IMPACTS OF INTRODUCTIONS ON THE CONSERVATION AND SUSTAINABLE USE OF AQUATIC BIODIVERSITY

Devin Bartley[1] and Christine V. Casal[2]

[1]Fishery Resources Division
[2]Biodiversity and Genetic Resources Programme
ICLARM, Manila, Philippines

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Alien species[2] are receiving international attention in fora such as the Convention on Biological Diversity and the FAO Code of Conduct for Responsible Fisheries. While much of the recent attention has focused on the adverse impacts, not all alien species are bad. As in agriculture and ornamental horticulture, alien aquatic species have contributed to an improvement of the human condition in many areas. The production of the African cichlid tilapia is much higher in Asia (>700,000 mt in 1996) than in most areas of Africa (39,245 mt); introduced salmonids in Chile support a thriving aquaculture industry that is responsible for approximately 20% of the world's farmed salmon. The practice of using species outside of their natural range to increase production or profitability can be expected to continue. The issue is not to ban alien species, or to abandon regulation of their movement, but rather, as stated in international codes of practice (ICES 1995) and the Convention on Biological Diversity, to assess the risks and benefits associated with their use and then, if appropriate, develop and implement a plan for their responsible use.

Risk assessment will require information from a number of sources on a number of areas such as the biology, ecology, and genetics of the alien species. The information will need to be readily available and understandable to those performing the risk assessment and to policy makers. Risk assessment must also include benefit assessment; an accurate accounting of the benefits derived from exotic species is essential. This note details information from two databases that stemmed from collaborative efforts of the European Community, ICLARM and FAO – FishBase (Froese and Pauley 1997) and DIAS (Database on Introductions of Aquatic Species) (Welcomme 1988; Bartley *et al*. 1997). The records in the databases came from questionnaires distributed internationally, from the literature, and from personal communications. The purpose of the paper is to examine what type of information is needed to make reasonable risk assessments and to use the databases to examine the impacts of alien species.

Impacts

Impacts of introduced species will fall into two broad categories – i) ecological, which includes biological and genetic effects and ii) socio-economic (Table 1). However, these two categories are not independent and socio-economic changes brought about by alien species can in turn cause more ecological changes. Thus, a reduction in native species may be from direct interaction with an exotic species, or it may result from increased fishing pressure or changes in land use brought about by the presence of a newly established species.

FishBase is a relational database that allows comparisons of multiple data-sets. Links of the Introductions module to the FAO Fishery Statistics (FAO 1998) module revealed that the contribution introduced fishes make to total fish production is about 17% (Figure 1).

Table 1. Some potential adverse effects of alien aquatic species

EFFECT	MECHANISM - BIOLOGICAL	MECHANISM - SOCIAL
Reduction or elimination of aquatic species	Competition, hybridization, predation/herbivory, disease transmission	Change in fishing pressure and access to resources; treatment measures to enhance introduced species
Change in terrestrial fauna	Change in abundance of preferred prey	Fish farms providing more food for birds and animals or killing predatory birds
Change in fishery management	Change in stock composition	Successful introductions lead to other introductions
Alteration in habitat	Burrowing, sediment mobilization, removal of vegetation	Change in land use, e.g. creation of fish farms
Socioeconomic impacts	Change in species abundance or distribution leading to changes in fishing or consumption practices	Change in access rights,land tenure; financial liability for damages through national and interntional legislation

Table 2. Effects of introduced fishes on ecological and (socioeconomic) environments, by reason for the introduction. Data represents number of records from FishBase

	REASON					
IMPACT	FISHING	AQUACULTURE	ORNAMENTAL	BIO-CONTROL	UNKNOWN	OTHER
ADVERSE	36 (2)	78 (8)	17 (5)	23 (9)	13 (0)	40 (12)
BENEFICIAL	16 (87)	52 (283)	11 (42)	11 (19)	3 (10)	6 (15)
UNKNOWN	28 (16)	76 (49)	9 (9)	8 (2)		21 (3)
BLANK	196 (299)	949 (815)	169 (150)	106 (122)	459	283 (328)

Impacts may depend on the objective of the introduction. Analyses of the database reveals that aquaculture development was the most often cited reason for fish introductions, and that government organizations were responsible for more introductions than any other group. Table 2 presents information that most of the ecological effects of introduced species reported were negative; however, the socio-economic impacts were reported to be more often beneficial and there were more positive socio-economic benefits reported than negative ecological impacts.

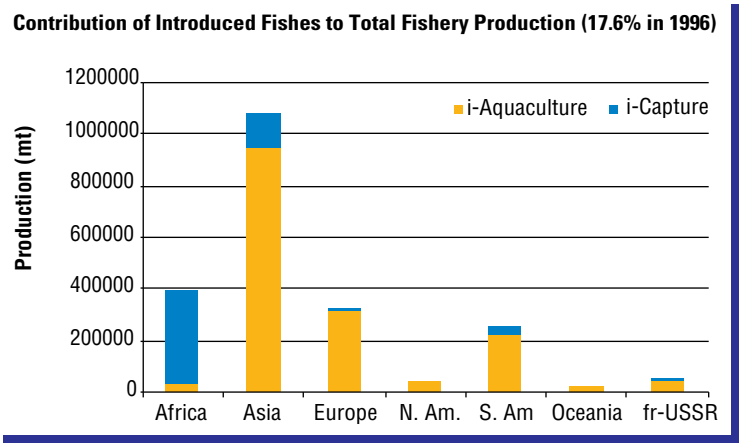

Table 3 presents some popular conceptions regarding impacts of alien species and how the databases can provide information to support or refute the generalizations. The purpose of challenging the broad generalizations is not to replace one generalization with another, but to provide some estimate of their validity.

The way forward

There are limitations to the present databases that must be born in mind when analyzing the data. Many of the data are from questionnaires distributed internationally and therefore may not be an accurate sample of species introduced or the actual impact of the introduction. Introductions that made a big impact would probably be preferentially reported, whereas introductions that did not work or produced only minor impact may be forgotten. In addition, the data-sets only report on the first introduction across national borders, subsequent introductions and movements of aquatic species within a country are not included.

FishBase, as the name implies, covers only fishes; DIAS includes other taxa, but is not a relational database. Efforts to include other taxa in FishBase, or a similar relational database are needed.

An accurate assessment of the impact of an alien species will only be possible if an accurate assessment of the "pre-introduction" ecological and socio-economic environments already exists. Unfortunately, in many areas of the world and especially in many inland areas of developing countries, this information is lacking. Chinese carp were introduced into barrier lakes in coastal Mozambique to establish aquaculture and a fishery with little or no knowledge of the species existing in this unusual habitat nor of the level of fishing activity the lakes already supported.

The Convention on Biological Diversity calls on Members to prepare and maintain a registry of alien species. The format of FishBase and DIAS may provide suitable models. The databases mentioned here focus on the species. This is understandable and effective for many purposes. However, in assessing risk from the movement of species from one area into another, a key factor is the receiving environment. National registries would be able to focus on more than the first introduction and could contain information on the environment that the alien has "invaded".

The amount of information necessary to predict accurately the impacts of alien species is extensive. Collaboration and sharing of information will be essential in order to take full advantage of the potential of alien species, while protecting aquatic biodiversity for present and future generations.

[1] Editor's note: editorial changes have been made to the original document.

[2] Other terms in use are introduced species and exotic species; all terms refer to species moved across international borders.

Catfish production in Thailand is based on the hybrid between the introduced African and the Thai catfish. Will hybrids affect native gene pools?

Table 3. Some popular conceptions regarding alien species

STATEMENT	INFORMATION FROM DATABASE	POSSIBLE BIASES IN DATA	REFERENCES
Most introductions fail	Where establishment was assessed, 65% of the introductions lead to established populations	Data from questionnaires, i.e. biased reporting	Moyle and Light 1996
Top carnivores are the most dangerous	Herbivores and carnivores were reported to cause negative impacts in >60% of the cases where impact was assessed, whereas the figure for omnivores was 81%	Small sample size of carnivore introductions	Moyle and Light 1996
r-selectd species[1] most likely to establish	Establishment success negatively correlated with max. size	Larger fish subsequently removed by fishing or other factors after establishment; larger fish take longer to establish noticeable populations	Pullin *et al*. 1997
Diverse environment hinders alien establishment	Data-set cannot address the issue		Moyle and Light 1996
Disturbed environment helps alien establishment	Data-set cannot address the issue		Moyle and Light 1996
Genome size inversely related to invasive ability	DNA content and chromosome number were not related to establishment success		Baker and Stebbins 1965

[1] species with high fecundity, short generation time, early age at maturity and usually small size.

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Introduced Atlantic salmon and rainbow trout have made Chile the world's second leading producer of farmed salmon behind Norway; but the effect on native fauna is largely unknown.

Black bass introduced from North America along with local red breasted bream are sold along the roadside in Zimbabwe.