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INTRODUCTIONS OF MOLLUSCAN SHELLFISH - PAST EXPERIENCE AND FUTURE CONSIDERATIONS

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ABSTRACT

For many years, deliberate introductions and transfers of molluscan shellfish have been made, usually for fisheries purposes to counteract declining stocks of local species while needing to maintain or increase production for market demand. There have been risks and costs. Many introductions were made without any form of control or regulation. In some cases, other species were accidentally introduced that were competitors, pests, predators or disease agents to native species. Legislation was formulated to control further introductions, including controls over the movement into and within the state or country. Further controls were put into place when the hatchery production of bivalve seed became more common practice in the mid-1960s. Guidelines in the ICES Code of Practice have been fundamental in providing advice to support and monitor planned introductions. Inevitably, deliberate introductions of molluscan shellfish will continue to take place around the world to support local fisheries and employment. Current changes in legislation to aid free trade between countries could increase the risks from accidental co-introductions and transfers. Unintentional introductions of molluscan shellfish as foulants on ships, in ballast water and in the aquarium trade should also be realised. Increasing the awareness of the risks involved is paramount.

Keywords: mollusc; aquaculture introductions; co-introductions; ballast water

INTRODUCTION

Since travel began, man has moved animals and plants around the globe for the purpose of trade and development. This has included molluscan shellfish primarily for direct consumption, aquaculture and more recently for the aquarium/ornamental industry. Alongside the obvious benefits of this trade, there are potential problems, some of which are described in this paper. As well as these deliberate introductions,

unintentional introductions of molluscan shellfish have also occurred via a number of vectors. Although many of these introductions have probably had no or little impact, there are other examples where the environmental and socio-economic impacts have been significant. Carlton (1999a, b) reviews many of these introductions of molluscs, the significance of some of the donor areas and the scale of impact once the introduction had occurred.

DELIBERATE INTRODUCTIONS

Aquaculture purposes

In many countries, the development and diversification of the aquaculture industry, including shellfish farming is dependent on introductions of species from other parts of the world. Reasons for these introductions include:

- to re-establish a commercial fishery after a decline in stocks of native species through disease, over-fishing, pollution, etc.,
- to develop an aquaculture industry or provide diversification for an already established industry, and
- to introduce new traits (e.g. disease resistance, improved growth and survival) to enhance production of species within an established industry.

On a global scale, the most successful introduction of a mollusc species for aquaculture is the Pacific oyster, *Crassostrea gigas* (Chew, 1990). It is native to Japan but has been introduced to every continent and is the most important oyster farmed. Nowadays, many millions of hatchery-produced seed are moved between countries and states to sustain this industry. The European oyster, *Ostrea edulis*, has been moved from its native habitat to the USA and Canada (Chew, 1990). In exchange, the American oyster, *Crassostrea virginica*, was introduced to Europe for many decades (Utting & Spencer, 1992) although it is of little interest there now since the introduction of the more successful *C. gigas*. The Manila clam, *Ruditapes (Tapes) philippinarum*, is another bivalve native to south-east Asia and introduced accidentally to the west coast of America and parts of Europe in shipments of Pacific oysters. Scallop aquaculture is relatively new to many countries and has involved the movement of broodstock adults. The most significant, in terms of the commercial production that resulted, has been the American bay scallop, *Argopecten irradians*, that was introduced to China from the USA (Guo et al., 1999). The Japanese scallop, *Patinopecten yessoensis*, has been introduced into France, Ireland, China and Canada to assess its commercial potential. Abalone are being considered for aquaculture but Minchin (1996) listed only one species *Haliotis discus hannai* that had been introduced from its native habitat (Japan) into Europe. These are some of the more well-known examples of introductions that have been made.

Introductions have also been made in an attempt to improve tolerance or resistance to disease in molluscs. In France for example, a range of *Ostrea* species were introduced under strict quarantine conditions (ICES, 1999) to assess their resistance to the disease agent *Bonamia ostreae* that severely affected the European native oyster (*O. edulis*) industry in the 1980s.

Aquarium trade

The marine ornamental trade is developing into a flourishing business in many countries and some exotic marine molluscs are moved for this purpose. Reliable data on the numbers and exact species are difficult to obtain. This is compounded by the fact that animals are often imported only to be re-exported again which makes interpretation of data difficult. Nonetheless, the aquarium trade is another route that will need careful control to reduce the potential threat of unwanted introductions. Currently, few countries have the appropriate legislation for such control. In addition, public awareness on the risks arising from introductions made through the aquarium trade is often lacking.

CONTROLS ON DELIBERATE INTRODUCTIONS

In most countries, there is national legislation to control the introduction and transfer of marine organisms. This has generally been formulated to prohibit or control the introduction of disease agents. In 1979, ICES took a lead in providing guidance on proposed introductions and transfers of marine organisms on a more global scale by formulating a Code of Practice (COP). The recommended procedures in this COP have been used to successfully introduce new species of molluscs for cultivation without the co-introduction of disease agents, pests, parasites or competitors (Utting & Spencer, 1992). This has been the basis on which hatcheries have been established in many countries since the mid-1960s for the commercial production of seed molluscs. The most recent version of the COP (ICES, 1995) includes guidance on disease, environmental and genetic aspects that should be considered to reduce the risks of adverse effects arising from introductions and transfers of aquatic organisms. Recently, several developing countries world-wide have expressed an interest in adopting the ICES COP as a definitive guide.

UNINTENTIONAL INTRODUCTIONS

Before appropriate legislation was implemented, there were several examples of accidental introductions occurring. This was due to a lack of awareness of the threats from introducing unwanted organisms, although in some cases it may have been the result of someone disregarding the legislation. There has been and never will be control over the latter situation although improved education on the risks of illegal introductions will always help to alleviate the problem.

Co-introductions with deliberate introductions

Some of the original introductions for aquaculture were made as imports of seed or half-grown animals for further on-growing in coastal waters. These shipments of oysters, that were collected from the wild, unfortunately led to the co-introduction of other competitors, pests, parasites and diseases (Chew, 1990; Utting & Spencer, 1992; Minchin, 1996). One particularly problematic co-introduction was the American slipper limpet, *Crepidula fornicata*, into Europe. Today it is found from Spain to Scandinavia (Minchin, 1999) and in some countries, France for example, it has

established large populations. Several other Asian algae and invertebrate species have also been transferred to new localities in shipments of oysters (Carlton, 1999c).

With trade barriers being lifted between nations, for example within the European Union, there has been some concern over the potential renewed threat of accidental co-introductions occurring. The co-introduction of dinoflagellate cysts, the Asian copepod, *Mytilicola orientalis*, and *C. fornicata* to Ireland in shipments of half-grown Pacific oysters from France is one recent example (Minchin, 1993, 1996) and shows the need for increased vigilance when checking imports.

Introductions via shipping

In the 1990s, it was recognised that shipping and in particular ships' ballast water is often responsible for the increasingly unexpected appearance of non-indigenous species in the aquatic environment. There are several examples of molluscs transferred by shipping including the zebra mussel, *Dreissena polymorpha*, which invaded the Great Lakes in USA/Canada in 1986 and Chinese clams, *Potamocorbula amurensis*, that were found in San Francisco Bay in 1986 (Carlton, 1992). The zebra mussel has since found its way back to other parts of Europe where it is rapidly spreading and becoming a pest species in some areas (Olenin et al., 1999). The American clam, *Ensis directus*, is another species moved in ballast from America to Europe (Voight, 1999). In 1998, the Asian whelk, *Rapana venosa*, was reported in Chesapeake Bay (Harding & Mann, 1999) and a few specimens have also been trawled from waters off the Brittany coast, France (P. Gouilletquer, personal communication).

The list of new species introductions and extensions to a species' range through shipping as a vector (in ballast water, in sea chests and attached to ships' hulls) grows longer and longer as more studies are carried out. This is likely to continue in the short term as more countries carry out baseline studies in ports and harbours to assess the need for ballast water controls in their national waters.

CONSERVATION & ENVIRONMENTAL ISSUES

Many of the introductions of molluscan shellfish have been beneficial to the development of the aquaculture industry but in some cases introduced species have bred successfully and established self-sustaining populations. In France, the oyster fishery is very dependent on seed Pacific oysters collected from the wild. In Australia, attempts were made to eradicate *C. gigas* as it bred successfully and was considered a pest in some regions because it displaced the native species, *Saccostrea commercialis*, (Pollard & Hutchings, 1990). In the UK and the Netherlands, there is a growing number of reports of naturally settled *C. gigas*. Increasing water temperatures have been implicated but a ban on the use of tri-butyl tin in antifoulant paints may also be a contributory factor. The Manila clam, *R. philippinarum*, has successfully colonised the upper shoreline along the north-west Pacific coast of the USA and Canada. An extension northwards to its range was probably dependent on increased water temperatures in shallow coastal embayments. This clam was also introduced to Italy

where it has bred and recruited on a regular basis and now supports a very successful fishery in the Venice Lagoon.

Rising sea water temperatures through global warming is of concern to many environmentalists because of the potential for introduced species to extend their range. However, the response of native species to increasing water temperatures should not always be expected to be negative. For example, European oyster seed is regularly produced in commercial hatcheries at temperatures several degrees above the ambient water temperature in the natural environment. More research on the responses of native species to anticipated environmental changes would help to allay some of the concerns and provide information on which management decisions can be made. Normally, the precautionary principle is used in situations where any uncertainty exists.

The use of triploid shellfish, which are theoretically sterile, is one way of reducing the potential negative environmental impacts of an introduced species. In the 1980s, research was carried out to produce triploids of many molluscan species (Beaumont & Fairbrother, 1991). In reality, many triploids were not entirely sterile but they were generally much less fertile than the diploid equivalent (Utting et al., 1996).

FUTURE CONSIDERATIONS

Increasing public pressure on governments to protect the environment will impact on deliberate introductions of molluscan shellfish in the future. At present, full risk assessments are generally needed before any new introduction is made and there may be even greater pressure to use native species wherever possible, even down to local genetic strains and stocks whenever and wherever appropriate.

Controlling ballast water introductions is recognised as a global problem but the implementation of legislation and/or guidelines on a global scale is likely to be constrained for several years. This is because of financial and operational (safety) reasons and the lack of appropriate technology. Nonetheless, more surveys will be carried out to determine species' distributions and the list of introduced species will rise in the short term. A major concern, however, is the decreasing number of good taxonomists and this needs to be addressed urgently to ensure molluscan species are identified correctly.

Modern technology, particularly IT developments, will allow the rapid transfer of information. The development of web-sites dedicated to introductions, including molluscs, on a global scale and access to e-mail will enable the more rapid exchange of information on which decisions can be made more readily. This is particularly appropriate with the increasing volume and speed of transportation around the world. However, it is apparent that the quantity and quality of data collected (e.g. on imports and exports) differ between countries and the reliability of the data cannot always be guaranteed. This has been a problem encountered by the ICES Working Group on the Introduction and Transfer of Marine Species when collating information for annual reports.

It is paramount that an awareness of the potential risks involved in the introduction of molluscan shellfish, as with all introductions, is brought to the attention of all concerned. Raising public awareness is essential but care must be taken to ensure that information is provided in a balanced and reasoned way.

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