Historical aspects of international movement of living aquatic species

D.M. BARTLEY and R.P. SUBASINGHE *

Summary: The use of exotic aquatic species to increase both the level of food production and the income generated by this production has been an established practice since the mid 19th century. At present, advances in husbandry have enabled large-scale movements of many different species over great distances. Despite a gradual fall in the volume of such movements since the 1960s, the practice still persists and continues to generate controversy in regard to the protection of native biological diversity, the spread of pests and disease, and socio-economic factors. The author presents the results of a recent international questionnaire on species introductions, distributed in an attempt to gain further insight into the uses and effects of introduced species.

Information was received on 654 introductions of aquatic organisms, mostly fish. Aquaculture was the main reason for most introductions, followed by the creation of fisheries, the ornamental fish trade, research, biological control, accident, natural diffusion, and the provision of bait and forage. National governments were responsible for 40% of the introductions, with the private sector accounting for 18%, individuals another 15% and international organisations 7%, with the remaining 20% being of unknown source.

The impact and benefits of many of the introductions reported were unclear. Most introductions (62%) probably did not result in the establishment of the exotic species in natural waters. Respondents reported that 63% of the introductions probably had no effect on the ecosystem: 25% of the impacts were judged positive, while for 58% the nature of the impact (positive or negative) was undetermined. Furthermore, 62% of the introductions probably had no effect on the socio-economic system: 40% of the impacts were beneficial, while in 55% of cases the respondents were undecided whether or not the impact was beneficial.

The authors recommend that planning, regulation and monitoring of introductions of aquatic species be imposed through adherence to international and national codes of practice. This will help to maximise benefits from the use of exotic aquatic species in the future.


* Fisheries Department, Food and Agriculture Organisation of the United Nations, Viale delle Terme di Caracalla, 00100 Rome, Italy.
INTRODUCTION

The use of exotic species to increase both the level of food production and the income generated by this production has been an established practice since the mid 19th century. The practice dates back much further, however, to the ancient Romans and medieval European monks who transported common carp (*Cyprinus carpio*) and some perch (*Perca fluviatilis*) around Europe and the Roman Empire; oysters were transplanted in the seas around the Greek Islands during the Golden Age of Greece, circa 500-400 BC (4, 22). The early transplantations and introductions were largely for a primitive type of aquaculture where fish were mostly held in impoundments or reservoirs; little controlled reproduction was practised at the time, except for the common carp (which is easily bred in captivity). Advances in controlled spawning of salmonids, primarily rainbow trout (*Oncorhynchus mykiss*), in the mid 19th century led to an increase in exports of these fish to other areas (25). At present, further advances in artificial spawning induction and other advances in husbandry have enabled large-scale movements of many different species over great distances.

Controversy over the use of exotic species stems from a number of highly publicised and spectacular successes and failures. Chile has become the second largest producer of farmed salmon in the world, as a result of the introduction of coho salmon (*O. kisutch*), Atlantic salmon (*Salmo salar*) and rainbow trout. The Chilean salmonid aquaculture industry provides foreign exchange and employment for thousands of people in areas where there are few other opportunities for development. In contrast, the introduction of the golden apple snail (*Ampullaria canaliculata*) to the Philippines - with the aim of increasing rural aquaculture production - has led to the infestation of 15% of Philippine rice fields, with losses as high as 75% in some areas (1). Perhaps the most famous controversy involves the introduction of Nile perch (*Lates niloticus*) into Lake Victoria, whereby a primarily artisanal fishery was transformed into a multi-million dollar industrial fishery and processing operation. Tremendous income was generated, but the socio-economic system of the surrounding community changed, and there have been estimates that perhaps hundreds of endemic species of fish may have been lost to predation by the Nile perch (6, 20). The practice of introducing exotic species persists, however, and continues to generate controversy in regard to the protection of native biological diversity, the spread of pests and disease, and socio-economic factors (7).

To gain a clearer view of the extent and impact of exotic species introductions, a global review of international movements of inland fish was undertaken by R.L. Welcomme of the Food and Agriculture Organisation of the United Nations (FAO) (25). This review listed 1,354 international movements involving 237 species of inland fish. Of the 237 species, the three most widely introduced were common carp, Nile tilapia (*Oreochromis niloticus*) and rainbow trout. These three species – as well as others, such as the black bass (*Micropterus* spp.), mosquito fish (*Gambusia affinis*) and grass carp (*Ctenopharyngodon idella*) – now occur in every continent except Antarctica, as a result of human-assisted movement. Welcomme reported a peak in introductions of freshwater fish species in 1960, followed by a gradual fall in the number of movements (25).

The information published in the above report (25) is currently being expanded to include introductions of marine species and invertebrates, and to incorporate information on the impact of these introductions on both the ecological and socio-
economic systems. A revised questionnaire was distributed throughout the world, primarily to government and academic institutions, requesting three general types of information on introduced species, as follows:

a) basic data (e.g. species, importing and exporting countries, year of introduction, reason, and who made the introduction)

b) status (e.g. whether the introduction resulted in self-sustaining populations and whether the organism is still used in aquaculture)

c) impact on the ecological and socio-economic systems.

The reported information in these three areas is summarised below.

**DATA ON INTERNATIONAL INTRODUCTIONS OF AQUATIC SPECIES**

To date, information has been received on 654 introductions of aquatic organisms (mostly involving fish), more than half (338) of which were not covered in the previous review. As the new questionnaire asked for additional information (25), all 654 introductions are considered in this report. The most frequently introduced genera were *Oreochromis* (which includes the Nile tilapia and several other tilapias), *Cyprinus* (which includes the common carp), *Oncorhynchus* (which includes rainbow trout and several Pacific salmon) and *Hypophthalmichthys* (which includes the silver and big-head carps).

Europe and Asia (including the Near East) were the regions reporting the greatest number of introductions with 178 and 163, respectively. The Caribbean reported 20 introductions, the former Soviet Union 21, Oceania 34, the Americas 121, and Africa 57. Freshwater species were by far the most frequently introduced, with 537 instances; marine, brackish and diadromous species were reported as being introduced in 71, 32 and 24 cases, respectively.

Similar to the trend reported by Welcomme (25), aquaculture was the main reason for most introductions, followed by the creation of fisheries, the ornamental fish trade, research, biological control, accident, diffusion, and the provision of bait and forage (Fig. 1).

The current questionnaire sought to obtain information on the parties or individuals responsible for the introductions. National governments were responsible for 40% of the introductions, with the private sector accounting for 18%, individuals another 15% and international organisations 7%, with the remaining 20% being of unknown source.

**STATUS OF THE INTRODUCTIONS**

Most introductions (62%) probably did not result in the establishment of the exotic species in natural waters (Table I). The status of introductions for the purposes of aquaculture, fisheries (including sport) and biological control is described in Table I. More often than not, introductions for fisheries and biological control did result in established populations. In the case of plant control, the established populations were reported to be based on continuous stocking of Chinese and grass carps. Of the 346
reported introductions for aquaculture, 112 cases resulted in the species being widely used and 157 resulted in the species being rarely used. The level of use following the remaining 77 introductions made for aquaculture is unclear, but is presumed to be low or non-existent.

**IMPACT OF THE INTRODUCTIONS**

The impact and benefits of many of the introductions reported were unclear (Table I). Respondents reported that 63% of the introductions probably had no effect on the ecosystem: 25% of the impacts were judged positive, while for 58% the nature of the impact (positive or negative) was undetermined. Furthermore, 62% of the introductions probably had no effect on the socio-economic system: 40% of the impacts were beneficial, while in 55% of cases the respondents were undecided whether or not the impact was beneficial. The nature of the impact of the majority of the introductions made for aquaculture was undecided, as was the nature of the impact of those made for snail and mosquito control, and for fisheries. The impact of introductions made for plant and algae control was less equivocal.

Aquaculture continues to be the principal reason for deliberate species introductions, and the contribution which introduced species make to aquaculture production is shown in Table II. With regard to fish, exotic species of salmon and trout
TABLE I
Responses to a questionnaire (distributed by the Food and Agriculture Organisation of the United Nations) regarding the impact of introductions of exotic species of aquatic animals

<table>
<thead>
<tr>
<th>Activity (no. of incidents)</th>
<th>Established in native waters?</th>
<th>Species still used in culture?</th>
<th>Probable impact on ecosystem?</th>
<th>Quality of ecosystem impact</th>
<th>Probable impact on socio-economic system?</th>
<th>Quality of socio-economic impact</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>WU</td>
<td>RU</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Aquaculture (346)</td>
<td>159</td>
<td>161</td>
<td>112</td>
<td>157</td>
<td>96</td>
<td>191</td>
</tr>
<tr>
<td>Fisheries and sport (200)</td>
<td>117</td>
<td>53</td>
<td>53</td>
<td>63</td>
<td>76</td>
<td>78</td>
</tr>
<tr>
<td>Plant and algae control (32)</td>
<td>19</td>
<td>10</td>
<td>13</td>
<td>12</td>
<td>19</td>
<td>8</td>
</tr>
<tr>
<td>Mosquito control (13)</td>
<td>13</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Snail control (3)</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Accident (36)</td>
<td>28</td>
<td>6</td>
<td>2</td>
<td>18</td>
<td>16</td>
<td>13</td>
</tr>
</tbody>
</table>

WU: widely used
RU: rarely used
B: beneficial
U: uncertain
A: adverse
-: no response
## TABLE II
**Contribution of introduced species to global aquaculture production in 1992**
(L. Garibaldi, unpublished findings)

<table>
<thead>
<tr>
<th>Category</th>
<th>Africa</th>
<th>North America</th>
<th>South America</th>
<th>Asia</th>
<th>Europe</th>
<th>Oceania</th>
<th>Former Soviet Union</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mt (%):</td>
<td>mt (%):</td>
<td>mt (%):</td>
<td>mt (%):</td>
<td>mt (%):</td>
<td>mt (%):</td>
<td>mt (%):</td>
<td>mt (%):</td>
</tr>
<tr>
<td><strong>Fish</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Native species</td>
<td>40,714 (79.2)</td>
<td>275,570 (91.7)</td>
<td>2,979 (3.6)</td>
<td>6,519,392</td>
<td>309,388</td>
<td>2,880 (26.8)</td>
<td>106,705 (89.8)</td>
<td>7,257,628 (88.4)</td>
</tr>
<tr>
<td>Introduced species</td>
<td>10,673 (20.8)</td>
<td>25,244 (8.3)</td>
<td>80,278 (96.4)</td>
<td>587,090 (8.3)</td>
<td>227,817</td>
<td>7,871 (73.2)</td>
<td>12,145 (10.2)</td>
<td>951,118 (11.6)</td>
</tr>
<tr>
<td><strong>Total (by continent)</strong></td>
<td>51,387 (100.0)</td>
<td>300,814 (100.0)</td>
<td>83,257 (100.0)</td>
<td>7,106,482 (100.0)</td>
<td>537,205 (100.0)</td>
<td>118,850 (100.0)</td>
<td>8,208,746 (100.0)</td>
<td></td>
</tr>
<tr>
<td><strong>Crustaceans</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Native species</td>
<td>87 (55.1)</td>
<td>35,822 (98.0)</td>
<td>116,958 (98.6)</td>
<td>667,070 (100.0)</td>
<td>60 (2.6)</td>
<td>1,112 (100.0)</td>
<td>-</td>
<td>821,109 (99.4)</td>
</tr>
<tr>
<td>Introduced species</td>
<td>71 (44.9)</td>
<td>739 (2.0)</td>
<td>1,660 (1.4)</td>
<td>- (0.0)</td>
<td>2,279 (97.4)</td>
<td>- (0.0)</td>
<td>-</td>
<td>4,749 (0.6)</td>
</tr>
<tr>
<td><strong>Total (by continent)</strong></td>
<td>158 (100.0)</td>
<td>36,561 (100.0)</td>
<td>118,618 (100.0)</td>
<td>667,070 (100.0)</td>
<td>2,339 (100.0)</td>
<td>1,112 (100.0)</td>
<td>-</td>
<td>825,858 (100.0)</td>
</tr>
<tr>
<td><strong>Molluscs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Native species</td>
<td>1,172 (65.2)</td>
<td>128,591 (78.0)</td>
<td>6,296 (98.1)</td>
<td>1,727,293 (100.0)</td>
<td>429,472 (75.9)</td>
<td>52,929 (91.8)</td>
<td>700 (100.0)</td>
<td>2,346,453 (92.9)</td>
</tr>
<tr>
<td>Introduced species</td>
<td>626 (34.8)</td>
<td>36,223 (22.0)</td>
<td>123 (1.9)</td>
<td>- (0.0)</td>
<td>136,656 (24.1)</td>
<td>4,708 (8.2)</td>
<td>- (0.0)</td>
<td>178,336 (7.1)</td>
</tr>
<tr>
<td><strong>Total (by continent)</strong></td>
<td>1,798 (100.0)</td>
<td>164,814 (100.0)</td>
<td>6,419 (100.0)</td>
<td>1,727,293 (100.0)</td>
<td>566,128 (100.0)</td>
<td>57,637 (100.0)</td>
<td>700 (100.0)</td>
<td>2,524,789 (100.0)</td>
</tr>
</tbody>
</table>

mt: millions of tonnes
account for the majority of aquaculture production in South America (Chile) and Oceania. For crustaceans, introduced species account for a larger proportion of production than native species only in Europe; this is principally due to the red swamp crawfish (Procambarus clarckii) and the kuruma prawn (Penaeus japonicus), and the lack of crustacean aquaculture in the region. In every region, native molluscs are produced in greater numbers than exotic species. The giant cupped oyster (Crassostrea gigas) contributes substantially to production in Africa, North America and Europe (L. Garibaldi, unpublished findings).

DISCUSSION AND CONCLUSION

The use of exotic species will undoubtedly continue. Aquaculture has been promoted as a means to help increase food production for a growing human population, and aquaculture has been the principal reason for fish introductions. At present, intensive management of inland bodies of water, through stocking and hatchery enhancement, may also include the use of exotic species in areas where local fish fauna is depleted or otherwise not utilised (11). Furthermore, the use of exotic species for biological control may reduce dependence on pesticides, herbicides and other toxic substances.

Several professional fisheries bodies have recognised the need for prior planning to maximise the benefits from exotic species. To this end, a Code of Practice was developed and accepted (in principle) internationally (5, 24). The principles of the Code are simple, but it places certain responsibilities on importers, exporters and resource managers (Fig. 2). Developing countries and rural areas may have difficulties complying completely with the Code, but an effort to apply it and to follow suggested protocols will at least force resource managers to consider the possible negative impacts of introductions.

Two main recommendations have arisen from this Code and, as expected, these two recommendations also provoke controversy. The first major recommendation is that, whenever possible, local species should be used in preference to exotic species. The second is that strict quarantine should be imposed on imports, and that only the offspring of fish originally imported should be released or utilised (24).

The use of native species rather than exotic species would reduce risks associated with pathogens and ecological impacts. Furthermore, native fish may have an established local market. In some developing areas, however, the performance of local species is unknown (15) and they have not been domesticated to an acceptable level for aquaculture. In addition, many local species are of no commercial interest, as they are not traded internationally or are so common that they are undervalued.

Quarantine requirements are included in most codes on introduced fishes. The Office International des Epizooties (OIE) has developed recommendations and protocols for the prevention of the international spread of diseases of aquatic organisms as part of the OIE International Aquatic Animal Health Code, which deals with the health surveillance of aquatic animals for the purposes of domestic and international trade. For marine and freshwater introductions, recommendations for policies on introductions and guidelines for their implementation – including methods to minimise the possibility of disease transfers – have also been developed by the International Council for the Exploration of the Sea (ICES) (2) and the European Inland Fisheries
Proposal to import, including:

- Planned use of exotic species
- Location of facility
- Passport information
- Source of exotic species

Independent review, including evaluation of:

- Disease organisms associated with exotic species
- Ecological requirements/interactions
- Genetic structure and hybridisation potential
- Socio-economic considerations
- Local species which may be affected

Advise/advice

Approval

Protocols if approved:

- Quarantine
- Confinement
- Monitoring

Refine proposal as recommended by review process

**FIG. 2**

**Diagrammatic Code of Practice on the introduction of exotic aquatic species**

(Adapted from Bartley [7])


An example of such recommendations is the ‘Code of Practice to Reduce the Risks of Adverse Effects Arising from the Introduction and Transfers of Marine Species’, which was developed by the ICES Working Group on Introductions and Transfers of Marine Organisms (9), and was revised in 1994 (13). EIFAC adopted the revised ICES
Code in principle at its 18th Session in Rome in 1994, but without developing specific text for inland waters.

The ICES/EIFAC Code of Practice recommends the following procedure for disease control in exotic fish introductions (24):

a) examination of each proposed transfer for the possibility of introducing associated pathogenic organisms and parasites

b) establishment of a broodstock in the importing country by transfer of eggs of the species to an approved quarantine facility where they will be examined regularly for pathogens

c) if no pathogens become evident, transplantation of first generation progeny, but not the original import, to culture sites or the natural environment

d) continuation of disease studies on transplanted individuals.

Such stringent measures are justified to protect existing aquaculture development and to avoid damage to indigenous species. The latter often lack natural resistance to introduced pathogens and may therefore be particularly vulnerable, not having been previously exposed to infection. In rural and developing areas with limited resources, however, the building and running of quarantine facilities may be difficult. Costs are perceived as prohibitively high, and resource managers are often anxious to expedite development; therefore quarantine facilities may not be provided.

Experience has shown that substantial financial losses can result from inadequate quarantine and the resulting import of pathogens (3). The cost of a quarantine facility must therefore be evaluated in the light of potential losses resulting from the introduction of a pathogen. A number of pathogens which have caused substantial economic losses to Asian aquaculture are believed to have been introduced along with exotic species, including the following:

- the copepod *Lernaea cyprinacea* and myxosporeans of the genus *Myxobolus*, which have caused problems in Indonesia (12)
- the agent of epizootic ulcerative syndrome (EUS), which has spread throughout much of the region (2, 21)
- several viral disease agents which are a continuing problem to prawn growers in Malaysia, Thailand and the Philippines (2, 14).

Tonguthai (23), for example, has estimated the losses caused by EUS in Thailand during 1982-1983 alone at approximately US$8.7 million, while Nash et al. (17) estimated a loss of US$30.6 million to the Thai shrimp industry in 1992 due to yellow head disease. Other similar examples include the crayfish plague caused by the fungus *Aphanomyces astaci* in *Astacus astacus* and bonamiosis (caused by the protozoan parasite *Bonamia ostreae*) in flat oysters in European aquaculture.

The history of the use of introduced species is filled with successes, failures and contradictions. A common element in most introductions is the lack of monitoring of the real impact on society and the ecosystem. In cases where a fishery or new industry developed – as with the introduction of Nile perch in Lake Victoria or salmon in Chile – monitoring consisted of yield statistics and income generated. Monitoring in Lake Victoria also consisted of documentation of the disappearance of many endemic species of cichlid fish. The impact of salmonid introductions on the native biodiversity
of Chile has generally been neglected (Institute of Fisheries Development, Chile, unpublished findings).

A problem with monitoring programmes is that the effects of an introduction are often not immediate, but may appear many years after the initial introduction. Nile perch were introduced into Lake Victoria in the late 1950s but did not make a significant contribution to the fishery until the early 1980s (20). Many of the introductions of grass carp which were initially thought not to have resulted in self-sustaining populations have now been shown to have established populations which reproduce in the wild (10). The introduction of the sea lamprey (Petromyzon marinus) to the Great Lakes of North America as a result of the opening of the St Lawrence seaway took 100 years to affect the native fisheries (8).

Pullin (19) points out that: 'Decision-making on the use of exotic species [...] is therefore a political process that requires [...] the best possible scientific evidence, geared toward [...] assessment of risks'. Unfortunately, knowledge of the ecological and socio-economic systems into which an organism will be introduced is often so meagre, and the risk assessment tools so difficult to utilise, that decisions are often taken on a purely political or short-term economic basis. It is also unfortunate that the lack of monitoring and assessment of past introductions has prevented researchers from benefiting fully from the over 1,500 'experiments' in species introductions which are documented in the FAO database.

* *


Résumé : Le recours à des espèces exotiques d’animaux aquatiques pour accroître la production destinée à l’alimentation humaine et le revenu ainsi généré remonte au milieu du XIXe siècle. Aujourd’hui, les progrès de l’élevage permettent des transferts à grande échelle de nombre d’espèces différentes sur de longues distances. Malgré un recul progressif du volume de ces transferts depuis les années 1960, cette pratique persiste et continue de susciter des polémiques sur la protection de la diversité biologique locale, la propagation de parasites et de maladies et les facteurs socio-économiques. Les auteurs présentent les résultats d’une enquête internationale menée par questionnaires et destinée à mieux cerner l’utilisation des espèces introduites et leurs effets.

Des informations ont ainsi été recueillies sur 654 introductions d’espèces aquatiques, essentiellement des poissons. A l’origine de ces introductions on retrouve essentiellement l’aquaculture, suivie, dans l’ordre, par la création de pêcheries, le commerce de poissons d’aquarium, la recherche, les contrôles biologiques, les accidents, la distribution naturelle, et enfin la fourniture d’appâts et d’aliment. Ces introductions ont été effectuées par des organismes publics (40 %), par le secteur privé (18 %), par des particuliers (15 %) et par des organisations internationales (7 %). Les 20 % restants n’ont pas d’origine connue.

Les réponses fournies concernant l’impact et les avantages de ces introductions ne sont pas très claires. La plupart de ces introductions (62 %) ne se sont probablement pas traduites par l’implantation d’espèces exotiques dans des eaux naturelles. D’après les réponses du questionnaire, 63 % des
introductions n'ont probablement pas eu d'incidence sur l'écosystème. Lorsqu'elles ont eu une telle incidence, celle-ci est jugée positive dans 25 % des cas, tandis que dans 58 % des cas elle n'a pas pu être déterminée comme positive ou négative. Par ailleurs, 62 % des introductions n'ont pas eu de conséquences sur le système socio-économique. Lorsqu'un tel impact a été constaté, il a été jugé positif dans 40 % des cas, mais dans 55 % des cas les personnes interrogées n'ont pas pu se prononcer sur sa nature positive ou négative.

Les auteurs recommandent que la planification, la réglementation et la surveillance de l'introduction d'espèces animales aquatiques soient rendues obligatoires par l'adhésion à des codes nationaux et internationaux de bonnes pratiques. Cela contribuera à optimiser les avantages liés à l'utilisation d'espèces aquatiques exotiques.


Resumen: La utilización de especies acuáticas exóticas para elevar tanto el nivel de producción alimentaria como los ingresos generados por dicha producción constituye una práctica bien establecida desde mediados del siglo XIX. En la actualidad, los adelantos en técnicas de cría hacen posible el movimiento a través de grandes distancias de un gran número de especies distintas. Pese a la reducción progresiva de tales movimientos desde los años sesenta, dicha práctica persiste y sigue generando polémica en lo que se refiere a la protección de la diversidad biológica local, la diseminación de parásitos y enfermedades y diversos aspectos socioeconómicos relacionados con esta actividad. Los autores presentan los resultados de una reciente encuesta sobre la introducción de especies ajenas al entorno local. Un cuestionario fue distribuido a nivel internacional con el fin de mejor aprehender los usos y efectos ligados a la introducción de dichas especies.

Se obtuvo información concerniente a 654 introducciones de especies acuáticas, en su mayor parte peces. La principal razón aducida para explicar la introducción de dichas especies fue la acuicultura, seguida por la creación de pesquerías, el comercio de peces de acuario, la investigación, el control biológico, diversas causas accidentales, la difusión natural y, por último, la distribución de cebos y alimentos. Estas introducciones fueron llevadas a cabo por organismos públicos en el 40 % de los casos, por el sector privado en un 18 %, por los particulares en un 15 % y por organizaciones internacionales en un 7 %. El origen del 20 % restante no pudo ser establecido.

El impacto y beneficios de muchas de las iniciativas resultaban dudosos. La mayoría de las introducciones (62 %) no se tradujeron probablemente en la implantación de especies exóticas en aguas naturales. Los interrogados respondieron que el 63 % de las introducciones no había tenido probablemente ningún efecto sobre el ecosistema: en el 25 % de los casos dicho efecto fue juzgado positivo, mientras que en un 58 % no era posible establecer la
naturaleza del impacto (positivo o negativo). Por otro lado, el 62% de las acciones no afectaron probablemente en modo alguno el sistema socioeconómico: su efecto recibió una valoración positiva en el 40% de los casos, y en otro 55% el interrogado dudaba en calificar tal impacto de beneficioso.

Los autores recomiendan la adhesión obligatoria de las actividades de planificación, regulación y monitoreo de la introducción de especies acuáticas foráneas a los códigos nacionales e internacionales de buenas prácticas profesionales. Ello ayudaría, en el futuro, a extraer el máximo beneficio de la utilización de especies acuáticas exóticas.


**

REFERENCES


