Linkages Between Development Assistance and Invasive Alien Species in Freshwater Systems in Southeast Asia

A Report & Resource Guide for the U.S. Agency for International Development

by

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GISP
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FOREWORD

The focus of this study on the linkages between development assistance and the management of invasive alien species in freshwater ecosystems had the challenge of contributing to and influencing the state of knowledge during the two years of its implementation. As in life and in travel, the journey may be more important than the destination.

From the initial intensive literature review and compilation of the rich bibliography of this study to the convening of our panel of experts to the virtual and actual interviews and the final peer review of this final report, the authors and the rest of their collaborators have had the opportunity to learn, share and question practice. Intended as a snapshot, it has been more of movie for which this publication is the final scene. There will be a sequel.

This effort is a success due in part to its coordination with other related efforts and with the cooperation and participation of a large number of institutions. We wish to especially thank the U.S. Fish and Wildlife Foundation and the Smithsonian Institution for managing and hosting this effort. We were proud to have had the opportunity to contribute to the objectives and effort of the U.S. National Invasive Species Council (NISC) and the Global Invasive Species Programme (GISP). Finally, we would like to express our appreciation to the authors, Alexis T. Gutiérrez and Jamie K. Reaser for their effort, dedication, persistence, charm and intelligence without which this product would not exist.

Tim Resch

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LIST OF ACRONYMS

ADB	Asian Development Bank
AIMS	Aquaculture of Indigenous Mekong Fish Species
ANSTF	Aquatic Nuisance Species Task Force
ASEAN	Association of Southeast Asian Nations
ASEANET	Southeast Asian Loop of Bionet International
BFAR	Philippine Bureau of Fisheries and Aquatic Resources
CABI	CAB International
CBD	Convention on Biological Diversity
CGIAR	Consultative Group on International Agricultural Research
EO	Executive Order
FAO	Food and Agriculture Organization
GAS	Golden apple snail
GEF	Global Environment Facility
GIFT	Genetically Improved Farmed Tilapia
GMT	Genetically male tilapia
GISP	Global Invasive Species Programme
IAS	Invasive alien species
IRRI	International Rice Research Institute
IUCN	World Conservation Union
MRC	Mekong River Commission
NACA	Network of Aquaculture Centres in Asia-Pacific
NGO	Non-governmental organization
NMP	National Management Plan
PD/A CRSP	Pond Dynamics/Aquaculture Collaborative Research Support Program
SIDA	Swedish International Development Cooperation Agency
UNEP	UN Environment Programme
USAID	U.S. Agency for International Development
USAID SPARE	USAID Strategic Partnership for Agricultural Research and Education
WDI	World Development Indicators
WorldFish Center	WorldFish

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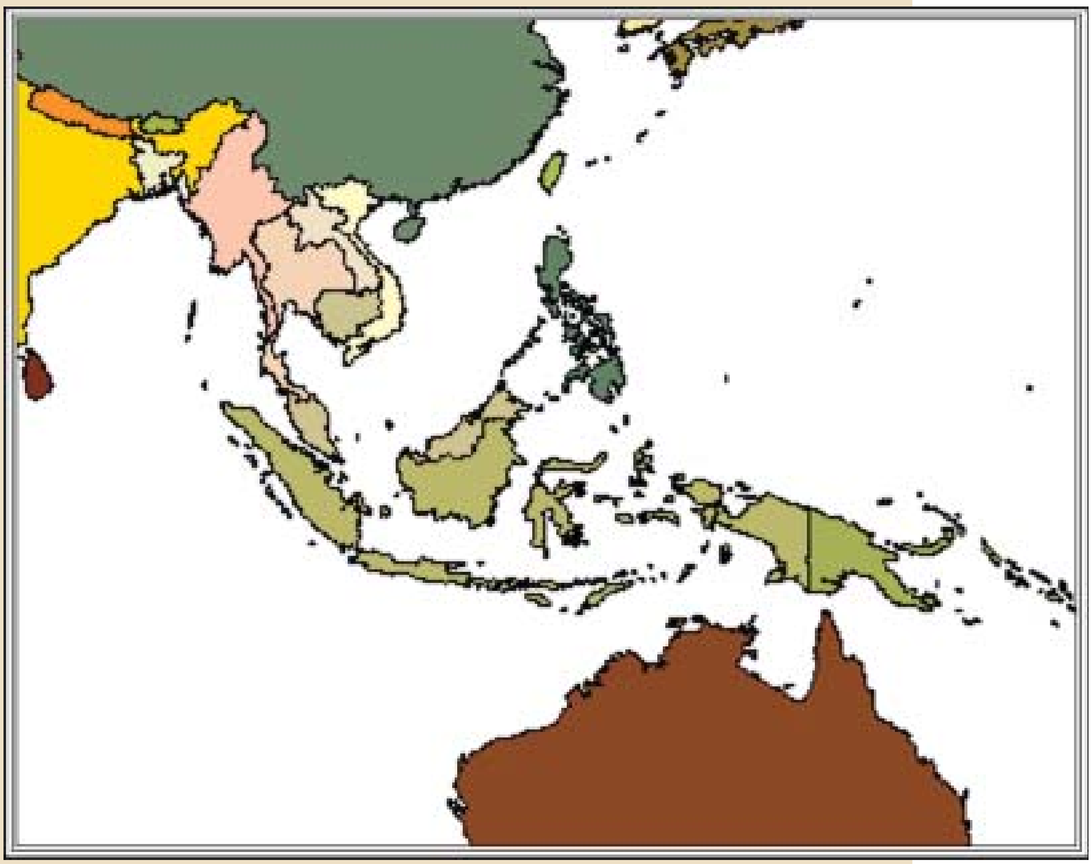


ASEAN countries. (ArcView, ESRI)

THE ASSESSMENT:

A CALL FOR ACTION

Action item forty-two of the U.S. National Invasive Species Council's National Management Plan (NMP)[1], calls for the U.S. Agency for International Development (USAID), in cooperation with the Global Invasive Species Programme (GISP), to initiate an assessment of international assistance as a pathway for the introduction of invasive alien species (IAS) (NISC 2001). In October 2001, in order to explore the feasibility of such an assessment, GISP and the U.S. government hosted a roundtable discussion on IAS and development assistance during the annual meeting of the Consultative Group on International Agricultural Research (CGIAR). Meeting participants reached the conclusion that there was an urgent need for a study of the potential pathways, including development assistance projects, by which IAS have become problematic in developing countries (see Appendix A). Policymakers and scientists at several regional workshops on IAS organized by GISP and the U.S. government in 2001-2002 also reached this conclusion (see Appendix B). In response to the NMP mandate and calls for action from the international community, USAID commissioned a preliminary assessment on the linkages between development assistance and IAS. This document reports on that assessment.

Southeast Asia was chosen as the focus region for the preliminary assessment because it has undergone rapid economic development in the last thirty years and currently supports some of the fastest growing economies in the world (e.g. Vietnam's GDP grew at 7% in 2002 while Thailand's GDP grew by 5% (WDI 2002)). USAID and several other international development agencies have played a critical role in the economic development of Southeast Asia, and have supported several projects in Southeast Asia's freshwater ecosystems. Freshwater systems are vital to the region's increasing human population as they provide fish, the primary source of protein, and water, and are the basis for a significant amount of the region's hydroelectric production.

The assessment was initiated in September 2002 and concluded in December 2003. Eight of the ten Association of Southeast Asian Nations (ASEAN)[2] member countries are included in the study (see Appendix D). Brunei Darussalam is a wealthy oil kingdom and thus did not meet our developing country criteria. Myanmar was not surveyed due to the U.S. funding restrictions. Our assessment did, however, reveal that representatives of both countries are aware of the threat posed by IAS and that there are regional and international

DEFINTIONS

For the purposes of this preliminary assessment, the internationally accepted term "invasive alien species" is used. ***Invasive alien species*** as defined under the Convention on Biological Diversity (CBD), means an alien species whose introduction and/or spread threaten biological diversity; an alien species is defined as a "species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce (CBD 2002a)." Not all alien species (also known as exotic, non-indigenous, or non-native species) are invasive.

Likewise, for the purposes of this assessment, ***development assistance*** is defined as any aid, either technical or financial, from a foreign organization to a developing country for the purposes of development.

Finally, ***pathway*** is the mode by which a species is transported from one area to another. Introductions of IAS can be intentional, for instance stocking a lake, or unintentional, such as the movement of a pathogen with the translocation of fish from one area to another.

[1] The U.S. National Management Plan on invasive alien species can be found at www.invasivespecies.gov

[2] ASEAN countries: Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam.

organizations (e.g., ASEANET and the UN Food and Agriculture Organization) engaging them on the issue.

The assessment examined three potential linkages between development assistance and IAS:

- **Development assistance as a pathway for the introduction of IAS;**
- **The impacts of IAS on development assistance projects; and**
- **Development assistance projects designed to minimize the impact of IAS.**

Two methodologies were employed for the assessment, first a review of existing information, including published literature and technical reports on invasion biology, freshwater ecosystems, development projects and aquaculture, as well as searches of the World Bank's, the Global Environment Facility's (GEF), and the USAID's databases for projects that may have led to the introduction of IAS or addressed their impacts. Secondly, technical experts were interviewed during visits to five of the eight focus countries in Southeast Asia. The countries visited included: Cambodia, Laos, Malaysia, the Philippines, and Thailand (see Appendix C).

Basic research was not conducted as part of this assessment. The authors hope, however, that the findings reported here will serve as a catalyst for further research on IAS in freshwater systems in Southeast Asia, as well as the development and adoption of best management practices for minimizing the impact of IAS.

In the succeeding pages, the three linkages between development assistance projects and IAS are presented, followed by recommendations for how USAID can address the threats of IAS. The appendixes are designed to serve as a reference of IAS in Southeast Asia. Included in the appendixes are country briefers of each focus country, relevant legal instruments, a detailed description of three USAID sponsored development projects, and a case study of tilapia (*Oreochromis niloticus*).

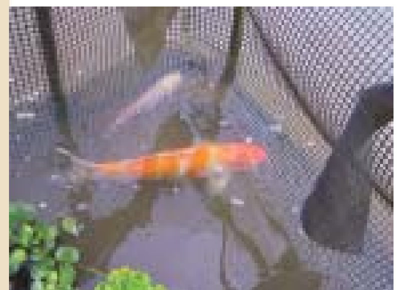
EXECUTIVE SUMMARY

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 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 socioeconomic 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.

USAID External Action

Policy

- Coordinate between USAID and other development agencies on projects and funding activities relevant to the prevention, management, control and eradication of IAS.
- Promote acknowledgement and enforcement of existing instruments governing sustainable management of fisheries, including protection of biodiversity (see Appendix E).
- 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 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.
- 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).

INTRODUCTION

Invasive alien species (IAS) are alien (non-native) species whose introduction and/or spread threaten biological diversity. The generalist, aggressive characteristics of IAS (Table 1) make them among the top drivers of environmental change globally, and threaten food security, human health, and economic development (Sala et al. 2000). The rate of introduction and diversity of IAS has rapidly increased in recent decades as a result of the globalization of trade and travel. Due to limits on financial, technological, and informational resources, developing countries are often least able to address the threats posed by IAS to agriculture and natural systems. This can and does create barriers to sustainable development.

The pathways by which IAS are introduced to aquatic systems are diverse and follow the patterns and trends of natural resource policy, trade, travel, and transport. In freshwater systems, intentional introductions of potential IAS can result from stocking of fish, releases of live bait, pets, plants and animals from aquaria and garden ponds, research subjects, biological control agents, food fish, and releases from aquaculture facilities (ANSTF 2003, Fuller et al. 1999, Lodge et al. 2000). IAS can be unintentionally introduced into freshwater systems by boats (e.g., hull fouling and ballast water) and recreational equipment (e.g., boats, fishing gear, etc) that are contaminated with alien organisms from other water bodies. Unintentional introductions can also occur when alien species escape from captivity and take up residence in the natural environment (ANSTF 2003, Fuller et al. 1999). Under some circumstances, the opening of sluice gates and/or removal of dams might also release IAS formerly held in reservoirs into the associated watershed (Graf 2003). Both intentionally and unintentionally

Table 1: Characteristics of Invasive Alien Species

Successful Species	Unsuccessful Species
a.) Large native range	a.) Small native range
b.) Abundant in original range	b.) Rare in original variability
c.) High genetic variability	c.) Low genetic variability
d.) Associated with humans	d.) Not associated with humans
e.) Female able to colonize alone	e.) Female alone unable to colonize
f.) Gregarious	f.) Solitary
g.) Vagile (able to move freely)	g.) Sedentary
h.) Broad diet	h.) Restricted diet
i.) Short generation time	
j.) Shift between r and k strategies	
k.) Larger than most relatives	

Source: (Ehrlich 1989)

introduced species can carry alien pathogens or parasites.

In recent years, there has been increasing evidence (Joffe and Cooke 1997) that development assistance projects have been a pathway for IAS introductions. Examples include the unintentional introduction of cassava mealybug (*Phenacoccus manihoti*) and banana nematode (*Pratylenchus musicola*) into Africa. International famine relief and military assistance programs have been associated with the unintentional introduction of the larger grain borer (*Prostephanus truncatus*) and parthenium weed (*Parthenium hysterophorum*) into Africa and recently the corn rootworm (*Diabrotica virgifera*) into Eastern Europe (Waage 2002). Water hyacinth (*Eichhornia crassipes*) projects provide the most well-documented case studies of the intentional introduction of an IAS[1] through development assistance activities. Introduced to African lakes as a potentially inexpensive source of biomass production, the plant quickly became invasive. It spread rapidly, clogging water bodies, limiting boat navigation, and reducing food security as fish died from oxygen depletion. It also devastated hydroelectric plants by clogging intake pipes and/or turbines (Joffe and Cooke 1997). As a result, an important economic development resource, electricity, became more costly. USAID, and other agencies, have thus spent millions of dollars to remove water hyacinth from Lake Victoria in order to restore the ecological health of the lake and economic integrity of local communities (USAID 2000).

Canal in Thailand covered with water hyacinth, detail of flower. (A.Gutiérrez)

Although IAS threaten all facets of biodiversity, evidence suggests that freshwater systems are especially susceptible and sensitive to their impacts. Human activities to increase economic productivity and well-being have contributed to the introduction of IAS into freshwater ecosystems and the vulnerability of these systems to IAS (Dalmazzone 2000). The movement of IAS is consistent with human activity patterns; in areas where there is little human disturbance there is low prevalence of IAS, and conversely in areas where human disturbance, IAS prevalence is higher (Sala et al. 2000). As a result of these changes global freshwater biodiversity is declining at far greater rates than is true for even the most affected terrestrial ecosystem (Ricciardi and Rasmussen 1999). Twenty percent of the 10,000 freshwater fish species have become extinct or are threatened, and IAS are one of principal causes. Forty-one percent of the world's human population lives in river basins that are under water stress (CBD 2002b), therefore when IAS impact ecological services essential for human livelihoods they impede development.

There are nineteen million hectares of freshwater lakes, reservoirs, rivers, and swamps in the Association of Southeast Asian Nations (ASEAN) region (Baluyut 1983). Thus watersheds and the ecosystem services they provide are an integral component of regional development. However, these freshwater systems are highly stressed and water quality in the region is declining rapidly. Current biological oxygen demand (BOD) is 1.4 times higher in Asian rivers than the world average (UNEP 2000). Asian rivers[2] also carry three times as much bacteria from human waste than the world average and more than ten times that of the Organization for Economic Development and Cooperation (OECD)[3] countries (ADB 1997). Surface waters in Asia carry twenty times more lead than surface waters in OECD countries, largely due to industrial effluents (ADB 1997). Asian reservoirs and lakes have more eutrophication problems than Europe, Africa, North America, or South America (UNEP 2000). Poor water quality leads to a reduction in the availability of oxygen for aquatic plants and animals. This loss of oxygen often stresses native species, but can favor IAS, which are typically generalists and can survive in a wider range of conditions (see Table 1).

[1] USAID was not the development agency that introduced water hyacinth into Lake Victoria.

[2] The Asian Development Bank defines Asian rivers as those rivers belonging to their developing member countries. It should be noted that according to Asian Environmental Outlook 2001 access to drinking water is worst in South and Southeast Asia. Approximately one and two people have no access to sanitation services and only 10% of the sewage is treated at the primary level ADB. 2001. Asian Environment Outlook. Asian Development Bank, Manila, Philippines.

[3] Organization for Economic Development and Cooperation

Efforts to develop hydrological resources for economic development (e.g., hydropower) have reduced water levels and depleted wetlands. Asian reservoirs are usually constructed to be multipurpose water bodies that will serve the fishing industry, agriculture community, local water users and power generation (Amarasinghe et al. 2001). The conversion of flowing rivers to reservoirs has changed the species assemblages in many rivers since reservoirs favor lacustrine species, not riverine. Typically, to maintain or expand fisheries, reservoirs are stocked with lacustrine species, which are often alien species (e.g., carps and tilapias) and potentially invasive.

Aquaculture of alien species, a common activity in reservoirs, has contributed to local economies and food security. However, poorly managed cage and pen aquaculture production can have negative consequences on human livelihoods, since organic loading from added feed and fish excretion reduces water quality (Starling et al. 2002, Santiago 1994). Given that fish often escape from their cages and pens, aquaculture can increase the region's risks of adverse impacts from an alien species (Courtenay and Williams 1992). Furthermore, cages and pens can occupy vast areas of the water body and thus interfere with natural movements and reproduction of the native fish species (Delos Reyes 1993, Pullin et al. 1993).

Until recently, aquaculture has depended on a handful of species throughout the world (Welcomme 1984). Several development assistance projects have been instrumental in bringing alien species into countries where they had not been previously found[4] . The results of these introductions have not always been beneficial; projects that sought to improve the livelihoods of local communities may have actually resulted in long term costs that exceeded the short term benefits derived from increases in fisheries production (Msiska et al. 1991). If development projects are to provide long-term benefits to local communities, project managers must evaluate the potential effects of IAS on their projects and natural systems.

[4] According to the Management Entity, PD/A CRSP does not introduce alien species into areas where they have not already been introduced.

Some development agencies have begun to recognize the links between development projects and IAS. For example, USAID has sponsored this assessment to better understand the linkage between development projects and IAS in the freshwater systems of Southeast Asia; the Swedish International Development Cooperation Agency has sponsored a study on the role of alien species in aquaculture in the Mekong.

Tilapia aquaculture pond in Philippines (A. Gutiérrez), tilapia specimen. (Norainy Mohd Husin).

FINDINGS

This assessment focused on three areas – (1) development assistance as a pathway of introduction, (2) development assistance projects adversely impacted by IAS, and (3) development assistance projects working to address IAS. Questions addressed in the assessment include:

- **Development Assistance as a Pathway of Introduction**
  - Is there evidence of projects introducing IAS?
  - Were IAS considered in project development?
  - Was monitoring conducted after the implementation of the project, and, if so what were the findings?

- **Development Assistance Projects Impacted by IAS**
  - Are there examples of IAS effecting development projects?
  - Did development projects adapt to address IAS?

- **Development Assistance Projects Working to Address IAS**
  - Are development projects eradicating/controlling IAS?
  - Are development projects educating staff and cooperating institutions about IAS?
  - Are development groups collaborating on IAS?

Each of the following sections contain a list of the technical experts interviewed, the results of the interviews and literature/database searches, and a discussion of the results. Due to the paucity of available information, the findings of the assessment are qualitative rather than quantitative. This is largely the result of a lack of prior project assessment and follow-up monitoring, as well as inconsistent reporting. The appendixes provide further detail on relevant topics and are referenced accordingly. They are meant to support the report, as well as to serve as a resource guide to IAS in Southeast Asia freshwater systems.

Development Assistance as a Pathway of Introduction

Development agencies have facilitated the introduction of IAS into Southeast Asia's freshwater systems through a number of pathways. Aquaculture, which often follows dam building, has caused the most significant problems (see Table 2 and Appendix F). The practice of aquaculture is formally defined as the cultivation of aquatic organisms in freshwater, estuarine, or marine waters, and includes fish, mollusks, crustaceans, and aquatic plants (Patrick 1999). From a market perspective, aquaculture can be more advantageous than capture fisheries because it more readily ensures the uniformity of product size or age, less stressed products, and reduces the physical damage to fish (Reilly and Kaferstein 1999). Moreover, when production volume is considered, aquaculture has a more efficient feed conversion rate in comparison to the propagation of terrestrial animals (Hatch and Tai 1997). From the development perspective, aquaculture can increase protein production, provide micronutrients to local communities (especially for women and children), serve as a source of supplemental income to rural farmers and communities, and allows for alternative uses of water resources (Egna 2004). The following section provides an overview of the history of aquaculture in Southeast Asia, the role of development agencies in its growth, and a summary of current projects supported by USAID.

Table 2: Objectives of Fisheries Development

- **The increase of fish production to obtain a cheap source of protein**
- **The gain of foreign exchange through the export of high-value species of fish and fishery products.**
- **The improvement of socio-economic conditions of small-scale fishermen.**
- **The increase of livelihood and employment opportunities for rural populations.**

Source: Baluyut 1989

Aquaculture in Southeast Asia

In the Philippines, freshwater and diadromous fish comprise nearly 14% of the total food supply (FAO and MFA 2003). Similarly, in the Mekong River basin, fish is the greatest source of protein for most of the area's 60 million people. In recent years, regional fisheries have been declining as a result of deforestation, alterations along the riverbanks, dam construction on the upper part of the river, over fishing, and the use of modern fishing equipment (Bangkok Post 2003). As freshwater capture fisheries decline, aquaculture has been increasingly promoted as the way to meet the gap between supply and demand (Dey 1998, Williams 1998).

Aquaculture is not a new activity in Asia; the Chinese have been practicing aquaculture as part of their traditional rural-agrarian economy for

4,000 years (Baluyut 1989). The Philippines and Japan began practicing aquaculture 300 to 400 years ago. However, today, in order to serve domestic as well foreign demands, aquaculture operates on a much larger and more intensive scale than traditionally practiced.

The development sector has frequently promoted aquaculture as the "blue revolution," believing that the improvement of fisheries culture practices will provide an ample supply of protein to millions of people, cheaply. From 1986-1996 global aquaculture production more than doubled in weight and value, and it now provides over a quarter of all fish consumed by humans (New 1997). In 2001, global inland aquaculture production totaled 22.4 million tons as compared to 8.8 million tones of inland capture fisheries (FAO 2002). In 2001, Southeast Asian freshwater aquaculture produced 1,407,887 million tons of fish. The growth of aquaculture has been particularly extraordinary in developing countries; in 1973, 58% of all aquaculture production occurred in developing countries, and by 1997, the percentage had increased to 89% (Delgado et al. 2003).

The pervasive mentality in the aquaculture community has been, and still is to a certain extent, that fish stocking (Table 3) is the most productive fishery management tool (Jenkins 1961). This belief has resulted in a lack of research on alternative methods to alien stocking and aquaculture and, until recently, a failure to recognize the significant risks posed by IAS (Kottelat and Whitten 1996). Therefore, a few herbivore and detritivore species (e.g. carps and tilapias) have been the basis for much of the growth of aquaculture. These species have been transferred around the world, often into habitat were they had never been before and they would never be if not for anthropogenic introduction. Numerous species that were imported for aquaculture have escaped from their ponds to become established in the wild (Welcomme 1984). Moreover, there has been a tendency to "suppress interest in local species of possibly equal or greater value (Welcomme 1984)," since foreign scientists have been more likely to promote those species they understood well, rather than trying to domesticate lesser studied species (Msiska et al. 1991). This resulted in the introduction of potentially IAS.

Table 3: Reasons to Stock in Lakes and Reservoirs

- **Colonize "empty, vacant or new ecological niches" in the system**
- **Provide species that are more desirable in the fishery**
- **Provide more fish for food and game**
- **Introduce hardy species that can cope with adverse conditions, e.g., drawdown or turbid water conditions**
- **Control aquatic weeds**
- **Restore balance of fish populations (Bhukaswan 1980)**

While aquaculture can provide a significant source of protein and revenue, the practice poses risks to native species, and the communities that depend on them, through competition with native species, predation, hybridization, and disease transmission, as well as nutrient enrichment. Aquaculture can be carried out in fishponds, fish cages and pens in lakes and reservoirs, paddy fields and can be monoculture or polyculture, as well as integrated with animal husbandry and crop farming (see Appendix G). In order to accomplish this production, the ecosystem in which aquaculture is conducted often is altered, either through construction of earthen ponds, damming of small rivers or addition of new inputs to the system (Baluyut 1983). For instance, with pond aquaculture earthen ponds are dug into fields. Once the ponds are constructed it is almost impossible to reclaim the land for other purposes due to the costs of dam removal, leeves and drainage structures. According to the 2001 Blue Millennium report, aquaculture in inland waters presents the greatest threat to biodiversity (IDRC et al. 2001). The majority of donor funding has gone to aquaculture projects instead of to restoring or maintaining capture fisheries (Baird 2001). In some communities, traditional capture fisheries are more commonly practiced then aquaculture (Baird 2001). This can lead to the dependency on introduced species, both native and non-native, both posing challenges to genetic and species diversity.

Other development activities, dam building for example, can facilitate the growth of aquaculture. According to the International Rivers Network, over the past ten years, construction of more than 100 large dams has been proposed in Southeast Asia (IRN 2003). Dams change the natural flow of rivers, which often leads to the destruction of fisheries habitats. When a dam is built on a river, an artificial lake (reservoir) is created, and habitats are created that support still-water (lenthic) organisms, rather than species frequenting flowing (lotic) water. For example, dam-induced changes in water flow, barriers to downstream spawning and feeding, and increases in sedimentation are known to favor lacustrine (still-water) species instead of riverine species of fish (Bhukaswan 1980). Reservoirs are thus stocked with lacustrine fish, often alien, to sustain or build a fishery (Usher 1997, Bhukaswan 1980). Some of these alien species are, or become invasive.

Kottelat and Whitten (1996) contend that introductions in South-east Asia have been conducted haphazardly in an effort to strengthen depleted wild populations or to improve the genetic quality of a population.

Many aquaculturists acknowledge that fish do escape and that they are nearly impossible to contain indefinitely. Fish are introduced into natural systems deliberately as a natural resource and as forage, and can escape ponds and cage or can be accidentally released during transport and handling. Kottelat and Whitten (1996) contend that introductions in Southeast Asia have been conducted haphazardly in an effort to strengthen depleted wild populations or to improve the genetic quality of a population.

While some fisheries personnel feel that the introduction of alien species increases freshwater diversity and thus "improves" it (Baluyut 1983, Kottelat and Whitten 1996), the majority of ecologists see introduced species as a threat, rather than a benefit, to ecosystem integrity (Sala et al. 2000). Given that food security priorities frequently take precedence of environmental issues, the current and potential impacts of alien species are typically either overlooked or ignored. FAO 236 (1983) reflects belief that has been held by many in the aquaculture community.

"However, notwithstanding the risks associated with the stocking of exotics in lakes and reservoirs, the fact remains that it has been the only successful means of maximizing fish production in reservoirs in the Southeast Asia (Baluyut 1983)."

Clearly, while aquaculture has the potential to provide low-cost protein to those who need it most, it is not without its cost. There is increasing evidence that aquaculture has contributed to the nutrient loading of water bodies and the introduction of IAS (McCrary et al. 2001, Santiago 1994). The introduction of alien species may lead to rapid increases in fish yields, but it may also cause consumer preferred native species to go to the point of extinction (Bailey 1980, Fernando 1976). In order to maximize the full potential of aquaculture, we must address the externalities that arise from the utilization of potentially invasive species. Furthermore, fisheries managers need to determine whether the benefits of alien species introduction are actually greater than the costs. If direct and indirect costs are taken into consideration, it is quite plausible that very few introductions of alien species actually resulted in increased fisheries productivity. Furthermore, in many instances, rehabilitations of the existing fishery might have been at least as cost-effective and had fewer deleterious effects (Eccles 1985).

Role of Institutions

Government Policies

Government policies are often one of the leading reasons why alien fish are introduced. As summarized in the table 3, aquaculture can be a means for producing cheap protein sources, as well as generating foreign exchange and improving livelihoods. Since fisheries policy has often sought to improve production, the environmental impacts of aquaculture, until recently, have not been taken into consideration.

According to the Food and Agriculture Organization's (FAO) 2002 report on the State of World Fisheries and Aquaculture, inland waters often are ineffectively governed (FAO 2002). Inland fisheries frequently are only subject to national jurisdictions. This can create problems since fisheries introductions, whether through stocking or cage culture, into watersheds are not guaranteed to stay in one part of the watershed. Neighboring countries ought to be consulted prior to the introduction of an alien species. Furthermore, the Asian Development Bank (ADB) reports that the current management practices in Asia are not precautionary, and that they react to existing problems instead of anticipating and preventing further problems from arising (ADB September 1997). Frequently, regional fishery bodies are not present, and if they are present they are advisory with no management powers.The problem is further complicated, since in many Asian countries both the Ministry of Conservation and the Ministry of Fisheries have responsibility for managing freshwater systems, however they are often working at cross purposes, one protecting the ecosystem and the other increasing yields (Kottelat and Whitten 1996). This can result in unsustainable management of freshwater aquaculture.

Common carp in pond, detail of specimen. (Norainy Mohd Husin).

Role of Development Agencies

International development agencies have sponsored aquaculture research and outreach programs in an effort to alleviate poverty, improve employment, and increase nutrition. In many ways, development agencies have fostered demand by regional governments for aquaculture expansion and intensification in Southeast Asia. The Asia Development Bank (ADB), for instance, supports the genetic improvement and dissemination of strains of species that have the potential for mass production (e.g., tilapia)[1]. At an August 2003 meeting, the Food and Agriculture Organization (FAO) stated that aquaculture is the way to meet the gap between the growing demand for fish and decreasing supply of wild stocks. In addition, FAO representatives stated that the "potential contribution of aquaculture to rural development, food security, hunger eradication, poverty reduction and national economic development is enormous (AP 2003)." Whitten and Kottelat (1996) point out that the development agencies commonly promoting aquaculture have a limited vision; they addresses the loss of protein quantity, rather than loss of biodiversity, which can provide a locally renewable, diverse source of protein. Ironically, in many cases, aquaculture actually exacerbates biodiversity losses. Furthermore, the authors conclude that projects on freshwater genetic biodiversity in Asia tend to focus on alien fishes (e.g., carps and tilapias) despite evidence and suspicion that they are damaging to native faunas.

[1] ADB's fisheries policy highlights that they will only support alien species introductions if they comply with biosafety guidelines ADB. September 1997. Policy on Fisheries. Asian Development Bank.

While this one-sided development approach has been and continues to be the norm, an increasing number of development agencies are beginning to evaluate the use of potentially invasive alien species and some are actively looking for alternatives. For example, the Swedish International Development Cooperation Agency (SIDA) recently commissioned a report to examine the pros and cons of alien species in aquaculture. USAID sponsors the Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP) and the Mekong River Commission (MRC), both of which have projects exploring indigenous aquaculture. Nevertheless, uncertainty and risk remain features of alien species aquaculture in Southeast Asia. Furthermore, as culture improvement programs for alien species grow in popularity, so will the uncertainty and risk of biological invasion.

The following section provides summaries of the freshwater aquaculture activities in being conducted in Southeast Asia by three development groups supported by USAID – PD/A CRSP, the WorldFish Center, and the MRC.

Pond Dynamics/Aquaculture Collaborative Research Support Program

Since 1982, USAID has sponsored the Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP) in an effort to "identify constraints to aquaculture production, and to design responses that are environmentally and culturally appropriate (CRSP 2002a)." U.S. scientists collaborate with scientists in Bangladesh, Brazil, Cambodia, Laos, Honduras, Indonesia, Kenya, México, Nepal, Panama, Peru, Philippines, Thailand, and Vietnam to improve production efficiency, research the use of new species for aquaculture, and strengthen the capacity of National Agricultural Research Systems (CRSP 2002b). The ultimate goals of PD/A CRSP are to raise small farmers' incomes and increase consumers' welfare by enhancing fish farm productivity, and to improve the well-being of the rural poor, while conserving or enhancing the natural resource base (CRSP 2002b). PD/A CRSP researchers have used both native and alien species in their research.

Six countries in this assessment are served by PD/A CRSP – Cambodia, Laos, Thailand, Indonesia, Philippines and Vietnam. Several alien species have been cultured in these countries, including tilapia (*Oreochromis niloticus*) and Pangasius catfish (*Pangasius pangasius*). PD/A CRSP researchers seek to improve aquaculture production by developing new feeding regimes and uses for wastes, as well as working with host-country institutions to implement best management practices. The majority of PD/A CRSP researchers conduct their research in closed ponds, although some programs do rely on pens in rivers or open ponds (Clair 2003, Gutierrez 2003). According to the PD/A CRSP Management Entity, in the last six to eight years the agency has gradually increased promotion of indigenous aquaculture and lessened its reliance on commonly used alien species (e.g., carps and tilapias). In the last two years, for instance, PD/A CRSP has investigated the possibility of three times as many native species for aquaculture than during their previous work plans.

Several of PD/A CRSP's projects in Southeast Asia have focused on improving the production efficiency or reducing environmental effluents of alien tilapia *(Oreochromis niloticus)*, a species which has been invasive in some ecosystems (Stockstad 2003, McCrary et al. 2001, McKaye and Ryan 1995, Msiska et al. 1991). The PD/A CRSP Management Entity contends that PD/A CRSP scientists have not been responsible for the introduction of new species, but have rather worked to improve production efficiency of already introduced species (e.g., tilapia). Regardless of who originally introduced the species, the potential risks to and impacts on native biodiversity remain. For instance, there is controversy over the invasiveness of tilapia (see Appendix G). In some parts of the world it has clearly out competed native species. Unfortunately, the lack of long-term monitoring of tilapia and other alien species in Southeast Asia's water bodies makes it difficult, if not impossible, to adequately assess the linkages between alien species introductions and biodiversity loss.

Resource managers and researchers in the region should recognize that the paucity of data on the impacts of alien species is not an indication that tilapia and other introduced species are harmless. Instead, they need to acknowledge that a significant research gap exists and seek to address it. Thorough long-term studies need to be undertaken to determine the benefits and costs of tilapia and other introduced species in Southeast Asia. Neither PD/A CRSP, nor any of the other efforts that were surveyed, have attempted to undertake such research.

DEVELOPMENT PROJECT: USAID Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP) (from CRSP 2002b)
SPONSORED BY: USAID
COUNTRIES: Cambodia, Laos, Thailand, Indonesia, Philippines, and Vietnam

CURRENT PROJECTS:

- Co-culture of Lotus and Hybrid Catfish to Recycle Wastes from Intensive Feeding
- Reproductive Performance and Growth of Improved Tilapia (*Oreochromis niloticus*)
- New Paradigm in Farming of Freshwater Prawn (*Macrobrachium rosenbergii*) with Closed and Recycle Systems
- Integrated Cage-Cum Pond Culture Systems with High-Valued Fish Species in Cages and Low-Valued Species in Open Ponds
- Mitigating Environmental Impact of Cage Culture through Integrated Cage-Cum-Cove Culture System in Tri An Reservoir of Vietnam
- Optimization of Nitrogen Fertilization Regime in Fertilized Nile Tilapia Ponds With Supplemental Feed
- Controlled Reproduction of an Important Indigenous Species (*Spinibarbus denticulatus*) in Southeast Asia
- Mitigating the Effect of High Temperature and Turbidity on Seed Production of Nile Tilapia from Hapa-in-Pond Systems
- Evaluation of Tilapia Aquaculture Best Practices in Central Luzon, the Philippines
- Insulin-like Growth Factor-I as a Growth Indicator in Tilapia
- Further Studies on Soil Quality in Aquaculture Ponds in Thailand

INTERVIEWED:

Dr. Remedios Bolivar, Central Luzon State University, PD/A CRSP Principal Investigator
Ms. Danielle Z. Clair, Assistant Director of Operations, PD/A CRSP
Dr. Hillary Egna, Director, PD/A CRSP
Dr. Chris Kohler, Southern Illinois University, PD/A CRSP Principal Investigator
Dr. Susan Kohler, Southern Illinois University, PD/A CRSP Principal Investigator
Dr. Yang Yi, Asian Institute of Technology, PD/A CRSP Principal Investigator

Mekong River Commission

The Mekong River Commision (MRC)'s mandate is to develop the resources of the Mekong River while ensuring their conservation. The Mekong has a rich capture fishery and, as such, the MRC views IAS as threat to biodiversity as well as fisheries production. In response to the demand from the lower Mekong countries (Cambodia, Laos, Thailand, and Vietnam) for the development of aquaculture in the basin, the MRC developed the Aquaculture of Indigenous Mekong Species (AIMS) program. (See Table 3 and Appendix F). The MRC approaches aquaculture as a complement to capture fisheries, not a substitute.

DEVELOPMENT PROJECT: Mekong River Commission Fisheries Program (from Matson et al. 2003)

SPONSORED BY: USAID sponsors the MRC not only the Fisheries Program
COUNTRIES: Cambodia, Laos, Thailand, and Vietnam

CURRENT PROJECTS:

- Aquaculture of Indigenous Mekong fish species
  - In an effort to meet the needs of its four member countries' and reduce the risks of aquaculture with alien species, the MRC has established a program to research and develop indigenous species for aquaculture. The MRC has found that indigenous fish have a high market demand and value (see Appendix F).

INTERVIEWED:

Dr. Chris Barlow, Fisheries Programme Manager, Mekong River Commission
Dr. Niklas Matson, Aquaculture of Indigenous Mekong Fish Species, Mekong River Commission

WorldFish Center

The WorldFish Center (formerly known as the International Center for Aquatic Living Resources Management (ICLARM)) works throughout the world to improve aquaculture production efficiency and food security, in an effort to reduce poverty (See Table 3). WorldFish Center staff recognizes that while alien species are important to the future development of aquaculture, they should be used only after proper risk assessments have been conducted. One of WorldFish Center's most prominent projects in Southeast Asia has been the development of the Genetically Improved Farmed Tilapia (GIFT). The project has drastically improved the production efficiency of tilapia through selective breeding (see Appendix G), but not a single study has been conducted to determine the potential impacts of these improved fish on the environment.

In addition to improving aquaculture production, the WorldFish Center develops fisheries management tools such as the fisheries database known as FISHBASE. FISHBASE provides fisheries officers access to information on life history, range, resilience, red list or pest status, and bibliographical references. The data enables resource managers and researchers to more effectively evaluate the risks and impacts of alien fish species. As a further effort to minimize the effects of alien species on biodiversity, the WorldFish Center has collaborated with other organizations to establish best practices for the use of alien species (e.g., see the Nairobi Declaration in Appendix E).

DEVELOPMENT PROJECT: WorldFish Center (from WorldFIsh 2003c)

SPONSORED BY: USAID
COUNTRIES: Cambodia, Laos, Thailand, Indonesia, Malaysia, Philippines, Singapore, Thailand, and Viet-

CURRENT PROJECTS:

- Floodplains Initiatives – (Seeks to develop methods for the management and conservation of tropical river fisheries, specific to the Mekong basin.)
- Institutional Capacity Building of the Inland Fisheries Research and Development Institute in Cambodia – Biological Aspects
- Maximizing the Contribution of Aquaculture and Ornamental Alien Species Towards Poverty Alleviation and Mitigating Negative Impacts on Biodiversity (Philippines, Malaysia)
- Transfer of Selective Breeding (GIFT) Technology for Aquaculture Improvement from the Philippines to Sub-Saharan Africa and Egypt
- Genetic Enhancement of Nile Tilapia and Utilization of F_1 Crossbred Clones as Control Populations Genetic Improvement of Tilapia
- Selection of Tilapia in Low Input Farming Systems
- Determination of High-Potential Aquaculture Development Areas and Impact in Africa and Asia
- Development of Sustainable Aquaculture Project (DSAP) (Identify factors responsible for successful development of rural aquaculture.)
- Community Assessment, Management and Monitoring of Local Aquatic Resources System for Improved Food Security in the Mekong Basin
- Strategies and Options for Increasing and Sustaining Fisheries and Aquaculture Production to Benefit Poor Households in Asia
- Impact of Production and Marketing of Freshwater Aquatic Products on Rural Livelihoods
- Legal and Institutional Frameworks and Economic Valuation of Resources and Environment in the Mekong River Region – A Wetlands Approach
- Community-Based Fisheries Management Program in South and Southeast Asia
- Understanding Livelihoods Dependent on Inland Fisheries in Bangladesh and Southeast Asia
- Fish Fights Over Fish Rights – Managing Exit from the Fisheries and Security Implications for Southeast Asia Capacity Building of the Inland Fisheries Research and Development in Cambodia

INTERVIEWED:

Ms. Christine Marie V. Casal, FishBase Project, WorldFish Center
Dr. Madan Mohan Dey, Senior Scientist, Agricultural/Resource Economist, Policy Research and Impact Assessment Program, WorldFish Center
Dr. Modadugu V. Gupta, Assistant Director General (International Relations), Research Coordinator INGA, WorldFish Center
Dr. Alphis Ponniah, Program Leader, Biodiversity and Genetic Resources Research Program, WorldFish Center
Dr. Mark Prein, Senior Scientist/Program Leader, Freshwater Resources Research Program, WorldFish Center
Dr. Roger S.V. Pullin, Ecotrack

Development Assistance Projects Adversely Impacted by IAS

Once IAS become established, they can reduce the effectiveness of development projects by increasing the costs and undermining the intended socio-economic benefits. Golden apple snail (*Pomacea canaliculata*) (GAS; see case study), a well-established IAS in Southeast Asia is one of the best-documented examples of this phenomenon. GAS poses a significant threat to agriculture and biodiversity, as well as water and food security projects. Since 1970, USAID has provided funding to the International Rice Research Institute (IRRI) in an effort to support research that will help increase food security worldwide (Moore 2003a). GAS undercuts these efforts by devastating rice production.

Several plant and fish species (see Table 4) are also known or suspected to reduce the effectiveness of development assistance projects. However, due to a paucity of adequate data, the extent of the problem is not clear. Development projects typically fail to monitor and thus evaluate the impacts of IAS on their projects. Thus, for this assessment, the authors had to heavily rely on interviews with researchers and development agency field staff to obtain reliable information.

Table 4: Examples of IAS that are Known or Suspected to Impact Development Assistance

Type of Project	Examples of Species Adversely Impacting Development Assistance
All Projects	Parasites and pathogens that move unintentionally
Irrigation and Drainage	Aquatic weeds (e.g., *Eichhornia crassipes*, Salvinia molesta, *Mimosa pigra, Pistia stratiotes.*)
Hydroelectric	Aquatic weeds (e.g., *Eichhornia crassipes*, Salvinia molesta, *Mimosa pigra, Pistia stratiotes.*)
Food Security	Specially in rice: Golden apple snail (*Pomacea canaliculata*), Rats (*Rattus spp*.); invasive fish (e.g., *Oreochromis niloticus, Cyrpinus carpio*)
River Basin Management	Invasive fish (e.g., *Oreochromis niloticus, Cyrpinus carpio*); aquatic weeds (e.g., *Eichhornia crassipes*, Salvinia molesta, *Mimosa pigra, Pistia stratiotes*)
Water-based tourism	Aquatic weeds (e.g., *Eichhornia crassipes*, Salvinia molesta, *Mimosa pigra, Pistia stratiotes*)
Watershed Development	Aquatic weeds (e.g., *Eichhornia crassipes*, Salvinia molesta, *Mimosa pigra, Pistia stratiotes*)

CASE STUDY:

Golden Apple Snail

(Pomacea canaliculata Lamarck, 1822)

In 1980, the Argentine golden apple snail (*Pomacea canaliculata*) was intentionally introduced into Asia 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.

Rice paddy attacked by GAS, rice stalks with eggs, eggs on water hyacinth, GAS shell. (A.Gutiérrez).

Biological Characteristics of GAS

In South America, where the species is native, GAS inhabits coastal swamps. In Asia, the species is most abundant in flood-prone areas and regions with poor water control, and persistently reappears in high productivity irrigated areas where dispersal through canals is easy. In its native Argentina, which is temperate and experiences seasonal weather, GAS take two years to reach reproductive maturity, while in tropical Southeast Asia GAS can reach reproductive maturity in two month (Lach et al. 2001), and attain high population densities (Cowie 2002) in the absence of natural predators (Halwart 1994). GAS tend to leave the water early in the morning and evening to lay bright pink batches of 25-500 eggs on rice tillers, sedges, rice field dikes, or any other firm, nearby object. After one to two weeks of deposition, egg masses gradually lighten in color prior to hatching. The new snails drop into the water and start feeding on algae and detrital matter (Halwart 1994).

Experimental studies have shown that 1 snail/m^2 of rice paddy can reduce the crop stand by approximately 20%, and 8 snails/m^2 can be reduce rice production by more than 90% (Basilio 1991, Hirai 1988). However, rice seedlings are only vulnerable to GAS within the first three weeks of planting, when the stocks are still tender. Without water GAS becomes inactive, but they are able to burrow into the mud and hibernate for several months, re-emerging when water is again available (Halwart 1994).

GAS in Asia

Importers and local governments believed that GAS could provide the basis for a highly successful social development program in Asia because they are easy and inexpensive to cultivate. The species was initially smuggled into Taiwan (1979-1980) and then imported into Japan (1981) and the Philippines (1982) through Department of Agriculture (Naylor 1996). However, importers and agency staff failed to adequately assess the risks of GAS introduction (Acosta and Pullin 1989). Consumers in Southeast Asia found GAS unpalatable and, since snails are known to be or host disease vectors, its importation was prohibited (Naylor 1996).

Once established, GAS can spread rapidly. In Taiwan, for instance, 2% of the total rice area had GAS in 1982, but 28% had become infested by 1986 (Cheng 1989, Mochida 1988). GAS and their eggs can move and be transported easily from one water body to another by humans, wildlife, irrigation, and flooding (Lach and Cowie 1999). GAS quickly spread throughout the Philippines and other countries in the region. Some countries (e.g., Malaysia and Vietnam) issued quarantine acts or banned cultivation in an attempt to prevent introduction of the species. However, the country-specific actions failed to prevent the species' spread and impacts throughout the region. GAS reached China, South Korea, Thailand, Indonesia, and Vietnam by the late 1980s. It is alleged to have entered Malaysia in the 1980s in produce from Thailand (Jambrai 2003). Laos and Papua New Guinea were affected in the early 1990s.

Costs

Planting practices in Southeast Asia's rice industry are transitioning from traditional planting to direct seeding in an effort to cut costs. The perceived savings, however, may be undercut by losses incurred when GAS consume the tender seedlings. Where GAS infestations are significant, replanting can cost at least twice the direct seeding "savings" per hectare (Warburton and Pingali 1993a, Warburton and Pingali 1993b). In the early 1990s, replanting costs were approximately $32 U.S. per hectare in well controlled GAS areas, but over $114 U.S. per hectare in poorly controlled GAS regions for double crop years (Warburton and Pingali 1993b). Naylor (1996) calculated that the aggregate cost for replanting in the Philippines would range from between US$2.8-10.3 million. Therefore, the total cost of GAS to the Philippines in 1990, including replanting and lost yield, was between US$28 and $45 million. This equates to 25-40% of the value of rice imports for the Philippines in 1990 (FAO 1992).

GAS infestation has contributed to a rise in non-market costs by adversely effecting biodiversity, human health, and food security. The snails eat native plants, as well as rice posing a threat to natural aquatic ecosystems. Filipino farmers believe that the native, palatable snail (*Pila luzonica*) has dwindled as a result of GAS infestations (Halwart 1994). It is not clear whether this is a result of inter-species competition, a rise in pesticide use, or both. Many of the pesticides used to control GAS are species-specific and, therefore, often kill non-target species (Naylor 1996). No research has been conducted to determine the impacts of GAS on native biodiversity.

GAS also poses threats to human health. The snails are known to serve as the intermediate hosts to the rat lungworm (*Angiostrongylus cantonensis*), a parasite which can cause eosinophilic meningoencephalitis, and thus paralysis and death, in humans (Chao 1987, Kliks 1992, Mochida 1988, Singh 1988). GAS can also play host to various trematodes that cause skin irritations (Keawjam et al. 1993).

Managing GAS also poses health risks. Farmers have suffered peeling toes, fingernails, headaches, skin disorders, and blindness, as a result of pesticides used to kill GAS (Halwart 1994). GAS can burrow into the soil and avoid the pesticides, or simply crawl out of the treated water (Van Dinther and Stubbs

1963). Snail populations have been found to recover quickly from pesticide treatments (Halwart 1994).

The loss of food security is one of the most important non-market costs that have occurred. Rice is a staple crop in Southeast Asia. GAS not only reduces the efficiency of rice production, and thus total yield. The decline in yields reduces the region's food security.

Benefits

GAS's high rates of reproduction and low input costs can produce substantial financial returns if there is a market for GAS (Naylor 1996). However, most communities prefer their native snail to GAS because the flesh is softer, and it is unlikely that GAS will gain popularity as human food or export in the future (Halwart 1994). Furthermore, its reputation as a pest is likely to make it even more unattractive to consumers.

Several countries, have developed alternative uses for GAS in effort to control the population. In Thailand, for example, there are efforts to use GAS for fertilizer. However, these efforts tend to be small-scale and limited in impact.

Development Assistance Projects Working to Address IAS

In Southeast Asia, development assistance agencies have addressed IAS in two ways: (1) through species-specific projects aimed at control and eradication and (2) by raising the awareness of the potential impacts of IAS with national governments. Unfortunately, it appears that these efforts are not always well coordinated and complementary. While many development agency staff are generally aware of the IAS issue, they tend to possess little knowledge of the specific IAS problems in their region or the multisector implications of IAS. This scenario in particularly true of biodiversity and food security projects.

As regional and global economic integration becomes more of a reality, ASEAN countries will need greater technical assistance in order to protect their ecosystems, as well as to comply with regional and international agreements. Table 5 provides a summary of development projects currently addressing IAS within Southeast Asia. These efforts are backed by seven international agreements that apply to Southeast Asia, and one regional agreement (see Appendix E). The agreements primarily address biodiversity conservation and plant protection and do not provide adequate provisions in light of future growth of aquaculture and other intensive uses of freshwater systems in Southeast Asia.

Table 5: Development Projects Addressing IAS

PROJECT/GROUP Network of Aquaculture Centres in Asia-Pacific (NACA) **Point of Contact** Dr. Melba B. Reantaso, Maryland Department of Natural Resources **Type:** Technical Assistance **Sponsors:** USAID; ACIAR; AusAID; DFID; FAO; VSO; World Bank; WWF **Countries:** Australia, Bangladesh, Cambodia, China, Hong Kong SAR, India, Korea (DPR), Malaysia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, Vietnam. Other participating (non-member) governments include Indonesia, Iran, Rep. of Korea, Lao PDR and Singapore.	**EXAMPLES OF ACTIVITIES:** ♦ Produced Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals. ♦ STREAM Initiative (Support to Regional Aquatic Resources Management) ♦ Aquaculture Health Programme ♦ Highland Aquaculture Programme ♦ Seafood Trade and Livelihoods Programme
PROJECT/GROUP Australian Centre for International Agricultural Research **Point of Contact** Dr. Paul Ferrar **Type:** Technical Assistance **Sponsors:** ACIAR **Countries:** Indonesia; Malaysia; Thailand; Philippines; Vietnam	**EXAMPLES OF ACTIVITIES:** ♦ Control of *Salvinia molesta* in Thailand, Indonesia, Malaysia and the Philippines using Brazilian weevil (*Cyrtobagous salviniae*). ♦ Control of *Mimosa pigra* in Indonesia, Malaysia, Philippines and Vietnam using natural enemies (*Acanthoscelides puniceus, A. quadridentatus, Carmenta mimosae*, and *Coelocephalapion pigrae*). ♦ Control of water hyacinth (*Eichhornia crassipes*) in Indonesia, Philippines and Malaysia using biological control agents (*Neochetina bruchi* and *Sameodes albiguttalis*)
PROJECT/GROUP UNDP **Type:** Technical Assistance **Sponsors:** GEF **Countries:** Cambodia; Laos; Vietnam; Thailand; Malaysia	**EXAMPLES OF ACTIVITIES:** ♦ Tonle Sap Conservation Project ♦ Mekong River Basin Wetland Biodiversity ♦ Conservation and Sustainable Use of Tropical Peat Swamp Forests and Associated Wetland Ecosystems ♦ Creating Protected Areas for Resources Conservation Using a Landscape Ecology Approach
PROJECT/GROUP World Bank **Type:** Technical Assistance **Sponsors:** GEF **Countries:** Indonesia; Philippines	**EXAMPLES OF ACTIVITIES:** ♦ The Greater Berbak-Sembilang Integrated Coastal Wetlands Conservation Project ♦ Coastal and Marine Biodiversity Conservation in Mindanao ♦ Maluku Conservation and Natural Resources Management

Table 5 (cont.): Development Projects Addressing IAS

PROJECT/GROUP Exotic species in Aquaculture: Problems and Prospects **Type:** Awareness Raising Activities **Sponsors:** SIDA **Countries:** Cambodia; Laos; Thailand; Vietnam	**EXAMPLES OF ACTIVITIES:** ♦ Conducted an assessment on positive and negative impacts of introduced aquaculture species in the four lower Mekong countries. Held workshops in each of the four countries. Seeking to help develop codes of conduct for the region.
PROJECT/GROUP International Workshop on the International Mechanisms for the Control and Responsible Use of Alien Species in Aquatic Ecosystems 26-29 August 2003, Yunnan, China **Point of Contact** Dr. Devin Bartley, FAO Dr. Simon Funge-Smith, FAO Mr. Felix Marttin, FAO **Type:** Awareness Raising Activities **Sponsors:** FAO/ NACA/ MRC/ UC Sea Grant/ IUCN/ AIT **Countries:** Cambodia; China; Myanmar' Laos; Thailand; VIetnam	**EXAMPLES OF ACTIVITIES:** ♦ Sought to inform representatives from the six Mekong Fisheries Ministries about the international mechanisms concerning species introduction, e.g., Convention on Biological Diversity (CBD) and Code of Conduct for Responsible Fisheries. FAO hopes to make the voluntary Code of Conduct for Responsible Fisheries more accessible to the Mekong countries
PROJECT/GROUP Prevention and Management of Invasive Alien Species: Forging Cooperation in South and Southeast Asia **Type:** Awareness Raising Activities **Sponsors:** GISP; US Government **Countries:** Afghanistan; Bangladesh; Brunei Darussalam; India; Indonesia; Laos; Malvides; Malaysia; Nepal; Pakistan; The Philippines; Singapore; Thailand; Vietnam	**EXAMPLES OF ACTIVITIES:** ♦ Workshop sought to raise awareness of the serious impacts that IAS present and promote regional cooperation to address this problem. Engaged participants from the Ministries of Agriculture and Environment. Participants from the workshop issued a regional statement calling for increased awareness, long-term programs of work as well as the establishment of coordination mechanisms and information exchange systems at national, regional and international levels through the creation of IAS National focal points and through the CBD's Clearing-house mechanism

CONCLUSIONS and RECOMMENDATIONS

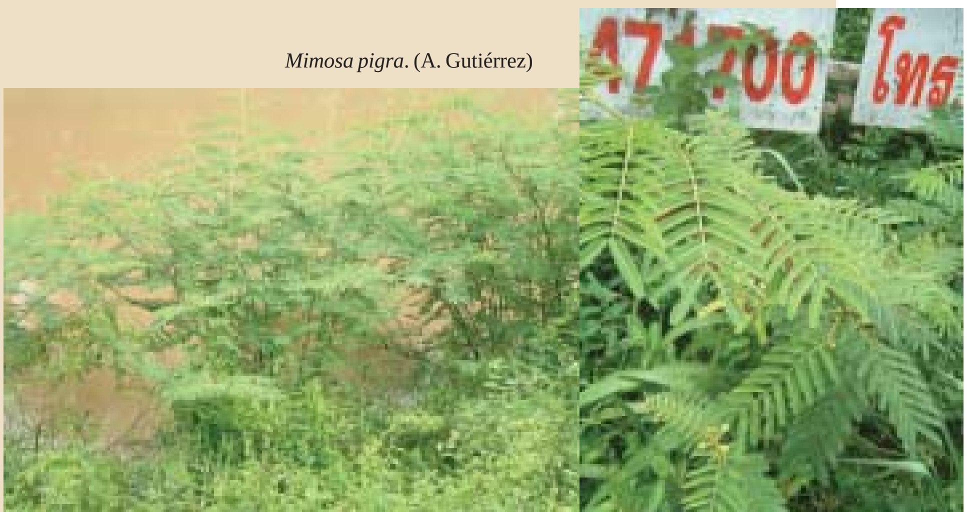
In Southeast Asia's freshwater systems, development assistance is linked with IAS in three ways – (1) development projects have been responsible for the introduction of IAS, (2) the effectiveness of development projects can be reduced by established IAS, and (3) some development agency staff are educating the region's governments on the risks posed by IAS, and, in a few cases, are directly managing IAS. Development agencies will be unable to achieve their goals to increase human well-being as long as IAS threaten food, water, and health security. In order to ensure the long-term sustainability of development projects, development agencies need to adequately assess the risks associated with the use of alien species and manage IAS where they are already established.

Mandates/rules/procedures for the prevention, monitoring, and control of IAS exist within the development agencies surveyed for this assessment. However, these mandates are often under the purview of one program and are not integrated throughout the agency. For instance, after Executive Order (EO) 13112 entered into force, the USAID Fisheries program saw the directive as effecting the agency's biodiversity programs and chose not to conduct a review of the implications for their own programs. Moreover, monitoring is not consistently, if ever, conducted after species have been introduced. Some development staff believes that, if the alien species they are using was previously introduced to the project country, they are not responsible for assessing or managing the species' impacts. This attitude can have serious consequences for natural systems and the development projects themselves. Furthermore, where monitoring and management of IAS are taking place, reporting tends to inconsistent and thus fails to provide adequate feedback and incentive to development staff.

Development agencies need to more effectively coordinate with each other in order to ensure the wise use of resources. As budgets shrink, coordination and collaboration between projects and agencies will be integral to foster IAS awareness raising and management efforts. Moreover, it is not sufficient for project staff to educate national ministries; a significant number of species introductions are also undertaken by the private sector. Thus, development agencies and governments need to work with large and small-scale private sector producers in order to ensure that best management practices are applied across all activities employing alien species in the region's freshwater systems.

As economic development and integration progress in Southeast Asia, the increased trade flows and sectoral development, especially hydroelectric, will face new challenges from IAS. Development agencies need to work with national governments, industry, and non-governmental organizations to build IAS prevention policies and practices into future agreements and projects. Recommendations for how development agencies can contribute to addressing IAS in Southeast Asia are listed in the Summary of Recommendations.

Mimosa pigra. (A. Gutiérrez)



Water hyacinth. (A. Gutiérrez)

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 socioeconomic 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.

USAID External Action

Policy

- Coordinate between USAID and other development agencies on projects and funding activities relevant to the prevention, management, control and eradication of IAS.
- Promote acknowledgement and enforcement of existing instruments governing sustainable management of fisheries, including protection of biodiversity (see Appendix E).
- 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 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.
- 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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APPENDIX A:
CGIAR Meeting Notes

Report of Session IUII – Invasive Alien Species, Agricultural Development, and the Aid Trade, CGIAR Stakeholder Meeting
October 31, 2001

Invasive alien species are alien organisms whose explosive population growth and spread causes harm to economies, the environment, or human health. Long recognized as threats to agriculture, invasive alien species are now also considered one of the leading drivers of biodiversity loss and environmental change. Growing world trade and ongoing changes in land use and climate are accelerating the appearance of new invasive alien species problems.

At a session organized by the Global Invasive Species Programme (GISP), the U.S. National Invasive Species Council (NISC), World Bank's Environment Department, CGIAR centers and donors identified the major invasive alien species issues in their sectors and discussed the priorities for addressing these.

Workshop participants agreed that:

- Invasive alien species can have a significant impact on development, affecting sustainability of livelihoods, food security and essential ecosystem services and processes.
- Target development assistance programes have reduced the threat or impact of particular invasive aliens species.
- Development assistance projects and emergency food aid programes have been significant pathways for the introduction of serious new invasive alien species to poor countries, either through contamination of imported plant and animal resources, or the deliberate introduction of beneficial species which subsequently become invasive and damaging.
- Cooperation between agricultural, environmental and related ministries will be essential to effective prevention and management of invasive alien species.

Participants noted that:

- The status of invasive alien species problems in developing countries is very poorly known relative to other regions, and CGIAR centers can contribute to assessment.
- Action against invasive alien species is constrained by a lack of awareness at the national and development agency level, where there is need to quantify the costs of invasive species problems.
- Centers are often challenged to deliver short-term benefits in productivity from new agricultural introductions, without sufficient knowledge on potential invasiveness of new plant and animal species or varieties. This identifies an urgent need for predictive tool to evaluate invasiveness.
- Besides direct input on agricultural production e.g. by invasive pests, alien plant and animal material can pose a serious threat to the erosion of valuable genetic resources, particularly in area of crop origin.
- Genetically modified organisms (GMOs) to the extent that they are potentially invasive and damaging, should be considered in programes on invasive alien species.
- Microbial systems have received far too little attention as potential areas of invasion and agricultural/environmental impact
- There are few truly effective barriers to species spread today, which creates a need to anticipate and understand emerging and potential problems, to prioritize these and to be proactive.

The following actions were supported at the meeting:

- An assessment of the status and threats posed by invasive alien species to developing countries should be undertaken, with specific effort to quantify impact and costs of invasive problems, relative to other development challenges.
- A study of pathways by which invasive alien species become problems in developing countries, with particular emphasis on the role which development assistance and emergency assistance plays in the creation of new problems.
- Development, in concert with GISP, the International Plant Protection Convention and Convention on Biological Diversity of best practices for governments, private sector and development assistance programmes which reduce risks to developing countries from invasive alien species.

It is proposed that GISP, NISC, and the World Bank develop these actions into a project, and that a committee of experienced specialists from CGIAR Centers be engaged for its design and to facilitate its execution. Results of (1) and (2) above would be reported to International Centers Week 2002.

Appendix B:
Recommendations from South-Southeast Asia Regional Workshop

Prevention and Management of Invasive Alien Species:
Forging Cooperation throughout South and Southeast Asia

Regional Workshop, 14-16 August 2002
Bangkok, Thailand

The delegates[1] of the South and Southeast Asia Regional Workshop on the Prevention and Management of Invasive Alien Species: Forging Cooperation throughout South and Southeast Asia co-hosted by the Royal Thai Government[2] in collaboration with the Government of the United States of America, and the Global Invasive Species Programme (GISP) have concluded that problems of invasive alien species (IAS) are causing significant ecological, economic, and social damages and pose ongoing threats to all countries within the region. They, therefore, recommend that the following actions related to the prevention and management of IAS be taken:

- 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);
- 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;
- Initiate assessments of problems related to IAS and develop early warning and monitoring systems;
- Encourage appropriate and relevant research on IAS issues;
- Provision adequate financial and technical support from relevant national, regional, and international assistance agencies to address IAS;
- Build capacity in terms of human resource development and technology transfer to address IAS;
- Promote community participation and involvement in efforts to address IAS;
- Encourage partnerships between public and private sectors in activities to address IAS;
- Promote awareness of IAS issues by convening workshops and seminars, as well as conducting publicity events and media campaigns; and
- Ensure the sustainability of IAS prevention and management activities in the region by developing long-term programes of action.

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[1] Representing Afghanistan, Bangladesh, Bhutan, Brunei Darussalam, India, Indonesia, Laos, Malaysia, Maldives, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, and Vietnam, ASEAN Regional Center for Biodiversity Conservation (ARCBC), CAB International (CABI), International Plant Protection Convention (IPPC) Secretariat, Food and Agriculture Organization (FAO), IUCN-World Conservation Union, South Asian Cooperative Environment Programme (SACEP), and Japan National Institute for Environmental Studies.

[2] Represented by the Office of Environmental Policy and Planning (OEPP) and Thailand Biodiversity Center (TBC), National Science and Technology Development Agency (NSTDA), Ministry of Science, Technology and Environment.

Appendix C:
Experts Consulted

Jambari H. Ali Associate Professor, Department of Biology, Universiti Putra Malaysia.

Oliver O. Agoncillo Development Assistance Specialist, Office of Environmental Management, USAID.

Ian Baird University of Victoria.

Devin Bartley Senior Fisheries Officer, FAO .

Chris Barlow Fisheries Programme Manager, Mekong River Commission.

Jerry P. Bisson Chief, Office of Environmental Management, USAID-Philippines.

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Guido Broekhoven Coordinator, Regional Forest Programme for Asia, IUCN.

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Arsenia G. Cagauan Associate Professor, Freshwater Aquaculture Center, Central Luzon State University.

Christine Marie V. Casal FishBase Project, WorldFish Center.

Bonifacio F. Cayabyab Deputy Director, National Crop Protection Center, Philippines.

Virach Chantrasmi Advisory Chairman, Vet Agritech Co. Ltd, Thailand.

Wilma R. Cuaterno Chief, Crop Protection Division, Bureau of Plant Industry, Department of Agriculture, Philippines.

Thomas Gloerfelt-Tarp Fisheries Specialist, Pacific Operations Department, Asian Development Bank.

Hans Guttman Environment Programme Coordinator, Environment Division.

Madan Mohan Dey Senior Scientist, Agricultural/Resource Economist, Policy Research and Impact Assessment Program, WorldFish Center.

Celso P. Diaz Director, Ecosystems Research and Development Bureau, Philippines.

Piyathip Eawpanich Thailand Programme Officer, IUCN.

Rolando B. Edra Chief, Philippine Council for Aquatic and Marine Research and Development, Philippines.

Paul Ferrar Research Program Manager, Australian Centre for International Agricultural Research (ACIAR).

Modadugu V. Gupta Assistant Director General (International Relations), Research Coordinator INGA, WorldFish Center.

Ian Harrison Resident Research Associate, American Museum of Natural History.

Zeb Hogan University of California-Davis.

Ravindra C. Joshi Senior Research Fellow, Crop Protection Division, Philippine Rice Research Institute.

Christopher C. Kohler Director of Fisheries, Fisheries and Illinois Aquaculture Center, Southern Illinois University.

Susan T. Kohler Associate Director, Dunn-Richmond Economic Development Center, Southern Illinois University.

Nelson A. Lopez Chief Inland Fisheries and Aquaculture Division, Bureau of Fisheries and Aquatic Resources, Department of Agriculture.

Kai Lorenzen Professor, Centre for Environmental Science and Technology, Imperial College of Science, Technology and Medicine, England.

Khamphoui Louangrath Deputy Director of Regulatory Division, Department of Agriculture, Ministry of Agriculture and Forestry, Laos.

Le Thanh Luu Acting Director, Research Institute for Aquaculture, Ministry of Fisheries, Vietnam.

Niklas Matson Aquaculture of Indigenous Mekong Fish Species, Mekong River Commission.

Roger Mollot World Wildlife Fund, Laos.

Lydia M. Morales Head, Fish Health & Water Quality Management, National Freshwater Fisheries Technology Center, Bureau of Fisheries and Aquatic Resources, Department of Agriculture.

Jeffrey McCrary Director, Faculty of Science and Environmental Technology, Universidad Centroamericana.

Peter-John Meynell Team Leader, Mekong Wetlands Biodiversity Conservation Programme.

Bun Narith Director Hydroelectricity Department, General Directorate of Energy, Ministry of Industry, Mines and Energy.

Banpot Napompeth Advisor, National Biological Control Research Center (NBCRC), Kasetsart University, Thailand.

Monemany Nhoybouakong Science, Technology & Environment Agency, Laos.

Oum Pisey Deputy-Director, Department of Planning and Legal Affairs, Ministry of Environment.

Alphis G. Ponniah Program Leader, Biodiversity & Genetic Resources Research Program, WorldFish Center.

Mark Prein Senior Scientist/Program Leader, Freshwater Resources Research Program, WorldFish Center.

Roger Pullin Ecotrak, Philippines.

Sundari Ramakrishna Director of Malaysia Programme, Wetlands International.

Melba B. Reantaso Aquatic Animal Research Pathologist, Maryland Department of Natural Resources.

Tyson Roberts Consultant.

Basilio M. Rodriguez Jr. Executive Director, GIFT Foundation International, Inc.

Soetikno Sastroutomo CABI Southeast Asia Regional Center, Malaysia.

Robert Schelly American Museum of Natural History.

Wansuk Senanan Department of Aquatic Science, Faculty of Science, Burapha University.

Tran Triet Chair, Department of Botany and Ecology, University of Natural Sciences, Vietnam National University.

Hean Vanhan Chief, Plant Protection and Phytosanitary Office, Department of Agronomy and Agricultural Land Improvement, Ministry of Agriculture, Forestry and Fisheries.

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Yang Yi Associate Professor, Aquaculture and Aquatic Resources Management, School of Environment, Resources and Development.

Dennis C. Zvinakis Regional Representative, United States-Asia Environmental Partnership, USAID-Thailand.

APPENDIX D:
Country Briefers

During the course of the assessment, previously undocumented, country-specific information was collected. The following tables summarize information compiled for this assessment, as well as findings relevant to freshwater systems compiled in the South-Southeast Asia regional workshop report (Pallewatta et al. 2003). These tables provide a baseline for information on IAS activities in Southeast Asia.

Kingdom of Cambodia

ECONOMY: Source: (WDI 2001), DIAS, FISHBASE, SSE Report	AGRICULTURE, value added (% OF GDP): INDUSTRY, value added (% of GDP): SERVICES, ETC., value added (% of GDP):	36.91 % 21.89 % 41.20 %
GDP PER CAPITA, PPP (current U.S.$): $ 1591.19	TRADE (% of GDP): 114.50 %	AID PER CAPITA (current U.S.$): $ 33.32

Source: (WDI 2001)

POPULATION: 13, 124,764	AREA:	TOTAL: 181,040 sq. km. LAND: 176,520 sq. km. WATER: 4,520 sq. km.

Source: (WorldFactbook 2003)

MINISTRIES ADDRESSING IAS:
- Ministry of Agriculture
- Ministry of Environment
- Ministry of Fisheries
- Ministry of Industry, Mines and Energy

KNOWN RIPARIAN IAS OF CONCERN:
- thorny sensitive plant (*Mimosa pigra)*
- golden apple snail (*Pomacea canaliculata*)

Source: Nuov et al. 2003, Pallewatta et al. 2003 DIAS, FISHBASE

KNOWN INTRODUCED AQUATIC SPECIES:
- water hyacinth (*Eichornia crassipes*).
- 15 alien species introduced since 1970:
  - 4 Chinese major carps:
    - silver carp (*Hypophtalmychtys molitrix)*
    - bighead carp (*Aristichthys nobilis)*
    - grass carp *(Ctenopharyngodon idella*)
    - common carp *(Cyprinus carpio)*
  - 3 Indian major carps:
    - rohu (*Labeo rohita*)
    - mrigal (*Cirrhinus mrigala*)
    - Catla (*Catla catla*)
    - Java tilapia (*Oreochromis mossambicus*)
    - Nile tilapia (*Oreochromis niloticus*)
    - Red tilapia (*O.niloticus x. O. mossambicus*)
    - African catfish (*Clarias gariepinus*)
    - Giant gourami (*Osphronemus gouramy)*

Source: Nuov et al. 2003, Pallewatta et al. 2003, DIAS, FISHBASE

RELEVANT REGULATIONS/LEGISLATION:

THEME 2 "ANIMAL WILDLIFE RESOURCES" Strategic Objective 2.2 calls for the reduction of the impact of alien invasive species on indigenous animal species (measures taken to prevent dissemination of alien invasive species.) Priority action 2.2 calls for a national monitoring program and database on alien invasive species and exploited wild animal species.

THEME 3 "FRESHWATER FISHERIES AND AQUACULTURE" of the Cambodian National Biodiversity Strategy and Action Plan, acknowledges that the "Fisheries Department with the assistance of a variety of development agencies has actively promoted aquaculture in the uplands for food security. . . . This aquaculture is predominantly based on introduced species of fish and as such may be a serious threat to local species biodiversity. . . . there are no guidelines regulating the importation of exotic species for culture, the scope for 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." One of the key issues identified in this section is the "shortage of suitable indigenous fish species for aquaculture production." Priority action 3.5 is the development of an indigenous fish aquaculture development project, which included the promotion of native fish production. (Cambodia-NBSAP 2002)

RELEVANT MINISTRIES:
- Ministry of Industry, Mines and Energy
- Ministry of Agriculture, Forestry and Fisheries
- Ministry of Environment
- Ministry of Water Resource and Metrology
- Ministry of Public Works and Transport

PROJECTS/MISC:

Ministry of Environment, Task Force on *Mimosa pigra*. *Mimosa pigra* has been found growing rapidly in low-lying areas near the Mekong River and the Tonle Sap Great Lake. Since 1985-86 *Mimosa pigra* became established in Cambodia, since 1990 it has been countrywide. *Mimosa pigra* allows sediment to accumulate in irrigation canals, reducing water flow. It forms dense thickets, which make it difficult to get access to electric power lines. It also takes over fallow rice paddies increasing the effort to reclaim the land. The task force gathered information on the distribution of *Mimosa pigra.*

PROJECT CONTACTS:

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Peter-John Meynell, Mekong Wetlands Biodiversity Conservation Programme.

Republic of Indonesia

ECONOMY:

Agriculture, value added (% of GDP):	16.99 %
Industry, value added (% of GDP):	45.55 %
Services, etc., value added (% of GDP):	37.45%

Source: (WDI 2001)

GDP per capita, PPP (current U.S. $):	Trade (% of GDP):	Aid per capita (current U.S.$):
$ 3019.57	77.11 %	$ 7.18

Source: (WDI 2001)

POPULATION: 234,893,453 (july 2003 est.)

AREA: Total: 1,919,440 sq km; Water: 93,000 sq km; Land: 1,826,440 sq km

Source: World Factbook 2003

MINISTRIES ADDRESSING IAS:
- Department of Agriculture
- Department of Forestry
- Department of Marine and Fisheries
- Indonesian Institute for Science

KNOWN RIPARIAN IAS OF CONCERN:
- giant sensitive plant (*Mimosa pigra*)
- golden apple snail (*Pomacea canaliculata*)

Source: Nuov et al. 2003, Pallewatta et al. 2003, DIAS, FISHBASE

KNOWN INTRODUCED AQUATIC SPECIES

water hyacinth (*Eichhornia crassipes*)	(Pallewatta et al. 2003)
clam (*Anodonta woodiana*)	(DIAS 1998)
walking catfish (*Clarias batrachus*)	(DIAS 1998)
golden apple snail (*Pomacea canaliculata*)	(DIAS 1998)
goldfish (*Carassius auratus auratus*)	Welcomme 1988)
North African catfish (*Clarias gariepinus*)	(Teugels 1986)
grass carp (*Ctenopharyngodon idella*)	(Shireman and Smith 1983)
common carp (*Cyprinus carpio carpio*)	(Kottelat 1997)
silver carp (*Hypophthalmichthys molitrix*)	(Skelton 1993)
mozambique tilapia (*Oreochromis mossambicus*)	(Trewavas 1982)
nile tilapia (*Oreochromis niloticus niloticus*)	(Trewavas 1983)
sailfin molly (*Poecilia latipinna*)	(Page and Burr 1991)
guppy (*Poecilia reticulata*)	(Rodriguez 1997)
snakeskin gourami (*Trichogaster pectoralis)*	(Rainboth 1996)
green swordtail (*Xiphophorus hellerii*)	(Wischnath 1993)
Southern platyfish (*Xiphophorus maculatus*)	(Rodriguez 1997)

Source: Nuov et al. 2003, Pallewatta et al. 2003, DIAS, FISHBASE

RELEVANT REGULATIONS/LEGISLATION:

UNDANG-UNDANG (LAW) No. 16/1992 Regulates animal/fish and plant quarantine (Pallewata et al. 2003).

Lao People's Democratic Republic

ECONOMY:

AGRICULTURE, value added (% of GDP): 50.89%
INDUSTRY, value added (% of GDP): 23.44%
SERVICES, ETC., value added (% of GDP): 25.67%

Source: (WDI 2001)

GDP PER CAPITA, PPP (current U.S. $): $ 1640.55	TRADE (% of GDP): 25.67 %	AID PER CAPITA (current U.S.$): $45.03

Source: (WDI 2001)

POPULATION: (July 2003 est.) 5,921,545

AREA: TOTAL: 236,800 sq km
WATER: 6,000 sq km
LAND: 230,800 sq km

Source: World Factbook 2003

MINISTRIES ADDRESSING IAS:

Science, Technology and Environment Agency (STEA)
Ministry of Agriculture and Forestry
Ministry of Public Health

KNOWN RIPARIAN IAS OF CONCERN:

giant sensitive plant (*Mimosa Pigra*)
golden apple snail (*Pomacea canaliculata*)
creeping sensitive plant (*Mimosa invisa*)

Source: Nuov et al. 2003, Pallewatta et al. 2003, DIAS, FISHBASE

KNOWN INTRODUCED AQUATIC SPECIES:

water hyacinth (*Eichhornia crassipes*)	(Pallewatta et al. 2003)
common carp (*Cyrpinus carpio*)	(Phoumavong et al. 2003)
bighead carp (*Hypothalmichthys nobilis*)	(Visser et al. 2003)
silver carp (*Hypothalmichthys molitrix*)	(Visser et al. 2003)
grass carp (*Ctenopharryngadon idella*)	(Visser et al. 2003)
Nile tilapia (*Oreochromis niloticus*)	(Visser et al. 2003)
Mozambique tilapia (*Oreochromis mossambicus*)	(Visser et al. 2003)
North African catfish (*Clarias gariepinus*)	(Visser et al. 2003)
goldfish (*Carassius auratus*)	(Visser et al. 2003)
mosquitofish (*Gambusia affinis*)	(Visser et al. 2003)
spotted steed (*Hemibarbus maculatus*)	(Visser et al. 2003)
oriental weatherfish (*Misgurnus anguillicaudatus*)	(Visser et al. 2003)
stone moroko (*Pseudorasbora parva*)	(Visser et al. 2003)
guppy (*Poecilia reticulata*)	(Visser et al. 2003)

Source: Nuov et al. 2003, Pallewatta et al. 2003, DIAS, FISHBASE

PROJECTS/MISC:

Aquaculture of Indigenous Malay Fish Species Project (see Appendix F)

RELEVANT REGULATIONS/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)
Quarantine legislation (1994)
Forest law (1996)
Water Resources Management Law (1996)
Plant Application Legislation (1996)
Land Law (1997)
Environment Protection Law (1999)
Pesticide Legislation (2000)

PROJECT CONTACTS

Ms. Monemany Nhoybouakong, Science, Technology & Environment Agency
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Ms. Khamphoui Louangrath, Department of Agriculture
Mr. Roger Mollot, World Wildlife Fund

Malaysia

ECONOMY:	AGRICULTURE, value added (% of GDP):	8.51%	
	INDUSTRY, value added (% of GDP)	49.11%	
Source: (DWI 2001)	SERVICES, ETC., value added (% of GDP)	42.39%	
GDP PER CAPITA, PPP (current U. S. $): $ 8724.82	TRADE (% of GDP): 214.30 %		AID PER CAPITA (current U.S. $): $ 1.12

Source: (DWI 2001)

POPULATION: (July 2003 est.)	23,092,940	AREA: TOTAL:	329,750 sq km
		WATER:	1,200 sq km
		LAND:	328,550 sq km

Source: World Factbook 2003

MINISTRIES ADDRESSING IAS:
- Ministry of Agriculture
- Malaysia Agriculture Research and Development Institute (MARDI)
- Department of Veterinary Services
- Ministry of Science, Technology and Environment

KNOWN TERRESTRIAL IAS OF CONCERN:
- giant sensitive plant (*Mimosa Pigra*)
- golden apple snail (*Pomacea canaliculata*)

Source: Nuov et al. 2003, Pallewatta et al. 2003, DIAS, FISHBASE

KNOWN INTRODUCED AQUATIC SPECIES:

water hyacinth (*Eichhornia crassipes*)	(Hassan Othman and Abu Hashim 2002)
aquarium water moss (*Salvinia molesta*)	(Hassan Othman and Abu Hashim 2002)
Red-eared tortoise (*Trachemys scripta elegans*)	(Hassan Othman and Abu Hashim 2002)
bighead carp (*Aristichthys nobilis*)	(Masuda et al. 1984)
goldfish (*Carassius auratus auratus*)	(Kottelat et al. 1993)
grass carp (*Ctenopharyngodon idealla*)	(Shireman and Smith 1983)
common carp (*Cyprinus carpio carpio*)	(Kottelat 1997)
mosquitofish *(Gambusia affinis)*	(Page and Burr 1991)
silver carp (*Hypophthatlmichthys molitrix*)	(Skelton 1993)
largemouth bass (*Micropterus salmoides*)	(Page and Burr 1991)
Mozambique tilapia (*Oreochromis mossambicus*)	(Trewavas 1982)
Nile tilapia (*Oreochromis niloticus niloticus*)	(Trewavas 1983)
wami tilapia (*Oreochromis urolepis hornorum*)	(Trewavas 1983)
guppy (*Poecilia reticulata*)	(Rodriguez 1997)
redbelly tilapia (*Tilapia zillii*)	(Teugels and Thys van den Audenaerde 1991)

Source: Nuov et al. 2003, Pallewatta et al. 2003, DIAS, FISHBASE

RELEVANT REGULATIONS/LEGISLATION:

PLANT QUARANTINE ACT 1976. Plant Quarantine Act 1976 and Plant Quarantine Regulations 1981 is under The Crop Protection and Plant Quarantine Division of the Department of Agriculture (DOA). The Act and Regulations provide the legislative power to carry out preventive and eradicative measures to safeguard the agriculture industry.

Plant Quarantine Act 1976 includes the prevention, control and eradication of dangerous pest found within the country. It is a continuous activity mainly on the inspection of premises (factories, nurseries etc.) and interception of dangerous pest at all entry points. As for now, 7 dangerous pests are being controlled under an extensive preventive and eradication program carry out by the department throughout Malaysia. These dangerous pests are Khapra beetle (*Trogoderma granarium*), golden apple snail (*Pomacea canaliculata*), papaya ringspot virus disease, banana bunchy top virus disease, *Cyperus papyrus*/*Cyperus japonica* (aquatic plants), *Rottboellia cochinchinnensis* (weed), and rice blast disease in paddy fields.

PLANT QUARANTINE REGULATION 1981. The Plant Quarantine Regulations 1981 stipulates the requirements which must be met for the importation of plants, plant products, growing media/rooting compost, beneficial organisms, plant pests and carrier of plant pests into Malaysia.

FISHERIES ACT 1985. Section 37 of the Fisheries Act 1985 on Promotion of development and management of in-land Fisheries. The Director-General may, in consultation with the State Authority concerned, promote the development and rational management of inland fisheries through-

(a) The conduct or co-ordination of research;
(b) The provision and maintenance of experimental and demonstration aquaculture stations, fish-breeding stations and training centres;
(c) The provision of advice and technical assistance to the appropriate authorities of the State;
(d) The provision of publicity and demonstration facilities and other connected services; and
(e) The provision of advice on measures for the prevention of fish diseases.

Section 40 of the Fisheries Act 1985 is about the control of live fish. Section 40 (1) specify that 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 the 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 a permit or in breach of any condition in a permit issued by the Director-General under this section shall be guilty of an offence.

Under Section 40 (2) of the same Act, the Director-General may 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.

Republic of the Philippines

ECONOMY:	Agriculture, value added (% of GDP):	15.09%
	Industry, value added (% of GDP):	31.64%
Source: (WDI 2001)	Services, etc., value added (% of GDP):	53.27%

GDP per capita, PPP (current U.S. $)	Trade (% of GDP)	Aid per capita (current U.S. $)
$3919.23	95.51 %	$ 7.37

Millions of Tons Produced in Inland Waters in 2001: 135, 845 MT

Source: (WDI 2001)

POPULATION: (July 2003 est.)	84,619,974	AREA:	Total: 300,000 sp km Water: 1,830 sq km Land: 298,170 sq km

Source: World Factbook 2003

MINISTRIES ADDRESSING IAS:

- Department of Agriculture
- Department of Environment and Natural Resources
- Department of Foreign Affairs
- Department of Interior and Local Government
- Department of Science and Technology
- Department Tourism
- Department of Trade and Industry
- Department of Transportation

KNOWN TERRESTRIAL IAS OF CONCERN:
Source: (Sinohin and Cuaterno 2002)

- giant sensitive plant (*Mimosa pigra*)
- golden apple snail (*Pomacea canaliculata*)
- haganoy weed (*Chromolaena odorata*)
- largeleaf lantana (*Lantana camara*)
- Chinese creeper (*Mikania micrantha*)
- Coomb teak (*Gmelina aborea*)
- Acacia (*Acacia mangium*)
- Red gum (*Eucalyptus camaldulensis*)
- Big leaf mahogany (*Swietenia macrophylla*)
- Apitong (*Dipterocarpus grandiflorus*)
- (*Leucaena leucocephala*)
- (*Toona ciliata*)
- (*Pheidole megacephala*)

KNOWN INTRODUCED AQUATIC SPECIES:

water hyacinth (*Eichhornia crassipes*)	(Cayabyab 2003, Sinohin and Cuaterno 2002)
salvinia (*Salvinia molesta* L.)	(Cayabyab 2003, Sinohin and Cuaterno 2002)
water lettuce (*Pistia stratiotes* L.)	(Cayabyab 2003, Sinohin and Cuaterno 2002)
water cabbage (*Limnocharis flava* L.)	(Cayabyab 2003, Sinohin and Cuaterno 2002)
hydrolia (*Hydrolia zeylanica* Vahl.)	(Cayabyab 2003)
hydrilla (*Hydrilla verticillata* L.)	(Cayabyab 2003)
vallisneria (*Vallisneria gigantean* L.)	(Cayabyab 2003)
Eleotrid (*Hypseoleotris agilis*)	(Escudero 1993, Sinohin and Cuaterno 2002)
white goby (*Glossogobius giurus*)	(Sinohin and Cuaterno 2002)
striped snakehead (*Channa striata*)	(DIAS 1998)
mosquitofish (*Gambusia affinis*)	(DIAS 1998)
Mozambique tilapia (*Oreochromis mossambicus*)	(DIAS 1998)
sailfin mollyfish (*Poecilia latipinna*)	(DIAS 1998)
guppy (*Poecilia reticulata*)	(DIAS 1998)
apple snail (*Pomacea gigas*)	(DIAS 1998)

marine toad (*Bufo marinus*)	(DIAS 1998, Sinohin and Cuaterno 2002)
American bullfrog (*Rana catesbiana*)	(DIAS 1998, Sinohin and Cuaterno 2002)
Leopard frog (*Rana tigrina*)	(DIAS 1998, Sinohin and Cuaterno 2002)
snakeskin gourmai (*Trichogaster pectoralis*)	(Rainboth 1996)
guppy (*Poecilia reticulata*)	(Rodriguez 1997)
sailfin molly (*Poecilia latipinna*)	(Page and Burr 1991)
Nile tilapia (*Oreochromis niloticus niloticus*)	(Trewavas 1983)
blue tilapia (*Oreochromis aureus*)	(Trewavas 1983)
Oriental weatherfish (*Misgurnus anguillicaudatus*)	(Talwar and Jhingran 1992)
largemouth bass (*Micropterus salmoides*)	(Page and Burr 1991, Sinohin and Cuaterno 2002)
bluegill (*Lepomisa macrochirus*)	(Page and Burr 1991)
channel catfish (*Ictalurus punctatus*)	(Page and Burr 1991)
suckermouth catfish (*Hypostomus plecostomus*)	(Sinohin and Cuaterno 2002)
silver carp (*Hypophthalmichthys molitrix*)	(Skelton 1993)
mosquitofish (*Gambusia affinis*)	(Page and Burr 1991)
common carp (*Cyprinus carpio carpio*)	(Kottelat 1997)
grass carp (*Ctenopharyngodon idella*)	(Shireman and Smith 1983)
North African catfish (*Clarias gariepinus*)	(Teugels 1986)
walking catfish (*Clarias batrachus*)	(Rahman 1989, Sinohin and Cuaterno 2002)
crucian carp (*Carassius carassius*)	(Vostradovsky 1973)
goldfish (*Carassius auratus auratus*)	(Kottelat et al. 1993)
bighead carp (*Aristichthys nobilis*)	(Masuda et al. 1984)

Source: Nuov et al. 2003, Pallewatta et al. 2003, DIAS, FISHBASE

RELEVANT REGULATIONS/LEGISLATION:

GUIDELINES ON PLANNED RELEASE OF GENETICALLY MANIPULATED ORGANISMS (GMOS) AND POTENTIALLY HARMFUL EXOTIC SPECIES (PHES)

Section 3. “The Biosafety Organization”

Point 3.2 *Institutional Biosafety Committee* “Any institution intending to undertake any planned release of GMOs or PHES into the environment must first set up an Institutional Biosafety Committee (IBC). The IBC shall be responsible for evaluating project proposals involving organisms covered by this monograph and for recommending the same for appropriate action by the NCBP. After the project is approved, the IBC shall be responsible for supervising, monitoring and reporting to the NCBP its progress. More importantly, the IBC shall make sure that the environment and human health are safeguarded in the conduct of any potentially biohazardous activities by the institution or by any of its employees or researchers. Likewise, the IBC shall be responsible for informing the surrounding communities of plans for planned release, including the concomitant risks thereof, if any.”

3.2.4 Requires annual reporting by the IBC.

Section 4. Procedures for Planned Release Application and Review

4.1 NCBP Approval – “No person or institution shall release into the environment any GMO or PHES without the prior approval of the NCBP. However, approval by the NCBP does not in any way exempt the project proponent from complying with any rules, regulations or requirements of other government regulatory authorities. It is the sole responsibility of the project proponent to determine if the proposed planned release requires any permit, license or approval of such regulatory authorities, and to obtain the same if required.”

4.6 *Scientific and Technical Review Panel*

(a) Upon receipt of the proposal from the NCBP Secretariat, the NCBP shall create a Scientific and Technical Review Panel (STRP) to evaluate potential adverse effects of the project to human health and environment. The STRP shall be appointed by the Chairman of the NCBP. It shall be composed of at least three (3) members drawn, if possible, from the pool of experts listed in the sectoral councils of the Department of Science and Technology. As far as practicable, no member of the NCBP shall be part of STRP.

Section 5. Monitoring and Reports

Calls for Monitoring of the planned release and reporting 90 days after completion of the release.

Section 7. Penalties and Sanctions

“In addition to the revocation of the project approval, any violation of the provisions of this monograph of the concealment of withholding by the proponent of any information necessary to evaluate risks to human health or the environment shall be ground for the forfeiture the proponent or institution for contributing to advanced scientific or technological research and development may be withheld. These penalties are exclusive of any other penalties that may be imposed under existing law, including, but not limited to, civil, criminal and administrative liabilities for gross negligence.”

PHILIPPINES FISHERIES CODE OF 1998 (REPUBLIC ACT 8550)

Sec. 10. *Introduction of Foreign Aquatic Species*

“No foreign finfish, mollusk, crustacean or aquatic plants shall be introduced in Philippine waters without a sound ecological, biological and environmental justification based on scientific studies subject to the bio-safety standards as provided for by the existing laws: Provided, however, that the Department may approve the introduction of foreign aquatic, species for scientific/research purposes.”

Sec. 47. *Code of Practice for Aquaculture*

The Department shall establish a code of practice for aquaculture that will outline general principles and guidelines for environmentally-sound design and operation to promote the sustainable development of the industry. Such Code shall be developed through a consultative process with the DENR, the fishworkers, FLA holders, fishpond owners, fisherfolk cooperatives, small-scale operators, research institutions and the academe, and other potential stakeholders. The Department may consult with specialized international organizations in the formulation of the code of practice."

Sec. 48 *Incentives and Disincentives for Sustainable Aquaculture Practices*

"The Department shall formulate incentives and disincentives, such as, but not limited to, effluent charges, user fees and negotiable permits, to encourage compliance with the environmental standards and to promote sustainable management practices."

Sec. 51 *License to Operate Fish Pens, Fish Cages, Fish Traps and Other Structures for the Culture of Fish and Other Fishery Products*

"Fish pens, fish cages, fish traps and other structures for the culture of fish and other fishery products shall be constructed and shall operate only within established zones duly designated by Local Government Units (LGUs) in consultation with the (Fisheries and Aquatic Resources Management Councils) FARMCs concerned consistent with national fisheries policies after the corresponding licenses thereof have been secured. The area to be utilized for this purpose for individual person shall be determined by the LGU's in consultation with the concerned FARMC: Provided, however, that not over ten percent (10%) of the suitable water surface area of all lakes and rivers shall be allotted for aquaculture purposes like fish pens, fish cages and fish traps; and the stocking density and feeding requirement which shall be controlled and determined by its carrying capacity: Provided, further, that fish pens and fish cages located outside municipal waters shall be constructed and operated only within fish pen and fish cage belts designated by the Department and after corresponding licenses therefore have been secured and the fees thereof paid."

Fisheries Administrative Order No. 214, Series of 2001

Outlines site selection and evaluation for aquaculture.

Sec. 7. Stock selection, stocking practices:

"b. Indigenous species shall be cultured whenever feasible;

c. Stock only healthy fry and fingerlings. Genetically improved fish species for stocking shall be sourced from government and accredited non-government hatcheries;

Sec. 8 Introduction of exotic and GMOs

"The introduction of exotic and GMOs shall be made after a sound ecological, biological and environmental justification based on scientific studies and subject to the biosafety standard as provided for by existing laws and regulations."

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 biomolecules

The order addresses the importation of live fish and fishery aquatic products, aquatic microorganisms, biomolecules including GMOs and endangered species. Requires a license for the importation of live fish and fishery products.

PROJECTS/MISC:

Non-governmental organizations working on IAS:

NGOs for Integrated Protected Areas, Inc.
Civil Society Counterpart Council for Sustainable Development
Southeast Asia Regional Institute for Community Education
Philippine Sustainable Development Network Foundation, Incorporated

Republic of Singapore

ECONOMY:	Agriculture, value added (% of GDP):		0.12%		
	Industry, value added (% of GDP):		32.00%		
Source: (WDI 2001)	Services, etc., value added (% of GDP):		61.33%		
GDP PER CAPITA, PPP (current U.S. $):	$22455.58	Trade (% of GDP):	N/A	Aid per capita (current U.S. $):	$ 0.23
Source: (WDI 2001)					

POPULATION: 4,608,595
(July 2003 est.)
Source: World Factbook 2003

AREA: Total: 692.7 sq km
Water: 10 sq km
Land: 682.7 sq km

MINISTRIES ADDRESSING IAS:
Agri-food and Veterinary Authority of Singapore
National Parks Board
Maritime and Port Authority of Singapore
National Environment Agency

KNOWN TERRESTRIAL IAS OF CONCERN:
Source: (Tan and Koh-Siang 2002)
giant sensitive plant (*Mimosa Pigra*)
golden apple snail (*Pomacea canaliculata*)
water spangle (*Salvinia molesta)*
giant African snail (*Achatina fulica*)

KNOWN INTRODUCED AQUATIC SPECIES with adverse ecological effects:
Malayan box turtle (*Cuora amboinensis*) (Tan and Koh-Siang 2002)

black marsh turtle (*Siebenrockielle crassicollis*)	(Tan and Koh-Siang 2002)
water hyacinth (*Eichhornia crassipes*)	(Tan and Koh-Siang 2002)
red eared terrapin (*Trachemys scripta*)	(Tan and Koh-Siang 2002)
striped keelback (*Xenochropis vittatus*)	(Tan and Koh-Siang 2002)
changeable lizard (*Calotes versicolor*)	(Tan and Koh-Siang 2002)
painted bullfrog (*Kaloula pulchra*)	(Tan and Koh-Siang 2002)
American bullfrog (*Rana catesbiana*)	(Tan and Koh-Siang 2002)
soft shelled turtle (*Trionyx sinensis*)	(DIAS 1998)
bighead carp (*Aristichthys nobilis*)	(Masuda et al. 1984)
goldfish (*Carassius auratus auratus*)	(Kottelat et al. 1993)
grass carp (*Ctenopharyngodon idella*)	(Shireman and Smith 1983)
Eastern mosquitofish (*Gambusia holbrooki*)	(Page and Burr 1991)
silver carp (*Hypophthalmichthys molitrix*)	(Skelton 1993)
Mozambique tilapia (*Oreochromis mossambicus*)	(Trewavas 1982)
Nile tilapia (*Oreochromis niloticus niloticus*)	(Trewavas 1983)
sailfin molly (*Poecilia latipinna*)	(Page and Burr 1991)
guppy (*Poecilia reticulata*)	(Rodriguez 1997)
snakeskin gourami (*Trichogaster pectoralis*)	(Rainboth 1996)
green swordtail (*Xiphophorus hellerii*)	(Wischnath 1993)
variable platyfish (*Xiphoporus variatus*)	(Rodriguez 1997)
catfish (*Liposarcus pardalis*)	(Tan and Koh-Siang 2002)
24-carat gold molly (*Poecilia sphenops*)	(Tan and Koh-Siang 2002)
mosquitofish (*Gambusia affinis*)	(Tan and Koh-Siang 2002)
green chromide (*Etroplus suratensis*)	(Tan and Koh-Siang 2002)

Source: Nuov et al. 2003, Pallewatta et al. 2003, DIAS, FISHBASE

Kingdom of Thailand

ECONOMY:
Agriculture, value added (% of GDP): 8.51%
Industry, value added (% of GDP): 41.99%
Services, etc., value added (% of GDP): 49.49%
Source: (WDI 2001)

GDP per capita, PPP (current U.S. $)	Trade (% of GDP):	Aid per capita (current U.S.$)
$ 6451.99	125.65%	$4.59

Source:(WDI 2001)

POPULATION: 64,265,276

AREA: Total: 514,000 sq km
Water: 2,230 sq km
Land: 511,770 sq km

Source: World Factbook 2003

MINISTRIES ADDRESSING IAS:
Department of Fisheries
Department of Livestock Development and Department of Agriculture
Ministry of Agriculture and Cooperatives (MOAC)
Ministry of Commerce
Ministry of Public Health
Ministry of Science, Technology and Environment (MOSTE), Office of Environmental Policy and Planning (OEPP)
Royal Forest Department

KNOWN TERRESTRIAL IAS OF CONCERN:

giant sensitive plant (*Mimosa pigra*)	(Napompeth 2002)
golden apple snail (*Pomacea canaliculata*)	(DIAS 1998)
Siam weed (*Chromolaena odorata*)	(Napompeth 2002)
mile-a-minute *(Mikania micrantha)*	(Napompeth 2002)
Croftonweed *(Ageratina adenophora)*	(Napompeth 2002)
apple snail *(Pomacea gigas)*	(DIAS 1998)
American bullfrog *(Rana catesbeiana)*	(DIAS 1998)

Source: Nuov et al. 2003, Pallewatta et al. 2003, DIAS, FISHBASE

KNOWN INTRODUCED AQUATIC SPECIES:

*water hyacinth (*Eichhornia crassipes*)*	(Napompeth 2002)
long-pincered crayfish (*Procambarus clarkii*)	(DIAS 1998)
mosquitofish (*Gambusia affinis*)	(Page and Burr 1991, Visser et al. 2003)
silver carp (*Hypophthalmichthys molitrix*)	(Skelton 1993, Visser et al. 2003)
rainbow trout (*Oncorhynchus mykiss*)	(Gall and Crandell 1992)
blue tilapia (*Oreochromis aureus*)	(Trewavas 1983)

Mozambique tilapia (*Oreochromis mossambicus*)	(Trewavas 1982, Visser et al. 2003)
Nile tilapia (*Oreochromis niloticus niloticus*)	(Trewavas 1983, Visser et al. 2003)
common carp (*Cyprinus carpio carpio*)	(Kottelat 1997)
grass carp (*Ctenopharyngodon idella*)	(Shireman and Smith 1983, Visser et al. 2003)
bighead carp (*Aristichthys nobilis*)	(Masuda et al. 1984, Visser et al. 2003)
goldfish (*carassius auratus auratus*)	(Kottelat et al. 1993, Visser et al. 2003)
Crucian carp (*Carassius carassius*)	(Vostradovsky 1973)
North African catfish (*Clarias gariepinus*)	(Visser et al. 2003)
guppy (*Poecillia reticulata*)	(Visser et al. 2003)
Redbreast tilapia (*Tilapia rendalli*)	(Visser et al. 2003)

Source: Nuov et al. 2003, Pallewatta et al. 2003, DIAS, FISHBASE

MISC: www.thaialienspecies.com

Socialist Republic of Vietnam

ECONOMY:	Agriculture, value added (% of GDP):	23.61%			
	Industry, value added (% of GDP):	37.83%			
Source: (WDI 2001)	Services, etc., value added (% of GDP):	38.55%			
GDP per capita, PPP (current U.S. $) Source: (WDI 2001)	$ 2102.64	Trade (% of GDP):	111.50%	Aid per capita (current U.S.$):	$18.04

POPULATION: 81,624,716 (July 2003 est.)

AREA: Total: 329,560 sq km; Water: 4,200 sq km; Land: 325,360 sq km

Source: World Factbook 2003

MINISTRIES ADDRESSING IAS:
- Ministry of Agriculture and Rural development
- Ministry of Fisheries
- Ministry of Science – Technology and Environment

KNOWN TERRESTRIAL IAS OF CONCERN:

giant sensitive plant (*Mimosa Pigra*)	(Minh Tu and Dinh Viet Hong 2002)
golden apple snail (*Pomacea canaliculata*)	(DIAS 1998, Minh Tu and Dinh Viet Hong 2002)

Source: Nuov et al. 2003, Pallewatta et al. 2003, DIAS, FISHBASE

KNOWN INTRODUCED AQUATIC SPECIES that have potentially adverse ecological impacts:

nutria (*Myocastor coypus*)	(Minh Tu and Dinh Viet Hong 2002)
water hyacinth (*Eichhornia crassipes*)	(Harlay et al. 1996)
bighead carp (*Aristichthys nobilis*)	(Masuda et al. 1984)
goldfish (*Carassius auratus auratus*)	(Kottelat et al. 1993)
North African catfish (*Clarias gariepinus*)	(Teugels 1986)
grass carp (*Ctenopharyngodon idella*)	(Shireman and Smith 1983)
silver carp (*Hypophthalmichthys molitrix*)	(Skelton 1993)
smallmouth bass (*Micropterus dolomieu*)	(Scott and Crossman 1973)
Mozambique tilapia (*Oreochromis mossambicus*)	(Trewavas 1982)
Nile tilapia (*Oreochromis niloticus niloticus*)	(Trewavas 1983)
bighead carp (*Aristichthys nobilis*)	(Masuda et al. 1984)

Source: Nuov et al. 2003, Pallewatta et al. 2003, DIAS, FISHBASE

RELEVANT REGULATIONS/LEGISLATION:

1990 – Ministry of Fisheries guidelines for importation of alien species for aquaculture or ornamental purposes

APPENDIX E:
Agreements

Binding Agreements

The following are all relevant international binding agreements that deal with IAS. There are few agreements that directly address IAS in freshwater systems. Adapted from Moore 2003b and Shine et al. 2000.

United Nations Convention on the Law of the Sea (UNCLOS)

http://www.un.org/Depts/los/index.htm

Date of Entry into Force: 16 November 1994

Assessment Countries' Participation:		Signatures:	
	Philippines (8 May 1984) Lao's PDR (5 June 1998) Malaysia (14 October 1996) Vietnam (25 July 1994) Indonesia (3 February 1986) Singapore (17 November 1994)		Cambodia Thailand

Relevant Provisions:

Part XII on "Protection and Preservation of the Marine Environment," Article 196 entitled "Use of technologies or introduction of alien or new species," covers both intentional and unintentional introductions of alien species into the marine environment.

"1. States shall take all measures necessary to prevent, reduce and control pollution of the marine environment resulting from the use of technologies under their jurisdiction or control, or the intentional or accidental introduction of species, alien or new, to particular part of the marine environment, which may cause significant and harmful changes thereto.
2. This article does not affect the application of this Convention regarding the prevention, reduction and control of pollution of the marine environment."

Does not provide for the eradication or control of alien species or the restoration of damaged marine ecosystems.

Section 9 on Responsibility and Liability, Article 235 states,

"1. States are responsible for the fulfillment of their international obligations concerning the protection and the preservation of the marine environment. They shall be liable in accordance with international law.
2. States shall ensure that recourse is available in accordance with their legal systems for prompt and adequate compensation or other relief in respect of damage caused by pollution of the marine environment by natural or juridical persons under their jurisdiction."

Section 4 on Monitoring and Environmental Assessment contains provisions for the monitoring and assessment of activities that could cause harmful changes in the marine environment.

Article 204, Monitoring of the risks or effects of pollution:

"1. States shall, consistent with rights of other States, endeavour, as far as practicable, directly or through the competent international organizations, to observe, measure, evaluate and analyze, by recognized scientific methods, the risks or effects of pollution of the marine environment.
2. In particular, States shall keep under surveillance the effects of any activities which they permit or in which they engage in order to determine whether these activities are likely to pollute the marine environment."

Article 206, Assessment of potential effects of activities:

"When States have reasonable grounds for believing that planned activities under their jurisdiction or control may cause substantial pollution of or significant and harmful changes to the marine environment, they shall, as far as practicable, assess the potential effects of such activities on the marine environment and shall communicate reports of the results of such assessments in the manner provided in article 205."

Section 5 on the International Rules and National Legislation to Prevent, Reduce and Control Pollution of the Marine Environment

Article 209 Pollution from activities in the Area, (1) International rules, regulations and procedures shall be established in accordance with Part XI to prevent, reduce and control pollution of the marine environment from activities in the Area.

Work Program(s):

UNGA/A/54/429 UNCLOS Report to the 54th Session of the UNGA (30 September 1999) "Protection and Preservation of the Marine Environment, Pollution from Vessels." Paragraph 417

UNGA/A/53/456 UNCLOS Report to the 53rd Session of the UNGA (5 October 1998) "Harmful aquatic organisms in ballast water."

Convention of Wetlands of International Importance especially as Waterfowl Habitat (Ramsar, Iran 1971)

http://www.ramsar.org

Date of Entry into Force: 21 December 1975

Assessment Countries' Participation:
Viet Nam (Acceptance 20 January 1989)
Malaysia (Ratification 10 March 1995)
Cambodia (Acceptance 23 October 1999)
Indonesia (Ratification 8 August 1992)
Thailand (Signature 13 September 1998)
Philippines (Acceptance 8 November 1994)

Non-Parties:
Lao PDR (actively considering becoming a party)
Singapore

Relevant Provision(s):

Not specifically mentioned in the Convention.

COP Decision(s):

COP VII – Resolution VII.14 on Invasive Species and Wetlands.

Urged Parties to: address the environmental, economic and social impact of the movement and transport of alien species, inventory alien species in wetlands in their jurisdictions; target IAS for eradication or control; adopt legislation to prevent the introduction and spread of IAS; and build capacity to identify IAS and enforce legislation. It also told the Ramsar Bureau to give priority to addressing IAS in working with other international organizations that are working on wetlands, to develop a data system on IAS that threaten wetlands and prepare case studies where IAS have had negative impact on wetlands and Ramsar sites. The Scientific and Technical Review Panel (STRP) was directed to prepare guidelines for managing IAS in wetlands and collaborate on guidance for legislation and other best management practices.

COP VIII – Resolution VIII.18 on Invasive species and wetlands.

Recognizes the threat IAS pose to wetlands, urges contracting parties to undertake risk assessments of alien species that may pose a threat to wetlands, urges contracting parties to identify the presence of IAS in Ramsar sites and other wetlands in their territory, urges contracting parties with shared wetland, river systems, and coastal/marine zones to cooperate fully in the prevention, early warning in transboundary wetlands, eradication and control of IAS.

Work Program(s):

Ramsar Strategic Plan 2003-2008 refers several times to IAS. Operational Objective 5 calls for the development of guidance and promotion of protocols and actions to prevent, control or eradication IAS in wetlands.

Ramsar and CBD agreed to include IAS as a cross-cutting issue for the third in a series of joint work plans.

Comment(s):

Ramsar uses the "wise use" concept. In 1990 it issued Guidelines for the Implementation of the Wise Use Concept, initially it did not mention IAS. The 1993 version did. The Guidelines now recommend that national legislation should include obligations to "refrain" from intentional introductions of IAS, take preventive measures to minimize the risk of unintentional introductions, make efforts to eradicate introduced species and provide for civil liability for those responsible for unlawful introductions.

Guidelines on management planning for Ramsar sites and other wetlands reference IAS as well.

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

http://www.un.org/law/ilc/texts/nonnav.htm

Date of Entry into Force: Not in force yet

Relevant Provision(s):

Applies to the protection, preservation and management of international watercourses, defined as systems of surface and ground waters that constitute a unitary whole and of which parts are situated in different States (Article 1 and 2).

Recognizes a watercourse State's right to equitably and reasonably use the watercourse and the duty to cooperate to protect and preserve the ecosystems of international watercourses and to develop them sustainably (Articles 5 and 20).

Specific provision on alien species, which addresses only prevention:
"Watercourses States shall take all measures necessary to prevent the introduction of species, alien or new, into an international watercourse which may have effects detrimental to the ecosystem of the watercourse resulting in significant harm to other watercourse States (Article 22)."

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

General obligation not to cause significant harm that requires a State causing significant harm to eliminate or mitigate the harm and to discuss compensation, where applicable (Article 7).

General obligation on Parties to cooperate and to exchange information (Articles 8, 9, 30 and 31). Detailed provisions cover notification for planned and emergency situations (Articles 11-19 and 28).

None of these provisions are alien-specific, but apply generally to all obligations under the Convention.
(Article 12) Purpose of notification to allow potentially affected States evaluate the possible effects of any planned measures.

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

http://globallast.imo.org/index.asp?page=mepc.htm

Date of Entry into Force: Not in Force Yet

Assessment Countries' Participation: N/A

Relevant Provision(s):

Article 2, Sec. 5 calls on the Parties to "undertake to encourage the continued development of Ballast Water Management and Standards to prevent, minimize and ultimately eliminate the transfer of Harmful Aquatic Organisms and Pathogens through the control and management of ships' Ballast Water and Sediments.

Article 4 on the "Control of the Transfer of Harmful Aquatic Organisms and Pathogens Through Ships' Ballast Water and Sediments" calls on each Party to ensure that the ships that fly their flag comply with the requirements of the Convention and each Party shall develop national policies, strategies or programs for Ballast Water Management.

Article 5 "Sediment Reception Facilities" states that each Party will undertake that there are "adequate reception facilities" at all ports and terminals where cleaning or repair ballast tanks occurs. Article 6 covers "Scientific and Technical Research and Monitoring." It calls for Parties to individually or jointly " (a) promote and facilitate scientific and technical research on Ballast Water Management; (b) monitor the effects of Ballast Water Management in waters under their jurisdiction."

Article 7 "Survey and certification" states that "(1) A Party shall ensure that ships flying its flag or operating under its authority and subject to survey and certification are so surveyed and certified in accordance with the regulations in the Annex."

Article 9 "Inspection of Ships" states that "A ship to which the Convention applies may, in any port of offshore terminal of another Party, be subject to inspection by officers duly authorized by that Party for the purpose of determining whether the ship is in compliance with the Convention. Except as provided in Article 10.2, any such inspection is limited to: (a) verifying that there is onboard a valid Certificate, which, if valid shall be accepted; and/or (b) inspection of the Ballast Water Record Book, [and/or (c) a sampling of the ship's Ballast Water, carried in accordance with the guidelines to be developed by the Organization. However, the time required to analyze the samples shall not be used as a basis for unduly delaying the operation, movement or departure of the ship.]

Section B of the Annex outlines the management and control requirements for ships which includes Ballast Water Management Plans, Ballast Water Record Books, Sediment Management for Ships, and Duties of Officers and Crew.

Section D sets Standards for Ballast Water Management and Section B outlines the procedures for survey and certificate requirements for Ballast Water Management.

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

http://www.wcmc.org.uk/cms/

Date of Entry into Force: 1 November 1983

Assessment Countries' Participation: Philippines (1February1995) signatory to the Memorandum of Understanding the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (1 September 2001)

Relevant Provision(s):

Article III specifically refers to IAS,

" (4) Parties that are Range States of a migratory species listed in Appendix I shall endeavour (a) to conserve and, where feasible and appropriate, restore those habitats of the species which are of importance in removing the species from danger of extinction; (b) to prevent, remove, compensate for or minimize, as appropriate, the adverse effects of activities or obstacles that seriously impede or prevent the migration of the species; and (c) to the extent feasible and appropriate, to prevent, reduce or control factors that are endangering or are likely to further endanger the species, including strictly controlling the introduction of, or controlling or eliminating, already introduced exotic species."

Migratory species listed in Appendix II to CMS may be covered under international agreements for their conservation and management (Article IV.1). CMS provides guidelines for these agreements in Article V. Article V, 5(e) states that "conservation and, where required and feasible, restoration of the habitats of importance in maintaining a favorable conservation status, and protection of such habitats from disturbances, including strict control of the introduction of, or control of already introduced, exotic species detrimental to the migratory species;"

Convention Biological Diversity (CBD) (Nairobi, 1992)

www.biodiv.org

Date of Entry into Force: 29 December 1993

Assessment Countries' Participation: Philippines (ratified 8 October 1993)
Singapore (ratified 21 December 1995)
Thailand (ratified 29 January 2004)
Vietnam (ratified 16 November 1994)

Relevant Provision(s):

Article VIII In-Situ Conservation. Each Contracting Party shall, as far as possible and as appropriate:

(g) Establish or maintain means to regulate, manage or control the risks associated with the use and release of living modified organisms resulting from biotechnology which are likely to have adverse environmental impacts that could

affect conservation and sustainable use of biological diversity, taking also into account the risks to human health;
(h) Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species.

COP Decision(s):

Decision IV/1C – "Alien species that threaten ecosystems, habitats and species". Requests the Subsidiary Body on Scientific, Technical and Technological Advice) to develop guiding principles for the prevention, introduction and mitigation of impacts of alien species and to report on those principles and related work program at the 5th COP.

Decision IV/5 "Conservation and sustainable use of marine and coastal biological diversity, including a programme of work"

Decision V/8: "Alien Species that Threaten Ecosystems, Habitats and Species"

VI/23 Alien species that threaten ecosystems, habitats or species set forth Guiding Principles for the Implementation of 8(h)

Work Program(s):

UNEP/CBD/SBSTTA/IV/4. SBSTTA Recommendation IV/4 requesting the Executive Secretary to develop, in cooperation with the Global Invasive Species Programme, principles for the prevention, introduction and mitigation of impacts of alien species, for consideration by the Subsidiary Body at its 5th Meeting.

UNEP/CBD/SBSTTA/V/4 – "Guiding Principles for the Prevention, Introduction and Mitigation of Impacts of Alien Species."

Cartagena Protocol on Biosafety to the CBD

http://www.biodiv.org/biosafety/default.aspx

Date of Entry into Force: 11 September 2003

Assessment Countries' Participation: Cambodia (accession 16 December 2003)
Indonesia (signed 24 May 2000)
Malaysia (ratified 2 December 2003)

Relevant Provision(s):

Article IV "This Protocol shall apply to the transboundary movement, transit, handling and use of all living modified organisms that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health." Living modified organism is defined as "any living organism that possesses a novel of combination of genetic material obtained through the use of modern biotechnology;" (An LMO could be defined as an IAS but an IAS is not necessarily an LMO. Cartagena was negotiated separately from article 8h which addresses IAS.)

Association of South East Asian Nations (ASEAN) Agreement on the Conservation of Nature and Natural Resources, (Kuala Lumpur 1985)

http://sedac.ciesin.org/entri/texts/asean.natural.resources.1985.html

Date of Entry into Force: Adopted, but not yet in force

Assessment Countries' Participation: N/A

Relevant Provision(s):

Contains obligations related to alien species along with other general obligations for transboundary cooperation that could be applied to movements of alien species.

Article 3.3.c – obligates countries to regulate or prohibit the introduction of exotic species, in the context of conserving marine and freshwater species genetic diversity.

Article 13.5(a) prohibits the introductions of exotic species in protected areas.

Articles 14 and 20.3(a) require prior assessment of the consequences of any activity that may significantly affect the natural environment both domestically in other countries.

Article 20 – Parties have a general obligation to take no action that may significantly affect the environment or natural resources of other countries, especially wildlife habitat.

Articles 18 and 20 require prior notification of actions that are likely to have significant impact beyond national boundaries and notification of emergency situations is also required and there is a general obligation to cooperate in monitoring activities.

World Trade Organization

http://www.wto.org/

Date of Entry into Force: 1 January 1995

Assessment Countries' Participation:

Members:	Indonesia	(1 January 1995)
	Malaysia	(1 January 1995)
	Philippines	(1 January 1995)
	Thailand	(1 January 1995)
	Singapore	(1 January 1995)
Observers:	Cambodia	
	Lao PDR	
	Viet Nam	

Relevant Provision(s):

Article XX of the General Agreement on Tariffs and Trade (GATT) has two exceptions to GATT rules that could be applied with regard to alien species Article XX(b) for the protection of human, plant or animal life or health; and Article XX (g) for the conservation of exhaustible natural resources.

WTO's binding dispute resolution system seeks to either remove or amend any trade-related measure that is inconsistent with WTO rules. To defend an exception for the protection of human, plant or animal life or health, as allowed under Article XX(b), a WTO Member has to demonstrate that "the policy objective behinds its measures falls within the range of policies for the purpose, that the measure is necessary to meet the policy objective, and that there are no reasonably available alternatives that are consistent with WTO rules." "An exception for the conservation of exhaustible natural resources must fall within the range of related policies, be related to the conservation policy objective, and be made in conjunction with restrictions on domestic production or consumption. To qualify for either of these exemptions, a WTO member must also show that its measure is being applied in a way that is neither arbitrary, unjustifiable, nor a disguised restriction on trade."

Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington, DC 1973)

http://www.cites.org

Date of Entry into Force: 1 July 1975

Assessment Countries' Participation:

Cambodia	(ratification 2 October 1997)
Indonesia	(accession 28 December 1978)
Malaysia	(accession 18 January 1978)
Philippines	(ratification 16 November 1981)
Singapore	(accession 28 February 1987)
Thailand	(ratification 21 April 1983)
Vietnam	(accession 20 April 1994)

Relevant Provision(s):

Permits and certificates under the provisions of Article III, IV and V are required for the trade in specimens of species included in Appendix I, II and III.

"Represents alternate model for regulating invasive species not already covered by the IPPC or other agreements. Convention intended to prevent harm in *exporting* country; however, can only be applied when species is endangered in exporting country and considered an invasive in importing country. Regulates only intentional movements."

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (Marakech, 1995)

http://www.wto.org/english/tratop_e/sps_e/sps_e.htm

Date of Entry into Force: 1 January 1995

Assessment Countries' Participation: Indonesia
Malaysia
Philippines
Thailand
Singapore

Relevant Provision(s):

A supplementary agreement to the WTO Agreement. Provides a uniform framework for measures governing phytosanitary measures for human, plant and animal life or health. Sanitary and phytosanitary measures are defined as any measure applied a) to protect human, animal or plant life or health (within the Member's Territory) from the entry, establishment or spread of pests, diseases, disease carrying organisms; b) to prevent or limit other damage (within the Member's Territory) from the entry, establishment or spread of pests.
Deals with import/entry of pests and measures to control their establishment or spread.

Annex A, Definitions

"1. Sanitary or phytosanitary measure – Any measure applied: (a) to protect animal or plant life or health within the territory of the Member from risks arising from the entry, establishment or spread of pests, diseases, disease-carrying organisms or disease-causing organisms; (b) to protect human or animal life or health within the territory of the Member from risks arising from additives, contaminants, toxins or disease-causing organisms in foods, beverages or feedstuffs; (c) to protect human life or health within the territory of the Member from risks arising from diseases carried by animals, plants or products thereof, or from the entry, establishment or spread of pests; or (d) to prevent or limit other damage within the territory of the Member from the entry, establishment or spread of pests." The term "animal" includes fish and wild fauna, "plant" includes forests and wild flora, "pests" include weeds; and "contaminants" include pesticide and veterinary drug residues and extraneous matter.

Article II on "Basic Rights and Obligations" state that

"1. Members have the right to take sanitary and phytosanitary measures necessary for the protection of human, animal or plant life or health, provided that such measures are not inconsistent with the provisions of this Agreement.
2. Members shall ensure that any sanitary or phytosanitary measure is applied only to the extent necessary to protect human, animal or plant life or health, is based on scientific principles and is not maintained without sufficient scientific evidence, except as provided for in paragraph 7 of Article 5.
3. Members shall ensure that their sanitary and phytosanitary measures do not arbitrarily or unjustifiably discriminate between Members where identical or similar conditions prevail, including between their own territory and that other Members. Sanitary and phytosanitary measures shall not be applied in a manner which would constitute a disguised restriction on international trade."

Article V outlines the "Assessment of Risk and Determination of the Appropriate Level of Sanitary or Phytosanitary Protection." Decisions are based on risk assessment using available scientific evidence, in situations where evidence is insufficient members "may provisionally adopt sanitary or phytosanitary measures on the basis of available pertinent information . . . In such circumstances, Members shall seek to obtain the additional information necessary for a more objective assessment of risk and review the sanitary or phytosanitary measure accordingly within a reasonable period of time." Fifteen months has in practice become the "reasonable period of time."

International Plant Protection Convention (IPPC)

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

Entered into Force: (3 April 1952)

Assessment Countries' Participation:		
	Cambodia	(Adherence 10 June 1952)
	Indonesia	(Ratification 21 June 1977)
	Lao PDR	(Adherence 28 February 1955)
	Malaysia	(Adherence 17 May 1991)
	Philippines	(Ratification 3 December 1953)
	Thailand	(Ratification 16 August 1978)

Relevant Provision(s):

In 1997, amendments were made to the IPPC to bring it into line with the 1995 WTO SPS Agreement, it is currently not in force.

Applies mainly to quarantine pests in international trade. Creates an international regime to prevent spread and introduction of plant and plant product pests premised through the use of sanitary and phytosanitary measures. Parties have established national plant protection organizations with authority in relation to quarantine control, risk analysis and other measure required to prevent the establishment and spread of pests that, directly or indirectly, are pests of plants and plant products.

"The governing body of the IPPC is one of three international organizations recognized under the WTO SPS Agreement as a standard-setting body, which gives IPPC standards effect beyond the Convention's own Parties. WTO Member States, whether IPPC Parties or not, must pattern their phytosanitary standards on those set by the IPPC. IPPC focuses on human, plant and animal health and safety, rather than on ecosystem integrity."

COP Decision(s):

- International Standards for Phytosanitary Measures
- Principles of Plant Quarantine as Related to International Trade
- Guidelines for Pest Risk Analysis
- Code of Conduct for the Import and Release of Exotic Biological Control Agents
- Requirements for the Establishment of Pest Free Areas
- Glossary of Phytosanitary Terms
- Guidelines for Surveillance
- Export Certification System
- Determination of Pest Status in an Area
- Guidelines for Pest Eradication Programmes
- Requirements for the Establishment of Pest Free Places of Production and Pest Free Production Sites

Work Program(s):

Report of the meeting Interim Commission on Phytosanitary Measures Exploratory Working Group on Phytosanitary Aspects of GMOs, Biosafetey and Invasive Species, Rome, June 2000.

Regional Binding Agreements

Plant Protection Agreement for the Asia and Pacific Region

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

Date of Entry into Force: 2 July 1956

Assessment Countries Status:	Cambodia	(Adherence 27 January 1969)
	Indonesia	(Ratification 21 December 1967)
	Lao PDR	(Ratification 17 March 1960)
	Malaysia	(Adherence 20 November 1957)
	Philippines	(Adherence 11 June 1962)
	Thailand	(Adherence 26 November 1956)
	Vietnam	(Definitive Signature 2 July 1956)

Relevant Provision(s):

Seeks to prevent the "introduction into and spread within the South East Asia and Pacific Region of destructive plant diseases and pests . . ."

Article I (b) defines "plant" or "plants" as "all species of plants or parts thereof, whether living or dead (including stems, branches, tubers, bulbs, corms, stocks, budwood, cuttings, layers, slips, suckers, roots, leaves, flowers, fruits, seeds and any other parts of plants);

Article II outlines Regional Committee that determines the procedures and arrangements for implementation of the Agreement. The Committee reviews all reports submitted Contracting Governments

Article III on the "Measures Regarding the Importation of Plants from Outside the Region" states that "For the purpose of preventing the introduction into its territory or territories of destructive diseases and pests, and in particular those listed in Appendix A to this Agreement, each Contracting Government shall use its best endeavours to apply with respect to the importation of any plants, including their packings and containers, and any packing and containers of plant origin, from anywhere outside the Region, such measures of prohibition, certification, inspection, disinfection, disinfestations, quarantine, destruction or other measures as may be recommended by the Committee, taking into consideration the provisions of Article V and VI of the International Plant Protection Convention."

Article V entitled "Measures Regarding Movement of Plants within the Region" states each Contracting Government "shall use its best endeavours to apply, with respect to the importation into its territory of any plants, including packings and containers, and any packings and containers of plant origin, from another territory within the Region, such measures or prohibition certification, inspection, disinfection, disinfestations, quarantine, destruction or other measures as may be recommended by the Committee, in addition to measures already adopted by each Contracting Government."

This agreement does not apply to plants imported for food or "for analytical, medicinal or manufacturing purposes; (b) all seeds of annual, or biennial field crops or vegetables, and all seeds or cut flowers of annual, biennial or perennial ornamental plants which are essentially herbaceous in character; and (c) any processed plant products."

Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin

http://www.mrcmekong.org/pdf/95%20Agreement.pdf

Date of Entry into Force: 5 April 1995

Assessment Countries Status:	Cambodia
	Lao PDR
	Thailand
	Vietnam

Relevant Provision(s):

Article 7 Prevention and cessation of harmful effects, "To make every effort to avoid, minimize and mitigate harmful effects that might occur to the environment, especially the water quantity and quality, the aquatic (ecosystem) conditions, and ecological balance of the river system, from the development and use of the Mekong River Basin water resources or discharges of wastes and return flows. Where one or more States is notified with proper and valid evidence that it is causing substantial damage to one or more riparians from the use of and/or discharge to water of the Mekong River, that State or States shall cease immediately the alleged cause of harm until such cause of harm is determined in accordance with Article 8."

Work Program(s):

In addition to the management of capture fisheries and the development of the AIMS program, MRC has conducted environmental monitoring throughout the Mekong basin. The Fisheries Programme has found that alien species are present in the basin, but has not observed significant impacts from them. The Environment Programme has found that *Mimosa pigra* is a problem around the Tonle Sap in Cambodia and in parts of Vietnam. Golden apple snail (*Pomacea canaliculata*) is also a problem for all of the lower riparian countries. At present the MRC's Environment Programme has not conducted any basin wide assessments of IAS, however there are plans to use radar on aerial flights to determine the extent of *Mimosa pigra* infestation.

Non-Binding (Soft-Law) Instruments, Guidelines and Best Management Practices

International Maritime Organization www.imo.org

Instrument:

IMO Resolution A.868(20) 1997 Guidelines for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens. Appendix 2: Guidance on safety Aspects of Ballast Water Exchange at Sea.

IMO Resolution A.74 (18) 1991: Guidelines for preventing the Introduction of Unwanted Organisms and pathogens from Ships' Ballast Water and Sediment Discharges.

Purpose:

All Member State Governments, ship operators, other appropriate authorities and interested parties are requested to apply these Guidelines. They provide guidance and strategies to minimize risk of unwanted organisms and pathogens from ballast water and sediment discharge.

Work Program:

Marine Environment Protection Committee Working Group – Draft International Convention for the Control & Management of Ships' Ballast Water and Sediments, MEPC 44/4, 2 December 1999. The proposed instrument is intended to address the environmental damage caused by the introduction of harmful aquatic organisms in ballast water, used to stabilize vessels at sea.

In July 2000, a Global Task Force convened by the IMO in coordination with United Nations Development Programme (UNDP) and the Global Environment Facility (GEF). The Task Force launched the Global Ballast Water Management Programme ("Globallast") as a concerted response to the problem of harmful marine organisms.

United Nations Conference on Environment and Development www.un.org

Instrument:

Agenda 21 (UNCED, 1992) http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21toc.htm

Purpose:

Chapter 15 Conservation of Biological Diversity

15.3 Acknowledgement that the inappropriate introduction of foreign plants and animals has contributed to the loss of the world's biological diversity and continues.

15.4 (h) Implement mechanisms for the improvement, generation, development and sustainable use of biotechnology and its safe transfer, particularly to developing countries, taking account the potential contribution of biotechnology to the conservation of biological diversity and the sustainable use of biological resources.

Chapter 16 Environmentally Sound Management of Biotechnology

16.3(a) Increase to the optimum possible extent the yield of major crops, livestock, and aquaculture species.

16.3(c) Increase the use of integrated pest, disease and crop management techniques to eliminate overdependence on agro-chemicals, thereby encouraging environmentally sustainable agricultural practices.

16.23 (f) Develop processes to increase the availability of planting materials, particularly indigenous varieties, for use in afforestation and reforestation and to improve sustainable yields from forest.

16.23(h) Promote the use of integrated pest management based on judicious use of bio-control agents.

16.32 Internationally agreed principles on risk assessment and management needed for all aspects of biotechnology.

Chapter 17 Protection of the Oceans, all kinds of Seas, Including Enclosed and Semi-enclosed Seas, and Coastal Areas and the Protection, Rational Use and Development of their Living Resources.

17.30(vi) States to assess individually, regionally and internationally, within IMO and other relevant international organizations, need for adopting appropriate rules on ballast water discharge to prevent spread of non-indigenous organisms.

17.79(c) (d) Strengthen the legal and regulatory framework for mariculture and aquaculture.

17.83 Analyze aquaculture's potential and apply appropriate safeguards for introducing new species.

Chapter 18 Protection of the Quality and Supply of Freshwater Resources: Application of Integrated Approaches to the Development, Management and Use of Water Resources

18.40 (e)(iv) control of noxious aquatic species that may destroy other water species.

IUCN – The World Conservation Union www.iucn.org

Instrument:

IUCN Guidelines for the Prevention of Biodiversity Loss Caused by Alien Invasive Species (2000)

Purpose:

Guidelines designed to increase awareness and understanding of the impact of alien species. Provides guidelines for: prevention, eradication, control and reintroduction.

Work Program:

Invasive Species Specialist Group, IUCN Species Survival Commission

Instrument:

IUCN Guidelines for Reintroductions (1995)

Purpose:

Guidelines on the introduction of endangered species. Mentions nonindigenous species as a threat to reintroduction, but also recognizes potential dangers of re-introduction itself.

Work Progam:

Re-introduction Specialist Group, IUCN Species Survival Commission

Instrument:

IUCN Position Statement on Translocation of Living Organisms: Introductions, Reintroductions, and Re-stocking (1987)

Purpose:

This IUCN statement describes the advantageous uses of translocations and the work and precautions needed to avoid the disastrous consequences of poorly planned translocations.

Work Program:

IUCN Species Survival Commission

Food and Agriculture Organization of the United Nations www.fao.org

Instrument:

Code of Conduct for Responsible Fisheries (1995) (http://www.fao.org/fi/agreem/codecond/codecon.asp)

Purpose:

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

Article 9.3.3 States should, in order to minimize risks of disease transfer and other adverse effects on wild and cultured stocks, encourage adoption of appropriate practices in the genetic improvement of broodstocks, the introduction of alienspecies, and in the production, sale and transport of eggs, larvae or fry, broodstock or other live materials. States should facilitate the preparation and implementation of appropriate national codes of practice and procedures to this effect. Sets out principles and international standards of behavior for responsible fishing practices, including aquaculture. The aim is to ensure effective conservation, management and development of living aquatic resources, respecting ecosystems and biodiversity. Legal and administrative frameworks are encouraged to facilitate responsible aquaculture. Pre-introduction discussion with neighboring states when non-indigenous stocks are to be introduced into transboundary aquatic ecosystems. Harmful effects of non-indigenous and genetically altered stocks to be minimized especially where significant potential exists for spread into other states or country of origin. Adverse genetic and disease effects to wild-stock from genetic improvement and non-indigenous species to be minimized; environmental damage to importing and exporting states exists; FAO to develop implementation guidelines.

Instrument:

Code of Conduct for the Import and Release of Exotic Biological Control Agents (1995) (http://www.fao.org/docrep/x5585E/x5585e0i.htm)

Purpose:

The Code aims to facilitate the safe import, export and release of exotic biological control agents by introducing procedures of an international level for all public and private entities involved, particularly where national legislation to regulate their use does not exist or is inadequate. Standards are described that promote the safe use of biological control agents for the improvement of agriculture, and human, animal and plant health.

Instrument:

Precautionary approach to fisheries (http://www.fao.org/DOCREP/003/V8045E/V8045E00.HTM)

Purpose:

Section 1. Precautionary Approach and Burden of Proof

6. “The precautionary approach involves the application of prudent foresight. Taking account of the uncertainties in fisheries systems and the need to take action with incomplete knowledge, it requires, *inter alia*:

a. consideration of the needs of future generations and avoidance of changes that are not potentially reversible;
b. prior identification of undesirable outcomes and of measures that will avoid them or correct them promptly;
c. that any necessary corrective measures are initiated without delay, and that they should achieve their purpose promptly, on a timescale not exceeding two or three decades;
d. that where the likely impact of resource use is uncertain, priority should be give to conserving the productive capacity of the resource;”

Section 6. Precautionary Approach to Species Introduction

104. “Because of the high probability that impacts of species introduction be of irreversible and unpredictable impacts, many species introductions are not precautionary. Therefore, a strictly precautionary approach would not permit deliberate introductions and would take strong measures to prevent unintentional introductions. Recognizing the difficulties with introductions, the objectives of a precautionary approach to species introductions in relation to capture fisheries should be to reduce the risk of adverse impacts of introductions on capture fisheries, to establish corrective or mitigating procedures

(as in contingency plan) in advance of actual adverse effects, and to minimize unintended introductions to wild ecosystems and associated capture fisheries.

105. In relation to aquaculture, experience has shown that animals will usually escape the confines of a facility. As a consequence, the introduction of aquatic organisms for aquaculture should be considered as a purposeful introduction into the wild, even though the quarantine/hatchery facility may be closed system.

106. Introduction and transfers (hereafter referred to as introductions) are an effective means to increase protein, generate income and provide employment. However, some intended and many unintended introductions may result in significant and serious impacts on capture fisheries. The numbers of unintended introductions, for example by means of ballast water, greatly outnumber those purposefully introduced for capture fisheries. In the case of introduced species for fishery purposes, the risk to capture fisheries can be reduced by the use of internationally accepted codes, such as the 1994 ICES Code of Practice. This code forms a basis for a more precautionary introduction and should be widely circulated and explained.

107. For a precautionary approach to fishery management, irreversible changes in the time scale of human generations and other undesirable impacts should be avoided, taking into account uncertainty. Species introduction, either purposeful and or unintended, may be such undesirable effects. Once a species has been introduced, it cannot usually be eradicated, although it may be possible to mitigate its undesirable effects.

110. Unintended introductions are inherently unprecautionary because they can rarely be evaluated in advance. A precautionary approach would aim at reducing the risk of such unintended introductions and minimize their impact."

Instrument:

Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals and the Beijing Consensus and Implementation Strategy (FAO Fisheries Technical Paper 402) (http://www.fao.org/DOCREP/005/X8485E/X8485E00.HTM)

Purpose:

Provides guidelines for developing a list of pathogens, diagnosing diseases, implementing effective programs for health certification and quarantine measures for aquatic animals. Develops guidance for creating disease zones and monitoring and reporting new diseases. Outlines the development of contingency plans. Details the importance of risk analysis and need for national strategies and policy frameworks.

American Fisheries Society (AFS) www.fisheries.org

Instrument:

North American Fisheries Policy (1995) (http://www.fisheries.org/html/Public_Affairs/Policy_Statements/ps_1.shtml)

Purpose:

Article V. Aquaculture facilities and practices should have minimal impact on natural aquatic environments and populations. Aquaculture must work closely with federal, state, and provincial regulators to control epizootic disease outbreaks, to prevent the release of exotic species into the wild. Where possible, federal, state, and provincial managers will encourage the aquaculture industry to use indigenous species in its facilities.

WorldFish Center, Technical Centre for Agricultural and Rural Cooperation, FAO, IUCN, CBD, and UNEP www.cta.nl

Instrument:

Nairobi Declaration (http://www.cta.nl/pubs/nairobi/declaration.pdf)

Purpose:

The Declaration put forward ten recommendations on how to promote aquaculture without compromising biodiversity. The recommendations ranging from seed quality to information sharing.

Recommendation three called for "responsible introductions", which states that, "Introductions of fish, including genetically improved strains and alien species, may have a role in the development of aquaculture. Any movement of fish between natural ecological boundaries (e.g. watersheds) may involve risk to biodiversity and there is need for refinement and wider application of protocols, risk assessment methods, and monitoring programs for introductions of fish, including genetically improved strains and alien species. States have an important responsibility in the development and implementation of such protocols and associated regulations, the establishment of clear roles and responsibilities, and capacity building. Such efforts should be linked to obligations pursuant to the Code of Conduct for Responsible Fisheries, the Convention on Biological Diversity, and other relevant international agreements (Nairobi 2002)."

Recommendation four called for the conservation of wild stocks through the identification of "priority areas" that should be managed "as conservation areas in which introductions of alien species and genetically improved strains should be prevented (Nairobi 2002)."

Recommendations eight and nine called for awareness raising and engaging stakeholders.

Recommendation ten on liability for adverse environmental recognizes that, "although an economic benefits can be derived through the use of alien and/or genetically improved species in aquaculture, in many cases, those to whom benefits accrue do not bear the costs associated with adverse environmental impacts. In view of this, there should be provision for liability; compliance (e.g., incentives) and restoration within policies and legislation concerning the movement and use of alien and genetically improved fish species in aquaculture (Nairobi 2002)."

While the Declaration is non-binding it has laid the ground for future policies and regulations on aquaculture with respect to biodiversity.

Florida Department of Agriculture and Consumer Services www.floridaaquaculture.com

Instrument:

Aquaculture Best Management Practices (http://www.floridaaquaculture.com/BAD/bmp_rule.pdf)

Purpose:

Provides best management practices for the construction, monitoring, ship, transportation and sale of aquaculture species. Section VII on non-native and restricted non-native species gives specific guidelines on non-native species containment and restricted non-native species containment. Section VIII outline health best management practices for aquaculture species.

U.S. Aquatic Nuisance Species Task Force www.anstaskforce.gov

Instrument:

Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process (http://www.anstaskforce.gov/gennasrev.htm)

Purpose:

Section II outlines the process for conducting pathway analyses and organism risk assessments.

U.S. National Aquaculture Association www.natlaquaculture.org

Instrument:

Non-Indigenous Species Policy (http://www.natlaquaculture.org/Policies.htm#Non-Indigenous%20Aquatic%20Species)

Purpose:

A six point policy that acknowledges the benefits and risks associated with non-indigenous species. Supports the "design and implementation of any reasonable plan or effort to minimize the risk of introduction or dissemination of unknown or clearly desirable aquatic nuisance species."

Demands that regulations/decisions on aquatic species be based on science and that laws/regulations to prevent the introduction or dissemination of "unknown and undesirable non-indigenous species neither supplant current laws and regulations which provide for the free and essential movement of aquaculture products . . ."

Australian Department of Agriculture, Fisheries and Forestry (AFFA) www.affa.gov

Instrument:

Australia's National Policy for the Translocation of Live Aquatic Organisms – Issues, Principles and Guidelines for Implementation (http://www.affa.gov.au/corporate_docs/publications/pdf/fisheries/translocation.pdf)

Purpose:

Sets forth framework to assess the potential risks associated with the movement of live aquatic organisms. Requires agreement of all jurisdictions prior to a translocation. All translocations should be based on "balanced risk assessment." Outlines risk assessment process.

Second International Symposium on the Management of Large Rivers for Fisheries www.lars2.org

Instrument:

LARS Statement & Recommended Actions (http://www.lars2.org/Statement_and_Actions_Required.pdf)

Purpose:

"Rehabilitate degraded ecosystems where possible. Prioritize schemes that ensure connectivity and protection of critical habitats."

APPENDIX F:
Overview of USAID Sponsored Aquaculture Programs

USAID Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP)

Interviewed:

Dr. Remedios Bolivar, Central Luzon State University, PD/A Principal Investigator
Dr. Ms. Ms. Danielle Z. Clair, Assistant Director of Operations, PD/A CRSP
Dr. Hillary Egna, Director, PD/A CRSP
Dr. Chris Kohler, Southern Illinois University, PD/A Principal Investigator
Dr. Susan Kohler, Southern Illinois University, PD/A Principal Investigator
Dr. Yang Yi, Asian Institute of Technology, PD/A Principal Investigator

Through USAID's Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP), U.S. scientists collaborate with scientists in over twenty countries. Current PD/A CRSP countries include Bangladesh, Bolivia, Brazil, Cambodia, Colombia, Ecuador, El Salvador, Ghana, Honduras, Indonesia, Kenya, Laos, México, Nepal, Nicaragua, Panama, Peru, the Philippines, South Africa, Tanzania, Thailand, and Vietnam. Six of the focus countries for this assessment are also PD/A CRSP countries – Cambodia, Laos, Indonesia, the Philippines, Thailand and Vietnam. The PD/A CRSP mission is to enrich livelihoods and promote health by cultivating international multidisciplinary partnerships that advance science, research, education, and outreach in aquatic resources.

PD/A CRSP investigators work to improve production efficiency, research the use of new species for aquaculture, and strengthen the capacity of National Agricultural Research Systems (CRSP 2002b). The eleventh Work Plan has a three-pronged approach, including production technology, watershed management, human welfare, health, and nutrition. Within these three areas of emphasis, specific investigations fall under eleven themes (see below). These themes were developed at regional stakeholder and expert panel meetings designed to identify constraints to aquaculture in developing countries.

PD/A CRSP Research Themes	
Environmental Impacts Analysis	Applied Technology and Extension Methodologies
Sustainable Development and Food Security	Seedstock Development and Availability
Production System Design and Integration	Disease, Predation Prevention, and Food Safety
Indigenous Species Development	Fish Nutrition and Feed Technology
Water Quality and Availability	Aquaculture and Human Health Impacts
Economic/Risk Assessment and Social Analysis	

PD/A CRSP research involves both native and alien species. According to the PD/A CRSP Management Entity, their investigators have not been responsible for the introduction of new species, but have rather worked to develop appropriate technologies for aquaculture in a sustainable, ecologically appropriate manner. Recent studies examine the potential for use of native species in aquaculture production to replace carp culture in Asia, for example (CRSP 2003)[1]. The majority of PD/A CRSP researchers conduct their research in closed ponds, although some researchers conduct their research in pens in rivers or in pens in open ponds (Clair 2003, Gutierrez 2003) where escapes are possible.

Several of USAID's projects in Southeast Asia have focused on improving the production efficiency or reducing environmental effluents of alien tilapia (*Oreochromis niloticus*), a species in which significant controversy exists regarding its invasiveness. In some parts of the world tilapia has clearly out competed native species. However, the lack of long-term monitoring of tilapia in Southeast Asia's lakes, reservoirs, and rivers make it difficult to determine the impacts on native biodiversity (see Appendix G). The paucity of data, however, must not be viewed as an indication that tilapia is harmless, but rather that significant information gaps need to addressed.

"USAID needs to substantially increase its programmatic emphasis and enlarge its financial and human resource commitments to global fisheries and aquaculture (USAID SPARE 2003)."

The PD/A CRSP Management Entity has stated in a written letter to the authors that, "in the project identified above, the outcome of the project is to improve a culture technique from an ecosystem and human health standpoint. Tilapia culture is prominent throughout the region, and it is important that if this species continues to be cultured (regardless of CRSP work), that it be done in a manner that is most beneficial for the local ecosystem. The CRSP does and will continue to sponsor work on examining alternative, native species for culture in Southeast Asia and throughout the rest of the world. CRSP agrees that tilapia culture can be deleterious, and extreme caution must be taken even when working with extant alien populations (Egna 2004)."

The Management Entity of PD/A CRSP asserts that principal investigators abide by U.S. National Environmental Policy Act (NEPA) and the laws and regulations of each country that they are working in. USAID headquarters in Washington, D.C. oversees PD/A CRSP. The Washington, D.C. office is responsible for coordinating with the National Invasive Species Council on the implementation of Executive Order (EO) 13112 which, in Section 2, calls for each Federal agency to identify actions that may affect IAS, undertake prevention of their introduction, detect and respond rapidly, control such species, monitor invasive populations, conduct research on IAS, and educate the public on IAS. Section 3 states that Federal agencies shall, "not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless . . . the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measure to minimize risk of harm will be taken in conjunction with the actions (EO13112 1999)." The EO 13112 clearly mandates that Federal agencies take steps to ensure that activities they sponsor do not serve as pathways for IAS. The USAID Fisheries program did not determine if adjustments should be made to their programs following adoption of the EO. When concerns have been raised about PD/A CRSP sponsored activities, the Management Entity or USAID field offices have responded when the concerns seemed credible to them. For example, the USAID field office in Nicaragua has decided to conduct training on best management practices for use of alien species after concerns were raised about tilapia aquaculture (Olive 2003). Moreover, PD/A CRSP, in collaboration with institutions in host countries, has conducted best management practices trainings and workshops for thousands of individuals throughout the life of the program. These trainings are constantly updated with new findings and consistent with the mission of the program and USAID.

In addition to domestic guidelines on IAS, USAID has supported the development and implementation of FAO's Code of Conduct on Responsible Fisheries. According to the Management Entity, at the last PD/A CRSP Technical Committee Meeting in March 2004, attendees revisited the FAO's Code of Conduct on Responsible Fisheries (CCRF, see Appendix E). PD/A CRSP participants and the Technical Committee agreed that the CCRF is useful in making programmatic decisions related to the future direction of the PD/A CRSP and has been informally using it for many years.

A recent "Review of the Status, Trends and Issues in Global Fisheries and Aquaculture, with Recommendations for USAID Investments" conducted by the Strategic Partnership for Agricultural Research and Education (SPARE) recommended several strategies for USAID fisheries and aquaculture activities, and highlighted several gaps that need to be addressed (USAID SPARE 2003). One

[1] While indigenous aquaculture is preferable to potentially invasive alien species, which could out compete native species, indigenous aquaculture is not without risk. The genetic makeup of the native populations could be altered due to the escape of cultured native species.

gap that was identified several times was consistent and adequate funding. This will be one of the most important factors in the continued development of ecologically sensitive aquaculture.

Recommendation six of the review states that USAID should take a holistic approach that considers the ecosystem, local economy, and the community as an integral part of program and research development[2]. The subsequent recommendation (7)[3] advises that USAID develop strategic plans and "regular impact assessments of an expanded fisheries and aquaculture portfolio," as well as recommends that USAID missions and regions include fisheries and aquaculture in their strategic plans. Thus far, there have not been any studies to evaluate the possibility that PD/A CRSP sponsored projects have contributed to the loss of biodiversity or ecosystem services. Funding is a major constraint of PD/A CRSP, and financial limitations hinder development of more indigenous aquaculture projects and monitoring.

Despite the advances in policy at PD/A CRSP offices in the U.S., it is not clear that the Management Entity is well aware of all of the activities of its principal investigators and we found in one instance that the U.S.-based offices provided information contrary to what was observed in the field. Furthermore, because the principal investigators are grant recipients rather than employees of PD/A CRSP, their approach can vary significantly. Clearly PD/A CRSP and USAID need to continue to integrate IAS awareness and prevention into its programs across biodiversity, water, sanitation, humanitarian assistance, economic growth, and trade projects.

Case Study on the development of indigenous aquaculture program by a PD/A CRSP Principal Investigator.
Source: Kohler and Kohler 2003.

Over the last six to eight years a handful of PD/A CRSP researchers have initiated work with native species for use in aquaculture. Peru has been the site of an innovative program to develop the broodstock for the indigenous aquaculture of *Colossoma macropomum*, *Arapaima gigas*, and *Piaractus brachypomus*. The project is aimed at providing subsistence farmers with a profitable cash crop, as well as fish for some local consumption. Through the cultivation of these fish, the communities have been able to develop a steady source of income and take up residence in a single location. The PD/A CRSP researchers have worked to develop a very active extension program, and are training a master aquaculturist who will in turn train other aquaculturists in their community.

The native fish are cultivated in pens in the river and fed local fruits and plant materials. These species grow up to 1 kg in one year. They are usually marketed at approximately 1 kg. They do not reach sexual maturity until four years of age when they weigh approximately four to five kilograms. Since, the farmers harvest the fish prior to sexual maturity, unwanted population growth is not a problem. The fish can survive poor water quality and low oxygen level in the water. Because *Colossoma macropomum*, *Arapaima gigas*, and *Piaractus brachypomus* have not been previously domesticated and the cultivation is for the community only and not for commercial level aquaculture, at the moment, there is no concern about the integrity of the genetic stock. Currently, the government is the sole producer of the stock seed, and thus the distribution is well controlled.

The PD/A CRSP project in Peru demonstrates that indigenous aquaculture programs can be a sustainable way of addressing food security and minimizing the risks of IAS. This project serves as a model for future PD/A CRSP projects in Southeast Asia.

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[2] Recommendation six "prioritize its assistance to fisheries and aquaculture activities that are more integrated, comprehensive, community-based, and use 'system approaches' – such as ecological and integrated farming/fishing systems research and extension approaches – in both rural and urban settings. The current agriculture emphasis of USAID is on plant commodity research, not on comprehensive, agro/aqua-ecosystems research/extension approaches. We urge the USAID to support long-term, applied research and development that makes expanded use of participatory ecological and social science tools to empower community control of fisheries and aquaculture systems; and to better integrate aquaculture and fisheries activities into the comprehensive management of natural and social resources of its missions, target nations and regions USAID SPARE, F. A. P. 2003. Review of the Status, Trends and Issues in Global Fisheries and Aquaculture, with Recommendations for USAID Investments. US Agency for International Development, Washington, DC.."

[3] "USAID needs to develop comprehensive strategic and implementation plans and regular impact assessments of an expanded fisheries and aquaculture portfolio. USAID missions and regions should include fisheries and aquaculture into their strategic plans for the comprehensive management of natural resources – or they will be incomplete – especially in regards to USAID plans for involvement in the issues of water allocation and quality, and plans for the management of marine and inland coastal areas Ibid.."

Peace Corps

Interviewed:

Ms. Susan Johnson, Peace Corps

Ms. Michele Thieme, World Wildlife Fund

Peace Corps projects have been linked to the introduction of alien species that are potentially invasive in Africa. In 2000, a letter was written to the Peace Corps from several scientists who were concerned that the Peace Corps was introducing potential invasive fish species (Bills et al. 2000). Current Peace Corps staff were unaware of the letter and no documentation is available to determine how the organization responded in 2000. However, some biologists in the region have apparently continued to express concern over the Peace Corps introduction of tilapia in Africa. Peace Corps documents pertaining to Southeast Asia failed to provide adequate information on projects involving alien species. It was thus impossible to determine where and how alien species are being used, and whether risk assessments or monitoring programs are being instituted.

Mekong River Commission's Aquaculture of Indigenous Mekong fish Species

Interviewed:

Dr. Chris Barlow, Fisheries Programme Manager, Mekong River Commission

Dr. Niklas Matson, Aquaculture of Indigenous Mekong Fish Species, Mekong River Commission

The lower basin of the Mekong River (Cambodia, Laos, Thailand, and Vietnam) is populated by approximately 60 million people, the majority of whom derived their income from agriculture and fishing. In 1995, the four lower basin countries signed an agreement on the sustainable development of the Mekong River, establishing the Mekong River Commission (MRC). The MRC assists the four parties in the sustainable development of the Mekong through fisheries, hydroelectric, and social development programs (USAID 2003). The MRC is also responsible for environmental management and monitoring of the basin's natural resources (MRC 2002b). Fisheries are one of the most important resources in the basin, estimated at greater than US$1million in market value (MRC 2002b). In addition, to their economic importance, fish provide the single most important source of animal protein for local communities (MRC 2002b).

The MRC acknowledges that the release of "live animals into the wild can have serious impacts upon biodiversity. This happens primarily through aquaculture when animals are either deliberately released into the wild through fish stocking activities, or when they 'escape' from fish farms (a common problem when ponds are flooded seasonally). Biodiversity can be adversely affected when exotic (alien species) compete with native species in the wild (MRC 2003)." Recommendations seven and eight of the recent report on "Biodiversity and Fisheries in the Mekong River Basin" stated that,

" (7) Management measures for the introduction or transfer of exotic species or strains should include consideration of genetic diversity and, in particular, the biodiversity of wild resources. This can be achieved through the development and, more importantly, implementation of workable codes of practice using pre-introduction assessments of the movement of exotic species of strains.

(8) Aquaculture should be managed to avoid significant negative impacts upon biodiversity. Negative impacts can result from the escape of exotic species, and from practices that destroy productive habitat (such as converting mangrove forests to shrimp ponds (MRC 2003)."

The 2002 report on Freshwater Aquaculture in the Lower Mekong Basin recommends risk analysis prior to the introduction of alien species and the corresponding policies (MRC 2002a).

"That a policy to promote the use of Mekong Basin species for aquaculture should be prepared by the riparian countries to improve broodstock management. This approach can be closely coordinated with catchment-based development approaches to aquaculture and fisheries. That a Mekong Basin policy for trans-boundary movement of aquatic animal species, including introduction of species, be formulated for catchments and Mekong countries (MRC 2002a)."

In July 2000, recognizing the rich biodiversity of the Mekong River and the needs of its member countries, the MRC created the Aquaculture of Indigenous Mekong fish Species (AIMS) program. The quality and quantity of seed has traditionally limited efforts to propagate native fish species. Working with the line agencies of Cambodia, Lao PDR, Thailand and Vietnam, AIMS has improved the culture systems for indigenous species through basic and applied research (Table 6). The MRC recognizes that even with indigenous aquaculture there is still risk to the genetic

Table 6: Aquaculture of Indigenous Mekong Species Priority. Stations in italics work with the species at a lower priority (Matson et al. 2003).

Species	Cambodia	Laos	Thailand	Vietnam
Anabas testudineus			Khon Kaen Station	*Cai Be Station*
Barbonymus gonionotus	Chrang Chamres Station	Km 8 Station		
Cirrhinus microlepis		Km 8 Station	*Yasothon, Nakorn Phanom and Surin Station*	
Cirrhinus molitorella		Nah Luang		
Leptobarbus hoevenii	Chrang Chamres Station			Cai Be Station
Hemibagrus wyckioides			Yasothon, Nakorn Phanom	
Osphronemus exodon		Nam Houm Station		
Pangasius bocourti			Khon Kaen, Kalasin, Nakorn Phanom	
Pangasianodon hypophthalmus	Bati Station			

composition of the wild capture fisheries, but that the risks are fewer with indigenous species than with alien species (MRC 2003). The MRC has shown that indigenous fish can have a high market demand and value (Figure 1), and that moreover, farmers and local consumers prefer them. The MRC is actively working to preserve the rich biodiversity of the Mekong and respond to the requests of their member countries through the AIMS program. The MRC plans to continue promoting indigenous aquaculture is as a complement to healthy inland capture fisheries.

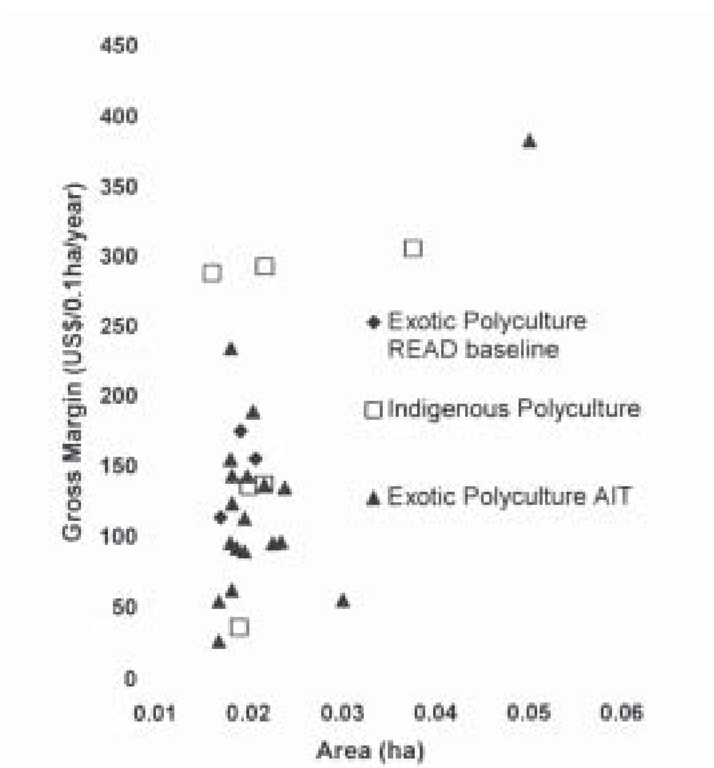

Figure 1. Estimates of relative profitability of small scale aquaculture polyculture using indigenous and exotic (alien) fish species in Cambodia. Gross Margin = Revenue - Variable Costs (labour included), i.e. excluding Fixed Costs.

WorldFish Center

Interviewed:

Ms. Christine Marie V. Casal, FishBase Project, WorldFish Center

Dr. Madan Mohan Dey, Senior Scientist, Agricultural/Resource Economist, Policy Research and Impact Assessment Program, WorldFish Center

Dr. Modadugu V. Gupta, Assistant Director General (International Relations), Research Coordinator INGA, WorldFish Center

Dr. Alphis Ponniah, Program Leader, Biodiversity and Genetic Resources Research Program, WorldFish Center

Dr. Mark Prein, Senior Scientist/Program Leader, Freshwater Resources Research Program, WorldFish Center

Dr. Roger S.V. Pullin, Ecotrack

The WorldFish Center, formerly known as the International Center for Living Aquatic Resources Management (ICLARM), is a member of the Consultative Group on International Agricultural Research (CGIAR) which works throughout the world to improve aquaculture production efficiency and food security and reduce poverty in developing countries through research, improvement of capacity, policy development and the promotion of sustainable agriculture development based on environmentally sound management of natural resources (WorldFish). WorldFish Center actively works throughout Southeast Asia. One of the donors to WorldFish Center has been USAID (WorldFish 2003a).

The mitigation of adverse impacts of alien species on aquatic biodiversity is a major thrust of the WorldFish Center's Biodiversity and Genetic Resources Research Program (BGRRP).

> "This thrust has been added this year [2003] to address the fact that most of the improved strains are alien species and that there is a need to develop strategies aimed at reducing the establishment of invasive alien species. The development of tools to assess risks and evaluate impacts will facilitate the development of guidelines and mechanisms for the introduction of improved strains. To handle the adverse impacts of alien species, the development of better management and policy response mechanisms is another area of focus. The emphasis would also be on maximizing the poor farmers' income through sustainable use of alien species in ornamental and aquaculture sectors (WorldFish 2003c)."

The development of the Genetically Improved Farm Tilapia (GIFT; see Appendix G) has been one of the most notable WorldFish Center projects in Southeast Asia. Tilapia is from the Nile basin in Africa and has had adverse impacts in Central America and Australia where it has been introduced. There are no long-term studies on the ecological impacts of tilapia in Southeast Asia. WorldFish Center's position on alien aquatic species and genetically modified organisms (GMOs)[1] states that "genetic enhancement and genetic conservation are interdependent and that rational scientific principles must be applied to both aspects (Pullin 1994)." In addition, "ICLARM secures independent appraisals of the possible environmental consequences of tilapia transfers and holds that the risks and benefits of transfers of exotic species and GMOs must be thoroughly appraised (Pullin 1994)." WorldFish Center's introduction policy on tilapia states,

> "ICLARM [now called the World FishCenter] has not been and will not be the agency to bring tilapias or any other exotic species into a country or a waterbody for the first time, without legal permission from the appropriate government and other authorities and without thorough prior appraisal of the possible consequences, including an assessment of public attitudes (Pullin 1994)."

The WorldFish Center has worked with its affiliates throughout the world to not only improve technical capacity through research and development, but also to assist countries in building the processes to make informed decisions about introduction and translocation of species. The 2002 Nairobi Declaration (see Appendix E) provides an example of WorldFish Center's efforts at promoting best practices in aquaculture. The WorldFish Center has also developed a fisheries database, known as FISHBASE, that details species' information, such as range, life history, bibliography, and potential invasiveness.

Because there may be a significant time lag between the introduction of a species and impacts arising from its invasiveness, alien species might not be perceived to be problematic until several years after introduction. Therefore caution must be exercised when introducing alien species. WorldFish Center is aware of the potential threats that alien species pose to biodiversity and is educating their partners on best management practices. However, there are several ways in which the WorldFish Center could better integrate best practices for minimizing the impact of IAS throughout its activities (see Recommendations on page 36). The development community at large would greatly benefit from a WorldFish-led monitoring program designed to assess the impacts of tilapia in Southeast Asia and identify best practice, adaptive management strategies. Thus far, WorldFish has not developed a program to mitigate the adverse impact of alien species in Southeast Asia, yet they are probably one of the best positioned organizations to do so.

[1] Invasive alien species (IAS) and genetically modified organisms (GMOs) are not synonymous. GMOs can be invasive, but IAS are not necessarily GMOs.

APPENDIX G:
Tilapia

History of Tilapia Culture in Southeast Asia

Why Tilapia?

The WorldFish Center's early assessments targeted tilapia (*Oreochromis* spp.) as the "prime candidate" for 'aquatic chicken' due to its desirable product attributes (ICLARM 1984), that it is a species that can be cultivated cheaply and rival chicken in the market. Some of the traits that make tilapia a desirable species for aquaculture include: simplicity to produce, hardiness, versatility, undemanding feed requirements, fast growth rate, relatively higher resistance to disease, flesh texture, and neutral taste (De Silva 2003, Young and Muir 2002). In addition, tilapia is available throughout the year. According to Young and Muir, when compared with other farmed species, tilapia production process is less intensive than that of other species and their production systems tend to have smaller dependence on chemicals (Young and Muir 2002). In addition, it can be cultivated intensively and semi-intensively, thus, in theory, making it possible for all socio-economic groups to cultivate it.

Tilapia's Biology

Tilapia is a tropical African fish species, inhabiting floodplains (Coates 1995). It is native to the coastal rivers of Israel, the Nile from below Albert Nile to the delta, Jebel Marra, Lake Chad basin, and the rivers Niger, Benue, Volta, Gambia, and Senegal (FishBase 2003). The fish has been extensively introduced all over the globe; its production base is larger than salmon. More than 81 countries actively farm tilapia, with the majority of tilapia aquaculture occurring in inland environments (Young and Muir 2002). Three species of tilapia are commonly introduced *O. mossambicus*, *O. niloticus*, and *O. aureus*. Freshwater O. niloticus (Nile tilapia) is used in 75% of farmed volume (Young and Muir 2002). Because it reproduces quickly and can tolerate numerous environmental conditions, it has been introduced throughout the tropics.

Of the three tilapia species that were introduced to Asia, only *O. mossambicus* and *O. niloticus* have made significant contributions to the region's freshwater capture fisheries. *O. mossambicus* was first introduced in Southeast Asia in the 1950s, while *O. niloticus* was introduced in the early 1970s and has since been consistently reintroduced. According to Gupta and Dey (2000), farmers prefer *O. niloticus* over *O. mossambicus* because it has a lighter flesh color and there is lower incidence of overcrowding. Nile tilapia requires low-input aquaculture and has a short generation interval, approximately eight months from egg to sexual maturity (Dey and Gupta 2000).

Many tilapine fishes have large native ranges and are abundant in their natural ranges. They also possess a high degree of morphological plasticity and genetic variability, as such they can adjust to several different environments. In their native ranges they are present in both freshwater and estuarine areas (Trewavas 1983). They can also survive across a broad range of water qualities (Stauffer et al. 1984, Welcomme 1984, Philippart and Ruwet 1982). Tilapia also have rapid growth rates, broad diets, and can withstand crowding (Hanley 1991). In addition, tilapine fishes are gregarious schooling species and are likely to migrate long distances (Stauffer 1984, Trewavas 1983, Fryer and Iles 1972). They are generally herbivores, but have been known to also consume insects, zooplankton, phytoplankton, vascular plants and larval/juvenile fishes (Hensely and Courtenay 1980). Tilapia are able to widely disperse, since the they are maternal mouthbrooders. Therefore, a single female can colonize a new environment herself by carrying her young in her mouth (Fryer and Iles 1972). Coupled with the fact that tilapia have a short generation time, that is they reach reproductive maturity in as little as six months and can have multiple broods each year (Stauffer 1984), tilapia are one of the easiest fishes to culture. In addition, tilapia are capable of tolerating wide ranges of salinity and low oxygen (Ross 2000, Stickney 1986). One limiting factor for tilapia production is that they have relatively low cold tolerance (Chervinski 1982). There are ongoing efforts to develop a cold resistant strain of *O. niloticus*, which would increase the range of tilapia's distribution and overcome a factor currently limiting production in some areas (De Silva 2003).

However, their reproductive biology is the greatest factor limiting efficient production. Precocious sexual maturation and unwanted reproduction of tilapia are considered constraints on its optimization in aquaculture since it causes overcrowding and stunting (Mair et al. 2002). As a result, there have been efforts to limit the breeding of tilapia. The first effort was to use hormones to reverse the sex of the tilapia so that they would be all male and thus reduce overpopulation of ponds. This process is known as sex-reversed tilapia (SRT). However, the reversal is not absolute; the sex ratios using SRT are usually lower than 90% male (Mair and van Dam 1996). This outcome arises as a consequence of the farmer's failure to adhere to strict protocols. Mair and Van Dam (1996) state the sex ratios in excess of 95% male are necessary to meet the goal of culturing all male stocks. As a result, in their opinion, SRT is not likely to continue to expand.

The second technology is known as genetically male tilapia (GMT). GMT's aim is the same as SRT to cultivate monosex male tilapia to address the problem of early sexual maturation and unwanted reproduction. The technology is based on combining hormonal feminization and progeny testing in a breeding program to mass-produce YY male genotypes that only sire male offspring when crossed with normal females. Under controlled conditions, GMT usually produces a greater than 95% male sex ratio. However, in culture, due to contamination, the reproduction of tilapia is significantly, but not completely, reduced. Mair and colleagues (2002) found that in farm trials in Philippines there was an increased profitability of tilapia culture over 100% through the culture of GMT in comparison to mixed sex tilapia. They also determined that GMT had the lower price premium over the unimproved fish. He concluded that widespread adoption of improved tilapia would increase production efficiency and has the greatest impact on the large number of urban and rural poor who depend on tilapia as important and affordable source of animal protein in their diet. Mair and DeSilva (2003, 2002) both state there is not widespread dissemination of GMT in Asia, except to a certain degree in Thailand and the Philippines.

Seed Quality

The GIFT fish (Genetically Improved Farmed Tilapia) has made for major improvements in tilapia seed. The GIFT fish was created by the WorldFish Center by combing selection methodology on a synthetic base population developed from newly introduced strains from Africa with domesticated Asian strains. Over five generations they were able to average a 13% genetic improvement and an estimated increase of 85% growth compared to the base population from which it was drawn (Eknath and Acosta 1998). The GIFT fish did not alter the sex of the fish, but improved the quality of the seed that has degenerated by inbreeding with feral fish for several generations. However, most GIFT fish undergo SRT, to prevent overcrowding in the ponds.

The environmental impacts of the GIFT fish are unknown (De Silva 2003), and it has been speculated that these fish are now so widely dispersed in the natural waters of the Philippines that they have altered the feral tilapia population (Rodriguez 2003). DeSilva (2003) states that since there have been no harmful effects by the GIFT fish reported then it is likely not harmful or because of its "genetic superiority, may be more invasive and increase its range of distribution" as a result the negative impacts of the GIFT fish may be more evident than with other feral *O. niloticus*. However, there has been no long term monitoring following the introduction of the GIFT fish to determine rates of escape and/or whether there are impacts of escapees. Therefore, it is impossible to determine whether the GIFT fish is benign or not.

Economics of Tilapia

DeSilva (2003) asserts that it is "difficult, if not impossible to single out a nation in which tilapia has not become established after introduction." As a result, tilapia are a significant contributor to the food supply of Asia, as well as contributing to freshwater capture fisheries in Asia. Tilapia is becoming the most popular freshwater fish in the Philippines and Indonesia (De Silva 2003). It is becoming a popular fish internationally as well.

As a result of tilapia's biological characteristics, it appeals widely to consumers in a range of different product formats and markets segments, as well as having competitive production costs (Young and Muir 2002). The capital costs of farming tilapia are composed of the holding facilities, water supplies, feeding and harvesting, transport and handling facilities, feed production and fish processing equipment, building, services and infrastructure. A table of the different types of holding facilities and their costs can be seen below.

Costs of Different Culture Systems
(Young and Muir 2002)

Holding Facility	Cost
Cages & Enclosures	$500-1,000 t installed capacity
Earthen Ponds	$800-2,000t
Lined Ponds	$1,000-3,000t
Tanks & Raceways	$2,000-8,000t
Recycle Systems	$5,000-15,000t

Production technologies in Asia are determined by the interaction of five factors (below). Table G-1 provides an overview of the most common types of culture.

- Physical environment;
- Culture facilities;
- Available nutrient inputs;
- Species feasible for culture; and
- Ability of the producers to balance all the factors in a profitable package.

Depending on the size of the physical location of the aquaculture facility, there are opportunities for economies of scale related to unit size of holding systems and reduced units of infrastructure costs; that is as the holding systems get bigger the infrastructure costs do increase at the same rate. Small-scale artisanal production systems can be relatively inexpensive, while hatchery capital costs are generally higher than the capital costs of outgrowing. The majority of operating costs are spent on feed and fertilizer – 40-75%, followed by seed (5-25%) and labor (5-15%). High-intensive systems incur significant capital amortization and energy costs, whereas small-scale artisanal systems that have a self-supply of fry and uncosted farm input may be negligible operating costs. Systems that are based on natural productivity, such as cages in reservoirs, incur lower costs. Competitive products can be produced in simple artisanal systems (i.e. by a small farmer) just as well as those produced in intensive production systems, i.e. a large private company (Young and Muir 2002).

Expansion of tilapia production is encouraged due to the "attractive margin" that producers receive; 2001 estimates show that tilapia can be produced for as low as U.S. $.50kg[1] and obtain as much as U.S. $2.3-3.0kg (Intrafish 2001). There is also evidence that the market for a valued added tilapia production is increasing (e.g. fillets). Fillet yields range from 22-45% profit margin, with current market prices of $5.0-7.0kg, Young & Muir state this suggest the potential for additional profit.

The majority of the world is already familiar with tilapia. Moreover, because of its widespread production coupled with Diaspora communities from Asia and Africa increasing in Europe and the U.S. tilapia's marketability will increase. There are currently three markets for tilapia – intense industrial production system, which supply mainly developed countries with live to value-added processed productions, then the commercial operation and finally the marginal poor communities (Young and Muir 2002). There are only few fish species that "command such a variety of positions in the global market (Paquotte 1998, Muir 1995)." Therefore, the production of tilapias and thus its introduction is likely to increase rapidly over the next few decades.

Tilapia is increasingly imported into the European Union (EU) and the United States. The EU has an increasing trade deficit in fish due to declining indigenous supplies from capture fisheries, while demand remains high since fish is perceived by consumers as healthy. France, Germany, the United Kingdom and Italy are the largest importers of fish for consumption. The EU market for tilapia is based in the ethnic African communities and the Asian communities, as tilapia is prevalent in their native homelands. The attributes of tilapia (i.e. white flesh) firm texture and neutral taste, match the EU consumer preference (Young and Muir 2002). However, it is unlikely that tilapia will be seen as a top tier fish in the EU markets.

In North America, tilapia is the third most important aquaculture species after shrimp and Atlantic salmon (Lister 1998). According to the FAO (2001), since 1992, the U.S. imports of tilapia have expanded nearly twelve-fold. Taiwan, China, Indonesia and Thailand have been supplying the frozen market, while Costa Rica, Ecuador, Columbia, Jamaica and Honduras supply the fresh fillets. Like the EU, the Asian communities of North America are the base market. In the U.S., tilapia market there is product differentiation of tilapia. The first type is cultured and harvested in the best quality environment and competes with grouper, snapper and swordfish. The second type is cultured with less quality, may contain inconsistencies in flavor, texture and thus commands a lower price. The third market is the sale of "wild tilapia"[2] from Latin America, therefore there is no quality control over the taste, as tilapia can assume different flavors depending on its feeding habitat (Young and Muir 2002).

The price of tilapia is significantly lower than the most demanded marine species, but is similar to freshwater species. DeSilva compared the growth of the tilapia industry with that of the cyprinids and salmonids and found that the rate of increase in tilapia culture was greater than that cyprinids and salmonids over all the time periods considered. Tilapia culture recorded the highest rate of annual growth over the last two decades amongst all finfish groups (De Silva 2003).

The demand for tilapia is likely to increase in the coming years, as it becomes more widely accepted in developed countries. Two constraints will have to be overcome for the successful development of the industry – seed quality and cold tolerance (Mair et al. 2002). The increase in consumption in developed countries will force producers in Asia to adopt more stringent production standards especially with regard to chemicals. According to DeSilva (2003) this will require tilapia culture practices to upgrade their facilities as well as the way they have dealt with this inexpensive commodity.

Characteristics of Tilapia Producers

Two surveys of tilapia producers examined the likelihood of adoption of the GMT and GIFT technology. Each survey provides information on the tilapia producers.

A study conducted by Mair and colleagues (2002) surveyed several hatcheries in the Philippines and found that the majority of them were not ensuring the genetic quality of their stocks. This can have negative implications if the altered tilapia were accidentally released or escaped into the natural

[1] This figure is inclusive of land, capital and labor, but not environmental cost.

[2] It is likely that this is feral tilapia and not actually native wild tilapia.

Table G-1: Types of Culture (Modified from http://www.aquatic.uoguelph.ca/fish/aquaculture/types/types.htm)

Type of Culture	Features	Pros	Cons
Cages	A mesh or wire cage is placed where water will flow through it, like lakes, rivers and reservoirs. The steady flow of water allows for nutrients to be carried into and out of the cage. The size of mesh is determined by the size of the fish, so to prevent escapes and predation from other species.	Can be practiced on a small scale in most water bodies.	Closed environment can facilitate the rapid spread of disease. May need to augment food sources, since the fish are not able to move to the food source. If the cage becomes damaged, fish can escape. Causes of cage escapes: cage breakage, vandals, poaching and predator breaching of cages (Patrick 1999).
Closed Systems	Large closed ponds that do not have outlets to water bodies. They require pumps and filtration systems.	Higher probability of no fish escapes.	Expensive to construct and operate.
Ponds	Ponds usually of about 1 ha that is either earthen or constructed with plastic liners. Sometimes can be constructed by damming parts of a river.	Less expensive to build than closed systems. Easily constructed.	If located near a water body, floods can result in the loss of the fish. Pollution from the ponds can seep into the ground.
Raceways	Raceways are usually large rectangular structures with water entering one end and leaving through the other. There is a constant flow rate, so fish continually have new water. Able to have large number of fish with little water. Raceways tend to have no filtration systems, and are open systems. Usually made of concrete, aluminum, or fiberglass. Most common in research centers or hatcheries.	Minimal Water	Raceways are expensive to operate and require a lot of space. Water needs to be treated before it is discharged in order to minimize pollution.
Culture based Fisheries	Culture based fisheries are those natural/man-made waterbodies that have been stocked with a species at one point and that species has now established self-recruiting populations.	Culture based fisheries can spur development in rural areas since small investment needed. Also feed is not necessarily needed, since it uses the natural production of the system.	Displacement of native species.
Rice-Fish Culture	Farmers stock fish in the rice field when it is flooded.	Allows farmers to cultivate two crops simultaneously and to have a crop during the time of the year that the rice field is fallow. Fish provide free fertilizer and in some cases can serve as a biocontrol agent for rice pests.	If a fence is not built and maintained around the field, during heavy rains or flooding, like in the rainy season in Southeast Asia, the fish can escape from the rice field.
Indigenous Culture	Relies on native species for aquaculture development.	Reduces reliance on alien species that could be potentially invasive. Consumers are already familiar with the product.	Escapes could still occur and the genetics between the domesticated native fish and the wild native fish may be distinct. Therefore, changes in the genetic composition of the wild population could occur if there is hybridization.

environment. Secondly, they found that 80% of the survey respondents reported that there was reproduction among their tilapia stocks, of those 60% said that reproduction is negative and 40% is positive. They attribute the 40% positive response as the farmers viewing the reproduction as a free source of fingerlings and that they do not perceive the effects of the recruits on the growth of the stocked. These effects could include decline of gene pool and stunting in the ponds due to overpopulation. Of the farmers that viewed recruitment[3] negatively, 40% said it led to overpopulation of the pond

[3] Self-recruiting species are cultivated species, native or non-native, that do not have to be repeatedly restocked after they have been introduced.

and 43% said it retarded growth. Less than 30% of the farmers surveyed sold their production, it was only in the middle-income municipalities that 66.7% of farmers sold less than 30% of their production. However, they did not find that wealth level of municipality was correlated with the amount of production sold. Fish were an important source of supplemental income for small-scale farmers, for mid-income farmers fishing was a secondary activity that was used for their own casual consumption. They found that of the improved tilapia, GMT has the lowest price premium over the unimproved fish and SRT has the highest. Mair and colleagues concluded that there was no evidence to suggest that it is the poorer or richer members of communities that enter into aquaculture. They also found that it is unlikely that introduction of genetics-based technologies like GMT will have much impact, either positively or negatively, on employment of poor people. To the contrary, it may in the long run have a large impact on urban and rural poor that depend on tilapia as an important and affordable source of animal protein in their diet.

The WorldFish Center conducted the Dissemination and Evaluation of Genetically Improved Tilapia Species in Asia (DEGITA) survey; they found that most tilapia farmers are small and medium scale operators that use semi-intensive systems. The cost of food and the cost of fry/fingerling are the two major costs in tilapia culture in Bangladesh, China, the Philippines, Thailand and Vietnam. The DEGITA survey also concluded that tilapia is consumed by low and medium income groups due to its low price relative to other fish species (Dey and Gupta 2000).

The DEGITA survey developed a profile of the average tilapia farmer. The farmers' ages tended to range from 40 to 48 years of age, and were generally male for all the countries but Thailand. The farmer's education ranged from 5 to 7 years. (The more education a person has the more likely they are to take a risk on using new technology (Panayotou 1982).) Crop farming, fish farming and animal husbandry all contribute to the income of fish farmers. Fishpond operators in the Philippines have more land that those fishers that use cages to cultivate tilapia. Of the countries surveyed, Bangladesh and Vietnam have the smallest landholdings (Dey et al. 2000). In Bangladesh and Thailand, the average farm size of surveyed fish farmers is similar to the national average for agricultural farms. In all the countries but China, there was a high percentage of the farmers owned their fish farms. In China, joint ownership or partnership is a common mode of operating a fish farm. Fishponds and Bangladesh and Vietnam were located close to the farmer's house, ponds in countries are used for several purposes, such as washing and bathing (Dey et al. 2000).

The Philippines, on the other hand, 100% of pond and cage operators cultivate tilapia in a monoculture. Dey and colleagues (2000) found that investment costs are higher in cages than in ponds and more cage operators manage their operations jointly. In Thailand, 84% of the fish farmers integrate tilapia cultivation with animal farming, whereas only 12% do so in Vietnam.

Dey and colleagues (2000) found that in Bangladesh, China, Thailand and Vietnam tilapia is raised for seven to eight months in pond polyculture instead of the typical six. The cultivation period is increased because farmers wait until all the fish reach marketable size and then harvest all of them together (Dey et al. 2000). The survey also found that stocking density is much higher in cages than in ponds. Pond operators in all of the countries fertilized their ponds and feed the fish. The survey concluded "freshwater aquaculture in general and tilapia farming in particular in four of these five countries is highly market-oriented, with more than 85% of the production marketed. . . . in all the countries, costs and returns to fish production vary widely due to differences in production environments, input use levels, culture practices and farming systems (Dey et al. 2000)."

Tilapia and Development

Tilapia cultivation is touted as a way to provide food and revenue for the "poorest of the poor." Tilapia culture is an important employment opportunity for rural areas, particularly those where employment opportunities are limited (Baluyut 1999). In Southeast Asia it tends to be rural and artisanal, often areas where there are not a lot of employment opportunities (De Silva 2003). Mair and colleagues (2002) conducted a survey of 260 households in poor communities in rural lowland and upland Philippines and the poorest areas of two urban areas, Manila and Baguio. The survey showed that the small and medium scale aquaculture producers in the Philippines are comparatively well off and cannot be thought of as the poorest of the poor. The Philippine rural poor are usually dependent on agriculture; the landless depend on steady/unsteady farm employment. The rural poor tend to have low levels of education and weak access to modern technology. Furthermore, the survey found tilapia farmers are weakly integrated into the cash economy or the market economy.

Fish in general, and especially tilapia, is important to the diet of both rural and urban poor (Mair et al. 2002). Eighty-five to 100% of respondents ate tilapia regularly, that is on average one to three times a week. In households in poor communities, which are often "food insecure," tilapia was the most common fish eaten due to its availability, preferred taste and lower price compared to other available fish. Mair and colleagues asserted that widespread introduction of genetically improved tilapia by producers should permit for efficient utilization of resources and together with the right market conditions it could have a significant impact on the livelihood of both urban and rural poor through improved food security and health (Mair et al. 2002). While, tilapia can provide for cheap food it does not necessarily result in economic development opportunities for the "poorest of the poor."

Food Security & Nutrition

Tilapia is often cited as an important protein source for the rural poor. However, there is little documentation to support this. A recent study in Bangladesh, that looked at nutrition derived from another introduced species, carp, found that it provided approximately 20 RE/100g vitamin A. While the small indigenous species (SIS) mola (Amblypharyngodon mola) provided up to 3,000 RE/100g (Roos 2002). Vitamin is necessary for healthy vision, growth and immune system. In addition, because mola is a smaller species it is often consumed with the bones and therefore calcium consumption is greater with mola than with carps, which are usually boned. Thus, the larger introduced species did not provide the same nutritional value that the SIS did. The authors concluded that it is important that SIS are used a polyculture with the introduced carp.

The study also found that of the surveyed households, fish that was bought in the market was the most important source of protein, followed by captured wild fish (Roos 2002). Moreover, there was insignificant consumption of fish from household ponds explained why the control, households without access to a pond, consumed the same amount of fish as fish producing households.

According to a 1996 World Bank report, in some parts of Asia, the larger and commercially more valuable exotic species, e.g. carp and tilapia, sold in urban areas have replaced SIS that had previously been sold and consumed in rural areas (Kottelat and Whitten 1996). Introducing alien species like, carps and tilapias, does not necessarily meet nutritional goals and as such development programs should carefully weigh the benefits and costs prior to introduction.

Case Studies of Tilapia's Impacts

Resource managers and development staff often claim that tilapia fills a vacant niche in Asia's lakes and reservoirs, because there are few "truly lacustrine species in the indigenous fish fauna in the Asia-Pacific (Fernando 1982)." Kottelat and Whitten (1996) refute this statement and assert that, "fisheries biologists have often regarded lakes as having many vacant ecological niches, sometimes not realizing that several species may occupy the same niche or that a single species may occupy a number of niches dependent on the season, time of day or life state or sex of the individual; in addition, niches which exist in one lake do not necessarily exist in another." Administrators do not realize that the classification of niches is artificial and most species are capable of utilizing different niches in different habitats. There have been no long-term studies of the impacts of tilapia in Southeast Asia. However, there are a few case studies of tilapias impacts in freshwater ecosystems from around the world, the section below presents a summary of them.

Philippines

The Philippines has been a leader in the production of tilapia culture and, as a result, experienced both the positive and negative impacts of tilapia. The Philippines has approximately 230,000 ha of lakes and reservoirs, and tilapia can be found in nearly all of them (Baluyut 1999). Guerrero (1999) investigated introduction dates for *Oreochromis* spp. for individual reservoirs and demonstrated that they became the dominant group in capture fisheries. Sampaloc Lake, Philippines is an example of the negative impacts of tilapia cultivation. It was devastated as a result of intensive tilapia farming in floating net cages (Santiago 1994). Cage culture in Sampaloc Lake began in 1976 and had grown to over 33ha in 1991. Once the cage culture exceeded more than 6ha, tilapia growth began to slow because of lack of natural food. As a result, in 1986 farmers started using commercial feeds at a rate of 180 tons/ha/yr, with a collective cage area of 33ha this amounted to 6,000 tons of feed dumped into the lake each year (Santiago 1994). Lost feed, fish faeces and other organic waste from the cage culture accumulated in the lake and in 1988 there were frequent occurrence of fish kills. This resulted in the loss of several millions of Philippine pesos in income. Santiago conducted a study to look at the dissolved oxygen level in the lake and found that there were almost anoxic conditions in the water column, except for the upper 2m. Therefore, below 2m tilapia would die. If feed fell below 1-2m the fish were not able to consume it because of low or no oxygen. Santiago also found the any minor turbulence in the lake would bring up anoxic and toxic water, which caused massive fish kills.

The concentration of dissolved oxygen in water is considered the most significant chemical factor influencing fish distribution in reservoirs (Bhukaswan, 1980). The biological oxygen demand (BOD) in the lake was between 12 to 20mg/l at different depths. The Philippine Department of Environment and Natural Resources indicated a high organic contamination is above 7mg/l (Santiago 1994). Ammonia concentration was also very elevated, it was 2.5mg/l. The pH ranged from 7.4 to 8.5, which is considered harmful (Santiago 1994). The sulphides concentration was also very elevated – between .8 to 10 mg/l. It was surprising that the fish were able to tolerate such high levels.

It has been found that high stocks of omnivorous fishes contribute to sustaining eutrophication by enhancing nutrient cycling (Starling et al. 2002). The uncontrolled development of aquaculture in cages and pens can cause an imbalance in aquatic ecosystems and a deterioration of the capture fisheries because of the high organic loading. Intensive exploitation of the reservoir resources via cage culture changes the trophic status of the reservoirs (Amarasinghe et al. 2001). As evidenced by Lake Sampaloc, if an ecosystem is pushed passed carrying capacity it will no longer be sustainable. Therefore, best management practices are needed to ensure that production is both economically and ecologically optimal.

Nicaragua

In Nicaragua, numerous tilapia (*O. niloticus*, *O. mossambicus*, and *O. aureus*) have escaped from cages into lakes and rivers, particularly Lakes Apoyo, Managua and Nicaragua. A 1995 study by McKaye and Ryan showed approximately an 80% decline in biomass of native cichlid fish in Lake Nicaragua compared with what Russian researchers had found in the early 1980s.

McCrary (2001) has conducted research in Lake Apoyo for over ten years. He concluded that there is significant presence of Nile tilapia (*O. niloticus*), and that they are occupying sites that some of the native species have been using for reproduction and food. McCrary found that the tilapia has eliminated *Chara* spp., a large aquatic plant, in Lake Apoyo. Tilapia is also competing directly with the native species for food. Due to the reduction of food options tilapia has switched to soft zooplankton and filamentous substrate algae, which is leading to increasing damage in the lake ecosystem. Tilapia is also occupying some of the reproduction sites of the native cichlids, called platforms. The combination of the movement of platforms and eradication of *Chara* spp. has led to internal erosion in the lake. In addition, there are increasing incidences of parasites among many of the fish in Lake Apoyo. Researchers suspect that tilapia is the vector for the parasite and are currently undertaking work to determine the source of the parasite.

Costa Rica

Costa Rica has also reported significant impacts from tilapia. In the Cano Negro Wildlife Refuge, a Ramsar site, tilapia has been linked to the displacement of native fish species. Tilapia was first introduced into Costa Rica in the 1960s as part of the aquaculture program of the Ministry of Agriculture and Livestock. It is now commonly found through the rivers in the Canas area of Costa Rica; it can be found in nearly 80% of Costa Rica’s rivers on the Caribbean and Pacific coasts in Lake Arenal. Researchers have found that tilapia has taken over niches, eaten the eggs of fish that feed off of vegetation and consumed large quantities of food. Tilapia is gradually becoming the dominant species in the ecosystem, which is having negative effects on the native species (e.g., guapote (*Parachromis dovii*), mojarra (*Amphilophus* sp.), barbudos (*Rhamdia guatemalensis*), and machaca (*Brycon* sp.)).

According to one researcher at a June 2001 meeting in Costa Rica, “Complete change is taking place in Costa Rican aquatic ecosystems. These are no longer the same ecosystems. Species diversity is being lost, because not only are fish being exterminated, which would be the most noticeable thing that can be seen. But there are also changes in the dynamics of phytoplankton and zooplankton, and also aquatic insects (IUCN 2001).”

Australia

Tilapia introductions to natural and quasi-natural waters in Australia have been accidental (De Silva 2003). In Australia, there is evidence that certain tilapia species in certain ecosystems (i.e. *O. mossambicus*) do not compete with native species for food, if anything they partition the food with native species. Arthington and colleagues (Arthington et al. 1994) conducted a two year study in an Australian reservoir and concluded that the *O. mossambicus* and two native species, *Leiopotherapon unicolor* (spangled perch) and *Tandanus tandanus* (freshwater catfish), do not compete for food because they have different foraging strategies. These species were chosen because the two native species have similar body size as *O. mossambicus* when it matures and they feed and breed in the same areas in the impoundment, namely shallow embayments with dense aquatic vegetation (Arthington et al. 1994). They concluded that the lack of competition is a likely result of the natural herbivory of *O. mossambicus* and its high utilization of phytoplankton. They also found that the diet of *O. mossambicus* varied with season and water level, whereas *L. unicolor*’s diet was more diverse and varied little with season but was more responsive to changes in water levels. *O. mossambicus* and *L. unicolor* partitioned the food resources very interestingly, *O. mossambicus* ate the leaves and stems of *Hydrilla verticillata* while, *L. unicolor* ate the inflorescences. There was almost no overlap in the diets of *O. mossambicus* and *T. tandanus*. This would indicate that there was no competition for food between the introduced *O. mossambicus* and the native *T. tandanus*.

Nonetheless, Australia is the only nation in the world that has classified tilapia as noxious (De Silva 2003). In addition, since 1963 tilapia imports have been prohibited (Michaelis 1989). Arthington and Bluhdorn (1994) believe that even though there few impacts were observed, it is not appropriate to assume that *O. mossambicus* will not have adverse impacts in the future, as there may be a time lag between introduction and evidence of impacts, direct or indirect, on the natural system.

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