (maintained by NBII, as stated earlier, it's currently 207 entries and growing) with sub-set on Aquatic IAS online databases (87 entries)

The Way Forward

The future of GISIN is bright but may progress more slowly than expected due to the voluntary nature of the network and the fact that everyone has their plate already full. However, much encouragement and support has been received, such as:

- NBII offered a free DiGIR training workshop that at least one IAS database programmer attended.
- GISP has offered to fund efforts to create a program of work for GISIN Steering Committee approval.

- Brazil/Argentina are translating and sharing their I3N database structure with GISIN participants
- Asia has prepared a proposal for a regional hub
- The GISIN concept is being presented at diverse meetings ranging from IUCN Biodiversity Commons in Scotland, Weeds Across Borders II, Beijing IAS Symposium, and a Peach Fruit Fly Regional Workshop in Africa, and this Penang Meeting.

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CAB-International: Its Activities Related to Information On Invasive Alien Species

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Introduction

The Center for Applied Biosciences International (CABI - www.cabi.org) is an inter-governmental, not-for-profit organization established by treaty-level Agreement among its 41 member countries. It seeks to help improve human welfare worldwide through the dissemination, application and generation of knowledge, with emphasis on agriculture, forestry, human health and the management of natural resources, and with particular attention to the needs of developing countries. It has its headquarters in Wallingford, United Kingdom and maintains an international network of regional centres around the globe.

The CABI *Publishing* programme (www.cabi-publishing.org) is broad based in terms of product type and has a focus on the applied life sciences. Product areas include

- *Bibliographic databases* delivered on the Internet, CD-ROM, and in print
- *Primary journals* delivered on the Internet and in print
- *Books* and *related products* including the Topics in International Health CD-ROM series developed with the Wellcome Trust.
- *Compendia* developed in collaboration with partners in government, industry and development
- Internet Knowledge Communities

CABI *Bioscience* (www.cabi-bioscience.org) operates from CABI Centres in the UK, Switzerland, Malaysia, Pakistan, Kenya and Trinidad & Tobago. CABI *Bioscience*'s unique multidisciplinary scientific capability, and its links with CABI *Publishing*, position it ideally for tackling some of the world's most challenging problems in agricultural sustainability and biological diversity. CABI *Bioscience* has mutually productive partnerships with many global organisations, agencies, foundations and corporations. By working together the complementary capabilities are combined to create a potent scientific force in support of sustainable development.

The CABI *Information for Development Programme* is an interdivisional programme providing information in applied life sciences. It supports programmes to design, build and sustain information and knowledge management systems in developing countries, as well as participates in access to research information initiatives.

CABI Activities Relevant To Invasive Alien Species Information

CABI Compendium Programme (www.cabicompendium.org)

The Compendium Programme, managed by CABI, plays a coordinating role in compiling expert inputs on chosen topics into global knowledge bases ("Compendia").

These are presented through innovative and user-friendly technology (the "Compendium Technology") on CD-ROM and the Internet.

To date, the Programme has completed three global development projects whose outputs are:

- The Crop Protection Compendium (CPC) (released 1999; after 4 years development; cost US$3.9M)
- The Forestry Compendium (FC) (2000; 3 years; $2.2M)
- The Animal Health and Production Compendium (AHPC) (2002; 2.25 years; $1.9M)

It is currently committed to the development of:

- The Aquaculture Compendium (AC) (2005; 2 years; $2M)

The existing Compendia already provide a great deal of information on invasive species of importance to agriculture, forestry and animal health and are proven to assist users in assessing risks and evaluating impacts and control of potentially harmful organisms.

Members of the Development Consortia have requested that more information be included on invasive species as a priority. This has resulted in the funding of an 18-month development project for the CPC which will add over 200 new data sheets on invasive weeds and other pests and provide information on 'invasiveness' and environmental impact on many more, for publication in July 2004. Next year, the Aquaculture Compendium will include information on a range of invasive aquatic animals, plants and disease agents, concentrating on species in husbandry and their health. Novel information technology is applied to provide choices for presenting and retrieving data.

There is current interest in the development of an Invasive Species Compendium from various Consortium members of existing Compendia, other users and from within CABI. In 2001-2002 a feasibility study for the development of an Invasive Species Compendium was initiated by USDA-ARS, a Consortium member of the CPC. This study consisted of discussions with numerous contacts, a user needs survey and an expert consultation in Washington DC in June 2002. This workshop recommended that the U.S. National Invasive Species Council (NISC, USA) ask CABI to take the lead in the development of an Invasive Species Compendium.

CABI Publishing

CABI *Publishing* produces over 60 new books each year. Its output consists of research monographs, student texbooks and major reference works, including dictionaries and encyclopaedias. Conference proceedings and practical handbooks for the professional reader are also key features of the list.

At least two books have been published by CABI *Publishing* on invasive species i.e., *Invasive Alien Species: A Toolkit of Best Prevention and Management Practices* (2001), and *Invasive Plant Species of the World : A Reference Guide to Environmental Weeds* (2003).

CABI and the Global Invasive Species Program

CAB *Bioscience* is a founder and partner of the Global Invasive Species Programme (GISP) and is responsible for co-ordinating GISP's activities in prevention and management of IAS. In an collaborative effort, CABI Bioscience produced the first *Toolkit for Prevention and Management of Invasive Alien Species* (Wittenberg and Cock 2001), and carried out a review of the efficiency and efficacy of existing measures for prevention, early detection, eradication and control of invasive species and their impacts for the SBSTTA 6 meeting of the Convention on Biological Diversity in 2002 and has worked with other partners to develop GISP's second phase of work

CABI *Bioscience* staff from different centres have also been actively participated and involved in the regional workshops on *Prevention and Management of Invasive Alien Species* : Forging Cooperation Throughout Southern Africa (June 2002), South and Southeast Asia (August 2002) and the Austral-Pacific (2003). Six proceedings and national reports from these workshops have been published by GISP (see www.gisp.org).

CABI South East Asia Regional Centre (SEARC)

CABI-SEARC in collaboration with ASEANET (The South East Asian LOOP of BioNET International) has recently conducted a survey, through questionnaires on Invasive Alien Species in South East Asia covering several topics, e.g. available regulation on IAS, responsible organisations dealing with IAS, R&D on IAS (monitoring, management, etc.), the most serious IAS in each country, available information/ databases, priorities for regional/international collaboration, etc.

The report from the survey can be summarized into the followings:

- A regional network on IAS should be established in SE Asia
- The golden apple snail (GAS) is considered the most serious IAS in SE Asia, followed by the aquatic weeds water hyacinth (*Eichhornia crassipes*) and salvinia (*Salvinia molesta*)
- An information network (databases) on IAS should be established in SE Asia
- Regional programmes to manage/control GAS and aquatic weeds should be initiated and coordinated with donor funding
- Capacity building on identification, early detection, survey and monitoring and on treatment should be implemented

Based on the report a draft proposal on the IAS database development has been prepared and submitted to donor agencies for funding consideration.

CABI-SEARC staff is also actively involved in the preparation and establishment of the Global Invasive Species Network (GISIN) through the participation in the Expert Meeting on this held in Baltimore, USA in April 2004 (Sellers et al. 2004 eds).

CABI's Wider Contribution to Addressing Invasive Alien Species Problems

In addition, CABI contributes to addressing invasive species problems and pest management in the following ways:

- Provision and management of information related to invasive species (e.g., research, surveys of IAS and their impacts, needs assessments, risk analysis, databases, compendia, journals, internet knowledge community such as ICMFocus.com).
- Capacity building (e.g., taxonomic services, training, formulation of management tactics, supporting policy and institutional frameworks, supporting national and regional programmes and actions,
- Specific services such as third country quarantine for biological control agents of invasive species (UK-Bioscience Centre, CABI-South East Asian Regional Centre in collaboration with Malaysian post entry quarantine facilities)

CABI is carrying out research and development on a number of fronts in environmentally friendly agricultural production including integrated pest management, rational pesticide use, and biopesticides. It supports the larger cause of biodiversity conservation through award wining research into cryo-preservation protocols for micro-organisms, conservation of endangered insects in the United Kingdom and investigating impacts of climate change on ecosystems.

Part 3
The Country Papers

Brunei

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Introduction

Brunei Darussalam is confined to a small area of land consisting of a small number of large rivers and lakes. As a consequence the existing freshwater aquatic fauna is not as varied compared to other comparatively larger countries in the region. However, there is a significant number of indigenous fish species that can be identified as local varieties.

Common exotic aquatic fauna in Brunei Darussalam

A few species such as tilapia spp. (*Oreochromis* spp.), common carp (*Cyprinus carpio*), Chinese carps, Indian carps, giant gouramy (*Osphronemus gouramy*), channel catfish (*Ictalurus punctatus*), and lampan jawa (Javanese carp) are commonly found in the country.

None of these species are found released into the natural water bodies and are not considered a hazard for the country's water bodies. There is no reservoir fishery or aquaculture systems in natural water bodies except those for tilapia, sea bass and grouper being cultured in cages mainly in the mostly populated areas of the Brunei River. The seedlings are produced either locally or imported from neighboring countries such as East and West Malaysia and Thailand.

Apart from this, there is a significant number of ponds being used for freshwater aquaculture in different parts of the country. Of the fish species mentioned above, only the tilapias and common carps have become established in freshwater cage culture. Tilapias do not produce seedlings in brackishwater cages. Common carps do not breed in the ponds. Therefore these varieties have not been identified as invasive.

Ornamental fish varieties

Most of the ornamental fish varieties are exotic to Brunei. There are about 200 to 400 species of ornamental fish (total of close to 1million imported fish) being imported into Brunei. Most of the imported ornamentals are used as food fish for arowana (*Scleropages formosus*) and other predatory varieties like flower horn (*Cichlasoma temporale* and *Cichlasoma citrinellum*). These fish species have not shown any negative impact on the country's aquatic fauna as they are confined to tanks and aquariums.

Other alien species

Aside from the species of freshwater ornamental and food fish varieties introduced into Brunei, there are a few varieties of shrimp known to be in abundance. These are the alien blue shrimp

(*Litopenaeus stylirostris*) and indigenous tiger prawn (*Penaeus monodon*). They are cultured and reared in ponds in gazetted areas identified by the Department of Fisheries as suitable areas for shrimp culture.

Aquatic plants

Importation of aquatic plants is negligible, but there are some hazardous aquatic plants present in the country such as water hyacinth (*Eichhornia crassipes*), eared watermoss (*Salvinia aurioculata*), lesser duckweed (*Lemna minor*), and hydrilla (*Myriophyllum* sp.)

These varieties may have been introduced during the World War II period in order for water bodies to be camouflaged as grounds. Water hyacinth has become a menace to almost all Asian and African countries.

Legislation

Most fish imported into Brunei require a health certificate from the exporter and there are quarantine facilities in most of the aquarium fish dealers. The health certificate requirement is not yetthoroughly implemented as a rule.

The sole authority for licensing the dealers of aquatic fauna is the Department of Fisheries which has the responsibility for implementing Section 61 of the Fisheries Act. Experiments were done and are being carried out, on the aquatic fauna and flora, by the Department of Museums in collaboration with the private sector. Some of the research is being carried out by the University of Brunei Darussalam (UBD) in collaboration with the Department of Fisheries concerns a rural aquaculture development program for green kissing gouramy, as this species is found in abundance in some of the natural water lakes in Tasek Marimbun. Since this is an indigenous species it's aquaculture has not shown any impact on biodiversity.

Plan and implementation of prevention of impacts of invasive aquatic flora and fauna

- Health certificate from the country of origin (required)
- Health Certificate on any commodity exported from Brunei Darussalam
- On border spot checking and random sampling
- Quarantine period of 10-14 days before releasing the commodity to the retail dealers
- Market survey of the industry of aquatic fauna introduced into the country
- Any clinical and/or investigative identification of diseases in any commodity should be either quarantined or destroyed
- Follow-up of the procedure by random checking
- All the dealers must have a quarantine facility in their own premises
- Transfer technology concerning quarantine and treatments to the public and those who deal with this industry
- Illegal dumping of unknown species to local water bodies being fined
- Public awareness and education

This could be carried out with the help of the relevant departments and through sponsorship of the private sector. Adopting international legislations and ISO certifications of the relevant subjects will enhance the implementation of the programme.

There should be a quarantine laboratory for aquatic and non aquatic commodities in the main importation facility like the international airport and a staff of qualified technicians should be on alert 24 hours of the day depending on the flight schedules.

Outbreaks of disease epidemics

There has been no major outbreak of disease in the country; however, there are a few cases of parasitic infestation like *Argulus* in some ornamental fish ponds belonging to private personnel.

Government agencies

Government agencies, ministries and non-governmental organizations that are involved in addressing IAS management in Brunei Darussalam are:

- Department of Fisheries, Ministry of Industry and Primary Resources (addressing fisheries Sector)
- Department of Agriculture, Ministry of Industry and Primary Resources (addressing agriculture sector)
- Department of Forestry, Ministry of Industry and Primary Resources (addressing forestry sector)
- Department of Environment, Parks and Recreation, Ministry of Development
- Department of Museum, Ministry of Culture, Youth and Sports
- University of Brunei Darussalam (UBD)

Future actions

National priorities for future work and strategies on aquatic IAS

- Fisheries Act and Regulations
- Import and Export Regulation
- Disease surveillance, Monitoring and Control System
- Fish Disease Action Plan for Emergence of Disease Outbreak
- Human Capacity Building and Infrastructure
- Public Awareness
- Implementation of Code of Conduct for Responsible Fisheries

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Part I: Aquatic Invasive Alien Species

Introduction

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. They represent all phyla, from microorganisms to various plants and animals, both terrestrial and aquatic.

At least 15 alien species have been introduced to Cambodia since 1969, among these are: (a) 4 Chinese carps such as silver carp (*Hypophtalmychtys molitrix*), bighead carp (*Aristichthys nobilis*), grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*); (b) 3 Indian major carps such as rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*) and catla (*Catla catla*); (c) tilapias such as Java tilapia (*Oreochromis mossambicus*), Nile tilapia (*Oreochromis niloticus*), Red tilapia (*O. niloticus* x *O. mossambicus*); (d) African catfish (*Clarias gariepinus*); and (e) giant gourami (*Osphronemus gouramy*). Most alien species can adapt well and grow very fast in the pond environment.

Introduction of exotic fish species into the country has been practiced for decades. Fish are introduced by accident or by intent for various uses including for both commercial and ornamental purposes.

Although Cambodia is rich in indigenous fish resource, many different varieties of alien fish species were introduced into farming since 1969 to supplement the demand for fish seed from wild. The prominent introduced species in Cambodia include carps, tilapia and a number of other African species. Since they grow faster and because there are already technologically developed for the reproduction and farming of those species, they are frequently introduced to be farmed in pond system and eventually escaped into the wild. Some fish were released into the wild (in closed reservoirs and canals) to enhance wild stock as well as to increase the fish production in the natural water bodies. A number of

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[26] *Responsible for preparation of Part II of this report*

fish species were released into the wild to control certain organisms in the local environment such as aquatic weeds. Some others, introduced for ornamental purposes in aquarium, are released intentionally or accidentally into natural water bodies.

Under heavy rainstorms or seasonal flood, fish may escape from farms that are not properly fenced or that are settled at inappropriate sites. Eggs get carried in on plants carelessly thrown away. In some cases, exotic species are introduced into native waters by private business.

Table 1. Alien species introduced in Cambodia.

Common name	Species	Source	Year	Reason	Use for aquaculture	Established in the wild	Ecological impact	Socio-economic impact (Aquaculture)
Silver carp	*Hypophtalmichtys molitrix*	Taiwan Vietnam	1969-1981	aquaculture	Widely used	Few	Unknown	beneficial
Bighead carp	*Aristichthys nobilis*	Vietnam	1981	aquaculture	Widely used	Few	Unknown	beneficial
Grass carp	*Ctenopharyngodon idella*	Vietnam	1981	aquaculture	Widely used	Few	Unknown	beneficial
Common carp	*Cyprinus carpio*	Taiwan Vietnam	1969-1981	aquaculture	Widely used	Few	Unknown	beneficial
Rohu	*Labeo Rohita*	Vietnam	1986	aquaculture	Widely used	Few	Unknown	beneficial
Mrigal	*Cirrhinus mrigala*	Vietnam	1980	aquaculture	Widely used	Few	Unknown	beneficial
Catla	*Catla Catla*	Vietnam	1980	aquaculture	Widely used	Few	Unknown	beneficial
Java tilapia	*Oreochromis mossambicus*	Vietnam	1980	aquaculture	Widely used	Natural reproduction	Site occupation in reservoir	beneficial
Nile tilapia	*Oreochromis niloticus*	Vietnam	1980	aquaculture	Widely used	Natural reproduction	Site occupation in reservoir	beneficial
Red tilapia	*O.niloticus x O. mossambicus*	Thailand	1991	aquaculture	Widely used	Unknown	Unknown	beneficial
Hybrid catfish		Vietnam	1981	aquaculture	Widely used	Unknown	Unknown	beneficial
African catfish	*Clarias gariepinus*	Vietnam	1981	aquaculture	Widely used	Unknown	Probably yes	beneficial
Giant gourami	*Osphronemus gouramy*	Vietnam	2000?	aquaculture	Few	Not yet	Unknown	beneficial
	Pomacea canaliculata	Asia	1990s	aquaculture	Rarely used	Unknown	Adverse	Adverse
Silver pacu	*Piaractus brachypomus*	Vietnam	2003					
Cuban crocodile	*Crocodilus rhombifer*	Vietnam	1986	aquaculture	Widely used	Unknown	Unknown	beneficial
Golden snail	*Ipomacea*	Thailand	1985 2001	aquaculture	Few	Widely used	Adverse	
Seaweed	*Cottonii*	Malaysia	1999	aquaculture	Widely used	Unknown	Unknown	beneficial

Status of Alien Species in the Natural Ecosystem

Information on exotic fish from migration study

Since 1997, the Fisheries Programme of the Mekong River Commission (MRC) has been accessing local knowledge in the Lower Mekong Basin. The objective of the study is to provide life cycle information about important Mekong fish species and other aspects related to migration and spawning. A number of exotics (*Hypophthalmichthys molitrix, Labeo rohita, Cyprinus carpio* and *Oreochromis niloticus*) have been recognized and recorded by local fishermen along the Mekong and its tributaries. The details of the species are listed in Table 2 where records of exotic species are highlighted and summarized.

Table 2. Recorded list of exotic species in Mekong mainstream and its tributaries

Species Name	Total species	Total records	Total Records (riparian country)	Total Records Cambodia	Provinces	Habitats	Remarks (for Cambodia only)
1. In the Mekong mainstream	191	12670					
Hypophthalmichthys molitrix			57	27	Kratie Stung Treng Kompong Cham Kandal	Mekong River	40 % of them do not know the species name. 60 % call the fish 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 % of them do not know the species name. 40 % call the fish as Trey Krum *(Osteochitus melanopleurus)* , Chinese Krum, Ka Ek Tmar, Ka Ek Crahom *(Morulius chrysophekadion)*

Table 2....*Continuation*

Species Name	Total species	Total records	Total Records (riparian country)	Total Records Cambodia	Provinces	Habitats	Remarks (for Cambodia only)
Cyprinus carpio			96	27	Kratie Stung Treng Kompong Cham Kandal	Mekong River	63 % of them do not know the species name. 37 % call the fish as Trey Dong, Kachep, Panay, Keab Srong, Sawka keo or Trey Chen.
Oreochoromis niloticus sps			40	4	Kratie Stung Treng Kompong Cham Kandal	Mekong River	75 % of them do not know the species name. 25 % call the fish as Tiger fish
In the Mekong Tributaries	173	6616					
Hypophthalmichtlys molitrix			22	18	Kandal Kompong Chhnang Stung Treng Ratanakiri Mondokiri	Tonle Sap Tonle Sap tributary Se Kong, Se San trib. Srepok tributary Srepok tributary	55% of them do not know the species name. 40% call the fish as Trey linh Thom, linh Heu, or linh Kam 5% call the fish as silver carp
Labeo rohita			26	18	Kandal Kompong Chhnang Stung Treng Ratanakiri Mondokiri	Tonle Sap Tonle Sap tributary Se Kong, Se San trib. Srepok tributary Srepok tributary	90% of them do not know the species name. 5% call the fish as Trey Kros *(Osteochiluslini)* 5% call the fish as silver carp
Cyprinus carpio			29	9	Kandal Kompong Chhnang Stung Treng Ratanakiri Mondokiri	Tonle Sap Se San Srepok tributary Srepok tributary	88% of them do not know the species name. 2% call the fish as Trey Pan Kov

Exotic fish species in Fishing Lot areas

The information gathering exercise was conducted in the Phnom Penh, Kandal, Kampong Cham, Siem Reap, and Battambang provinces. Informal interviews were carried out with key informants such as fishing lot researchers, fisherman and fishing lot owners. The survey was focused on obtaining production/catch data of exotic species by species per year. The results of the survey are described below:

Phnom Penh

There is a fishing area in the outskirt of Phnom Penh City (Cheng Ek Fishing Lot or Fishing Lot No. 1) surrounding Cheng Ek Lake. The following four exotic species were caught: common carp *(Cyprinus carpio)*, bighead carp *(Aristichthys nobilis)*, silver carp *(Hypophthalmichthys molitrix)*, and tilapia *(Oreochromis spp.).* These exotic species were caught since the fishing season of 1997-2000 with an approximate volume of 20-60 kg per year. Since the fishery reform started in year 2000, the lot was abolished and released to fisheries community. The latest information by villagers indicated that fish species composition of the total catch in the lot is now mostlyoccupied by tilapia species.

Kandal Province

The exotic species caught from Fishing Lot Nos. 01, 03, 04, 05, 13, 14,16, and 17 from 199-2000 was around of 300-500 kg/year. The production were mostly of common carp *(Cyprinus carpio)*, Indian carp *(Labeo rohita)*, and tilapia. The size ranged between 0.2 kg to 1 kg per fish. The catch period was from January to March using fishing gears, bag net and seine net.

Kampong Cham Province

In Kampong Cham Province, from the fishing season of 1998-1999, exotic species were present in Fishing Lot No. 10. Common carp *(Cyprinus carpio),* Indian carp *(Labeo rohita),* and tilapia species were caught at a volume of approximately 50 to 60 heads/year. The sizes of fish caught are: (a) tilapia (weight between 0.3 and 0.5kg/fish); (b) common carp (weight between 2- 4kg/fish); and (c) Indian carp (weight between 2-4kg/fish). The catch period was from October to December, harvested through long trough shaped-bamboo trap.

Siem Reap Province

The quantity of exotic species caught from Fishing Lot Nos. 4, 5, 6 and 7 in Siem Reap was approximately 1 600 kg in 1997-1998, and in year 2000-2001, the total catch was only 720 kg. The major exotic species caught was mostly rohu (*Labeo rohita*) that local people call “Indian carp”. Details are provided in Table 3.

Common Ornamental Fish Species in Cambodia

The ornamental fish culture has a long history in Cambodia since the Angkor era (11th century). Many previous writers in the country such as Toeing Ngear and Pikho Som (1900) had written many pages about the beauty of fish in the water. Some folktales written many pages about the beauty of fish in the water. Some folktales mentioned the wild gourami fish. Since then

Table 3: Rohu *(Labeo rohita)* **production caught from Fishing Lot Nos. 4, 5, 6, and 7 in Siem Reap Province from 1997-2001.**

Fishing Lot No.	1997-1998		1998-1999		1999-2000		2000-2001	
	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**

many people cultured the wild gourami. People culture fighting fish in the jar or bottle for hobbies and competition, especially during the New Year 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, Vietnam, Singapore and Malaysia, some famous indigenous species like Siamese fighting fish (*Betta*) is also available in Thailand and Viet Nam. Furthermore, Tiger botia (*Botia macracantha*) and Asian bonytongue (*Scleropages formosus*) which are both expensive and famous are also available in neighboring country. However, some exotic species such as angel fish (*Pterophyllum heckel*), koi carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), etc. which can breed in aquarium without using any hormone, are not imported so much.

The purposes of the culture depend on socio-economic status of the family. Some people, especially government staff, culture fish only as a hobby using inexpensive seed like goldfish. More affluent people culture more expensive species such as Golden Asian bonytongue because of its beauty and perceived luck. Furthermore, as culture for beauty and luckbecomes more widespread, many people in the cities are encourage to culture ornamentals for business purposes. Businessmen import some exotic species from Thailand and Vietnam; some of them do the breeding by themselves. Vaddhna (1996) categorized the culture of ornamental fish into three purposes: (a) for beauty; (b) for small-scale business; and (c) for medium-scale business.

Impacts of introduced exotic fish species

Until now, there is no clear evidence or documentation of exotic species causing risk to the environment in Cambodia. In reality, some bad effects have been experienced. It is considered that exotic species in Cambodia may have caused some positive and negative impacts to the economy, biodiversity and the aquatic ecosystem.

Introduction of exotic fish species in aquaculture could contribute to the protein supply especially for the poor and could also creating job opportunities for many people who live far from the natural water bodies and in remote areas. Most exotic species introduced in Cambodia are easy to breed and grow fast in ponds with very low input.

Battambang Province

The quantity of exotic species caught from fishing lot Nos. 1, 2 and 3 in Battambang Province from 1999 to 2001 are described in Table 4 below.

Table 4. Exotic species caught in Fishing Lot Nos. 1,2 and 3.

Species	1999-2000		2000-2001	
Fishing Lot No. 1	**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)*	no record	-	70	0.2-0.5
Total	**150**		**500**	
Fishing Lot No. 2				
Indian carp *(Labeo rohita)*	12.5	2.3	-	-
Common carp *(Cyprinus carpio)*	17	-	-	-
Silver carp *(Hypophthalmichthys molitrix)*	14	-	-	-
Total	***43.5***			
Fishing Lot No. 3				
Indian carp *(Labeo rohita)*	-	2.5-5	-	-
Silver carp *(Hypophthalmichthys molitrix)*	-	0.5	-	-
Total	**15**			

Impacts of introduced fish may include hybridization with endemic fish species, alterations of habitats and water quality, competition for food and space, predation and the introduction of exotic parasites and diseases (Courtenay and Stauffer, 1984; Moyle *et al.* 1986 and Arthington, 1989).

There is no study in Cambodia to determine if introduced fish have altered aquatic habitats and whether it has implication on local species and population. However, there are reports from elsewhere indicating that exotic species caused changes to the biological, chemical and physical characteristics of the local environment and created under favorable conditions to local species. It is reported that pest fish cause problems by eating plants and uprooting plants when feeding on the animals in lakes or streambed sediments. The disturbance of bottom substrates by common carp (*Cyprinus carpio*) during feeding has been attributed to increased turbidity. This has implication on other species in search for food. In addition, this lowers the water clarity and could make the pond water too dirty for submerged plants to get enough light to grow. Once the plants reach the bed sediments, they are even more easily disturbed and water clarity drops further, so the whole system is on a downward spiral. These activities are detrimental to the environment, causing loss of aquatic vegetation, erosion of riverbanks, increased water turbidity and higher nutrient levels. It destroys the 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 & 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 out-compete the ability of local species to the same resource. The decline of endemic fishes has most often been reported in disturbed and polluted habitats. Ability to frequently reproduce species such as tilapia may easily take up space that would otherwise be used by endemic species. This may have strong implication, during the dry season in particular, when water is normally confined to small ponds.

Predation could be on young live fish of endemic species or on them at their earlier stages of egg and larval development. However, there is no information in Cambodia whether introduced species become predators to local species. Introduction of fish is partly responsible for importing parasites and causing outbreaks of diseases. Although many parasites require intermediate host, some parasites have been transferred through introduction of fish.

Existing policies on introduction of fish species

Currently there are no detailed guidelines or regulations for the importation of exotic species for culture, or environmental impact studies and environmental standards required for fish farms. Under these conditions, the development of freshwater aquaculture raises the question of potential negative impacts of introduced alien species on native fish stocks.

Table 5. Some common alien ornamental fish culture in Cambodia.

No.	Common name	Scientific name	Families
1	Black ghost knife fish	*Sternarchus albifrons*	
2	Giant gourami	*Ophronemus goramy*	Anabanidae
3	Leeri fish	*Trichogaster*	Anabatantidae
4	Red-finned fish	*Metynnis*	Characidae
5	Black tetra fish	*Gymnocorymbus*	Characidae
6	Oscar	*Astronotus ocellatus*	Cichlidae
7	Angel fish	*Pterophylum heckel*	Cichlidae
8	Discus	*Symphysodon*	Cichlidae
9	Jewel cichlid	*Hemichromis bimaculatus*	Cichlidae
10	Tiger botia	*Botia macracantha*	Cobitidae
11	Koi carp	*Cyprinus capio*	Cyprinidae
12	Gold fish	*Carassius auratus*	Cyprinidae
13	Bellybarred pipefish	*Hippichthys spicifer*	Indostomidae
14	Midget sucker catfish	*Hypostumus*	Loricariidae
15	Guppy of million Fish	*Poecilia*	Loricariidae
16	Plety	*Platypoecilus maculatus*	Loricariidae
17	Badis	*Badis badis burmanicus*	Nandiae
18	Giant arapaima	*Arapaima gigas*	Osteoglossidae
19	Swordtail	*Xiphophorus*	Poeciliidae
20	Goonch	*Bagarius yarrelli*	Sisoridae
21	Malayan angle	*Monodactylus argenteus*	Toxotidae

Some recommendations from the Department of Fisheries include culturing exotic species in earthen ponds or cages using appropriate management techniques in order to avoid the escape of these species into the natural water body. The introduction of indigenous fish species is one of the options that the Department of Fisheries is considering to further replace the exotic species in aquaculture.

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 environments should be allowed to be imported. The Government should promote aquaculture of exotic species in areas far from natural water bodies.
- The Ministry of Agriculture should prepare guidelines on the management of movement of the fish products.
- Future research development and extension on aquaculture of indigenous species should be undertaken.
- Implementation of international and regional codes of conduct should be taken into account. Aquaculture should be integrated with land use planning so that certain areas can be separated for aquaculture of exotic species.
- Fish releasing ceremony must use only indigenous species.
- More research should be carried out on the impacts of already introduced exotic species on the environment.

Current management strategies for alien species

The government should set up regulations concerning importation and culture of aquatic alien species suing the following considerations:

- Careful selection of species, those of good health, free of serious pathogens and good quality seed;
- Species which are easy to culture, grow fast and with high economic value;
- Regulation on the stocking of fish species in natural water bodies should be developed; and
- Research should be carried out on the impact of existing exotic species on environment and risk assessment studies should be conducted before allowing introduction of new species.

Conclusion and Recommendations

Exotic species are present in significant quantities in the natural habitats both in the Mekong mainstream and its tributaries. Given the landscape and seasonal flood fluctuation in the country, it is difficult for Cambodia to control the introduction of alien fish species into the natural environment. Efforts to do so should involve collaboration among all countries at least those within the Mekong basin.

There is no research programme in Cambodia that focuses on identification and catch production per year of fish exotic species by various type of habitat or the impacts of these species to the natural resources, etc. If in the future, exotic fish species increase their populations in the natural habitats, it would present great difficulty in natural resource management.

Impact assessment of fish exotic species in Cambodia should be undertaken; awareness of species identification among fisheries researcher and fisherman should be strengthened. Research on the impacts of fish exotic species on the aquatic environment is very important for natural resource conservation and management.

Individual countries and persons can act independently and responsibly to help safeguard local environment from the risks of exotic fish species introduction. The most important thing to do is to prevent alien fish from entering the local environment, and at the individual level to prevent the release of exotic fish into waterways.

Part II: Associated Trans-boundary Aquatic Animal Pathogens

Introduction

The kingdom of Cambodia is a country rich in biodiversity. The country has approximately 500 indigenous freshwater fish species (Rainboth, 1996) which occupies various ecological niches, including plankton feeders, detritus feeders, predators and opportunists. Fisheries and aquaculture development is an important contributor to the national economy of Cambodia. Fish is an important diet of the Cambodian people and more than 75% of the animal protein intake is derived from fish (DoF, 2000). Fish cultured in cages is reported to have originated in Cambodia about a century ago and it is still the major culture system contributing to inland aquaculture in the country. Pond culture is of recent origin which started during the 1960s.

The issue of aquatic invasive alien species is new to Cambodia. Among the introduced aquatic animal species are mostly fish. Nuov *et al. (* 2003) have identified at least 18 introduced aquatic alien species in the country including snail, crocodile and seaweed.About 15 alien species of fish, mostly carps, were introduced to Cambodia. Fishes and shrimp (*Penaeus monodon*) were imported from Vietnam and Thailand, and the main reason for introduction of aquatic species into the country is for the development of aquaculture. On the positive impacts, several of the introductions are highly successful providing social and economic benefits to people with the increase in fish production for consumption, income and employment generation. However, the introduction of fish was reported to have led to the establishment of population in natural water bodies, and indigenous fish have been reported to decline due to exotic species such as tilapia which contributed up to 80% of the catch in Chhek Ek Lake near Phnom Penh. There is a serious risk of spread of diseases within the aquaculture sector. Several diseases and parasites have been diagnosed in the introduced aquatic animal species. It is not clear if all these diseases and pathogens came with the imported fishes.

Movement of aquatic animal species

Cambodia exports some 30 000 to 40 000 mt of freshwater and marine/coastal fish and aquaculture products and other live aquatic animals every year to several countries such as Hong Kong China, Singapore, Malaysia, USA, Australia, Vietnam, Thailand and France.

Some aquatic animal species such as the broodstock of *Clarias gariepinus,* fingerlings of hybrid *C. batrachus x C. gariepinus*, carps, tilapias, shrimp (*P. monodon*) and market-size *M. rosenbergii* have been imported without any assessment of the risks of pathogen transfer. This movement of aquatic species could involve a degree of disease risks to Cambodia's water bodies.

History of major disease outbreak

Disease is one of the major problems faced by the aquaculture farms, and many countries have faced major social and economic impacts resulting from uncontrolled disease outbreak. In Cambodia, diseases have had serious economic impacts on shrimp farms in Koh Kong, Kompot and Sihanouk Ville.

The Fish Disease Diagnostic Laboratory of Cambodia's Department of Fisheries found that there have been many diseases and parasitic organisms that have apparently accompanied introduced fish species to the country. The pathogenic agents (e.g. protozoans, monogeneans, crustaceans, bacteria, fungi) were found in freshwater fish from aquaculture farms and the wild.

White spot syndrome virus (WSSV) caused serious mortalities on commercially farmed shrimp. Farming of shrimp (*P. monodon*) in Cambodia was negligible before 1988, although there were few traditional extensive shrimp farms in Kompot Province. In mid-1991, intensive shrimp farming systems were introduced to Koh Kong Province by Thai shrimp farmers and businessmen. The intensive shrimp farming sector relied mainly on Thailand for the supply of most inputs, such as feed, seed, chemical and equipment. A 1995 review of this sector showed that the intensive shrimp farms in Koh Kong Province increased to 1 000 ha but because of WSSV and increasing environmental problems, the area utilized for shrimp farming declined to about 850 hectares in 2000, decreasing gradually thereafter.

Current status of trans-boundary aquatic animal pathogens

In Cambodia, the general public is not fully aware of the harm caused by aquatic invasive alien species. Cambodia has no policy on introduction and would prefer to use local species for aquaculture.

The implementation of FAO/NACA's Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals in an effective manner requires an appropriate national administrative and legal framework, as well as sufficient expertise, manpower, infrastructure and equipment.

Cambodia's strategies for the control of risks of pathogen transfer posed by the movement of live aquatic animals have been developed and the status is described below.

Aquatic animal health and quarantine responsibility

The DOF of the Ministry of Agriculture, Forestry and Fisheries is the government institution responsible for aquatic animal health. This mandate used to belong to the Department of Veterinary and Animal Production. There is poor coordination between the two departments and the country lacks laws and regulations on aquatic animal health and quarantine.

Aquatic animal health and quarantine legislation and regulation

So far there is no available regulation or guideline on the import of aquatic animal species, animal health and quarantine. Recently, the Department of Fisheries reviewed and revised the existing fisheries law and added some chapters/articles of legislation and regu pertaining to aquatic animal health and quarantine. This legislation will be cover movement of live aquatic animals within Cambodia and among Asian and other countries. In the draft revised Fisheries Law, local movements of live aquatic animals is legislated.

Surveillance, Monitoring and Diagnosis of Diseases of Aquatic Animals

In Cambodia, the reporting of aquatic animal pathogens is inadequate because of the lack of suitable diagnostic capability in terms of facilities and trained personnel at the national and provincial levels.

Current management strategies for trans-boundary aquatic animal pathogens

There are no detailed guidelines or regulations for the importation of exotic species for culture, or studies on environmental impacts and environmental standards required for fish farms. Under these conditions, the development of freshwater aquaculture raises the question of the potential negative impacts of introduced alien species on native fish stocks. The existing laws and regulations need to be revised to incorporate relevant provisions in regional and international agreements and guidelines such as the FAO Code of Conduct for Responsible fisheries, the FAO/NACA Asia Regional Technical Guidelines Health Management for the Responsible Movement of Live Aquatic Animals, the OIE International Aquatic Animal Health Code, and the WTO SPS Agreement.

The current strategy on trans-boundary aquatic animal pathogens control includes:

- Careful examination of application for import of aquatic animal species;
- Exhaustive research on the biological characteristics of imported species;
- No permit issued to import infected aquatic animal species;
- Requiring a health certificate from the exporting countries of aquatic animals;
- Good quality aquatic animal seed;
- Good pond/tank preparation (drying out of pond/tank and disinfection protocols).

Recommendations

The recommendations to strengthen national capacity to address risks from trans-boundary aquatic animal pathogens are as follows:

- Develop and implement trans-boundary animal movement regulations.
- Implement international and regional codes of conduct.
- Establish quarantine systems to control the importation of aquatic animals;
- Establish a central laboratory with modern equipment and trained manpower for disease identification.
- Develop national reporting systems for aquatic animal diseases.
- Build capacity building in risk analysis, procedures for monitoring and disease surveillance.
- Public awareness on negative impacts of alien species should be enhanced;
- Conduct risk assessment studies before allowing the introduction of new species.
- Carry out research on the impacts of existing exotic species on the environment.
- Do not allow importation of alien aquatic animal for aquaculture without proper risk analysis.

- Formulate rgulations for the stocking of fish species in natural water bodies .
- Exchange information on trans-boundary aquatic animal pathogensbetween countries.

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Part I: Aquatic Invasive Alien Species

Introduction

Issues related to invasive alien species (IAS) and genetically/living modified organism (GMO/LMO) are becoming public issues in Indonesia. In the case of IAS, public awareness have increased to certain level since people have begun to recognise that introduced species (whether animals or plants) occupy more and more space disturbed the habitats of indigenous species and spread invasively in the environment.

Government efforts directed at conserving the environment and its natural resources started in 1982 when the Environment Law was enacted in 1982. It was revised and replaced by a new environment Law No. 23/1997, and the issuance of Law No. 5/1990 concerning the Conservation of Live Natural Resources and Its Environment. However, regulations regarding the prevention of the introduction of IAS are not included in those laws.

Significant effort was taken by the Ministry of Agriculture (MoA) by issuing Ministrial Decree No. 411/1995 concerning the Importation into the Territory of the Republic of Indonesia of Biological Agents. The decree provides a comprehensive measure to deal with the introduction of living organisms intended for biological control as well as for other purposes. To complement the decree, the Minister of Agriculture has also issued Decree No. 412/1995 which formed the Biological Agents Commission. This Decree stated that every biological agent imported to Indonesia must be covered by an import permit issued by the Minister of Agriculture and careful assessment has to be conducted prior to the importation to ensure that the objective of the importation can be attained and the potential adverse effects avoided. Any importation of biological control agent, whether the species is exotic or already occurring locally, shall be made according to the provisions of the Decree. Only those

27 *Responsible for preparation of Part I of this report*

28 *Responsible for preparation of Part II of this report*

agents found (after careful examination of a special group of experts) to be effective against a target pest and not harmful to human, animal and plant life or health and the environment, will be recommended to be provided with a permit granted by the Minister of Agriculture. Many biological control agents (mostly insects) have been imported and successfully introduced without causing adverse effects to the environment.

Aquatic Alien Species in Indonesia

The importation or introduction of aquatic organisms (aquatic plants and aquatic animals) has been done as novelties, ornamentals, and for animal or human consumption. Introduction of aquaculture species has been an established practice since the middle of the 19th century. The history of the introduction of new species of aquatic animals in Indonesia began in 1932, i.e., by the introduction of guppies from Japan. The introduction of live aquatic species, for aquaculture purpose began in 1949 with the introduction of grass carp (*Ctenopharingodon idelis*) from China (Table 1). In addition to the introduction of fish for aquaculture purpose, ornamental fish such as guppies (*Poecilia reticulata)* and 'black ghost knife fish' (*Apteronotus albifrons)* from Singapore have also been introduced. The fishes are cultured in Indonesia before sending them back to the international market.

In general, the introduction of aquaculture species has successfully increased aquaculture production. Among the aquaculture species introduced to Indonesia, common carp is currently the most popular cultured freshwater fish. Recently, genertically improved farmed tilapia or GIFT Tilapia has become popular and is cultured intensively, mainly for export.

Table 1. Chronological introduction of aquaculture species into Indonesia.

No.	Introduced Species	Country of Origin	Year of Introduction
1	Grass carp (Ctenopharryngodon idelis)	China	1949
2	Common carp (Cyrprinus carpio)	China	1951
3	Siam catfish (Pangasius sutchi)	Thailand	1972
4	Mola (Hypophthalmichthys molitrix)	Taiwan	1973
5	Hybrid tilapia (Oreochromis niloticus x O. mossambicus)	Taiwan	1975
6	Catfish (Clarias gariepinus)	Taiwan, Hongkong	1985
7	Hybrid of tilapia (strain Chitralada)	Thailand	1988
8	Genetically improved farmed tilapia (GIFT)	Philipines	1988
9	Freshwater pompret (Colossoma sp)	South America	1990
10	White shrimp (Penaeus vannamei)	Hawaii, USA	2001
11	White shrimp (Penaeus stylirostris)	Hawaii, USA	2002

Even though there is no accurate data on the introduction of the water hyacinth *Eichornia crassipes* to Indonesia, it is believed that the plant entered Indonesia as an ornamental plant, which then spread extensively and uncontrollably into open waters. This plant is now considered as an invasive species especially in the open waters of Rawa Pening, Wasur National Park, and many other lakes and rivers. Other introduced aquatic plants considered as invasive species are *Pistia sp., Salvinia sp.,* and *Azolla spp.*

Table 2. List of introduced aquatic IAS and their impacts.

Scientific Name (Indonesian or English Name)	Impacts
Lebisstes reticulates (Ind. Ikan seribu)	*invasive competitor for feed and space*
Cleptomus spp. (Ind. Ikan sapu-sapu)	*invasive competitor for space*
Vandelia sp. (Engl. *Vampire catfish*)	invasive predator
Serrasalmus sp. (Engl. Piranha)	invasive predator
Liposesteus sp. (Engl. *Alligator gar*)	invasive predator
Silurus alansis	invasive predator
Esox masquinongy	invasive predator
Electrophorus electricus (Engl. *Electric eel*)	hazard to human
Tetraodon spp.	Invasive predator

On the other hand, exotic aquatic animals considerd as invasive species include: guppy *Lebistes reticulates* (competitor for feed and space), *Cleptomus spp.* (competitor for space), and the snail *Pomacea canaliculata* (attacks rice plants even as it failed as an additional protein source for the people) (see Table 2).

Management efforts and awareness campaign on IAS control programs are very limited. These are not undertaken nationwide and are not fully operational. The Ministry of the Environment (MoE), the focal point of the Convention on Biological Diversity (CBD), implements limited activities on management of IAS. Integrated activities to deal with IAS has not been conducted. The Ministry in cooperation with several government institutions and non-governmental organizations (NGOs) had undertaken or is in the process of undertaking the following activities:

- IAS assessment in Indonesia (past, present and future) to find out available information generated by scientists of research centers and universities on the impacts and control methods during the last two years;
- National seminar on biodiversity and control of IAS;
- Developed an academic paper for the prevention and controlling of IAS in Indonesia which involved universities, research centres and NGOs;
- Identification by the MoE of organizations or parties to be involved in the IAS control program. These are:
    - Ministry of Agriculture (MoA);
    - Ministry of Forestry (MoF);
    - Ministry of Marine Affairs and Fisheries (MMAF);
    - Indonesian Institute for Science;
    - Universities (Gajahmada, Bogor Institute of Agriculture, etc);
    - NGOs (The Nature Conservancy, Wetland Indonesia, Kehati Foundation, etc.); and
    - Other stakeholders.

During the last two years, an ad-hoc committee of scientists coordinated by the MoE in coordination with the other three ministries (MoA, MoF and MMAF) under the Working

Group on Environment are preparing technical draft guidelines to regulate IAS. The draft law have been submitted to the national authority, but its substance have been considered to be superimposing the Quarantine Law, thus the draft will most probably will degraded into a government decree level.

Quarantine institutions have the vital duty to mitigate the risk of animal/fish/plant pests and diseases introduction and spread (domestically and/or international). In this respect, it is sensible that mitigation measures against the risks of introduction of IAS into Indonesian territory should be covered by quarantine inspection services. Thus the quarantine service should be a lead party in the national control program against IAS. The quarantine is widely considered as the main operational instrument for the control of IAS. Quarantine instruments work on the basis of commodity approach or commodity-based measures, where commodity movements are considered as pathways for animal/fish/plant pests and diseases introduction. Exotic agents causing injuries or even death to animals, fishes, and plants, can also be simultaneously hazardous to the environment.

Fish quarantine measures in Indonesia are operated by the Centre for Fish Quarantine (CFQ) under the MMAF, which complies with the codes and standards recommended by Office Internationale des Epizooties (OIE). The measures covers fish and fish product.

The environment control instrument works on the basis of a species-approach or species-based measures, where species as moving commodities are considered as the main target to control. When a species have the potential to cause environmental hazard and detrimental to other organisms especially the indigeneous species, the species is considered to be IAS. The environment control measure is operated on the basis of environment regulations such as Undang-Undang No.23/1997 covering provisions contained in the CBD. Differences and similarities exist between the quarantine and environment control instruments. These include the following:

- Most or all of fish pests and diseases are IAS, but not all IAS are quarantine targets.
- Most or all of fish pests and diseases cause fish injuries more directly and immediately compared to IAS which need longer time to expand, spread and causing hazard.
- Risk of exotic aquatic organism introduction is more considered as a fisheries economic risk, compared to the risk of IAS which has a wider impact covering the whole ecosystem as a whole.
- Operationally, quarantine and environmental control measures have similar procedures, where scientific approachesfor IAS seem to be much more comprehensive.
- Responsibility of country origin of IAS is not elaborately regulated, where country origin of exported commodities in quarantine measures is elaborately regulated in the export certification system.

Recommendations

Because of improved global transportation, increasing trading volume and frequency, and induced global spreading of fish pests, diseases, IAS in this millennium, it is necessary to set up a single legal system and designate a single organization to undertake biosecurity in Indonesia. The policy of GoI in managing IAS is still in infancy. The general lines of control, strategy laid by the government are listed below:

1. Prevention of the introduction of species which has the potential of becoming an IAS has to be operated in all ports of entry throughout the Indonesian archipelago, by integrating quarantine and environment risk assessment prior to the introduction. Institutionally, the MMAF should work collaboratively with the MoE.
2. Control or eradication of IAS which has already established domestically, has to be jointly operated by all biological security agencies (such as MMAF, MoA, and MoF) under coordination of the MoE as the 'focal point' of CBD;
3. The operation conducted in the entry points has to avoid any legal confusion affected by improper implementation of the regulations from the various provisions contained in different international treaties such as that of CBD, OIE Codes or IPPC;
4. Database on IAS provided (domestically or internationally) have to be established by relevant agencies;
5. Legal framework dealing with control of IAS in Indonesia has to be established as basis for risk analysis and certification system;
6. International standards/recommendations issued by the CBD Secretariat has to be adopted and disseminated.

Part II: Associated Trans-boundary Aquatic Animal Pathogens

Introduction

Trans-boundary movements and introduction of exotic aquatic animals are necessary for aquaculture development and ornamental fish trade. However, such practices have been recognized as posing a high risk of introducing new exotic pathogens and spreading diseases from one area to another.

The history of the exotic disease in Indonesian aquaculture begins in 1932, in which the introduction of guppies from other country was suspected to cause parasitic disease outbreak in the country caused *Ichthyophthinius multiflilis* (Sachlan, 1952). In 1970, *Lernaea cyprinacea* infection was reported on freshwater fish in West Java followed by infection with *Myxobolus sp., in* 1978 due to the introduction of some strain of common carp that caused significant economic losses on carp in Java and Sumatera (Djajadiredja *et al.*, 1983). In mid-1981, there was a substantial economic losses on freshwater species in Java due to the epizootic ulcerative syndrome (EUS) caused by *Aphanomyces invadans* (Callinan *et al.*, 1995; Bastiawan *et al.*, 1996). The introduction of the pathogen was suspected to have been associated with the importation of common carp from Taiwan. Since then the disease spread to other areas affecting other freshwater fish as well as wild species in Sumatera and Kalimantan islands. The origin of two viral diseases, the iridovirus in grouper (Owens, 1994) in Sumatera Island and viral nervous necrosis (VNN) first detected in 1997 in seabass cultured at Banyuwangi, East Java (Zafran and Yuasa, 1999), is still unclear.

The occurrence of yellow head virus (YHV) and white spot syndrome virus (WSSV) in shrimp is not clearly associated with the introduction of shrimp. However, WSSV has been most likely introduced from another country based on the chronological disease occurrence in Asia-Pacific region. Yellow head virus was first reported on cultured giant tiger shrimp

(Penaeus monodon) in Gresik, East Java (Rukyani, 1994); while WSSV has been reported to cause mass mortality in *P. monodon* in Indonesia since 1994 (Sunarto, 1995).

Since March 2002, Indonesian aquaculture has faced a serious problem with massive mortality of koi and common carps *(Cypninus carpio)* due to the outbreak of koi herpesvirus (KHV) (Sunarto *et al*., 2002). The disease was introduced into Indonesia through the importation of koi from Hong Kong. It is estimated that the outbreak has caused losses of more than US$ 5 M within 3 months period. The disease has spread rapidly from Java to Bali and Sumatera islands. It has become very difficult to prevent the spread of the disease to other islands. Another important disease affecting shrimp, Taura syndrome virus (TSV), was first detected from white shrimp, *P. vannamei,* cultured in East Java (Lightner, 2002). The shrimp was first introduced into the country by a private company from Hawaii in November 2000. The shrimp was allowed to be introduced by Indonesian government as the species of the shrimp was certified as specific pathogen free (SPF) of TSV and WSSV.

In view of the negative impacts of trans-boundary aquatic animal pathogens and diseases associated with the movements and introduction of aquaculture species, the government of Indonesia has recently set up a regulation of species introduction in order to protect Indonesian aquatic organisms from being affected by exotic pathogens.

Trans-boundary Aquatic Animal Pathogens

National Aquatic Animal Health Management Strategy

Indonesia's current policy with regard to fish health has been developed through its participation in the recently concluded FAO/NACA/OIE Asia-Pacific Regional Programme for the Development of National and Asia Regional Technical Guidelines onHealth Management for the Responsible Movement of Live Aquatic Animals (FAO/NACA 2000). Indonesia was one of the 21 regional governments that endorsed the Regional Technical Guidelines and the related Beijing Consensus (see FAO/NACA 2000). The current policy vision was expressed in Indonesia's National Strategy on Fish Health Management. The general objective of the National Strategy is to standardize Indonesia's fish health management program in order to promote adequate disease control methods in aquaculture production systems, contribute to the development of sustainable aquaculture, and fulfill Indonesia's obligations as a member of the international community (Rukyani *et al.,* 2003). Thus the general approach being taken by the Government of Indonesia (GoI) to fish health management is to support policies, legislation and practices that are both scientifically sound and generally accepted by regional trading partners and the broader international community (Arthur, 2003). The draft National Strategy identifies ten programs that need to be addressed. These are: (1) Surveillance, Monitoring and Reporting of Fish Disease; (2) Fish Quarantine; (3) Regional and International Collaboration; (4) Fish Disease Control (Contingency Planning); (5) Public Awareness; (6) Research and Development; (7) Rules and Regulations; (8) Institutional Framework; (9) Fish Resource and Environmental Management for Aquaculture; and (10) Funding Resource. Table 3 shows an analysis of the implementation of the National Strategies against the elements contained in the Technical Guidelines.

Current Status of Trans-boundary Aquatic Animal Pathogens

Since the Directorate General of Fisheries (DGF) was promoted to be the Ministry of Marine Affairs and Fisheries (MMAF) three years ago, there are three principle institutions whose mandates are related to fish health management including regulation, research, surveillance, monitoring and diagnosis. These institutions are the **Directorate for Fish Health and the Environment** (DFHE) nder Directorate General for Aquaculture, **Center for Fish Quarantine (CFQ)** under Secretariat General, and the **Central Research Institute for Aquaculture (CRIA)** under Agency for Marine and Fisheries Research (Appendix 2). Coordination and cooperation between the three principal government agencies involved in fish health management should be further developed and strengthened through inter-agency consultative and working groups (Arthur, 2003). There are also various commissions and committees, university, professional association, private sector and other stakeholder whose concern to fish health management in the country.

In order to focus the efforts of controlling the most devastating diseases, the National Fish Health Commission (NFHC) has declared WSSV, TSV, VNN and KHV as the most significant diseases of aquatic animal in Indonesian aquaculture. The disease reporting and monitoring were also adjusted accordingly.

White Spot Syndrome Virus (WSSV)

Epidemiology. Since the middle of 1994, a disease that causes cumulative mortality of up to 100% was reported in numerous shrimp farms in northern coast of East, Central and West Java, Indonesia (Sunarto, 1995). Since then the disease has been reported in all shrimp production centers in the country. The new disease, in which the pathognomonic characteristic sign was the presence of white spots on the cuticle and was called white spot syndrome (WSS), referred to as white spot syndrome ('penyakit bercak putih' in the Indonesian language), was the most threatening disease that had ever occurred in Indonesian shrimp farms. The disease occurred in on-growing juvenile shrimp of all ages and sizes. It affected both cultured and wild penaeids shrimp. The major cultured shrimp species in Indonesia are black tiger shrimp *(Penaeus monodon)* and white shrimp (P. *merguiensis).* Infection of WSSV was also found in wild shrimp, *Metapenaeus ensis.* Recently, white shrimp (*P. vannamei)* was also affected by the disease, however, WSSV infection was not reported in *P. stylirostris* yet. Recent surveillance on wild broodstocks of *P. monodon* conducted by Fish Health Research Laboratory shows that wild stocks have high infection rate (40-80%) of WSSV. The economic impact of WSS in Indonesian shrimp industry is difficult to determine. It is estimated that in 1999, only 20% of shrimp ponds were in operation due to the disease. Most of the ponds remained unoperated, with some being converted to tilapia and milkfish ponds. It is believed that the disease causes economic losses of US$ 300 per year.

Diagnostic Capability. At the farmer and district laboratory levels, WSS may be diagnosed from its pathognomonic clinical signs, *i.e.* the appearance of white spots in the carapace and body surface (diagnostic Level I). Histopathological changes (diagnostic Level II) and molecular-based methods (diagnostic Level III) were also used as confirmative diagnostic method for the disease. All major fish disease laboratories have been installed with PCR unit and are capable of detection WSSV. However, there

Table 3. Implementation of national aquatic animal health management strategies against the elements contained in the Technical Guideline

Elements in the Technical Guidelines	Status of Implementation
Pathogens to be considered	Based on Ministerial Decree No. 17/2003 dated 9 June 2003, there are 51 fish diseases of quarantine importance in Indonesia, *i.e.*, 18 viral diseases, 11 bacterial diseases, 5 mycotic diseases and 17 parasitic diseases. The complete list of the disease is attached in Appendix 1. Based on socio-economic and ecological impacts, National Fish Health Commission (NFHC) declared WSSV, TSV, KHV and VNN as the most significant aquatic animal diseases in Indonesian aquaculture.
Disease diagnostics	Although Indonesia has a long history of work on fish diseases, there is still very limited expertise and diagnostic capability in the country. Most laboratories in Indonesia is under category of Laboratory Level I and Level II, which is capable only to conduct fish disease diagnostics based on clinical signs and observation of environmental changes (Level I) and based on parasitology, mycology, bacteriology and histopathology works(Level II). There is no laboratory facilities and expertise for fish virology. A national laboratory for fish virology is being set up, however staff expertise need to be further developed. Diagnostic Level III is conducted through PCR test using both commercial kits and specific primer based on the OIE Diagnostic Manual. The assays are routinely used as diagnostic tools for viral diseases. So far 22 laboratories have been installed with PCR facility.
Health certification and quarantine	This issue is being addressed: Ministerial Decree No.34/2003 dated 17 September 2003 pertaining legal documents required for fish quarantine including standard form of health certificate. This law requires application of strict quarantine measures.
Disease zoning	Despite of lack of stringent surveillance program, an emergency zoning was applied during the beginning of KHV outbreak, *i.e.* Java Island is declared as an infected zone and other islands as free zone. The objective of zoning was to prevent the spread of the outbreak from Java Island to other islands by restriction of movement of koi and common carps from Java Island to other islands (Ministerial Decree No. 28/2002 dated June 2002).
Contingency Planning	Part of this issue is being addressed: Development of 'National and Provincial Task Force on Fish Disease Control'. At the district level, there are fish disease officers, whose responsibility includes reporting and control of disease outbreak.

Table 3....*Continuation*

Elements in the Technical Guidelines	Status of Implementation
	In the future, there will be rules and regulations concerning permits for fish farmer involved in the aquaculture sector. Fish farmers are bound to comply with control measures on fish disease outbreak.
Import risk analysis (IRA)	The IRA document has been drafted. The competent authority for the implementation of IRA is the Ministry of Marine Affairs and Fisheries (MMAF). The Directorate of Fish Health and Environment (DFHE) has responsibility for the development of policies, rules and regulations on fish health management and environmental protection, including IRA. The Centre for Fish Quarantine (CFQ) has operational responsibility for fish health with regards to import and export matters, including implementation of IRA.
Institutional development and	The Directorate of Fish Health and Environment (DFHE) under the capacity building Directorate General of Aquaculture (DGA), MMAF was established in 2001. The DFHE is responsible for the development of national policy on fish health management. However, technical implementation units to applying and enforcing its policies and regulations are still lacking. The Centre for Fish Quarantine (CFQ) has also been established. The Centre is in charge of the management of fish quarantine in Indonesia. The Director of the Centre is responsible to the Secretary General of MMAF. Institutions involved on fish health management includes the centres for fish quarantine, research institutes, implementing units under DGA, universities, provincial and district fisheries service and the private sector. Regular training courses for fish health workers are being conducted by the DFHE and CFQ. The training includes basic training on fish health management, specific training on parasitology, mycology and bacteriology, fish medicine, PCR, etc. Under an FAO- TCP project, national trainings were conducted to deliver knowledge of general fish health management for fisheries officer and farmers, legislation for policy maker, epidemiology and virology for laboratory staff.
National strategies and policy frameworks	Several national workshops have been conducted to develop National Strategy. Through extensive consultations, the document is ready to be published and disseminate to stakeholders. The next step would be integration of the strategies into national fisheries development.

are variations on the capability and methods used. Standardization and harmonization of the application of PCR for the detection of WSSV in shrimp need to be taken into account.

Taura Syndrome Virus (TSV)

Epidemiology. Based on the Decree of DGA No. IK.530/D3.9389/X/OOK dated 10 October 2000, the Government of Indonesia (GoI) allow the importation of white shrimp *(Penaeus vannamei)* for research purpose. The exotic shrimp was imported from Taiwan, Hawaii and the United States of America. In July 2001, GoI officially released permits that allowed the importation of white shrimp for culture purpose. Since then, the shrimp has been cultured in 15 out of 30 provinces in Indonesia.

Taura syndrome virus (TSV) has been detected in *P. vannamei* from East Java, Indonesiain November 2002 (Lightner, 2002). In response to Dr. Lightner's letter dated 4 November 2002 to OIE pertaining 'confirmation of TSV in Indonesia', the Government of Indonesia has conducted active surveillance in Java islands (East, Central and West Java) and Sumatera (Lampung Province). Despite active surveillance on *P. vannamei, TSV* infection was not found in West Java and Banten provinces. However, a sample fromBrebes, Central Java and most of samples originating from East Java (Banyuwangi, Situbondo, Pasuruan, Bangil, Sidoarjo, Malang) were TSV-positive. TSV mostly caused mortality to 1-2 months old *of P. vannamei* reared in intensive culture system (120 Pls/m^2). The affected shrimp showed reddish discoloration on the tail and multifocal necrosis (black spot) on the body surface. The disease caused mortality rate of up to 75%. It is suspected that TSV first occurred in Banyuwangi and Situbondo before spreading to other districts in East Java through movement of infected post-larvae (PL). Banyuwangi and Situbondo are two of the main shrimp (*P. monodon* and *P. vannamei)* production centers. They produced both seed and marketable shrimp. Samples of *P. monodon* originating from Brebes (Central Java), Situbondo (East Java) and Bali islands were also PCR-positive against TSV. TSV-positive samples have also been detected in *P. vannamei* originating from Maros, South Sulawesi and from Sumbawa Island. All of the samples were confirmed by PCR-based methods. It is suspected that the disease came into Indonesian aquaculture due to illegal importation of broodstock and PL from abroad. There is no data on the economic impact of TSV in Indonesian shrimp industry.

Diagnostic Capability. All levels of diagnostics (Levels I, II and III) are available in the country. However, PCR technique using both commercial kits and primer based on OIE Manual are being used as confirmative diagnostic method for the disease.

Viral Nervous Necrosis (VNN)

Epidemiology. VNN was first reported in hatchery-reared seabass *(Lates calcarifer)* in Banyuwangi, East Java in 1997 (Zafran and Yuasa, 1999). However, the origin of the virus is still unclear. In June 1999, it was detected in larvae and juvenile humpback grouper in Bali, in which the disease caused mass mortalities in PL stage. In February 2000, the disease was associated with mass mortalities in seed production of humpback grouper in North Sumatera. A similar disease problem was also reported in Batam Island and Lampung Province, Sumatera. VNN has been reported in Bali, East Java, Lampung, Batam islands and North Sumatera. The disease can be vertically transmitted from infected broodstock to its offspring and horizontally transmitted from infected carriers and contaminated environment.

VNN caused by a nodavirus was the most serious disease during the seed production of grouper in Indonesia. Although VNN mostly caused problems in larvae and juvenile, the virus was also detected in grow-out fish and in broodstock. Most of VNN cases occurred in humpback grouper *(Cromileptes altivelis),* however, it was also reported in tiger grouper *(Epinephelus fuscogutathus),* orange-spotted grouper (*E. coioides),* marbled grouper (*E. polvphekadiai),* and barramundi *(Lates calcarifer)* (Koesharyani *et al*., 2001). The susceptible ages among grouper were between 10 day-old and 4 month-old, where mass mortalities frequently occurred from 20-30 day-old. Mortalities rapidly decreased after 3 months of age, and the virus could be rarely detected from 1 year-old moribund fish (Yuasa and Koesharyani, 2000). There is no data on the economic impact due to the disease.

Diagnostic Capability. There are no obvious clinical signs that can be used for diagnosis of VNN by Level I diagnosis. Therefore, diagnosis of VNN was mainly based on results of histopathology (Level II) and PCR assay (Level III).

Koi Herpesvirus (KHV)

Epidemiology. The first episode of mass mortalities of cultured koi *(Cyprinus carpio)* was recorded during the end of March 2002 in Blitar, East Java. It occurred, after heavy rains, on new fishes introduced from Surabaya, the capital city of East Java. The fish was imported from China through Hong Kong in December 2001 and January 2002. The outbreak, which occurred on koi carp of all ages, caused high mortality up to 8O-95%. However, big fish was more susceptible than small fish. Infected fish was lethargic, showed loss of balance and gasped for breath. Common gross signs include sloughing-off of the epithelium with loss of mucus and rough haemorrhages in the operculum, fins, tail and abdomen and severe gill damage (Sunarto *et al*., 2002). Some diseased fish showed blister-like lesions on the skin, so called ‘penyakit melepuh’ in Indonesian language.

The second episode of disease outbreak occurred in cultured common carp *(Cyprinus carpio)* at the end of April, 2002 in Subang regency, West Java. The gross signs of the diseased common carps were extremely similar with the signs in koi carp. Due to immediate harvest, there was an over supply of fish in the region. Therefore, farmers sole the infected in very low price (Rp 3,000/kg; normal price Rp 7,000/kg). Economic losses consist of more than 450 metric tons of common carp cultured in running water systems.

The third episode of the outbreak occurred since June 2002 in cultured common carp in floating netcages at the Citarum river system, West Java. The system is consisted of of the Saguling Reservoir (upper portion), Cirata (middle) and Jatiluhur (downstream). There are 4 425 units floating net cages of mostly common carp in the Saguling Reservoir. The first disease outbreak of this nature was reported among common carps at the end of May to early June 2002. There was no data on the losses, but it was estimated that 40-50% of cages were affected. Weeks before the outbreak, there were some farmer who introduced common carp from Subang region due to low price of fish.

The fourth episode of the outbreak occurred in February 2003 among cultured common carps in Lubuk Linggau, South Sumatera. Since then the outbreak spread to Bengkulu and Jambi provinces.

Based on the clinical history, gross signs, experimental infection and PCR detection of naturally and experimentally diseased fish, it is strongly suspected that Koi Herpesvirus (KHV) is involved on the serious outbreak. Since then the disease was commonly referred to as KHV by all stakeholder in Indonesia. Therefore in this paper, KHV is referred to as "Koi mass mortality" under "Unknown diseases of serious nature" in the FAO/NACA Quarterly Aquatic Animal Disease (QAAD) report. KHV only affected koi and common carps (*Cyprinus carpio*). Mortalities occurred only among koi and common carps but not other fish despite the use of polyculture system in affected areas. Based on a survey conducted in March 2003, KHV has been reported from almost all areas in Java Island, Bali. Lampung, Bengkulu, South Sumatera, East Kalimantan, South and Central Sulawesi. Recently, the disease has been reported to occur in Jambi. The disease is horizontally transmitted from infected fish and contaminated environment. The vertically transmission from infected broodstock to its offspring need to be further studied.

Diagnostic Capability. The most obvious clinical sign of the disease is gill damage. This clinical sign (Level I) has been used by fish farmer and district fisheries officers to recognized the disease and subsequently report the case to the DFHE. Unfortunately, no typical histopathological changes has been found in most of KHV outbreak in Indonesia. Therefore, confirmatory diagnosis of KHV was mainly based on the results of PCR assay (Diagnostic Level III).

Current Management Strategies for Trans-boundary Aquatic Animal Pathogens

The GoI has been concerned with the movement of live aquatic animal and its associated trans-boundary aquatic animal pathogens and potential impacts of the establishment and spread of the diseases since the issue arise. The country has put efforts to manage the diseases through the development of policy, regulation and technical guidelines to manage trans-boundary aquatic animal pathogens (the National Strategy). In order to prevent the introduction of trans-boundary aquatic animal pathogens and the establishment and spread of the diseases, the Government has implemented management strategies, both concerning policies and technical aspects.

Development and strengthening of the Centre for Fish Quarantine (CFQ).
The Centre is in charge of the management of fish quarantine in Indonesia. By the enactment of Government Regulation No. 15 of 2002 concerning Fish Quarantine, basic legal conditions required for the implementation of fish quarantine actions became stronger. The regulations put in order, among others, basic provision on quarantine requirements, quarantine actions, quarantine areas, kinds of pests and their carrier, places of entry and export, development of quarantine mindedness, investigation and penalty. According to the regulations on the importation of fish, all importation of live fish, dead fish, and fish product is subject to quarantine measures, *i.e.* importation must be made through designated points of entry; accompanied by a fish health certificate; and notified and submitted to Fish Quarantine Inspector upon arrival of the consignments. In addition, notwithstanding the conditions mentioned above, the importation of live fish must be covered by an Import Permit, which may contain additional conditions for the said importation. The additional conditions will be determined, on case-by-case basis, by the DGA depending on the risk/s involved. By doing this, quarantine plays an important role as a first barrier for the prevention of the introduction of trans-boundary aquatic animal pathogens and the establishment and spread of newly emerging disease.
Establishment of The Directorate of Fish Health and Environment (DFHE).
The directorate is responsible for the development of national policy on fish health management in the country. The policy includes development of the National Strategy and IRA. However, there is lack of technical implementation unit to apply and enforce its policies and regulations. In the case of the KHV outbreak, the GoI immediately responded to the outbreak through issuance of the following regulations and actions:

- In order to prevent the spread of the outbreak, the Director General of Aquaculture (DGA) immediately released a circulation letter to district fisheries services pertaining koi and common carp mass mortality.
- In 20 June 2002, An Emergency Disease Control Task Force on a Serious Disease of Koi and Common Carps in Indonesia referred to as the ''Task Force'' was organized by NACA. The Task Force, consisted of international, national and local experts, was organized to conduct an emergency assessment of the disease situation through epidemiological investigations, field observations and laboratory examinations.
- Based on the recommendation of the Task Force, in 2 July 2003, the MMAF released Ministerial Decree No. 28/2002 that officially declared Java Island as an isolated area of the disease and moving carp and koi from Java Island to other islands were strictly prohibited. In addition, importation of common carp and koi into the country was temporarily not permitted.
- In order to control the outbreak, on 20 August 2002, the DGA released Decree No. 3750/2002 regarding the formation of a national task force on the control of disease outbreak in freshwater fish.
- In the same month, the FAO approved a technical assistance program to the GoI through FAO's Technical Cooperation Programme "Health Management in Freshwater Aquaculture" (TCP/INS/2905 A). Besides providing technical assistance and consultancy on health legislation, epidemiology, virology and

fish health management, the project also set up information system and established a virology laboratory.
- In 3 October 2002, the MMAF released Ministerial Decree No.40/2002. This second Ministerial decree, associated with serious disease outbreak in koi and carp, declared that Java and Bali are pronounced as infected areas and movement of live fish from these islands to another location within the country should follow quarantine check for KHV. Importing koi and common carp is permitted only from KHV-free country.
- Information on KHV was disseminated widely across the country with the use of TV, radio, newspaper, posters, pamphlets and technical guideline.

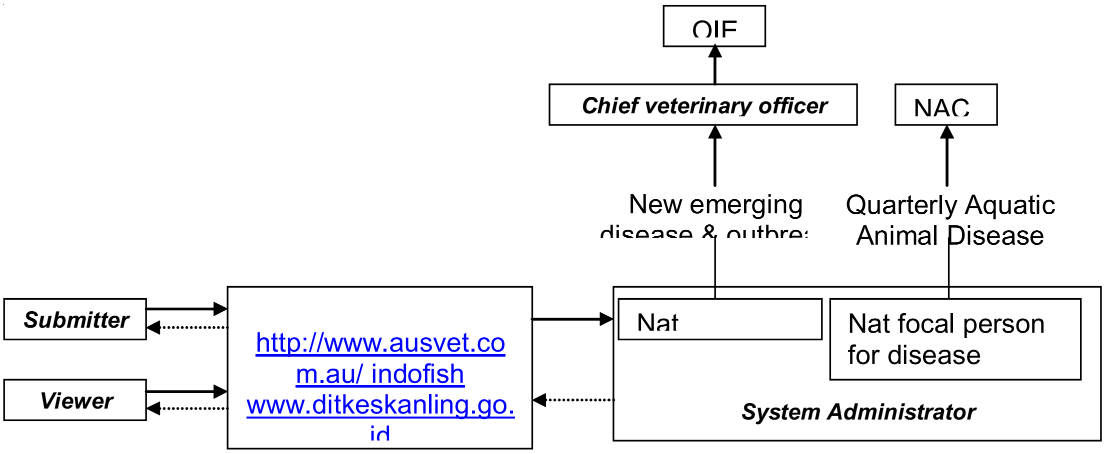
Indonesian Aquatic Animal Health Information System

A coordination mechanism and information exchange systems at national level is being established. However, IAS National Focal Points, who will create and establish links with regional and international levels, have not yet been appointed. Coordination and information exchange system are being practiced through aquatic animal health information system. Three major systems on fish health in Indonesia were determined to be: (a) formal, (b) inter-laboratory networks, and (c) computerised information system. The conventional fish health information system in Indonesia is the disease reporting system through the formal channels of district and provincial fisheries offices to the DGA. This system is very formal and largely depends on the bottom-up pathway where fish farmer report a disease occurrence in their farm to the district fisheries officer, and so on. By using this system, very limited fish disease report was received by the National Coordinator on Fish Health and consequently the top-down pathway of national and provincial summary is hardly produced. Even though the system covers the whole districts in the country, the effectiveness of the system should be improved. Virtually no active surveillance was done using this system. As a result, a limited number of Quarterly Aquatic Animal Disease Report to NACA/OIE was produced during this period.

The inter-laboratory networks (ILAN) support the existing formal fish health reporting system in the country. The networks consist of laboratory under the Research Agency, Directorate General of Aquaculture, University, Quarantine Office, and private sector as indicated in Fig. 1. The inter-laboratory networks play an important role on the development of the Indonesian Quarterly Aquatic Animal Disease Report to NACA/OIE. The ILAN also plays a significant role in information exchange on fish disease and laboratory techniques. The networks need to be expanded by involving other laboratories, particularly the one from private sector. A 'Directory of Fish Health Laboratory in Indonesia' is being published and disseminated to each of laboratories and other stakeholders in the country. The information is shared through Indonesian Network on Fish Health Management (INFHEM Newsletter). The National Fish Health Commission (NFHC) is responsible for coordinating activity of aquatic animal health.

During the FAO-TCP project, an internet-based aquatic animal health information system was developed by the International Consultant, Dr. Angus Cameron of Ausvet Australia **(www.ausvet.com.au/indofish).** Another website was also developed by DFHE **(www.ditkeskanling.go.id)** (Figure 1).

Figure 1. Internet-based Aquatic Animal Health Information System in Indonesia and Disease Reporting Pathway to NACA and OIE.



IAS and associated aquatic animal pathogens have been addressed in the National Strategy, with emphasis on the prevention of the introduction and spread, and protection of aquaculture industry and natural fisheries resources. However, action plans has not been developed yet.

In order to prevent associated trans-boundary aquatic animals pathogens transfer due to the introduction of IAS, the GoI has issued 'procedure for the introduction of new species of aquatic animal into Indonesia' (Ministerial Decree No. 08/2004). To manage the spread of trans-boundary diseases within the country, the DGA has issued Decree No. 4999/2002 pertaining to technical guidelines for the movement of common carp from Java to other islands and Circulation Letter No. 213/2004 pertaining to movement of live shrimp which are free of TSV and WSSV.

The impact of fish introduction to Indonesian waters has been commonly reported to involve displacement of native fish populations, hybridization with endemic fish species, predation, as well as introduction of exotic parasites and diseases. These negative impacts have not been previously carefully and seriously considered at the time of aquatic species introduction. Many of the most dangerous pathogens and diseases in aquaculture industry do not exist in Indonesia. The country is aware of the need for an effective quarantine program for aquatic animals and has already initiated actions to strengthen the existing system.

The Agency for Marine and Fisheries Research (AMFR) has prioritised research on newly emerging diseases mostly due to the introduction of trans-boundary pathogens, *i.e.* KHV, TSV, WSSV and VNN. Adequate financial and technical support from relevant national, regional, and international assistance agencies to address trans-boundarydiseases has been received by GoI. In case of KHV outbreak, immediate assistance was provided by the Network of Aquaculture Centres in Asia-Pacific (NACA) and partners, by fielding an Emergency Disease Control Task Force on a Serious Disease of Koi and Common Carps in Indonesia consisting of three fish health experts in July 2002.

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Although Indonesia has a long history of work on fish diseases, there is very limited expertise and diagnostic capability of fish diseased in the country. There is lack of laboratory facilities and expertise, particularly on field of fish virology. Through a FAO TCP project TCP/INS/2905(A) 'Health management in Freshwater Aquaculture', national laboratory for fish virology is being set up. Human resource development is being addressed through trainings and workshops on the field of legislation, epidemiology, fish health management for fisheries officers and farmers, and virology for laboratory workers. In addition, DFHE and CFQ provide annual basic training on fish health management and advanced training on fish health management including parasitology, mycology, bacteriology, histopathology, immunology and biology molecular techniques.

The government has promoted community participation and partnerships between public and private sectors in its efforts to address trans-boundary pathogens. In response to the Circulation Letter No. 213/2004, the East Java Shrimp Community immediately provided positive response by sharing their PCR facility for the testing of TSV and WSSV. Therefore, in East Java, PCR testing against TSV and WSSV is being conducted by provincial and national laboratories, the government quarantine service and the private sector. However, the health certificate is only issued by the government quarantine service as the competent authority. The government has promoted awareness of IAS and associated trans-boundary disease by conducting national workshops on IRA and National Strategy.

Managing Trans-boundary Aquatic Animal Pathogens in Farm Level

Technical guidelines for the control of trans-boundary diseases (WSSV, TSV, VNN and KHV) in farm level have been published by DFHE. Described below are the basic principles contained in the guidelines:

Managing of WSSV should be done at all levels of shrimp production starting from shrimp hatchery until grow-out ponds. In the hatchery, the PCR technique was used for screening broodstock before spawning. Only broodstocks, which are free from WSSV were used as spawner. The post larvae (PL) should also be screened for WSSV. If infected, the whole tank should be treated with 20 ppm chlorine and then be discarded.

Combinations of PCR technique and formalin treatment have proved as the best strategy for managing WSS in grow-out pond. The benefit of PCR screening combined with formalin treatment is to maintain low-intensity of WSSV infections in shrimp, hence significantly reducing the disease outbreak in the ponds. WSSV-free PLs were bathed in 150 ppm formalin for 30 minutes to separate the weak and unhealthy individuals. Only the healthy PLs, which are actively swimming against the water current, were then stocked into the ponds. WSSV status during the rearing periods was monitored through regular PCR checking at Day 25 and Day 55. Semi-quantitative PCR technique allows us to distinguish light and severe infection of WSSV. If the WSSV infection is light, the culture may be continued with improvement of culture condition. However, when the WSSV infection is severe, immediate harvest is the only way to reduce economic losses.

To maintain low level of WSSV infection, biosecurity concept should be applied. Closed system with zero or minimum water exchange might be the best solution to have consistent and environmentally sound shrimp production. The key component of closed system is the application of bioremediator (probiotics) and high level of aeration. Managing WSSV outbreak in grow-out shrimp may also be achieved through enhancement of shrimp defence mechanism using immunostimulants such as fucoidan, peptidoglycan, and lipopolysaccharidc. Combination of prophylactic measures such as screening of PL with PCR, use of specific pathogen free broodstock and PL, immunostimulants and good management practices will be helpful in controlling WSS outbreak in Indonesian shrimp farms. To prevent the introduction of TSV to their farm, most of shrimp farmer use specific pathogen free (SPF) and specific pathogen resistance (SPR) post larvae, which is imported from Hawai and Florida. The shrimp was then cultured in a pond that strictly applied biosecurity concept, which is similar with the one for prevention of WSSV.

There is no way to cure VNN infected fish. However, various counter-measures may be applied to reduce the occurrence of the disease. It started with screening of broodstock or PL using nested-PCR technique. Disinfection of tanks and equipment after each batch of seed production and removal of small or weakened or dead fish from rearing tanks would reduce the occurrence of the disease. Increasing the amount of intake water and administration of antibiotic may also be applied. All these measures did not completely eliminate VNN infection but significantly decreased the mortality (Yuasa & Koesharyani, 2001).

There is no way to treat KHV-infected fish. However, various counter measures may be applied to reduce its occurrence. To prevent the spread of the disease, movement of koi and common carp, water, and equipment from infected areas are prohibited. Immediate removal of death fish from rearing facilities (tank, pond and cage) and from common water body would reduce the occurrence of the disease. The dead fish should be burned or buried.

In an isolated farm such as koi farm, biosecurity concept may be applied. Pathogen eradication using disinfection may be applied only in closed culture system such as earthen pond, tank and aquarium, before stocking with KHV-free fry or fry originating from areas with no history of the disease. There are several breeding areas still considered free from the disease. However, quarantine measures for at least 14 days must be applied for newly introduced fish. To reduce stress, it is recommended to reduce the stocking density and apply high dose of vitamin C. However, this biosecurity concept is not practical to be applied in open culture systems such as running water and floating netcages.

Progress in Implementing Recommendations[1] for Managing Trans-boundary Aquatic Animal Pathogens

Trans-boundary diseases are causing significant ecological, economic, and social damages and pose ongoing threats to sustainable development of aquaculture in Indonesia. The oI has implemented recommendations for prevention and managing trans-boundary diseases. Table 4 shows the progress of the implementation.

Recommendations to Strengthen National and Regional Capacity to Address Risks from Trans-boundary Aquatic Animal Pathogens

- Creation of IAS and associated trans-boundary diseases National Focal Points;
- Improvement of the Indonesian Aquatic Animal Health Information System;
- Finalising the National Strategy and IRA documents;
- Development of a clear action plan to prevent and manage trans-boundary diseases; and.
- Identify research needs to prevent and spread of trans-boundary diseases.

Table 4. Progress of the implementation of recommendation for prevention and managing trans-boundary diseases.

No.	Recommendation[1]	Implementation
1	Establish coordination mechanisms and information exchange systems at national, regional, and international levels by the creation of IAS National Focal Points and through the Convention on Biological Diversity's (CBD) Clearing-house Mechanism (CHM)	IAS National Focal Points has not been appointed yet. However, Indonesian Aquatic Animal Health Information System is being developed for exchange of aquatic animal health.
2	Ensure political commitment in terms of policy, legislation, enforcement, and implementation of activities to prevent and manage IAS initiated through national and regional strategies and action plans.	Development and strengthening of the Centre for Fish Quarantine (CFQ) by the enactment of Government Regulation No. 15 of 2002 concerning Fish Quarantine. Establishment of the Directorate of Fish Health and Environment (DFHE), which is responsible for the development of national policy on fish health including the National Strategy and IRA. However, a clear action plan is not developed yet. Regulation regarding IAS and associated pathogens.
3	Initiate assessments of problems related to IAS and develop early warning and monitoring systems	The impact of IAS includes displacement of native fish populations, hybridization with endemic fish species, predation, as well as associated trans-boundary diseases. The country is aware of the need for an effective quarantine program for aquatic animals and has already initiated actions to strengthen the existing system.
4	Encourage appropriate and relevant research on IAS issues	AMFR has prioritised research on new emerging diseases including WSSV, TSV, VI\T and KHV.
5	Provision adequate financial and technical support from relevant national, regional, and international assistance agencies to address IAS	NACA's Task Force on KHV outbreak FAO TCP project on Health Management on Freshwater Aquaculture ACIAR project on the harmonization of PCR technique for the detection WSSV in shrimp

[1] Recommendations of the "Prevention and Management of Invasive Alien Species: Forging Cooperation throughout South and Southeast Asia Regional Workshop, 14-16 August 2002, Bangkok, Thailand

Table 4... ***Continuation***

No.	Recommendation[1]	Implementation
6	Build capacity in terms of human resource development and technology transfer to address IAS	Participation on the regional workshop on IRA, Technical Guidelines, etc. Conducting workshops on legislation, epidemiology, virology and fish health management for fisheries officer and farmer (FAO-TCP project). DFHE and CFQ provide annual basic and advantage training on fish health management including IRA topic.
7	Promote community participation and involvement in efforts to address IAS	Round table discussion with East Java Shrimp Community immediately regarding Circulation Letter No. 213/2004.
8	Encourage partnerships between public and private sectors in activities to address IAS	
9	Promote awareness of IAS issues by convening workshops and seminars, as well as conducting publicity events and media campaigns	Conducting national workshops on IRA and National Strategy
10	Ensure the sustainability of IAS prevention and management activities in the region by developing long-term programmes of action.	

[1] Recommendations of the "Prevention and Management of Invasive Alien Species: Forging Cooperation throughout South and Southeast Asia" Regional Workshop, 14-16 August 2002, Bangkok, Thailand.

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Appendix 1. List of quarantine fish diseases in Indonesia (Based on Ministerial Decree No 17/2003)

A. *Viral Diseases:*

1. Channel catfish virus disease (CCVD)
2. Spring viraemia of carp (SVC) & Swimbladder inflammation (SBI)
3. Infectious pancreatic necrosis (IPN)
4. Infectious haematopoetic necrosis (IHN)
5. Lymphocystis
6. Infectious hypodermal and haematopoetic necrosis (IHHN)
7. *Baculovirus penaei* (BP)
8. *Monodon baculovirus* (MBV)
9. Baculovirus midgut gland necrosis (BMGN)
10. Yellow head disease (YHD)
11. Hepatopancreatic parvovirus (HPV)
12. Taura syndrome (TS)
13. White spot syndrome (WSS)
14. Golden eye disease (GED) or Sleepy grouper disease (SGD)
15. Lymphoidal parvovirus
16. Type C baculovirus (TCBV)
17. Viral nervous necrosis (VNN)
18. Epithelioma papillosum (*Herpesvirus cyprini*)

B. *Bacteria Diseases:*

1. Furunculosis (*Aeromonas salmonocida*)
2. Bacterial kidney disease = BKD (*Renibacterium salmoninarum*)
3. Fish mycobacteriosis (*Mycobacterium marinum, M. fortuitum, M. chelonei*)
4. Nocardiosis (*Nocardia sp*)
5. Edwarsiellosis (*Edwardsiella tarda*)
6. Enteric septicaemia of catfish (*Edwardsiella ictaluri*)
7. Streptococcosis (*Streptococcus sp*)
8. Pasteurellosis (*Pasteurella piscicida*)
9. Enteritic red mouth disease (*Yersinia ruckeri*)
10. Gaffkemia (*Aeromonas invadans var homari*)
11. Red spot disease (*Pseudomonas anguillaseptica*)

C. *Mycotic Disease:*

1. Sand paper disease/Swinging disease/Ichthyoporosis (*Ichthyophonus hofferi*)
2. Branchiomycosis (*Branchiomyces sanguinis*)
3. Branchiomycosis (*Branchiomyces demigrane*)
4. Aphanomycosis (*Aphanomyces astaci*)
5. Epizootic ulcerative syndrome (*Aphanomyces invadans*)

D. Parasitic Disease:

1. Whirling disease (*Myxobolus/Myxosoma cerebralis*)
2. Pleistophorosis (*Pleisthopora hyphessobrycon*)
3. Pleistophorosis (*Pleisthopora anguillarum*)
4. Ceratomyxosis (*Ceratomyxa shasta*)
5. Henneguyan disease (*Henneguya exiilis*)
6. Cotton shrimp disease (*Thelohania duorara*)
7. Cotton shrimp disease (*Thelohania penaei*)
8. Bonamiosis (*Bonamia ostreae*)
9. Haplosporidiosis (*Haplosporidium nelsonii*)
10. Haplosporidiosis (*Haplosporidium costale*)
11. Marteiliosis (*Marteilia refrigens*)
12. Marteiliosis (*Marteilia sydneyii*)
13. Perkinsosis (*Perkinsus marinus*)
14. Ergasiliosis (*Ergasilus sieboldi*)
15. White tumor in siam catfish (*Nosema sp*)
16. Lytoceatosis (*Lytoceatus parvulus*)
17. Paragonimiasis (*Paragonimus pulmonalis*)

Appendix 2. Summary of Current Mandates of Governmental Departments and other Agencies concerned with Fish Health Management (Arthur, 2003)

MINISTRY OF MARINE AFFAIRS AND FISHERIES (MMAF)

Directorate General for Aquaculture
Directorate for Fish Health and the Environment
- Develops policy and legislation related to fish quarantine (shared)
- Responsible for disease control and prevention in aquaculture
- Responsible for conducting import risk analysis (IRA)
- Controls introduction of fish into inland waters
- Responsible for disease monitoring and surveillance activities
- Submits reports on national disease status to FAO/NACA

Secretariat General
Center for Fish Quarantine
- Develops regulations, technical guidance and standards for fish quarantine
- Implements quarantine for both international and domestic movements of live fish, including: issuance of health certificates, border inspections, laboratory diagnostics, quarantine of shipments
- Develops technical cooperation with other institutions, both nationally and internationally

Research Agency for Marine Affairs and Fisheries
Central Research Institute for Aquaculture
- Conducts research on diseases of fish

Other agencies with related concerns

National Commission on Fish Health (and other committees)
Reports to the Director General for Aquaculture
Provides advice on fish health issues

National Commission on Introductions and Transfers (Proposed)
Reports to the Director General for Aquaculture

Ministry of Forestry
- Enforces CITES
- Concerns about impacts of exotic diseases on biodiversity

Ministry of Trade
Concerned with fees for quarantine services

Ministry of Agriculture
Chief Veterinary Officer
Official reporting to OIE (However, fish disease reporting is done by MMAF via FAO/NACA)

Ministry of Health
Concerns related to zoonotic diseases (i.e.,those transmitted from aquatic animals and their products to man)

Universities
- Provide ad hoc diagnostic expertise and advice
- Training
- Applied research

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Lao PDR

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Part I: Aquatic Invasive Species

Introduction

Before the past decade, few policies and strategies had been developed with respect to fisheries development and related matters. Efforts were on the following activities: (a) conservation of natural resources and the development of fish farming by decentralizing the fisheries management functions to local authorities; (b) building awareness on the adverse impacts on the use of illegal and destructive fishing gears; and (c) promoting the sustainable utilization and use of indigenous fish species, establishment of fish breeding facilities, use of non-carnivorous species in aquaculture, and careful use of exotic species in aquaculture. The country has no policy on introduction of exotic species, which are the main species in aquaculture.

The fisheries management measures enforced by local authorities created many conflicts and problems because they did not respond to the needs of the grass root level.

There is a Prime Minister Decree No 118, dated October 1989, concerning the management and conservation of wildlife including aquatic animals; and a second Prime Minister Decree No 85, dated May 1993, concerning animal (including fish) management. These decrees were later developed into regulations and used for the management and control of the movement of the live animals including fish.

Aquaculture development in Lao PDR has been initiated since the 1950's. During the 1960's, with assistance from the United States Agency for International Aid (USAID), fish seed farms were built in many provinces (e.g. Vientiane, Savannakhet, Champassak, Sayaboury and Luang Prabang). In early 1970's, new hatcheries were constructed in the northern provinces (Houaphanh, Xiengkhuang and Oudomsay) as well as in Vientiane Capital with technical assistance from the FAO/UNDP and the Mekong River Commission (MRC). During the 1990's a number of private hatcheries were built in many provinces, especially in Vientiane Capital. Based on the 2001 Annual Report of the Department of Livestock and Fisheries (DLF), 30 fish hatcheries are currently operating including 13 private hatcheries; 9 hatcheries are under construction.

Introduction of Aquatic Alien Species to Lao PDR

The main purpose of introducing aquatic alien species into the country is for aquaculture. The species which played important roles in aquaculture are: three species of Indian carps, three species of Chinese carps, tilapia, common carp and African catfish (see Table 1). Many aquatic alien species entered the Lao territory by accidental movement and some were for other purposes even though Lao PDR has more than 500 fish species in its water systems (Kottelat, 2001) out of 1200 species reported in the Lower Mekong Basin (Rainboth,1996).

Introduction of aquatic alien species for aquaculture started in 1965 (common carp and tilapia); in 1977, three species of Indian carps (catla, rohu and mrigal) and three species of Chinese carps (big head carp, silver carp and grass carp) were introduced to Laos. During the 1980's, African catfish (*Clarias gariepinus)* was introduced from Vietnam.

Current management for IAS

- The National Wildlife Conservation Day (or Fish Releasing Day) is celebrated annually on the 13th of July where an official from the Ministry of Agriculture and Forestry or an officer from the authorities (provincial, districts and communities) grace the occasion. This celebration emphasizes stocking on un-aggressive fish species and promoting indigenous fish species.
- The DLF and NAFRI/LARReC (National Agriculture and Forestry Research Institute/Living Aquatic Resources Research Center) in collaboration with MRC-Fisheries Programme conduct research and studies on using the Mekong fish species for aquaculture, in order to replace the exotic species. Seven species (i.e., *Barbodes gonionotus*, *Cirrhinus microlepis*, *C. molitorella*, *Puntioplites falcifer*, *Clarias macrocephalus*, *Morilus chrysophekadion* and *Osphronemus exodon*) were selected for this study. These species will be used in aquaculture and for release into the natural water bodies, especially during National Fish Releasing Day cerebration each year on 13th July.
- The DLF with collaboration with the Asian Institute of Technology (AIT) organized a workshop on impacts of introduced exotic species under financial assistance from SIDA. The workshop recommendations and suggestion are listed below:
    1. The workshop agreed with the presented technical reports related to the history of alien fish introduction and its impacts on the local natural resource.
    2. Recognizing that the introduction of exotic fish has a positive impact on the socio-economy of the country and several negative impacts on the country's aquatic resources, the workshop agreed to expand the positive impact and limit the negative impact.
    3. Understanding that grass carp, African catfish and common carpare species risky to the aquatic ecology and environment, the workshop agreed that those mentioned introduced fish should not be promoted to be released into water bodies without an in-depth technical study.
    4. Recognizing that the importation of aquatic animals and aquatic plants

Table 1. Aquatic alien species introductions to Lao PDR.

Species (Scientific name)	Year	Introduced from	Socio-economic Effect (beneficial undecided adverse, no data)	Ecological Effect (beneficial, undecided, adverse, no data)	Introducer (individual, government, international organization, private sector, other, unknown)	Reason (Aquaculture, ornamental, etc. * Please see list at the bottom of the table!)	Established in the wild (probably not, not, probably yes, yes, unknown)
Catla catla	1977	Thailand and India	Beneficial	Undecided	organization	Aquaculture	Probably not
Cirrhinus mrigala	1977	Thailand, India	Beneficial	Undecided	organization	Aquaculture	Probably yes
Clarias gariepinus	1980	Viet Nam	Undecided	Adverse	No Data	Aquaculture	Probably yes
Ctenopharynodon idella	1977	China	Beneficial	Adverse	organization	Aquaculture	Probably not
Cyprinus carpio carpio	1977	Thailand and India	Beneficial	Adverse	organization	Aquaculture	Established
Labeo rohita	1965	Thailand	No Data	No Data	organization	Aquaculture	Probably yes
Labeo rohita	1977	Thailand and India	Beneficial	No Data	organization	Aquaculture	Probably yes
Oreochromis mossambicus	1955	Thailand	No Data	Adverse	No Data	Unknown	Established
Oreochromis mossambicus	1965	Thailand/Japan	No Data	Adverse	No Data	Aquaculture	Established
Oreochromis niloticus	1977	Japan	Beneficial	Adverse	organization	Aquaculture	Established
Pomacea canaliculata	1986	Thailand	Adverse	Adverse	No data	Unknown	Established
Pomacea canaliculata	1992	Asia	Adverse	Adverse	No data	Unknown	Established
Abottina rivularis	Unknown	China	No data	No data	No data	Accidental	Established
Acheilognathus barbatulus	Unknown	China	No data	No data	No data	Accidental	Established
Hemibarbus maculatus	Unknown	China	No data	No data	No data	Accidental	Established
Pseudorasbora parva	Unknown	China	No data	No data	No data	Accidental	Established
Rasborinus lineatus	Unknown	China	No data	No data	No data	Accidental	Established

Table 1...*Continuation*

Misgurnus anguillicaudalus	Unknown	Viet Nam	No data	No data	No data	Accidental	Established
Puntius semifasciolatus	Unknown	Viet Nam	No data	No data	No data	Accidental	Established
Pelodiscua sinensis	Unknown	China	No data	No data	Individual	Aquaculture	Unknown
Gambusia affinis	1978	No data	No data	No data	Unknown	Pest control	Established
Hypophthalmichthys molitrix	1978	Japan	Beneficial	Undecided	Organization	Aquaculture	Probably not
Aristichthys nobilis	2002	JapanChina	Beneficial	Undecided	Organization	Aquaculture	Probably not
Neosolanx eligodo	2001	China	No Data	No Data	Organization	Research	Probably not
Hypostomus plecostomus	Unknown	Thailand	Adverse	No Data	Individual	Ornamental	Unknown

pose a high risk to the introduction of fish disease into the country, the country should set up regulations for controlling aquatic animal diseases.

5. The workshop recommended to publish technical guidelines, regulations, measures and policies on sustainable aquaculture and fishery in order to reduce the negative impacts and promote the positive impacts.
6. The workshop recommended to look for appropriate conditions and methodologies to establish technical infrastructure that will provide export and import services.
7. Increased public awareness on the negative impact of introduced aquatic animals and aquatic plants into the country should be promoted in order for them in participate in monitoring and managing the existing problems together.
8. Studies for solving the expected future problems should be continued.
9. Studies on the economic feasibility of culturing indigenous species should be undertaken.

Recommendations

At present, the risks lie on uncontrolled movement of species and genetic strains into and within the basin due to lack of policy. It is suggested that the member countries should establish harmonized policies such as:

- Code of conduct to reduce the impacts for introduction of aquatic invasive alien species to the country.
- Regional guidelines on standardardization of quarantine and animal health certification including aquatic animals.
- Strengthening regional cooperation in living aquatic species movement and management, capacity building and information sharing.

Part II: Associated Trans-boundary Aquatic Animal Pathogens

Fish disease has so far not been a serious problem in aquaculture production in Lao PDR, compared to other countries in SE Asia. Some fish diseases were reported to occur in the remote cool part of northern and southern regions of the country. These include: *Lernaea* sp., *Gyroductylus* sp., *Ichthyophthirius* sp, *Epistylis* sp., Epizootic ulcerative syndrome (EUS), *Oodinium* sp. and *Edwardsiella* sp. Nevertheless, the government, particularly the DLF and LARReC, is quite concerned about fish disease issues and is trying to find solution. These two institutions have the responsibility on aquatic animal health management, and since 1999, health management is a priority research subject.

Pathogen diagnosis capacity and facility. Present capacity of Lao PDR in disease diagnosis consist of capability to perform bacterial, fungal and parasitic examination but not for viral diagnosis. The bacteriology laboratory of DLF has the ability to isolate and identify most bacterial species. External and internal examination for protozoan and metazoan parasites are regularly undertaken during fish disease diagnosis. Human resource capability is limited.

Recommendations

- Improvement of the diagnostic facilities
- Improvement of the human resource capacities
- Needs diagnostic technical guidelines
- Information dissemination to the local community
- Awareness the local concerned authorities
- Improvement of the existing local network

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Malaysia

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Part I: Invasive Aquatic Alien Species

Introduction

Invasive alien species were not considered as a major threat to the aquaculture and the fisheries industries, but rather a threat to the public safety. There are evidences to show that the intentional introduction has caused irreparable damage to the environment, habitat and species; however, these are not documented. The Convention of Biological Diversity (CBD) has categorized invasive alien species as a cross-cutting issue as will be shown in the case of Malaysia.

Most of the introduced aquatic alien species in Malaysia are freshwater species, particularly ornamental fish, mainly for aquaculture and trade purposes. Since there was little or n study done on the impacts of the introduction of invasive alien species to the environment, habitat and species, its seriousness of the impacts has not been adequately evaluated. The matter was further aggravated by the low capability of the responsible State authorities to manage inland ecosystems. The Department of Fisheries Malaysia as the authority in fisheries and aquaculture, however is concentrating mainly on the development of these sectors to meet the Third National Agriculture Policy. There is no policy in place to control, manage and eradicate invasive alien species. Hence very little or insignificant effort is given to address the impacts of invasive alien species and associated trans-boundary movement. However, there are regulations to control the imports of some of the invasive species, enacted as a result of concerns raised by the public. Until today, there is no regulation to control, manage and regulate the pathogens associated with trans-boundary movement. This paper will deliberate on some of the impacts of introduced invasive alien species, and recommendations to strengthen national capacity to address risks from the introduction.

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Government Policies for the Live Fish Trade

The government through the Department of Fisheries has laid down policies on the importance of regulating the live trade of fish. Live fish trade is very much encouraged, particularly to promote the ornamental fish trade. The advent of the aquaculture industry has somehow contributed to the increase in the live fish trade, particularly te trade in fry and fingerlings. However, only the imports of certain prohibited exotic or alien species fish is being regulated under the Custom Act 1967, the Fisheries Act 1985, and the Malaysian Fisheries Development Board (MFDB) 1971, for the purpose of safe-guarding the public from their menace rather than to protect the environment, habitat and species.

For all imports of live fish, the Custom Act 1967, the licence issued under MFDB Act 1971 and the permit issued by the Department of Fisheries under the Fisheries Act 1985 must be complied by all traders.

Legislation for the Control of Live Fish Trade

Fisheries Act 1985

The live fish trade in Malaysia is regulated under the Fisheries Act 1985 and the various regulations under the Act. In this Act, fish is defined as "any aquatic animals or plant life, sedentary or not, and includes all species of finfish, crustacean, mollusc, aquatic mammals, or their eggs or spawn, fry, fingerling, spat or young, but does not include any species of otters, turtles or their eggs". The control of the movement of live fish is governed under Sections 40 (1) and 40 (2) of the Act.

Under *Section 40 : The control of live fish movement is stipulated as follows:*

(1) Any person who –

- *(a) imports into or exports out of Malaysia;*
- *(b) transports from West Malaysia into the Federal Territory of Labuan or the State of Sabah or Sarawak;*
- *(c) transports from the Federal Territory of Labuan or the State of Sabah or Sarawak into West Malaysia;*
- *(d) transports from Federal Territory of Labuan into the State of Sabah or Sarawak;*
- *(e) transports from the State of Sabah into the Federal Territory of Labuan or the State of Sarawak; or*
- *(f) transports from the State of Sarawak into the Federal Territory of Labuan or the State of Sabah,live fish without any permit or in breach of any condition in a permit issued by the Director-General under this section shall be guilty of an offence.*

Section 40 (2) prescribes the authority of the Director-General to impose such conditions as he thinks fit in the permit, including conditions concerning the state of cleanliness of the fish to be exported, imported or transported and measures to avoid the spread of communicable fish diseases, or to avoid or control the release into the natural environment of non-indigenous species of fish.

Offenses under this Section is liable for a fine of not more than twenty thousand Malaysian Ringgit, or a jail term for a period not more than two years, or both.

Fisheries Regulations (Prohibition of Imports, etc) 1990

This regulation states that no person shall import, sell, rear, culture or keep any live fish listed in Table 1. There are 7 genera that are prohibited from importation, primarily due to their threats to the public safety. Those that pose a threat to the environment, habitat and species, however are not listed. Offenders will be fined with not more than one thousand Malaysian Ringgit or a jail term for a period not exceeding one year, or both.

Table 1: List of Genera Prohibited for Import under the Fisheries Regulations (Prohibition of import, etc.), 1990.

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1. *Serrasalmus*/*Serrasalmo*/*Pygocentrus/Catoprian*
2. *Pygopristis*
3. *Colossoma/Piaractus*
4. *Mylossoma*
5. *Mylopus/Myleus*
6. *Pristobrycon*
7. *Myletes*

This regulation is considered inadequate to control the trans-boundary movement of exotic or invasive alien fish species and associated trans-boundary pathogens. Hence, this regulation is now under review. The control of the live fish trade (both export and import) have been incorporated in the review, including relevant provisions in the Committee for the International Trade of Endangered Species (CITES). However, invasive alien species is not included. It can be incorporated if information on the invasive alien species at regional and global levels is available.

Impacts of Invasive Alien Species

There are about 90 aquatic exotic or alien species that have been introduced intentionally for aquaculture and ornamental fish trade as updated in the FAO's Database on Introductions of Aquatic Species (DIAS) and the Global Invasive Species (GIS) lists. Majority of these introduced species are freshwater fish imported to supplement the ornamental fish trade. The number, however is not exhaustive, as there are many more species unaccounted for. Of these, very few species are invasive which caused irreparable damage to the environment, habitat and species. There are no published data and statistics; some known impacts associated with some of the introductions are summarized in Table 2.

From Table 2, it is evident that the armoured catfish or the municipal fish (*Hypostomus sp*.) and the flat head fish (*Chaca chaca)*, have shown greatest impacts on the environment, habitat and species (Mohsin & Ambak, 1983). The reason for the introduction was that the fry has aesthetic value which is important for an ornamental fish. Somehow the fish escaped into the public water body, became established as scavengers, and propagated at an alarming rate.

Table 2: List of some known impacts caused by aquatic IAS.

Scientific/ Common name	Year of Introduction	Country of Origin	Purpose of Introduction	Impacts of Introduction
Hypostomus sp.	1970's	Argentina Brazil	Ornamental	Established in shallow rivers, scavenger, rake and sour river bank and river bed, water becomes very turbid, some of indigenous species, particularly the cyprinids such as *Osteochilus sp.*
Arapaima gigas	1970's	Argentina Brazil	Ornamental	Very voracious, grows to gigantic size in captivity, sharp teeth, posed danger to public, not known whether they have escaped and established in the wild.
Serrasalmus sp. *Mylossoma* *Myletus* *Mylopus/Myleus* *Pygocentrus* *Pygopristis*	1970 1970 1970 1970 1970 1970	Brazil	Ornamental	Posed danger to public as they are a look-alike to "piranha" which is known to attack human.
Piaractus *Micropomum* (Pacu)	1978	Argentina Brazil	Ornamental	Although banned, allowed to culture in ponds and cages in reservoirs, escaped into reservoir when PE net was bitten by the sharp teeth, not known whether capable of propagating in the reservoir.
Flower horn	1990	Taiwan	Ornamental	Discarded into public water when the market price dropped, not known to establish in shallow lakes. Being a ciclid, they need to build nest for breeding, cannot spawn in fast flowing rivers.
Cherax quadricarinatus (red claw)	1990	Australia	Aquaculture	Known to forage on aquatic weeds. Easily propagated in the wild (report from Australia). Banned to protect paddy production.
Peacock bass	1990	South America	Ornamental	Carnivorous and voracious feeder. Escaped into ex-mining pool and established, displacing indigenous species such as *Notopterus notopterus, Rasboras sp.* and *Osteochilus sp.*

The fish have invaded some shallow rivers particularly in the urban areas, where domestic and restaurant garbage either intentionally or unintentionally are being washed down during heavy showers, thus providing food for their survival. One such river system is the Klang-Gombak River which meanders through the Federal Territory of Kuala Lumpur.

Multi-stakeholder studies undertaken in the 1990's, to rehabilitate and restore the ecology of this river, was futile. This was due to irreparable damage caused by this species, through constant raking and scouring of the river bed, making the water very turbid with very high levels of suspended solids. The study also showed that a number of indigenous species were displaced, particularly the cyprinids, which once dominated the river. Stocking of indigenous species at the upstream, such as the giant freshwater prawn (*Macrobrachium rosenbergii)* and the cyprinid (*Puntius gonionotus)* did not really succeed due to deteriorating water quality.

The giant prawn, which requires brackishwater at the downstream to breed, is not able to by-pass the barrier of flat head fish; hence, the prawns were not able to propagate.

Other species such as *Arapaima gigas, Colossoma macropomum, Mylossoma* sp. are prohibited mainly because of their biological features that pose a danger to the public. The carnivorous A. gigas has sharp piercing teeth and can attain a gigantic size in captivity; its escape into the inland water bodies might pose a great danger to the public at large. Similar threat is also seen from *Colossoma macropomum*, although this species is not carnivorous. The importation of piranha (Mylossoma sp.) is prohibited based on its well known record of attacking human in the Latin America.

The black and the red tilapia, introduced from Latin America, also posed a threat to the environment and species, as they can propagate in shallow rivers by building nesting structure, causing displacement of indigenous species. Since the fish is consumed locally, the impact is not really felt so much. It is postulated that this species might cause some indigenous species to be displaced or extinct; this, however, cannot be confirmed as there is no study on this matter.

The red claw crayfish, *Cherax guadricarinatus*, was introduced from Australia in the early 1990's for aquaculture purposes. The impact to the freshwater ecosystem was not known then. This species is now known to forage on aquatic weeds efficiently, too efficient, that if it escapes into the paddy field, it may forage the whole field in no time. Hence, a ban was imposed on all importation in the mid-1990's but the species was already in the country. The culture was not successful as its growth was too slow and it became uneconomical as the price it commanded did not commensurate with the high inputs and required long culture period.

In the marine environment, the incidental introduction of invasive alien species through ballast waters from ships and cargo vessels have caused significant losses to the fisheries industry. One example is the red tide phenomenon occurring in Malaysia, particularly in Sabah, Sarawak and the Federal Territory of Labuan. Formerly caused by a tropical dinoflagellate, *Pyrodinium sp.,* which produces a deadly toxin that is fatal to both human, fish and bivalve molluse. Consumption of infected fish or bivalve molluse can be fatal. The recent occurrence of red tide was caused by a new dinoflagellate species, Cochlodinium sp., alien to the tropics and originating from temperate waters; this species caused fish kills, including morrtalities among bivalve molluses. This dinoflagellate produces toxins harmful to fish, particularly the pelagics, but it is not known to affect human being.

The lack of awareness on the impacts of the introduced alien species, and the lack of information on their impacts and possible threat to the environment, habitat and species by the authorities, are the main reasons for the consequent lack of mitigating and precautionary measures to combat the invasive alien species.

Recomendations

The subject of invasive alien species is considered relatively new. Very little is being done to address the risks, threats and impacts associated with its introduction. Awareness is very much lacking among the policy makers, local governments and the public at large, on the risks and impacts associated with its introduction. Hence, it is recommended that a holistic approach to combat invasive alien species be looked into, which also looking at what needs to be done to rehabilitate or restore the environment, habitat and species that have already being affected by the intentional or unintentional introduction. This would help the policy makers and enforcement agencies in combating the problems more effectively.

The following recommendations address the risks associated with the introduction of invasive alien species, and the impacts or problems caused by the introduction.

(i) Capacity building to formulate national strategy and action plan to combat the impact of invasive alien species

There is very little information on aquatic invasive alien species, particularly on the risks and threats they pose to the environment, habitat and species as advocated the Convention on Biological Diversity (CBD), the Cartagena Protocol on Biosafety and CITES. Hence, a more concerted effort on capacity building and awareness on their threats and risks associated with the trans-boundary movements, should be enhanced to include not only the policy makers, but also all stakeholders including non- governmental organizations. Since invasive alien species is a cross-cutting issue, it has to be addressed holistically, taking into account all the environmental, ecological, habitat and species aspects of the risks in order to formulate a national strategy and action plan to combat the impacts of the invasive alien species on the environment, ecology, habitat and indigenous species.

There is lack of awareness, understanding and comprehension by policy makers on the subject of risk analysis, risk assessment, risk management and risk communication for invasive alien species. Although there are already a number of courses organized at the regional level on these topics, the lack of awareness and understanding of the risks and impacts associated with invasive alien species makes it ineffective to implement the initiatives at the national level. Hence, there is a need to develop a simple, practical and easy to use guide manual with diagrams and flow charts for easy comprehension, which can then be translated by member countries into their own vernacular language without having to re-synthesize the contents. An easy to use guide will also be useful for enforcement of personnel to implement the required regulations at the point of entry. By using this approach, training can be conducted by the national authority much more effectively as all the manuals are already available, and it is only a matter of having them translated into the national language.

(ii) Establish a Clearing-House Mechanism

Article 18.3 of the CBD encourages contracting parties to establish a Clearing-House Mechanism (CHM) in order to facilitate and promote technical and scientific co-operation. A CHM is an information network made up of electronic and non-electronic media. This mechanism, can perhaps be adopted or established for the invasive aquatic alien species for the ASEAN region. There is already a dearth of information on invasive aquatic alien species produced by many regional organizations. Dissemination of information between countries, and within CHM will help avoid duplication of work, promote transfer of technology, and enable formulated objectives to be achieved more quickly. Organizations such as NACA and FAO can play a pivotal role in this region to establish the CHM for invasive aquatic alien species. In this context also, the Cartagena Protocol on Biosafety can also be adopted in addressing the risks and threats posed by the invasive aquatic alien species.

(iii) Restoration and Rehabilitation Programmes

Damage to the environment, habitat and species caused by the introduction of invasive alien species needs to be appraised by all ASEAN countries in order to collect and collate information pertaining to the extent of the damage, and to facilitate in the formulation of restoration and rehabilitation programmes, including eradication program where feasible. Some of this damage is irreparable, but some can still be rectified. Efforts to rehabilitate and restore some of the damaged, lost or displaced environment, habitat and species should also be given attention. Regional efforts should also concentrate on soliciting funds to undertake such programmes on a regional basis. The involvement of the civil society groups and all stakeholders as well as policy makers is imperative to ensure that national restoration and rehabilitation programmes are achieved.

Conclusions

In order to combat the impacts of invasive aquatic alien species, more awareness programme and information gathering are needed to keep the society well informed of the risks and threats posed by the intentional or unintentional introduction. Strategy or action plan needs to be formulated to combat the risks and threats associated with the trans-boundary movement of invasive alien species. More practical approach to combat these cross-cutting issues should be looked into holistically, involving not only policy makers, but also all stakeholders and civil society at large, including programmes to restore and rehabilitate environment and habitats that have been damaged by the introductions.

Part II: Associated Trans-boundary Aquatic Animal Pathogens

Introduction

The increase in the import and export of live food fish, fry and aquarium fishes during the last two decades resulted in the parallel increase of fish disease occurrence such as the epizootic ulcerative syndrome (EUS) in 1976 (Kamonporn, 1994), white spot syndrome virus (WSSV) epidemic during 1994-1995 (Anon., 1996; 1999), vibriosis, scale-drop disease and a range of parasitic infections in both freshwater and marine environments (Shariff & Subasinghe, 1993). A socio-economic survey during the period 1994 to 1998 on the impacts of fish diseases in aquaculture revealed an estimated loss of RM 82.63 million (Anon., 1999).

Currently, a number of new diseases of aquatic organisms, particularly of aquaculture and ornamental interest, were introduced through movement of broodstocks, eggs, fry and fingerlings (Mohd. Noor & Fauzidah, 2003). The more recent findings showed the presence of koi herpes virus (KHV) (Hassan, 1995), viral nervous necrosis (VNN) (Chuah & Kua, 2003), iridovirus (Oseko, 2004) and Taura syndrome virus (TSV) (OIE/NACA, 2004; unpublished data). They have been proven harmful to the local aquaculture and ornamental fish production. Under this scenario, the WTO-SPS and other international aquatic animal health requirements have brought about increased awareness and enhanced local efforts to ensure maintenance of aquatic animal health and safety of the aquatic environment in general as outlined in the 'Code of Conduct for Responsible Fisheries, Section 7.5.1'. Therefore fish health management with respect to trans-boundary aquatic animal pathogens (TAAPs) has been given 'topdown priority' and the Department of Fisheries has undertaken various programs in the 'Five Year Plans' starting from 1986 (5^{th}, 6^{th}, 7^{th}, 8^{th} and 9^{th}) and until 2010. Although the said awareness and concerted efforts have resulted in positive directions on fish health policies, development programs and governmental implementations, there are still a lot of room for improvement in the over-all national context with regards to the containment of the trans-boundary aquatic animal pathogens (Choo & Md. Akhir, 2001). In this paper, an attempt is made to summarize the strategies, developments, implementation and the progresses achieved towards managing the current trans-boundary aquatic animal pathogens.

Associated Aquatic Animal Health Pathogens

National Aquatic Animal Health Management Strategies

Table 1 shows the status of implementation of the elements in the Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals.

The level of surveillance for the above pathogens/diseases is currently limited (Zaharah & Kua, 2003). Surveillance is not continuous or consistent. However, the following activities are carried out:

- Studies on the presence serious pathogens are carried out during fish disease case investigations.
- Diagnosis is carried out for these pathogens: (a) viral diseases such as WSSV, iridovirus, VNN, TSV, YHV and KHV; (b) bacterial disease such as Vibriosis, Aeromonas hydrophila and Streptococcus sp.; (c) fungal disease such as Aphanomyces spp., and (d) parasitic diseases such as cryptcaryosis, monogeneans, Benedenia sp., and Neobenedenia sp. Those diseases in the OIE list are also included.
- Repeated field investigations with multistage samplings are carried out to determine disease prevalence in affected areas.
- Observational studies on trans-boundary aquatic animal diseases at main entry points of live animals through established quarantine procedures.
- Laboratory examinations of samples (fry and broodstock of shrimp, fish and ornamentals) submitted by the Fisheries Assistants (Aquaculture Extension Officers) or other stakeholders for certification.

Table 1. Status of implementation of the elements in the Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals

	Technical Elements	Current	To be Implemented	Planned Strategies
1	Guiding principles based on Beijing consensus	Based on the TG & Beijing Consensus	Code of Conduct for Responsible Fisheries, Section 7.5.1	Documentation of National Aquahealth Plan; International co- operation
2	Pathogens to be considered	OIE list; new & emerging pathogens with negative impact in the region	Priority list for local & regional pathogens (warm water species); OIE International Aquatic Animal Health Code, 2001	Database, information system at NAFISH with international linkages
3	Quarantine and health certification	Existing Quarantine Centers (KLIA, Penang, B.K. Hitam, Tg. Kupang; Licensing & permit issuance, enforcement; network of main quarantine centers as import/export control	Pathogen inventory list and epidemiology 8 more Quarantine Centers or Stations	Network of quarantine centers; International cooperation and linkages on trans-boundary aquatic animal pathogens
4	Disease zoning	Under consideration	According to aquaculture industry zones (AIZ); Accreditation of operational systems	Certification (Aquaculture Estate Certification Scheme); Disease free zones & Immediate Response Task Forces for mitigation purpose
5	Import risk analysis	As required by species, e.g, the recent issue of *Littopenaeus vannamae*	Risk analysis for the safe movement of aquatic animals (FWG/01/2002) for all new imported species	Harmonized RA (qualitative and quantitative risk analysis); Development of local expertise
6	Institutional development and capacity building	National Fish Health Research Centre (R&D; Level III diagnostics; main referral center) FFRC, BARC, NAPFRE, MFBRC & FRIS (for Level II & as secondary referral laboratories) Diagnostic Service Laboratories (Level II) in major ZIA/Clusters Fisheries Act, 1984	Upgrading of capacity & expertise; Human resource development Upgrading of capacity & expertise Human resources development 9 additional Level II diagnostic centers	To develop a national network of quarantine, diagnostic and R&D centers with sufficient funding, equipment and additional man-power and training for staff; International collaboration in R&D
7			Inland Aquaculture Regulations Aqua Health Plan	National regulations; Aqua health plan; machinery of authority & manpower

Table 1... Continuation

	Technical Elements	Current	To be Implemented	Planned Strategies
8	Implementation strategies	Enforcement of Fisheries Act and other rules and regulations; CITES Act	Application of sustainable principles	Code of practices for movement of aquatic animals to control trans-boundary aquatic animal pathogens Inland Aquaculture Regulations Quarantine Regulations; Well informed and knowledgeable staff & stake-holders; Powerful and efficient extension network

Current Status of Trans-Boundary Aquatic Animal Pathogens

A summary of the status of trans-boundary aquatic animal pathogens in Malaysia is given in Table 2 below.

Table 2: A summary of trans-boundary aquatic animal pathogens in Malaysia.

Recorded Trans-Boundary Aquatic Animal	Year	Occurrence		Surveillance, Diagnostics & impact remarks
		Initially	Currently	
EUS with multiple pathogen infections (viral, bacterial & fungal agents)	1976; 1986	Northern States of Peninsular Malaysia	Few sporadic cases	No records on the source of the pathogen. Some monitoring work started in 1976. Affected species initially were riverine and freshwater pond cultured species. Occasional reports by farms using imported fingerlings of *Channa striata* and *Clarias macrocephalus.* (Shariff & Law, 1986 cited by Kamonporn, 1994)
YHV	1992	Northern States of Peninsular Malaysia	Nil	Source was imported *Penaeus monodon* fry from neighboring countries. Resultant major epidemics immediately occurred affecting almost all shrimp culture areas. This did not reappear again in epidemic scale but suspected to be present occasionally in wild brood stocks of *P. monodon.* (Anon, 1996; Wang, 1997)

Table 2: A summary of trans-boundary aquatic animal pathogens in Malaysia.

Recorded Trans-Boundary Aquatic Animal	Year	Occurrence		Surveillance, Diagnostics & impact remarks
		Initially	Currently	
WSSV	1994	In all states of Malaysia except Sarawak.	Few sporadic cases & restricted to certain areas only	Source was imported *Penaeus monodon* fry from neighboring countries. Caused major losses and many shrimp farms were shut down. Presently health management principles has helped to control and prevent epidemics. (Anon., 1996;1999; Wang *et al.*, 1999, 2000; Oseko, 2002; Palanisamy, 2002).
KHV	1998	unknown	unknown	Hassan, 1995; Najiah, 2003; Azila, 2004
Red Sea bream irido viral disease in sea bass	2000		Few cases	Imported fingerlings of red drum (*Sciaenops ocellatus*) from Taiwan spread this virus disease to *Lates calcarifer* stocks kept in cages in close proximity (Oseko, 2004).
VNN	2003	Pulau Langkawi	Terengganu	Imported grouper fry from Indonesia (Chauh & Kua, 2003)
TSV	Jan-March, 2004	Only in Manjung District, Perak	Suspected	The farms were involved in the culture of banned *L. vannmei.* (NAFISH unpublished data reported to NACA/OIE, 2004)

The DoF has developed new capabilities to screen and diagnose aquatic animal diseases (Palanisamy *et al.*,2001). The monitoring and reporting of disease problems have been facilitated by the National Fish Health Research Center (NAFISH); the existing quarantine centers in KLIA, Johor, Penang, Bk. Kayu Hitam, Kuching, Kota Kinabalu and Tumpat as well as a number of aquaculture R & D centers of the Fisheries Research such as: Brackishwater Aquaculture Research Center (BARC) of Kedah, National Prawn Fry Production and Research Center (NAPFRE) of Johor State, Freshwater Fisheries Research Center (FFRC) of Melacca, and Marine Fish Fry Production and Research Center (MFFRC). The diagnostic capabilities of each institute/center is shown in Table 3 on the next page.

The format of diagnostic reporting is for domestic use and includes the following findings: case history, virology, bacteriology, mycology, parasitology and histopathology (and when necessary electron microscopy which is partially done at USM) with a final section for recommendations to overcome the disease problems. The NACA/OIE Quarterly Aquatic Animal Disease reporting format is being used by DoF centers to report diseases to the National Coordinator on Health based at the NAFISH.

Table 3. Diagnostic capability of various fish health laboratories and quarantine centres of DOF.

Name of Center	Diagnostic Capacity (Levels I, II & III)	Remarks
NAFISH	Up to level III	Main referral national center & major fish health R&D role, NACA/OIE reporting co-ordination; AQIS certification, WSSV/YHV/ TSV/IHHN Certification
BARC	Level II with PCR capability for WSSV	Secondary referral center
NAPFRE	Level II with PCR capability for WSSV & VNN	Secondary referral center
FFRC	Level II	Secondary referral center
MFFRC	Level II with PCR capability for WSSV	Secondary referral center
FRIS Likas Center, Sabah Quarantine Centre,	Level II with PCR capability for WSSV Level II Level II with PCR capability for WSSV	Secondary referral center Secondary referral center Secondary referral center
KLIA & Subang Quarantine Centre,	Level I	Quarantine function
Johor Quarantine Centre,	Level I	Quarantine function and assists infish health extension work
Bk Kayu Hitam Quarantine Centre,	Level I	Quarantine function
Penang Quarantine Centre,	Level I	Quarantine function
Kota Bharu Quarantine Centre,	Level I	Quarantine function
Kuching Quarantine Centre,	Level I	Quarantine function
Kota Kinabalu University Laboratories (UPM, UM & KUSTEM)	Up to level III	Fish health academia, also assist in diagnostics of special cases

Current Management Strategies for Trans-boundary Aquatic Animal Pathogens

Malaysia lacks a documented aquaculture health management plan. There are only some discussion papers on policy matters (Kechik, 1993; Kamaruzaman, 2001). However, currently, the FAO documents like the 'Asia regional technical guidelines on health management for the responsible movement of live aquatic animals and the Beijing consensus and implementation strategy', the 'Manual of procedures for the implementation of the Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animal' and the 'Code of Conduct for Responsible Fisheries, Section 7.5.1' are used. The following strategies are applied to prevent or minimize the riskof the trans-boundary aquatic animal pathogens:

a) Legal, enforcement and control measures. Several measures are implemented under the Fisheries Act 1985, Section 40(1) and 40 (2), Customs Act. These are:
   i. Control of import and export live animals
   ii. Introduction of relevant policy matters
   iii. Appropriate quarantine measures
   iv. Enforcement and punitive measures
b) Cooperation within governmental agencies, stakeholders and with local non-governmental organizations.
c) Cooperation with regional and international authorities/agencies like FAO, NACA, OIE and ASEAN.
d) Infrastructure. Provision of quarantine and fish inspection centers, diagnostic laboratories, IT facilities and miscellaneous logistics were being developed since the 5^{th} Malaysia Plan until present. This will be continued to the 9^{th} Malaysia Plan until year 2010.
e) Capacity building: an on-going activity.
f) Training of manpower to handle the trans-boundary aquatic animal pathogens problem
g) Contingency measures such as national task forces, immediate response teams, risk analysis (e.g. in the case importation of *Litopenaeus vannamei,* fry and broodstock), and development of code of practices.
h) R & D measures for diagnostics (improvements, antibody probes and molecular based techniques) of pathogens, preventive medicines (e.g. vaccines), eradication (biological controls and probiotics), treatment (safe chemotherapy minus antibiotics) and development of Specific Pathogen Free (SPF) or Specific Pathogen Resistant (SPR) animals.

Progress in Implementing Recommendations for Managing Trans-Boundary Aquatic Animal Pathogens

The implementation of legal, enforcement and control measures are in progress as indicated below:

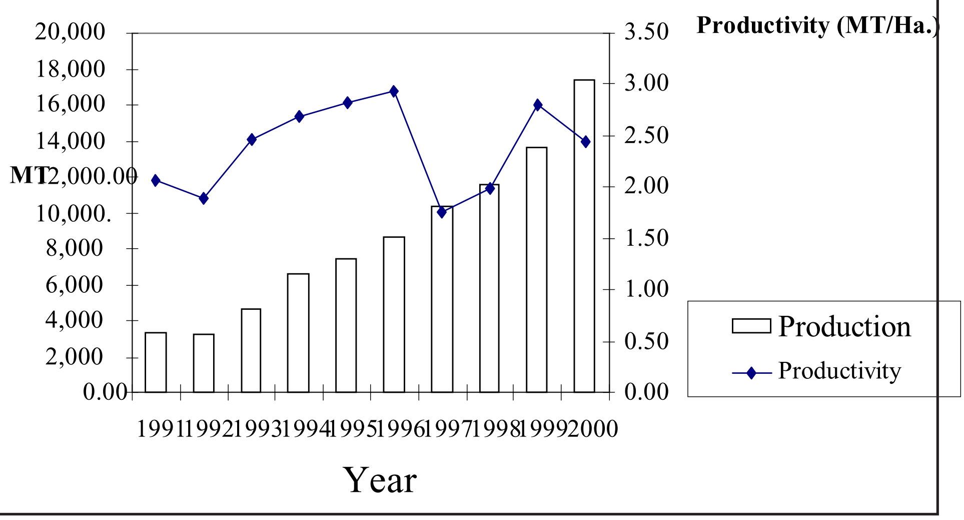
- Besides the enforcement of the Fisheries Act, 1985, Section 40(1) and 40 (2), new regulations such as 'Inland Aquaculture Regulation' and 'Fish Quarantine Regulations are awaiting parliamentary approval.
- To control the entry and exit of aquatic animal pathogens, standard import and export procedures of live animal have been established (Mohd. Noor & Fauzidah, 2003). The agencies involved in the implementation and operation of the procedures are DoF (Competent Authority), Fisheries Development Authority and the Royal Customs Department. Cooperation of DoF (Competent Authority) with Department of Veterinary Services (DVM), Fisheries Development Authority, Sarawak Ministry of Agriculture and DOF, Sabah in the control of TAAPs is smoothly carried out through the joint implementation of standard import and quarantine procedures.

- *Import procedures* include:
  - ✓ Application Form, FQ1DoF
  - ✓ Import License from Fisheries Development Board (LKIM)
  - ✓ Import Permit from DoF
  - ✓ Health Certificate from the exporting country
  - ✓ Details of species (common and scientific name, quantity, no. of containers/ cartons/ packaging)
  - ✓ 2 copies of invoices
  - ✓ Airway Bill
  - ✓ Custom Form K1
  - ✓ CITES Certificate, where applicable
- Implementation of *quarantine procedures* include:
  - ✓ Importer/owner must have quarantine facilities approved by Competent Authority (DoF)
  - ✓ Upon arrival, all consignment must be quarantined for specified duration
  - ✓ Send adequate samples of every species to laboratory for observations
  - ✓ Used water, packing materials, containers and other associated shipping materials must be disinfected/ sterilized
  - ✓ Treatment for infected fish until all fish is free of diseases
  - ✓ If treatment is not successful, destroy all consignments
  - ✓ Get approval from CA, if extended period of quarantine is necessary
  - ✓ Record any abnormality/ mortality during quarantine
  - ✓ Bury or destroy the dead in an incinerator
  - ✓ Only fish certified as pathogens free can be released for transfer
- *Specific protocols* as stipulated by the DoF (Competent Authority) for the prevention of TAAPs that might be possible through introduction or transfer of aquatic animals include the following:
  - ✓ Any individual intending to introduce or tansfer new live aquatic species for commercial purposes must obtain written approval from the Competent Authority.
  - ✓ Detailed information on the biological and other characteristics of the live aquatic species must be provided for risk analysis, e.g. feeding habits and food organisms utilized, reproductive pattern and strategy (when, where, how), competition with other species, predation by or on the species, migration routes and timing (if applicable) and disease history.
  - ✓ Once approval by the Competent Authority has been granted, only a small quantity (to be specified by Competent Authority) is allowed to be introduced.
  - ✓ Upon arrival, the consignment has to be surrendered to Competent Authority for further risk analysis and monitoring.
- *Regional cooperation.* This has been well received through the disease reporting network. Adoption of harmonized disease diagnosis techniques with the help of the 'Asia Diagnostic Guide to Aquatic Animal Disease' (Bondad-Reantaso *et al*.,

2001) has been useful. Other mechanisms worth mentioning include that of the grouper network, the SEAFDEC fish health management on-line training course, and participation in KHV workshops.

- *Infrastructure, capacity building and training.*
  - ✓ *Infrastructure:* The Malaysian government has made a number of arrangements through the Five-Year Plans since the late 1980s to build additional quarantine centers and diagnostic centers at strategic locations to check the TAAPs. A total of 7 quarantine centers are already in operation and 8 more will be developed before year 2010.
  - ✓ The NAFISH was commissioned in the year 2002 to play a major role in R & D and as the national referral centre for fish health in the country.
  - ✓ The DoF has taken measures to equip NAFISH to provide training for quarantine and fish health extension workers of DoF. Todate, 30 and 6 quarantine/laboratory staff have been trained on Levels I and Level II diagnostics, respectively.
- *Contingencies and other measures.* A number of programs have been carried out. Some important ones are listed below:
  - ✓ A National Committee to combat WSSV epidemic headed by the Director General of Fisheries Malaysia was set up in 1995. A task force was also set up at the same time to assess the WSSV epidemic and to make recommendations to overcome the problem. The implementation of the recommendations resulted in the development of code of practices for sustainability, disease screening, control on the trans-boundary movement of brood stock and fry, setting of PCR laboratories, certification of fry and training of stakeholders on health management to overcome disease problems. Most shrimp farms have gone into operation now and production of shrimp is on the increase (Fig. 1).

Fig. 2 Shrimp Productivity of Malaysia since the outbreak of WSSV (Subramaniam, 2003a; b)



- ✓ A qualitative IRA was carried out in 2003 to assess the impact of introducing *L. vannamei* into Malaysia. This lead to the ban of import of fry/broodstock and also the culture of the species. However, illegal entry of the species is still causing problem.
- ✓ CITES procedures are followed in cases of trans-boundary movement of aquatic animals.

Recommendations

Recommendations to strengthen national and regional capacity to address risks from Trans-boundary Aquatic Animal Pathogens (TAAPs) are as follows.

- Capacity building
- ✓ strengthening of the national SPS regulation and risk analysis capacities
- ✓ enhance the upgrading of the NAFISH through hiring of additional staff and provision of advance equipments. This will develop NAFISH into an international referral center.
- ✓ enhance and upgrade the other R & D and quarantine centers in order to provide better diagnostic services.
- ✓ development of additional quarantine centers fish diagnostic laboratories is important in view of the active trade on aquatic animals and recent negative impacts of WSSV, VNN and TSV.
- ✓ enhance and increase surveillance resources, in terms of funding and personnel, and facilitate the formation of a national databank and information system which can be linked to regional and international aquatic health information systems.
- ✓ provision of adequate training for the R & D, fish health management and quarantine staff to develop the required level of diagnostic capability. International expertise to train the local staff and standardize the diagnostic procedures.

- Adequate funding and manpower.
- ✓ Adequate funding is necessary for the implementation of surveillance, R & D activities and other fish health management operations. Funding is important for international linkages and collaboration.
- ✓ The Competent Authority and her machinery currently need to re-engineer the present structure in order to eliminate the present acute shortage of man-power for the implementation and operation of quarantine, R & D and fish health extension activities and to achieve efficient operations.
- ✓ Regional and international linkages must be encouraged.
- ✓ Facilitate regional and international linkages for the purpose of technical assistance, bilateral assistance and information exchange.

- Implementation of mandatory requirement for Risk Analysis
- ✓ Mandatory requirement for qualitative and quantitative Risk Analysis is important under current situations. Proper documentation of national fish health plan

and risk analysis technical guides to ensure harmonized risk analysis.

  - ✓ The national agency must facilitate the training of stak-holders to understand the decision making process of IRA.
  - ✓ Active extension activities must be implemented nationwide to update the knowledge of stakeholders in the IRA process and impacts of TAAPs..

- Greater importance must be given to the adoption and implementation of 'Code of Conduct for Responsible Fisheries, Section 7.5.1' with respect to conservation, management and exploitation of living aquatic resources. This is important to protect and preserve the aquatic environment.

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Myanmar

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Part I: Aquatic Invasive Alien Species

Introduction

The Union of Myanmar is geographically situated in southeast Asia between latitudes 09 32' N and 28 31' N and latitudes 92 10' E and 101 11' E. Myanmar is bordered on the north and northeast by the People's Republic of China, on the east and southeast by Lao PDR and Thailand (on the Bay of Bengal) and on the west by Bangladesh and India.

Myanmar has total area of 261 228 square miles (677 000 square km). It stretches 582 miles (936 km) from east to west and 1 275 miles (2 051 km) from north to south. The length of continuous frontier is 3 828 miles (6 129 km), sharing 1 370 miles with China, 1 310 miles with Thailand, and 832 miles with India, 1 687 miles with Bangladesh and 148 miles with Laos. The coastal length from the mouth of Naaf River to Kawthaung is 1 760 miles.

Myanmar is divided longitudinally by four big rivers forming a large delta region before flowing down into the open sea. Almost one fifth of the country, in terms of area, is inundated during monsoon and post-monsoon periods. These inundated areas are very rich in native fishes which are harvested and consumed by Myanmar people as low-cost source of animal protein. It was reported that in 2003, the per capita consumption was 26 kg.

It has to be assumed that Myanmar people prefer to eat local fishes that they are accustomed to. Due to easy catch from the wild, aquaculture was uncommon and unfavorable among the people. However, from 1953 to 1954, the Department of Fisheries (DoF) initiated freshwater aquaculture with tilapia, kissing gouramy and common carp imported from Indonesia. It aimed to develop freshwater aquaculture that would play an important role in fish production to feed the people and in the future, for export purposes.

The people of Myanmar were initially reluctant to consume imported fish species because the appearance, color and size were new to them although the fish had similar taste to the local species, tolerant to adverse water conditions, and easy to spawn with minimum manipulation.

Imported common carp was named as the same local and notorious carp in "Inn Lay " Lake. It was said that the fish ate the dead bodies of human being that were sunk down by the lake people as they has no land to bury the dead bodies. So there was one saying that when "Inn Thar " (lake man) dies, he becomes alive as "Nga phane" and when "Nga phane" dies, he reincarnates as "Inn Thar" (lake man).The DoF later imported Chinese carps to support the development of aquaculture in order toincrease the income of fish farmers and to fully utilize the varied topographic and climatic conditions favorable for aquaculture activities. Indigenous species like major carps have high priority among fish farmers.

There were no specific fishery laws until 1989. Four fisheries laws including Law Relating to Aquaculture were promulgated. Under this law, fish is defined as 'all aquatic organisms living in whole or part of their life cycle in the water including eggs, larvae, fry, post-larvae, juveniles, etc.'. Aquatic organisms also include aquatic plants, seedling and seeds. Section 35 of this law also states that prior approval from the DoF should be obtained when importing or exporting live fish in and out of the country.

To implement this provision of the law, the government designated the DoF as the competent authority and the Director-General (DG) and Deputy Director-General (DDG) as responsible officers. The basic principles of conservation and preventive measures are explained to potential importers of live fish to facilitate their application. Importers have to comply with the regulations required by the DoF. Apart from Section 35, Section 39 A and B, states that the Minister of Livestock and Fisheries has the right to issue the proceedings with approval of the Government and the DG of the DoF also has the right to issue notifications with the approval of the Ministry of Livestock and Fisheries. Up to the present, no proceedings and notifications with respect to Invasive Alien Species (IAS) have been issued. However, the DoF is taking uttermost care and appropriate safeguards on the importation of alien fish to Myanmar.

Aquatic Alien Species in Myanmar

Myanmar had imported exotic aquatic species since 1954. Examples of aquatic alien species are described below:

Common carp (Cyprinus carpio)

Common carp (*Cyprinus carpio*) was imported in 1953-1954 from Indonesia and again in 1978 from Israel for culture purposes. In the beginning it was not popular among farmers, at present time the fish had becomes one of the commercially culturable species. The fingerlings of this fish were stocked in the natural water bodies; no negative impact has been reported so far; the fish were found to have established in the wild.

Kissing gouramy (Trichgaster pectoralis)

Imported from Thailand in 1954, cullture has not been popular and the fish is not used in grow-out farms. The fish has spread in the wild andbecame dominant in some inland water bodies. It supports food security and income generation in rural areas. There is no report on negative impact in the environment.

Giant gouramy (Osphronemus gouramy)

The fish was imported from Indonesia in 1955. The fish is not popular in Myanmar and has not been stocked into the wild.

Mossambique tilapia (Oreochromis mossambica)
The fish was imported in 1954 but the country of origin was not known. It was again imported in 1993 from China. The fish is popular and common in the grow-out culture. It has been stocked into the natural water bodies and man-made dams. There is no report of negative impact in the environment.

Nile tilapia (*Oreoctromis niloticus*)
The fish was imported in 1977 from Thailand for grow-out culture. The fish is getting more popular than the Mossambique tilapia. It has spread into the wild environment including man-made dams. The fish is used as bio-manipulater in tiger shrimp grow-out ponds. The environment-friendly shrimp culture demonstration in which Nile tilapia was used as a tool for elimination of sludge in the shrimp ponds was conducted in collaboration with DoF Myanmar and SEAFDEC-AQD with successful results. It is said the mucous secreted by Nile tilapia can diminish the luminescent bacteria. There is no report of negative impact in the environment.

Chinese carps (Grass carp - Ctenopharyngodon idellus; Silver carp - Hypophthelmichthys molitrix; Bighead carp - Aristichthys nobilis).
Chinese carps of above three species were imported in 1967 from China. Induced spawning of the said species was successful in 1987. Grass carp is a significant species that can eliminate grass, weeds and other submerged aquatic macrophytes. Therefore million of fish seed have been stocked into natural lakes where there are abundant weeds. Negative impact in the environment has not been reported.

Walking catfish (Clarias macrocephalus; Clarias gariepinus)
With a view to produce hybrid catfish fingerlings of *C.gariepinus* x *C.macrocephalus*, these fishes were imported as parent stocks from Thailand in 1990. The culture of hybrid catfish was popular in Thailand at that time. Before that, the fingerlings of hybrid catfish were imported from Thailand by the private sectors as the demand for this fish seed was very high. So the DoF had no way except to import parent stocks of these fishes. Seed production in Myanmar was quite successful. However, the grow-out culture of the said hybrid catfish was not successful with very low survival rate of about one percent. This may be due to the lack of technical know-how on the culture of this new species. The African catfish *C. gariepinus* can attain fast growth; over 10 kg body weight of this fish was found in the wild. The African catfish is a voracious eater, highly carnivorous with unpleasant meat texture. According to religious and cultural practices, Myanmar people are accustomed to stock fish seeds (including those of African catfish) into lakes during special occasions. The African catfish are known to bite the fins, tails of other big fish and also appendages of turtles and tortoises, so it is believed that they eat up smaller fish. The culture and seedp production of African catfish and hybrid catfish were banned since 1994.

Pangasius hypophthalmus
The fish is known as *P. sutchi*. The fish was imported from Thailand in 1982 and again in 1990 together with walking catfish. They were first used as parent stock; seed productionbecame successful in 1993. In 2002, the fish became most popular after a study visit of a Myanmar delegation to Vietnam. Cage culture of this species is quite encouraging. Seeds are stocked in lakes and reservoirs. The domestic consumption of this fish is considerably low. The fish is omnivorous and there is no report of negative impact in the environment..

Percu or Fresh-water pomfret (Piaractus brachypomus)
This fish, popularly known as freshwater pomfret, was imported in 2001 from Thailand. Seed production was successful since 2002. The fish is now getting popular among fish farmers. The fish is slightly similar to the Amazon fish 'piranha. The fish use its maxillary teeth to bite the fins of other fish. The fish may be economically beneficial but may cause some adverse effects due to its feeding habits.

Tapian or Thai barb (Puntius gonionotus)
This fish was imported in 1996 from Thailand, and seed production has been successful since 1998. Myanmar also has similar species of barbs. This is now one the popular and economically beneficial fish species for fish farmers; seeds have been used in stocking program to the natural waters. There is no report of negative impact in the environment.

Chitala (Notopterus chitala)
This species was imported in 1997 from Thailand. The fish has good growth and similar to the native species *Notopterus notopterus*. Propagation of Chitala is still at the experimental stage.

Super shrimp or Blue shrimp (Litopenaeus stylirostris)
The shrimp aquaculture development project in Myanmar was implemented from 2000 to 2003. The Myanmar DOF is fully aware of the advantages and disadvantages of alien species and associated trans-boundary movement of aquatic organisms. Initially, the development project encouraged only local species such as tiger shrimp (*Penaeus monodon*) which is in abundance in Myanmar. However, as a means of encouragement to the private sector, the DOF permitted to import the post-larvae of ''super shrimp'' or blue shrimp (*Litopenaeus stylirostris*) and the species was experimentally cultured near Yangon, capital of Myanmar. Due to very low salinity during the raining season, the survivality was poor and the species did not generate much interest among shrimp farmers.

Pacific white shrimp (Litopenaeus vannamei)
The shrimp farmers made a lot of request to the DOF to allow the importation of *L. vannamei*. The DOF consulted with the scientists from NACA, SEAFDEC and other agencies. As an experiment, however, Myanmar permitted the importation of 500 parent stocks of *L. vannamei* from Hawaii and seed production at an isolated shrimp hatchery was allowed. All the imported *L. vannamei* died on the way to the hatchery. For the second time, the DOF permitted a private farm to import one million post-larvae of *L. vannamei* from Hawaii and culture o the species was allowed in the same area. Only 3 to 4 tons of *L. vannamei* was harvested. Myanmar has some problems of white spot syndrome virus (WSSV) and is not willing to introduce Taura syndrome virus (TSV) disease. This is the main reason Myanmar has strictly banned the importation of *L. vannamei.*

Recommendations

Recommendations to Strengthening National and Regional Capacity to Address Risks from invasive alien species (IAS) include the following:

- Introduction of alien aquatic species should not be made if it compromises the safety of the country's natural resources and ecosystems.

- Some species that are known not to cause negative impact to fishery resources and ecosystem may be introduced; however, it is important raise awareness prior to its introduction.
- 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 have sufficient safeguards through high health management and screening method.
- Introduction of *P. vannamei* to Asia and the pacific region is still questionable. Myanmar is still keeping the species in the list of species whose importation is prohibited.
- Collaboration among regional and global scientists on risk analysis is necessary prior to introduction of alien aquatic species.

Part II: Associated Trans-boundary Aquatic Animal Diseases

Current Status of Trans-boundary Aquatic Animal Pathogens

Tthe pathogens of concern to Myanmar are epizootic ulcerative syndrome (EUS), white spot virus syndrome (WSSV), infectious hypodermal and haematopoietic necrosis virus (IHHNV), yellow head disease (YHD), Monodon Baculovirus (MBV), bacterial white spot syndrome (BWSS) and luminous bacterial disease (LBD). Polymerase chain reaction (PCR) is the diagnostic method used for WSSV, IHHNV and TSV. In the case of bacterial disease, isolation and culture is used especially for luminous bacterial. There are reports on the occurrences of parasitic infections; these needs further identification to the species level. Together with the expansion of aquaculture, incidents of mass mortality or growth retardation in farms have been observed and reported. In many ways, these may be related to the pond management malpractices or may be due to infection of pathogens. The DoF disseminates and educates farmers to follow Good Aquaculture Practices (GAP). Beginning 2004, The DoF enhanced field surveys and inspections of fish and shrimp farms in the states and divisions. The survey team is composed of technicians from the aquatic animal health and the aquaculture sections, local fisheries officers and other local stakeholders.

Forms, for reporting disease occurrence, are provided to managers/owners of culture ponds and hatcheries, and required to be filled up and returned to the Aquatic Health Section directly or through the appropriate local fisheries officers. In the case of an emergency disease situation, first hand report should immediately be given directly to local fisheries officer and/or the Aquatic Animal Health Section. Upon receipt of the report, the Aquatic Animal Health Section will evaluate the case and determine what actions are necessary to deal with the problem. Fish and shrimp farmers are organized and this allows them to deliberate on important issues (such as farm management and aquatic animal health) during meetings and workshops through the aquaculture extension activities provided by the DoF.

Current Management Strategies for Trans-boundary Aquatic Animal Pathogens

The DoF has set up a Disease Diagnostic Laboratory with technical assistance FAO through the TCP/MYA/2523 project. The laboratory has recently been upgraded with PCR machines. Technical assistance and training are provided by FAO, SEAFDEC, NACA and AAHRI.

Since 1998, Myanmar has participated in the FAO's Regional Technical Cooperation Programme TCP/RAS/6971 and 9605 "Assistance for the Responsible Movement of Live Aquatic Animal" in close collaboration with NACA. Myanmar took part in the development of the Asia Regional Technical Guidelines for the Responsible Movement of Live Aquatic Animal and Beijing Consensus and Implementation Strategy. Myanmar participated in the following regional workshops: (a) FAO/NACA health management workshops in Bangkok, Thailand in 1998 and in 2000 in Beijing, China; and (b) APEC workshop on Capacity and Awareness building on Import Risk Analysis (IRA) for Aquatic Animal held in Bangkok, Thailand in 2002.

National Aquatic Animal Health Management Strategy

Myanmar has also committed to develop a national strategy on aquatic animal health. Myanmar's National Strategy Framework on Aquatic Animal Health was developed during a national workshop held in Yangon on 10-11 April 2002. The workshop recommended the following priority elements of the National Strategy:

(1) Formation of Myanmar's Committee on Aquatic Animal Health (CAAH);
(2) Review of the Aquaculture Law 1989 with a view to update, revise or formulate provisions on aquatic animal health management through orders/ directives to be issued by the Director-General of DoF;
(3) Development of a human resources development program that will upgrade capabilities and facilities for disease diagnostics, research and education and extension;
(4) Development of a mechanism for aquatic animal disease surveillance and reporting; and
(5) Communication and awareness rising among all relevant stakeholders.

Formation of Myanmar's CAAH has been completed. Regarding the review of the Aquaculture Law, the Minister of Livestock and Fisheries has the right to issue Proceedings; while the Director-General of DoF has the right to issue the Notifications. To enforce the National Strategy, the DoF is preparing to issue the Notifications regarding the IAS and trans-boundary aquatic animal pathogens. Development of human resources, development of mechanisms and communication and awareness rising are on-going activities. Currently the laboratory has Levels I-III diagnostic capacities. The staff have basic skills in operating a bacteriology laboratory. So far, the laboratory is capable of detecting *Vibrio* species. Viruses such as WSSV, IHHNV and TSV are detected using PCR kits. The DoF has requested the FAO, NACA and SEAFDEC to provide necessary support to enhance the capacity the aquatic animal health management program in Myanmar. The DoF conducts activities to disseminate knowledge and information on aquatic animal health to farmers and other stakeholders.

Table 1 shows the status of implementation of the elements of the Technical Guidelines.

Table 1. Status of implementation, technical guidelines.

Elements in the Technical Guidelines	Status of Implementation
Pathogens to be monitored	For finfish, the following diseases (level of diagnosis indicated) are included: Epizootic ulcerative syndrome (EUS) – Level I Parasitic infection (monogeneans and digeneans) – Level I
	For crustaceans, the following diseases are included: White Spot Syndrome Virus (WSSV) – Level III Infectious Hypodermal Haematopoietic Necrosis Virus (IHHNV) – Level III Taura Syndrome Virus (TSV) – Level III Yellow Head Virus (YHV) – Level I Monodon Baculovirus (MBV) – Level I Bacterial White Spot Syndrome – Level I Luminous Bacterial Disease – Level II
Disease Diagnosis	The country has varying levels of diagnostic capability depending on the pathogen/disease of concern (see above)
Health certification and quarantine	Being implemented
Disease zoning	At the level of awareness raising
Contingency planning	Implemented but limited capacity

Recommendations

Aquatic animal health management is a challenging sector in aquaculture development. It is an important issue for developing countries where the trans-boundary aquatic animal pathogens are common. In this regard, regional collaborative programs should be continued. Myanmar needs further support in upgrading capacities in technical knowledge and practical experience. Table 2 indicates the progress in implementing recommendations for managing trans-boundary aquatic animal diseases.

Table 2. Progress in Implementing Recommendations for Managing Trans-boundary Aquatic Animal Pathogens.

Activities	Implementation Status
Coordination	The Aquatic Animal Health Section (AAHS) of the Department of Fisheries (DoF) as the National Focal Point for IAS
Political commitment	The DoF should enhance and empower capacity of AAHS in collaboration and support from international regional organizations such as FAO, NACA and SEAFDEC
Early warning and monitoring	AAHS has prepared and published information (leaflets, pictures, etc) relating to the negative impacts of IAS.
Research	Collection of information and data
Support	Avail supprot of FAO, NACAand SEAFDEC
Human resources development	Limited
Community participation	Being introduced
Partnership	Collaborate with Myanmar Fisheries Federation and universities
Awareness	Inter-departmental consultation not yet conducted, public awareness activities planned
Sustainability and prevention	Myanmar is always participating in aquaculture development programs of FAO, NACA, SEAFDEC

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Part I: Aquatic Invasive Species

Introduction

In May 16, 1975, Presidential Decree 704 was enacted to accelerate and promote the integrated development of the fishery industry and to keep the fishery resources of the country in optimum productive condition through proper conservation. The said decree encourages and promotes the exportation of fish and fishery aquatic products to enable fisheries to contribute positively to the development and growth of the national economy. Presidential Decree 704 gives authority to the Bureau of Fisheries and Aquatic Resources (BFAR) jurisdiction and responsibility in the management conservation, protection, utilization and disposition of all fishery and aquatic resources of the country except municipal waters. Section 18 of PD 704 specifies the requirement of a permit for importation or exportation of fish and fishery products for propagation or other purposes. Several implementing rules and regulations in the form of Fisheries Administrative Orders (FAOs) aimed at regulating the movement of fish (including alien species) and fishery products into and from the Philippines were enacted. The most significant are FAO Nos. 126 and 189 prohibiting the importation of piranha and live shrimp and FAO Nos. 135 and 192 which contain the rules and regulations governing the importation of fish and fishery/aquatic products.

Due the to rapid advancement in modern biotechnology which led to the development of new products which might pose risks to human health and environments, Executive Order No. 430 was issued in 1990 creating the National Committee on Bio-safety of the Philippines (NCBP). The Committee issued the first and second editions of the Philippine Bio-safety Guidelines in 1991 and 1996 respectively. The guidelines are aimed at regulating the importation, transfer and use of genetically modified organisms (GMOs) and potentially harmful exotic species, focusing on work performed under contained condition.

In 1992 and 2000, by virtue of Special Orders issued by the Secretary of the Department of Agriculture (DA), several committees were formed to look into the introduction of exotic species and GMOs.

In 1997 the Departments of Agriculture, Health (DOH), and Interior and Local Government (DILG) jointly issued Administrative Order No. 01 to regulate the harvest, gathering, transport and sale of shellfish within the Philippines. The order regulates the in-country movement of shellfish to prevent the spread of unwanted organisms that might be present in the shellfish, i.e. red tide-causing organism. The same order defines the National Red Tide Task Force (NRTTF) whose mandate is monitor the red tide cell density in sea water and toxicity level in shellfishes in Philippine waters. A Philippine Guidebook on Toxic Red Tide Management was published in 1999. It contains basic concepts on the ecology, public health significance and socio-economic consequences of red tide. The guidebook also provides existing policies concerning red tide management, administration, mitigation, response recovery and management program.

Republic Act 8550 otherwise known as the Philippine Fisheries Code of 1998 was passed into law in 1998. It is an act providing for the development, management and conservation of the fisheries and aquatic resources integrating all laws pertinent thereto and for other purposes. Sections 10, 67, and 100 incorporate regulations pertaining to the intentional introductions of aquatic species. The law authorized the BFAR as the government agency responsible for the implementation of the provisions in the said sections. The following are the most recent and relevant FAOs governing the movement of live aquatic animals:

a) FAO, No. 220, Series of 2001. Operation of the Fish Health Laboratories and collection of fees and charges therefore;
b) FAO No. 207, Series of 2001. Prohibiting the importation and culture of imported live shrimp and prawn of all stages;
c) FAO No. 221, Series of 2003. Further regulating the importation of live fish and fishery/aquatic products under FAO no. 135 s. 1981 to include micro-organisms and bio-molecules;
d) Fisheries Office Order No. 211, Series of 2003 – Amendment to Fisheries Office Order No. 147-01, series of 2001: Designation of Regional Fish Health Officers (RFHOs) of BFAR;
e) Fisheries Memorandum Order No. 240, Series of 2003- Regulations on Trans-boundary movement of Shrimp Post-larvae;
f) Fisheries Memorandum Order No. 078, Series of 2003 Restriction on entry of live fish species importation from Taiwan and China;
g) Fisheries General Memorandum Order No. 014, Series of 2004. Guidelines for the implementation of Fisheries Memorandum Order 240: Regulation on trans-boundary movement of shrimp post-larvae; and
h) Fisheries Memorandum Order No. 013, Series of 2004 – Imposition of active surveillance mechanism for all shrimp hatcheries nationwide as part of the strict implementation of the National Action Program to Control White Spot Syndrome Virus (WSSV) in shrimp.

Other legal instruments in the form of Presidential Decrees, Circulars and Orders were discussed and listed in Reantaso (1977).

Introduced Marine Pests (IMPs)

The BFAR and the Marine Science Institute of the University of the Philippines (UP MSI) represented the Philippines in the development of a regional risk management framework for APEC Economies for use in the control and prevention of introduced marine pests (IMPs) held in Hobart, Australia on 12-15 November 2001. In the said workshop the Philippines recognized the significance of introduced marine pest and the need to build capacity and capability to identify, detect and manage introduced marine pests as well as the need to set guidelines and standards and prioritize issues regarding hazards of introduced marine pests.

Ballast water

The Maritime and Ocean Affairs of the Department of Foreign Affairs (MOA-DFA) formulated the country's position on the control and management of ships' ballast water and sediment to prevent, minimize and ultimately eliminate the transfer of Harmful Aquatic Organisms and pathogens. A country team composed of members from government agencies (Philippine Coast Guard, Philippine Ports Authority, Maritime Industry Authority, BFAR -DA, Coastal Marine Management Office-DENR, Environmental Management Bureau-DENR), the academe (UP MSI), the private sector (Filipino Ship Owners' Association), and non-governmental organizations such as Conservation International and the World Wildlife Fund) was formed. The team came up with a position paper on the draft text of the International Convention for the Control and Management of ships' Ballast Water and Sediments for presentation to the International Conference on Ballast Water Management for Ships held on 9-13 February 2004 at the headquarters of the International Maritime Organization (IMO) in London.

Aquatic Alien Species

Current status and knowledge of impact of aquatic alien species

The problems caused by the introduction of alien aquatic species, i.e. finfishes (*Oreochromis niloticus, O. niloticus, Poecilla latipinna, Clarias batrachus),* snail *(Pomacea canaliculata)* in the country has been discussed by Reantaso (1997). Specific adverse effect and a list of more introductions of alien species are given in Table 1.

Below are some information on the status and knowledge of impact of some aquatic alien species.

Janitor Fish (Hypostomus plecostomus)

The *Hypostomus plecostomus* was imported into the country as an aquarium fish and was not meant to be reared in natural bodies of water. However, its accidental release in Laguna Lake was brought about by heavy flooding resulting from typhoons in the country. It quickly thrived and posed a significant threat to the existing economically-important food fish in the lake. Reports show that it has dominated the lake so much so that it now constitutes 10-38 percent of the total fish trap catch in Siniloan (Laguna province) area and dominates the daily fish catch by marginal fisherman. Since the fish has practically no value, the tendency os for the fish to be thrown back to the water. This has aggravated the problem. There have been reports of it destroying the nets and pens of the fish farmers.

A consultation workshop was held to determine the management and control strategies to remedy the problem. The workshop agreed to determine ways to make use of the fish through other products, e.g. using the skin as leather source for making bags, shoes and other accessories; conversion into fish meal; and as protein source. BFAR will issue prohibition on the in-country movement and release of the fish in the environment.

Table 1. Listed introduction of the alien species in the Philippines

Name	Common name	Year	Introduced from	Effect(Socio-economic/ Ecological/ Status	Reason	Reference
Ameiurius catus	**??**	1935	USA (California)	Not established	aquaculture	DIAS, year
Anabas testudineus	??	Unknown	Malaysia	Beneficial	aquaculture	DIAS
Aristichthys nobilis	Bighead	1968	Taiwan	??	??	Guerrrero 1981
Bidianus bidianus	Silver perch	?	Australia	Still under experimentation as culture fish	aquaculture	BFAR
Carasius carassius	Crucian carp	1964	Japan	Established	aquaculture	Guerrrero 1981,DIAS
Catla catla	Catla	1967	India	??	aquaculture	Guerrrero 1981
Chana striata	??	1908	Malaysia	??	aquaculture	DIAS
Cherax quadricarinatus	Red claw		Australia	Under IRA by BFAR	aquaculture	Paclibare et al 2004
Cichla spp	Peacock bass			Confiscated with compensation	ornamental	Paclibare *et al*. 2004
Cirrhinus mrigata	Mrigal	1967	India	Not established	aquaculture	Guerrrero 1981,DIAS
Clarias batrachus	Thai catfish	1972	Thailand	Displacement of native catfish, *Clarias macrocephalus*	aquaculture	Guerrrero 1981, Juliano et al, 1989,Reantaso 1997
Clarias gariepinus	??	1985	Thailand	Private sector	aquaculture	DIAS
		1985	Taiwan, China	Unknown	aquaculture	DIAS
		1987	Thailand	Private sector	??	DIAS
Colossoma macropomum	??	??	??	??	??	??
Cristaria plicata	Singapore	1970	unknown	Not established	ornamental	DIAS
Ctenopharyngodon idella	Grass carp	1967	India	Established, beneficial	aquaculture	Guerrrero 1981
Cyprinus carpio	Common carp	1915	Hongkong	No adverse effect reported	aquaculture	Guerrrero 1981
		1925	Canton,China	??	aquaculture	Guerrrero 1981
		1926	Formosa	??	aquaculture	Guerrrero 1981
Fundulus heteroclitus	Mosquito fish	1905	Honolulu Hawaii	??	??	Guerrrero 1981
Gambusia affinis	Mosquito fish	1905	Honolulu Hawaii	??	??	Guerrrero 1981
Helostoma temmincki	Kissing gourami	1950	Thailand	??	??	Guerrrero 1981

Name	Common name	Year	Introduced from	Effect(Socio-economic/ Ecological/ Status	Reason	Reference
Hypopthalmichthys molitrix	Silver carp	1968	Taiwan	Established	aquaculture	DIAS, Guerrrero 1981
Hypostomus plecostomus	Janitor fish	??	??	Established,adverse, competitor, destroy pens and cages	ornamental	BFAR, LLDA
Ictalurus punctatus	Channel catfish	1974	California, USA	??	??	Guerrrero 1981
Labeo rohita	Rohu	1967	India	??	??	Guerrrero 1981
Lepomis cyanellus		1950	USA	Established	aquaculture	DIAS
Lepomis macrochirus	Blue gill	1950	USA	Government		Guerrrero 1981
Megalobrama amblycephala	??	1944	China	Private	Aquaculture	DIAS
Micropterus salmoides	??	1907	USA	Beneficial	aquaculture	DIAS
Misgurnus anguillicaudatus	Loach	1942-43	Japan	??	??	Guerrrero 1981
Nicropterus salmoides	Black bass	1907	Folson, California	??	??	Guerrrero 1981
Oreochromis aureus	tilapia	1977	USA, Singapore	Adverse, competitor in aquatic farms	aquaculture	Guerrero,1981DIAS
Oreochromis mossambicus	tilapia	1950	Thailand	Adverse effect on native species, *Mistichhthys luzonensis, Sardinella*	aquaculture	DIAS, Juliano et al 1989,Reantaso, 1997
Oreochromis niloticus	tilapia	1972	Thailand	*tawilis*	aquaculture	Guerrrero 1981, Mercene 1995, Reantaso 1997
		1973	Thailand and Israel	??	aquaculture	Guerrrero 1981, Dias
Oreochromis spirulus	tilapia	1985	Saudi Arabia	??	aquaculture	DIAS
Oreochromis spp.	tilapia	1979	Taiwan, China	??	aquaculture	DIAS
Osphronemus gouramy	Giant gouramy	1927	Indonesia	??	??	Guerrrero 1981
Pangasius hypophthalmus	??	1978	Thailand	Private	aquaculture	DIAS
		1982	Thailand	Private sector	aquaculture	DIAS
Pangasius sutchi	Pla swai	1978	Thailand	??	??	Guerrrero 1981

Name	Common name	Year	Introduced from	Effect(Socio-economic/ Ecological/ Status	Reason	Reference
Penaeus stylirostris		1980				
Penaeus vanamei	White shrimp	1980	Taiwan	Smugling	aquaculture	FHS-BFAR
Poecilia latipinna	Sailfin molly	1914	Hawaii	Adverse, pest in brackishwater	Mosquito control	Dias,Juliano et al. 1989, Reantaso, 1997
Poecilia (Mollienesia) reticulata	Mosquito fish	1905	Honolulu Hawaii			Guerrrero 1981
Pomacea canaliculata	Golden snail	1980	USA (Florida)	Adverse, private sector, illegal, displacement of native snails Pila luzonica, pests	ornamental	DIAS, Acosta and Pullin, Reantaso, 1997
Pomacea gigas		1980	USA (Florida)	Adverse’ private sector, illegal	aquaculture	DIAS
Puntius gonionotus	Tawes	1956	Indonesia	established	aquaculture	DIAS, Guerrrero 1981
Puntius javanicus		1956	Indonesia		aquaculture	DIAS
Tilapia zillii	Zill’s tilapia	1970	Israel		aquaculture	DIAS
		1973				Guerrrero 1981
		1977				DIAS
Trichogaster leeri	Pearl palsalid	1938	Thailand	established	aquaculture	DIAS, Guerrrero 1981
Trichogaster pectoralis	Snake skin plasalid	1938	Thailand		aquaculture	Guerrrero 1981
Trichogaster trichopterus	Three spotted plasalid	1938	Thailand			Guerrrero 1981

Red claw (Cherax quadricarinatus)

A special permit was given to a German couple with the agreement that no release will be made prior to the result of experimentation being conducted by the BFAR in collaboration with the Central Luzon State University (CLSU). The purpose of the experiment is to know the extent of burrowing activities and the damage to rice plants the red claw could inflict.

Pacific white shrimp (Litopenaeus vannamei)

The importation of live shrimp and prawn of all stages was banned in the Philippines since 1993, and culture of imported Pacific white shrimp was banned in 2004. Illegal importation of *Litopenaeus vannamei* led to its proliferation in some areas of the Philippines. Rampant culture in Central Luzon led to the banning of its culture. The law was strictly implemented supported by issuance of several memorandum orders including the apprehension and detention of the white shrimp operator as well as confiscation of smuggled live fry into the country (see Table 2**).**

Table 2. Summary of apprehension and detention activities for white shrimp operators.

Date	Airport	Volume Confiscated	Quantiy (total no. of fry)	Value in pesos[1/]
22 Sept 2002	Ninoy Aquino International Airport (NAIA)	63 boxes milkfish fry and 42 boxes shrimp fry	6.3 M	PHP 1.57M
09 March 2003	Subic Freeport International.	100 boxes shrimp fry	15 M	PHP 3.75M
08 May 2003	NAIA	67 boxes shrimp fry	10.05 M	PHP 2.51 M
07 July 2003	Diosdado Macapagal International Airport; United Postal Service (UPS) Courier Plane	5 boxes shrimp fry Liquid dietary feed	1.0 M	PHP 0.6M
11 July 2003	Laoag International. Airport	44 boxes shrimp fry	6.6 M	PHP 2.31M
04 Nov. 2003	NAIA	24 boxes shrimp fry Xiamen, China	3.6 M 3.6 M	PHP 1.26 M

[1/] *1US$ = approx. 49 Pesos*

To further stop the rampant mis-declaration of live fish importation to these ports of entries, the following BFAR office directives were issued:

- Formation of Shrimp Importation Monitoring and Surveillance Task Force (SIMS) dated January 14, 2003.
- Fisheries Memorandum Order 078, Series of 2003. Restriction of entry of live fish species importation from Taiwan and China.
  - Entry of live fish importation from either Taiwan or China, particularly the milkfish (*Chanos chanos*) fry is restricted only to the Ninoy Aquino International Airport.
- Fisheries General Memorandum Order No. 119 Series of 2003. Guidelines on the importation of milkfishfry.
  - This is an additional guideline in the implementation of FAO No. 221, Series of 2003, in view of the persistent illegal importation of shrimp fry, which is prohibited by law, under the guise of milkfish fry.

- The implementation of the total ban was further strengthened with the passing of a resolution by the Philippine Shrimp Industry Association (PHILSHRIMP) in its National Shrimp Congress held in March 30 to April 1, 2004, fully supporting the ban and stricter implementation of FAO No. 207, Series of 2001. A manifesto was also signed during the Congress enlisting the full cooperation of PHILSHRIMP in the implementation of the ban.

Current Management Strategies for Alien Species

The management strategies that are currently in place for managing the introduction and spread of alien species into the country lies in FAO No. 221, Series of 2003. Further regulation concerning the importation of live fish and fishery/aquatic products are contained in FAO No. 135, Series of 1981, which includes microorganisms and bio-molecules. The said FAO are jointly being implemented by two sections within BFAR that have responsibility over the movement of live aquatic animals. These are the Fish Health Section (FHS) under the office of the Director and the Foreign Trade and Miscellaneous Permit Section under the Fisheries Regulatory and Quarantine Division (FRQD).

The Fish Health Officers (FHOs) and the Fisheries Quarantine Officers (FQOs) implement the health management process as defined in the Asia Regional Technical Guidelines on Health Management for Responsible Movement of Live Aquatic Animals and the Beijing Consensus and Implementation Strategy (FAO/NACA 2000). The FHO implements the pre-border (exporter) and post-border (importer) activities while the FQO implements the border activities in the trans-boundary movement of live aquatic animals.

Conduct of quarantine and inspection services

As seen in FAO No. 221, Series of 2003, all importation of live fish and fishery aquatic products, aquatic microorganisms, bio-molecules including GMOs and endangered species, are subjected to the following **categories**: low-risk species, medium-risk species, high-risk species and prohibited or banned species. These categories, prepared by BFAR in cooperation and coordination with the Bureau of Plant Industry, Bureau of Animal Industry, and Protected Areas and Wildlife Bureau, are based on risks as described below:

i.) ***Low-risk species*** – species such as aquarium fish that are perceived to present no ecological, genetic and disease threats to native Philippine species and to aquaculture.

ii.) ***Medium-risk species*** – species used in aquaculture or in aquarium or ornamental fish trade and considered by BFAR to pose potential environmental impact. This may include species both native or translocated species and previously introduced species in natural bodies of water.

iii.) ***High-risk species*** – exotic species, known for its potential use for food or sportthat have not been introduced into the country but with limited distribution; GMOs and other species whose eradication or restriction is considered desirable.

iv.) ***Prohibited or banned species*** – species banned for importation under national and international laws or agreements. This includes exotic species whose importation is prohibited due to their known adverse effect on local fauna, human health and the environment.

Procedures and Requirements for Importation

i.) ***Filing of form***

The importer must show intention to import live fish and fishery/aquatic products including microorganisms and bio-molecules through the filing of his application at least five working days prior to the importation of low-risk species and ten to 15 working days for medium-risk species. The decision whether or not to import high risk species will be given 30 days after the evaluation of the proposal and submission of other documents which may be required by the Import Risk Analysis (IRA) Panel.

ii.) ***Review by Import Risk Analysis Panel***

All applications for importation is subject to review by the IRA Panel, which was created by virtue of Memorandum issued by BFAR Director in 2000. The IRA Panel serves as the secretariat and clearing house of all importation cases, and may use a group of experts to resolve individual cases whenever necessary. The panel, chaired by a fish health officer, has five permanent members who shall have the following minimum qualifications: a) one member shall be a member of the Philippine Bar; b) one member shall be a fish health officer; c) one member shall be a regulatory fisheries quarantine officer; d) one member shall be a member of NFARMC; and e) one member shall be a fishery biologist (on call depending on the required expertise). The importation requirements are dependent on the category of the commodity according to a list issued by BFAR (Section 7, FAO 221, Series of 2003).

iii.) ***Importation Requirements***

For low-risk species the requirement is duly accomplished form. Risk analysis shall not be required except when there is a reported significant outbreak in the county of origin.

For medium-risk species the requirements are:

- Duly accomplished application form;
- Duly accomplished proposal form with emphasis on health, ecological and genetic impacts of the proposed importation;
- Results of import risk analysis by the IRA Panel;
- Health certificate from the competent authority of the country of origin to be presented upon arrival;
- The quarantine and inspection requirements shall be based on the decision of the BFAR IRA Panel, which may require a quarantine period of 24-28 days on a case-to-case basis after the release of the shipment from the airport to the BFAR's quarantine facility, with costs to be borne by the importer.

For high-risk species the requirements are:

- Duly accomplished application form;
- Duly accomplished proposal form with emphasis on health, ecological and genetic impacts of the proposed importation;
- Results of import risk analysis by the IRA Panel;

- Health certificate from the competent authority of the country of origin to be presented upon arrival of the consignment at NAIA or other designated ports of entry. On a case-to-case basis, the BFAR may specify certification requirements for individual species and/or shipments to ensure freedom from specified diseases as deemed necessary; and
- Quarantine and inspection until the first generation (F1) offspring for high risk species to be imposed after release of the shipment from the airport to the BFAR quarantine facilities with costs to be borne by the importer.

iv.) Inspection

For security purposes **live fish and fishery/aquatic products are subjected to inspection requirements upon arrival at the NAIA, the only designated point of entry for live fish and fishery/aquatic products.** The importer is required to submit import documents (original copy of the import permit, photocopies of the pro-forma invoice, packing list and airway bill (bill of lading) to BFAR Fisheries Quarantine Officer.

For medium and high-risk species, a copy of health certificate is required. Consignments not accompanied by import permit and/or health certificate shall be confiscated and destroyed. The FQO checks the species identity and conducts a visual inspection. If the fish is clearly unhealthy, s/he shall require the treatment of the shipment in the importer's holding facility under the supervision of a fish health officer or, if the unhealthy fish poses high risk of contaminating healthy stocks, the shipment shall be confiscated and destroyed. A laboratory examination of the shipment shall be conducted by the BFAR FHO at the expense of the importer.

The risk analysis, conducted for each and every importation lies in the mechanism being implemented by the IRA Panel. Each and every importation passess through the panel except for those that belong to the first category or low-risk species. Paclibare *et al.* (2004) provide examples of importation cases handled by the IRA Panel. The APEC manual provides further guidelines on conducting IRAs (Reantaso *et al.,* 2004).

Recommendations

Recommendations to strengthen National and Regional Capacity to address risks from invasive alien species and trans-boundary aquatic animal pathogens include the following:

1. Invasive alien species are an international problem and international organizations like the FAO, NACA and other relevant agencies should consolidate their actions and prepare a regional program to regulate its trans-boundary movement. The program should include prevention, early detection, eradication and control of invasive alien species.
2. The BFAR should take the lead role in the formulation and implementation of activities to combat the introduction of invasive alien species in cooperation and collaboration with other concerned agencies, i.e. Department of Environment and Natural Resources (DENR) and the Department of Transportation and Communication (DOTC).

3. NACA, FAO and IMO should help the region in the preparation of a regional technical implementing guidelines on invasive alien species using a standardized set of analysis tools for use by member countries. Assistance is also required in provisions of training, responses to untoward incidents, possible use of existing funds available in case damage occurred in case of ballast water through ship and mechanism for environmental valuation.
4. NACA and FAO should develop a Regional Network on invasive alien species through the use of modern technologies. This should be put in place for quick notification and dissemination of information.
5. Capacity and capability building of BFAR staff to prevent the introduction and control the negative effect of introduced invasive alien species is also recommended.

Part II: Associated Trans-boundary Aquatic Animal Pathogens

Introduction

Shrimp diseases are the major problem of the aquaculture industry. White spot syndrome virus (WSSV) is still the most important pathogen, causing disease in shrimp. The virus was first detected in 1999 in cultured P. monodon at the northern region of the country. The late entry of the virus into the country, compared to other neighboring countries, could be attributed to the precautionary measure issued by the BFAR way back in 1993 through FAO No. 189, Series of 1993, prohibiting the importation of live shrimp of all stages as a response to prevent the introduction of yellow head virus (YHV) arising from the prevailing disease outbreak in certain Asian countries at that time. WSSV caused massive mortalities in P. monodon grow-out farms in Bacolod, Negros Occidental in January 2000 (OIE Regional Aquatic Animal Disease Yearbook, 2000; FAO/NACA QAAD reports). Since then, the virus has been detected in major shrimp producing areas in the country. Right after its first detection, BFAR conceived the national action program to control WSSV in shrimp and it is still being implemented.

Yellow head virus (YHV) is also known to be virulent and highly pathogenic for shrimp but its devastating effect was not felt by the shrimp industry. The prevalence and geographical distribution of YHV was documented and was found to exist in major shrimp producing areas particularly the Visayas and Mindanao, and to a lesser extent in Luzon. However, there was no significant mortality associated with the virus among infected farms (Natividad *et al.,* 2002; Albaladejo *et al.,* 1998).

Epizootic Ulcerative Syndrome (EUS) first occurred in Laguna Lake (Luzon) in 1985-1986 (Llobrera, 1987), affecting several freshwater and estuarine fish species in Luzon Island (Reantaso *et al.,* 1994). However, EUS has also been reported in Mindanao Island in 1999, specifically in Campostela Valley, the Caraga region and South Cotabato. It was last reported in Mindanao Island in January-February 2000 in the areas of Agusan del Norte, Dipolog City and Davao del Norte. The disease was last reported in Visayas Island in Iloilo province in October 2002 in a catfish grow-out pond (OIE, FAO/NACA Quarterly Aquatic Animal Disease Report, 1999-2003).

Viral encephalopathy and retinopathy (VER) is suspected to be causing disease problemsin groupers since 1998 (OIE, 1998; NACA/FAO 1998) but was not confirmed due to limited capability to diagnose the disease (Somga et al., 2001). The first confirmed case of VER was reported in April 2001 in hatchery-bred grouper larvae and some *Epinephelus coloides* broodstock in SEAFDEC-AQD, Iloilo where affected fish larvae showed increased mortality at approximately 20 days with high mortality in 1-2 weeks time (OIE, 2001; NACA/FAO, 2001). In March 2003, VER was also detected in tilapia fry from Negros Occidental (OIE, 2003).

Koi herpesvirus (KHV) has been one of the emerging pathogens affecting common and koi carps. Although KHV has yet to be reported in the country, BFAR issued an order for temporary suspension of importation of common and koi carps as a precautionary measure to protect the local carp industry. At present, the government is promoting and boosting carp production, and implements a national carp dispersal program for inland bodies of water uch as major lakes and dams. Risk analysis should also be applied to enhancement programs.

Transboundary aquatic animal pathogens

National aquatic animal health management strategies

The BFAR Fish Health Network implements fish health management activities in the country. The Network created by the Bureau Director is composed of core technical staff of the FHS (Central Office) and Regional Fish Health Officers (RFHOs) from 15 BFAR Regional Offices. The FHS technically supervises and sets the direction for diagnostic activities, disease surveillance and reporting for all the Regional Fish Health Laboratories (RFHL). The RFHOs coordinate with the fisheries officers of the country's local government units. Regular meetings and workshops are conducted to update and continue professional education and training of the RFHOs, and to harmonize fish health management activities in the country.

As stated in FAO No. 220, Series of 2001, entitled "*Operation of the Fish Health Laboratories and collection of fees and charges thereof",* the Fish Health Laboratories hall perform the following: **a)** conduct fish disease diagnosis; **b)** conduct water quality analysis related to disease diagnosis, fish health problems and fish kill; **c)** provide technical advice on fish health management; **d)** conduct fish disease surveillance and reporting system; **e)** provide technical support to the fish inspection and quarantine services; **f)** conduct on-site visits to fish farms and places where there are fish health problems; **g)** conduct fish kill investigations; and h) provide technical support on quality control of animal feeds, veterinary drugs and chemicals in aquaculture.

As per Fisheries Office Order (FOO) No. 221, Series of 2003, Regional Fish Health Officers (RFHOs) have been designated (as amendment to FOO No. 147-01, Series of 2001, Designation of Regional Fish Health Officers of BFAR). As such they shall perform the following functions: **a)** assist in the planning, directing and implementing of the national program on fish health management; **b)** supervise/operate the regional fish health laboratories and its satellite laboratories in their respective areas of jurisdiction; **c)** implement FAO No. 220, Series of 2001; **d)** conduct fish kill investigations and implement the National Strategy on fish kill investigation, reporting and prevention; **e)** provide technical support to the fish inspection and quarantine services; **f)** to act as quality control officer on the regulation of animal feed, veterinary drugs and products in aquaculture; **g)** submit quarterly accomplishment reports related to program implementation to the Bureau Director. In addition, RFHOs are deputized as Aquatic Animal Feeds and Veterinary Drugs and Products Control Officers, also responsible for the implementation of residue monitoring reports and plan in accordance with European Union Council Directive 96/23/EC. **Table 3** shows the list of fish health laboratory in the Philippines with the corresponding level of capabilities.

The fish health laboratories are developed based on the needs of the fishery activities in each region as decided by the Regional Directors who have full administrative control of the regional offices. **Table 4** shows the status and plan for aquatic animal health management strategies for the key elements contained in the technical guidelines.

Current status of trans-boundary aquatic animal pathogens

Fish health officers are monitoring the occurrences of diseases in the country. Nationwide disease surveillance and monitoring are being implemented and RFHOs and other laboratories submit quarterly reports to the Central Office for consolidation and inclusion in the OIE, FAO/NACA Quarterly Aquatic Animal Disease Report. There are significant diseases that will be discussed in this paper to emphasize the level of action at the national level.

White Spot Syndrome Virus (WSSV)

BFAR has installed sixteen Polymerase chain reaction (PCR) equipments in the Central and Regional Fish Health laboratories for the detection of WSSV since the year 2000 as part of the National Action Program to Control White Spot Virus in shrimps. These PCR machines are used for the screening of *P. monodon* fry before stocking and monitoring for early detection of the virus during the grow-out stage, and for the issuance of health certificate for the in-country movement of shrimp fry. There are also other laboratories in the country such as the Negros Prawn Producers Marketing Cooperative Incorporated, the SEAFDEC-AQD, and the UPLB-Institute of Biotechnology that conduct PCR test for WSV.

Fisheries Memorandum Order No. 240, Series of 2003 (Regulations on trans-boundary movement of shrimp postlarvae) requires hatchery operators, brokers and traders to secure a health certificate prior to transport, indicating that shrimp post-larva are free from WSSV using PCR test from BFAR Fish Health Laboratories and recognized private laboratories. The health certificate should be presented to the Fisheries Quarantine Service Officers at the ports of entry and exit. This Order also instructed all RFHOs to strictly implement disease surveillance and reporting system, and report immediately all WSSV disease outbreaks to the Central Office for immediate action of the Quick Response Team.

Table 3. List of Fish Health Laboratories in the Philippines

A. BFAR Fish Health Lab.	Location	Contact Person	Tel/Fax No.	Diagnostic Level
Central Office	860 Quezon Avenue, Quezon City	Ms. Simeona E. Regidor	(02) 3725055	I, II-abc, III-ad
Region I	West Dagupan, Pangasinan	Ms. Marina Dumol	(75) 523085	I, II-ab
Region II	Tuguegarao, Cagayan	Ms. Evelyn Ame	(78) 8444261	I, II-ab
Region III	San Agustin, San Fernando City,	Ms.Carmencita Agustin	(45) 9612784	I, II-ab
Region IV-A	Pampanga FFRS, Los Banos, Laguna	Ms. Ligaya Cabrera	(49) 5360705	I, II-a, III-a
Region IV-B	Ambulong, Tanauan, Batangas	Mr. Rolando Miranda	(02) 4212138	I, II-ab
Region V	NIA Compound, EDSA, Quezon City	Ms. Edna Tud	(54) 4773948	I, II-ab
Region VI	Mercedes, Camarines Sur	Ms. Priscilla Pangantihon	(33) 3369878	I, II-ab
Region VII	Muelle Loney St., Iloilo City	Ms. Carolina Lopez	(32) 2530661	1, II-ab, III-a
Region VIII	Arellano Blvd., Port Area, Cebu City	Ms. Remedios Lequin	(53) 3213152	I, II-ab, III-a
Region IX	CRM Center, Diit, Tacloban City RT Lim Blvd., Kawa-kawa, Zamboanga,	Ms. Carol Moron	(88) 8569610	I, II-ab, III-a
Region X	City	Ms. Evie Lumingkit	(62) 9918192	I, II-ab, III-a
Region XI	Macabalan, Cagayan de Oro City	Mr. Raul Millana	(64) 4211213	I, II-ab, III-a
Region XII	Magsaysay Ave., Davao City Vensu Bldg., National Highway	Ms. Sarah Mae Mamalangkap	(82) 2245058	I, II-ab
Region XIII	General Santos City Surigao City, Surigao del Norte	Ms. Anna Melissa Talavera	(85) 342 5255	I, II-ab, III-a
Autonomous Region of Muslim Mindanao	ARMM ORG Complex, Cotabato City	Ms. Cheryl Dimacisil	(64) 4211234	I
Cordillera Autonomous Region	Guisad, Baguio City	Ms. Petra Gayagay	(74) 4436716	I, II-ab
B. Other Government & Private Fish Health Laboratories				
National Institute of Molecular Biology and Biotechnolology* University of the Philippines at Los	UPLB, Los Banos, Laguna	Dr. Veronica Migo	(49) 5360547	I, II, III
Banos (UPLB) Fish Health Section Department Southeast Asian Fisheries Development Centre	Tigbauan, Iloilo City	Dr. Gilda Lio-Po	(33) 3362937	I, II, III
(SEAFDEC-AQD) Negros Prawn Prod. Marketing Coop. Inc.	JTL Bldg., BS Aquino Drive, Bacolod City	Ms. Roselyn Usero	(34) 4332131	I, II-ab, III-a
(NPPMCI) Bohol Aquaculture Foundation, Inc.	Maribojoc, Bohol	Mr. Daniel Vergara	(38) 5049211	I, II-ab, III-a

Diagnostic Levels

- I Diagnostic activity limited to observation of animal and the environment and clinical examination (on-site or field diagnosis)
- II Diagnostic activity includes: a) parasitology, b) bacteriology, c) mycology and d) histopathology
- III Diagnostic activity includes: a) virology PCR-WSV, b) electron microscopy, c) molecular biology and d) immunology-ELISA (drug residue analysis)

**National reference laboratory for WSSV*

Table 4. Status and plan for Aquatic Animal Health Management Strategies for the key elements contained in the Technical Guidelines.

ELEMENTS	STATUS	PLAN
Pathogens to be Considered	Aquatic Animal Diseases listed in the OIE and FAO/NACA	Formulation of a National List of Diseases
Disease Diagnosis	BFAR diagnostic capability is at different levels *(Please see Table 3)*	Establishment of a permanent Central Fish Health Laboratory
Health Certification and Quarantine Measures	Health Certification and quarantine requirements is contained in the approved FAO No. 221, Series of 2003: Further regulating the importation of live fish and fishery/aquatic products under FAO No. 135, Series of 1981, to include microorganisms and biomolecules. This FAO was drafted by the BFAR Fish Health Staff in 1998. Several consultations and public hearings attended by National Fisheries Resources Management Council (NFRMC) and other government agencies, industry and reviewed by fish health experts, before the Department of Agriculture Secretary's approval in March 2003.	Formulation of a detailed implementing rules and regulation for this Order
Disease Zoning		Information gathering/ collection and strengthening disease surveillance and diagnostic capability for OIE, FAO/ NACA listed aquatic animal diseases (VER, Iridovirus) and emerging disease (KHV)
Disease Surveillance and Reporting	The RFHOs conduct regular monitoring and extension service on health management in aquaculture farms and submit their quarterly accomplishment report to the FHS-Central Office for consolidation and assessment. Disease surveillance/ reporting is also coordinated with other fish health laboratories (SEAFDEC-AQD, UPLB-Institute of Biotechnology, NPPMCI) regarding their diagnostic cases/laboratory examinations for inclusion to the Quarterly Aquatic Animal Disease Report submitted to the OIE, Tokyo, Japan and NACA, Bangkok, Thailand.	Develop a national database for disease reports and develop linkage among fish health laboratories through network, in coordination with Fisheries Information Management Center
Contingency Planning	Precautionary measures through issuance of Memorandum Circulars	Precautionary measures through issuance of Memorandum Circulars, etc.

ELEMENTS	STATUS	PLAN
Important Risk Analysis	Import risk analysis (IRA) for aquatic organisms as one of the salient features of the approved FAO No. 221, of the salient features of the approved FAO No. 221, Series of 2003, has already been institutionalized.	Development of National Guidelines on IRA Continue awareness raising on IRA through participation to symposia, conference, seminar, as resource speaker/ lecturer Database of Aquarium fish for routine importation Inventory/update on the status of the introduced fishes including environmental impacts including ornamental fish Develop a national list of pathogens in the country Surveillance on OIE-listed aquatic animal diseases important in the country.
National Stategies and Policy Frameworks	BFAR is responsible for the implementation of laws pertaining to conservation of fisheries and aquatic resources as mandated by the Republic Act 8550. Implementing rules and regulations are issued in the form of Fisheries Administrative Orders (FAOs). Other legal instruments are in the form of Fisheries Office Order (FOO), and Fisheries Memorandum Order (FMO). The following are the regulations addressing transbounday pathogen: a) FAO No. 220, Series of 2001. Operation of the fish health laboratories and collection of fees and charges thereof; b) FAO No. 207, Series of 2001. Prohibiting the importation and culture of imported live shrimp and prawn of all stages; c) FAO No. 221, Series of 2003. Further regulating the importation of live fish and fishery/aquatic products under FAO No. 135, Series of 1981 to include microorganisms and biomolecules. d) FOO No. 211, Series of 2003. Amendment to fisheries office order no. 147-01, series of 2001. Designation of regional fish health officer e) FMO No. 240, Series of 2003. Regulations on transboundary movement of shrimp post larvae; f) FMO No. 014, Series of 2004. Guidelines for the implementation of Fisheries Memorandum Order 240: Regulation	Review and formulation of relevant Fisheries Administrative Order to address management strategies for trans-boundary aquatic animal pathogens

	on transboundary movement of shrimp post-larvae; h) FMO No. 013, Series of 2004. Imposition of active surveillance mechanism for all shrimp hatcheries nationwide as part of the strict implementation of the national action program to control white spot syndrome virus in shrimp.	
Implementation Strategies	Aquatic animal health strategies are being implemented by the FHO, under the technical supervision of the fish health section of the central office (BFAR-Fish Health Network) in coordination with and involvement of other private and government agencies and non-governmental organizations	Institutionalization of national aquatic animal health management strategies

Yellow head virus (YHV)

Although YHV was detected in *P. monodon* in 1999 there were no significant mortalities associated with the virus. No further surveillance has been conducted for YHV after the study of Natividad *et al.* (2002) on the prevalence of yellow head virus in cultured black tiger shrimp (*P. monodon*) in the Philippines which revealed that The BFAR has no laboratory diagnostic capability for YHV detection hence it coordinates and taps the UPLB-Institute of Biotechnology and provided funding support for this study.

Epizootic Ulcerative Syndrome (EUS)

The EUS that first occurred in Luzon Island in 1985 has also been reported in the island of Mindanao in 1999 and then again in Visayas Island in 2002. The disease in Mindanao was detected through the surveillance being implemented by BFAR-RFHOs while the detection of EUS in the Visayas was reported by SEAFDEC-AQD (OIE, year; NACA/FAO, year). The diagnostic capability for EUS of BFAR RFHLs is at Level I. Samples are collected, fixed and sent to the Central Office Fish Health Laboratory for confirmatory diagnosis using histopathology. EUS was last reported in October 2002 in Iloilo, Visayas (OIE,2003; NACA/FAO, 2003).

Viral Encephalopathy and Retinopathy (VER)

BFAR has Level I and II (histopathology) diagnostic capabilities for VER, whereas, SEAFDEC fish health laboratory has level III diagnostic capability. In grouper culture areas, the RFHOs conduct regular extension work for health monitoring and coordinate with the Central Office regarding disease and health problems. BFAR and SEAFDEC diagnostic cases for VER are included to the OIE and FAO/NACA QAADs.

The first confirmed case of VER was reported in April 2001 by SEAFDEC-AQD in their hatchery bred grouper larvae and some *E. coioides* broodstock. Diagnostic methods conducted were histopathology, reverse transcriptase PCR (RT-PCR) and cell culture (OIE, 2001; NACA/FAO, 2001).

In 2003, SEAFDEC detected VER in tilapia fry (OIE, 2001'NACA/FAO, 2001). Since tilapia is a major species in freshwater and brackishwater aquaculture, early detection of disease is vital in formulating contingency measures. At present, a master plan for tilapia is being formulated and health management is one of its key components.

Koi Herpes Virus (KHV)

So far, KHV has not yet been reported in the Philippines. When there was an outbreak of mass mortalities of Koi and common carps in Indonesia (East Java) in 2002, BFAR issued an order for the temporary suspension of carp importation in June 2002 and conducted consultations with the stakeholders (aquarium fish traders including hobbyists) and other concerned government agencies. It was unanimously agreed that Koi should be imported from Japan, where there is no reported KHV at that time and should comply with the health certification and quarantine requirements prior to issuance of an import permit by BFAR. However, with the KHV outbreak in Japan in 2003, BFAR issued again an Order for the temporary suspension for importation of koi carp in January 2004. BFAR disseminated information regarding KHV and used the materials provided by NACA (Brochure on KHV developed by Indonesia) to its Regional Offices and Centres and Local Government Units and to intensify/strengthen the reporting and monitoring of health/ disease problems of carps in their area. KHV was also included as one of the topics in BFAR conducted seminar/training as means of information dissemination.

BFAR has also participated in the recently conducted International Symposium on Koi Herpes Virus organized by Government of Japan, SEAFDEC, and OIE in Yokohama, Japan in March 2004. This workshop provided updates and developments on KHV and its control strategy.

At present BFAR has no laboratory diagnostic capability (Level III) for KHV and considering its importance for the growing carp industry in the country it is important that BFAR should develop its diagnostic capability for this emerging viral disease.

Current management strategies for trans-boundary aquatic animal pathogens

There are several management strategies that are being implemented by the FHS, i.e. networking, establishment of fish health laboratories, creation of Import Risk Analysis Panel, and conduct of disease surveillance and reporting system.

The creation of BFAR Fish Health Network provides easy coordination and effective implementation of programs and activities on fish health management, facilitates quick response on matters related to disease and health problems. The Network also implements a standardized and harmonized procedure for field and laboratory examination.

The establishment of BFAR Fish Health Laboratories and capacity building for diagnostic test using PCR for WSSV has been useful for the shrimp fry screening before stocking, monitoring of shrimp at the grow-out ponds, for issuance of health certification for the in-country movement of shrimp fry, and for serving walk-in clients. The diagnostic service and technical assistance became more accessible to fish farmers and to other private and government agencies. The health and disease surveillance, monitoring and reporting is already in place and BFAR Regional fish health laboratories have been established with different levels of diagnostic capability.

Progress in implementing recommendations[1] for managing trans-boundary aquatic animal pathogens

Republic Act (RA) 8550, otherwise known as the Philippine Fisheries Code of 1998 provides for, among others the strengthening of Fisheries Inspection and Quarantine (FIQS) Service in BFAR. Provision of Section 67 of this Code states that FIQS shall have the following functions:

a) Conduct fisheries quarantine and quality inspection of all fish and fishery/ aquatic products coming into and going out of the country by air or water transport, to detect the presence of pest and diseases. Fish found to harbor diseaseshall be confiscated and disposed of in accordance with environmental standards and practices;
b) Implement international agreements/commitments on bio-safety and biodiversity as well as prevent the movement of trade of endemic fishery and aquatic resources to ensure that the same are not taken out of the country;
c) Quarantine such aquatic animal and other fishery products determined or suspected to be with fishery pest and disease and prevent the movement of trade from and/or into the country of these products so prohibited or regulated under existing rules and regulations as well as international agreements of which Philippines is a State Party;
d) Examine all fish and fishery products coming into and going out of the country which may be a source or medium of fish or diseases and/or regulated by existing fishery regulations and ensure that the quality of fish import and export meet international standards; and
e) Document and authorize the movement or trade of fish and fishery products when found free of pest and diseases and collect necessary fees prescribed by laws and regulations.

Pursuant to this RA 8550 and conformably with international agreements, the Secretary of Department of Agriculture approved FAO No. 221 in March 2003. The Order does not only cover live fish but also fishery products, microorganisms and bio-molecules. Fish and fishery products include not only finfish but also mollusks, crustaceans, echinoderms, marine mammals and all other products of aquatic resources in any form.

The Import Risk Analysis in the Order does not only focus on fish health concerns but also on public health and ecological concerns as well. Fish species for importation will be categorized based on risk: 1) low-risk species, 2) medium-risk species, 3) high-risk species, 4) prohibited or banned species. The levels of risk have been discussed in Part 1,2,iii of this document. The corresponding health certification and quarantine requirements shall be imposed based on risk.

BFAR participates in regional and international meetings, training/workshop, symposia regarding trans-boundary-aquatic animal diseases. This serves as basis and tools for national strategies and program development and implementation. The BFAR also conducts seminar and workshops to its Regional Fish Health Officers to disseminate information on trans-boundary pathogens and ensure the implementation of programs in their respective areas. Consultation meetings are also held with different stakeholders (industry, NGOs, other government agencies) in the management of trans-boundary pathogens.

Recommendations

Recommendations to strengthen national and regional capacity to address risks from trans-boundary aquatic animal pathogens include the following:

- At the national level, the Philippine Government should strongly support the establishment of a Permanent Central Fish Health Laboratory that will supervise and serve as reference laboratory for its regional and its ancillary fish health laboratories in the country.
- Building diagnostic capacity on the emerging trans-boundary aquatic animal pathogens such as VER, KHV, Iridovirus, and spring viraemia of carp and develop a quick notification mechanism regarding disease outbreak.
- Professional education and training of Quarantine and Fish Health Officers should be continued.
- Strengthening the coordination with and involvement of other government agencies, local government units, non-governmental organizations, research institutions, universities and private agencies and stakeholders for effective implementation of a national program for the management of trans-boundary aquatic animal pathogens should be continued.
- Regional and international organizstions should continue in providing technical (through trainings, seminars conference, symposia) and financial support in addressing and management of trans-boundary aquatic animal pathogens.

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Singapore

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Introduction

Singapore is a small island state of about 685 km^2 and is strategically located at the crossroads of major shipping routes connecting Asia and the rest of the World. It is also a major air hub for trade and tourism, supporting by a robust infrastructure and extensive linkage to 140 cities in 50 countries, with more than 3 250 weekly flights ferrying passengers and cargo to and from all parts of the world (Source: EDB Singapore). It is therefore inevitable that alien species are introduced into the island, whether deliberately or inadvertently, for various purposes. Impacts of alien species to the ecosystem or biodiversity of local flora and fauna may sometimes be disastrous. However not all alien species are invasive, many are unable to survive beyond the confines of human habitats or cannot establish themselves successfully in the native environment. Nevertheless it is the responsibility of relevant authorities to coordinate their efforts in managing the ever-increasing threat brought about by transboundary movements of invasive alien species (IAS).

Besides the possible impact on ecosystem and biodiversity of the indigenous biota, IAS may pose great economic havoc through the introduction of pathogens that may cause serious disease outbreaks in the agriculture industry. In the context of aquatic IAS, the spread of pathogens and diseases with transboundary movements of live aquatic animals is affecting aquaculture production worldwide. Singapore has a small and thriving coastal aquaculture industry producing about 4% of the estimated 100 000 tonnes of fish consumed annually. In addition, Singapore's ornamental fish industry, with a sizable farming industry producing Singapore $36 million value of freshwater ornamental fish in 2003, remains the top exporter in the global market. It is therefore important for Singapore to have in place proper measures to prevent the spread of aquatic animal diseases through transboundary movement of live aquatic animals in order to ensure a sustainable and productive aquaculture industry.

Managing aquatic invasive alien species

The status of aquatic IAS in Singapore has been reviewed in a number of publications (Chou and Lam, 1989; Ng et al., 1993; Tan and Tan, 2003). Noticeably, the urbanisation of Singapore over the past 30 years may have caused greater impact on the indigenous biodiversity than the ecological threat brought by IAS. The FAO Database on Introductions of Aquatic Species (DIAS) has 39 records of introduction of aquatic species into Singapore. Twenty-six species (67 percent) of freshwater fish were introduced for ornamental purposes, and most of these fishes have not established themselves in the wild. Ng et al. (1993) reported that these species introduced via the aquarium trade have not significantly affected the fauna in forested streams. Examples of introduced species establishing in native waters include the guppy, Poecilia reticulata, once introduced for mosquito control and now well known for its ornamental beauty. The red-eared terrapin, Trachemys scripta, from North America, and other turtles such as the Malayan box turtle Cuora amboinensis and black marsh turtle, Siebenrockiella crassicollis, were naturalised in urban Singapore possibly due to escapes from aquariums of hobbyists or release in connection with religious practices. Of the 12 species of aquatic animals introduced into Singapore for aquaculture purposes, most were not known to have established themselves in the wild (DIAS, FAO). One notable example of deliberate introduction that has well-established populations throughout Singapore is the African tilapia, Oreochromis mossambicus, which was introduced during the Second World War as a potential source of protein (Tan and Tan, 2003).

The Agri-Food & Veterinary Authority (AVA) is the national authority responsible for the regulation of importation and exportation of live aquatic animals. The core mission of the Authority is to ensure a resilient supply of safe food, safeguard the health of animals and plants and facilitate agri-trade for Singapore. It is empowered by the Fisheries Act (Chapter 111), Animals and Birds Act (Chapter 7) and the Wholesome Meat and Fish Act (Chapter 349A), which provide the legislative framework for the regulation and monitoring of live aquatic animal trade. All importers and exporters of live aquatic animals must be licensed by AVA. Thereafter, each consignment must be declared by the licensed-trader and approved by the AVA prior to importation or exportation. For ornamental fish, all importers and exporters are required to have a government-approved premises with facilities for holding, quarantining and packing of ornamental fish. The Committee on International Trade for Endangered Species (CITES) permits are required for the import and export of endangered ornamental fish species such as the Asian Arowana (Scleropages formosus). In addition, any introduction of Genetically Modified Organisms (GMO) requires the approval from the National Genetic Modification Advisory Committee (GMAC).

As noted earlier, many of the introductions of alien species into the natural environment came about through the escape or release of such animals by hobbyists or for religious purposes. The Agri-Food & Veterinary Authority has recently launched public education programs through the media on responsible pet ownership. Public awareness on the risks and consequences of releasing animals into the wild were also conveyed through exhibitions organized by the Singapore National Parks Board as well as through volunteer groups advising the public against irresponsible introduction of aquatic animals into the reservoirs or lakes. Under the National Parks Act, it is an offence to release animals into the nature reserves or parks and anyone caught doing so can be fined up to Singapore $10,000.

Transboundary aquatic animal pathogens

The transboundary movement of live aquatic animals always poses the risk of pathogen transfer that could seriously impact any industries that would otherwise stand to benefit from the introduction itself. For example in Singapore the ornamental fish industry, which has a huge export trade and a sizable farming industry, could be seriously crippled if exotic aquatic diseases were introduced. The dependence on seed stocks from foreign hatcheries or wild-caught population is also a problem faced by the aquaculture industry in Singapore, risking the potential impact of transboundary aquatic disease incursion. Recent reports of Koi Herpes Virus (KHV) outbreaks in the region serve a solemn reminder of the importance of proper health management at the national and regional level and to be ever vigilant against possible incursions of transboundary aquatic animal pathogens.

Problems caused by disease incursions in Singapore have been reported by Chua et al. (1993), Chua et al. (1994), Chang et al. (1997), Chang et al. (2002) and Kueh et al. (2003). Bacterial and parasitic infections are the most common causes of fish mortalities in coastal aquaculture farms in Singapore. In recent years, the emergence of viral diseases in marine foodfish is of concern to the Authority and this has been reflected accordingly inregional fish health databases such as the NACA/FAO and OIE Quarterly Aquatic Animal Disease (QAAD) Report. A summary of economically important diseases of aquatic animals in Singapore is given in Table 1.

Table 1. List of economically important diseases of aquatic animals in Singapore.

Diseases	Pathogen Type	Species Affected
Freshwater Ornamental Fish		
Hexamita Infestation	Parasitic	Discus, *Symphysodon spp.* Angelfish, *Pterophyllum spp.*
Tetrahymena Infestation	Parasitic	Guppy, *Poecilia reticulata*
Velvet disease, *Oodinium* spp.	Parasitic	All species
White spot disease or "Ich", *Ichthyophthirus multifilis*	Parasitic	All species
Marine Foodfish		
Gill flatworms, *Dactylogyrus* spp.	Parasitic	Marine foodfish including groupers, mainly *Epinephelus species*
Streptococcus spp.	Bacterial	Marine foodfish including seabass, *L calcarifer*
Systemic iridoviral disease	Viral	Marine foodfish including groupers, mainly *Epinephelus species* and mullet, *Mugil cephalus*
Viral encephalopathy and retinopathy	Viral	Marine foodfish including seabass, *Lates calcarifer* and groupers, mainly *Epinephelus species*
Vibriosis, *Vibrio* spp.	Bacterial	All species

National Aquatic Animal Health Management Strategy

The Agri-Food & Veterinary Authority (AVA) is the national authority responsible for aquatic animal health management in Singapore. It is empowered by the Fisheries Act (Chapter 111), Animals and Birds Act (Chapter 7) and the Wholesome Meat and Fish Act (Chapter 349A), which provide the legislative framework for the regulation and monitoring of live aquatic animal trade and health management. Apart from implementation of specific monitoring programmes for the purpose of health certification for live fish trade, AVA also carries out surveillance for significant pathogens and conduct regular surveys of fish farms and exporters premises.

Fish Health Certification Programme

Certification has become a prerequisite for international movement of aquatic animal and a means of facilitating trade among countries. The Agri-food and Veterinary Authority (AVA) is the only authority in Singapore which provide fish health certification services to the live fish trade and industry. With the ever increasing live fish consignments being exported from Singapore, certification is primarily based on a good and reliable system of inspection and monitoring of the fish farms and export premises.

Accredited Ornamental Fish Exporter Scheme

For the purpose of health certification for export of ornamental fish, AVA implements the Accredited Ornamental Fish Exporter Scheme to monitor fish health status and sanitation of export premises. The Scheme, initiated in 1983, is to encourage Singapore exporters to export healthy fish that are of high quality through maintenance of high standards of hygiene and sanitation in their packing premises. The Scheme enables exporters with good management practices to obtain accreditation for their export premises and obtain health certificates based on their good track record of management practice on hygiene and sanitation, and fish quality rather than through inspection of every consignment. Membership to the Scheme is voluntary and through application by companies that are licensed importers and exporters of ornamental fish. Prior to the approval of membership, the premises would be subjected to initial screening by AVA, including inspection of the premises and fish stock, water sampling for laboratory examination and checking the records of the fish ales maintained by the company. There must not have been any history of fish disease occurrences or of any gross mortality in the fish stocks in the packing premises during the one month preceding the commencement of membership.

A Code of Practice is incorporated into the Scheme to provide guidelines on the management of incoming and outgoing fish, routine care of fish held in the premises and packing of fish for export and maintenance of packing premises. In addition, members also have their own quality control measures to ensure that only good quality and healthy fish are included in their consignments. More importantly, member must also meet the requirements of the importing countries.

Surveillance and Monitoring Programmes for Aquatic Animal Pathogens

Ornamental fish samples taken from exporters' premises have been screened for epizootic haematopoietic necrosis virus (EHNV), infectious pancreatic necrotic virus (IPNV), infectious haematopoietic necrosis virus (IHNV), viral haemorrhagic septicaemia virus (VHSV), spring viraemia of carp virus (SVCV) and Koi Herpes Virus (KHV) with negative results to date. Imported juvenile marine foodfish are routinely screened for viral encephalopathy and retinopathy (VER) virus and red sea bream iridoviral virus (RSIV). Out of the 11 OIE-listed and 3 non OIE-listed but prevalent in the Asia Pacific region finfish diseases and reportable to OIE/NACA, viral encephalopathy and retinopathy (VER or viral nervous necrosis) has been occasionally observed in fish cultured in local waters, including newly imported juvenile marine fish. Surveillance of wild marine fish, targeted at VERV and RSIV, has also been carried out for the past two years. VERV and RSIV have not been detected in wild fish to date.

Farm and Export Premises Survey

Surveys of fish farms and exporter premises are carried out on a monthly/quarterly basis by AVA. For these surveys, AVA officers visit fish farms and interview farmers on their farming and production methods. Additionally, farmers who encounter disease problems/outbreaks can approach the Authority for assistance, either by telephone or in-person at AVA centres. Disease investigations are carried out by officers from Aquatic Animal Health Branch, Epidemiology and Surveillance Branch and Aquaculture Branch, who work closely on these reported disease cases. Prompt action is taken to ensure that farm visits are made and the affected species inspected. Samples are usually taken back to the laboratories for full post-mortem examination and disease diagnosis. Farmers are then advised on the course of action to take. If treatment is necessary, AVA staff will be on hand to train or guide farmers on proper treatment procedures. Farmers will also be notified of the results of investigations and given necessary advice.

Specific Import and Quarantine Requirements

Besides the compulsory requirement of import licences and permits for all aquatic animals consignments coming into Singapore as described above, AVA imposes specific import and quarantine requirements for certain high-risk consignments coming in from sources where outbreaks of significant diseases are known. In the recent outbreak of KHV around the region, AVA has instituted compulsory inspection, testing and quarantine of all koi consignments from countries with known outbreaks of the infectious disease. Fish are required to be quarantined at the importers' premises for a minimum period of 3 weeks, during which samples from the consignment, or sentinel koi cohabitating with these imported koi, are subjected to testing for KHV by tissue culture. Only when test for KHV is negative will the fish be released from quarantine. KHV positive koi consignments will be destroyed, and the premises disinfected .

Development of Good Management Practice for Aquaculture

A Good Management Practice Scheme has been established for ornamental fish farms in Singapore. The Scheme, currently on a trial basis involving participation from some 13 farms, is voluntary and members are required to fulfill certain criteria in good farm management and adhere to a Code Of Practice. The Code specifies guidelines on the various aspects of farming such as maintenance of farm premises, water quality management, farm hygiene, husbandry, pond/tank management, feeds and feeding, fish health management, water drainage and treatment, harvesting and post harvest/packing procedures and proper recordings. The farm is subject to regular inspection by AVA to ensure compliance. AVA is also in the process of developing a Good Aquaculture Practice (GAP) Scheme for foodfish farms.

Implementation of the Technical Guidelines

The Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals (FAO/NACA 2000) has provided valuable guidance for the implementation of national and regional fish health management strategy in reducing the risks of transboundary aquatic animal pathogens. Integration of the guidelines should, however, take into consideration of national circumstances and the status of regional countries in regard to their capacity in aquatic health management.

Singapore has the legislative framework for the regulation and monitoring of live aquatic animal trade and the associated health management. This applies to various aspects of national aquaculture development such as farming area demarcation and development, farm licensing, pollution control, import/export regulation and disease control and reporting. AVA is the designated national Competent Authority (CA) empowered to oversee the implementation of the Technical Guidelines and has the responsibility to administer appropriate health management and certification programmes.

The development of diagnostic capabilities for aquatic animal pathogens is well demonstrated by the level III diagnostic procedures used in the detection and screening of new viral diseases (Chang *et al*. 2001). Increasingly, PCR and tissue culture techniques are being used in our Aquatic Animal Health Laboratory to detect some OIE-listed viruses in surveillance programmes. The Authority will continue to upgrade its diagnostic capability to detect pathogenic agents to meet prevailing challenges through R&D, external collaboration and staff training.

As reported above, active and passive surveillance programmes are in place to detect selected significant OIE-listed aquatic animal pathogens. These programmes together with our regular farm surveys and disease investigations provide the basis of the Quarterly Aquatic Animal Disease Reports submitted to OIE and FAO/NACA. To further enhance the effectiveness of our aquatic animal pathogen surveillance programmes, a cross-functional committee has been set up by AVA to review existing fish health surveillance and monitoring protocols in order to provide a more systematic approach towards managing the risk of transboundary aquatic animal disease spread. The Authority is also looking into the methodology for import risk analysis so as to minimize risk to the local aquaculture industry.

Awareness of the Technical Guidelines and the associated risks of transboundary movement of aquatic animals were communicated to stakeholders. Sharing sessions were organised or presentations made during meetings with associations and industry business clusters to raise the awareness of the private sector. One further example of sharing with the industry stakeholders is the publication of the impact of KHV on regional countries in the Ornamental Fish Business Cluster Newsletter.

At the regional level, AVA will continue to monitor the progress of national implementation of the Technical Guidelines and the National Coordinator shall report the progress accordingly at the regional platforms. Singapore will continue to prepare national quarterly reports for submission to OIE and NACA/FAO through the appropriate channel.

Recommendations

To provide an effective feedback and communication channel at the regional level, the existing disease reporting system (Quarterly Aquatic Animal Disease Reports) developed by NACA, FAO and OIE should be continued and further developed. This is important so that essential data could be disseminated quickly for countries to take the necessary precautions or establish diagnostic capability to meet the challenges of emerging diseases.

Awareness to the benefits of the Technical Guidelines can be raised within the farming sector - in the form of sharing sessions with stakeholders to raise their awareness of regional situations on disease outbreaks (e.g. KHV) and to promote responsible health management practices. At the regional level, sharing country experiences in implementation of the Technical Guidelines can be encouraged. In this context, National Coordinators play an important role in data sharing among countries and disseminating relevant information to the stakeholders in their respective countries. National capacity building as well as strategic alliances among aquatic animal health resource centers in the region and other international fish health/disease experts can be promoted. The development of a good disease reporting system through sound surveillance programmes, personnel training and information sharing will facilitate working towards the development of sound health management strategy.

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Introduction

Initiatives to combat adverse impacts from alien species in Thailand have been carried out under the National Committee on the Convention on Biological Diversity for which the Office of Natural Resources and Environmental Policy and Planning (ONEP) (formerly Office of Environmental Policy and Planning or OEPP), Ministry of Natural Resources and Environment (formerly Ministry of Science and Environment), serves as the secretariat. The Committee appointed the Working Group on Alien Species in January 23, 1996 to compile information on non–indigenous species in the country and undertake consultation in order to formulate measures to control and prevent loss of biodiversity resulting from the spread of alien species. The Working Group was chaired by the National Biological Control Research Centre (NBCRC). Two meetings were held in 1996 and 1997 by the Working Group and ONEP to discuss and exchange experiences on alien species in Thailand. Legal aspects on controlling and eradicating alien species were discussed. A list of approximately 1,500 species that includes aliens has been compiled (http://www.onep.go.th/bdm/index.html). Issues related to trans-boundary pathogens did not receive much attention in these meetings. There is no specific institution or division in the Department of Fisheries (DOF) dealing with "aquatic invasive alien species". However, the DOF has set up the Biosafety Committee whose authority is to regulate the importation of the "aquatic alien species" or non-indigenous aquatic animals. Typically, the importation of live aquatic alien species is prohibited.

Common alien species in Thai aquaculture

Introduction of many exotic aquatic animals to Thailand were undertaken with the following objectives: (a) aquaculture, (b) ornamental fish, and (c) biological control of aquatic plants or weeds. An early record indicated that gold fish, *Carassius auratus,* was first introduced into Thailand in 1692 as pet. In 1913, common carp, *Cyprinus carpio* and Chinese carps were introduced for aquaculture. The mosquito fish (*Gambusia affinis*) were imported to control mosquitoes and grass carp (*Ctenopharyngodon idella*) to control aquatic weeds. Over 100 species of exotic aquatic animals have been imported intoThailand. The common alien species in aquaculture are common carp, koi carp, goldfish, Indian and Chinese major carps, tilapia, African walking catfish, channel catfish, Chinese soft-shelled turtle, brine shrimp (*Artemia* spp.), and Pacific white shrimp (*Penaeus vannamei*). Some aliens which have been identified as invasive species include armor sucker catfish, African walkingcatfish, hybrid walking catfish (*Clarias gariepinus* X *C. macrocphalus*) and apple snails (*Pomacea canaliculata and P. gigas*).

Habitat disturbance

Amazon apple snail was introduced into Thailand in 1989 as an aquarium pet. Scientists presumed that 10,000 – 20, 000 snails could eat rice plants covering an area of 1 600 m^2 overnight. Farmers use endosulfan to kill the snails. However, the chemical also har, other animals in the ecosystem. An invasive aquatic plant, the water hyacinth *Eichhornia crassipes* was introduced into Thailand in 1901 from Indonesia. The plants had remarkably adapted to environment and has a very high reproduction rate, thus, easily covering natural water bodies.

Genetic pollution, erosion and restoration

As a demand for high growth and disease resistant fish increased, artificial breeding between African walking catfish (*Clarias gariepinus*) and native walking catfish (*C. macrocephalus*) became widely practiced in Thailand. These hybrids have replaced the native species, walking catfish *C. batrachus,* for aquaculture. Some hybrids have escaped or released into the wild. The hybrids have more aggressive behavior, causing severe genetic erosion among *Clarias* species such as *C. batrachus* and other native species. Fighting for the risk of native species extinction, the DOF implemented a long-term research breeding program of rare indigenous aquatic animal species. One of the most remarkable achievements is the Mekong giant catfish breeding program for which thousands of fish had been released to the wild, reservoirs and the Mekong River.

Diseases and parasite carriers

International fish trade has been spreading diseases to many countries for years (Håstein, 2000). In Thailand, an introduction of common carp and Chinese carps (*Hypopthalmichys molitrix, Ctenopharyngodon idellus, Aristichthys nobilis*) for food fish culture in the past also introduced the anchor worm, *Lernaea cyprinacea*, into the aquatic ecosystem. An introduction of shrimp from China caused white spot syndrome virus (WSSV) epidemic. An illegal introduction of Pacific white shrimp caused Taura syndrome virus (TSV) outbreaks in Thailand. Importation of ornamental fishes also introduced many new pathogens such as *Hexamita*, *Tetrahymena* and iridoviruses.The occurrences of ranavirus infection in tadpole, frog and fish cultured in Thailand might have come from the healthy aquatic animal carriers which have been imported into the country. Generally, some parasites or pathogens have wide host ranges including food fish and ornamental fish. The susceptible hosts exhibit disease clinical signs and invariably die. However, the resistant hosts or the disease-recovered fish can serve as reservoir or carriers of the pathogens.

Management strategies to control trans-boundary pathogens

The strategy for aquatic animal health management in Thailand had been discussed during a series of seminars and workshops among staffs from the DOF, Department of Livestock Development (DLD), universities, private sectors and farmers held in Bangkok in May 2001. Under the "*National Strategy for Control of Aquatic Animal Diseases*", nine strategic plans developed from these consultations were accepted by the DOF, 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 regulated by the DOF. Existing legislations [e.g. 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)] did not include provisions for control of aquatic animal diseases. These three Acts have brief sections on movement regulations of imported and exported aquatic animals. However, Thailand has a law to control animal disease outbreaks called the Animal Epidemic Act B.E. 2499 (1956), which is under the authority of DLD. A joint working group from DOF and DLD has been appointed to determine how the animal law could be applied to aquatic animals. Beginning July 1, 2004, this Animal Epidemic Act has been implemented to control aquatic animal diseases. A total of 27 aquatic animal diseases has been listed under this Act to control the epidemic of aquatic animal diseases in the country.

National body responsible for managing the use of alien species

The national body to manage the use of alien species in Thailand was not clearly established. However, after ratification of the Convention on Biological Diversity (CBD) in January 2004, Thailand has strengthened the coordinating mechanisms for the implementation of the national policy, strategies and action plans on the conservation and sustainable use of biodiversity through the following National Committees: (a) the National Environment Board; (b) the National Committee on the Conservation and Use of Biodiversity; (c) the National Committee on the Convention on Biological Diversity; and (d) the National Committee on Wetland Management. These Committees consist of representatives from non-governmental organizations (NGOs), universities and different ministries. The relevant departments and offices are: (a) DOF; (b) Royal Forest Department; (c) Department of Agriculture; (d) DLD; and (e) the Office of Natural Resources and ONEP.

The ONEP based in the Ministry of Natural Resources and Environment is the national body for invasive alien regulation as this Office serves as the national focal point for CBD. However, at the department level, the DOF has the authority to regulate and control the importation of the aquatic animals. The importation of aquatic alien species is generally prohibited. Risk analysis is conducted before introduction of aquatic alien species which i=are deemed necessary for aquaculture and commercial purposes. If the pathogen risks and ecological risks are negligible or manageable, introduction is permitted.

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Part I: Aquatic Invasives Species

Introduction

Vietnam has more than 3 200 km of beach, many reservoirs, river systems which have great potential for aquaculture development. With the main purposes of ensuring food security, increasing biodiversity and production, many new species of aquatic animals were introduced to Vietnam. Black tilapia *(Oreochromis mossambicus)* was the first alien species introduced to Vietnam in 1951. Introduction of new species to Vietnam has so far increased aquaculture production since many species have adapted to the new environment, and became the main cultured species. However, some species have some negative impacts to the environment, gene conservation, etc. (Tuan, 2002).

Current Status of Aquatic Alien Species in Vietnam

For more than 50 years since the first new species was introduced, 17 freshwater alien species were imported to Vietnam from 12 countries (Table 1). These include 2 shrimp species (Table 3), 4 amphibian species (Table 4) and 2 molluscan species (Table 5). At the moment, the Ministry of Fisheries (MOFI) has a project of producing a list of alien species. So far, Vietnam has a list of live species imported into the country (Tables 1-5).

Introduction of 14 freshwater species was undertaken by research institutions (Pham Anh Tuan, 2002). These species have almost adapted to the Vietnamese conditions and became the common cultured species in freshwater aquaculture especially in VAC (horticulture-aquaculture-livestock) culture system. Among these species, 58.8 percent became the main freshwater aquaculture species; grass carp *(Ctenophryngodon idellus)* imported from China, tilapia *(O. niloticus)*, and Indian carp such as rohu *(Labeo rohita)* and mrigal *(Cirrhinus mrigala)* were most popular. Catfish *(Clarias gariepinus)* and common carp *(Cyprius carpio)* were not used as purebred but used as broodstock for producing hybrid fry. These hybrid fish grow very fast and quite suitable for Vietnamese conditions (Tuong, 1977). Hybrid carp named V1 became one of the most popular species for freshwater culture in Northern Vietnam (Thien, 1990).

Results from evaluation of five species such as *Xtiobus cyprinellus, Anguila anguila, Catla catla, Silurus glanis* and red tilapia *(Oreochromis sp.)* imported from Cuba revealed slow growth, and that they no potential for aquaculture development in Vietnam, therefore they were not widely distributed (Tuong, 1985). Introduction of new species to Vietnam also also had some negative impacts. Black tilapia *(O. mossambicus)* were widely cultured in the 1970's and 1980's. However, they are considered as "trash fish" as they reproduce very early at small size with very low production.

Table 1: List of alien imported fresh water fish species (Tuan, 2002)[1].

No.	Vietnamese Name	Scientific Name	Country of Origin	Purpose of Importation
1	Cá rô phi ðen	*Oreochromis mosambicus*	Taiwan,Thailand, Philippines	Culture
2	Cá rô phi v±n	*O. niloticus*	Taiwan,Thailand, Philippines	Culture
3	Cá rô phi xanh	*O. aureus*	Philippines	Seed quality improvement
4	Rô phi hÓng	*Oreochromis* sp.	Cuba, Philippines	Seed quality improvement
5	Cá tr¯ m cÏ	*Ctenopharyngodon Idellus*	China	Culture
6	Cá Mè tr¯ ng Trung QuÑc	*Hypophthalmichthys molitrix*	China	Culture
7	Cá mè hoa	*Aristhichthys mobilis*		Culture
8	Cá chép Hungary	*Cyprinus carpio L*	China	Cross breeding
9	Cá chép vàng	*Cyprinus carpio L*	Hungary	Cross breeding
10	Cá rô hu	*Labeo rohita Hamilton*	Indonesia	Culture
11	Mrigal	*Cirrhinus mrigala*	Thailand, India	Culture
12	Catla	*Catla catla*	Laos, Thailand	Culture
13	Cá trâu miÇng rÙng	*Xtiobus cyprinellus*	Laos Cuba	Culture
14	Cá trê phi	*Clarias gariepinus Burchell*	Africa	Cross breeding
15	Cá chình	*Anguilla anguilla*		Culture
16	Cá chim tráng	*Calossoma brachiomun*	China	Culture
17	Cá nheo	*Silurus glanis*	China France	Culture

[1] *Currently being revised by the Ministry of Fisheries.*

The hybrid fry of *C. gariepinus* together with other catfish species escaped to the wild and cross-bred with other Vietnamese catfish species causing difficulty for gene conservation (Tuan, 2002)

Golden snail is an example of an alien species which had negative impact to Vietnam. The Latin name of golden snail imported to Vietnam as well as the exact date of importation have not been confirmed. Some information showed that it was imported from the Philippines in 1998. Between 1989 and1990, some agencies privately advertised and encouraged golden snail culture. Beginning the year 1992, it showed negative impacts to the rice field. In 1995, 214 districts belonging to 53 provinces had golden snails at different levels. Golden snails had invaded 31 429.85 ha comprised of 22 659.64 ha of rice, 460.33 ha of morning glory, 8 309.88 ha pond and 1 147.23 km river (Tuan, 2002). Because of the serious negative impact of golden snail, the Prime Minister gave Direction No. 528/T.Tg dated 29/9/1994 and Direction No. 151/T.Tg dated 11/3/1995 banning its culture and eradicating existing ones.

Table 2. List of live imported marine species (Tuan, 2002) [1].

No.	Vietnamese Name	Scientific Name	Country of Origin	Purpose of Importation
1	Cá giò	*Rachrycentron canadum*	Hong Kong	Culture
2	Cá hÓng	*Lutianus enrythropterus*	Hong Kong, Taiwan	Culture
3	Cá mú/song	*Epinephelus akaara*	Taiwan	Culture
4	Cá ch½m	*Lates calcarifer*	Taiwan, United State of America, Thailand, China	Culture
5	????	*Scianops ocelatus*	China	Culture
6	Cá t§m	*Hisodauric sp*	Russia	Testing
7	Cá vu?c M?	*Setaenops ocellatus*	China	Culture
8	????	*Parosomus major*	China, Taiwan	Culture
9	Cá chim	*Trachinotus blochii*		Culture
10	Cá mãng	*Chanos chanos*	Taiwan	Culture

[1] *Currently being revised by the Ministry of Fisheries.*

Table 3. List of live imported shrimp species (Tuan, 2002).

No.	Vietnamese Name	Scientific Name	Country of Origin	Purpose of Importation
1	Tôm vÏ céng	*Cherax* sp.	Australia	Experimental trials
2	Tôm th» chân tr¯ ng	*Penaeus vannamei*	Taiwan, Hawai	Culture
3	Tôm càng xanh	*Macrobrachium rosenbergii* de Man	Thailand	Culture
4	Tôm hùm bông	*Panulirus omatus*	Philippines, Taiwan	Culture
5	Tôm He	*P. merguiensis*	Taiwan	Culture
6	Tôm sú	*P. monodon*	Thailand, Malaysia, Taiwan, Australia, Philippines	Culture

Table 4. List of live amphibians imported species (Tuan, 2002).

No.	Vietnamese Name	Scientific Name	Country of Origin	Purpose of Importation
1	Ba ba	*Trionys sinensis*	Taiwan, Thailand	Culture
2	**XXXX**	*Rana catesbeiana*	China trials	Experimental
3	**XXXX**	*Rana ranch*	Cuba trials	Experimental
4	Cá sau nuroc ngot Cu ba	*Crocodilus rhombier*	Cuba trials	Experimental

Table 5. List of live imported mollusc species.

No.	VN name	Latine name	Country of Origin	Year of Importation	Purpose of Importation
1	Trai Ngoc	*Pinctada fucata*	China, Japan	1997	Pearl production
2ý	Trai ma thi nuroc man	*Pteria martensii*	*China*	1994, 1996, 1999, 2000 2001	Pearl production
3	Sò ðiep	*Argopectens irradias*	China China	2001 2001	Aquaculture Aquaculture
4	Oc burou vàng	*Pomacea* sp.	Philippis	1998	Aquaculture

The impacts of the introduction of other brackish and marine alien species to Vietnam have not yet been evaluated.

Current Management Strategies for Alien Species

Circular Letter 04/TS-TT dated 30/8/1990 provides the law dated 25/4/1989 which protects and develops aquatic resources, encourages agencies and private sector to import live species for aquaculture purpose. This law states that importing live species has to follow strict quarantine procedures at the border. With untested, unrecognized species, it is illegal to have seed production of that species at any place in Vietnam.

Decision 344/2001/QDD-BTS 2/5/2001 of MOFI on fisheries import and export for the period of 2001-2005 has been released. This document provides a list of species which can be imported into the country without any testing period required. These include 34 freshwater fish species, 17 brackishwater and marine fish species, 3 species of freshwater crustaceans, 15 marine crustacean species, 4 freshwater molluscan species, 16 marine molluscan species, 3 freshwater amphibian species and 15 marine phytoplankton species. Any species not in this list and intended to be introduced to Vietnam has to pass quarantine procedures.

Decree 48/CP 12/8/96 and Circular Letter 04-TT/BVNLTS dated 10/10/1996 states that if any agency or person that illegally import alien species causing damage to aquatic resources would be banned and fined. Smuggling played a serious role in having illegal imported species.

Progress in Implementing Recommendations for Managing Aquatic Alien Species

The government will soon apply import risk analysis (IRA) guidelines for importing live species. The guidelines have now been circulated for comments and will be finished by the end of 2004. Six research institutions and universities have roles during the testing phase before advising MOFI for final approval of importation or distribution of alien species.

There are, however, some limitations such as untimely issuance of laws, decrees, and directives regarding this matter. For example, the first importation started in 1951 but it was only in 1989 that the decree on importing of alien species was issued. Lack of human resources and capacity related to quarantine work is also a limiting factor.

Part II: Associated Trans-boundary Aquatic Animal Pathogens

Current Status of Trans-boundary Aquatic Animal Pathogens

With freshwater alien fish species, the pathogens which entered Vietnam were mostly parasites, especially with Indian carp. With mrigal, 20 new parasite species (*Chloromyxum mrigalae, Myxobolus carnaticus, M. calbasui, M. catale, M. curmucae, M. hosadurgensis, M. indicus, M. mrigalae, M. shetti, M. vanivilasae, M. vedavatiensis, M. venkateshi, M. yogendrai, Scyphidia pyriformis, Thelohanellus mrigalae, Dactylogyrus chauhanus, D. mrigali, D. brevifurcatus, D. yogendrai, and Gyrodactylus elegans)* were introduced to Vietnam. However, research showed that that only few species can adapt with Vietnam conditions (Te, 2001).

Imported grass carp from China is suffering from two kinds of diseases, i.e. red spot disease and hemorrhagic disease, caused by pathogens associated with the importation of alien species. Shrimp faming is currently faced with serious crustacean diseases. These include white spot disease (WSD), yellow head disease (YHD) and most recently Taura syndrome virus (TSV), following the importation of white leg shrimp.

Epizootic ulcerative syndrome (EUS) is another important finfish disease present in Vietnam. A disease similar to EUS has been reported during late 1970s and early 1980s; however, no research has been regarding this disease.

Current Management Strategies for Trans-boundary Aquatic Animal Pathogens

All imported live animals are kept isolated and distribution is not allowed until the final result of pathogen test has been completed. The newly established National Fisheries Quality Assurance and Veterinary Directorate (NAFIQAVED) has the responsibility for following up the resuts of pathogen testing. If the result of the pathogen test is positive for certain diseases, the imported batch will be destroyed. With the establishment of the NAFIQAVED, more effort on health management in the aquaculture sector will be provided. In addition, three other centers, whose focus will be on environment, disease monitoring and early warning, will be established. These developments show that the government is more concerned about trans-boundary aquatic animal diseases.

Progress in Implementing Recommendations for Managing Trans-boundary Aquatic Animal Diseases

Diseases of concern. The government updated the list of quarantine diseases; however, revision needs to be done. For disease reporting, the OIE disease list is being used which is parallel will the national disease list.

Disease diagnostics. During the last few years, Vietnam had developed capacities in disease diagnostic levels (I, II, III), especially at the three research institutions (RIA Nos. 1, 2, 3). Many provincial DOFI have laboratories for disease diagnostics, some have PCR machines. Human resource problem still remains in terms of capacity and sustainability.

Health certification and quarantine. These documents are issued by NAFIQAVED, but pathogen testing is done by RIAs or branches of NAFIQAVED depending on geographic location.

Disease zoning. The MOFI is still at the awareness raising stage on this subject.

Contingency planning. NAFIQAVED and three centers for Environment, Disease Monitoring and Early Warning have responsibilities to make plans and budget or disease outbreak. The government provides fund for emergency disease outbreak. The fund is monitored by NAFIQAVED.

Import risk analysis. The MOFI will soon issue guidelines for the importation of live, alien aquatic animals, replacing old guidelines which are not anymore suitable at this present

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Case Study on the Invasive Golden Apple Snail in ASEAN

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Abstract
The golden apple snail (GAS), *Pomacea canaliculata* (Lamarck), a freshwater ampulariid, is one of the world's worst invasive alien species. It is distributed primarily in Asia, North America and South America; the later being its home of origin. The unique morphological and biological traits make them survive in diverse and harsh environments. In this case study, we highlight what makes GAS invasive and show the mechanisms and pathways of their spread over time and space. An overview of the cost of GAS invasion from the loss of aquatic native biodiversity and impacts on social, environmental and economic levels are presented. New knowledge-based information and tools to manage GAS in future are crucial for its early detection and containment in risk-prone countries. Such knowledge is derived from lessons learnt from the Philippine experience on GAS invasion.

Introduction

Introduction to Golden Apple Snail. The golden apple snail (GAS), *Pomacea canaliculata* and/or *Pomacea* spp. (Gastropoda: Ampullariidae), is known by an array of common names, which has created confusion as the term "golden" refers not to their colour, but to the amount of money people could make by raising them. However, GAS is the most frequently used common name for the major pest species in South-East Asia. It is listed as one of the 100 World's Worst Invasive Alien Species (IAS), as its invasion ability is based on unique morphological and biological characteristics that makes it an effective aquatic invasive species and thus favour the snails' capacity to survive under adverse environmental conditions and still reproduce rapidly. However, the invasiveness of this biological species is manageable. Thus it can still be utilized for useful purposes. In the Philippines, the government promoted GAS production in 1982 and 1984, as a national livelihood program to increase the protein intake of low-income Filipino rice farmers and as an additional source of income for them.

GAS feeding habits and damage. GAS is a highly voracious nocturnal herbivore. It destroys newly transplanted rice. GAS damage is characterized by missing hills and floating leaf fragments in the rice field. It cuts the base of young seedlings with its layered tooth (radula) and eats the succulent, tender rice leaves. The extent of damage to the rice crop depends on snail size, snail density, and the growth stage of the rice plant. A density of three GAS per square

Key References

meter causes significant yield loss, with much greater damage to direct-seeded rice and young seedlings transplanted at 18-21 days. GAS that are 40-mm are generally the most destructive size, irrespective of rice establishment method, causing 100% destruction of the rice seedlings in the germinating stage and at least 20% in transplanted seedlings. GAS of 10-mm size can damage direct-seeded rice even after 1 day. However, 5-mm sized GAS does not damage rice seedlings, instead feeding on algae and other organic matter at the field water surface. GAS adults also feed on azolla, morning glory, sweet potato, taro, and other aquatic plants. Adults measuring 22-26 mm can consume up to 15 g of azolla in 12-24 h. GAS damage is severe in lower portions of the fields where water stagnates.

GAS invasion mapping. GAS has become a major pest of rice in all rice-growing countries (introduced by multiple pathways either deliberately or inadvertent), including lowland plants in North and South America. The most recent serious GAS invasions have been reported from the Dominican Republic and South Korea. GAS was introduced to Japan as early as 1964 as an aquarium pet. Damage to rice was reported in 1984 and in the same year it was declared a quarantine pest in Japan. In Thailand, it was introduced in 1982 and its first outbreak was recorded in 1988. In Vietnam, it was introduced in 1988 and declared as a quarantine pest in 1993. By 1997, it had spread to 7 out of 61 provinces. In Malaysia, GAS was first detected in 1990 and by 1993 started damaging several hectares of rice. In Cambodia, GAS was introduced in 1991. In Asia, distribution continues to expand westward. Large rice growing regions of India, Bangladesh, China, and Australia are at high-risk of future GAS invasion. The following generalizations can be made. First, it attains pest status about four years after its introduction in a country. Second, local establishment is a key feature of invasion. Third, its establishment is stochastic (or its spread in the countries where it has been brought in or introduced after its establishment is random). Fourth, GAS typically persists once established.

Potential problems. The losses to Philippine rice crops from GAS in the 1980s amounted to US$ 1 billion. Annual global agricultural economic losses from GAS range from $55 to 248 billion/yr. By 1990, the GAS infested area increased to more than 600,000 ha. Surveys conducted in 1991 in the Philippines showed that the infestation had increased to 900,000 ha. At present, it is a major biotic constraint in all regions and rice ecosystems of the Philippines, including the Ifugao Rice Terraces.

GAS poses human health hazards by being an intermediate host of the rat lungworm (*Angiostrongylus cantonensis*, a human endoparasite), which if ingested causes *eosinophilic meningoencephalitis*. Direct injury to the bare feet of farm workers from sharp-edged empty shells in rice fields during field operations leaves them open to infections.

Environmental problems that stem from GAS management are water pollution, including loss of biodiversity in waterways as a result of pesticide misuse/abuse. In addition to GAS being ranked as a pest of national importance, it is blamed for the decline of the edible native apple snail, *Pila conica* (Gray) [often erroneously referred to as *Pila luzonica* (Reeve)] and the 'jojo or yoyo' fish (*Mirgurnus anguillicaudatus*) in the Ifugao Rice Terraces. This is probably because of competition for common habitat and resources.

All available GAS information is readily available in accessible electronic format, including CD-ROM and on the website **http://www.applesnail.net** under the Pest Alert Section.

Current GAS management practices. Integrated management methods are recommended for GAS, but Filipino farmers use commercially available synthetic molluscicides (niclosamide and metaldehyde) as their first line of defense, without considering the toxic hazards to themselves or to non-target organisms. Expenditure on synthetic molluscicides in 1998 was estimated at US$2.4 million. In 1993, farmers spent about US$9 ha^{-1} for pest management. This figure has swelled to about US$23 ha^{-1} even with the proper use of registered commercial molluscicides, with a countrywide expenditure of US$7.4 million per year. The chemical approach is unsuitable for resource-poor Filipino rice farmers. For these and other reasons, it is important to either prevent GAS damage through low-cost, technically efficacious, and environmentally sustainable control options to stabilize and increase rice productivity in the direct-seeded rice and transplanted rice systems, or to explore utilizing the snails within the rice farming systems context.

Constraints to GAS management. The shift from transplanted rice to direct-seeded-rice culture has caused even greater GAS problems. Good field leveling and shallow water management practices can reduce GAS damage in lowland irrigated transplanted rice systems, but this practice is extremely difficult in direct-seeded and upland rice, and in flood-prone areas. While farmers could experiment with a combination of preventive or corrective control measures, many of these are labour-intensive (see Figure). For instance, missing hills can be replanted but the replanting costs, with replanting up to 4 times, could drain the physical and financial resources of the rice farmers as it entails costs for additional seedlings and replanting time. Unprotected applications of organo-tin compounds with a knapsack sprayer have caused several human health risks, such as peeling toenails and fingernails, headaches, skin disorders, blindness, and even death.

After the banning of these molluscicides, the application of pesticides (insecticides and fungicides) for GAS control also needs to be viewed critically. The use of endosulfan on GAS increased considerably but high toxicities of this chemical to fish in rice fields following its application, led the Philippine authorities to remove this chemical from the market. GAS populations also recover quickly from pesticide sprays as they can avoid exposure by burrowing into the soil or simply crawling out of treated water onto clay clumps or standing vegetation. Egg masses deposited on standing vegetation above the water and GAS carried into fields with irrigation water from neighbouring fields remain sources of constant re-infestations. Another important consequence of the use of toxic insecticides is the negative impact on IPM in rice farming systems.

One recommendation is to avoid spraying insecticides in the first few weeks after transplanting as this suppresses natural enemies and could lead to rice pest resurgence. However, it is exactly during this period that rice farmers tend to kill GAS by spraying pesticides. Although installing screens at water inlets has been recommended to minimize the entry of large-sized GAS into rice fields and to facilitate hand-collection, younger and small GAS, including neonates, can easily enter undetected. Hand-picking GAS and crushing GAS egg masses by using hand-operated smashing devices are highly labour intensive practices and unfeasible in large paddy fields. Physical control of apple snails by rotary cultivator is efficient, decreasing snail density drastically, such that in a submerged direct sowing situation the area damaged by the snails in a rotary cultivation field was 2.3% but 48.1% in the uncultivated field.

Management options—new paradigm. GAS can be used as an animal feed (tiger shrimps, ducks, pigs, poultry and fishes) and as human food. As feed, it could replace meat meal or fishmeal in animal diets. The protein content (62.5%) is comparable to that of Peruvian fish meal (61.2%) but a little bit lower than meat meal (66%). GAS is also a good source of mineral, as indicated by its calcium (35%) and phosphorous (1.22%) contents, and of energy (3,336 kcal kg^{-1}). Uncooked fresh GAS meal in swine diets can be used up to 15% , up to 10% in the diet of native chicks.

Feeding trials on Nile tilapia in aquaria showed that GAS meat meal at 75-100% of the diet mixed with rice bran is beneficial. In cage culture of Nile tilapia, fish grown on a snail-meal-based diet were superior to those fed with a fishmeal-based diet. For freshwater prawn (*Macrobrachium rosenbergii*) larvae, 60 % GAS meat meal in dried form mixed with rice bran, shrimp meal, and fishmeal gave good growth.

As food for humans, GAS can be cooked with coconut milk, pickled as an appetizer, and made into *kropeck* (snail cracker). One of the major obstacles to the popularization of GAS is their short shelf life. PhilRice researchers in partnership with a rice farmer developed a new recipe, *chicharon* (cracker), from GAS. This recipe is unique among GAS recipes in that it is devoid of water, has no offensive odour, has a longer shelf life, and can readily be used as an ingredient in other recipes.

GAS is also a hopeful agent for paddy weeding. In fact, many organic and some non-organic farmers use GAS for weeding in Japan, the Philippines, and South Korea without using herbicides. This technique has been spread by organic farmers who wish to reduce or stop the use of agricultural synthetic chemicals and utilize GAS as feed supplements for farm animals. The relationship between rice farmers and GAS has evolved into a symbiotic one, thus conserving the non-target aquatic faunal diversity. The benefits of utilizing GAS as biological weeding agents far exceed the benefits obtained by utilization of ducks, carp, or tadpole shrimps for paddy weeding. However, to utilize GAS for paddy weeding in areas that are not yet infested with GAS should be strictly prohibited. The benefits of the technique as an ecologically sustainable and cost-saving technology have been demonstrated among farming communities, by researchers, and by agricultural technicians. Insights on how to utilize resident (field) GAS populations for weed control have been documented and a video film explaining the technique is linked at **http://www.openacademy.ph/elearning/goldenkohol/** .

Conclusion

It is evident that GAS is continuing to spread to other countries *via* multiple pathways including deliberate and inadvertent introductions. However, any one deliberate introduction may have a relatively greater chance of establishment than many inadvertent introductions. Economic, human health, and environmental problems are caused by GAS invasion, which is irreversible. The repair cost is enormous. Old management options are labour-intensive, not economical, non-sustainable, and many are harmful to the environment. However, new options are environment-friendly, income generating and healthy. The knowledge gaps are tremendous, especially in the taxonomic identification of GAS, and thus, efforts to integrate molecular genetic and morphological taxonomic approaches are important.

Information is very scarce on the utilization of GAS as feed and on the carry-over of pathogens/parasites to aquaculture species and to people. Some efforts have been made by us to raise large-scale awareness in the fastest and most economical ways, including development of websites and video films, holding of forums, and distribution of posters to quarantine agencies, farmers, and extension staff. The role of aquatic predators in GAS management is poorly understood. We are currently investigating long-term effects of paddy weeding by GAS, especially on possible weed species shifts and changes in abundance, and any effects on other beneficial organisms in Philippine rice ecosystems.

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Figure. Farmers' Activities and Measures to Control GAS Based on Rice Plant Growth Stages.

(Modified from Rice IPM Network, 1991)

Rice pla

Farmers

Farmers
Experts'