PROCEED GS OF ... SHOP

INTRODUCTIONS & TRANSFERS OF MARINE SPECIES

Achieving A Balance Between Economic Development and Resource Protection

PROCEEDINGS OF THE CONFERENCE & WORKSHOP

INTRODUCTIONS & TRANSFERS OF MARINE SPECIES

Achieving A Balance Between Economic Development and Resource Protection

OCTOBER 30 – NOVEMBER 2, 1991
HILTON HEAD ISLAND, SOUTH CAROLINA

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PREFACE

A conference and workshop titled "Introductions and Transfers of Marine Species: Achieving a Balance Between Economic Development and Resource Protection" was held October 30 to November 2, 1991, on Hilton Head Island, S.C. The event provided a forum for the presentation and discussion of issues and ideas which may influence introduced species policy in the future. Invited speakers were asked to:

- provide a historical review of species introductions and transfers;
- describe the current state of knowledge on the benefits and risks of marine species introductions and transfers;
- examine current issues and concerns, with particular focus on marine species;
- review existing legislative and regulatory policies at the international, national, regional and state levels;
- discuss programs being developed at the federal level to address these issues; and
- generate recommendations that support balanced ecological and economic resource goals.

Conference topics explored emerging issues confronting the United States and culminated in a workshop where these issues were examined from the perspective of South Carolina.

The introduction and transfer of marine species into and within the United States has occurred for decades. As a result of increasing consumer demand for seafood, the need for stock enhancement programs, the growth of aquaculture, the marine bait and tropical fish industries and the pursuit of scientific research, the number of marine introductions and transfers has increased.

Concern over the deliberate movements of marine organisms is the possible introduction of diseases, parasites, competitors and/or predators not presently indigenous to the receiving environment. However, history has demonstrated that for some species, introductions can prove socially and economically beneficial.

It is not surprising, therefore, that the introduction, transfer or release of marine species has led to strong debate about the relative benefits and risks, and in some cases has resulted in prohibitive management measures.

The apparent lack of information available to decision-makers, extension personnel and the public and private sectors has fueled the debate. Often emotional decisions based on perceptions, rather than objective decisions based on sound information and balanced judgements, are made. This conference and workshop attempted to address these issues based on the current level of knowledge available to scientists and decision-makers.

ACKNOWLEDGEMENTS

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In addition, the following individuals took time out of their busy schedules to actively participate and assist in the organization and planning of the conference and workshop:

- Jesse Chappell, Southland Fisheries Corporation
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Finally, the editor wishes to thank Sara Kau, Cyndi Russell, Leigh Handal and Bill Hartley of the S.C. Sea Grant Consortium for their efforts in preparing the written material for publication.

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Historical Perspectives on Exotic Species

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I am an historian who is supposed to provide you with an historical perspective on exotic species. Unfortunately, that perspective has not been sought very often in relationship to exotic species. The Massachusetts Institute of Technology celebrated its centennial with the slogan, "The Future: We Never Look Back," which sums up rather well the notion of progress in modern society. I certainly hope that the scientific community is willing to look back in spite of the hold that the concept of progress has upon its thinking. The historical record can inform us particularly in light of Alfred W. Crosby's observation in *The Columbian Exchange: Biological and Cultural Consequences of 1492* that the most important consequence of Columbus' voyages lay in the transfer of plants and animals between the Old World and the New.

That said let me advance the following observations.

1. Agriculture as we know it in the United States would be impossible without introduced organisms. American agriculture is based almost entirely upon introduced species. Of all the animals involved in American agriculture only the turkey, the Muscovy duck and (maybe) one type of chicken are native to the United States. And of the plants that are cultivated as part of the agricultural system, corn (maize), potatoes, some beans, squash, sweet potatoes and some berries are native. Everything else is introduced, even the honeybee brought by Englishmen in the 1640s in order to pollinate the fruit trees they were introducing. Domestic pets like the cat and most dog breeds were also introduced, the Indians having no need for such animals.

2. The most beneficial introductions in American history have concerned land animals and plants and those have almost entirely been associated with agriculture. There are reasons why this is so. All of the animals and plants used in agriculture had been observed in use and in close proximity for millennia. While it is generally true as Walter Courtenay has stated that "It is virtually impossible to predict how an exotic organism will behave in a new environment," the knowledge that agriculturalists had amassed minimized the surprises that could occur.

Spaniards brought horses into the southwest in the 1570s while English ships carried "one hundred Kine and other Cattell [sic]" to Jamestown in 1611 (four years after settlement). Within three years, wild hogs were already "infinite" in Virginia, but this was no surprise for domestic livestock had turned wild for centuries when provided opportunities. Settlers knew that and, in fact, there is reason to believe that those settlers, knowing what might happen, desired the impact that their domestic animals released into the American environment would have upon both the "wilderness" and Indian agriculture.

Of course, the very term "beneficial" comes totally from a European perspective, for the agricultural species were the dynamic elements of the dramatic changes in environment that occurred after 1607, crowding out native species, changing the genetic mix, changing the habitat from woodlands to fields, causing erosion, etc. Of non-agricultural species that have proven to be beneficial for human purposes, biologists point to the striped bass, ring-necked pheasant and Chukar partridge. Three aquatic species, while having their supporters, have received mixed reviews at best – the common carp, brown trout and the Pacific oyster.

The significance of this point cannot be overemphasized. America itself would not have been possible without those agricultural species being so adaptable. Europeans would only cross the Atlantic if a reliable supply of familiar European products was present. It meant that much greater biological density became available because the number of cultivatable food plants in the United States tripled, and it meant that Americans have been consistently the best fed people in the world – a fact that has attracted more people than all the religious and ideological forces that have so often been cited as explanations for the vast migration of people to America.

3. No escaped biological organism has come to be considered beneficial by Americans. Man's careless and improper agency – "escape," after all, implies losing control over – has produced much adversity in nature. This list is endless and includes imports like the European

black rat which jumped ship in Jamestown in 1609 and spread so rapidly that three decades later an observer noted that "the Lord sent upon the Countrey [sic], a very grievous scourge and punishment, threatening the utter ruin and desolation of it;" and the common house mouse and the cockroach which came on ships about the same time. While escapes from ships remain an avenue in more recent times – fire ants, for example – animals have found other avenues into the American environment.

The so- called "walking catfish" was imported for the aquarium trade in the early 1960s and then escaped from a truck transporting a supply across Florida (the aquarium trade has occasioned many escapes); the tench which washed into the Potomac River in 1889 when federal fish ponds were flooded; the sea lamprey and the alewife which came through the Welland Canal into the Great Lakes after the flow was re-routed; the pink salmon when 10,000 eggs were flushed down the drain of a research facility into a sewer from which they moved into Lake Superior; or like the escape of "killer bees" (African bees) from a research facility which have moved steadily across contiguous land from Venezuela to the United States.

Plant organisms, too, have gotten into the American environment by accident. Dandelions, daisies, plantain, dock, crab grass, and nettles all arrived in the folds of clothing, in animal dung, and mixed in with "good" seeds during the 17th and 18th centuries. Crosby notes that in America today, many meadows exist where one would not be able to find a single species of plants that predate Columbus. Sometimes as with stem rust, the organism producing the harm "piggy-backed" in on an introduced species. In the early 1700s stem rust almost eliminated the wheat industry in the colonies. Then in the 1750s, New England farmers discovered that barberry, an imported ornamental, served as an alternative host and called for its eradication without success.

4. Almost all introductions to the waters of the United States have proven to be a mixed blessing while many introduced land organisms are judged beneficial by human beings. To the already mentioned brown trout, common carp and Pacific oyster, I would add the water hyacinth, hydrill and alligator weed. The water hyacinth was introduced into a private pond in Florida as an ornamental and soon entered the waterways of Florida. Millions of dollars are now spent annually trying to clear it out of waterways throughout the South. These efforts include introducing the glass carp in order to control it, hopefully without becoming a problem itself. And, I would add the freshwater shrimp, introduced for diversity's sake into Flathead Lake in Glacier National Park. Unfortunately, these shrimp eat the same food that young salmon do and, thus, the salmon population has declined precipitously. Ironically, the salmon were themselves introduced to be food for eagles. And in the Great Lakes, the introduction of smelts in 1912 as a food source for the Japanese salmon that were intended to replace the vanished Atlantic salmon has hastened the demise of the Lake whitefish and Lake herring by feeding on the same sources. In 1944, when the smelt population suddenly but temporarily declined, the largest increase of whitefish yearlings in history occurred.

5. The technological fix – whatever is wrong can be remedied by applying technology – is translated bio- logically as what God has left undone, humans can do, or if we humans have done something wrong with the environment, we can fix it! Several of these ill-designed efforts to fix matters have already been mentioned; e.g., the shrimp-salmon-eagle relationship at Flathead Lake and the smelt-Japanese salmon-Lake whitefish relationship. In Hawaii where 90% of the native bird species have disappeared because of the introduction of various organisms, cutworms and armyworms were devouring sugarcane; the myna bird was introduced to control the worms. The myna birds ate the worms, but also ate the fruit of the recently introduced lantana plant and excreted lantana seeds throughout the state. Hawaii, therefore, decided to introduce a parasitic insect to deal with the lantana. Additionally, the myna birds made so much noise that they irritated residents and tourists alike, threatening grave financial repercussions. Hotel managers turned to firecrackers, high frequency sound waves and illegal shootings to chase the birds from their hotels.

6. The notion that humans have the "right" to complete what God has left undone stems from the way that people have interpreted Genesis and other scriptural passages. Genesis 1:26 states "Be fruitful and multiply, and replenish the earth, and subdue it, and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moves upon the earth." Historians and theologians have disagreed over the amount of blame to place upon the Judeo-Christian tradition for the environmental problems of the world, but there is no doubt that human beings have frequently used these and other words to provide overarching sanction for their activities, including introducing exotic species into supposedly deprived environments.

7. That the American experience during the colonial period and in the case of immigrants has often been shaped by sentiment and by "nostalgia" seems to be the only explanation for introducing domestic cats or various types of dogs or brown trout or the songbirds that were introduced into American cities in the 1870s and 1880s – starlings, nightingales, blackbirds, song thrushes, and English sparrows.

8. The beneficiaries in the case of exotics in American history are quite frequently not the ones who must suffer from potential adverse circumstances. In the broadest terms, the supposed beneficiaries of livestock introductions, the Europeans, passed the immediate adverse effects of those introductions on to the Indians, who paid a fearful price in the degradation of their agricultural habitat and the dislocation of their seasonally nomadic style of life.

In Hawaii, the sugar cane growers did not have to shoulder the major part of the burden brought on by the myna birds. And, in the mainland, where decentralization is still the rule rather than the exception in spite of Executive Order 11987 (1977) and the Lacey Act (1900), Missouri attempted to exclude glass carp from its waters; but once Arkansas introduced glass carp, Missouri suffered the consequences. And, very recently, the opposition of South Dakota, Minnesota and Canada to the introduction of the zander (because of the danger of disease transmission and fears of crowding out native fish) has been ignored by North Dakota. Should the zander be introduced and prove to be a disaster, the consequences in these neighboring jurisdictions will provide a classic example of Garrett Hardin's "tragedy of the commons."

9. Historically, what has happened in environmental terms is no different from what has controlled much of human activity, where immediate and short-term needs are placed before delayed and long-term considerations. From the start, the perceived economic and survival needs of American society have taken precedence over possible long-term consequences. This attitude of doing what is necessary right now has not changed over four centuries, remaining one of the strongest motivations for introducing a species. For example, in the case of kudzu, that ubiquitous vine of the South, the fact that observers reported from Japan that this vine was "dangerously aggressive in its tendencies to grow anywhere" stopped no one from planting it in the South. The problem – the erosion of railroad rights of way – was real, and the future could take care of itself. Today, when the problem is identified as uncontrolled growth of water hyacinths, of hydrilla, or of other aquatic vegetation, the solution is the glass carp although warnings are sounded. The future, after all, will be taken care of when it gets here.

10. The ethnocentric attitudes exhibited by settlers from Europe were in part revealed as attitudes of alienation from nature and hostility to "wilderness." Civilization represented a superior mode of living and those human beings who came to America believed that anything that they could do to hurry the transformation of America from uncultured "wilderness" to a civilized state was not only permissible, but preferable. Historians have labeled this the "frontier mentality."

Every species imported from Europe, including in some kind of vague way the pests, helped convince these "new Americans" that they were superior to the environment and the denizens of the "wilderness," the Indians. Europeans used those introductions as psychological supports and as physical instruments of their transforming superiority.

Magnifying this attitude was the sense early Americans had that Indians mismanaged and wasted natural resources. Since white man thought that Indians didn't believe in the concept of private property, and didn't use land either wisely or extensively, they believed the Indians had thus forfeited their rights to that land. Europeans could do whatever they wished with it.

To early Americans and many later ones, too, the total sum of all the natural resources available for use was infinite. Adding organisms to any specific environment was, therefore, both an affirmation and an extension of that belief.

11. For American historians, the one hundred years of existence of the frontier has frequently been at the center of interpretations to explain the essence of the American experience. Briefly stated, many historians visualize a series of stages rolling consecutively across the continent producing behavioral traits, cultural development and institutional characteristics as they go. The frontier thus provides the great common shared experience that governs the American experience. In this Frontier Theory, trappers and mountainmen, miners, cowboys (husbandmen), pioneer farmers, agriculturalists and townspeople, while not driven by the presence of introduced species, are each in different ways empowered by their presence. Without those species none of the psychological and spiritual effects that grew out of the physical presence of the frontier would exist to influence American history. Indeed, the sense of victory which flows around the triumph of human beings over the environment – the frontier – and which dominates American history would be absent.

12. Introduced species have played an important role in placing the United States within the commodity system of western capitalism. Most of the plants and animals that fuel that system are introduced species. While Americans might describe exotic species as beneficial or desirable even if they provide only beauty or pleasure, the impression of benefits imported usually increases in due proportion to the value of the species used as a commodity. Certainly, wheat is valued more than daisies, or sheep more than ring-necked pheasants or smelts more than

alewives. The potential for profit that a species possesses because of its significance within the com- modity system has constituted a major reason why a species is likely to be introduced. Today, participation in the commodity system may be perceived more indirectly, such as when aquatic species are considered for introduction because of their potential sporting value or potential for aquatic weed control.

13. Introduced species enter an environment more easily than they can be removed. Efforts over the years to get rid of a wide range of both animal and plant species that have been imported demonstrate the validity of this statement. The black rats which jumped overboard in 1609 have become millions (billions?) despite all efforts to eradicate them. Kudzu, fire ants, water hyacinths, sea lampreys, feral pigs, horses, burros and dogs, barberries, crabgrass, dandelion, the common carp, cockroaches, gypsy moths and Japanese beetles along with many others are now well-established in the United States and have defied both small and large-scale attempts to eliminate them. As an example, in 1975 at least 26 aquatic imports lived in Florida waters. Beginning in January 1977, a massive eradication program reduced that number to 21. A new ecosystem – almost always far less complex than the one they helped replace – has grown up with them.

14. Finally, human beings who have chosen either collectively or individually to introduce exotics into the United States have proven to be no more able to see into the future or to avoid the pitfalls of Murphy's Law than human beings functioning in other areas of life. Camels failed in the desert; Japanese salmon failed in the Great Lakes; caribou failed in Maine despite being thought to be sure things. On the other hand, the glass carp, it was thought, would never spawn outside its native rivers. Well, it has!

If there are any propositions that historians are sure of, it is that human beings can predict future consequences only in limited circumstances and Murphy's Law will take effect, sooner or later. To argue that a research facility can be made totally secure against the escape of the organisms within is to fly in the face of the human condition. The killer bee invasion just now beginning in Texas is an ecological disaster that occurred because a visitor to the Venezuela laboratory where the bees were being studied under great precautions lifted up a screen and let 26 queens and their entourages loose. Traveling 200-300 miles annually they are now endangering a $20 billion a year industry. A stupid person disobeyed all the warning signs, but has human kind ever had a defense against stupidity? And because we do not and cannot by our very nature fully know any consequence, no human choice is without a high probability of error.

The historical record demonstrates that only when plants and animals have worked together for millennia (as with various organisms used in agriculture) can there be any assurances about the future consequences of exotics in any environment. The Great Lakes on the other hand shows what happens when human agency is uncontrolled. The sea lamprey and alewife came into the upper Lakes through the Welland Canal (would a modern day Environmental Impact Statement predict what happened?), the smelt was introduced, the pink salmon was flushed into a sewer, the common carp swam in from tributaries and the Erie Canal, and the zebra mussel came in with ship ballast. These dominant animal organisms are all exotics with little benefit to mankind. The Lake ecosystems now in place are far inferior to those that existed in the Lakes before 1700. That dramatic change matches the changes wrought on the land but without at least the tradeoffs that the similar dramatic ecological changes left on the landscape of America.

Species Introductions and Transfers in Agriculture

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Five hundred years ago, a band of Portuguese and Spanish sailors lead by an Italian explorer ushered in an era of unprecedented species introductions and transfers. The plants, animals, and peoples of the Western Hemisphere were completely unlike those of the Old World. While the transfers moved in both directions between the Old and New Worlds, for our discussion, the livestock species came primarily from the Old to the New World.

Species introductions influence many aspects of the ecology receiving the introductions. This paper will discuss briefly the impacts on the recipient culture, fauna, and flora.

IMPACT ON CULTURE

The Spanish explorers, missionaries, and settlers brought familiar livestock with them. Horses were the first animals introduced. They were used to carry the explorers and their burdens. Horses found their way into the hands of Native Americans. Greatly increased mobility altered their way of life from nomadic hunter/gatherers to mounted hunters and warriors. These horses also provided transportation to the European settlers on the Western frontier. They were used as riding horses, to pull wagons and plows, as pack horses and as cow horses. Inevitably, many of these horses were abandoned or escaped to become feral.

The feral horses commonly known as mustangs became the symbol of the freedom of the wild west. These animals were an important source of income to the frontiersmen who captured and traded them all the way to the east coast. Spanish horse genetics provided a major foundation for most American horse breeds.

Cattle were likely the second species introduced. Brought to breeding centers in the Caribbean, they were then distributed to North, Central and South America. These animals provided the foundation for dozens of specific breeds generically known as Criollo cattle. North American examples include the Texas Longhorn and Florida Cracker.

The Texas Longhorn was managed very extensively in the Southwest and over three centuries adapted to the harsh range life. The Longhorns were the economic basis for settling large parts of the southwest and supplied the beef for the massive immigration to the industrial centers of the Northeast following the Civil War. This is an era memorialized in story and song as part of American folklore. But by 1923, this breed had been usurped and existed only in three wildlife refuges and on a few spreads belonging to cantankerous old timers. An act of congress saved the Texas Longhorn from certain extinction. By the 1960's when the market demand for lean beef had evolved, the Longhorns were remembered and are once again an important part of the beef industry.

The Florida Cracker Cattle or Pineywoods Cattle evolved in the heat, humidity, parasite load, seasonal drought, and rough forage of the Southeast. Florida Crackers became the basis of the Florida beef industry at the turn of the twentieth century. By the 1930's, stockmen had discovered that Brahman Cattle crossed on the Cracker produced a hybrid with a market carcass superior to either parent breed. It only took a few decades before the pure Florida Cracker had nearly disappeared. The conservation work of The American Minor Breeds Conservancy and some enthusiastic supporters in Florida has resulted in the organization of a breed association and recognition to those who had valued the qualities of the Cracker Cattle through thin as well as thick.

The Spanish also brought sheep and goats which evolved into unique breed types. In the Southwest, the Navajo Churro sheep along with the horse transformed the Navajo and Hopi Indians into sheep herding and weaving cultures. Retaliatory livestock massacres by the Army in the 19th century and mismanagement by BIA resulted in the loss of purity of Navajo Churro flocks. Until recently, wool for traditional weaving had been imported from Afghanistan and Pakistan. Now the Navajo Sheep Project under the direction of Dr. Lyle McNeal of Utah State University has lead the restoration of the breed and a reintroduction to the reservation flocks. Native American cooperatives are marketing Navajo Churro wool, lamb, and weaving as important sources of tribal income and cultural identity.

In the southeast, the sheep introduced by the Spanish evolved in a different direction to result in the Gulf Coast Native sheep. This population was shaped mainly by natural selection. The animals are extremely parasite resistant, produce a large sturdy lamb ready to face the challenges of the world, and have a long productive life.

IMPACT ON ANIMALS

Successful species introductions result in changes for the indigenous animals. The American Bison, Bighorn Sheep, and Pronghorn antelope were all displaced on the American Plains by cattle. Later introductions of European breeds displaced the earlier introductions and were revolutionary in their impact on American livestock. The Shorthorn breed was the first international livestock product and held preeminence through the 19th and early 20th century. The Hereford altered the range cattle by overtaking the Longhorns to produce a fatter, more blocky carcass demanded by a population wanting quality beef. The cultural impact resulting from this demand for fatty beef continues to attract attention as a national health problem. Beef producers are altering their product with genetic selection and production changes to provide a lower fat product.

The Merino Sheep craze of the 19th century was a response to the need for raw material for the burgeoning New England textile industry. The Cotswold sheep, which had financed the Elizabethan explorations of the 16th and 17th centuries were also contributors to the American economic expansion of the 19th century. The Cotswold was very popular and produced a long lustrous fleece for the woolen mills. These introduced breeds pushed aside the older introductions in favor of superior wool productions.

This story is being repeated in other livestock industries. Dual purpose Dominique and New Hampshire chickens have been replaced by specialist poultry strains that excel in either meat or egg production. The Ayrshire, along with most other dairy breeds are being supplanted by the Holstein. As a result, nearly a dozen breeds of swine are now extinct, replaced by a few production breeds.

Hybridization of wild species is not much of an agricultural problem since there are no wild North American relatives of our livestock except the turkey. Wild turkeys will potentially interbreed with domestic sub-species. This is a concern in some states where wild turkeys are being reintroduced as a game bird. In my opinion, any wild turkey that would have anything to do with a brainless broad breasted domestic bird deserves to have his genes diluted.

IMPACT ON PLANTS

The early New England settlers cleared the forests to provide fields and pastures. Devon cattle were an early importation because this breed provided important draft abilities as well as meat, milk, and hides for the colonists. The breed nearly became extinct in the 1960's when specialization for beef or dairy pushed them aside. Fortunately, this historic breed has been rescued by conservation activity, and population numbers have increased from 150 in 1970 to well over 500 now.

The clearing of forests was repeated across the Northeast until the frontier reached the prairies of the midwest. As the prairies were broken, many indigenous plants were lost, replaced by exotic forage grasses and grains for livestock feed. The vast plains allowed North America to become the largest producer and consumer of animal protein in the world.

Livestock populations which become feral can become agro- and eco-disasters. Ossabaw Island swine have adapted over three centuries to the harsh environment of their coastal home. Some of the unique physiologic adaptations include high salt tolerance, extraordinary fat storage, and non-insulin dependent diabetes. But the character of the plant life on the island has been altered by the rooting of the pigs so that there is little understory and few forest fires because of the lack of vegetation accumulation seen in other southern coastal environments.

The Santa Cruz Island sheep prospered on their California Channel Island home but the plant communities were ravaged. Exclusion of the sheep has resulted in a remarkable recovery of indigenous plants. Further, removal of the sheep from the island has offered an opportunity to study the genetic adaptation in this unique environment. Unfortunately, this adaptation has now changed as the animals adapt to their new captive mainland environment.

But feral animals do not always produce environmental degradation. We were pleased to learn more this summer of the Mono Island goats. This population has lived on an arid island between Puerto Rico and the Dominican Republic for centuries with little impact on the native flora or fauna. For the present these animals will be left in situ and will continue to represent an interesting genetic resource preserved and handed down to us from the Spanish Explorers.

CONCLUSIONS

Improved livestock will usually supplant indigenous livestock even though they may be locally better adapted. The success of our livestock industry has lead to efficiency and uniformity. Genetic uniformity comes at the expense of genetic diversity. This erosion of genetic diversity is the reason the American Minor Breeds Conservancy is engaged in breed conservation. Diversity is the source of our selection to meet the livestock needs of the future.

Livestock introductions provide some interesting lessons which might be applicable to aquaculture. I will conclude with a summary of these lessons.

1. A structure must be designed before any introduction to determine and monitor the impact of the introduction. Despite careful planning, the unexpected is inevitable. Responses to the unexpected must be part of the planning.
2. Compatible matching of the introduced species and the environment should be an overriding goal. Species should be considered for introduction into an environment which requires minimal alteration. The introduced species should result in minimal impact on the environment as a result of its presence.
3. Introduced species often have a restricted genetic base. Care must be taken to assure genetic diversity to maintain a healthy breeding population and to allow adaption to inevitable changes.
4. Technology must be adequate to control the introduced species in the new environment. Technology used to control the environment must not be disrupting to other species.

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A Summary of Fish Introductions in the United States

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The United States now has 69 species of foreign (or exotic) fishes established in its open waters (Courtenay et al. 1991, Courtenay 1991, Table 1). Had environmental conditions been more favorable for introduced species to establish, this nation could perhaps be host to twice that number of exotic fishes by now. This potential is illustrated by the fact that another 55 species of exotic fishes and an uknown number of additional species belonging to at least eight genera have been collected from open waters. Another 14 species became established and later died out – usually from cold temperatures – or were purposefully eradicated (Courtenay et al. 1984, 1986).

These introductions did not occur at once but over a long time. The first introduction was that of the goldfish, apparently made during the 1680s, obviously brought by colonists on sailing ships from Europe (DeKay 1842). The federal government entered the introduction arena in the 1870s with the creation in 1871 of the U.S. Fish Commisssion, the ancestor agency of the National Marine Fisheries Service and the U.S. Fish and Wildlife Service. The first U.S. Fish Commissioner was Spencer F. Baird, a most accomplished zoologist who surrounded himself with the best biological talents of his time. Baird was solely responsible for organizing and funding the most extensive surveys of our aquatic fauna ever attempted, at a time when much of that fauna was largely unknown to science (Adler 1989). Baird was also responsible for initiating what is now the Division of Fishes of the National Museum of Natural History. Baird lived in a time when what I call "the Introduction Paradigm" ruled. In fact, many of the explorations of our inland western fish fauna were conducted to determine sites for introductions of non-native species.

During Professor Baird's tenure as U.S. Fish Commissioner, he directly involved the federal government in introducing aquatic species. One of his first was the common carp, *Cyprinus carpio*, imported in the 1870s (Baird 1879), over 40 years after an individual successfully introduced the species into western California (Moyle 1976). He also imported two fishes belonging to the same family as carp–the tench, *Tinca tinca*, and ide, *Leuciscus idus*. Initially, these fishes were received from Europe and cultured in Baltimore, Maryland, and later moved to culture ponds near the Potomac in Washington, D.C. for political impact. A flood in 1889 washed all three species into the Potomac where they became established (Baird 1893).

Professor Baird was also responsible for importing a fish that is generally recognized as having been a "good" introduction – the brown trout. This fish was first introduced into the Pere Marquette River, Michigan, in 1884 (Mather 1889, Goode 1903). It is touted by fishery managers as an example of why exotic fishes should be introduced. Introduction of the brown trout, however, has not been without environmental problems. It has seriously damaged populations of native golden trout in California (E.P. Pister, pers. comm.), native brook trout in the Great Smoky Mountains National Park and adjoining waters (S. Moore, pers. comm.), and native Atlantic salmon in northeastern states (D. Goldthwaith, pers. comm.). In summary, an introduction that has been beneficial in many areas can also be detrimental in some.

Introductions became a major focus of the U.S. Fish Commission from the late 1870s through the first two decades of this century (Laycock 1966). Specially built rail cars hauled exotic fishes imported from Europe and species native to the eastern United States westward for release, and returned with western fishes such as rainbow trout and Pacific salmons, destined for introduction into midwestern and eastern waters. Often personnel in these fish cars found themselves parked on bridges over rivers while the steam engine took on water. Not to let an opportunity pass, they oftentimes dumped fish into the river below, failing to record these introductions in the log. This and similar kinds of governmental activities have made it impossible to determine what fish species were actually native to some drainages (Courtenay 1991).

The federal government largely got out of the fish introduction business in the 1970s, a century after it initiated these activities. The Constitution and Bill of Rights left certain powers to the states, and the states followed the example set by the federal government in making their own introductions. To this day, any state can legally introduce a species even if adjoining states sharing the same drainage basins object. To this day, through federal aid programs, the federal government continues to assist states in making introductions (Courtenay 1991).

Over time, governmental agencies continued to introduce fishes into inland waters of the contiguous United States. In addition, individuals, perhaps groups of citizens, and the fish culture industry made unauthorized introductions that also became established as reproducing populations. Introductions accelerated largely after World War II, and much of this increase was due to growth of the aquarium fish industry and hobby (Courtenay and Stauffer 1990). In Florida and southern California in particular, there were numerous escapes and sometimes intentional releases of aquarium fishes from culture facilities. In most states, hobbyists released and continue to release unwanted pet fish into open waters. In some states, these unauthorized and illegal introductions have compounded management policies of agencies, yet the agencies themselves continue to make introductions, claiming that they are "safe."

A breakdown of established exotic fishes shows that the contiguous United States now has 50 species, Hawaii has 34, 17 of which are shared with the mainland, and Alaska, so far, has none (Courtenay 1991). With that exception, every state has at least two or more established species. The comparatively large numbers in Florida and California are mostly due to escapes of aquarium fishes from culture. Aquarium fishes, however, exist in thermal springs and outflows of many western states from Arizona north to Idaho and Montana (Minckley and Deacon 1968, Courtenay et al. 1987, Courtenay and Stauffer 1990, Courtenay and Williams, in press).

In addition to introduced exotic fishes, approximately 168 species of fishes have been moved and became established beyond their historical ranges of distribution (Courtenay and Taylor 1984). This represents approximately 20% of the native fish fauna of North America north of the Mexican plateau.

A review of introduction sources of established exotic fishes shows that the aquarium fish culture industry and hobby have been responsible for approximately 51% of the introductions (Courtenay and Stauffer 1990), with authorized introductions made for food but primarily sport comprising 22%. Although introductions made for biological control, escapes of fishes being cultured for food or biological control, and species discharged in ballast water by ships make up far smaller percentages, all three are sources of many of the most recent introductions. Releases from these sources can be expected to increase (Courtenay and Williams, in press). One exotic fish is known to have established after a research project in which it was being used was terminated (Belshe 1961).

Introductions of exotic fishes into island ecosystems have had an interesting history. Native fishes are few in fresh waters and are closely tied to their marine ancestral environment. Thus, as reservoirs were constructed, habitat was created that invited introductions of both exotic and mainland U.S. fishes with little or nothing to lose as a result (Maciolek 1984, Erdman 1984). Hawaii intentionally created recreational fisheries through introductions and largely did so on a planned basis. In the 1950s, Hawaii attempted several introductions of marine fishes from the western Pacific; some became established, but none is considered to have been generally beneficial to marine sport or commercial fisheries (Maciolek 1984, Randall 1987). A deluge of unauthorized introductions, mostly aquarium species, in recent years has rapidly boosted the number of established exotic fishes in Hawaii (Devick 1989a). Puerto Rico never had a plan for its introductions, and what is established there was largely introduced on whim and in "shotgun" fashion.

Every introduction will result in changes to the receiving ecosystem (Courtenay et al. 1974). These changes may be dramatic and detrimental, they may occur quickly or often not for several decades following introduction, and they may range from major to almost neutral. Predation on one or several parts of the food web is generally the earliest negative impact observed. But one does not need to be a predator to be a competitor. Competitive interactions can take one or several forms (competition for food, space, behavioral alterations, etc.), and are the least studied and, therefore, the least understood of relationships between introduced and native species (Taylor et al. 1984). They are, however, probably the major basis by which introduced species displace or replace native species. Hybridization, resulting in altering gene pools that took thousands to perhaps millions of years to evolve, thus reducing the adaptability of a species, is mainly a concern when the introduced species is a congener of one or more native forms. Nevertheless, introductions, including those of exotic species, have resulted in intergeneric hybrids (Maciolek 1984, Burkhead and Williams 1991). Introductions can also serve as vectors for new diseases and parasites (Snieszko 1971, Hoffman and Schubert 1984).

Of the 69 established exotic fishes, some have been quite detrimental, but for the majority I have to report that their impacts have not been examined. This lack of information should not have become a reason for those who favor introductions to state that there have been few negative impacts, but this, unfortunately, has occurred. Those who make such claims, based on ignorance, are calling into question their own credibility. Rarely have agencies that made intentional introductions conducted studies to test anything other than approval of constituents.

Time contraints do not permit me to detail those introductions that have proved detrimental (see Taylor et al. 1984, Courtenay et al. 1985, Courtenay and Robins 1989), and Rick DeVoe asked me to devote time to those that were beneficial. I heard it said recently that "Beauty is in the eye of the beholder, but we can all agree on what 'ugly' is." Opinions on introductions that have been beneficial versus those that have not fall into a similar situation. Of the 69 established exotic species that became established, I believe that only four species could be considered beneficial. My criteria include that the introduction:

1. met its intended goals,
2. was advantageous to one or more user groups, and
3. created minimal negative impact to native species or habitat.

Of these four introductions, only two have demonstrated no negative environmental impacts. I previously mentioned the brown trout. A second example is the peacock cichlid, *Cichla ocellaris*, introduced into reservoirs in Hawaii and Puerto Rico where it has become a popular angling species without so far showing detrimental effects (Erdman 1984, Devick 1989b). This species was recently intentionally introduced in extreme southeastern Florida where it is reported to prey mostly, but not exclusively, on other introduced cichlid fishes. It was, in part, introduced to feed on previously introduced cichlids that had become dominant, but instead probably has added additional "cichlid pressures" to native fishes.

The two that had no negative impacts were introduced into a situation where none could have occurred. In extreme southern California lies a basin called the Salton Sink. Its greatest depth is 66 meters (or 235 feet) below sea level. At one or more times in the geological past, it served as an embayment of the Gulf of California, doubtless harboring a variety of marine fishes. Periodically it was flooded by the lower Colorado River. At the turn of this century, it was dry. To provide irrigation water to the rich Imperial Valley, a canal was dug along a former river bed from the lower Colorado River near Yuma, Arizona, into the Sink. Prior to construction of dams on the Colorado and during the period of 1905 to 1907, the dike near Yuma was breached by floods, and water rushed into the almost completed canal, located in a former river bed (Sykes 1937). The Salton Sink filled with fresh water and many Colorado River fishes (including introduced common carp). In 1916, all fishes (with the exception of striped mullet, *Mugil cephalus*) in the newly formed Salton Sea were freshwater species. By 1929, as salts were leached from the bed of the sea, many of the freshwater fishes were eliminated due to rising salinities. By the 1950s, salinity of the Salton Sea had reached that of sea water. A number of introductions of fishes and invertebrates were made during intervening years, but most failed (Walker 1961).

Then in the late 1940s and early 1950s, the California Department of Fish and Game assembled a group of chemists, hydrologists, invertebrate zoologists and ichthyologists to plan a series of stockings of the Salton Sea (Walker 1961). Marine species, many from the Gulf of California, were utilized. Among these were the bairdiella, *Bairdiella icistia*, introduced for forage and sport fishing, and a larger predatory drum, the orangemouth corvina, *Cynoscion xanthulus*. Introductions of smaller forage species were done first, in the late 1940s. The result of all this was to turn the Salton Sea from an unproductive body of water into a highly productive fishery resource (Walker et al. 1961). Unfortunately, other interests became involved in the early 1960s when the Mozambique tilapia, *Oreochromis mossambicus*, native to southeastern Africa, escaped from an aquarium fish farm and became established on the eastern edge of the Salton Sea. In the 1970s, agricultural interests introduced the redbelly tilapia, *Tilapia zilli*, also from Africa and the Jordan River of the Near East, into canals around the perimeter of the Salton Sea for aquatic weed control.

Also in the 1970s, Mozambique tilapias, then common in the lower Colorado River near Yuma, Arizona, successfully invaded the southern end of the Salton Sea, probably through the Alamo and All American canals, and by 1980 had become the dominant fish species in the Salton Sea. Populations of one non-game species, the desert pupfish, *Cyprinodon macularius*, collapsed, probably due to predation and behavioral incompatibility with introduced mosquitofish, either or both *Gambusia affinis* and *G. holbrooki*, sailfin mollies, *Poecilia latipinna*, and juvenile tilapias. What the eventual impacts of the tilapias will be on the sport fishes remains to be seen (Courtenay and Robins 1989).

In summary, the history of fish introductions into the United States has not been a series of glowing successes but rather one that has had few positive results and some known negative impacts. These results, however, had varied geographically. Certainly, most of our reservoirs in the southeast and midwest would not provide productive fisheries if introductions had not been made. Introductions of the same species into western reservoirs have had disastrous impacts to numerous native fishes (Minckley

1991). Many are quick to blame construction of dams and other environmental perturbations for declines of western fishes, but a study in Clear Lake, northern California, indicates that even in an environment in which there have been minimal perturbations other than introductions, impacts to native species have occurred (Moyle 1976). Thus, what is considered good in one area may prove very detrimental in another.

There are no hard and fast answers to be learned from the history of fish introductions in the United States or elsewhere--just lessons of risks, mistakes, additions of needless species, and some few successes. What we should have learned is that:

1. Those species that became established did so because they were ecological generalists or specialists with an ability to readily adapt.
2. The receiving waters and existing biological communities were hospitable.
3. Things we do not understand can go beyond our expectations and get out of control.

What we should ask ourselves is do we really know enough about our own biological resources and how they operate to safely make introductions of non-native species? Should we take the risk of modifying or possibly destroying those resources for what could amount to short term gains in trade for perhaps permanent losses? Like beauty, values are in the eye of the beholder, but ugly could be the end result.

Finally, I am not suggesting that intentional introductions are inherently bad or wrong. What I am saying is be very careful – do research to test the risks as well as the potentials, and get peer opinions and reviews by other entities that could be affected before any open releases are made. No introduction is so urgent or important that it should not pass at least this level of testing. If the introduction is made, monitoring of the receiving ecosystem to examine the results should be requisite.

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Table 1. Exotic fishes established in the United States of America

FAMILY	SPECIES	STATES[1]	YEAR OF RELEASE
Clupeidae	*Herklotsichthys quadrimaculatus*	HI	1958
	Sardinella marquesensis	HI	1955
Salmonidae	*Salmo trutta*	AZ, AR, CA, CO, CT, DE, GA, ID, IL, IN, IA, KY, ME, MD, MA, MI, MN, MO, MT, NB, NV, NH, NJ, NM, NY, NC, ND, OR, PA, RI, SC, SD, TN, UT, VA, VI, WA, WV, WI, WY	1884
Osmeridae	*Hypomesus nipponensis*	CA	1959
Cyprinidae	*Brachydanio rerius*	WY	>1984
	Carassius auratus	most except Alaska and Florida	1680s
	Ctenopharyngodon idella	AR, LA, MO, MS, TN, TX	1960s
	Cyprinus carpio	all except Alaska	1831
	Hypophthalmichthys nobilis	MO	>1986
	Leuciscus idus	ME	>1877
	Puntius semifasciolatus	HI	1940
	Rhodeus sericeus	NY	1920s
	Scardineus erythropthalmus	ME,NY	1890s
	Tinca tinca	CA, CO, CT, ID, NM?	>1877
Cobitidae	*Misgurnus anguillicaudatus*	CA, HI, ID, MI, OR	1930s
Clariidae	*Clarias batrachus*	FL	1960s
	Clarias fuscus	HI	<1900
Loricariidae	*Ancistrus* sp.	HI	1980s
	Hypostomus sp.[2]	FL	<1958
	Hypostomus sp.[2]	NV	1960s
	Hypostomus sp.[2]	TX	1960s
	Pterygoplichthys multiradiatus	FL, HI	1960s
Belonidae	*Strongylura kreffti*	HI	1988
Cyprinodontidae	*Rivulus harti*	CA	1960s
Poeciliidae	*Belonesox belizanus*	FL	1957
	Poecilia mexicana	CA, HI, ID, MT, NV, TX	1960s
	Poecilia reticulata	AZ, CA?, FL, HI, ID, NV, TX, WY	1960s; 1922 (HI)
	Poecilia sphenops	HI	<1950?
	Poecilia vittata	HI	<1950?
	Poeciliopsis gracilis	CA	<1965
	Xiphophorus helleri	FL, HI, ID, MT, NV[3], WY	<1962; 1922 (HI)
	Xiphophorus maculatus	FL, HI, NV[3]	1960s; 1922 (HI)
	Xiphophorus variatus	FL, HI, MT	1960s
Synbranchidae	*Monopterus albus*	HI	<1900

Continued Table 1. Exotic fishes established in the United States of America

Serranidae	*Epinephelus argus*	HI	1956
Percidae	*Gymnocephalus cernuus*	MN, WI	1986?
Lutjanidae	*Lutjanus fulvus*	HI	1955?
	Lutjanus kasmira	HI	1955
Sciaenidae	*Bairdiella icistia*	CA	1950
	Cynoscion xanthulus	CA	1950
Cichlidae	*Astronotus ocellatus*	FL, HI	1958; 1952 (HI)
	Cichla ocellaris	FL, HI	1986; 1961 (HI)
	Cichlasoma bimaculatum	FL	1950s
	Cichlasoma citrinellum	FL	<1981
	Cichlsoma managuense	UT	1980s
	Cichlasoma meeki	FL, HI	1970s; 1940 (HI)
	Cichlasoma nigrofasciatum	ID, NV	1960s
	Cichlasoma octofasciatum	FL	1960s
	Cichlasoma spilurum	HI	1984
	Cichlasoma urophthalmus	FL	1980s
	Geophagus surinamensis	FL	<1982
	Hemichromis bimaculatus	FL	1960s
	Oreochromis aureus	AZ, CA, FL, GA?, NC, OK, TX	1960s
	Oreochromis hornorum	CA	1970s
	Oreochromis macrochir	HI	1958
	Oreochromis mossambicus	AZ. CA, FL, HI, TX	1960s; 1951 (HI)
	Pelviachromis pulcher	HI	1984
	Sarotherodon melanotheron	FL, HI	1950s; >1970 (HI)
	Tilapia mariae	FL, NV	<1974
	Tilapia rendalli	HI	1957
	Tilapia zilli	AZ, CA, HI, NC, TX	1960s
Mugilidae	*Valamugil engeli*	HI	1955
Channidae	*Channa striata*	HI	<1900
Blenniidae	*Parablennius thysanius*	HI	1971
Gobiidae	*Acanthogobius flavimanus*	CA	<1963
	Neogobius melanostomus	MI	1988
	Proterorhinus marmoratus	MI	1988
	Tridentiger trigonocephalus	CA	<1965
Anabantidae	*Trichopsis vittata*	FL	1970s

[1]State abbreviations follow system of U.S. Postal Service.
[2]One unidentified but distinct morphological species in each state.
[3]Hybrid between *Xiphophorus helleri* and *X. maculatus*.
Most Hawaiian data from Maciolek (1984), Randall (1986), and Springer (1991).

THE IMPORTANCE OF INTRODUCED MARINE SPECIES TO THE DEVELOPMENT OF THE MARINE AQUACULTURE INDUSTRY IN THE UNITED STATES AND PUERTO RICO

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ABSTRACT

A portion of the marine aquaculture industry of the United States is based upon species which were introduced to the areas in which they are being cultured. Those introductions have been from other nations in some cases (various species of penaeid shrimp, Japanese oysters) and from other parts of the U.S. in others (Atlantic salmon, striped bass). The most successful commercial mariculture of introduced species has been achieved to date with Japanese oysters and Atlantic salmon. Given the present conservative climate within the regulatory and scientific communities, the prospect for additional introductions in the foreseeable future appears to be remote.

INTRODUCTION

With notable exceptions such as corn (maize), tobacco, and turkeys, agriculture in the United States is largely based upon introduced species. During the majority of the time since Europeans began arriving in North America, the introduction of exotic plants and animals went unquestioned. Virtually anyone who thought, for whatever reason, that a particular organism might be desirable, could release that organism into the environment with impunity. Of course, there have also been a number of nonintentional introductions, some of which have led to serious environmental problems. So, along with the species that made American agriculture the envy of much of the world have come, by one means or another, a variety of plants and animals that are today considered to be undesirable, but which have become firmly established.

While some of the environmental impacts of exotic introductions to the United States are obvious to all (destruction of forests by Gypsy moths, smothering of native trees by kudzu, the recent arrival of the so-called killer bees), many ecological consequences associated with introduced species are subtle and sometimes difficult to detect. Ecologists have only within recent years begun studying the ramifications of exotic introductions, and the theory that has developed comes largely from perturbed systems. Of interest to aquaculturists is the observation by Carlton and Mann (1981) that once an exotic species is established in the sea it becomes unmanageable in the biological sense; that is, its reproduction and dispersal cannot be effectively controlled. The same may or may not be true of species introduced to terrestrial and freshwater environments.

As the impacts of introduced species on endemic flora and fauna, and sometimes upon the landscape itself, are becoming more widely recognized, an increasingly conservative approach to introduced species has developed, first within the scientific and environmental activist communities, and subsequently among the regulatory agencies. Commercial mariculture in the U.S. began before severe restrictions on the introduction of new species were in effect, but because it is a fledgling industry with relatively few species under culture, the number of introduced species is relatively small. Even so, the admonition of Courtenay (1988) relative to exotic freshwater species would also seem to be highly applicable to marine organisms. He indicated that guidelines for importation should be developed and containment security practiced in conjunction with aquaculture species both as a means of enhancing the future of aquaculture and protecting natural resources.

Aquaculturists are well aware of the potential problems that can occur in conjunction not only with the introduction of culture species into areas where they did not previously occur, but also from the potential introduction of diseases and parasites that may impact both the culture species of interest and native organisms. Examinations of the issues surrounding the introduction of aquaculture species include those of Mann (1979), Shelton (1986), Elston (1988, 1989), Kohler (1988), McVey (1988), and Davidson and Brick (1988).

Introductions can result from the movement of a domestic species to an area where it had not previously been established or from the import of a species from another nation. Examples of both types of introduction can be found among U.S. mariculture species. In some cases the introductions were made specifically for mariculture purposes, while in others the introductions were initially made to augment recreational or commercial fisheries.

In this examination of the use of introduced species in U.S. mariculture, the discussion is concentrated on species which are currently being produced commercially. A number of additional species have been examined by aquacultural researchers but have not been adopted by commercial mariculturists. This review does not include marine plants which have some mariculture potential, nor does it include euryhaline fishes such as tilapia, some species of which readily adapt to the marine environment and all of which are exotics. Finally, the introduction of Pacific salmon into the Great Lakes where populations have been maintained through natural spawning and the annual stocking of fish produced in hatcheries, is an entirely freshwater activity and not considered to be within the scope of this paper.

SPECIES UNDER CULTURE

In 1988, total world aquaculture production was estimated at 14 million tons (FAO 1990), of which 300,000 tons, or 2% was produced in the United States. Of that 2% of world aquaculture production, about 75% was from freshwater species, leaving only 0.5% of world aquaculture production attributable to United States mariculture. Some 80% of the U.S. mariculture production of 75,000 tons in 1988 was in the form of oysters.

Invertebrates

Mariculturists involved with invertebrates have been primarily interested in crustaceans and molluscs. Introductions have been both with species brought into North America from other continents and with North American translocations.

Penaeid shrimp

Shrimp farming has developed rapidly in the last 10 to 15 years in tropical and subtropical regions of the world, with most of the effort being placed on species within the genus *Penaeus*. Commercial shrimp farming has been quite successful in Ecuador, Panama, Japan, Indonesia, and most recently, China. A number of other countries have also become involved with varying degrees of success. There appear to be no more than 25 to 30 shrimp mariculture operations in the U.S. at the present time (Table 1). They range in size from less than one ha to about 200 ha (Chamberlain 1991, Hopkins 1991, Pruder 1991) and are located primarily in Hawaii, South Carolina and Texas. There is also one shrimp farm in Puerto Rico (Shleser et al. 1991). Shrimp culture experienced a flurry of activity in Florida over a period of several years, but there appears to be little or no activity in that state at present (Hopkins 1991).

Research throughout much of the 1970s was focussed on native brown (*Penaeus aztecus*), white (*P. setiferus*), and pink shrimp (*P. duorarum*). Difficulties of various kinds led researchers to turn toward exotic species which seemed to hold certain advantages with respect to ease of culture. Currently, most producers in the U.S. are involved with *P. vannamei* which was introduced from Latin America, though there continues to be interest in *P. stylirostris*, another Latin American species, and *P. monodon* from Asia. *P. penicillatus* has also been investigated in the U.S. by researchers interested in producing a cold tolerant shrimp (Chamberlain 1991).

The potential for expansion of shrimp culture varies from one place to another. It has been estimated that Puerto Rico could accommodate about 1500 ha of shrimp culture ponds but that land use conflicts and permitting restrictions are curtailing development (Shleser et al. 1991).

While shrimp farming is economically possible in South Carolina (Rhodes 1991), the climate in that state, and even in Florida, leads to a restricted growing season (Hopkins 1991). Further, problems with foreign competition from nations that not only have the advantage of longer growing seasons in many instances, but which may also enjoy lower land and labor costs and fewer permitting constraints, have made it difficult for shrimp farmers in states like Florida and South Carolina to compete. Wetland protection legislation and water quality protection have made obtaining permits for shrimp farms increasingly difficult. Availability of postlarvae and the cost of shrimp feed have also been reported as impediments to shrimp culture in the southeastern United States (Hop-

Table 1. Status of shrimp farming in the United States.

Location	Number of Farms	Area (ha)	Production	Reference
Florida	1 hatchery	NA	Not reported	Hopkins (1991)
Hawaii	5 (1988)	NA	about 225 tons	Pruder (1991)
Puerto Rico	1 (10 proposed)	0.1	Not reported	Shleser et al. (1991)
South Carolina	15 (in 1988)	913.5	247.4 tons	Hopkins (1991)
Texas	Not reported	234.0	about 550 tons	Chamberlain (1991)

kins 1991). Yet, French et al. (1991) predicted that about 56,000 ha in South Carolina could be developed into shrimp farms and projected up to $2.4 billion to the state's economy annually and the creation of 13,900 jobs.

Chamberlain (1991) reported that the total land area available for shrimp ponds in Texas may be in excess of 12,000 ha. Contraints include water quality degradation as a result of high stocking densities and concern over the impacts of viruses on shrimp growth and survival.

The state of Hawaii has had a history of interest in aquaculture development and was the first to come up with a comprehensive aquaculture plan and a development program for aquaculture. Shrimp culture, first with freshwater shrimp (*Macrobrachium rosenbergii*) and more recently with penaeids, has generated much of the aquaculture interest. Of concern to Hawaiian aquaculturists has been the potential introduction of diseases with imported shrimp larvae. Quarantine facilities have been established in an attempt to reduce the possibility of such disease introductions, and a new virus disease, infectious and hematopoietic necrosis (IHHN) was identified early in the 1980s (Lightner et al. 1983). The virus was introduced in postlarval *P. stylirostris* and *P. vannamei* from Costa Rica and Ecuador. *P. stylirostris* imported from Florida and Tahiti (which originated from South or Central American broodstock) were also found carrying the disease. IHHN and other viruses have led to catastrophic losses of shrimp in some cases, while effects have been moderate to insignificant in others (Lightner et al. 1988).

The published literature does not detail the potential impacts on native flora and fauna of shrimp introductions by aquaculturists. However, exotic shrimp have been found in nature. Asian tiger prawns (*P. monodon*) have been reported from Georgia and South Carlina coastal waters. Their presence has been attributed to escapement from mariculture facilities (Smith 1988). Pacific white shrimp (*P. vannamei*) have recently been found in conjunction with the wild shrimp harvest in Texas (William Rutledge, Texas Parks and Wildlife Department, personal communication, 1991). Because of the intolerance for cold temperatures by the exotic shrimp being grown in that state, the consensus is that the shrimp that are appearing in otter trawls represent escapees from shrimp farms.

Oysters

Oyster culture in the U.S. is, with the exception of the hatchery phase of production, a relatively low technology activity. In some regions the distinction between oyster culture and the capture of wild oysters is blurred. The difference tends to be associated with the stocking and limited management of leased grounds with respect to the oyster culturist and the exploitation of natural oyster beds by the commercial fisherman. Placement of shell substrate into the environment for the settlement of naturally produced oyster spat has been practiced by oyster culturists to enhance the capture fisheries.

Oyster culture along the Atlantic and Gulf of Mexico coasts of the U.S. is based upon the American oyster, *Crassostrea virginica*. Diseases, red tide outbreaks, and pollution have led to reductions in total oyster catch in those areas over the past few decades. While production of the American oyster has declined, aquaculture of an exotic species, the Pacific oyster (*C. gigas*) in Washington state, has grown rapidly. The 39,000 tons of Pacific oysters produced in Washington during 1988 exceeded for the first time the total estimated production of 24,000 tons of American oysters from the Atlantic and Gulf coasts (Chew and Toba 1991).

The American oyster, which has been named as a possible culture candidate in the Caribbean, was introduced into Hawaii and grown in trays in an intensive culture pilot-scale operation (Sandifer 1991). The Pacific oyster has also been mentioned with reference to potential species for culture in the Caribbean (Sandifer 1991).

In the late 1800s the Olympia oyster, *Ostrea lurida*, which is native to the Pacific Northwest, was in decline from disease, adverse winter weather conditions, and overharvesting (Chew 1990). American oysters were introduced from the east coast, but that introduction had failed by end of the second decade of the current century. Introductions of adult Pacific oysters also failed because of high mortality during shipping.

Pacific oysters were successfully introduced to the west coast of the United States and Canada from Japan as spat beginning in the 1920s (Chew 1990). Because of poor natural spat survivability in North America, it was necessary to import spat annually in order to maintain the beds (Quayle 1969). The shipments were curtailed during World War II, but began again after the conclusion of that conflict. In recent years, private hatcheries have been developed in Washington to the extent that the import of spat to Washington and Oregon has been discontinued. Alaska continues to maintain a strict policy on the importation of Pacific oysters (Meyers 1989).

By producing triploid oysters which do not produce gametes, thereby making them less milky and attractive for the market during the spawning season, Pacific oyster growers are able to supply the market on a year round basis (Allen et al. 1989). Breese and Malouf (1977) suggested that *C. rivularis* might have culture potential in Oregon, particularly during summer when the quality of *C. gigas* is poor. With the introduction of triploid *C. gigas*, discussion of bringing in yet another exotic species of oysters to the Pacific Northwest seems to have waned.

The success of the Pacific oyster, coupled with the problems that are plaguing the American oyster industry, have led to an interest in the introduction of Pacific oysters to the Atlantic coast. That possibility is currently being investigated with due consideration being given to potential impacts that the introduction of the exotic might have on native flora and fauna.

Other Invertebrates

Various other introductions of marine invertebrates have been discussed by mariculturists, but few examples of additional viable industries having been established can be documented. One is the Manila clam industry of Washington which grew out of the accidental introduction of *Venerupes japonica* with Pacific oysters.

Hatcheries have been developed to produce stock for planting on suitable beds (Chew 1990), and at least some leasing and clam bed management which can be considered aquaculture is occurring. The American lobster, *Homarus americanus*, which is native to the northeastern United States, has been introduced to California for research purposes. No commercial production of American lobsters has developed to date.

Fishes

Atlantic salmon

Development of the technology under which salmon could be reared in floating net-pens began in the late 1960's in Washington state (Novotny 1974). Experimental work with exotics including the masu or cherry salmon (*Oncorhynchus masu*) from Japan and various masu and Atlantic salmon (*Salmo salar*) by native Pacific salmon crosses was being undertaken by the early 1970s (Mighell 1981). None of the hybrids ever found its way into production by aquaculturists.

Commercial salmon aquaculture in Washington was initially based on native species such as the coho (*O. kisutch*) and chinook (*O. tshawytscha*). During the 1980s the National Marine Fisheries Service introduced Atlantic salmon to net-pens in Puget Sound, Washington for the purpose of spawning and rearing their offspring in order to re-establish stocks that were in decline along the Atlantic seaboard. The restocking program was highly successful, and after a few years Atlantic salmon eggs were being produced in surplus and were subsequently made available to net-pen salmon farmers in Washington. The fish farmers have now established their own brood stocks and have become self-sufficient in producing their own eggs.

Many of the net-pen facilities established in Washington were owned or controlled by Norwegian firms which had been growing Atlantic salmon successfully for a number of years. The availability of Atlantic salmon in the Puget Sound area was undoubtedly attractive to those firms. In addition, Atlantic salmon had been found to be particularly well adapted to net-pen culture. They are docile, grow rapidly, display good food conversion, and bring a premium price in the market. Many of the commercial producers have now established their own hatcheries to supply their annual needs and the needs of other producers who do not have hatcheries. Thus, virtually all the salmon now being produced in Washington net-pens are Atlantics.

Spawning is carried out in the late fall. The eggs are incubated in freshwater and the resulting alevins are typically reared in circular tanks for a year until they reach the proper size for smolting (about 40 g). They are then introduced into marine net-pens for the remaining two years of growout.

Concern has been expressed that Atlantic salmon escapees from net-pens could develop spawning populations and may displace one or more native salmonid species. As discussed by Fluharty (1991), Atlantic salmon that escape from net-pens often survive, but they do not spawn successfully in Washington.

Pacific salmon have been introduced to Hawaii where they have been raised as a part of a demonstration project which uses cold water pumped up from the deep ocean to grow a number of marine species.

Oregon does not allow net-pen culture of salmon and the private ocean ranching activity in that state, which was entirely based on native species of salmon, has been discontinued. Alaska allows ocean ranching only by nonprofit corporations and does not allow net-pen salmon culture. Opposition to aquaculture, spurred undoubtedly by the recent low prices of salmon on the world market, has led to the possibility that all forms of salmon culture, including nonprofit ocean ranching, will be outlawed in the future.

Striped Bass

With the decline in natural striped bass (*Morone saxatilis*) populations along the Atlantic coast, attributable both to overharvest and the impacts of pollution on spawning and rearing habitat, interest in aquaculture has been developing. Striped bass can be reared in either fresh or saltwater, though like salmon, spawning and early rearing take place in freshwater. Striped bass were introduced to the west coast of the U.S. as a sport fish long before anyone became interested in their commercial culture, but now that the interest has developed, fish farmers in California have become involved with their culture.

To date, total aquaculture production of striped bass and the more popular hybrid striped bass which is formed by crossing striped bass with white bass (M. *americana*) has been relatively small. Much of that culture occurs in freshwater since growth of both striped bass and the hybrids are as good or better than in seawater. The market for striped bass and hybrid striped bass has not as yet been well tested.

Other species

Most of the other fish species that have been mentioned as candidates for U.S. mariculture are native to the waters of North America. Among the types of fishes that have been mentioned are milkfish, snapper, dolphin (mahi mahi), grouper, and flatfishes such as flounders and halibut. Research is being conducted on many of those fishes, but there is no commercial culture of them in the U.S. at the present time. If economically viable culture methods can be established for one or more of those species, it is possible that attempts will be made to introduce them outside of their natural ranges. Sufficient safeguards are in place through the permitting process to prevent such introductions before their potential impact is established.

CONCLUSIONS

The mariculture industry in the U.S. is quite small compared to freshwater aquaculture and, while it has employed introduced species in some instances, the numbers of introductions which have led to the establishment of commercially successful ventures remains small. Species other than those discussed above have been mentioned as possible candidates for introduction by mariculturists, and in some instances research has been undertaken to examine the potential success of such introductions. There are few instances where such research has led to the development of an industry. Exotic species of penaeid shrimp and the introduction of Atlantic salmon to the state of Washington are notable examples.

Aquaculturists have not, in the past, expressed much concern about species introductions. It may appear to be largely a matter of chance that the number of exotic mariculture fish species is somewhat less than for their freshwater counterparts. At least part of the reason for the difference is associated with the fact that marine fishes which have been of interest to aquaculturists tend to be much more difficult to rear than their freshwater counterparts. Marine fish tend to have very small eggs which hatch into larvae that are difficult to maintain, and which require living food for some period before they can be trained to accept prepared diets.

With respect to invertebrates, the interest of mariculturists seems to be on the existing species along with native species of mussels, clams, and scallops. That does not mean that there will not be attempts to introduce exotic species in the future, but once again the permitting process may make that difficult. It is likely that native species will be turned to first. Successes with some of the exotic shrimp species may also cause U.S. researchers to go back and examine native penaeids to determine if the previous problems with respect to culture can now be circumvented. It is unlikely that a native oyster will be found to replace the Pacific oyster. Methods to overcome disease problems with C. *virginica* have eluded shellfish disease scientists for decades while natural populations have been descimated. Movement of the American osyter from infected areas to new grounds where the diseases might become epizootic to previously unexposed species is of concern and is generally carefully controlled.

With respect to both vertebrates and invertebrates the situation with regard to exotic introductions may not change significantly in the future since appropriate safeguards are now generally in place. Accidental introductions that ultimately lead to commercial mariculture cannot be ruled out but would have to be considered unlikely to occur with any degree of frequency.

An additional area that deserves mention involves the augmentation of existing populations of exotic organisms with new introductions of the same species. One can easily imagine that an Atlantic salmon farmer in Washington might want to bring in new fish if someone develops an improved stock in Norway or Maine, for example. Such introductions should be undertaken with caution because of the potential for introducing diseases and parasites which may not have been present in the animals that were first inrroduced to a region.

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MARINE SPECIES INTRODUCTIONS BY SHIPS' BALLAST WATER: AN OVERVIEW

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A rapidly growing concern in the United States in the 1990s is the increasingly unexpected appearance of non-indigenous marine, brackish and freshwater organisms in coastal waters.

A few examples from the last few years alone are startling:

- Zebra mussels (*Dreissena polymorpha*) invade the U.S.-Canada Great Lakes in 1986
- Chinese clams (*Potamocorbula amurensis*) invade San Francisco Bay in 1986
- Japanese crabs (*Hemigrapsus sanguineus*) are first found on the New Jersey shore in 1988
- Asian copepods (*Pseudodiaptomus* spp.) are first found in the Columbia River in 1989 and in southern California in 1986
- European bryozoans (*Membranipora membranacea*) are discovered in the Gulf of Maine in 1987
- European fish (the ruffe *Gymnocephalus cernuus*, the tubenose goby *Proterorhinus marmoratus*, and the round goby *Neogobious melanostomus*) and the European water flea *Bythotrephes cederstroemi*, all invade the Great Lakes in the 1980s.

All of these invasions are now linked to the release of ballast water from ocean-going vessels (Carlton 1985, 1987, 1989, Carlton et al. 1990, Moyle 1991 and Schormann et al. 1990). Australian workers have similarly documented fish, invertebrate and algal invasions by ballast water, including the introduction of a Japanese species of red-tide dinoflagellate, with considerable impact on shellfish industries (Hallegraeff and Bolch 1991, Hallegraeff et al. 1990, Jones 1991, and Williams et al. 1988). Numerous other unusual appearances around the world of marine organisms, from plankton to nekton, may be related to ballast water discharges. In the United States, toxic red tide dinoflagellate blooms have been discovered in the past 20 years at many coastal sites where they were unknown historically. As in Australia, many if not most of these occurrences may be due to initial inoculation by ballast water, with subsequent sporadic episodes due to the encystment-excystment cycle typical of many bloom-forming dinoflagellate species.

BALLAST WATER: A BRIEF PRIMER

Ballast water, and associated sediments, may range from fully marine, to brackish (estuarine), to fresh. Ballast is taken aboard vessels for trim, stability, maneuverability, crew comfort and other reasons. Bilge water, in contrast, is that water that collects in the bilges above the vessel's keelson. Ballasting and deballasting practices (the amount and frequency of water exchanged) vary tremendously with vessel type, cargo, weather and crew experience and practice. Thus, a ship may ballast up water in Foreign Port A and release it in U.S. Port B, a ship may begin to take water in after it leaves Port A and continue to do so for the next 100 or more miles, and then release it as it approaches the U.S. coast, or a wide variety of other combinations. The water in a given ship may represent multiple uptake sources, mixed within a single tank or unmixed in different tanks. The age of the water/sediment may vary tremendously. Many ships ballast and deballast every few days depending upon port calls and displacement requirements; other vessels may hold water in a peak deep tank for six or more months. Practices of ballast water (and sediment) movement may also vary with individual port characteristics and requirements and the nature of the cargo being loaded or offloaded.

The capacity of ships to carry water and sediment varies with vessel type. A fully loaded vessel in a cargo leg may have only a few hundred gallons (cubic meters) of residual water, or, indeed, it may actually ballast up water in a peak tank for displacement (adjustment) purposes. Capacities of empty vessels range to the tens of millions of gallons: a woodchipper from Japan may carry 6 million gallons; a collier from Asia may carry 26 million gallons; a bulk carrier from Europe may have a capacity approaching 50 million gallons. Vessels of all types can carry ballast water. Inbound vessels in cargo may also carry ballast (amounts that would be considered negligible by the maritime industry but nonetheless capable of supporting living organisms).

Ballast water quality varies in the same manner that water quality would vary in a given donor port region. If the original water and sediment are polluted, then the ballast would be polluted. Except for now rare in situ contamination aboard the vessel (such as by petroleum products), water does not become polluted after being ballasted. However, oxygen, temperature, salinity and nutrients may change during the voyage, and these changes may lead to changes in the biotic composition of the water.

In summary, ballast transport can be viewed as a sequence of events (Fig. 1), beginning with the donor region (stage I) and ending with the establishment of nonindigenous species (stage V) (Carlton 1985). The number of species involved presumably declines with each stage (and thus the shorter box per stage), but the relative importance and indeed the precise nature of the filters between stages are poorly known (and thus the fixed width and length of each link between the stages).

Between 1987 and 1991 Sea Grant-funded studies were conducted by the author, Jon Geller, Debby Carlton and other associates at the University of Oregon Institute of Marine Biology on ballast water and biological invasions in the Port of Coos Bay, Oregon. Approximately 400 living species of zooplankton and phytoplankton, including the larval and juvenile stages of many bottom-dwelling and fouling marine organisms, were discovered to be released in Coos Bay by cargo vessels arriving from Japanese ports. The Oregon studies are the only extensive studies on the composition of ballast biota entering U.S. waters. Williams et al. (1988) report on Australian work, and Locke et al. (1991) report on recent Canadian studies.

INTERNATIONAL AND NATIONAL RESPONSE TO BALLAST WATER INVASIONS

The introduction of Japanese dinoflagellates to Australia and of the zebra mussel to North America were the catalysts for the first major international and national responses to global ballast water transport.

In November 1991, the United Nations' International Maritime Organization (IMO), responding to 1989 and 1990 initiatives from the Australian and Canadian governments, issued international guidelines for the "control of discharge of ballast water containing harmful marine organisms" (IMO 1991).

In 1989 and 1990, the Canadian and Australian governments instituted voluntary guidelines for the exchange of ballast water at sea by inbound vessels. In Canada these guidelines were restricted to vessels entering the Great Lakes; no guidelines were instituted for marine waters. In the United States, Public Law 101-646, entitled the "Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990" was passed in November 1990. In this law, aquatic nuisance species are defined as "nonindigenous species that threaten the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural or recreational activities dependent on such waters."

Under this law, the U.S. established Great Lakes voluntary ballast water control guidelines identical to those of Canada. These voluntary regulations become law in November 1992. As with Canada, no regulations were instituted for non-Great Lakes U.S. waters. However, the Act establishes a National Ballast Water Control Program. This Program includes three studies on the introduction of aquatic nuisance species by vessels: a ballast exchange study, a biological (ecological and economic) study and a shipping study.

The shipping inquiry is defined as "a study to determine the need for controls on vessels entering waters of the United States, other than the Great Lakes, to minimize the risk of unintentional introduction and dispersal of aquatic nuisance species in those waters. The study shall include an examination of – (a) the degree to which shipping may be a major pathway of transmission of

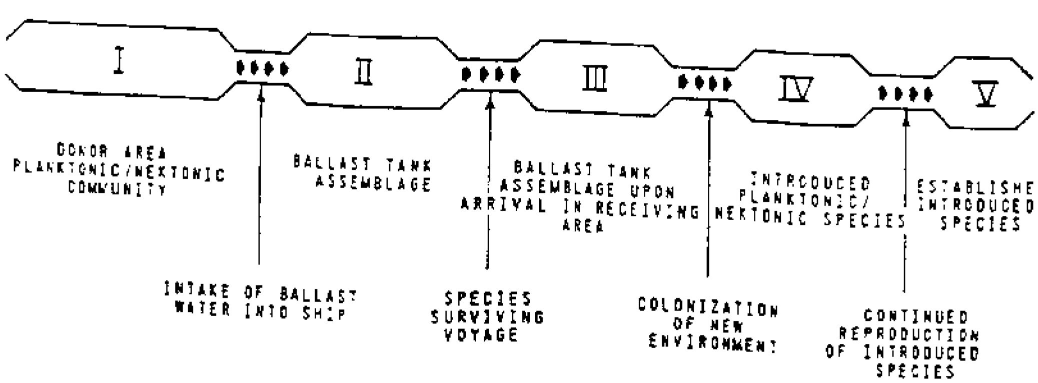

Figure 1. Theoretical sequence of events in the dispersal and introduction of foreign organisms by ships' ballast water.

aquatic nuisance species in those waters; (b) possible alternatives for controlling introduction of those species through shipping; and (c) the feasibility of implementing regional versus national control measures."

In response to this legislation, and through funding provided by the U. S. Coast Guard and the National Sea Grant College Program (NOAA), we established the National Biological Invasions Shipping Study (NABISS) in November 1991 to undertake the "Shipping Study." (As of July 1992 the "ballast exchange" and "biological" studies have not yet commenced.)

Our approach in NABISS to the three sections of the Shipping Study are:

(a) Assess shipping and ballast water release patterns in 15 to 20 major U. S. ports on Atlantic, Gulf and Pacific coasts, including Alaska and Hawaii; determine the sources and amount of ballast water arriving in American waters (typical day, month, year) by type of vessel (for example: bulk carriers, container ships, tankers), including both "Acknowledged Ballast" (recorded ballast on board) and estimates of "Cryptic Ballast" (unrecorded ballast on board).

(b) Analyze proposed alternatives (such as ballast exchange, heating, UV, chemical biocides, electrical, ultrasound, providing sterile ballast water, etc.) through a series of criteria (such as effectiveness, cost (time and money), practicability, safety to crew and vessel, etc.), and then ranking of alternatives based on criteria.

(c) Analyze geographic patterns of ballast discharge relative to volumes and sources, combined with an analysis of the geographic patterns of biological invasions, and with theoretical models of the susceptibility and/or resistance of different environments to biological invasions.

The NABISS study is due for completion in 1992-1993.

EPILOGUE

The invasion of nonindigenous species into natural communities alters the structure and function of these systems, and may lead to radical changes in the value of coastal waters for food, recreation, and industrial uses. Invasions may also lead to dramatic changes in the ecological functioning of these communities -- in terms of predation, prey availability and competition between species. Hundreds of case histories of invasions in natural ecosystems have demonstrated the vast potential magnitude of change and reorganization as a result of introductions of exotic species.

Detailed knowledge of what species are invading or could invade, the mechanisms by which they are transported into our coastal waters, such as ballast water and sediments, and the rate and scale of the inoculation of exotic organisms, are clearly the critical foundation to prevent such introductions.

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An Overview of Management Principles and Objectives for a Marine Species Introduction Policy

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WHAT IS AN INTRODUCED SPECIES?

An introduction occurs when a species is intentionally or unintentionally moved by human activities to a geographical region where it had not previously existed. Introductions should not be confused with natural migrations or invasions. Likewise, introductions should not be equated with supplemental stocking or re-stocking programs. Although aquatic species do not recognize international boundaries, it must be recognized that humans do. Accordingly, it is oftentimes useful to distinguish between introductions that are national or international in scope.

WHY INTENTIONALLY INTRODUCE SPECIES?

The majority of intentional introductions are made for aquaculture or recreational sportfishing purposes. Introductions are made for aquaculture when target native species do not exist or do not have the same positive attributes as the non-native forms. Introductions are made to enhance sport fisheries, either in the form of gamefish to be directly caught by anglers, or as forage fish to serve as food for existing game species. Introductions for aquaculture and recreational sportfishing are valid objectives. They both have been extensively implemented and have terrestrial counterparts in farming, forestry and wildlife management.

WHAT CAN GO WRONG WITH INTRODUCTIONS?

Environmental risks associated with introduced aquatic organisms can be classified into five broad categories: habitat alteration, trophic alteration, spatial alteration, gene pool deterioration, and introduction of diseases (Kohler and Courtenay 1986). Courtenay and Robins (1989) reviewed several case studies of introduced aquatic organisms in which some or all of these risks manifested themselves resulting in severe environmental impacts. It is clear from these and other case studies (e.g., see Taylor et al. 1984, Herbold and Moyle 1986, Hughes 1986, Moyle et al. 1986) that actual impacts and the degree to which they manifest, are dependent upon not only the biology of the introduced species, but also the specific characteristics of the receiving system. Accordingly, an introduction made to one area might pose a greater or lesser risk than to another.

WHAT CAN GO RIGHT WITH INTRODUCTIONS?

There is no question that aquaculture has and will continue to play a major role in meeting the ever increasing demand for seafood products. In many areas suitable for aquaculture, species having high commercial potential simply do not exist. In such cases, introductions represent the only means to develop an aquaculture industry. In other cases, species exist and may even be cultured, but other species might be better, or they might fill a different market niche. Aquaculture is an industry, and like any other industry it creates employment and contributes to the Gross National Product. In the United States it is estimated that seafood imports approach 4 billion dollars annually. Consequently, aquaculture represents an excellent means for decreasing trade imbalances. Japan, for example, is a net importer of fish from the United States.

Development of recreational sportfishing through use of introductions also has positive economic ramifications. For example, the salmon fishery of the Great Lakes, all based on introduced species, is a billion dollar annual industry.

HOW DO WE MANAGE INTRODUCTIONS?

Considering that there are both potentially positive and negative ramifications with respect to introductions, there are three basic choices that can be made regarding policy. The first would be to continue a laissez-faire attitude of anything goes. Ultimately, this path will lead to one or more ecological disasters. The second choice would be to prohibit all introductions. This outcome could be the death nail for aquaculture in many regions. It also would prevent enhancement of valuable sport fisheries. The third choice, and certainly the most practical choice, would be to allow some introductions and to prohibit others.

HOW DO WE DECIDE WHICH INTRODUCTIONS TO MAKE?

Kohler and Stanley (1984, 1984b) presented a protocol concerning introduced aquatic organisms that requires:

1. Establishment of an evaluation board or committee,
2. Promulgation of a formal proposal for each proposed introduction,
3. Evaluation of the proposed introduction employing a Review and Decision Model,
4. Standards for research facilities conducting preliminary studies,
5. Necessary permits and disease-free certifications, and
6. Written reports on outcomes of introductions submitted to the evaluation board and local natural resource agency(s).

This or a similar protocol should ensure that introductions are not made without taking into account the risks and benefits of the action.

HOW DO WE REDUCE RISKS FROM INTRODUCTIONS?

Kohler (in press) developed conceptual models that describe the elements associated with risks of introductions of aquatic organisms and how these elements are related. The models include: Index of Colonization, which is based on escape and acclimatization potentials of the non-indigenous species; Index of Impact, which is based on the vulnerability of the receiving system(s) and the threat potential of the non-indigenous species; and a combination of the two indices, the Index of Risk. The elements of each index are assigned relative numerical values ranging from 0.0 (least risk) to 1.0 (highest risk) based on the best available scientific information. It is the relative weighting of each element that is critical rather than absolute values. Overall index values will range from 0.0 to 1.0. By separating risk into its major components and assigning relative values to each it becomes possible to identify where management steps should be implemented. The object of risk management with respect to introduced species will be to take steps to reduce the Index of Risk to the lowest value that is economically feasible.

HOW DO WE DEVELOP POLICY ON INTRODUCTIONS?

The uproar that has followed the unintentional introduction of the zebra mussel via ship ballast waters into the Great Lakes has created an atmosphere in the federal government that all introductions must be seriously curtailed. Overzealousness in this regard could not only have serious negative economic impacts, but could ultimately lead to a loosening of restrictions. For example, if regulations become too restrictive then the aquaculture and recreational fishing industries could be seriously damaged. Under such circumstances, industry and state agencies could question the constitutionality of such regulations. Lawsuits would likely follow. Eventually policies may loosen or even be overturned altogether. The only winners in this scenario would be the legal community.

An alternative (and better) scenario would have the federal government give a mandate to each state to develop guidelines concerning introductions of aquatic species. Resource managers within the respective states could jointly develop guidelines with resource users. The federal government could subsequently harmonize the guidelines in consultation with the states' resource agencies and other countries and international organizations. Such a process would take more time to implement but would keep the federal government from making policy that is not in the best interest of the nation or the environment. What is needed is policy that facilitates the wise use of introduced species and the elimination of unintentional introductions.

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AN INTERNATIONAL PERSPECTIVE ON SPECIES INTRODUCTIONS: THE ICES PROTOCOL

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The International Council for the Exploration of the Seas (ICES), located in Copenhagen, has been concerned with the problems associated with the intentional and accidental movement of marine organisms since at least 1968 (ICES Proces-Verbal de la Reunion, 1968: 79):

> *"During the discussion which arose the need for the establishment of principles to guide member countries contemplating the transplantation or acclimatization of alien species of marine animals or plants was mentioned. There was general agreement on the advisability of giving attention to this subject, and it was agreed that the Committee would return to it in 1969. It was also mentioned that the Office International des Epizooties, Paris, was concerned with this matter."*

In 1969, ICES established what since 1981 has been known as the "Working Group on Introductions and Transfers of Marine Organisms." The Group held its first formal meeting in 1970 in London under the chair of Professor H. A. Cole. Subsequent meetings were held in 1971, 1973 and 1974. The first reconvened meeting met under the chair of Dr. Carl Sindermann in 1979 at the Fisheries Laboratory (MAFF) at Conwy, Gwynedd, North Wales. Meetings have been held each year since 1979 in Europe and Canada. Dr. James Carlton became the third chair of the WG in 1991. Since 1979, the WG has published four ICES Cooperative Research Reports (CRRs), listed here in the Literature Cited. A fifth CRR, summarizing introductions and transfers of marine invertebrates, fish and algae in ICES member countries from 1980 to 1990, is in press (1993).

THE ICES CODE OF PRACTICE

As a result of the early meetings of the Group, ICES adopted a Code of Practice on October 10, 1973 "to reduce the risks of adverse effects arising from introduction by non-indigenous marine species." Modifications proposed by the ICES Working Group on Marine Pathology & Diseases in 1978 and by the newly-reconvened Working Group on Introductions in 1979 led to the publication of a "Revised Code" adopted by ICES in 1979. A "1990 Revised Code," replacing all previous versions, was adopted in October 1990 in Copenhagen. The 1990 Code incorporates changes in the handling of brood stock, and adds a new section II (b). Explanations of the Code are provided in detail in ICES Cooperative Research Report 130, "Guidelines for Implementing the ICES Code of Practice Concerning Introductions and Transfers of Marine Species" (1984) and ICES Cooperative Research Report 159, "Codes of Practice and Manual of Procedures for Consideration of Introductions and Transfers of Marine and Freshwater Organisms" (1988).

The Revised 1990 Code of Practice is included here as an Appendix 1. The ICES Code is divided into four major parts:

1. A recommended procedure for all species prior to reaching a decision regarding new introductions
2. Recommended action if the decision is taken to proceed with the introduction
3. A suggestion that regulatory agencies are encouraged to use the strongest possible measures to prevent unauthorized or unapproved introductions
4. A recommended procedure for introduced or transferred species which are part of current commercial practice.

A fifth section acknowledges that "countries will have different attitudes toward the selection of the place of inspection and control of the consignment, either in the country of origin or in the country of receipt."

Sindermann (1991) summarized the body of the ICES Code of Practice as follows: "The species proposed for introduction should be studied in its native habitat. The study should include known diseases, pest and predators, food habits, and biotic potential. To be included would be consideration of pathological, environmental and genetic implications of the introduction. The study should extend over several years, and the results should be examined by a committee of specialists. If a decision is made to proceed, then a brood stock should be established in quarantine in the recipient country. Only the F-1 generation should be introduced to open waters, provided that no problems emerge."

Since 1979 a variety of versions of the "Revised Code" appeared. For example, Mann's (1979) version (Appendix I, pp. 355-357) is the original 1973 code. Sindermann's (1984) publication is that of the CRR 130 (see Literature Cited), with the exception of a word change in section IV(a), where the word "microbiological" has been substituted for the original "microscopic". Rosenthal's (1985) version is the 1979 Code, although CRR 130 (1984) is cited by mistake as the source of the published text in Rosenthal's paper. Sindermann's (1986) paper combines certain elements of the 1979 Council version (the parenthetical statement at section I is the original one, beginning, "This does not apply...") and the CRR 130 version. None of these versions, however, are so different as to substantially modify the intent of the Code.

THE APPLICATION OF THE ICES CODE OF PRACTICE

Since its first appearance in 1973, but particularly since 1979, the ICES Code of Practice has gained steadily increasing international acceptance and use. In 1985, the UN/FAO "European Inland Fisheries Advisory Commission" (EIFAC) adopted the ICES Code and produced a modified version; in 1988 EIFAC and ICES jointly issued procedural guidelines for the use and interpretation of the Code. Throughout ICES member countries, the Code is now widely known and has been translated into some member languages.

One requirement of the Code (section I (d)) is that member countries contemplating a new introduction or transfer should present to the Council (and thus to its Working Group on Introductions and Transfers) a detailed prospectus, including the information outlined in sections I (a), (b), and (c) of the Code. The WG thus responds to requests for comments from federal or state agencies; the WG does not offer unsolicited advice. The WG studies requests at its annual meetings, but often has found the information provided to be incomplete, and WG reviews typically take two or more years.

In the United States, unlike all other ICES countries, individual states may proceed with most introductions and transfers without the need of federal sanction. Thus, individual states could communicate with ICES directly, as opposed to this role being assumed by the federal governments of other countries. States under ICES purview are Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, North Carolina and South Carolina. There is a good deal of differential knowledge and understanding of the ICES Code of Practice in these states among different agencies. Thus, introductions and transfers proceed in these states without ICES always being notified.

FUTURE DEVELOPMENTS

The ICES Code of Practice is not a fixed, immutable document. As new quarantine and pathological-detection techniques evolve, and as new approaches and perspectives on genetic and environmental concerns develop, the Code will inevitably change. This inevitably presents difficulties for those who seek to follow the Code of Practice. These difficulties arise, however, from the perspective that the ICES Code is or should be a fixed document, as if it were a founding constitution of a state. An alternative and perhaps more robust perception would be that the Code is rooted more in a regulatory framework, and regulations are continually modified as scientific knowledge, the varying degrees over time of environmental concern, and human societal attitudes and economic needs change. Thus, for example, in concert with developments of the 1980s and 1990s, consideration is now underway relative to the inclusion of a new section in the Code relative to the release in marine waters of genetically modified organisms (GMOs).

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REVISED 1990 CODE OF PRACTICE TO REDUCE THE RISKS OF ADVERSE EFFECTS ARISING FROM INTRODUCTIONS AND TRANSFERS OF MARINE SPECIES

I. Recommended procedure for all species prior to reaching a decision regarding new introductions. (A recommended procedure for introduced or transferred species which are part of current commercial practice is given in Section IV).

a. Member countries contemplating any new introduction should be requested to present to the Council at an early stage information on the species, stage in life cycle, area of origin, proposed plan of introduction and objectives, with such information on its habitat, epifauna, associated organisms, potential competition to species in the new environment, etc., is available. The Council should then consider the possible outcome of the introduction, and offer advice on the acceptability of the choice.

b. Appropriate authorities of the importing country (including fishery management authorities) should examine each "candidate for admission" in its natural environment, to assess the justification for the introduction, its relationship with other members of the ecosystem, and the role played by parasites and diseases.

c. The probable effects of an introduced species in the new area should be assessed carefully, including examination of the effects of any previous introduction of this or similar species in other areas.

Results of (b) and (c) should be communicated to the Council for evaluation and comment.

II. If the decision is taken to proceed with the introduction, the following action is recommended:

a. A broodstock should be established in a quarantine situation approved by the country of receipt in sufficient time to allow adequate evaluation of its health status. The first generation progeny of the introduced species can be transplanted to the natural environmental if no diseases or parasites become evident in the F1 progeny, but not the original import. In the case of fish, broodstock should be developed from stocks imported as eggs or juveniles, to allow sufficient time for observation in quarantine.

b. The F1 progeny should be placed on a limited scale into open waters to assess ecological interactions with native species.

c. All effluents from hatcheries or establishments used for quarantine purposed in recipient countries should be sterilized in an approved manner (which should include the killing of all living organisms present in the effluents).

d. A continuing study should be made of the introduced species in its new environment, and progress reports submitted to the International Council for the Exploration of the Sea.

III. Regulatory agencies of all member countries are encouraged to use the strongest possible measures to prevent unauthorized or unapproved introductions.

IV. Recommended procedure for introduced or transferred species which are part of current commercial practice:

a. Periodic inspection (including microscopic examination) by the receiving country of material prior to mass transplantation to confirm freedom from introducible pests and diseases. If inspection reveals any undesirable development, importation must be immediately discontinued. Findings and remedial actions should be reported to the International Council for the Exploration of the Sea.

b. Inspection and control of each consignment on arrival.

c. Quarantining or disinfection whenever possible and where appropriate.

d. Establishment of broodstock certified free of specific pathogens.

V. It is appreciated that countries will have different attitudes toward the selection of the place of inspection and control of the consignment, either in the country of origin or in the country of receipt.

For further details and procedures see: ICES Cooperative Research Report 130: "Guidelines for Implementing the ICES Code of Practice Concerning Introductions an Transfers of Marine Species" (1984, 20 pp.) ICES Cooperative Research Report 159: "Codes of Practice and Manual of Procedures for Consideration of Introductions and Transfers of Marine and Freshwater Organisms" (1988, 44 pp.)

DEFINITIONS

For the application of this code, the following definitions should be used:

Marine species: Any aquatic species that does not spend its entire life cycle in fresh water.

Introduced species (= non-indigenous species, = exotic species): Any species intentionally or accidentally transported and released by humans into an environment outside its present ranges.

Transferred species (= transplanted species): Any species intentionally or accidentally transported and released within its present range.

Quarantined species: Any species intentionally or accidentally transported and released within its present range.

Quarantined species: Any species held in a confined or enclosed system that is designed to prevent any possibility of the release of the species, or any of its diseases or any other associated organisms into the environment.

Country of origin: The country where the species is native.

Exporting country: The country from which a specific consignment of a species (regardless of its native region) is received.

Broodstock: Specimens of a species, either as eggs, juveniles, or adults, from which a first or subsequent generation may be produced for possible introduction to the environment.

Disease: For the purpose of the Code, "disease" is understood to mean all organisms, including parasites, that cause disease. (A list of prescribed disease agents, parasites, and other harmful agents is made for each introduced or transferred species in order that adequate methods for inspection are available. The discovery of other agents, etc., during such inspection should always be recorded and reported).

Current commercial practice: Established and ongoing cultivation, rearing, or placement of an introduced or transferred species in the environment for economic or recreational purposes, which has been ongoing for a number of years.

Established species: Species with existing reproductive populations.

Maintained species: Species which are reproducing in aquaculture for several generations without artificial spawning.

NOTES

a. It is understood that an introduced species is what is also referred to herein as an introduction; a transferred species as a transfer, and a quarantined species as a species in quarantine.

b. Introduced and transferred species, as defined above, include those species subject to the ICES Code of Practice, part I to III, and IV, respectively.

c. Introduced species are understood to include exotic species, while transferred species include exotic individuals or populations of a species. It is, thus, understood that the general term "exotic" can include both introduced and transferred species.

d. It is understood for the purpose of the Code that introduced and transferred species may have the same potential to carry and transmit disease or any other associated organisms into a new locality where the disease or associated organism does not presently occur.

The North American Salmon Conservation Organization: An International Example

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BACKGROUND

In December, 1982, the United States joined other nations bordering the North Atlantic Ocean in the formation of the North Atlantic Salmon Conservation Organization (NASCO) by international treaty agreement through act of Congress. The purpose of this treaty is:

1. To promote the acquisition, analysis and dissemination of scientific information pertaining to salmon stocks in the North Atlantic Ocean and
2. To promote the conservation, restoration, enhancement and rational management of salmon stocks in the North Atlantic Ocean through international cooperation.

While there is no Convention Area specified, the Convention applies to the salmon stocks which migrate beyond areas of fisheries jurisdiction of coastal States of the Atlantic Ocean north of 36 degrees N latitude, throughout their migratory range. The organization consists of the following: a council; three regional commissions: a North American Commission, a West Greenland Commission, and a North-East Atlantic Commission; and a secretary.

The Council (which consists of all Contracting Parties) will work to provide needed services. The Council will provide a forum for the study, analysis and exchange of information on salmon stocks subject to the Convention. The Council will consult with other entities to cooperate concerning salmon stocks beyond Commission Areas. In doing so, the Council will coordinate the activities of the Commissions and establish working arrangements with the International Council for the Exploration of the Seas (ICES) and other fisheries and scientific organizations. This governing body will also make recommendations concerning the undertaking of scientific research, supervise and coordinate the administrative, financial and other internal affairs of the Organization, and coordinate the Organization's external affairs.

The Commissions have three basic functions. These functions include to provide consultation and cooperation among their members, to propose regulatory measures for intercepting salmon fisheries, and to make recommendations to the Council concerning the undertaking of scientific research. Canada and the United States are the members of the North American Commission. Each nation is represented at Commission meetings by three Commissioners. In the case of the United States, they are appointed by the President.

DEVELOPMENT OF THE DISCUSSION DOCUMENT

A discussion document has been prepared in various stages since 1983 upon request of the North American Commission after formation of its Bilateral Scientific Working Group that year. Concern was originally voiced by Canadian members of the Commission over the potential for disease and ecological interactions that could negatively impact wild Atlantic salmon stocks existing along the east coast of North Amercia if indiscriminate movement of salmonids continued to occur. Originally, the concern arose from the perceived threat posed by coho salmon introductions into the area. (When compared with others in the northern hemisphere, it is generally agreed that the Atlantic salmon stocks in Atlantic Canada, especially in Labrador, have undergone the least disruption as a result of man's actions.) It was felt that there was strong justification to institute more effective protective mechanisms to protect these valuable genetic resources.

Over the eight-year period since the Scientific Working Group was established, numerous reports and updates have been provided to the North American Commission. During this period of activity, periodic references were made to the various protocols in existence at the time. Included in these reviews were the 1973 ICES Code of Practice and Guidelines for Implementation, the 1987 Code of Practice of the European Inland Fisheries Advisory Commission (EIFAC), the 1986 Advisory Document 86/27 of the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC), and the 1986 American Fisheries Society's (AFS) Position on Introductions of Aquatic Species.

The current document titled, "Introductions and Transfers of Salmonids: Their Impacts on North American Atlantic Salmon and Recommendations to Reduce Such Impacts" (numbered NAC(89)13), culminates this activity to date and includes appropriate concepts and protocols from the above mentioned documents. The content of this document, endorsed by the NAC of NASCO in 1989, is the subject of my slide presentation today.

The following is a synopsis of the presentation and follows the sequence of issues in the document. A complete copy of the subject document can be obtained by either writing to me, c/o Fisheries, USFWS, One Gateway Center, Newton Corner, MA 02158 or FAXing a request to 617/969-6783.

The document resulted from the need to develop a comprehensive plan to address the following concerns: introductions, enhancement, hatchery practices, escapees, and selective fisheries. In 1984, NAC/NASCO established a bilateral scientific working task force to write a report documenting the need for this organization. In 1986, NAC/NASCO expanded this working group. NAC/NASCO adopted the policy and action plan developed by task the force in 1987. By 1989, the discussion document had been completed.

Currently, the United States has Title 50 CFR as a control mechanism, as well as some state legislation and a regional committee in the New England area of the country. Canada also has some control mechanisms , as well as some state legislation and a regional committee in the New England area of the country.

Canada also has some control mechanisms in place. The fish health protection regulations, as well as some provincial regulations and a regional introductions and tranfers committee, working to amerliorate the current conditions. These controls are considered to be inadequate, because they lack proper authority and they do not address genetics or ecological interactions.

These protocols were officially adopted by the North American Commission of the North Atlantic Salmon Conservation Organization at its Annual Meeting held in Washington, DC during the week of June 8, 1992.

The entire report is divided into four parts: Part I is the focus of this review and provides a brief systematic summary of the Fish Health, Genetic, and Ecological Protocols, which are detailed in Parts II-IV respectively. It introduces a Zoning concept for application of the protocols. References relating to the individual disciplines (fish health, genetics, and ecological issues) are provided in Parts II-IV.

The standards are considered minimal. As such, agencies may upgrade these if there is scientific justification, or if fishery managers need to have greater assurance that biological characteristics of the wild population will be conserved and protected. These protocols will be reviewed every two years and amended as necessary by the contracting parties (US and Canada).

INTRODUCTION

The North American Commission (NAC) of the North Atlantic Salmon Conservation Organization (NASCO) recognizes the potential for adverse fish health, genetic and ecological effects on Atlantic salmon stocks via introductions and transfers of salmonids. Interest is increasing to introduce or transfer non-indigenous species, stocks and/or strains of salmonids for aquaculture, restoration of historic populations and/or improvement of recreational fisheries. These introductions or transfers pose an undue and irreversible risk to wild Atlantic salmon populations if adequate safeguards are not taken.

The NAC, at its ninth annual meeting, June 1992, adopted protocols and guidelines for the introduction and transfer of salmonids, as contained in this report, for use in the North American Commission Area. The fundamental objectives of these protocols are:

(a) To minimize the risk of introduction and spread of infectious disease agents (fish health);
(b) To prevent the reduction in genetic variance and prevent the introduction of non-adaptive genes to wild Atlantic salmon populations (genetics); and
(c) To minimize the intra- and interspecific impacts of introductions and transfers on Atlantic salmon stocks (ecology).

ZONING OF RIVER SYSTEMS

The NAC has adopted the concept of Zoning for application of these protocols to the NAC Area. Three zones have been designated based on the degree of degraduation of manipulation that has occurred on the wild Atlantic salmon populations have been variously affected by human activities. (Figure 1)

These activities include over-harvesting, selective fishing, habitat deradation, mixing of stocks, introduction of non-indigenous fish species, and spreading fish diseases. Atlantic salmon stocks in northern areas (Zone I) have generally been least affected, and those stocks in the southern area (Zone III) have been most affected by humans.

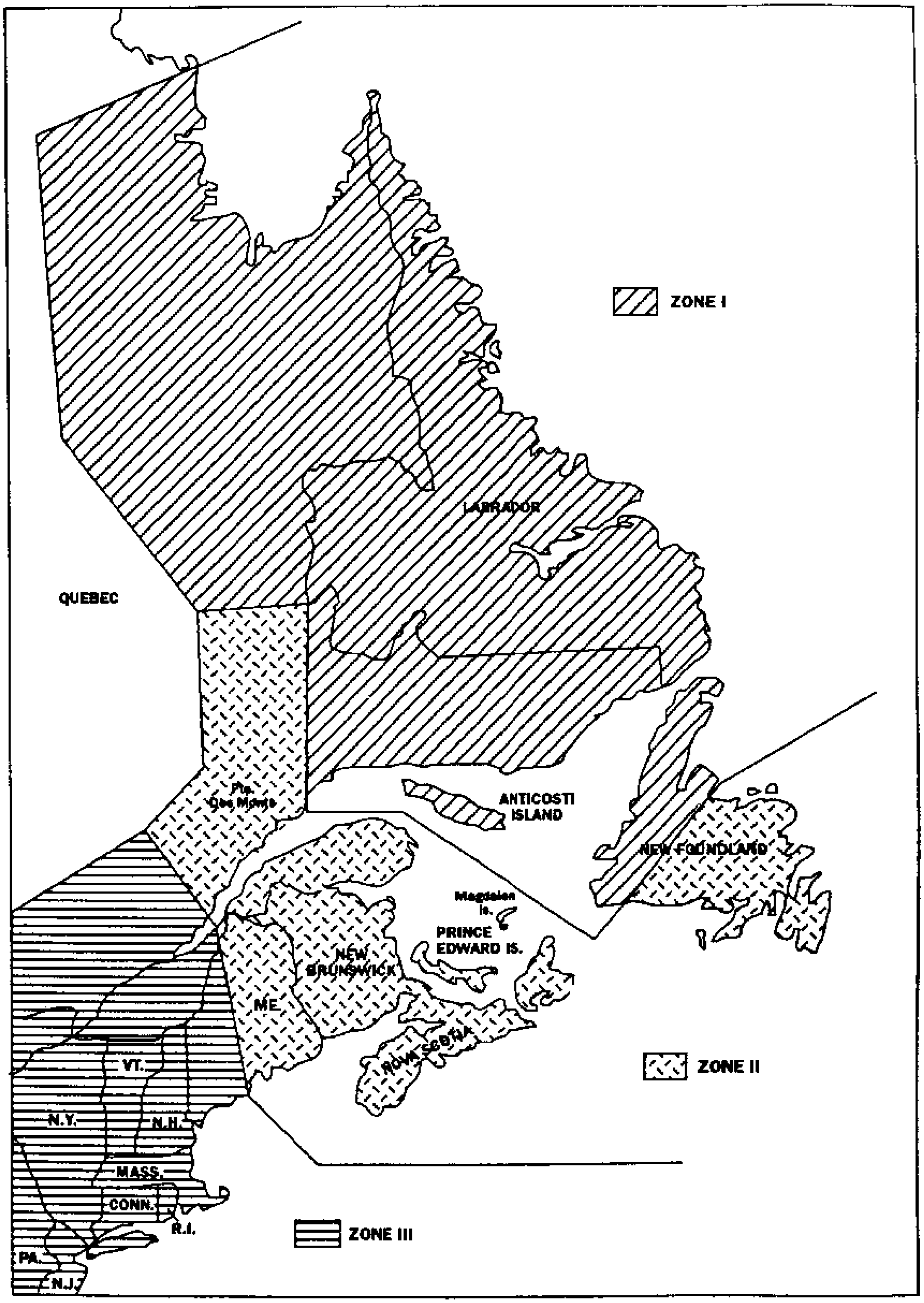

Figure 1. Map of eastern Canada and northeastern USA showing the 3 zones proposed for implementation of protocols.

In order to allow operational flexibility within in a Zone, river systems have been classified at Class I, II, or III rivers. Generally, rivers will have the same classification as the Zone in which it is in.

For example, in Zone II, river systems will be mainly categorized as Class II. However, a river system may be assigned a higher classification than the Zone in which it is located (e.g.,) Class I river in Zone II) to allow additional protection for valuable Atlantic salmon stocks.

In extenuating circumstances and if a river is sufficiently isolated from other rivers, it is acceptable to have a river with a lower classification than the Zone in which it is located (e.g., Class III rivers within Zone II or Class II rivers in Zone I). All rivers are presently classified at the same level as the Zone designation. Member countries wishing to change the location of Zone boundaries or to have rivers of a lower classification within a Zone should submit their recommendations, with scientific justifications to NAC.

DESCRIPTION OF ZONES

Zone I: Geographic Area: Northern Quebec, Labrador, Newfoundland (west coast) and Anticosti Island.

Rivers are classified primarily as Class I. They are pristine rivers with no significant man-made habitat alterations, no history of transfers of fish into the watersheds, and no fish rearing operations in the watersheds.

Zone II: Geographic Area: Quebec rivers flowing into Gulf of St. Lawerence south of Pet. des Monts, Gaspe region of Quebec, Magdalen Islands, Prince Edward Island, New Brunswick, Nova Scotia, Newfoundland (except west coast), St. Pierre and Miquelon Islands, and State of Maine east of Rockland.

Rivers are classified primarily as Class II watersheds in which one or more of the following conditions occur: the habitat has been altered; non-indigenous wild or hatchery-reared Atlantic salmon have been released; or aquaculture has been conducted in marine cage culture.

Other species may be present in land-based facilities. Introduced species such as rainbow trout would be treated as indigenous if a population has been established for ten or more years.

Zone III: Geographic Area: Lake Ontario, southern Quebec draining to St. Lawrence River, State of Maine west of Rockland, New Hampshire, New York, Connecticut, Massachusetts, New Jersey, Rhode Island, and Vermont.

Rivers are classified primarily as Class III watersheds in which habitats have been altered, or where fish communities are destabilized, or exotic species are present.

PROTOCOLS

Protocols Applicable to all Three Zone Classifications

(1) Reproductively viable Atlantic salmon of European-origin (strain), including Icelandic-origin, are not to be released or used in Aquaculture in the North American Commission Area. This ban on importation or use of European-origin Atlantic salmon will remain in place until scientific information confirms that the risk of adverse genetic effects on wild Atlantic salmon stocks is minimal.

(2) No live salmonid fishes, fertilized eggs, gametes, or fish products are to be imported from IHN enzootic areas, unless sources have an acceptable history of disease testing demonstrating the absence of IHN (eg. Great Lakes Fish Health Disease Committee protocol requirements). IHN infected areas, currently include State of Washington, Oregon, Idaho, California, Alaska, British Columbia, Japan, and parts of Taiwan and France.

(3) Prior to any transfer of eggs juveniles or brook stock a minimum of three health inspections of the donor facility will be undertaken during the two-year period immediately preceding the transfer; and the inspections must reveal no evidence of either emergency or restricted fish pathogens in the donor population (see Part II).

(4) Prior to any movement of non-native fishes into a river system or rearing site inhabited by Atlantic salmon the agency with jurisdiction shall review and evaluate fully the potential for interspecific competition which would adversely impact on the productivity of wild Atlantic salmon populations. Such evaluations should be undertaken, as far as possible, with information on the river in which the introduction is to occur and from similar situations.

(5) Hatchery rearing programs to support: introduction, re-establishment, rehabilitation and enhancement of Atlantic salmon should try to comply with the following measures:

(a) Use only F1 progeny from wild stocks;

(b) Derive broodstock from all phenotype age-groups and the entire run of a donor population;

(c) Avoid selection of the "best" fish during the hatchery rearing period; and

(d) During spawning, make only single pair mating from a broodstock population of no less than 100 parents. Should the number of one sex be fewer than 50, the number of spawners of the other sex should be increased to achieve a minimum N of 100.

Protocols Applicable to Zone I

Zone I consists of Class I watersheds where every effort must be made to maintain the existing genetic integrity of Atlantic Salmon stocks. The following summary protocols apply:

(a) General within Zone I
• no Atlantic salmon reared in a fish culture facility are to be released into a Class I river, a another river which has its estuary less than 30 km from a Class I river, or a marine site less than 30 km from a Class I river (distances would be measured in straight line(s) from headland to headland);
(b) Rehabiliation
• fisheries management techniques will be used to ensure sufficient spawners such that spawning escapement exceeds a minimum target level to maintain an effective breeding population;
• habitat that becomes degraded will be restored to the greatest extent possible;
(c) Establishment or re-establishment of Atlantic salmon in a river or part of a watershed where there are no salmon
• use transfers of adults or juvenile salmon from the residual population in other parts of the watershed;
• a near-by salmon stock which has similar pheno typic characteristics to the lost stock could be transferred it there is no residual stock and provided an effective breeding population is maintained in the donor watershed;
• if the biological characteristics of the original stock are not known or there was no previous stock in the recipient watershed, then transfer broodstock or early life stages from a nearby river having similar habitat characteristics;
(d) Aquaculture in marine or freshwater cages, or land-based facilities;
•rearing of fish at locations in the marine environment, in a Class I river, or in a watershed with estuary less than 30 km (measured in a straight line(s) headland to headland) from the estuary of a Class I river is resticted to land-based facilities using reproductively sterile fish, or indigenous fish species such as brook trout or arctic charr;
• rearing of fish at locations in the marine environment, or in a watershed with estuary greater than 30 km (measured in a straight line(s) headland and headland) from Class I rivers in permitted in either sea cages or land-based facilities with reproductively sterile fish or with brook trout or arctic charr provided that the risk of adverse effects on wild Atlantic salmon stocks is minimal;
(e) Commerical ranching
• no commercial ranching of salmonids is permitted within 30 km of the estuary of a Class I river (measured in a straight line(s) headland to headland).
• at locations greater than 30 km from the estuary of a Class I river, reproductively sterile Atlantic salmon, reproductively viable brook trout or Arctic charr, and reproductively sterile non-indigenous species may be ranched provided that the risk of adverse effects on wild Atlantic salmon stocks are minimal;

Protocols applicable to Zone II

(a) General within Zone II
• reproductively viable non-indigenous species and reproductively viable Atlantic salmon stocks non-indigenous to the NAC area are not to be introduced into watersheds or into the marine environment of Zone II;
• Restoration, enhancement and aquaculture activities are permitted in the freshwater and marine environments;
(b) Rehabilitation
• The preferred methods are: to improve degraded habitat and ensure escapement to sufficient spawners through fisheries management;
• If further measures are required, use residual stocks for rehabilitation and enhancement. If the residual stock is too small, select a donor stock having similar life history and biochemical characteristics from a tributary or nearby river;
• Stocking of hatchery-reared smolts is preferred to reduce competition with juveniles of the natural stocks;
(c) Establishment or re-establishment into rivers having no Atlantic salmon populations:
• To establish an Atlantic salmon stock, use a stock from a nearby river having similar stream habitat characteristics;
• If re-establishing a stock, use a stock from a nearby river which has similar biological characteristics to the original stock;
• It is preferable to stock rivers with broodstock or early life history stages (eggs and fry);
• If eggs are spawned artificially, use single pair matings and optimize the effective number of parents.
(d) Aquaculture in marine or freshwater cages, or land-based facilities:
• It is important to apply methods which minimize escapees;
•Develop domesticated broodstock using local stocks; or, if local stocks are limited, use nearby stocks;
• Reproductively viable non-indigenous species may

only be introduced into land-based facilities where risk of escapement is minimal.

• non-indigenous species may be introduced into the wild or used in cage rearing operations if the fish are reproductively sterile and the risk of adverse ecological interactions is minimal;

(e) Commerical Ranching

• Commerical Atlantic salmon ranching will only be permitted at release sites located greater than 20 km from the estuary of a Class II river (measured in a straight line(s) headland to headland) and it is demonstrated that the activity will not negatively affect wild Atlantic salmon stocks

• Non-indigenous species or distant national Atlantic salmon stocks may be used if the fish are reproductively sterile and the risk of adverse ecological interactions in minimal;

Protocols applicable to Zone III

(a) General within the Zone

• Indigenous and non-indigenous salmonid and non-salmonid [except reproductively viable Atlantic salmon stocks non-indigenous to the NAC Area] fishes may be considered for introduction or transfer if fish health and genetic protocols are followed and negative impacts on Atlantic salmon can be shown to be minimal using careful ecological impact evaluation;

(b) Rehabilitation

• Habitat quality should be upgraded wherever possible;

• Rebuilding stocks can be achieved by controlling exploitation and by stocking cultured fish;

(c) Establishment or re-establishment

• Transfer source stocks from nearest rivers having similar habitat characteristics;

• Stock with juvenile stages (eggs, fry and/or parr). If eggs are spawned artificially, use single pair matings and optimize the effective number of parents;

(d) Aquaculture

• Rearing in Marine or freshwater cages, or land-based facilities:

• Use of local stocks is preferred but non-indigenous stocks may be cultured;

• Marine cage culture can be widely practised; but, preferred locations are at least 20 km from watersheds managed for salmon production (measurements are by straight lines from headland to headland);

• Culture of non-indigenous species in land-based facilities on Class III watersheds is permitted in adequately controlled facilities where risk of escapement is minimal;

(e) Commercial Ranching

• Commercial ranching of salmonids is permitted if it is demonstrated that the activity will not negatively affect Atlantic salmon rehabilitation or enhancement programs or the development of wild Atlantic salmon stocks;

GUIDELINES FOR APPROVAL OF INTRODUCTIONS AND TRANSFERS

Both proponents and agencies responsible for managing salmonids have a responsibility for ensuring that risk of adverse effects on Atlantic salmon stocks from introductions and transfers of salmonids and other fishes is low. Reasonable laws to protect wild stocks should be enacted by each agency, as necessary. Resource management agencies will determine protection for habitats with Atlantic salmon potential.

Responsibility of Proponent

The proponent must submit an application for introduction or transfer of fishes to the permit-issuing agency. This request must provide a full justification for the introduction or transfer such that a complete evaluation will be possible prior to issuance of a permit. The list of information to be included in the jusrification for introductions and transfers is in Section 4.4, below. The lead time required for notice and justification of introductions and transfers will be determined by the permit-issuing agency. Proponents should be aware of the protocols established for introductions and transfers.

Responsibility of Government Agencies Having the Authority to Issue Permits

These agencies shall be those entities having the responsibility for fishery management within the receiving area. The responsibilities of the agencies shall include:

(1) Establish, maintain, and operate a permit system and inventory for all introductions and transfers of fishes.

(2) Enact regulations required to control the introductions and transfers of fishes as per established protocols.

(3) Establish a formal scientific evaluation process to review all applications (private and government agencies) for the introduction and transfers based on the potential impact on the productivity of Atlantic salmon.

(4) Within the Zones each agency may be more restrictive in classifying individual watersheds. Rarely, a less restrictive classification may be applied to an individual watershed if its estuary is at least 30 km in zone I, or 20 km in zone II (measured in straight lines headland to headland) from a watershed with a higher classification.

(5) Annually, submit to the NAC Scientific Work-

ing Group the results of the permit submission/ review process, and a list of introductions and/or international transfers proposed for their jurisdiction.
(6) Prevent the release of fishes which will adversely affect the productivity of wild Atlantic salmon stocks.

Responsibilities of the NAC/Scientific Working Group on the Salmonid Introductions and Transfers

(1) Maintain an inventory of all introductions of sal monids, transfers of salmonids from IHN-infected areas, and importation of salmonids across national boundaries into the Commission Area.
(2) Review and evaluate all introduction and transfers referenced in Section 4.3 (1) above, in relation to the NAC protocols and report the results to the North American Commission.

Preparation of Proposals

The following information is required, by the permit issuing agency, with applications involving introductions and transfers of salmonids, except for restocking into source river. This information will be used to evaluate the risk of adverse effects on Atlantic salmon stocks.

(1) Name the species, strain and quantity to be in troduced or transferred, and include:
a. Time of introduction or transfer.
b. List anticipated future introductions or transfers.
c. List previous introductions and/or transfers.
(2) Area, place, river or hatchery from which the fish will be obtained.
(3) Proposed place of release and any interim rearing sites.
(4) Disease status of donor hatchery, river or other location from which fish are obtained.
(5) Disease status of recipient facility or stream (where available).
(6) Objective of the introduction or transfer and the rationale for not using local stock or species.
(7) For non-indigenous species, provide the available information on the proposed species' life history, preferred habitat, potential parasites and disease agents, and potential for competition with Atlantic salmon in the recipient waters or nearby waters.
(8) Information on similar transfers or introductions.
(9) Proposed procedure for transportation from donor to recipient site.
(10) List measures to be taken to prevent transmission of disease agents and to reduce the risk of escape of fish.
(11) Species composition at proposed site of introduction and adjacent rivers.
(12) Climatic regime and water chemistry, including pH of waters at the site of proposed introduction and of adjacent rivers.
(13) For indigenous species determine the life history and biological characteristics of donor stock. This would include such characteristics as run timing, time of spawning, age-at-maturity, size-at-age etc.
(14) Potential of introduced or transferred fish to disperse to nearby streams.
(15) A bibliography of pertinent literature should be appended to the proposal.

Evaluation of Proposals

The evaluation of proposals will be the responsibility of the permitting agency and will focus on the risk to Atlantic salmon production and potentialproduction associated with the proposed introductions and/or transfers. The evaluation will be based on the classification of the recipient watershed. All requests for introduction or transfers must provide sufficient detail (Section 4.4, above)such that the potential risk of adverse effects to Atlantic salmon stocks can be evaluated.

The evaluation of potential adverse effects of fish health will consider the disease history of the donor and recipient facility and/or watershed with specific reference to the potential for transferring emergency diseases. The risk of detrimental genetic effects of introducing a non-indigenous stock into a river will be evaluated taking into consideration the phenotypic and life history characteristics of the donor stock, the biochemical information (mitochondrial/nuclear DNA and enzyme frequencies, if available), and geographic distance between donor and recipient locations. The evaluation of the risk of ecological effects on Atlantic salmon populations is more involved. Introduction of non-indigenous Atlantic salmon stocks and/or non-indigenous species will be evaluated by considering the life history and habitat requirements of the transferred fish.

The introduction of non-indigenous species poses a significant risk to the productivity of the Atlantic salmon stocks. Evaluation will be by comparison of the habitat requirement and behaviour of both the proposed introduced species and the indigenous Atlantic Salmon stock at all life stages.

The habitat requirements and areas of possible interactions with Atlantic Salmon has been described for 14 fish species 9see Part IV, Ecological Subgroup report). These can be used to provide a cursory evaluation of the life history stage at which interactions would occur. However, more detailed information on stocks and habitats in both donor and recipient locations would be required in the form of an envirogran (example is provided in Part IV). Where insufficient data are available, research will be required prior to permitting the introduction or transfer.

An outline example of the type of information which is available in the species summaries (Part IV) is presented below for rainbow trout:

(1) Conditions under which interactions will occur:

- spawning - rainbow may dig up Atlantic salmon redds
- interaction of yearlings - compete for space
- rainbow trout juveniles are more aggressive than juvenile Atlantic salmon in pools
- large are trout are piscivorous

(2) Low interaction:

- in streams where Atlantic Salmon do not utilizes
- salmon well established
- aquaculture using sterile fish or land base facility

(3) Conditions under which no interaction will occur. It would be permissible to use reproductively viable rainbow trout:

- habitat with pH less than 5.5
- rainbow already present in recipient stream
- disturbed ecosystems where Atlantic Salmon are absent and sport fishing would be improved

GLOSSARY

Applicant: See proponent.

Aquaculture: The culture or husbandry of aquatic fauna other than in research, in hobby aquaria, or in governmental enhancement activities.

Commerical Ranching: The release of a fish species from a culture facility to range freely in the ocean for harvest and for profit.

Competition: Demand by two or more organism or kinds of organisms at the same time for some environmental resource in excess of the available supply.

Containment: Characteric of a facility which has an approved design which minimizes operator error to cause escape of fish, or unauthorized persons to release contained fish.

Diversity: All of the variations in an individual population, or species.

Enhancement: The enlargement or increase in number of indiviuals in a population by providing access to more or improved habitats or by using fish culture facility production capability.

Exotic: See introduced species.

Fish: A live finfish.

Gamete: Mature germ cell (sperm or egg) possessing a haploid chromosome set and capable of formation of a new individual by fusion with another gamete.

Genetics: A branch of biology that deals with the heredity and variation of organisms and with the mechanisms by which these are effected.

Indigenous: Existing and having originated naturally in a particular region or environment.

Introduced species: Any finfish species intentionally or accidentally transported or released by Man into an environment outside its native or natural range.

Isolation: Means restricted movement of fish and fish pathogens within a facility by means of physical barriers, on-site sanitary procedures and separate water supply and drain systems and cultural equipment.

Mariculture: Aquaculture in sea water.

Native: See indigenous

Niche: A site or habitat supplying the sum of the physical and biotic life-controlling factors necessary for the successful existence of a finfish in a giver habitat.

Non-indigenous: Not originating or occurring naturally in particular environment; introduced outside its native or natural range.

Population: A group of organisms of a species occupying a specific geographic area.

Predator: An individual that preys upon and eats live fish, usually of another species.

Proponent: A private or public group which requests permission to introduce or transfer any finfish within or between countries and lobbies for the proposal.

Quarantine: See Annex IX-Part II.

Rehabilitation: The rebuilding of a diminished population of a finfish species, using a remant reproducing nucleus, toward the level that its environment is now capable of supporting.

Restoration: The re-establishment of a finfish species in waters occupied in historical times.

Salmonid: All species and hybrids of the Family Salmonidae covered by the AFS checklist special publication No. 12, "a list of Common and Scientific Names of Fishes from the United States and Canada".

Species: A group of interbreeding natural populations that are reproductively isolated from other groups.

Stock: Population of organisms sharing a common gene pool which is sufficiently discrete to warrant consideration as a selfperpetuating system which can be managed.

Strain: A group of individuals with a common ancestry that exhibits genetic, physiological, or morphological difference from other groups as a result of husbandry practices.

Transfer: The deliberate or accidental movement of a species between waters within its native or natuarl geographic range, usually with the result that a viable population results in the new locations.

Transferred species: Any finfish intentionally or accidentally transported and released within its native or natural geographic range.

FEDERAL AND PROVINCIAL POLICIES FOR MARINE SPECIES INTRODUCTIONS AND TRANSFERS IN ATLANTIC CANADA*

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INTRODUCTION

Canada has vast fisheries resources in both fresh and marine waters, which support economically important activities. These include commercial fishing (mostly marine species), recreational fishing (mostly freshwater species), and aquaculture (both freshwater and marine species). In many areas, fish also comprise an important component of the food of native peoples.

Over the past 20-30 years, there has been increasing pressure to introduce or transfer aquatic organisms for use in enhancement of recreational fisheries, or to provide seedstock or improved broodstock for commercial aquaculture operations. Shipment of aquatic organisms from one area to another raises concerns that diseases might be introduced or spread, that genetic variability of wild stocks might be affected, or that there could be ecological impacts (competition for food, space, spawning areas).

To minimize disruption of local populations, and to help ensure the sustained availability of fish stocks, governments have developed regulations and policies that apply to introduction and transfer of fish stocks. This presentation outlines the legal and administrative framework under which introductions and transfers of aquatic organisms are managed in Atlantic Canada (Nova Scotia, New Brunswick, Prince Edward Island, and Newfoundland). Examples are provided of recent introductions and transfers of fish to this region and their impact, and observations are made on the strengths and weaknesses of related regulations and policies.

FEDERAL AND PROVINCIAL JURISDICTION RELATED TO FISHERIES

"Canada, like the United States, . . . is a federal state. It consists of ten partially self-governing geographic units called provinces, together with two federally-administered territories, and a federal government located in Ottawa. . . . Legislative authority is divided in Canada between the federal and provincial governments by the British North America Act." (Wildsmith 1982).

The division of responsibilities of federal and provincial governments related to fisheries can be summarized as:

1. Federal Government
- Commercial and recreational fisheries in tidal and non tidal waters
- Inspection for quality of food for human consumption
- Interprovincial and international trade
- Shipping and navigation
- Federal public property

2. Provincial Government
- Property ownership
- Intraprovincial trade
- Water use within a province
- Provincial public property

Hence the federal government is responsible for the conservation and protection of fisheries resources that provide the basis for commercial and recreational fisheries in freshwater and marines waters, including control of activities that might impact on health, genetic diversity and ecological balance of fisheries resources. This responsibility is undertaken by the Department of Fisheries and Oceans through the Fisheries Act.

However, the Department of Fisheries and Oceans works closely with provincial agencies in administering fisheries. In some provinces, administration of fisheries has been delegated to provincial governments, and they are also involved in licensing for recreational fisheries.

NATIONAL REGULATIONS

The Fish Health Protection Regulations were promulgated under the Fisheries Act, and were implemented in 1977 (Anon 1984, Carey and Pritchard 1989). They apply to live eggs and fish of cultured salmonids, dead cultured salmonids and eggs of wild salmonids, imported to Canada or transferred between provinces.

Shipments of stocks covered by these regulations must be accompanied by Import Permits issued by Local Fish Health Officers, who are appointed by the Minister of Fisheries and Oceans to administer the regulations in each province.

Compliance with these regulations requires that source facilities must have four consecutive satisfactory inspections over 18 months (i.e., develop a disease history). If it is confirmed that selected fish disease agents are absent, a Fish Health Certificate may be issued. This Certificate then becomes the basis for issuing Import Permits.

The Fish Health Protection Regulations are presently under review, and it is anticipated that significant amendments will be made. These will include introduction of a zoning concept and expansion of the regulations to cover other finfish, molluscs and crustacea.

Under Section 4 of the Fisheries Act, the Minister or his representative may give permission to obtain fish for purposes of stocking, artificial breeding, or for scientific purposes. This Section of the Fisheries Act is used infrequently, but has been useful in facilitating transfers of stock for research purposes.

PROVINCIAL REGULATIONS

Under the Fisheries Act, Provincial Fisheries Regulations have been promulgated to address specific issues in each province. While these regulations are administered on a province by province basis, all amendments to the regulations require approval by the federal Department of Fisheries and Oceans.

In each set of provincial regulations there is a section dealing with introductions and transfers. Essentially, there is a requirement for a permit to introduce aquatic organisms to waters of the province, or to transfer organisms from one watershed to another within a province. Permits are issued if fish meet health certification requirements, and will not adversely affect local species (i.e., there will be no negative genetic or ecological impacts).

Introductions/Transplant Committees have been established in each province to review and provide advice on proposals to introduce or transfer aquatic organisms, including recommendations of conditions under which introductions or transfers may be safely undertaken.

POLICIES RELATED TO INTRODUCTIONS AND TRANSFERS

A number of policies have been developed in Atlantic Canada that apply to introductions and transfers. Selected examples include:

Provincial

A policy for introductions and transfers of salmonids has been developed for the province of Newfoundland and Labrador (Anon 1990). Transfers or introductions of salmonids from outside North America or from west of the Continental Divide in North America will not be approved. Procedures for introductions (e.g., rainbow trout) and transfers (e.g., Atlantic salmon, brook trout) to Newfoundland are outlined in the policy. For introduction of non-indigenous species or for transfer of new strains, there is an increasing emphasis on the use of reproductively sterile fish to minimize ecological or genetic impacts of escaped/released fish on local populations.

A policy on introductions and transfers of all fish species, including shellfish (e.g., oysters, mussels) is under development for Prince Edward Island. P.E.I. has become an important area for culture of shellfish species, and particular attention in the draft policy will be paid to procedures for introduction and transfers of shellfish species. This includes measures to reduce the potential for transferring disease agents in shellfish imported live from other regions or countries for the food market.

Regional

Aquatic organisms do not respect political boundaries, and it is very important that nations/provinces/states collaborate closely on the subject of introductions and transfers because of the potential impact that actions by one can have on a neighbour. An excellent example of what can be accomplished through this type of collaboration is the work undertaken by the Scientific Working Group that comes under the North American Committee, North Atlantic Salmon Conservation Organisation.

The Scientific Working Group is preparing recommended procedures to minimize the impact of introduction and transfer of salmonids on Atlantic salmon populations in eastern Canada and U.S.A. (Anon 1989). The procedures are designed to reduce the health, genetic, and ecological impacts of these introductions and transfers.

National

The Department of Fisheries and Oceans is working on a policy on introductions and transfers that reflects national concerns, and applies to both freshwater and marine species of aquatic organisms. The policy will also address the problems related to release of genetically modified aquatic organisms (i.e., those organisms that contain introduced genetic material). One option is that introduction of genetically modified organisms to Canadian waters will be treated as if they were exotic species, and will only be released if they are reproductively sterile.

SOME PRINCIPLES USED TO MANAGE INTRODUCTIONS AND TRANSFERS

A number of common principles are being adopted with increasing frequency in legislative or policy initiatives that relate to introductions and transfers of aquatic organisms in Canada. These include:

- Prefer "risk management" as opposed to "zero risk"
- Establish conditions and standards for introductions and transfers, rather than requiring proof of safety from exporter
- Base regulations and policies on good science
- Harmonize regulations and policies, where possible, with other national or international standards
- Require detailed proposals that assess the positive and negative biological, social, and economic impacts
- Industry should assume at least part of the cost of studies/conditions related to introductions or transfers from which they benefit
- Consider an introduction or transfer to aquaculture facilities as a likely release to the natural environment
- Release of genetically modified organisms should receive the same scrutiny as for introduction of an exotic species
- There should be consultation and cooperation between neighbouring provinces/states
- In the aquatic environment, prevention is better than cure

RECENT INTRODUCTIONS AND TRANSFERS

A synopsis of introductions and transfers that took place in 1990 in Atlantic Canada (Anon 1991) is shown in Appendix I. These included shipment of a range of finfish and shellfish species for aquaculture development and research. To indicate in greater detail how introductions and transfers are administered in Atlantic Canada, two examples are provided below with information on the purpose, procedures, conditions of importation and outcome of the projects:

Example I - Arctic Char Introduced to Prince Edward Island

- Proposal reviewed by a federal-provincial Introductions Committee. Private operator wanted to rear non-indigenous Arctic char, and sell juveniles to aquaculture industry in other provinces
- Established conditions to prevent disease introduction:
  - Allowed importation of disinfected eggs only
  - Required that all broodstock be lethally sampled for disease tests. Shipment would not have been permitted if viruses found
  - Eggs/juveniles held in quarantine for additional disease testing. Fish would have had to be destroyed if any pathogens of concern were detected
- Established conditions to prevent ecological impact:
  - Land-based hatchery required extra precautions to prevent escapement during rearing
  - No char to be released to waters of Prince Edward Island
- No genetic impact expected because Arctic char was not indigenous to the area

The outcome of this project is summarized below
- No diseases introduced
- A few fish escaped, but numbers considered insufficient to establish a natural population
- A business was established to help meet the extreme shortage of seedstock in other provinces
- Good example of identification and management of risk

Example II - European Oyster Introduced to Atlantic Canada

- Introductions Committee reviewed proposal. Governments agreed to import European oyster to help aquaculture industry diversify
- Conditions established to minimize disease introduction:
  - Import adults from stocks considered to be free of diseases of concern
  - Hold adult broodstock in quarantine. Spawn broodstock, then destroy
  - Hold progeny in quarantine for one generation. Test for diseases, and destroy if any disease of concern detected
  - Only progeny from F1 generation released from quarantine
- Established requirements for comparing biology of European oyster with local species under local conditions, and assessing potential ecological impact
  - Required experimental culture in controlled areas before large scale commercial culture permitted
- No genetic impacts expected because species was not indigenous to area

The outcome of this project is summarized below:
- No diseases introduced
- No ecological impact because species does not reproduce naturally in Atlantic waters
- Oyster culture industry diversified, now considered a potential source of disease-free stock for reseeding waters in Europe

OBSERVATIONS ON REGULATIONS AND POLICIES IN ATLANTIC CANADA

In general, the record of enabling introductions and transfers of salmonids in Atlantic Canada has been good, and to the best of our knowledge the impact on local fisheries resources has been minimal. Cooperation between federal and provincial fisheries agencies in matters related to introductions and transfers of aquatic organisms has been good. Strong research programs with salmonids in the fields of health and ecology provide the basis for development of effective regulations and policies, and there are mechanisms to facilitate regular communication both interprovincially and with counterparts in the U.S.A..

A Sub-Committee established under the 9th Working Group for Fish and Fish Product Inspection, Canada-U.S.A. Free Trade Agreement, is providing a valuable forum for discussions on harmonization of regulations related to fish health protection in our respective countries. Canada is also represented on ICES committees dealing with introductions and transfers of marine organisms.

More scientific information is needed on the genetic impacts of transferring strains of salmonids to new areas, in order to improve existing policies.

The regulations and policies related to introductions and transfers of shellfish are not as advanced as for salmonids, although steps are being taken to address this problem. The scientific data base, especially on shellfish diseases, needs to be expanded for use in developing effective policies and regulations.

Canadian and U.S.A. agencies should also consider establishing formal mechanisms for collaborating on harmonization of procedures for controlling introductions and transfers of shellfish, so as to minimize the impacts of introductions and transfers of aquatic organisms in one country on a neighbour's resources.

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Appendix I. Deliberate introductions and transfers to Atlantic Canada 1990.

FINFISH

1. **For Rearing or Release**	**Source of Stock**
Atlantic salmon	Interprovincial
Brook trout	Interprovincial U.S.A.
Arctic char	Interprovincial
Rainbow trout	Interprovincial U.S.A.
2. **For Research (to Quarantine)**	
Atlantic salmon	Interprovincial
Norway	Scotland
Chinook salmon	Interprovincial
Channel catfish	U.S.A.

INVERTEBRATES

1. **For Rearing or Release**	
Sea scallops	Interprovincial
Blue mussels	Interprovincial
2. **For Research**	
Sea scallops	Interprovincial
Bay scallops	Interprovincial
European oysters	Interprovincial

Procedures for Research Involving the Planned Introduction into the Environment of Organisms with Deliberately Modified Hereditary Traits

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INTRODUCTION

To address this conference on Introductions and Transfers of Marine Species is especially gratifying, because the conference theme, "Achieving a Balance Between Economic Development and Resource Protection," is precisely the theme that the Animal and Plant Health Inspection Service (APHIS) has been striving to achieve as it has developed regulations pertaining to the products of biotechnology. The U.S. Department of Agriculture (USDA), like other Federal agencies, regulates biotech products on a case-by-case basis under its existing statutory mandate. USDA's broad historic authority to protect plant and animal health is applicable to the regulation of plants, microorganisms, and veterinary biological products developed through biotech processes. The USDA agency with the major responsibility for regulation of these processes is APHIS.

As a regulatory agency, APHIS faces the challenge of developing regulations that are informative, rational and scientifically based, thus avoiding regulatory uncertainty which can slow down new product development, discourage investment in biotechnology and lead to the complete abandonment of the technology. Regulations must prevent uncertainty and act as a catalyst for safe technology transfer.

On the other hand, to fulfill our mandate of protecting American agriculture, we must ensure that new products do not threaten this industry, public health or the environment. For how can we adequately safeguard American agriculture without protecting the environment in which plants and animals thrive and flourish?

Traditionally, development of regulations that neither over- nor under-regulate has been one of the most formidable tasks for the federal government. However, such a framework is vital to this nation's competitive capabilities which are dependent, in part, upon our abilities to translate new and improved technologies into practice. Biotech is a key technology that can be safely applied to existing and emerging needs.

USDA REGULATORY AUTHORITY

USDA has broad regulatory authority to protect U.S. agriculture against threats to animal health, to protect against adulteration of food products made from livestock and poultry, and to prevent the introduction and dissemination of plant pests. This authority is applicable to genetically engineered animals, plants, and microorganisms.

Plants

The regulatory process for the environmental release of plants with deliberately modified hereditary traits is well-developed and will serve as an example of the procedures followed by APHIS when processing permits for an environmental release. Under the authority granted by the Federal Plant Pest Act (FPPA) of May 23, 1957, as amended, and the Plant Quarantine Act (PQA) of August 20, 1912, as amended, USDA regulates the movement into and through the United States of plants, plant products, plant pests, and any product or article that may contain a plant pest at the time of movement. These articles are regulated to prevent the introduction, spread or establishment of plant pests new to, or not widely prevalent in, the United States. The regulations implementing this statutory authority are found in 7 CFR Parts 300 through 399.

Specifically, under regulations codified at 7 CFR 330.200, APHIS' Plant Protection and Quarantine administers a permit program that prohibits the movement of any plant pest from a foreign country into the United States or interstate unless authorized under a permit issued by USDA. Should a plant pest be introduced, APHIS also exercises remedial measures to prevent the interstate spread of a plant pest that could constitute a threat to agriculture.

USDA published a rule on June 16, 1987, pursuant to the FPPA and PQA, 7 CFR Part 340, which establishes a permit requirement for the introduction of genetically engineered organisms that are plant pests or that USDA has reason to believe are plant pests. Part 340 can be seen as an extension of the existing regulations in 7 CFR 330.200 to the products of genetic engineering technology.

This final rule, which became effective on July 16, 1987, provides that an organism or product altered or produced through genetic engineering would be regulated if the donor organism, recipient organism, or vector or vector-agent: (1) belongs to a group designated in the list in 340.2, or is an unclassified organism; (2) meets the definition of "plant pest;" and (3) is being imported, moved interstate, or released into the environment.

Genetic engineering is defined as the genetic modification of organisms by recombinant DNA techniques.

Plant pest is defined in the FPPA (7 U.S.C. 150aa (c)) as,:

> "*Any living state (including active and dormant forms) of insects, mites, nematodes, slugs, snails, protozoa, or other invertebrate animals, bacteria, fungi, other parasitic plants or reproductive parts thereof; viruses, or any organisms similar to or allied with any of the foregoing; or any infectious agents or substances, which can directly or indirectly injure or cause disease or damage in or to any plants or parts thereof, or any processed, manufactured, or other products of plants.*"

In summary, a permit is required from APHIS for any one of three reasons:

1. If the organism has been genetically engineered by recombinant DNA techniques.
2. If the organism is included in the list of taxa that contain plant pests, and meets the definition of plant pest, or the classification is unknown.
3. If the organism is being imported, moved interstate, or released from containment.

An innovative feature of Part 340 is the provision for a petition to amend the list of organisms in 340.2 by adding or deleting a genus, species, or subspecies. A petition to amend must contain a statement of grounds and supporting literature, data, or unpublished studies, as well as opposing views or contradictory data. A petition that meets these requirements will be published in the Federal Register for comment. If a petition is approved, the list in 340.2 will be amended.

To apply for a permit under the provisions of Part 340, two copies of a written application must be submitted to APHIS. Application form 2000 is used to apply for each of the four kinds of permits:

1. A permit for release into the environment.
2. A permit for interstate movement of regulated articles between contained facilities.
3. A permit for importation of a regulated article into a contained facility.
4. A courtesy permit is issued to expedite movement of organisms not subject to regulation under 7 CFR 340.

A key provision of the rules administered by APHIS is the requirement that notification and a preliminary review of an application be sent to the state in which the release is to occur within 30 days of the receipt of the application. Concurrence from the state is requested before Federal action is taken on the permit, and the state is viewed as a partner in the review and evaluation process for these permits.

In the period from July 1987 to August 31, 1991, APHIS granted 177 permits for field testing of genetically engineered plants and microorganisms, and 1,020 permits for movement (importation and/or interstate) of organisms regulated under 7 CFR 340. In accordance with the requirements of the National Environmental Policy Act (NEPA), an environmental assessment was prepared for each environmental release permit. The public is informed of the receipt of applications for environmental releases, permits for field tests, and the availability of the environmental assessments through notices published in the Federal Register.

Among the first generation of field tests–and I would include the 21 permits issued in 1988 as the first generation–about half the tests were for herbicide tolerance in tomato and tobacco. The remaining half were nearly all for insect and disease resistance, also in tomato and tobacco. The more recent applications show a much greater range of plants used for experimentation (including rice and soybeans), and a more complex range of disease resistance and other characteristics. Three permits were issued for field trials of a microorganism engineered to contain a gene that is toxic to the European corn borer. Based on this limited sample, I think we can say that breakthroughs involving major crop plant diseases and quality characteristics are under way in these field tests.

Animal Health

In the area of animal health, the Virus-Serum-Toxin Act (VSTA) of 1913, as amended, provides APHIS with the authority to regulate all veterinary biologics that are imported into the United States, shipped or delivered for shipment interstate or intrastate, and that are exported. The VSTA is administered by APHIS in the same manner for genetically engineered and naturally occurring organisms and products. Veterinary biological products produced by recombinant methods are evaluated on a case-by-case basis using the same stringent standards for licensing used for conventionally produced products. There are currently eight fish disease products licensed or permitted for importation or exportation into or from the United States. None of those products have been produced by recombinant DNA methods.

The VSTA and general animal quarantine laws also provide APHIS with the authority to regulate transgenic animals that may pose a risk to animal health. This authority is strengthened by Executive Order 11987 of May 24, 1977, which provides executive agencies with authority to restrict the introduction of exotic species into the natural ecosystems of the United States. A more extensive discussion of this order will follow later in this conference.

Fish and Aquatic Organisms

Fish with deliberately modified hereditary traits, as well as other genetically engineered aquatic organism, do not generally fall under the same regulatory authorities used by USDA to regulate plants, plant pests, and animal health. Research to date on gene transfer in aquatic organisms has mostly concentrated on fish, with at least 14 transgenic fish involving 9 different genes developed in the laboratory. However, as of September 1991, there has only been a single request for movement of a genetically engineered fish outside of laboratory conditions.

In 1989 the Alabama Agricultural Experimental Station (AAES) requested USDA funding of a proposal to conduct experiments with genetically modified carp in outdoor research ponds located at Auburn University, in Auburn, Alabama. These carp had been genetically modified using recombinant DNA technology and contained a rainbow trout growth hormone gene. The transgenic carp have been reported to be 22 percent larger, on the average, than their sibling controls at the same age.

AAES scientists believed that an outdoor pond environment would ensure a higher survival rate of transgenic fish, enhance the spawning ability of the fish, and increase the validity of the research findings on the growth rate and behavior in an environment that more closely simulates aquaculture conditions. The outdoor pond environment more closely resembles the environment where many fish are raised commercially than do indoor tanks or raceways.

An issue central to USDA approval of the proposed research was the obligation to comply with the provisions of NEPA. NEPA requires federal agencies to analyze the environmental impacts of major federal actions significantly affecting the quality of the human environment. The Office of Agricultural Biotechnology of the USDA analyzed the environmental impacts of the proposed research, considered various alternatives of the research, and prepared an environmental assessment which was published in the Federal Register on February 16, 1990.

Based on comments received on that environmental assessment, especially concerns that were raised regarding confinement conditions, new alternatives were developed for this research. These alternatives incorporated new research ponds of superior design that substantially reduced the potential for transgenic fish escapement.

As a result, a revised environmental assessment and finding of no significant impact were published on November 21, 1990. Upon completion of the new containment ponds at AAES constructed according to specifications in the environmental assessment, the transgenic fish were placed outdoors in the spring of 1991.

A critical issue that was involved in the preparation of the environmental analysis for the AAES proposal, and that will be especially difficult to resolve for any actions involving transgenic marine organisms, is defining the environment affected by the action. The affected environment in the AAES proposal was considered to be natural bodies of water directly in the AAES drainage basin. These water bodies are a creek and the receiving water body for that creek, which is a reservoir created by both upstream and downstream impoundments of the Tallapoosa River.

Marine systems are generally not as contained as freshwater systems, nor are boundaries readily defined. In marine systems the affected environment could be broadly defined, which would increase substantially the issues and concerns that would need to be addressed in environmental documents such as environmental impact statements. Therefore, outdoor testing of genetically engineered marine organisms, other than in containment ponds, would likely require a complex environmental analysis.

SUMMARY

Several principles form the basis for USDA regulations regarding research involving the planned introduction into the environment of organisms with deliberately modified hereditary traits. One principle is to make "informed decisions" which have analyzed and considered the available alternatives that are necessary for risk identification, management, and evaluation. APHIS is dedicated to reviewing field tests for regulating genetically modified organisms on a case-by-case basis and to providing a thorough analysis of potential effects of these organisms on the environment.

Another principle is to coordinate and work with state and federal government agencies to eliminate duplication, and to facilitate harmony in international regulatory oversight. APHIS regulations have procedures for notification and collaboration with state officials. Additionally, APHIS has entered into mutual notification and collaboration agreements with other federal agencies that regulate products of biotech. The Biotechnology Working Group of the President's Council on Competitiveness, with several representatives from APHIS, is currently assessing the existing regulations regarding issues such as food safety of organisms derived from biotechnology.

Regarding biotech regulation, APHIS is committed to the following goals:

- to develop a balanced regulatory framework;
- to assure that the regulatory structure is scientifically based;
- to maintain a regulatory structure based on risk; not process;
- to have a regulatory structure that protects agriculture and the environment, while facilitating safe technology transfer.

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The views expressed in this article are those of the authors and do not necessarily represent those of the United States Government.

Procedural Requirements for Marine Species Introductions Into and Out of Hawaii

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INTRODUCTION

Live marine plants and animals have been intentionally introduced into the Hawaiian Islands for eighty years or more. Historically and currently the reasons for marine plant and animal importation into Hawaii have been:

1. sale of live shellfish or raw seaweed for human consumption;
2. sale of fish or invertebrates in the aquarium trade;
3. aquaculture propagation of fish, invertebrates, seaweeds or algae; and
4. deliberate stocking of fish and shellfish into marine waters for fisheries development.

Introductions of marine animals into Hawaii for deliberate stocking or those which are recognized to have probably entered the state by unofficial means are the subject of previous reviews (Brock 1960, Kanayama 1967, Randall and Kanayama 1972, Maciolek 1984, Randall 1987). Also, increasingly various marine invertebrates have been recorded from Hawaiian nearshore marine habitats which apparently represent unintentional species introductions by human related activities. These introductions will not be discussed in detail here except in so far as to make the following points. Establishment (species is propagating naturally) of alien marine animal species in Hawaii has occurred apparently by the processes of purposeful translocation (deliberate introductions to enhance opportunities for commercial fisheries), accidental introduction with groups of marine species imported and stocked for the purpose of establishment (Randall 1987) or as an unintended consequence of the national and international shipping trade. As far as is known marine species have not become established in Hawaiian marine waters via importation for the aquarium trade or live seafood products for human consumption.

Today, however, emphasis has shifted away from the practice of introducing new species for fisheries development. Thus, in recent years marine species have not been imported into state waters for stocking by the managers of the state's marine resources and for recreational fisheries. This development is a topic primarily historical interest.

Introductions into Hawaii for aquaculture purposes is the subject of a recent review (Davidson et al. 1992). Twenty-three species of marine plants and animals have been imported into the Hawaiian Islands for aquaculture development (Table 1). None of these species is known to have become established through an aquaculture-related importation. A species of polychaete worm (*Polydora nuchalis*), however, is suggested to have been accidentally introduced and established through an aquaculture importation (Bailey-Brock 1990).

Table 1. Marine Species Introduced Into Hawaii for Aquaculture Development 1978 – 1991

ALGAE	MOLLUSKS
Macrocystis pyrifera	*Haliotis* spp.
Porphyra tenera	*Mercenaria mercenaria*
Spirulina sp.	*Crassostrea virginica*
Dunaliella bardawi	*C. gigas*
Tolypothrix tenius	*Pinctada fucata*
CRUSTACEANS	ECHINODERMS
Penaeus stylirostris	*Strongylocentrotus franciscanus*
P. vannamei	
P. japonicus	
P. monodon	FISH
P. chinesis	*Salmo salar*
P. indicus	*Oncorhychus kisutch*
Homarus americanus	*Coryphaena hippurus*
Artemia salina	*Paralichthys olivaceus*

Also, large quantities of iced or frozen fish and shellfish enter the state daily for sale in retail markets. While the animals in these shipments are killed, and themselves pose no risk as a new species introduction, some of the living microorganisms associated with these fisheries and aquaculture products may be of potential significance as a disease hazard to aquaculture ventures. Moreover, it is well known that raw products such as shrimp and squid often enter surface waters in Hawaii when used as bait in recreational fishing.

Agriculture has contributed substantially to economic development in the State of Hawaii. The major agricultural crops, both plant and animal, are non-native species which were introduced into the Hawaiian Islands for the specific purpose of cultivation. Many years ago, laws were enacted which govern the importation of live plants and animals into the Hawaiian Islands. These regulations were established as a means to protect the agricultural industries and the native Hawaiian ecosystems from degradation by alien species. The regulatory mechanism governing plant and animal importation into Hawaii is currently applied to all introduced species including marine plants and animals. The purpose of this presentation is to briefly outline the organization and function of these procedures.

SPECIES IMPORTATION REGULATORY PROCEDURES

The introduction into Hawaii of all live animal and plant species is under the regulatory jurisdiction of the Department of Agriculture (DOA), State of Hawaii and, for animal and plant entries from foreign countries, agencies of the Federal Government (Brock 1986). Killed or live marine fish and shellfish products imported into the state and marketed directly for human consumption are regulated for public health concerns by the Department of Health, State of Hawaii and the Federal Food and Drug Administration.

State of Hawaii, Department of Agriculture (DOA) regulations concerned with live marine plant and animal introduction into Hawaii are in Chapter 71 of the Hawaii Administrative Rules. These statutes are administered by the Division of Plant Industry, Plant Quarantine Branch (PQB), DOA. The Board of Agriculture (BOA) is the body responsible for policy and decisions regarding these statutes. Plant Quarantine Branch staff administer and carryout the policies therein (ie. issue import permits, inspect imports at the designated ports of entry, enforce regulations, etc.).

When a request to introduce a new marine animal or plant species is made, the importer completes and submits an import permit application form to the PQB, DOA. The application is reviewed by members of two committees (Advisory Subcommittee on Invertebrate and Aquatic Biota and the Advisory Committee on Plants and Animals). The PQB compiles the comments and recommendations of the Advisory Committee and Subcommittee, reviews the application and recommends a course of action to be taken by the BOA. The BOA provides a decision on the application after reviewing the submittal, the input by the two committees and the recommendations of the PQB. This decision is reached during a formal BOA meeting. The average time taken for a new species introduction application to pass through the review and BOA decision process is about 90 days.

When the BOA has reviewed and provided a decision on an import permit application, the species considered then goes onto a species list maintained by the PQB. Species on the list are categorized into one of the following groupings:

1. conditionally approved for resale and the pet trade use under general safeguard conditions;
2. restricted entry level one (R1) [approved for possession by commercial or private parties];
3. restricted entry level 2 (R2) [approved for importation by government agencies or research institutions]; and
4. prohibited entry.

Any modification to the species list is made through the formal BOA decision making process.

If permission for the species introduction is granted by the BOA, the PQB issues the requested import permit. This import permit will have listed on it the conditions by which the introduction will be allowed. It is the responsibility of the importer to abide by the conditions listed on the import permit. Failure to do so will result in regulatory action by the DOA. The introduction into Hawaii of live marine plants, animals or microorganisms without a valid import permit issued by the PQB, DOA, State of Hawaii, is in violation of state law. It is the responsibility of the importer to insure that a proposed introduction of live marine organisms into Hawaii conforms to U.S. Federal regulations.

When a species has been categorized on the PQB species list and is allowed for introduction, import permits for further entry of that organism are issued administratively by the PQB. Applications for permitted species introductions are made in writing to the PQB. Typically, the requested import permit is issued by PQB within two weeks of receipt of the permit application.

Requests for the transfer of introduced marine plants or animals (R1 or R2 categories) between islands in the Hawaiian chain are made in writing to the PQB. Permission for such transfers are provided administratively.

Unless permission which allows for release has been specifically given by the BOA for a particular species, introduced groups of marine organisms must be maintained in captivity. Furthermore, under current policy in Hawaii, imported marine animals for aquaculture development are usually isolated upon entry on the premises of the importer. An isolation system is one where the aquatic animals are held in tanks or other non-dirt bottom enclosure and the effluent water is either discharged into a dispersion well or disinfected prior to release (Brock 1986). Import isolation areas and water disposal systems are evaluated and approved by the staff of the PQB.

The duration of the isolation or quarantine rearing period and pest, predator and pathogen inspection methods used for imported marine organisms for aquaculture development will vary depending on the species and life stage, the current knowledge of pests, predators and pathogens of the introduced species, the disease history for the species at the point of origin and the type and results of the pest, predator and pathogen inspection carried out for the imported group prior to arrival in Hawaii.

INSPECTION FOR PESTS, PREDATORS AND PATHOGENS OF MARINE ANIMALS IMPORTED INTO HAWAII

Upon entry into Hawaii, groups of marine species are visually inspected by PQB personnel at the port-of-entry. Post-entry examination for pests, predators and pathogens using laboratory methods are carried out for selected species of marine aquatic animals where such examinations are indicated in the conditions on the import permit issued for the species. Post entry inspection has been routine for groups of marine animals introduced for the purpose of aquaculture development. These examinations are conducted by the Aquaculture Disease Specialist, Aquaculture Development Program, Department of Land and Natural Resources, State of Hawaii or, in some cases, by an agent of the importer. Typically, diagnostic evaluation includes several procedures with histopathology examination being a routinely applied monitoring protocol. Except under exceptional circumstances, inspection for pests, predators or pathogens are not carried out using laboratory methods for introduced lots of live shellfish for human consumption or fish and invertebrates imported in the aquarium trade.

PROCEDURAL REQUIREMENTS FOR MARINE SPECIES TRANSFERS OUTSIDE OF HAWAII

Currently, there are no State of Hawaii statutes which regulate the out-of-state movement of live marine species which originate in the Hawaiian Islands. When requested by the exporter, health inspection reports are provided by the State's Aquaculture Development Program for cultured marine animals that originate from populations on aquaculture farms or facilities in Hawaii. Export inspections have been carried-out for the following marine species: *P. stylirostris*, *P. vannamei*, *P. monodon*, *Mugil cephalus* and *Coryphaena hippurus*.

The purpose of the export health inspection report is to summarize the disease history and laboratory examination results for the population from which the exported group of animals is derived. The information is intended as an aid to the responsible authorities receiving the shipment, to assist these officials make informed decisions regarding the potential risk of pathogen translocation, the need for post entry quarantine of the imported group and the need for additional pathogen/disease testing.

SUMMARY

Live marine plants and animals are currently permitted entry into the Hawaiian Islands for sale in markets and restaurants, for the aquarium trade, and, much less frequently, for aquaculture development. The introduction and movement of imported groups of marine plants and animals is regulated by the Department of Agriculture, State of Hawaii. The organization and procedures governing species introduction have been in operation for many years.

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Optimizing Resource Conservation and Sustained Utilization Objectives in the Development of West Coast Shellfish Transport Regulations

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Managing shellfish transports often brings the two objectives of resource management and aquaculture commerce into real or seeming conflict. Both of these objectives have positive benefits. Aquaculture development is clearly dependent on the preservation of natural resources and environmental quality for its existence. Nonetheless, plans to introduce farmed or potentially farmable species to new areas or to establish routine transfers of established species require consideration of the potential risk to the natural resource (due to ecological and disease transfer risks) against consideration of the benefits to aquaculture and resource management.

We describe here an ongoing interactive process now taking place in Washington state to develop workable regulations to resolve shellfish transport issues. This first phase of this process, involving only Washington state directly, is a joint government-tribal-private industry cooperative effort. Subsequently, through the Shellfish Transport Subcommittee of the Pacific Marine Fisheries Commission, this process will attempt to harmonize shellfish transport regulations between Alaska, British Columbia, Canada, California, Hawaii, Oregon and Washington.

ANIMAL TRANSPORTS ARE INEVITABLE

The need for such a process is necessitated by the fact that the transportation of aquatic animals throughout the continent of North America and between North America and other continents is inevitable. The aquaculture industry is often regarded as the primary practitioner of this activity. If this were so, the regulation of shellfish transports would be relatively easy. In fact, the transport of aquatic animals or their fresh tissues, which may contain viable infectious agents, is practiced by several other user groups. These include commodity distribution of harvested or husbanded fishery products, movement of aquatic animals for research purposes, movement of fish and shellfish by the general public and transfer of aquatic organisms in ship ballast water.

We recognized that it was not possible to devise a perfect process in a single regulatory document. In particular, the regulation of shipping ballast water is outside the authority of Washington state government. The regulation of fishery commodities intended for human consumption is not within the jurisdiction of resource management agencies in Washington and the movement of shellfish by an individual or the general public cannot be effectively controlled by law. Nonetheless, we set out to construct a regulatory framework which would manage the tangible aspects of this issue as fairly and uniformly as possible and would address the less accessible aspects of this problem through recommendations for additional legislation to appropriate agencies or through recommendations for educational programs.

POLICY PROCESS IN WASHINGTON STATE

In January 1990, the Assistant Director for Shellfisheries of the Washington Department of Fisheries appointed a committee to make detailed recommendations on the regulation of shellfish transport. The formation of this committee was the result of concern from members of the aquaculture industry that existing regulations did not clearly and fairly address problems of the risk of shellfish introductions and that the existing regulations were not uniformly applied. The seven-member committee consisted of two members appointed by a shellfish industry group, the Pacific Coast Oyster Growers Association, two members from the Washington Department of Fisheries, one member from the Washington Department of Agriculture, one member representing tribal shellfishery interests and one individual with expertise in shellfish disease. These individuals were responsible for the specific regulatory concepts we present in this paper[1].

The committee decided early in the process that the portion of the Washington Administrative Code dealing with shellfish transports required a substantive overhaul which would necessitate a public review process. At the time of this writing the committee had finished the draft regulation, but the state government and public review process had not been completed. In this report, we will abstract the basic concepts of the proposed regulation.

This process represents what we believe is an all too rare effort in which the major interest groups concerned with marine resource utilization and management have achieved a consensus on how to implement that management. Regardless of the final details of the regulation adopted in Washington state, we believe the following approach will essentially be adopted into state regulation.

ESSENTIAL ELEMENTS OF WASHINGTON DRAFT REGULATIONS

The regulations establish that it is unlawful for any person to import or transfer shellfish into or within the state for any public or private purpose without first obtaining a state permit. This includes the import of any marine invertebrates into the state for aquacultural, research or public display purposes but excludes shellfish which are market-ready and intended for consumption as a food product and which are not placed in contact with state waters. The regulations encourage policies on the specific requirements of shellfish health management that harmonize, to the maximum extent possible, with the requirements of the member states and province of the Pacific Marine Fisheries Commission (namely California, Oregon, British Columbia (Canada), Alaska, Washington, Hawaii – referred to as the west coast commerce region).

The regulations establish an advisory committee to make recommendations on the import and intrastate transfer of shellfish products.

For purposes of disease control, the regulations require definition of the frequency, duration and procedures for disease certification of shellfish species imported into Washington from the west coast commerce region. This certification would be implemented by maintaining three lists of established species (and their defined geographic areas of origin) that may be transferred within or imported into Washington from the west coast commerce region. The first list includes those native or introduced shellfish species that are established in Washington state. Intrastate transfer of species on this list is accomplished with a minimal permit. The second list includes only List 1 species imported into Washington from the west coast commerce region. List 2 is limited to those species and specific areas of origin (coastal zone, bay, estuary, river) from the west coast commerce region that have an acceptable health history documentation and disease-free tissue certification. These species will require disease-free tissue certification every three years, but this requirement is subject to waiver if it is judged that sufficient information is otherwise available to indicate that the species and geographic source remain free of Class A (representing the highest risk) shellfish diseases. List 3 will include only established species from the west coast commerce region for which a health history documentation and disease-free tissue certification have been initiated but not completed by permit application for the specific area of origin. Importation will be permitted for applications on List 3 contingent upon the absence of any Class A shellfish disease determined by the initial health history documentation and disease-free tissue certification conducted prior to any import of shellfish. During the initial importation period of 12 months, one additional disease-free tissue certification will be required. Pending the determination of the absence of Class A shellfish diseases as determined in the tissue examinations, the shellfish species and source may be placed on List 2, 12 months following its placement on List 3.

The regulations require the implementation of detailed procedures for health history documentation, disease-free tissue certification and revocation of import permits.

The regulations also provide definition of detailed requirements for health history documentation and disease free tissue certification, development and maintenance of state staff expertise in shellfish health, maintenance of a list of approved shellfish health professionals, determination of uniform operational and reporting requirements for private and governmental shellfish sources, and establishment of two lists of infectious shellfish diseases. Discovery of Class A shellfish diseases will preclude the importation of shellfish from the geographic source from which the discovery was made. Discovery of Class B shellfish diseases (enzootic or low risk diseases) will not preclude importation but Class B diseases must be reported upon discovery by permit applicants or holders. Finally, the regulations define the detailed requirements for construction, maintenance and operation of shellfish quarantine systems for use in the state of Washington.

The regulations contain procedures for importation of shellfish species which are not established in Washington, or for stocks of established species located outside of the west coast commerce region. All applications for importation of non-established species will be referred to the advisory committee. A Washington state process (State Environmental Policy Act) is triggered to review the ecological effects of the proposed introduction. If the application is provisionally approved, the following requirements must be met:

1. A health history documentation covering a minimum of five years for the proposed species and

area of origin must indicate the absence of Class A shellfish diseases.
2. A disease-free tissue certification of the proposed species collected from the site of origin must indicate a similar lack of Class A shellfish diseases before shellfish may be imported into an approved quarantine facility.
3. Imported parent stock shellfish may never be released into state waters. Only the succeeding generation of shellfish offspring, produced within the quarantine facility, may be released, subject to the specific requirements.
4. The WDF may require the co-cultivation of established shellfish species in the quarantine facility and a disease-free tissue certification of these species.
5. The offspring of the imported stock cannot be released from quarantine less than one year from the date the parent stock were imported into the quarantine facility. The offspring will be eligible for release after one year in quarantine, contingent upon the lack of discovery of Class A shellfish diseases.

Finally, the regulations provide for the holding or production, in quarantine, of established or non-established shellfish species which are not intended for release into state waters. Shellfish may be maintained, cultured or propagated in an approved quarantine facility provided they are determined free of Class A shellfish diseases. An exemption to this may be granted to institutions having an approved quarantine facility whose primary activity is research and who are specifically engaged in research on the infectious shellfish diseases.

FURTHER REVIEW OF DRAFT REGULATIONS

The draft regulations will be subject to further governmental, committee and public review. In addition, the regulations have been reviewed by representatives of a public aquarium and a marine research facility operated by a public university. Representations of the marine facility were concerned that the regulations would entail increased costs and hinder basic research. University laboratories have always posed problems with respect to marine animal transport. On the one hand, they clearly contribute important basic knowledge and discovery through their research activities. Historically, there has been little regulation of animal transports by such facilities. These facilities should be regulated in a uniform manner with all other research groups. Often, however, researchers regard their activities as being somehow outside of the regulatory process and many exotic animal introductions have occurred from such facilities. In this and other components of implementing the draft regulations, complete uniformity must be the objective to be achieved by a defined date, but some transitional implementation of regulations in the intervening period will be necessary to maximize the beneifts of the regulation and minimize the impact on various activities.

WEST COAST REGIONAL PROCESS

Under an existent memorandum of understanding, marine resource management agencies from Alaska, British Columbia, Canada, California, Hawaii, Oregon, and Washington ahve agreed to cooperate on shellfish transport issues under the auspices of the Pacific Marine Fisheries Commission. Representatives of the appropriate agenicies of these governments have been notified of the process underway in Washington state and have been consulted for advice on speicific details. The representatives will review and comment on the Washington draft regulations. The objective is to harmonize the Washington draft regulations, as early in the process as possible, with the requirements of the other regional governments. We anticipate taking up the matter of regional cooperation on shellfish transport regulations in 1993.

PHILOSOPHY OF SHELLFISH TRANSPORTS

Specific regulatory decisions regarding shellfish transports must often be made in the face of insufficient technical information. Thus it is of utmost importance to recognize that the philosophy toward animal transports will often determine the character of regulations and their implementation as much or more so than supporting technical information. Therefore, it is incumbent on resource managers to adopt a reasonable ansd workable philosophy on aquatic animal transports, recognizing the need for a stronger technical information base and for the education for all user groups.

Committee members: Mr. Richard Burge and Ms. Lynn Palensky, Washington Department of Fisheries, Mr. Ken Cooper and Mr. Richard Wilson representing Pacific Oyster Growers Association, Mr. David Fife representing Northwest Indian Fisheries Commision, Dr. John Pitts representing Washington Department of Agriculture and Dr. Ralph Elston from Battelle Marine Sciences Laboratory, Sequim, Washington. Committee established by Dr. Judith Freeman, Assistant Director, Washington Department of Fisheries.

Battelle, Pacific Northwest Laboratories supported the time of R. Elston on the development of these regulations.

Characteristics of the Procedures for Marine Species Introductions in Florida

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The Florida Department of Natural Resources manages, protects and regulates Florida's marine resources. Therefore, introduction of any organism into marine waters of the State of Florida falls under the purview of the Department. Introduced organisms can be defined as species not native to an ecosystem. Marine introductions in Florida can fall into several categories, including introduction of non-indigenous species, introductions for stock enhancement purposes, and introduction of species for aquacultural production.

Introduction of non-indigenous species into Florida's waters has had a history of negative impacts and has resulted in losses of native natural resources and increased costs to society through required control and eradication procedures. Introductions of non-indigenous species into marine waters is addressed directly by Chapter 370.081 of the Florida Statutes. The statute states that "it is illegal to import or possess any marine animal, not indigenous to the state, which, due to the stimulating effect of the waters of the state on procreation, may endanger or infect the marine resources of the state or pose a human health hazard." The statute lists specific animals not to be imported and authorizes additions to the list. It also states that "it is unlawful to release into the waters of the state any non-indigenous marine plant or marine animal not included in [the list of prohibited species] or prohibited by rules and regulations adopted pursuant to [procedures that allow additional prohibited species to be added]."

The Florida Department of Natural Resources has a research program designed to assess marine fisheries stock enhancement. Stock enhancement is an attempt to increase the numbers of a severely depleted or extirpated stock by purposeful culture and release of organisms. The Department has formulated a draft marine stocking rule to ensure that enhancement programs are conducted so that natural stocks will not be adversely affected by releases of cultured animals. The draft rule addresses husbandry, health, genetics and mark/recapture of the released stock. The draft rule requires that prior to release of any stock, the licensee must provide documentation that animals to be released have undergone a disease screening program by a licensed veterinarian, pathologist or certified fish health specialist. To protect the genetic integrity of natural stocks, the draft rule requires the licensee to provide a summary of the husbandry practices employed at the hatchery that have been used to minimize inbreeding and loss of genetic diversity. The rule also requires that the stock to be enhanced or supplemented be genetically identified or if the two stocks are genetically distinct, then release of animals must be in the same area from which the broodstock were captured. With regard to molluscan shellfish (oysters, clams and mussels), the draft rule includes a "reduced risk" policy which is designed to encourage the development of shellfish aquaculture. The draft rule requires seed stock to be produced from broodstock which has been collected from the intended release site. The licensee shall certify via a recognized shellfish pathologist that the seed stock are free of diseases that may threaten endemic populations. Seed stock produced from local broodstock and cultured in local waters are exempt from disease certification requirements.

Aquaculture of indigenous marine species has been conducted in Florida for many years. Aquaculture of non-indigenous marine species may be allowed by issuance of appropriate permits, with permits considered on a case-by-case basis. Release of non-indigenous species produced by aquaculture is prohibited. Rules for the capture of indigenous broodstock for aquaculture that are otherwise protected from capture are allowed by permit procedures. The Florida Aquaculture Policy Act, Chapter 597, took effect October, 1988. This act set public policy concerning aquaculture and designated the Florida Department of Agriculture and Consumer Services as the lead agency. The Act established an Aquaculture Interagency Coordinating Council to "establish positive interagency cooperation to foster the development of the state's aquaculture industry." The Act also established the Aquaculture Review Council, composed of industry representatives, with specific responsibilities:

a. to formulate and recommend to the Commissioner of Agriculture rules and policies governing the business of aquaculture by studying and evaluating aquaculture issues.

b. to develop, on a quarterly basis, a list of issues of concern to the aquaculture industry to be forwarded immediately to the Aquaculture Interagency Coordinating Council and to the chairmen of the House and Senate committees on aquaculture.

c. to provide an analysis of the issues described in paragraph (b) to the Aquaculture Interagency Coordinating Council at its next meeting. The analysis shall include, but is not be limited to, specific facts, regulatory provisions, and explanations of the specific hardships identified by industry.

Georgia's Strategy for Controlling the Introduction of Marine Species

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Georgia apparently shares an attitude of caution respecting importation of shellfish with many other states. Officials in Georgia's Department of Natural Resources (DNR) acknowledge the existence of a specific, unofficial policy of exclusion of shellfish importations based on authority identified in O.C.G.A. Sec. 27-2-19, included verbatim below. The term "unofficial" is used because the policy is not formalized in a regulation at this date.

> **27-2-19. *Wildlife importation permits.*** *It shall be unlawful to import any wildlife other than fish, pen raised ducks, pen raised turkey, and pen raised quail without obtaining, at no cost, a wildlife importation permit from the department. The department shall only issue such a permit when it has determined that the issuance of the permit is in the best interest of the wildlife of this state. If such a permit is issued, the department shall prescribe the term for each such permit and may impose any conditions it determines necessary to ensure adequate public safety and the best interests of the wildlife of this state.*

While no express definition of the terms "wildlife" or "fish" have been found, it is almost certain that the provision differentiates between "fish" and "shellfish" because other statutory enactments and several regulations clearly refer to and treat "fish" and "shellfish" distinctly. Thus, to import "shellfish" one would need a permit.

A superficial, subjective conclusion as to why State officials seem opposed to importation is that they attribute the recent decline in oyster resources to epidemics of MSX and Perkinsus disease – which apparently is equated with interstate shellfish movement. Their concerns probably include many other species of parasites, diseases, predators, etc.

While accepting the presumption against importation, the statute quoted above obviously does not absolutely prohibit introduction of shellfish from other jurisdictions. Even so, the criteria considered relevant to an application to import nor the standards by which the criteria are brought to bear are available. Classically, the function of properly promulgated regulations are nonexistent regarding importation techniques and safeguards. In light of the practical seriousness of bureaucratic inertia, the most efficient approach to resolution of this matter may be political. A political process has already begun. A 1989 state statute established an aquaculture study commission to perform a general exploration of the aquaculture industry in Georgia. Their report is discussed in more detail below. (Georgia Law 1989, page 284).

Several other statutes and regulations govern various aspects of shellfish culture, harvest and marketing. The DNR has published a regulations brochure that addresses other coastal animal resources in addition to oysters and clams. This informal publication does not consistently identify whether the sources included are statutory or regulatory, but one can gain an overview of the scope of the DNR's concerns from this document.

The most comprehensive statutory provisions that regulate oysters and clams are found in the Code at Title 27, Chapter 4, sections 190 through 199. Subjects include permits, times, methods and limits of shellfish harvest, culture, transport, sanitation and bed leasing. While a logical argument could be made that the relevant State official has authority to regulate shellfish importation pursuant to discretion granted in these sections, such is not the focus or primary intention of this portion of the law.

Another statute deals explicitly with controlling importation, transportation, sale and possession of "wild animals" (Title 27, Chapter 5, Sections 1 through 3). While this statute is not explicitly focused on shellfish, it grants sweeping discretionary authority to the Board of Natural Resources to supplement the list of wild animals that shall be subject to its importation prohibitions. It is included here for its potential rather than for its present applicability. The statute currently encompasses various species in the Classes: Mammalia, Reptilia, Osteichthyes and Chondrichthyes. While the Class including clams is not expressly included, these animals could be added to the prohibited list by merely promulgating a regulation.

Yet another source of authority for an agency of State government to influence shellfish importation is found in a regulation empowering the DNR to require importers to secure permits for "wild animals under domestication or in custody" (Georgia Rules, Chapter 40-13-8-.04).

The Georgia Department of Agriculture administers the regulatory program concerned with the handling, storage, shucking, packing, shipping and sale of shellfish (Georgia Rules, Chapter 40-7-12-.01 through .10). Even though this regulation is not focused on inter-jurisdictional transportation of shellfish, the mandate to protect public health and welfare carries with it sufficient authority to make relevant an official concern with potential diseases and harmful organisms from other states and localities. In the usual course of agency action, one would not expect the Department of Agriculture to involve itself in this specific area. However, the broad terms of the legal authority pursuant to which the Department promulgated these rules is a further indication of comprehensive legislative intention. Related authority of the Department of Agriculture respecting sanitation, distribution and commercial transportation of fish and seafood is found at Title 26, Chapter 2, section 315.

The authority of the DNR to regulate the taking of oysters and clams was changed in a 1988 amendment by removing an exception to "taking" provisions whereby out-of-season "taking" for "transplanting" purposes was removed from the law. The effect of the amendment was to give the DNR greater subjective discretionary authority over the relevant activities. Thus, while Georgia does not have an explicit, formal policy respecting interjurisdictional movements of shellfish, there is ample evidence of the state's developing position in this matter. These conclusions have been pieced together by the author from indirectly related documents, personal communications and subjective evaluations of the operational style of the DNR.

At this stage of development of a policy on interjurisdictional transfers into Georgia, the author prefers to adopt an ambivalent position. Having counseled aquaculture clients in the past who claim persecution by law enforcement personnel, the author is sensitive to their point of view. At the same time, there is justification for a sympathetic attitude toward the cautious, conservative stance the Georgia DNR has taken in this matter – especially regarding the introduction of true "exotic" species. There seems to be a consensus among fisheries biologists that there is less compelling logic behind the DNR's ban of such movement of out-of-state individuals of an indigenous species–such as hard clams. While the descriptive literature of this conference alludes to successful introduction in the past, there probably are many more disasters – whether accidental or intentional.

It appears that Georgia's present strategy for controlling introduction of out-of-state species – whether indigenous, non-indigenous or exotic – is simply to prohibit them. There are some narrow exceptions that will have to suffice for pioneering aquaculturists until cooperative agreements can be formalized with exporting jurisdictions. The framework for such agreements has already been developed.

I am certain that most of you are familiar with the Atlantic States Marine Fisheries Commission's Procedural Plan to Control Interjurisdictional Transfer and Introductions of Shellfish. It is a detailed effort to establish reciprocal policies and practices to facilitate interstate movement of shellfish, while retaining absolute authority to prohibit such transfers on a case-by-case basis. The plan seems comprehensive, and it contains many or most of the features described at this conference by representatives of other states who have already developed mechanisms to control their interstate movements. It includes the following elements, among others, some of which are evident in the only existing contract between the state and an aquaculturist in Georgia. Some of those elements include:

1. retention of ultimate control in the State;
2. requirements of timely notice of all proposed movements of the permitted species;
3. uniform certification procedures and submissions;
4. imposition of primary costs upon an applicant;
5. recognition that some decisions will have to be made without complete information; and,
6. substantive openness of all data and information.

The Procedural Plan is a 50 to 60 page document that the DNR says contains the conditions and procedures that it accepts as the basic guiding principles for its future importation activities.

In what may be called a very tentative, experimental step into these troubled waters, the DNR has expressed its interest in the fledgling industry in Georgia by drafting a standard "Experimental Fisheries Contract." The contract outlines conditions to implement the department's concern for introduction of diseases that might threaten endemic shellfish populations. Thus, in the highlights of that contract, one can discern at least a part of what will be Georgia's "strategy" in this matter. A few of the elements of that contract include:

1. Applies to *Mercenaria mercenaria*;
2. Parties are the State and a private entrepreneur;
3. Requires certification of seed source and planting site;

4. Indemnifies the State for costs and liabilities;
5. Retains minute, absolute control by State;
6. Requires comprehensive transport documents;
7. Requires hands-on supervision and inspection by state personnel;
8. Ensures absolute access by State to aquaculturist's premises and facilities;
9. Includes waiver by aquaculturist of damage claims against federal and state governments for injuries to the enterprize arising from maintenance and improvement of navigable waters;
10. Provides instantaneous termination rights in the state; and,
11. Includes various conventional contract terms.

To the best of my knowledge, this is the only such contract of its kind presently in force in Georgia (although there was an earlier, similar experimental contract with another arm of the State). While this experimental contract is far less stringent than the cooperative proposal among states mentioned above, it does shed some light on Georgia's policies. There is another study document in draft stage at this time that reveals further aspects of the evolutionary development of Georgia's strategies and procedures concerning aquaculture.

After several applicants in Georgia were denied permits to construct aquaculture intertidal impoundments in the early 1980s, there was an effort to amend our Marshland Protection Act to facilitate these activities. The conservation community expressed serious reservations about the bill, so a compromise study committee bill was enacted to empanel a citizen's group to assess the opportunities and problems of the industry in Georgia. Its first, limited release draft report was dated September 4, 1991, entitled the "Georgia Aquaculture Development Commission's Aquaculture Development Plan. Although the Regulatory section has not been approved by the Commission, or by the DNR, it specifically incorporates the "procedural plan" mentioned earlier.

Finally, the introduction to the Regulatory Issues Section of the Commission's report alludes to unfortunate tensions between aquaculturist interests and the DNR in Georgia. In one case, according to documents in the public record, a fish farmer accused the state DNR and many of its personnel of an unauthorized seizure of his 1223 white sturgeon. He claimed actual damages of $38,109,492.00. The complaint is a 106-count historical road map of citizen frustration with what is perceived to be state inequity and unconcern about the aquaculture industry in general and its alleged mishandling of one struggling entrepreneur.

Many lessons can be learned from this proceeding without having to declare allegiance to either side of the contest. In addition to the perspectives of this entrepreneur aquaculturist, one can discern the seriousness with which the State approaches its duty to protect against what it perceives to be threats from imported pests, diseases, predators, parasites and unwanted species. While the author wishes to remain committed to assisting with the development of an aquaculture industry in Georgia, that mission is not inconsistent with an appreciation of the cautious approach of the State in this evolving natural resources policy.

It is obvious that Georgia lags far behind states such as Washington, Hawaii and Florida in initiating and facilitating the interjurisdictional transfers of fish upon which a viable aquaculture industry depends. Some citizens have experienced great losses and limitations as a result of that cautious policy. However, in embracing the Procedural Plan components of the Atlantic States Marine Fisheries Commission Draft Report, the State has indicated, at least preliminarily, its preferred approach to the many problems that will arise from aquaculture-related activities. Much work, both political and scientific, remains to be done before Georgia develops an aquaculture industry that requires or depends upon interstate transfers.