AQUATIC NUISANCE SPECIES PROGRAM

Aquatic Nuisance Species Task Force
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EXECUTIVE SUMMARY

Since the European colonization of North America, a large number of nonindigenous species have been introduced into the United States as a result of human activities. In the past decade, several nonindigenous aquatic species, including the zebra mussel, ruffe and Asian clam, have been unintentionally introduced into the United States with substantial, immediate effects on human activities and the receiving ecosystems. The rate of introductions into the Great Lakes has increased with the expansion of human population and development in the Basin.

In response to the zebra mussel infestation and other concerns about nonindigenous aquatic species introductions, the Nonindigenous Aquatic Nuisance Prevention and Control Act (Act, 16 U.S.C. 4701-4741) was enacted in 1990. It provides an intergovernmental mechanism for the development of a cooperative national program to:

- reduce the risk of or prevent the unintentional introduction and dispersal of nonindigenous aquatic species that may be nuisances;
- ensure prompt detection of the presence of and monitor changes in the distribution of nonindigenous aquatic species; and
- control established aquatic nuisance species in a cost-effective, environmentally-sound manner.

An Aquatic Nuisance Species Task Force (Task Force) co-chaired by the U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration was established to coordinate governmental efforts related to nonindigenous aquatic species in the United States with those of the private sector and other North American interests. The Task Force consists of seven Federal agency representatives and eight ex officio members appointed by the Co-chairs to represent non-Federal governmental entities.

This report presents the cooperative Aquatic Nuisance Species Program (Program) adopted by the Task Force. The Program addresses all new nonindigenous aquatic species activities that are conducted, funded, or authorized by the Federal Government, except those involving intentional introductions. It seeks to complement effective existing nonindigenous species activities rather than supplant them. To achieve its three goals, the Program consists of three essential elements as well as several supporting elements and related activities:

CORE ELEMENTS

Prevention: Establish a systematic risk identification, assessment and management process to identify and modify pathways by which nonindigenous aquatic species can be introduced and spread.

Detection and Monitoring: Create a National Nonindigenous Aquatic Nuisance Species Information Center to coordinate efforts to detect the presence and monitor distributional

changes of all nonindigenous aquatic species, identify and monitor native species and other effects, and serve as a repository for that information.

Control: The Task Force or any other potentially affected entity may recommend initiation of a nonindigenous aquatic species control program. If the Task Force determines, using a decision process outlined in the Program, that the species is a nuisance and control is feasible, cost-effective and environmentally-sound, a control program may be approved.

SUPPORT ELEMENTS

Research

a. Research Coordination: Coordinate nonindigenous species research to ensure identification of comprehensive, high priority research needs that support the central elements of the Program and other regional and national concerns.
b. Research Protocol: Established and being implemented to prevent the introduction or spread of nonindigenous aquatic species as a result of research authorized under Subtitle C of the Act.
c. Research Grants: Allocate funding for competitive university research grants consistent with national needs and priorities.

Education: Encourage and facilitate efforts to inform and educate a wide range of audiences about potential problems associated with the unplanned introduction and spread of nonindigenous species and ways to prevent introductions and dispersal of and to control aquatic nuisance species.

Technical Assistance: Ensure coordinated application of existing capabilities.

ZEBRA MUSSEL PROGRAM

National Program: Ensure coordination among the wide range of governments and other entities and interests addressing this infestation and timely synthesis and dissemination of information about zebra mussel control, including protection of native species and ecosystems likely to be adversely effected.

Public Facility Research and Development Program: U.S. Army Corps of Engineers for the Assistant Secretary of the Army for Civil Works is developing methods to prevent and control infestations associated with public facilities.

RELATED ACTIVITIES

State Aquatic Nuisance Species Management Plans and Grants: Plans submitted by States are reviewed using guidelines to be developed. Funding for matching grants for the States to implement approved management plans has not yet been requested or appropriated.

Ballast Water and Shipping Initiatives: Voluntary ballast exchange or treatment guidelines for ships entering the St. Lawrence River from the high seas were jointly issued by the U.S. and Canadian Coast Guards in March 1991. Mandatory ballast water management regulations for vessels entering U.S. ports in the Great Lakes after operating on the high seas took effect on May 10, 1993, at the beginning of the Great Lakes shipping season. To minimize the risk that ruffe will spread from western Lake Superior, the Great Lakes shipping industry adpopted a voluntary ballast water management plan in 1993. Regulations to prevent the introduction of aquatic nonindigenous species into the freshwatwer portion of the Hudson River which is connected to the Great Lakes through the Erie Canal were proposed, in response to 1992 amendments to the Act, in June 1994.

A study to evaluate introduction of nonindigenous species by shipping into U.S. waters other than the Great Lakes has been completed and is undergoing Administration review before being submitted to the Congress in early 1994. A companion study of the environmental effects of ballast water discharges on U.S. waters and areas in U.S. waters where ships can safely exchange ballast water will be initiated in the Spring of 1994 and completed by mid-1995. After human cholera was detected in the ballast water of several vessels entering ports on the Gulf of Mexico in the Fall of 1991, the U.S. Coast Guard published International Maritime Organization ballast water guidelines and requested voluntary compliance by mariners who enter U.S. waters. A study of options for controlling the introduction of nonindigenous species through ballast water is expected to be completed in 1994.

Biological Study: A comprehensive effort to document and compare the ecological, economic, and other relevant effects--both positive and negative--of a substantial sample of nonindigenous aquatic organisms in selected geographic areas was initiated in 1993.

Management of responsibilities mandated to the Task Force is an important consideration in light of its interagency nature and the traditional roles of the Federal agencies involved. Implementation of the Program will be a cooperative effort with States, Tribes, local governments, non-governmental entities, and other countries. To the greatest extent possible, implementation will build on and fill gaps in effective existing activities and programs rather than supplanting them. Although responsibilities are assigned to the Task Force that are agency specific, implementation will be assumed by individual agencies in line with their specific mandates, priorities, expertise and funding. Potential participation by a variety of Federal agencies and other entities is suggested. The need for comprehensive, continuing evaluation of the effectiveness of the Program is highlighted.

Other requirements of the Act, including the Intentional Introductions Policy Review, listing of the zebra mussel as injurious wildlife, and development of a Brown Tree Snake Control Program do not relate to the Program and are addressed independently. However, the research protocol requirements apply to the Brown Tree Snake Control Program.

INTRODUCTION

Since the European colonization of North America, a large number of nonindigenous aquatic species have been introduced into the United States and adjacent waters (Carlton 1990). For example:

- at least 4,500 species of foreign origin have established free-living populations in this country (Office of Technology Assessment 1993);
- thirty-two species of nonindigenous marine organisms were identified in one small estuary, the South Slough National Estuarine Reserve, in Coos Bay, Oregon (Carlton 1991);
- at least 136 nonindigenous aquatic species are present in the Great Lakes (Mills et al. 1991); and
- more than 172 exotic vertebrate species, including at least 50 aquatic species, have become established in the United States (Williams 1987).

The rate of nonindigenous species introductions into the Great Lakes has increased in several stages since 1810 in response to expansion of human population and development in the Basin (Mills et al. 1991, Figure 1). Construction of the St. Lawrence Seaway to provide ocean-going vessels access to the Lakes is a principal reason for the abrupt jump in the rate of introductions since 1960. Additional introductions into the Great Lakes, including the antipodes snail and an amphipod, are expected (Mills et al. 1993).

In the 1980s, several nonindigenous aquatic nuisance species (ANS), including the zebra mussel and ruffe, were introduced into the United States as an unintentional consequence of human activities. Ruffe have begun to spread into western Lake Superior (Figure 2) while zebra mussels are now found throughout much of eastern North America (Figure 4, page 37). Effects of these two species on human activities and the receiving ecosystems have been immediate and substantial.

A brief summary of typical effects on human activities and ecosystems of nonindigenous species, their benefits and costs to society, and hazards associated with the control of ANS is presented in Appendix A. To provide an overview of the full range of situations and consequences, the effects of intentional and unintentional introductions using examples from United States as well as foreign waters are discussed. In addition, some of the literature on nonindigenous aquatic species and their effects is summarized.

The harm caused by recent introductions, particularly the zebra mussel, and concern about a possible increase in the number of unintentional introductions resulted in passage of the Nonindigenous Aquatic Nuisance

Prevention and Control Act of 1990 (Act, Appendix B). This statute, including minor amendments in 1992, mandates development and implementation of a comprehensive national program to prevent and respond to problems caused by the unintentional introduction of nonindigenous aquatic species into waters of the United States. Although

beneficial consequences are acknowledged,the national program must focus on how to avoid, minimize and ameliorate future adverse impacts of nonindigenous aquatic species.

This document describes the ANS Program (Program) adopted by the ANS Task Force (Task Force) established by the Act. Members of the Task Force and its ANS Work Group involved in developing this document are identified in Appendix C.

The Program helps fulfill the intent of the Act by:

- reducing the risk of unintentional introductions of nonindigenous species in waters of the United States;
- controlling, when warranted, ANS that become established; and
- protecting adversely affected native species and ecosystems.

Goals, priorities, and approaches for ANS activities conducted or funded by the Federal Government are identified. Specific prevention, detection and monitoring, control, research, education, and other activities are described. Coordination of Federal activities with those of State and other governments and other interested parties, Great Lakes regional coordination, and international cooperation are ensured.

An approach for implementing the Program is discussed, including potential responsibilities and roles for Federal agencies and others.

As required by the Act, implementation will be consistent with all applicable Federal, State and local environmental laws. In addition, the Program does not affect the authority of the States and their political subdivisions to control ANS nor affect State jurisdiction over their fish and wildlife resources. The U.S. Fish and Wildlife Service (FWS) and National Oceanic and Atmospheric Administration (NOAA) will be responsible for implementing the Program in consultation and cooperation with the Task Force.

Four activities authorized by the Act--ballast water and shipping initiatives, the public facility research and development program, coordination of nonindigenous species activities in the Great Lakes, and State ANS management planning and grants--are not identified as components of the Program. However, these activities (with the possible exception of the grant program) are integral to any comprehensive Program and, therefore, they are described in this document in recognition of this relationship.

Other requirements of the Act, including the Intentional Introductions Policy Review, listing the zebra mussel as injurious wildlife, and development of a Brown Tree Snake Control Program do not relate to the Program and are addressed separately. However, the research protocol requirements apply to the Brown Tree Snake Control Program.

An annual report describing the Program is to be submitted to the Committee on Merchant Marine and Fisheries and Committee on Public Works and Transportation of the U.S. House of Representatives and the Committee on Environment and Public Works and the Committee on Commerce,Science and Transportation of the U.S. Senate. The

first report was to be submitted within one year of enactment, but has been delayed until the Program is completed. In addition to satisfying requirements of the Act, this document is of interest to, and is directed toward, a much wider audience.

Common names of organisms are used throughout this document; scientific names for each species cited are included in Appendix D.

The broad scope and multi-agency, intergovernmental emphasis of the Act could lead to semantic misunderstandings that prevent effective and timely implementation. Lack of standard terminology has been an impediment in addressing other nonindigenous species problems (Shafland and Lewis 1984). To avoid such problems, the Task Force has adopted the definitions in Table 1.

Development and Review of the Program

The ANS Work Group, consisting of staff from Task Force agencies (Appendix C), drafted the Program. After extensive review by the Task Force, a draft was submitted for clearance by the Departments of Commerce and the Interior and then the Office of Management and Budget. After obtaining Administration clearance in the Fall of 1992, information about the proposed Program and opportunities for public review and comment were widely disseminated.

Briefings about the proposed Program were provided for House and Senate committee staffs in October 1992. A notice of its availability, planned public meetings, and a request for comments was published in the FEDERAL REGISTER in November. Press releases about the document and public meetings were prepared and distributed to many media outlets and other contacts, especially in the vicinity of the public meetings. This information generated inquiries from print and electronic media as well as technical and professional publications and resulted in many news stories, notices, and other articles about the proposed Program and the public meetings.

More than 1,300 copies of the proposed Program were distributed to a broad array of interested individuals and organizations, including governmental agencies and employees, Members of Congress, Indian Tribes, conservation and environmental organizations, professional societies, academicians, industry and commercial interests, the media, and others.

In addition, six public meetings were held during December 1992 to provide an opportunity for the Task Force to explain the proposed Program, respond to questions, and listen to comments. They were held in regions of the Nation where nonindigenous species are a significant concern, including Baltimore, Maryland; Buffalo, New York; Duluth, Minnesota; Tampa, Florida; Newark, California; and Honolulu, Hawaii. An opportunity to comment was also provided during the Task Force's November 20, 1992, meeting in Ann Arbor, Michigan.

Each public meeting was chaired by one or more ANS Task Force members. More than 130 people participated and raised several relevant concerns and questions. Both electronic and print media reported on the public meetings.

The public comment period on the proposed Program closed on February 3, 1993. Written responses were submitted by 35 entities, including nine Federal agencies or employees, 10 State agencies, a binational organization, three conservation organizations, a sportfishing organization, two professional societies, an academician, seven industry representatives, and two individual citizens.

Comments and questions from the public review ranged from editorial and format suggestions to basic issues about the nature and scope of all aspects of the proposed Program. Respondents supported or took no position on the overall proposed Program; none opposed it. Using content analysis techniques, the ANS Work Group identified a number of concerns and issues in the comments received as the basis for review and appropriate revision by the ANS Task Force. That review concluded that few substantive changes were warranted, but that the document should be clarified in several areas.

A summary of public comments with responses together with a final draft of the Program reflecting those responses to comments was presented to the Task Force for review and approval at its November 9, 1993, meeting. After additional changes based on the Task Force's review, this document was finalized.

Table 1. Definitions

Aquatic Nuisance Species (ANS): A nonindigenous species that threatens 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. ANS include nonindigenous species that may occur in inland, estuarine and marine waters and that presently or potentially threaten ecological processes and natural resources. In addition to adversely affecting activities dependant on waters of the United States, ANS adversely affect individuals, including health effects.

Aquatic Species: All animals and plants as well as pathogens or parasites of aquatic animals and plants totally dependent on aquatic ecosystems for at least a portion of their life cycle. Bacteria, viruses, parasites and other pathogens of humans are excluded.

Ballast Water: Any water and associated sediments used to manipulate the trim and stability of a vessel.

Control: Activities to eliminate or reduce the effects of ANS, including efforts to eradicate infestations, reduce ANS populations, develop means to adapt human activities and facilities to accommodate infestations, and prevent the spread of ANS from infested areas. Control may involve activities to protect native species likely to be adversely affected by ANS. Preventing the spread of ANS is addressed in the Prevention Element of the proposed Program; all other control activities are included in the Control Element.

Ecosystems: In the broadest sense, these are natural or "wild" environments as well as human environments, including infrastructure elements. An ecosystem may be an animal or plant in the case where the species involved is a pathogen or parasite.

Environmentally Sound: Methods, efforts, actions or programs to prevent introductions or control infestations of ANS that minimize adverse impacts to the structure and function of an ecosystem and adverse effects on non-target organisms and ecosystems and emphasize integrated pest management techniques and nonchemical measures.

Established: When used in reference to a species, this term means occurring as a reproducing, self-sustaining population in an open ecosystem, i.e., in waters where the organisms are able to migrate or be transported to other waters.

Exclusive Economic Zone: The Exclusive Economic Zone of the United States established by Proclamation Number 5030 of March 10, 1983, and the equivalent zone of Canada.

Exotic: Nonindigenous species that are not native to the continental United States. In Hawaii and the insular territories and possessions of the United States, exotics are nonindigenous species that are not native to each area.

Great Lakes: Lake Ontario, Lake Erie, Lake Huron (including Lake St. Clair), Lake Michigan, Lake Superior, and the connecting channels (St. Mary's River, St. Clair River, Detroit River, Niagara River, and St. Lawrence River to the Canadian border), including all other bodies of water within the drainage basin of such lakes and connecting channels.

Intentional Introductions: The import or introduction of nonindigenous species into, or transport through, an area or ecosystem where it is not established in open waters for a specific purpose such as fishery management. Even when the purpose of such import or transport is not direct introduction into an open ecosystem (e.g., for aquaculture or display in an aquarium), introduction into open waters as the result of escapement, accidental release, improper disposal (e.g., "aquarium dumping"), or similar releases is a virtually inevitable consequence of the intentional introduction, not an unintentional introduction.

Synonyms: Purposeful, Deliberate.

Integrated Pest Management: The control of pests utilizing a practical, economical, and scientifically based combination of chemical, biological, mechanical or physical, and cultural control methods. Coordinated application of non-chemical control methods is emphasized in order to reduce or eliminate the need for pesticides. Integrated pest management is a balanced approach which considers hazard to the environment, efficacy, costs, and vulnerability of the pest. It requires: (1) identification of acceptable thresholds of damage; (2) environmental monitoring; and (3) a carefully designed control program to limit damage from the pest to a predetermined acceptable level.

Nonindigenous Species: Any species or other viable biological material that enters an ecosystem beyond its historic range, including any such organism transferred from one country into another. Nonindigenous species include both exotics and transplants.

Synonyms: Introduced, Exotic, Alien, Foreign, Non-native, Immigrant, Transplants.

North America: The continental land mass encompassing the United States, Canada, and Mexico.

Pathway: The means by which aquatic species are transported between ecosystems.

Prevention: Measures to minimize the risk of unintentional introductions of nonindigenous aquatic species that are, or could become, ANS into waters of the United States.

Public Facilities: Federal, State, regional and local government-owned or controlled buildings, structures and other man-made facilities, including water intakes, boat docks, electrical power plants, locks and dams, levees, water control structures, and publicly-owned fish culture facilities. Electric generating stations, water supply systems and similar facilities operated by public utilities or other non-governmental entities are also considered public facilities.

Species: A group of organisms all of which have a high degree of physical and genetic similarity, can generally interbreed only among themselves, and show persistent differences from members of allied species. Species may include subspecies, populations, stocks, or other taxonomic classifications less than full species.

Transplants: Species native to North America which have been introduced into ecosystems within the continent where they did not occur prior to European colonization. In other words, such species did not historically occur in the location in question.

United States: The 50 States, the District of Columbia, Puerto Rico, Guam, and all other possessions and territories of the United States of America.

Unintentional Introduction: Introduction of a nonindigenous species that occurs as a result of activities other than purposeful importation, transportation or introduction, such as by the discharge into open waters of ballast water or water used to transport live fish, mollusks or crustaceans for aquaculture or other purpose. Involved is the often unknowing release of nonindigenous organisms without any specific purpose. The virtual certainty of escapement, accidental release, improper disposal (e.g., "aquarium dumping"), or similar releases of nonindigenous species not intended for such release is considered the consequence of the original intentional introduction, not an unintentional introduction.

Synonyms: Accidental, Incidental, Inadvertent.

Vector: A biological pathway for a disease or parasite, i.e., an organism that transmits pathogens to various hosts. Not a synonym for Pathways as that term is used in the Program.

Waters of the United States: The navigable waters and the territorial sea of the United States. Since ANS can move or be transported by currents into navigable waters, all internal waters of the United States, including its territories and possessions, are included. The Territorial Sea of the United States is that established by Presidential Proclamation Number 5928 of December 27, 1988.

Synonyms: United States Waters.

Nonindigenous Species Programs and Activities

For over a century, there has been substantial interest in and concern about imports of aquatic organisms and their transfer within the United States. As a result, a variety of Federal and State programs have been established to both facilitate and regulate such introductions. Most of these programs address problem infestations; a few promote or regulate introductions. An understanding of the nature and scope of these existing activities is essential if the Program is to effectively build on, rather than duplicate, ongoing governmental efforts.

In addition, interest in nonindigenous fish, shellfish, algae and plants for commercial purposes remains high. Because of the substantial adverse impacts of the zebra mussel infestation, the private sector has become deeply involved in control activities since 1989.

Examples of existing nonindigenous species programs and activities--both governmental and non-governmental--are described in Appendix E to illustrate the range of involvement with this issue. However, Federal efforts to detect and monitor exotic fishes, ballast water and shipping activities, and the Public Facility Zebra Mussel Control Research and Development Program authorized by section 1202(i)(2) of the Act are described in the Program (pages 19, 40 to 45, and 46 to 47, respectively). Also presented in Appendix E are funding estimates for selected Federal nonindigenous species activities for fiscal years 1990 through 1993.

PROGRAM

The minimum content of the Program, including specific guidance about several program elements, is established by the Act. Together with several related requirements, these program elements provide a comprehensive framework for an effective national effort to achieve the goals of the Program. The scope and goals of the Program and strategies and actions for each of its elements and related requirement are presented in the remainder of this section.

SCOPE

The Program addresses all new nonindigenous aquatic species activities that are conducted, funded or authorized by the Federal Government, except those involving intentional introductions. Activities authorized or funded under the Act, existing activities redirected to implement the Program, or recent initiatives such as those directed towards zebra mussels are included. Not included are effective nonindigenous species efforts authorized under other statutes such as aquatic plant research and control programs of the U.S. Army Corps of Engineers (USACE), Bureau of Reclamation (BOR), and Tennessee Valley Authority (TVA). However, in consultation with State agencies, potentially affected industries, and other interested parties, the Intentional Introductions Policy Review is addressing intentional introduction issues independent of the Program.

To avoid splitting responsibility for closely related activities, new nonindigenous responsibilities associated with existing programs will be excluded from the Program. For instance, the Program will not address sea lamprey control in the Great Lakes, including the recently initiated sterile male release component, which would remain the responsibility of the binational Great Lakes Fishery Commission.

Zebra mussels were a major impetus for passage of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990. While addressing that problem, the language of the statute and its legislative history clearly mandate that the Program be broader. The Program must focus on all concerns and issues related to unintentional introductions and control of nonindigenous aquatic species that are or could become nuisances in United States waters. This includes protecting the diversity of native species and ecosystems as well as avoiding or minimizing economic losses and direct effects on human activities.

Nonindigenous aquatic species that are or could become nuisances do not recognize political boundaries. The United States shares waters with Canada and Mexico; its territories and possessions are in close proximity to many island nations in the Caribbean Sea and Pacific Ocean. Nonindigenous species introduced in those countries can readily spread into the United States through several pathways. Therefore, the Program recognizes that effective management of nonindigenous aquatic species that are or could become nuisances requires cooperation with foreign countries.

GOALS

The Act is intended to prevent unintentional introductions into United States waters and to control infestations of nonindigenous aquatic species that are or could become nuisances. Detecting the presence and monitoring the distribution and status of nonindigenous aquatic species in the United States and adjacent areas are essential to timely and effective prevention and control. Research, education, technical assistance and other activities are essential functions supporting attainment of these goals. Hence, the key goals of the Program are to:

- reduce the risk of further unintentional introductions of nonindigenous aquatic species that are or could become nuisances in United States waters and reduce the likelihood that such organisms will spread from one location to another within the United States;
- ensure prompt detection of nonindigenous aquatic species in the United States or in waters shared with neighboring countries and continuous monitoring of changes in the distribution and status of such organisms once introduced as well as documentation of native species impacts and other effects; and
- ensure, when warranted, the timely, cost-effective control of ANS in a manner that avoids or minimizes harm to non-target organisms and ecosystems.

CORE PROGRAM ELEMENTS

PREVENTION OF INTRODUCTIONS AND DISPERSAL

Preventing the initial introduction and subsequent dispersal of nonindigenous aquatic species, collectively referred to as "prevention", is central to the Program. This program element includes measures to minimize the risk of unintentional introductions of nonindigenous aquatic species that are or could become nuisances. Anticipating and avoiding problems rather than reacting once a nonindigenous aquatic nuisance exists is the focus of this element and a cornerstone of the Program.

In the absence of effective prevention efforts, many additional nonindigenous species are likely to be introduced. Some are likely to adversely impact human activities or harm receiving ecosystems at levels that rival those encountered with the zebra mussel. Numerous control efforts with undesirable environmental or other consequences which would otherwise be unnecessary will be implemented in response to such introductions.

In the Act, preventing the spread of nonindigenous aquatic species from infested areas is included in the Control Element. Concepts and techniques for preventing the introduction of exotic species from overseas as well as other parts of North America are similar to those employed to prevent the dispersal of nonindigenous species after they are established in new ecosystems. Consequently, this aspect of control is included in the Prevention Element.

An epidemiological model is the basis for the Prevention Element. When viewed in the context of this model, prevention could focus on:

- all nonindigenous aquatic species that could be introduced;
- all environments into which they could be introduced; or
- pathways that connect ecosystems and allow the movement of viable aquatic organisms from place to place.

Interruption of pathways is the most feasible and effective approach for preventing unintentional introductions and subsequent dispersal of nonindigenous species. Focusing on pathways concentrates action on the most easily disrupted element of the system. The number of pathways is much more limited than the number of locations (i.e., environments) or species. Nevertheless, targeting pathways remains a large task that will require substantial effort.

Ballast water is a generic pathway that is known to transport a wide variety of nonindigenous aquatic organisms that exemplifies why interruption of pathways is the most effective approach. Vessels call at numerous ports, each with a unique species assemblage. Focusing on one or even a few species or ports, therefore, would not significantly reduce the likelihood of additional species introductions. Transport of aquatic species could be effectively minimized or eliminated, however, by treating the ballast water and other known pathways on the ship every time it leaves port.

For instance, simply exchanging freshwater ballast in mid-ocean with sea water could be helpful since water from the high seas usually contains fewer organisms and they are much less likely to survive in the receiving fresh- waters than are freshwater organisms. However, ballast water exchange is not totally effective and only should be considered an interim measure. While 89 percent of ships entering the upper St. Lawrence River from the high seas in 1990 voluntarily exchanged at least some of their ballast water at sea in response to a Canadian Coast Guard request, only 67 percent of the live freshwater zooplankton originating in foreign ports were eliminated (Locke et al. 1991).

Nonindigenous aquatic organisms can be carried in a pathway by various means including floating in the water (Bauer and Hoffman 1976), attached to or incorporated in other transport media (Shotts and Gratzek 1984), in host species found in a pathway, attached to a surface such as a boat hull or the wall of a ballast tank, or in sediments.

Table 2 lists potential generic pathways by which nonindigenous aquatic species might be unintentionally transported into and within the United States. Since this is not a comprehensive list, other generic pathways are likely to be identified in the future. In addition, each generic pathway may involve a potentially large number of origin and destination combinations.

Generic pathways such as those identified in Table 2 can result in several types of introductions:

- transporting nonindigenous aquatic species between continents;
- dispersing exotic species previously introduced into North America; and
- transporting native North American species to regions where they are not established.

Thus, ballast water can transport nonindigenous aquatic species between North American coastal ports or in the Great Lakes as well as from overseas. As a consequence, modification of pathways will be appropriate for preventing both initial unintentional introductions and subsequent dispersal of ANS.

Table 2. Potential Generic Pathways Involved in the Unintentional Introduction of Nonindigenous Aquatic Species

Shipping

- Ballast water and sediments
- Anchor chains and chain lockers
- Sanitary water
- Hull surfaces
- Bilge water and sediments
- Propeller-shaft housing
- Trash/refuse/garbage

Relocation of Floatable Oil/Gas Drilling Rigs, Dry Docks, Navy Tenders

Recreational Boating

- Hull surfaces
- Waste sanitary water
- Bait wells
- Bilge water and sediments
- Motors
- Associated tools and equipment

Media (e.g., water, seaweed, soil, etc.), Containers and Equipment Used to Transport or Store Live Organisms

- Aquarium fish, plants, etc.
- Bait
- Aquaculture fish, shellfish, plants, etc.
- Fishery management (e.g., fish stocking)
- Research specimens
- Ornamental, other plants
- Pathogens in target animals

Fresh or Frozen Seafood Transport and Disposal

Human-Created Water Connections

- Navigation canals (e.g., Erie and Welland Canals)
- Interbasin water transfers (e.g., for irrigation, municipal/industrial water supply, etc.) (Meador 1992)

Natural Pathways

- Waterfowl and other water birds
- Hybrid backcrosses
- Tornadoes, hurricanes, other storms

Risk Identification, Assessment and Management Process

Determining in advance whether a nonindigenous species will become a nuisance is difficult, often impossible. Therefore, all potential pathways for unintentional introductions of nonindigenous aquatic species into new locations must be scrutinized to achieve an acceptably low level of risk.

The following process will be used to systematically identify pathways, establish the likelihood of each pathway successfully transporting aquatic organisms, and develop and implement appropriate methods for interdicting potential nuisance organisms. Identification, assessment, and interruption of pathways will involve the following steps:

1.Identify pathways, including origin-destination combinations within each generic pathway, which may be involved in unintentional introductions of nonindigenous aquatic species. Most of the work associated with this step will be accomplished early in the implementation process, but must be continuously updated as new information and insights about the problem become available.

2.Establish the order in which pathways will be analyzed based on an evaluation of the level of risk of introductions or other relevant criteria. Such priorities must be periodically reviewed and updated as necessary.

3.Systematically sample pathways, beginning with the highest priorities, to ascertain what organisms are being transported by each. If there are other reasons to believe that organisms not detected by the biological sampling are being transported in a pathway, those organisms should also be identified during this step.

4.Assess the risk that organisms detected in a pathway will become established and a nuisance in the receiving ecosystem, including identification of native species and ecosystems likely to be affected.

5.Identify possible means of interrupting pathways determined to be transporting a species of concern. These means must be evaluated to determine whether they are technically and biologically feasible, cost-effective, environmentally sound, and otherwise viable. Methods which are effective against a wide spectrum of pathways and organisms are preferred.

To coordinate implementation of this process, the Task Force has established a Risk Assessment and Management (RAM) Committee. The RAM Committee will provide advice to the Task Force on priorities for pathway analysis and development and implementation of preventive measures. Membership will include representatives of involved Federal agencies, State, tribal and other governmental entities, affected industries, and other interested entities.

Implementation of this process will be coordinated with implementation of the Detection and Monitoring and Research Program Elements and information dissemination strategies. For instance, research relating to generic prevention issues such as developing or refining sampling techniques and risk assessment methodologies will be required. In

addition, specific pathways or classes of organisms should receive further study. The RAM Committee will seek to coordinate those studies.

Education programs will be developed to support specific prevention initiatives. For instance, the United States Coast Guard (USCG) has initiated education activities intended to prevent further introductions of nonindigenous aquatic species in ballast water. A USCG pamphlet describing how ballast water can be a source of nonindigenous aquatic species invasions, and what is being done about this problem, is included as Figure 5, page 43).

DETECTION AND MONITORING

New nonindigenous aquatic species are certain to be introduced into United States waters despite best preventative efforts. In acknowledgement of this certainty, a recent workshop on introductions in the Great Lakes recommended establishment of a broad-based clearinghouse for information about nonindigenous aquatic species (Mills et al. 1993). Monitoring measures must be established to detect any introductions, track their dispersal, and document their effects.

Whether a species is a nuisance often cannot be determined until it has become established and disperses. Definitive determinations may require years of observation and extensive analysis. Hence, concerns about whether most nonindigenous aquatic species might be nuisances will exist for extended periods. Given these circumstances, the Program focuses on detecting introductions and monitoring the dispersal of all nonindigenous aquatic species rather than just actual or potential nuisances.

Timely detection of nonindigenous aquatic species that are or could become nuisances can identify gaps in prevention screening and facilitate corrective actions to close those gaps. Reliable information about the distribution, rate and direction of dispersal, and reproductive status of a nonindigenous species is crucial in determining whether it should be considered a nuisance and in estimating likely impacts. Such information also is useful in preventing the establishment or spread of potential ANS and in identifying research needs and priorities.

The objectives of this Detection and Monitoring Program Element are to:

- maximize the likelihood of early detection of nonindigenous aquatic species throughout the United States and, through cooperative efforts, elsewhere;
- monitor the spread of nonindigenous species and their effects on native species and ecosystems and on human facilities and activities in a timely manner;
- provide timely notification to appropriate entities of the detection and dispersal of all nonindigenous aquatic species and their effects; and
- alert the Task Force of the detection of new, or significant changes in distribution of previously reported, nonindigenous aquatic species which are or may become nuisances.

One means of accomplishing these objectives would involve establishing a nationwide monitoring network to continuously sample the full range of aquatic ecosystems in the

United States. However, this approach is likely to be prohibitively expensive (Courtenay and Hensley 1980) and would not take advantage of, and might even duplicate, existing aquatic biology data-gathering mechanisms and efforts.

In view of such problems, several approaches for detecting the presence and monitoring the spread of exotic fish and other nonindigenous organisms were reviewed. In recent years, several scientists collected information about new nonindigenous aquatic species in United States waters in conjunction with their research activities. The Florida Game and Fresh Water Fish Commission requests all employees to complete a standardized report on any observed exotic fish (Courtenay and Hensley 1980). The National Agricultural Pest Information System developed by the Animal and Plant Health Inspection Service (APHIS) contains information about known aquatic nuisance plants (Anonymous 1987).

The Zebra Mussel Information Clearinghouse at Brockport, New York, managed by the New York Sea Grant Marine Advisory Service, collects information about zebra mussels and publishes a bimonthly bulletin, the Dreissena polymorpha Information Review. That publication provides comprehensive, timely information on the distribution of the infestation, native species and other impacts, research, and other matters. Several other Sea Grant programs in the Great Lakes region monitor the distribution of zebra mussels. USCG District Nine collects information about the presence, depth, and density of zebra mussels in the Great Lakes as part of its routine maintenance of aids to navigation and vessel inspection and makes this information available to interested parties. FWS facilitated the establishment of cooperative programs to detect the presence and monitor established zebra mussel populations in high risk areas throughout the 48 coterminous States.

The National Fishery Research Center in Gainesville, Florida, developed a cost-effective, timely information system on the presence and distribution of exotic fishes and certain exotic mollusks. An informal network of Federal, State, and academic researchers; biologists with Federal and State fishery and other aquatic-oriented agencies; and others has been established. These individuals provide information about exotic fish as a spinoff of their regular studies or assignments. In addition, information about the presence of new introductions and changes in the distribution of previously detected nonindigenous aquatic species is obtained from a variety of other sources, including publications and museum collections. Recently, the National Fishery Research Center established a computer-based geographic information system to allow faster retrieval and quicker, more effective analysis of information in its extensive and growing database.

The detection and monitoring approach adopted for the Program builds on and institutionalizes the varied experience of these successful existing efforts. Three activities that will provide cost-effective, timely and reliable detection and monitoring of nonindigenous aquatic species are envisioned:

1.an information system;
2.extensive coordination with related efforts; and
3.field studies.

Information System

The goal of the information system is to provide timely, reliable data about the presence and distribution of nonindigenous aquatic species. Ideally, this would be an interactive system. A National Nonindigenous Aquatic Species Information Center (Center) will be established with the following components:

1. Data Repository and Information Management. Using geographic information system (GIS) technology supported by significant information management and analysis capability, a computerized data repository will be established to collect, analyze and disseminate information about the presence and distribution of nonindigenous aquatic species and their effects. Species files containing publications and correspondence as well as computer data will be established for each nonindigenous aquatic species reported to the Center. All information obtained about species of concern will be maintained in a comprehensive and integrated database and be readily available to interested entities.

2. Occurrence Detection and Reporting. Information for the GIS will be obtained from a variety of sources such as researchers, field biologists, fishermen, and others involved in activities in the aquatic environment. This information will be provided either directly to the Center or through intermediaries, such as university researchers, State fish and wildlife agency staff, Sea Grant Marine Advisory Service agents, and research laboratories.

The need for timely information about sightings of nonindigenous aquatic species and the existence of the Information System and its capabilities will be publicized. Informants will be actively solicited through personal communication, announcements in professional publications and other media, at technical meetings, and other appropriate means. Published reports in a broad array of journals and museum collections, a traditional source of information about the presence and distribution of nonindigenous species, will also be reviewed.

Another source of information will be ongoing biological data gathering. These include the Environmental Monitoring and Assessment Program (EMAP) conducted by the U.S. Environmental Protection Agency (EPA), USACE's native mussel monitoring programs, the Biomonitoring of Environmental Status and Trends (BEST) Program of the National Biological Survey (NBS), the U.S. Geologic Survey's National Water-Quality Assessment (NAWQA) Program (Leahy et al. 1990), NOAA's Status and Trends Program, and activities of the Agricultural Research Service and APHIS. Non-federal efforts such as the Natural Heritage Program and Conservation Center Network associated with The Nature Conservancy and participating States would also be asked to contribute. The staff of such programs will be alerted to the possibility of observing nonindigenous aquatic species during their field studies and requested to rapidly report actual or suspected occurrences together with information about any native species or other effects detected.

Center staff will be available to consult with informants, including assisting in the identification of potential nonindigenous species. The Center will ensure that appropriate species experts confirm specimen identification.

3. Information Transfer. The Center will promptly disseminate information about all confirmed sightings and impacts to interested parties. Literature summaries and biological synopses, including an assessment of its nuisance potential and information about effective control strategies and techniques, will also be prepared and disseminated for each detected nonindigenous aquatic species and periodically updated or revised when warranted.

4. Communications. Rapid communication of oral and written information will be a hallmark of the proposed information system. This will facilitate and encourage timely reporting of possible new nonindigenous aquatic species and prompt dissemination of confirmed reports about the presence, or changes in distribution, of such organisms and their effects. Advanced communications technology will be employed to the extent necessary and feasible.

The information system also will be used to maintain information generated in conjunction with implementation of the Control and other elements of the Program.

Coordination

Many Federal and State agencies and numerous other entities have ongoing biological monitoring activities and may be interested in contributing to this national effort. Detection and monitoring activities must be coordinated with other elements of the Program to: ensure all relevant concerns and interests are identified and considered; avoid duplication of efforts; and help ensure the most effective use of available financial and staff resources. Such coordination will be achieved through the Detection and Monitoring Committee established to advise the Task Force on detection and monitoring issues and priorities and to ensure coordination of detection and monitoring efforts.

Field Study Capability

The Detection and Monitoring Element of the Program should have a field study capability to complement existing capabilities and to ensure the effectiveness of this activity. Such capability is necessary to confirm the presence of reported or potential nonindigenous species as well as to determine their distribution, whether they have become established, and any impacts that can be readily identified. Depending on the organisms involved and the questions to be addressed, this capability will allow timely initiation of biologically appropriate systematic surveys. Specific field studies could be conducted by any of a variety of entities depending on the nature and location of the organism and other factors. Allocation of any field capability funded among the diverse issues and concerns likely to be encountered will be coordinated through the Task Force's Detection and Monitoring Committee.

CONTROL OF AQUATIC NUISANCE SPECIES

Control tends to be a focal point of many nonindigenous species initiatives. Exploration of control methods is frequently the initial response once a new nonindigenous species is detected or an established species begins to have a noticeable effect. However, this

emphasis has become increasingly controversial with greater scrutiny of the efficacy and potential side-effects of existing control programs.

Cooperative programs for control of established ANS are authorized, but not mandated.31 The purpose of such control programs is to minimize harm to the environment and the public health and welfare. Control may be initiated without regard to the source of the introduction (i.e., intentional versus unintentional introductions) or when it was introduced. Control includes eradication of infestations, reductions in populations to some acceptable level, and adaptation of human activities and facilities to accommodate (i.e., work-around) infestations. This includes efforts to protect native species and ecosystems likely to be adversely affected by infestations. Although preventing the spread of nonindigenous aquatic species is defined as control in the statute, this aspect of control is addressed in the Prevention Element of the Program. Given biological differences and the decision processes involved, control programs will tend to focus on specific species or groups of closely related species rather than applying to many types of organisms.

ANS can be controlled by several general methods, including chemical, biological, mechanical or physical, and habitat management practices. Proper evaluation and use of selective chemicals may provide effective control of aquatic invaders with a minimum of ecological hazard or other side-effects. On the other hand, concern exists among biologists, public health interests and the general public about the environmental safety and long-term impacts of chemicals used to control ANS. Carefully planned biological control programs may provide rapid, cost-effective control while posing negligible ecological problems. However, identification and screening of biological control agents invariably takes many years and improperly screened biological control agents have themselves become nuisance species in the past.

Mechanical or physical control of ANS, although often very expensive, can be the most appropriate technique in some circumstances. For instance, several engineering devices for power plants and other installations, including flushing affected areas with hot water, show considerable promise for reducing biofouling by zebra mussels. To protect native species and biodiversity, the establishment of refugia in natural habitats or artificial culture where ANS can be excluded or controlled may be necessary. Modifying natural habitats or other environments such as water intakes by changing management practices can prevent or reduce the effects of infestations.

No single method is likely to provide the necessary control of ANS. Hence, a comprehensive control strategy involving a combination of techniques referred to as Integrated Pest Management (IPM) is usually necessary for an effective control program.

Few, if any, control methods are without some environmental risk. However, when properly used, including continual monitoring for effectiveness and ecological side-effects, environmentally sound control of at least some ANS can be achieved.

Affordable and effective control often requires a prompt response to an infestation before the organism becomes established or widely dispersed. Therefore, when a reasonable chance exists that a newly detected nonindigenous aquatic species could become a

nuisance, a quick determination of whether control may be feasible and warranted is essential.

The Task Force or any other affected agency or entity may recommend initiation of control.32 However, the Task Force itself will not conduct control programs. When a recommendation that control be initiated is received, the Task Force will follow the procedures summarized in Table 3 to ensure prompt and systematic evaluation of the proposal and, if warranted, approval of a control program. The following discussion elaborates on the steps and decisions outlined in Table 3.

Step 1. Any affected entity, including individuals, may recommend initiation of a control program. Recommendations must be supported with sufficient scientifically credible information for the Task Force to make the preliminary risk assessment required in Step 2. In developing a proposed control program for Task Force approval, proponents must consult other entities likely to be effected and involve them in the evaluation of the problem and identification of proposed control strategies and methods.

Step 2. Upon receiving a recommendation to initiate control of a nonindigenous aquatic species, the Task Force will make a preliminary risk assessment. Key considerations to be addressed in the risk assessment include whether the species is or is likely to become established and, if so, is it presently or potentially a threat to the environment, including native species and ecosystems, public infrastructure, other human facilities and activities, and the public health and welfare. Another important consideration is whether the species is likely to become established in other locations.

Step 3. If, based on the preliminary risk assessment, the species of concern appears to be, or may become, established and a nuisance (particularly over a wide area), a control program based on IPM principles and techniques may be developed. Entities interested in obtaining approval for control under the Act are responsible for preparing a comprehensive control program and submitting it to the Task Force for approval. The proposal must be substantial and include all information necessary for the decisions to be made.

A thorough review of all scientific and other relevant information and experience related to the species' biology, behavior and effects, especially in other areas where previously introduced, is essential. The need for control, including an assessment of the consequences of less than full control and no control, must be discussed. The proposed control program must include a clear statement of its objectives (e.g., the nature and extent of control that is feasible and desirable).

The strategy and actions necessary to achieve the stated objectives should be described and prioritized. Viable alternatives to the proposed strategy and actions should be identified and the reasons they are less desirable discussed. For each alternative, such evaluations should consider the technical and biological feasibility; effectiveness in such terms as the likelihood of success and expected reduction of harm to effected ecosystems and activities; financial, social, environmental and ecological costs; benefits, including costs avoided; cost-effectiveness; expected harm to non-target organisms and

Table 3. Procedure for Proposing, Authorizing and Conducting Programs to Control Aquatic Nuisance Species

ACTION/TASK	RESPONSIBILITY
RISK ASSESSMENT	
1. Recommend that control be authorized /initiated	Any entity
2. Preliminary determ. that the target nonindigenous aquatic spp. is estab. and is/may become a nuisance	Task Force
3. Develop proposed control program using IPM techniques that fulfills the requirements of subsection 1203(e) of the Act and submit to the Task Force	Entity proposing control or other interested party
4. Independent evaluation, based on IPM principles, of effectiveness of proposed control program compliance with law. Consult with appropriate entities	Task Force committee
5. Determine if control is warranted	Task Force
RISK MANAGEMENT	
6. Identify cooperator(s) to lead or conduct the control program	Task Force
7. Develop control program	
a. Revise and refine proposed control program	Cooperator(s) and Task Force comm.
b. Initiate formal compliance with NEPA, ESA Cooperator(s) and other environmental laws	Task Force comm.
8. Publish notices about proposed control program and solicit comments. Complete consultation with affected governmental, other appropriate entities.	Task Force
9. Approve control program	Task Force
10. Seek/obtain necessary funding	Cooperator(s)
11. Initiate control activities	Cooperator(s)
12. Monitor implementation and periodically evaluate effectiveness, benefits, costs, envir. soundness	Task Force comm. with cooperator(s)
13. Modify control program when needed/ appropriate	Task Force and cooperator(s)

ecosystems; environmental soundness; public health and welfare; and other relevant information.

Step 4. As the basis for Task Force decisions regarding a proposed control program, species specific committees or, possibly, a standing committee will be established to conduct an independent technical evaluation to confirm, reject, or modify the preliminary risk assessment made in Step 2. Such committees shall include representatives of the range of entities likely to be effected by any control program. From the information provided, the committee would complete an evaluation based on IPM principles and techniques to determine if:

- the species is established in some waters of the U.S. and is likely to spread elsewhere;
- the species is, or has the potential to become, a nuisance where presently established or elsewhere;
- a comprehensive review of the literature and other knowledge about the species and its effects has been completed;
- a control program is needed and, if so, the level of control that is feasible and desirable, including an adequate description of the consequences of no control or less than full control;
- the proposed objectives of the control program are stated clearly; and
- the proposed strategies and actions are clearly stated, appropriate, correctly prioritized, and likely to achieve the stated objectives, including whether other strategies and actions, or combinations thereof, may be more technically or biologically feasible or effective, cost-effective, or environmentally-sound.

Based on the available information, the committee will recommend whether control is warranted and if the proposed control program should be implemented. The committee report should indicate the likelihood that the proposed control program will be effective, whether it would be environmentally sound, and otherwise explain the basis for its findings and conclusions. Modifications to the proposed control program should be recommended to bring it into conformity with statutory requirements, make it more effective or environmentally sound, or otherwise make it more desirable.

The committee will initiate consultations with affected Federal agencies, States, Indian Tribes, local governments, interjurisdictional organizations, and other appropriate entities.

Step 5. Based on the findings, conclusions, and recommendations of the Committee and after consultation with appropriate entities, the Task Force must determine whether control is warranted, i.e., whether to initially approve a control effort. This determination must be made consistent with the standards discussed for Steps 2 through 4.

Step 6. Since the Task Force will not undertake the control program, one or more qualified organizations must be identified to assume this responsibility. A range of entities will be considered to serve as the Task Force's cooperator in conducting control programs. In addition to Federal agencies having the expertise and basic mission responsibility, the Task Force will offer State and other governmental entities and

nongovernmental organizations with the necessary expertise the opportunity to conduct or participate in each control program.

Step 7. Two related tasks are necessary to finalize the control program:

1. The cooperator or cooperators who agree to conduct the control program, along with the Task Force committee, will revise and refine the proposed control program as necessary in response to comments, questions, and suggestions about the earlier version and any new information. The purpose of this review will be to ensure comprehensive and effective achievement of the target level of control. The Task Force must concur with the revised control program.

2. Formal consultations and other actions must be initiated by the cooperator(s) and Task Force committee to ensure that the control program complies with the National Environmental Policy Act of 1969 (NEPA, 42 U.S.C. 4321 et seq.), the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.), and other applicable Federal, State, and local environmental laws.

Step 8. The Task Force will announce its findings and intent to approve the revised control program and the availability of NEPA and other documents through notices in the FEDERAL REGISTER, major newspapers in the region affected, principal trade publications of affected industries, and elsewhere as appropriate. Those notices will request comments about the completeness, effectiveness, and other aspects of the revised control program. Copies of the revised control program, environmental documents, a request for review and comments, and any other pertinent information will be widely distributed.

Step 9. No more than 180 days after publishing a notice of intent to approve the revised control program, the Task Force will complete consultations with all appropriate governmental and other entities. After modifying the revised control program as appropriate in response to comments received through consultations and in response to notices, the Task Force will approve a final control program and its implementation.

Steps 10 and 11. The cooperator(s) who have agreed to lead or conduct the control program would then obtain the necessary funding and begin implementation of the approved control program.

Step 12. The cooperator(s) will provide periodic reports to the Task Force regarding implementation activities and costs, results obtained, and the environmental effects of those activities. The Task Force committee will periodically review the implementation of each approved control program to ensure compliance with all requirements and evaluate effectiveness and environmental soundness.

Step 13. The Task Force committee will authorize or direct minor modifications of approved control programs to ensure that control activities remain effective and environmentally sound. Indications or allegations of non-compliance with an approved control program, lack of effectiveness or environmental soundness, or other problems will be investigated promptly by the Task Force. After appropriate public notice,

consultation with appropriate entities, and an opportunity for comment by the cooperators, changes will be made, if warranted, in the control program.

Because of significant differences in the complexity, scope, and approach of each control recommendation considered by the Task Force, no standard processing period can be established. However, all recommendations will be processed as expeditiously as possible.

This decision process may be terminated, or decisions may be deferred, at a number of points if necessary information is lacking, or required determinations such as biological or technical feasibility, cost-effectiveness, or environmental soundness cannot be made. Conversely, more than one iteration may be necessary before the Task Force makes a final decision.

Decisions to terminate the process and not authorize a control effort will be reviewed periodically. For instance, if studies indicate that a species under consideration is not likely to become a nuisance, this conclusion should be reassessed periodically when there is reason to suspect its status has changed or other new information becomes available.

All correspondence related to requests to initiate a control effort and all documentation, including analyses developed, used in deliberations about control recommendations will be retained in a "species file" maintained by the Detection and Monitoring Information System.

The proposed control decision process should be followed for control activities that are part of an approved State ANS Management Plan. Adherence to the decision process required under this program element is not an explicit requirement for such State plans. On the other hand, the extensive public involvement and intergovernmental coordination required, the need to comply with applicable environmental laws, and consistent implementation of the Act suggest that this decision process also should be applied to control activities in State ANS management plans.

Control activities initiated and conducted under other authorities are not subject to the decision process outlined here. However, any Task Force involvement in such control efforts would be subject to this process.

SUPPORT PROGRAM ELEMENTS

RESEARCH

Timely, pertinent research is essential to the success of the Program. Scientifically valid information about the taxonomy, life history and physiology of nonindigenous aquatic species, their effects on the environment and human activities, and their potential for becoming a nuisance is required for the multitude of decisions needed to refine and implement the Program. In addition, biologically sound information is necessary to identify effective techniques for prevention, detection, monitoring, and control.

The Research Element of the Program involves three components--research coordination, the research protocol, and competitive grants for research--discussed below.

Research Coordination

The Task Force must ensure that a broad range of research is conducted concerning nonindigenous aquatic species. Priority research areas to be supported include:

- environmental and economic risks associated with the introduction of nonindigenous aquatic species into the waters of the United States;
- principal pathways by which nonindigenous aquatic species are introduced and dispersed;
- possible methods for the prevention, monitoring, and control of nonindigenous aquatic species; and
- assessment of the effectiveness of nonindigenous aquatic species prevention, monitoring, and control methods.

Extensive research addressing these and related concerns has been conducted by a variety of governmental and non-governmental entities in the United States, Canada, and elsewhere. The pace of such research has increased in recent years along with concern about nonindigenous species infestations, especially the zebra mussel. A number of such research projects are described in Appendix E. Research related to specific problems and issues will be conducted under the core Prevention, Detection and Monitoring, and Control Elements of the Program.

Most existing research on nonindigenous aquatic species deals with problem infestations. No comprehensive mechanism or framework exists for establishing national research needs and priorities for all nonindigenous aquatic species. Other than discussions among researchers interested in the same issue and several symposia focused on nonindigenous species held over the past decade, there has been little broad-based coordination of such research. No nonindigenous species research journal has been established, although there is growing interest in initiating such a publication. Perhaps the Newsletter of the Introduced Fish Section, American Fisheries Society comes the closest to fulfilling such a need.

Effective coordination on a less global scale does occur in several instances. The most notable example is in the Great Lakes. Building on long and continuing involvement with and concern about nonindigenous species, the research community from the United States portion of the region recently reached consensus on nonindigenous species research needs and priorities for the United States portion of the Great Lakes. That effort resulted in the publication in August 1990 of the Coordinated Program of Research on NonIndigenous Species in the Great Lakes. A copy of that consensus document prepared by the United States Great Lakes Non-Indigenous Species Coordinating Committee is included as Appendix F. Participation in that effort is being broadened to include Canadian interests.

Prompt coordination of zebra mussel research from the onset of the infestation is another notable instance of effective, but limited, coordination of nonindigenous species research

activities. The research projects and findings have been summarized at many meetings and in an increasing number of publications.

An interagency Federal Aquatic Plant Management Working Group (FAPMWG) meets annually to coordinate Federal research on aquatic weeds, most of which are nonindigenous species. Members of the FAPMWG include the USACE, TVA, BOR, and APHIS.

NBS has a small exotic fish research program that, in effect, coordinates much of the research on this class of nonindigenous species. Begun about 15 years ago, that program operates from a laboratory in Gainesville, Florida, specifically designed to prevent the release or establishment in open ecosystems of exotic fish used in research activities.

Lack of research effort and interest is not the problem. The problem is the lack of a mechanism for involving the research community in comprehensive and continuing efforts to identify nonindigenous aquatic species research needs and to focus research activities on priority needs. The Research Coordination Committee (RCC) was established by the Task Force to ensure such broad-based coordination. The RCC will include representatives of the diverse community of affected interests such as Federal, State and other governmental entities, the private sector, and Canadian and Mexican representatives.

The RCC will annually seek consensus on the universe of nonindigenous aquatic species research needs that address both emerging and ongoing problems and issues. The RCC will also seek broad consensus on research priorities. In developing such consensus, the RCC will consider the status of nonindigenous species in various regions of the country, their potential risk to ecosystems and human activities, the potential significance of the research in resolving policy issues, and other relevant factors.

Periodically, the RCC will convene coordination meetings with the research community and other interested or affected parties. To the extent practicable, joint or concurrent meetings will be held with specialized organizations such as the Federal Aquatic Plant Committee, Introduced Fish Section of the American Fisheries Society, Society for Ichthyology and Herpetology, and American Malacological Union. A variety of other contacts will also be established.

Research Protocol

Some past research activities have resulted in the spread of nonindigenous species. Concerns were expressed during congressional deliberations leading to enactment of the Act that such activities might continue to introduce or spread nonindigenous species, especially zebra mussels. As a consequence, Congress included provisions in the Act in an attempt to avoid such possibilities even though importing and transporting nonindigenous species for research purposes is an intentional introduction (see Table 1).

An early version of legislation that became the Act would have addressed such concerns by prohibiting nonindigenous species research in any location where the subject species was not already established. As an alternative to such arbitrary and unnecessary

restriction on research activities, the statute enacted requires that the Task Force establish and follow a protocol to ensure that research conducted or funded under authority of Subtitle C of the Act does not result in the introduction of ANS into United States waters.

The Task Force established a Research Protocol Committee (RPC) to develop and periodically update the Research Protocol for its consideration and to ensure effective implementation of the approved process. By September 1991, three drafts of the research Protocol had been prepared and circulated for Task Force and other comment. In response to comments from two entities, an extensively revised version was tentatively approved by the Task Force in April 1992, subject to further public comment. An announcement of the availability of and an opportunity to comment on the approved Research Protocol was provided by notice in the FEDERAL REGISTER on September 24, 1992 (57 FR 44207). Based on about 30 comments in response to that notice, the Research Protocol was modified and the revised version was approved by the Task Force and completed in September 1993.

The Research Protocol (Appendix G) consists of two parts: a risk assessment and a set of guidelines that will ensure necessary confinement of potential ANS. It establishes a process and provides decision criteria for evaluating the risk that research projects, including the transport of specimens to the research site, are likely to result in the introduction or dispersal of present or potential aquatic nuisances species. The Protocol will be reviewed periodically and revised when appropriate based on implementation experience and other insight.

Allocation of Competitive Research Grants

The Task Force allocates funds appropriated for competitive grants for research on all aspects of aquatic nonindigenous species that are, or have the potential to become, nuisances. Funding for these grants is to be appropriated to, and administered by, NOAA's National Sea Grant College Program (NSGCP) and the Cooperative Fish and Wildlife Research Units Program (CFWRUP) now part of the recently established NBS.

The Task Force will annually determine national nonindigenous aquatic species research needs and priorities as discussed in the Research Coordination section. The NSGCP and CFWRUP will then develop a joint Request for Proposals reflecting those needs and priorities that will be issued to the scientific community. Funding will be available to universities and research institutes and laboratories. Proposals received will be directed to the NSGCP or CFWRUP for funding consideration, depending on the organisms, habitats, or topics to be investigated. Other entities with an interest in a particular research proposal may fund all or part of the study.

Proposals submitted for funding under this provision will undergo scientific peer review. Successful projects must comply with the Research Protocol. Selection of projects for funding will be competitive, based on both scientific merit and responsiveness to the research needs and priorities agreed to by the Task Force. Proposals will be recommended for funding, returned for appropriate modification of experimental design, or rejected. Projects funded through NSGCP will be administered through the local Sea

Grant Institution; projects funded through the CFWRUP will be administered through NBS' Regional Offices.

EDUCATION

Lack of public knowledge of ANS problems, including the pathways by which they are introduced and dispersed, has contributed to unintentional introductions. Changes in the philosophy and behavior of individuals are essential to the effectiveness of any program to deal with these problems. Increasing public awareness about nonindigenous species issues and problems facilitates species identification, prevention of introductions and translocations, and control. It also generates essential public support for implementing preventive and corrective programs.

Several State agencies and others have developed effective educational materials and activities related to specific nonindigenous aquatic species problems and threats. Several ongoing educational campaigns, sometimes undertaken as part of broader recreational fishing ethics efforts, are aimed at preventing improper bait disposal by recreational fishermen. A coalition of Minnesota interests are distributing a color poster featuring zebra mussels and the ruffe. FWS and the States of Florida and Hawaii have developed informational materials on the dangers of releasing unwanted aquarium specimens into open waters. Hawaii's materials are supported by radio and television public service announcements. USCG has developed a pamphlet describing how ballast water can be a pathway for invasions by nonindigenous species and identifying actions that avoid such problems for distribution to shipping interests in the Great Lakes (Figure 5, page 43).

The Great Lakes Sea Grant Network developed a widely distributed, wallet-size zebra mussel identification card that encourages reporting sightings to the Zebra Mussel Information Clearinghouse in Brockport, New York. That Clearinghouse publishes the bi-monthly Dreissena polymorpha Information Review containing information on zebra mussels for researchers, affected entities, and the general public. Posters and a fact sheet aimed at preventing the spread of zebra mussels to non-infested waters by fishermen and boaters are being distributed at boat landings and marinas in Pennsylvania by its Department of Environmental Resources. FWS offices involved in zebra mussel detection and monitoring have developed educational materials and have conducted technical seminars in response to the zebra mussel infestation.

Public information and education directed to a wide range of audiences must be included in the Program. Decision-makers in all levels and branches of government should be the primary audience. Industrial users of water; recreational users of aquatic resources; the aquaculture and aquarium industries; aquarium owners; zoos and arboretums; the research community; professional, trade and interest groups; and the general public should also be addressed.

Education will be integral to each element of the Program. As a consequence, the majority of educational activities will be undertaken as part of other program elements. This is particularly true for the Prevention, Detection and Monitoring, and Control Elements and the Zebra Mussel Demonstration Program. Approaches and educational activities will differ among program elements and their components as appropriate.

However, alerting appropriate government agencies and other entities and interests about the problem and providing information on identification of the species of concern and how to prevent it from spreading will often be a common theme.

The principal focus of this element is general education about the problems caused by nonindigenous species and the need to prevent introductions. However, no separate apparatus for developing educational materials and programs is proposed. Instead, implementation of such consciousness-raising efforts will be through existing education programs of the constituent Task Force agencies and other interested parties. Currently, FWS and NOAA's NSGCP have such capabilities.

The Task Force will encourage and facilitate initiatives by others, including assisting with identification of potential audiences, developing appropriate education materials and curricula, and making cooperators aware of available educational resources. Several specific educational programs can be initiated at relatively little incremental cost. As an example, information on measures to prevent transfer of zebra mussels is being incorporated into the boating safety programs conducted by the USCG Auxiliary. Similarly, information on boat-related pathways is provided in the context of USCG Auxiliary courtesy boat inspections. Natural history museum and nature center exhibits and programs also may be cost-effective means for informing citizens about nonindigenous species and their effects.

TECHNICAL ASSISTANCE

Technical assistance to States and local governments and other entities and individuals will be provided under the Program to minimize the environmental, public health, and safety risks associated with ANS, including early warning of infestations and information about appropriate responses.

Technical assistance related to management of ANS will require coordination of many water users, ranging from sportsmen to municipal and industrial interests. Technical assistance will:

- inform of impending or potential problems;
- provide access to the best technology and information available to minimize economic impacts and prevent further spread;
- synthesize available scientific information into forms that can be utilized by managers and decision-makers;
- provide an early warning capability; and
- provide information regarding success of management programs in place to prevent new introductions.

This capability currently exists in coastal regions, including the Great Lakes, through the NOAA's NSGCP Marine Advisory Services network. The Department of the Interior can provide such technical assistance through its nationwide network of Cooperative Fish and Wildlife Research Units, Fishery Assistance Offices, and IPM Coordinators. The U.S. Department of Agriculture has technical assistance capability through its Cooperative State Extension Service. Together, these Federal technical assistance capabilities provide

national coverage, but their application will require significant interagency cooperation and interaction to realize that potential.

ZEBRA MUSSEL PROGRAM

In adopting the Act in late 1990, Congress was acutely aware of the unprecedented impacts and rapid spread of the zebra mussel infestation in the Great Lakes. There was also great concern that the infestation would soon spread to many other regions of the Nation (Figure 3) with impacts similar to those in the Great Lakes. Since enactment, zebra mussels have spread throughout the Great Lakes and well beyond (Figure 4).

The Zebra Mussel Element of the Program will ensure emphasis on the immediate zebra mussel problem. It will also demonstrate how to organize large-scale, coordinated responses to significant ANS problems. The Program is to be conducted in the Great Lakes or any other waters of the United States where zebra mussels are, or may become, a problem.

The Assistant Secretary of the Army for Civil Works, in consultation with the Task Force, must develop a program of research and technology for the environmentally sound control of zebra mussels in and around public facilities. Although arguably a free-standing requirement, this research and development mandate is clearly related to, and should be acknowledged as part of, the Zebra Mussel Program (see subsequent section).

Many zebra mussel research, education, monitoring, and control activities have been initiated since the infestation was discovered in 1988. A broad array of United States and Canadian Federal, State, Provincial, regional and localgovernmental entities, industry organizations, municipal water supply systems, public utilities, industries, universities, and many others are involved. Information about a number of these activities is presented in Appendix E. Federal funding devoted to zebra mussel activities is displayed in Table E-1.

Building on many years of involvement with nonindigenous species problems, significant coordination of diverse and extensive zebra mussel activities has been accomplished in the Great Lakes region through the ad hoc efforts of research and governmental entities. For instance, the ad hoc United States Great Lakes Non-Indigenous Species Coordinating Committee, made up of Federal, State and academic researchers and managers, recently developed a Coordinated Program of Research on Non-Indigenous Species in the Great Lakes (Appendix F). That document has been used for identifying and prioritizing the universe of zebra mussel research needs.

The Great Lakes region has established an effective nonindigenous species network that has facilitated zebra mussel coordination efforts to date. With the spread of zebra mussels beyond the Great Lakes and the continuing explosive growth of zebra mussel activities and information, effective coordination will become increasingly difficult, yet imperative. In addition, the rapidly growing information base resulting from zebra mussel research and control activities must be synthesized into practical recommendations for reducing the impacts of the infestation and preventing its spread. Such information must also be

disseminated in a timely manner to the broad array of parties interested. Hence, a more formal, national coordination mechanism is necessary.

Given these circumstances, the most effective role of the Task Force in the near term is to ensure that:

- efforts directed toward the zebra mussel, especially research, are adequately coordinated; and
- the rapidly expanding information base related to effective, environmentally sound control methods is synthesized into relevant control strategies and technologies and disseminated to a wide array of interests in a timely manner.

To achieve these objectives, the Task Force has established a Zebra Mussel Coordination Committee (ZMCC) involving representatives of the full range of entities affected by or involved with zebra mussels. This includes the Great Lakes Panel on Nonindigenous Species and Canadian participants. Since the infestation is most severe there, the principal focus of the ZMCC initially is expected to be Great Lakes issues and problems. As the zebra mussel infestation spreads, however, representation on the ZMCC and the issues and problems addressed will broaden correspondingly.

The Task Force will annually review the focus and direction of the Program to ensure that its emphasis changes in concert with the evolution and maturation of the problem. For instance, if a consensus emerges that important activities are not being addressed, the Task Force may want to encourage, or even take the lead in, the development of programs to fill such gaps. If such evaluations identify other more effective coordination mechanisms, the Task Force would consider deferring its coordination role to that alternative mechanism. Such evaluations will also be useful in guiding the response to future ANS problems.

RELATED ACTIVITIES

STATE AQUATIC NUISANCE SPECIES MANAGEMENT PLANS

State governors, after opportunity for public review, may submit a comprehensive ANS management plan for review and approval by the Task Force, and a public facility zebra mussel management plan for review and approval by the Assistant Secretary of the Army for Civil Works. At this time, no Federal funds have been budgeted for this purpose nor are any budget requests contemplated. FWS and USACE for the Assistant Secretary of the Army for Civil Works will develop guidelines to assist the States in the preparation of these plans. That guidance will address the scope and content of the State plans and will facilitate Task Force review of plans submitted.

The process of preparing and reviewing State plans is independent of the Federal Aquatic Nuisance Species Program. However, State activities related to nonindigenous aquatic species can be an integral component of a comprehensive national Program without diminishing State prerogatives. Hence, the Task Force will review the State plans for consistency with national objectives and seek to integrate State plans and priorities with the proposed national Program. During the course of reviewing State plans, technical

assistance in the form of comments on and suggestions about the effectiveness and environmental-soundness of proposed State measures may be provided.

The Act does not contain an explicit requirement that control activities included in an approved State management plan be subject to the decision process required by the Act. However, the requirements for State management plans, mandatory compliance with applicable environmental laws, and consistency with the national Program together suggest that the Control Element decision process should also apply to State plans. Several States are developing ANS management plans for approval by the Task Force. The natural resource management agencies in New York and Minnesota have been directed by their legislatures to develop and submit State plans. On December 15, 1993, the Department of Environmental Conservation on behalf of the Governor submitted New York's Nonindigenous Aquatic Species Comprehensive Management Plan. The Task Force must approve that plan by mid-March 1994 or return it with recommended modifications. Minnesota's plan is nearing completion and is expected to be available for public review during the Spring or Summer of 1994. Wisconsin and Michigan are also preparing ANS management plans for public review later in the year.

Under the auspices of the Chesapeake Bay Program, four of the basin's States, the District of Columbia, and two Federal agencies will soon adopt a policy regarding the introduction of nonindigenous aquatic species. Each management jurisdiction will then be able to establish consistent implementation policies and prepare compatible species specific control plans. The State of Maryland is prepared to develop such documents which may become the basis for an ANS plan submitted for Task Force approval.

BALLAST WATER AND SHIPPING INITIATIVES

Ships have always been a pathway by which exotic species, including diseases, have been introduced into and transported within North America. Before water was routinely used as ballast, many plants and other organisms were introduced through the disposal of solid ballast (Carlton 1990). Since the early 1900s, ballast water has been associated with the transport of exotic species. A ship may take on ballast water in one port, including any living organisms in that water, voyage across an ocean to another port and discharge its ballast water along with any organisms that survived the trip. Hundreds of species, including the zebra mussel, are estimated to have been introduced into North America by this pathway (Carlton 1985). Although there has always been the threat of a nuisance species being unintentionally introduced in this manner, the problems brought on by the zebra mussel prompted public and legislative attention to this issue.

As a result of this attention, the USCG was directed in 1989 to study the options available to control the introduction of nonindigenous species through ballast water. In mid-1990, USCG submitted an interim report to the Congress detailing the problem of nonindigenous species throughout the world and efforts underway to address that problem (Anonymous 1990). A paper on preventative options was attached to the report. Of the alternatives considered in the paper, the most feasible and economical was to exchange freshwater ballast with sea water while en route from one port to another. While organisms may still be taken in with the ballast water exchanged on the high seas (i.e., more than 200 miles offshore), those organisms will probably not survive when

discharged in freshwater. A draft of the final report is under review within the Administration.

Great Lakes Requirements

Subtitle B of the Act directed the USCG to take two actions to reduce the risk of introducing and spreading nonindigenous aquatic species into the Great Lakes through the ballast water of vessels. By June 1991, voluntary guidelines based on the best scientific information available were to be established. In addition, mandatory regulations were to be issued by December 1992.

In March 1991, guidelines applying to vessels carrying ballast water that, after operating on the high seas, were inbound for the St. Lawrence River above Quebec City or the Great Lakes were jointly issued by the U.S. and Canadian Coast Guards. The guidelines, which fulfill the statutory requirement, encourage ship-masters to treat their ballast water or exchange it at sea at a depth of at least 2000 meters. If exchange at sea is not practicable, ballast could be exchanged in the Laurentian Channel in depths greater than 300 meters.

The required ballast water management regulations took effect on May 10, 1993, at the beginning of the Great Lakes shipping season. They apply to vessels carrying ballast that have operated beyond the EEZ when they enter the Snell Lock of the St. Lawrence Seaway at Massena, New York, regardless of other ports of call during that voyage. In addition to exchange of ballast water on the high seas, the regulations allow retention of ballast water in sealed tanks and, with prior approval of the Commandant of the USCG, other environmentally sound ballast water management methods. No vessel entering Snell Locks may operate on the Great Lakes unless its master describes the ballast water management efforts carried out and certifies the vessel is in compliance with the regulations. USCG may take ballast water samples during transit of the Snell Lock to assess compliance with and the effectiveness of these regulations. To date, the emphasis of this sampling has been on checking the salinity of ballast water to verify compliance.

With the adoption of the mandatory regulations, the joint United States-Canadian voluntary guidelines were terminated. However, the Canadian Coast Guard amended the guidelines and reissued them on March 31, 1993, to cover vessels entering their ports above Quebec City.

The USCG established an educational and technical assistance program for both its field personnel and employees in the shipping industry to encourage compliance with the ballast exchange guidelines and the ballast water regulations. A video and pamphlet (Figure 5) describing how ballast water can be a pathway for invasions by nonindigenous species and identifying actions for avoiding such problems is provided to all mariners entering the United States port at the Massena Locks. That educational material has also been distributed widely to the shipping industry in the Great Lakes.

Two other recent events have occurred that relate to ballast water management and shipping effecting the Great Lakes. The Act was amended in November 1992 to direct the USCG, in cooperation with the Task Force, to issue regulations by late 1994 for

vessels entering the Hudson River above the George Washington Bridge. The purpose of these mandatory regulations is to prevent the introduction and spread of aquatic nonindigenous aquatic species into the freshwater portion of the Hudson River which is connected with the Great Lakes through the Erie Canal. They are expected to be similar to the existing regulations for vessels entering the Great Lakes through the St. Lawrence Seaway. Recently, proposed regulations developed in response to this requirement were published.

A voluntary ballast water management plan for Western Lake Superior also was developed in the spring of 1993 by the Great Lakes shipping industry in cooperation with the Task Force's Ruffe Control Committee (Anonymous 1993). The purpose of the plan was to minimize the risk of intra- and inter-lake spread of ruffe. Implementation began at the start of the 1993 shipping season.

National Shipping Initiatives

The Act also directs that two studies, a Shipping Study and a Ballast Exchange Study, be conducted to evaluate the introduction of ANS by vessels into waters other than the Great Lakes.

risk of shipping related introductions into waters other than the Great Lakes. The study examines ballast water, a known pathway, as well as other pathways associated with shipping, such as anchor chains, chain lockers and hull surfaces. In addition, options for preventing such pathways from transporting additional nonindigenous organisms will be identified and evaluated. Specifically, the Shipping Study is to:

- determine the degree to which shipping acts as a major pathway to the introduction and spread of nonindigenous species;
- identify possible alternatives for controlling any pathways associated with shipping; and
- determine the feasibility of implementing regional versus national control measures.

The Study has been completed and a final draft of the report is undergoing agency and Administration review. The report is expected to be submitted to Congress in 1994.

The second shipping-related analysis, the Ballast Exchange Study, was assigned to the Task Force in the Act. The purposes of this study are to:

- assess the environmental effects on the diversity and abundance of native species in marine, estuarine, and freshwaters of the United States of ballast water discharges; and
- identify alternative areas, if any, in United States waters where ships can safely exchange ballast water without risking the introduction or spread of nonindigenous species.

This study is scheduled to begin in the Spring of 1994 and is expected to be completed by June 1995.

International Efforts

To date, only the United States, Canada, and Australia have legislative or regulatory provisions addressing this issue.

In May 1989, the Canadian Coast Guard issued voluntary guidelines requesting ships to exchange their ballast water on the high seas before entering the Gulf of St. Lawrence. The St. Lawrence Seaway Authority has been monitoring compliance with the guidelines by asking the masters of the vessels to complete survey forms. In 1990, compliance was estimated to be between 80 to 90 percent.

In February 1990, the Australian Quarantine and Inspection Service (AQIS) issued voluntary guidelines aimed at reducing the possible introduction of nonindigenous species. The guidelines provide vessels the option of:

- providing a certificate from the responsible national government stating that the harbor sediment where the ship took on ballast was free from toxic dinoflagellates;
- reballasting at sea en route to Australia;
- agreeing not to release ballast water while in Australian waters;
- entering into a "Compliance Agreement" with AQIS to maintain ballast contents in a clean condition;
- implementing an approved treatment process to eliminate possible harmful organisms; or
- discharging ballast water to an on-shore treatment facility.

Seventy-eight percent of the vessels entering Australian waters claimed to be in compliance with those guidelines.

The International Maritime Organization (IMO) has become the focus of international efforts to prevent the spread of aquatic organisms by shipping activities. At the 32nd Session of its Marine Environment Protection Committee (MEPC), held in July 1991, the Committee agreed on guidelines for ballast water programs that could be adopted by port states. The guidelines provide procedures that can be used to manage ballast water, encourage flag states to alert their seafarers of the problems associated with ballast water and sediments, and promote further research on the issue of ballast water management.

After human cholera was detected in the ballast water of several vessels entering ports on the Gulf of Mexico in the Fall of 1991, the USCG published the IMO guidelines. Voluntary compliance by mariners with the IMO guidelines was requested to decrease the possibility of further introductions of cholera and other pathogens into United States waters.

The MEPC, at its 34th Session in July 1993, established a Harmful Aquatic Organisms Working Group to address this issue on a continuing basis. The Working Group is to consider further development of the IMO guidelines as the basis for a new annex to the International Convention for the Prevention of Pollution from Ships, 1973, as modified

by the Protocol of 1978 MEPC also asked the Working Group to investigate the possibility of an international symposium on this issue.

PUBLIC FACILITY ZEBRA MUSSEL CONTROL RESEARCH AND DEVELOPMENT PROGRAM

The zebra mussel is widely distributed in the Great Lakes and is predicted to cause up to $5 billion in damage by the year 2000. The infestation has spread rapidly throughout the river systems adjacent to the Great Lakes; eventually, much of the United States is expected to be infested. Encrustation by this biofouling organism can adversely affect and has even shut down activities and systems that use surface waters. These include those associated with lake and river-borne vessels, hydropower facilities, locks and dams, municipal water supplies, and other water intake and control structures.

In response to this threat, the Assistant Secretary of the Army for Civil Works has established a program of research and technology development for the environmentally sound control of zebra mussels in and around public facilities. Responsibility for this program has been delegated to the USACE. Its objective is to develop, for rapid implementation, zebra mussel prevention and control strategies and methods for public facilities. Achievement of this objective will facilitate development of proactive, environmentally sound control programs that will minimize adverse effects and fiscal burden of zebra mussel infestations in and around public facilities. This objective will be achieved by accomplishing the following tasks:

Management, Coordination, and Information Transfer. A host of other organizations (United States and foreign government agencies, the hydropower industry, municipal water supply companies, and universities) have begun programs of research and technology development related to the zebra mussel problem. Coordination will be essential to minimize duplication of effort and maximize exchange of information. For example, the hydropower and municipal water supply industries in Europe clearly have the lead in application of engineering design management techniques. To avoid duplication of efforts, existing and emerging information will be used to the maximum extent feasible. Technical assistance to regional, state, and local entities concerned with the zebra mussel problem is essential for timely and effective implementation of control strategies in and around public facilities. Publication of a wide array of documents, ranging from technical papers and reports to newsletters intended for a nontechnical audience, will be guided in this task.

Evaluate Environmental and Physiological Factors Affecting Zebra Mussel Control Strategies. This task has two components. The first involves investigations at selected field sites of early infestation colonization rates in relation to biotic and abiotic variables. Techniques for assessment and prediction of zebra mussel population growth will be developed to support proactive implementation of control strategies. These investigations will also support development of environmentally sound control plans by contributing information on and methods for evaluating ecological consequences of zebra mussel infestations and their control. The second component involves selected laboratory and field studies of zebra mussel physiology in relation to control methods. For example,

natural seasonal shifts in physiological indices of mussel condition may be useful for determining the best timing of control attempts.

Evaluate and Improve Control Methods. Investigations will be conducted to determine desiccation, thermal tolerance, and susceptibility to low oxygen to improve options for the physical control of zebra mussels. Existing chemical and biological control technologies, including oxidizers (chlorine, ozone, etc.), molluscicides, and microbial inhibitors of mussel attachment will be evaluated. Environmental impacts of control technologies will be evaluated.

Formulate Strategies for Prevention and Control of Zebra Mussel Infestations In and Around Public Facilities. This task involves engineering design, operations, and maintenance of facilities and structures affected by zebra mussels, and will be divided into three areas. Control strategies will be developed and evaluated for: a) hydropower and locks and dams, b) other water control structures, and c) waterborne vessels, including dredges. Potential problems, priorities, and elements for the best available control strategies will be designed for specific facilities and structures through a series of technical workshops. These workshops will include industry and government representatives selected for their detailed knowledge of the design, operation, and maintenance of particular facilities and structures as well as engineers and scientists recognized for their expertise in zebra mussel control research and technology development. Elements of control strategies will include early detection monitoring, preventive options and maintenance, remedial action, re-design options, and seasonal avoidance and minimization.

BIOLOGICAL STUDY

A major impediment to resolution of many nonindigenous aquatic species policy issues is the lack of comprehensive, objective information about the effects of introductions. A paradox of the debate is the limited number of complete, balanced and scientifically sound comparisons of the positive and negative consequences of nonindigenous species.

Other than for insects and diseases introduced for pest control, few programs involve the development of systematic, balanced studies before a species is introduced. Proponents of intentional introductions stress beneficial results and tend to overlook and/or downplay undesirable consequences. Only recently have some proposed introductions been challenged resulting in somewhat open debate about the nature, likelihood, and extent of positive and negative consequences. Unfortunately, these debates tend to be fueled by rhetoric and adversarial posturing to the detriment of objective, scientific development of information to resolve the complex issues involved. Because substantial awareness of and concern about unintentional introductions is very recent, little attention has been paid to these issues to date.

A biological study to determine whether nonindigenous aquatic species threaten the ecological characteristics and economic uses of waters of the United States other than the Great Lakes must be completed. A comprehensive effort to document and compare the ecological, economic, and other relevant effects--both positive and negative--of a substantial sample of nonindigenous aquatic organisms in selected geographic areas was

initiated in 1993. When completed, this study will provide government policy-makers, scientists, engineers, industry, and the general public with a much more comprehensive and objective basis for more informed decision-making regarding a myriad of nonindigenous species issues.

PROGRAM PRIORITIES

The complexity and potential magnitude of unintentional introductions necessitates the ambitious goals established by the Act and its broad authority. However, rational and effective allocation of limited funding and personnel resources among diverse goals and program elements of this comprehensive authority is difficult. Clearly defined program priorities must be the basis for deciding how to use those limited resources and are required by the Act.

Priorities for the Program are multifaceted and interlinked. None of the program elements identified in the Act or proposed in this report would be implemented to the exclusion of the others. To the contrary, all aspects of the Act must be addressed concurrently. The challenge is to find the appropriate mix of elements for each level of effort.

Another consideration relates to the timing of activities, i.e., those undertaken in the near-term versus over the longer-term. In the developmental phase (i.e., first three to five years), a major focus of attention will be on establishment of prevention and detection and monitoring capabilities. Ensuring that a comprehensive and responsive nonindigenous aquatic species research capability is established to support the core elements of the Program and to meet other needs will also be a high priority. However, as the prevention, detection and monitoring, research, and other components of the Program become operational and routine, control initiatives are likely to assume a larger role.

While the remainder of this discussion relates to priorities among elements of the Program, important priority issues within each program element also exist. Intra-element priorities are addressed in the discussion of each element.

Prevention stands out among the other elements in terms of importance. If the initial introduction or subsequent dispersal of ANS is prevented, no detection, control, research, education, or other activities will be necessary. As the most effective and certain means of avoiding ANS problems, this element has the highest long-term priority in the Program and should be implemented even under the most constrained budgets.

Since prevention is unlikely to be completely successful, timely knowledge of the presence of a new nonindigenous aquatic species in United States waters or waters shared with other nations is essential. Monitoring changes in the distribution and abundance of nonindigenous aquatic species is also important. Therefore, detection and monitoring must also be a high priority.

A large number of nonindigenous aquatic species are already established in the United States; additional ANS are likely to be introduced in the future despite implementation of prevention initiatives. Consequently, control activities may be warranted to eliminate or minimize the impacts of such species. The priority of those activities will depend, however, on a variety of factors and will be addressed on a case-by-case basis.

Research is an essential supporting element for the three core elements --prevention, detection and monitoring, and control. However, it will generally relate to specific nonindigenous aquatic species problems and to issues associated with each of the core elements. Therefore, its priority will be linked to those core elements. Likewise, the other support elements will relate primarily to the priorities of the core elements.

The Zebra Mussel Demonstration Program and State ANS management plans are also important priorities. The Zebra Mussel Demonstration Program provides an opportunity to demonstrate an integrated approach to management of an ANS infestation. The State management plans provide a vehicle for coordination and cooperation among all involved entities, an essential ingredient to the success of the Program.

PROGRAM IMPLEMENTATION

The Task Force is responsible for ensuring comprehensive, timely implementation of the Program. Rather than just being a Task Force effort, however, implementation must bring to bear the capabilities of all interested or affected parties in a truly cooperative venture. Appropriations are authorized for FWS and NOAA to implement the Program. In addition, they may issue regulations necessary to implement the Program that will be particularly important in implementing any prevention or control decisions made by the Task Force.

Given the complex and wide-ranging problems and issues of nonindigenous species and the comprehensive nature of the Program, cooperation and coordination are essential to successful implementation. Cooperative efforts of Federal agencies and their field organizations with States, Tribes, local governments, non-governmental entities, other countries, and other interested entities will be a hallmark of implementation.

How to most effectively manage responsibilities mandated to the Task Force is an important consideration in light of its interagency nature and the traditional roles of the Federal agencies involved. Implementation of the Program will be most effective when individual activities are assigned to specific organizations with relevant responsibilities and expertise rather than trying to accomplish them through an intergovernmental task force. Task forces coordinate activities of involved agencies and other entities to achieve consistency among their activities rather than implementing programs. They encourage agencies and other interested entities to take actions that reduce duplication of efforts and address identified needs. Although the Act assigns responsibilities to the Task Force, Federal agencies and others will be responsible for implementing the Program in line with their specific authorities, priorities, and funding.

Federal and other entities potentially involved in implementing the Program have a wide variety of basic missions and expertise. Most, however, are likely to be involved in only a few aspects of the program elements and subsidiary activities. To provide a sense of this diversity, potential participation by Task Force agencies and others in key activities associated with each program element based on known areas of strength and interests is indicated in Table 4. Specific involvement will be contingent on the availability of funds.

Potentially, the Program could conflict with, duplicate, or otherwise adversely effect a number of existing nonindigenous aquatic species programs and activities. Therefore, to the greatest extent possible, implementation will seek to build on and dovetail with existing initiatives rather than supplant them. Identifying and filling gaps in existing programs and activities will be emphasized. Where compatible or complementary program goals are involved, State and other appropriate participation and the use of existing facilities and programs will be encouraged. Established mechanisms for transferring research results and technical information and for disseminating educational materials will be utilized as much as possible.

Implementation of the Program will seek to minimize changes in, or even prohibitions of, many activities that would be affected by ANS prevention and control activities. Numerous industries, individuals, and other activities potentially could be impacted. However, such adverse consequences must be balanced against the possible effects of new nonindigenous aquatic species infestations likely to occur if no action is taken. While some adverse effects on other human endeavors will be unavoidable, they will not be greater than absolutely necessary and will reflect a balancing of benefits and costs.

In response to such considerations and the large number of entities potentially interested in participating in the Program, several committees have been established to advise the Task Force on implementation. In addition to the required Great Lakes Panel on Nonindigenous Species, committees of the Task Force include the ANS Work Group (i.e., staff from Task Force agencies), Research Protocol Committee, Ruffe Control Committee, Risk Assessment and Management Committee, Detection and Monitoring Committee, Research Coordination Committee, and Zebra Mussel Coordination Committee. Each of these committees is discussed in relation to the relevant program elements.

A procedure for designating ANS is necessary. Several elements of the Program (e.g., prevention and control) and related activities (e.g., approval of State ANS management plans) require the Task Force to determine that a nonindigenous species is a nuisance. Other Federal statutes such as the injurious wildlife provision of the Lacey Act of 1900 (18 U.S.C. 42) and the Federal Noxious Weed Act of 1974 (7 U.S.C 2801 et seq.) and State laws authorize the designation of organisms that might be considered ANS. The Task Force, governmental entities, other organizations, or individuals may want to petition to have a nonindigenous species designated a nuisance for a variety of other reasons.

To ensure that requests to designate species as nuisances are substantial, allow consistent designations of ANS, and facilitate such determinations, the Task Force will develop designation criteria and procedures consistent with applicable Federal law. A registry of proposed and designated ANS, including information submitted or developed in support of those decisions, will be maintained in the Detection and Monitoring Information System.

Nonindigenous aquatic species present complex, rapidly evolving problems and policy issues for which solutions are often neither obvious nor simple. Substantial understanding of these problems and issues and how to most effectively respond to them exists. However, much more will be learned as implementation proceeds and the theories and assumptions underlying the Act and Program are tested. Hence, the Program, and the Act, should be modified where appropriate based on such "lessons learned."

Comprehensive evaluations of the extent to which and how effectively program goals are being met and whether available resources are allocated in the most effective manner will be a crucial and continuing responsibility of the Task Force. This should include annual reviews of all Federal and, to the extent practicable, other nonindigenous species

activities. Such evaluations will also provide a solid basis for recommending amendments of the Act when it comes up for reauthorization in 1995. The Task Force may subsequently establish a committee to oversee or conduct such evaluations.

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Appendix A

ECOLOGICAL AND ECONOMIC EFFECTS OF AQUATIC NUISANCE SPECIES

Nonindigenous species have the potential to cause significant ecological problems because they have been introduced into a habitat in which there are no co-evolved controls. Lack of natural controls (such as pathogens, parasites, and predators) in a new site may allow a species to grow at or near its potential, exponential growth rate. It has long been observed that introduced species often build up to high population numbers, then decline, repeating this cycle several times before settling into relative equilibrium in their new habitat (Elton 1958).

If such species become established, they may disrupt species relationships in the new habitat, reduce yields of economically important crops and game species, contribute to public health problems, and produce other adverse effects. In other, perhaps many, instances, nonindigenous species quickly die due to adverse conditions in the environment where they are introduced or fail to thrive and eventually die-out for a variety of reasons.

Not all introductions have produced unfavorable results: most of the grain, vegetable, and fruit crops grown in the United States are of foreign origin (Sharples 1983). Often, biological control agents are nonindigenous species that have been screened and otherwise tested for host-specificity to reduce the risk of their becoming invasive. Simberloff (1981) noted that the literature on exotics is probably biased to reflect those species that have become spectacularly invasive, rather than those that either have not survived or have persisted but generated only minor ecological disruption. Clearly, there are many cases in which introductions have produced lasting commercial successes accompanied by apparently negligible ecological disturbance.

This appendix provides a brief overview of the literature on nonindigenous aquatic nuisance species regarding the following topics: 1) typical ecological impacts; 2) direct impacts on human endeavors, particularly in terms of costs due to weed control and diminished game stocks; and 3) common control measures used in management of such species, and the adverse ecological effects that can be associated with them. While focusing on zebra mussels as a species of particular concern, other aquatic invaders in North America and elsewhere are discussed to illustrate these topics.

ECOLOGICAL EFFECTS OF AQUATIC NUISANCE SPECIES

As a nuisance species proliferates, its behavior and interspecific interactions often change in the new habitat. The introduced species may prey upon, outcompete, parasitize, or cause disease in native species, and in the worst cases, drive them to extinction. For example, largemouth bass were intentionally introduced into Lake Atitlan, Guatemala, in 1958 for the purpose of upgrading the fishery there and stimulating the tourist industry. The net results of the introduction proved to be very mixed, as the bass population did

grow rapidly, but at the expense of smaller native fish species, some of which were driven to extinction (Paine and Zaret 1975).

Lake Victoria, East Africa, originally supported numerous endemic cichlids and tilapia, that were consumed fresh and also preserved and sold over a large surrounding region. Lake Victoria is a habitat of considerable interest to biologists because it is a center of radiation of an unusually high number of endemic fish species; several hundred cichlid species have evolved in the Lake (Barel et al. 1985). The piscivorous Nile perch was introduced into the Lake in the 1950s, again with the intention of improving the fishery. Since the introduction of the perch, virtually all indigenous fish of commercial importance have disappeared from the Nyanza Gulf region of the lake. The perch has already eliminated the herbivorous native species, and now feeds predominantly on its own young and is estimated to comprise well over 80 percent of the fish biomass in this part of the Lake. The Nile perch is expected to move southward and eventually permanently diminish the unique species richness in Lake Victoria.

The zebra mussel, native to the Black and Caspian Seas region and now found throughout much of Europe, was unintentionally introduced into the Great Lakes, most likely by ballast water. It was first observed in Lakes St. Clair and Erie in 1988. Since then, populations have exploded and zebra mussels have been found in all five of the Great Lakes and in the Hudson, Susquehanna, Ohio, Tennessee, Mississippi, Illinois, and Arkansas River basins. The zebra mussel is significantly impacting native clam populations in Lakes Erie and St. Clair by colonizing their shells, thus interfering with their food supply. Although there were at least 18 species of native clams in Lake St. Clair in 1986, biologists are now concerned that the mussel could become virtually the only filter-feeding mollusk in the Lake, at least in the "overshoot" phase of its growth cycle. Initially, concern was expressed that the mussel would impact walleye, a popular, relatively high valued fish in the Great Lakes, by encrusting reefs, their preferred spawning habitat (Roberts 1990). However, this problem does not appear to be as significant as feared.

The sea lamprey, a parasitic invader to the Great Lakes, exemplifies how serious the ecological consequences of such an introduction can be. The lamprey apparently inhabited only Lake Ontario before completion of the Welland Canal in 1924. Although the lamprey migrated slowly into the upper lakes, by World War II it had become well established and was seriously impacting the indigenous populations of lake trout. By the 1950s, trout populations were severely reduced. Lake trout were extinct in Lake Ontario, and virtually extinct in Lakes Huron and Michigan, with only remnant populations remaining in Lake Superior. Before the lamprey was brought under adequate control, it had also contributed to the decline of most other remaining stocks of commercial value in the lakes (Christie 1974).

Introduced pathogens can cause massive die-offs of native fauna that have not developed defenses against them over evolutionary time. Oyster populations in Chesapeake Bay which have been devastated by the introduced disease Multinucleate Sphere X is a classic example. Other introduced pathogens include salmonid whirling disease of trout,

Infectious Hypodermal and Hematopoietic Necrosis virus in shrimp, and several parasites of mussels.

The significant impacts that invasive species can have on native species generate severe second-order effects in the ecosystem into which they are introduced. Changed interspecific interactions lead to disruption of food chains and, as in the case of the zebra mussel, an exotic species can dramatically change trophic relationships by diverting a disproportionate share of the primary productivity (phytoplankton, in this case). Consequently, such first-order or direct changes can in turn endanger populations of native species, and facilitate the growth of previously innocuous pests. For example, in the case of introduction of largemouth bass into Lake Atitlan, the population of a giant pied-billed grebe endemic to the lake was threatened after the bass had impacted its food sources (Paine and Zaret 1975). In the case of Lake Gatun, in Panama, peacock bass were introduced in 1965, again with intentions of upgrading the fishery. The carnivorous bass greatly diminished populations of smaller native fish species and eventually contributed to an outbreak of malaria mosquitoes because the smaller fish no longer consumed their larvae.

In the Sacramento-San Joaquin estuary, exotic copepods (Sinocalanus doeri and Pseudodiatomous spp.) have displaced an indigenous copepod (Eurytemora affinis). These foreign copepods were probably introduced through ballast water. Due to the fact that the native species is a preferred prey source for native fish in the larval stage, these introductions are expected to reduce larval survival of estuarine stocks, some of which are already vulnerable due to habitat alteration.

The sea lamprey, after virtually eliminating the lake trout, began to prey upon less preferred species and as a result dramatically changed the species composition of the Great Lakes. The lamprey subsequently severely reduced whitefish and burbot stocks, then began preying upon lake herring and cisco species (Christie 1974). Although it is difficult to distinguish definitively between the amount of decline due to lamprey predation and that attributable to fishing pressure and to the introduction of other invaders, particularly the alewife, the presence of the lamprey is implicated in significant reductions in all of the above cases.

DIRECT IMPACTS OF NUISANCE SPECIES ON HUMAN SOCIETY

The introduction of exotics, and their disruption of the host ecosystem, can ultimately have important socioeconomic repercussions. We have seen that the invader can threaten native stocks of economic importance such as those exploited commercially or used for subsistence. Or, it can generate significant public expense through biofouling, a process by which materials such as plant foliage and mollusk shells clog waterways, damage moving equipment parts, and colonize sunken structures.

Roberts (1990) estimated that the total costs associated with the control of the sea lamprey and restocking the Great Lakes with trout amounted to tens of millions of

dollars. This figure does not include present annual expenditures on lamprey control, or lost revenues due to reduced catches during the period prior to lamprey control.

Since the elimination of the native fishery in Lake Atitlan, Guatemala, the introduced largemouth bass are most effectively caught using SCUBA gear or from motor boats. Since these techniques are beyond the means of the average native fisherman, fishing no longer provides supplementary income in this community (Paine and Zaret 1975).

Likewise, the introduction of Nile perch arguably has not increased the total market value of fish caught from Lake Victoria in East Africa. In terms of pounds caught, the annual perch catch is higher than that of native species. However, Nile perch sell for only one thirtieth as much as indigenous fish. As with Lake Atitlan, the introduction of Nile perch also produced adverse sociological effects. Fishermen who could formerly subsist on small-scale native fisheries are being driven out of business and production is being concentrated in the hands of wealthier individuals who can afford the larger, stronger, and more expensive nets required to harvest the Nile perch (Barel et al. 1985).

Several exotic aquatic plant species are notable for biofouling of lakes, streams, and impoundments. In addition to increasing the rate of eutrophication and sedimentation in these water bodies, aquatic weeds reduce navigability by catching in boat propellers, and impair recreation values by diminishing water quality on public lands.

Hydrilla and alligatorweed, two imports from South America, were responsible for extensive clogging of waterways and irrigation ditches in the Southern United States from the turn of the century until the last few decades, and Eurasian watermilfoil has created similar problems in northern lakes and streams since about 1950. Nuisance growths of Eurasian watermilfoil have been reported across the U.S. and Canada (Smith and Barko 1984). Alligatorweed and watermilfoil are both propagated vegetatively; a major means of dispersal is transport of stem fragments by water movement and boat transport.

Barnacles and zebra mussels can also cause expensive biofouling if their populations reach outbreak proportions. The zebra mussel specifically is a prolific colonizer and is able to grow on stone, steel, concrete, wood, plastic, and glass. Zebra mussel densities along lakeshores and riverbanks can exceed one hundred thousand individuals per square meter (O'Neill 1990).

The zebra mussel is already fouling water intake pipes at electric power plants and public water supply facilities along Lake Erie and the Niagara River. Mechanical problems associated with this colonization include loss of intake head, and serious clogging of water lines and equipment. Cleaning and treatment of these facilities is projected to be quite costly; plant redesign and zebra mussel control for the seventy-two nuclear and fossil fuel generating plants in the Great Lakes Basin are anticipated to cost more than $860 million over the next ten years (O'Neill, 1990). Municipalities and industries in the region are also projected to spend about another billion dollars controlling mollusk growths over the same period.

Biofouling by the mussel will probably also impact commercial navigation and recreational boating. Larval mussels drawn into a vessel's cooling system can settle and grow there, ultimately leading to engine overheating and damage. Marker buoys in the Great Lakes can sink due to the weight of attached mussels; this has already occurred in Lakes Erie and St. Clair (O'Neill 1990). Thus, in addition to affecting ecological relationships, the introduction of exotics can also have significant direct effects on human society.

CONTROL MEASURES AND THEIR IMPACTS

Four general methods can be used to control the proliferation of invasive aquatic species: chemical, biological, mechanical or physical, and cultural. Each control method can have adverse side effects on nontarget species and otherwise impact ecosystems. Specific damages that can occur vary with the particular product and the target ecosystem, and are difficult to accurately predict.

Chemical Control

Chemical control programs involve the application of aquatic herbicides and selective pesticides to aquatic flora and fauna. However, unexpected impacts on nontarget organisms and ecological processes often occur due to the toxicity of the chemicals used and variability in the aquatic systems treated. The specific ecological risks posed will vary depending on the species, toxicity, fate, transport, and persistence of the chemical chosen, whether or not it bioaccumulates, and other pertinent features of the system impacted. Such features are discussed in depth in the ecotoxicological literature. There are notable successes however: chemical control has been used very profitably in the case of the sea lamprey. The International Great Lakes Fishery Commission developed a selective toxicant which takes advantage of the parasite's life history. Lamprey adults migrate upstream to spawn in gravel beds. After hatching, the lamprey lives as a sedentary larva (ammocoete) in the gravel beds for 2-3 years. Only after emerging from this stage does it migrate back to the lakes and become parasitic. A selective toxicant was developed which is applied to the gravel beds in the spring to kill the ammocoetes: 3 triflouromethyl-4-nitrophenol (TFM) (Christie 1974). TFM is used in conjunction with physical barriers installed on streams which prevent adults from returning to the spawning grounds. This combination of approaches is effectively controlling the parasite in the Great Lakes.

Chemical control techniques can also be used rather effectively on aquatic weed species without generating significant ecological side-effects. 2,4-D and diquat have been used in aquatic weed control since the 1960s and typically control such troublesome vegetation effectively with limited harm to aquatic fauna. However, whenever large amounts of vegetation decompose in aquatic systems, depletion of dissolved oxygen can occur which can lead to significant faunal die-off, particularly during high-temperature conditions (Charudattan 1991).

The environmental hazards that may be posed by chemical control of zebra mussels vary considerably depending on the specific chemicals, application and concentrations used. Managers of power plants would like to identify safe chemical methods for treating lake water that is circulated through their cooling systems. Chlorine and ozone can both be used for this purpose, but must be removed from discharge water to comply with State and Federal water standards. Technically, removing added ozone is more difficult than dechlorinating water in power plant applications. At this point, no affected power plant on the Great Lakes considers either treatment of cooling water to be economically feasible. Chlorination of service water used by utilities and plants for smaller-scale uses such as fire fighting and lubrication is already common because such water is used in much smaller amounts, and can be more economically treated to meet state discharge limits.

Commercial molluscicides are organic toxicants that can be used to treat process water in instances where it can be held in place for periods of six hours or longer. These compounds can be very effective: according to O'Neill (1991), nuclear power plants which utilize them have obtained 90 percent die-off rates. The active ingredients in molluscicides can be removed by treatment with bentonite clay. Field tests with large fish exposed to water treated in this manner have shown no toxicity. Some environmentalists are concerned that the inert ingredients that bentonite does not remove may cause adverse environmental effects, but as yet these effects are not well understood.

Several organometallic compounds are used to keep the zebra mussel from adhering to boat hulls and other sunken structures. Tributyl tin oxide is currently applied to commercial vessels, but poses serious problems for the environment because it ablates from the hulls and is toxic to aquatic organisms. Organometallic compounds also bioaccumulate. Copper compounds are often used for the same purposes in states where the use of tributyl tin is restricted, but all heavy metal-based paints pose the same types of environmental problems. Initial field trials indicate that zinc may prove to be very effective in limiting the growth of the mussel. Although chemists are presently investigating application of zinc-based compounds, none have yet been developed.

Experimental silicon paints that prevent zebra mussels from adhering as tightly as usual to a surface are also in limited use. Drawbacks of these paints include their expense and their water solubility that requires frequent reapplication.

Biological Control

Biological control involves searching for the natural enemies of a pest or nuisance species, especially those that co-evolved in its original habitat, and introducing them in a controlled manner. They re-establish environmental resistance (i.e., a complement of natural control agents) and maintain pest species numbers at a much lower level. Another strategy often effective against pests such as some insects and sea lamprey in the Great Lakes that reproduce only once during a season or lifetime involves releasing sterile males to limit reproductive success. However, this approach is just beginning to be employed in aquatic ecosystems. Biological control agents can themselves become pests

and consequently must be screened carefully before introduction (Huffaker 1971). Biological methods have been applied much more intensively to control terrestrial invaders, particularly insect pests, than to aquatic species (Dahlsten 1984).

Nuisance species usually are not eradicated by biological control; pest populations are simply held at less damaging levels. It is counterproductive, from the standpoint of biological control, to drive pest numbers towards extinction, because the control agent population will ultimately suffer as well. Biological control does not produce results as rapidly as chemical and mechanical controls, because in order to work properly, an entire agent population, and sometimes a complex of several agent species, must become established. It may be virtually ineffective in entire regions due to adverse weather or unexpected interference from other species. In the case of aquatic weed control on private property, landowners often prefer to apply herbicides to rapidly restore water clarity and improve the water for swimming rather than to wait for the lag period needed for biological control agents to become established (Charudattan 1991).

However, in spite of such drawbacks, biological control can be an extremely effective means of limiting invasive species populations, because the populations of the beneficial organism can grow as rapidly as the exotic pest did in its "overshoot" growth phase. It is typically also a cost-effective strategy, because the net cost associated with importing, screening, rearing, and releasing a control agent is typically a fraction of that of the annual (or more frequent) use of pesticides or mechanical controls. The introduction of a biological control agent usually has very minimal adverse ecological impacts as well, if it has been screened to selectively prey upon the one pest of concern.

A biocontrol strategy has been very successfully implemented in order to control alligatorweed in the Southern United States. The main biotic control agent in the program is the alligatorweed flea beetle. The beetle is supplemented in its activity by a moth (Coulson 1977). Waterhyacinth has also become considerably less troublesome after the introduction of two weevil species to Florida and California from South America (Charudattan 1986). In reality, aquatic weeds often infest a body of water in concert and need to be managed together.

Some research is now underway to identify species capable of biologically controlling zebra mussels. A consortium of electric utilities is sponsoring a search for a bacterial agent to which this species is susceptible. Activity of natural predators can also be enhanced to some degree. Dr. David Garten at Ohio State University and researchers with the U.S. Fish and Wildlife Service are investigating the ability of a bottom-feeding fish, the freshwater drum, to feed on the mussel. This fish is equipped with strong teeth in the back of its throat which give it the ability to crack mussel shells. Researchers believe that by placing fishing restrictions on the drum, enhanced recruitment of large individuals may reduce the mussel population in Lake Erie. However, they do not advocate importing the drum into the other lakes. Because diving ducks are an important predator of the mussel in Europe, the U.S. Fish and Wildlife Service is also studying the behavior of tufted ducks in the Great Lakes. Researchers have determined that more diving ducks are visiting the lakes in the winter since the mussel was introduced, but this is not

expected to result in significant control of the mollusk, because diving duck populations are presently limited by disturbance of their summer nesting sites in the subarctic (Gannon 1991).

Mechanical or Physical Control

Mechanical or physical control techniques are frequently effective and appropriate, but often are labor intensive and therefore very expensive. Chopping aquatic weeds or harvesting them with underwater weed cutters and scraping mollusks and other organisms from boat hulls, pilings, ladders and docks and piers are well known examples of such control. However, such procedures must be performed repeatedly during the growing season and, in the instance of vegetatively propagated plants, can actually exacerbate dispersal. Mechanical or physical control is often best used in conjunction with chemical, biological and cultural control measures as part of an "integrated pest management" (IPM) control strategy.

In addition to physically scraping the zebra mussel from boat hulls and other structures, there are a number of other promising mechanical control techniques now being investigated. Hot water circulated through the pipes for periods of half an hour to forty-five minutes will kill mussels colonizing power plants. Many power plants on the Great Lakes are considering retrofits to provide them with this capability. Preliminary studies have also shown that ultrasound transducers in plant pipelines stun young mussels and affect them physiologically, impairing their ability to colonize. Ultraviolet-B radiation also appears to be capable of killing zebra mussel larvae, and promises to be a useful way to treat drinking water (O'Neill 1991).

Cultural Control

Cultural control involves manipulating the environment of an invading organism to reduce its ability to become established, develop nuisance population levels, or even survive. This approach is particularly useful in highly disturbed environments where no-target impacts are likely to be more acceptable. For instance, draining wetlands or other water bodies is used to hold populations of carp in waterfowl impoundments in check and to reduce stands of aquatic plants in reservoirs and irrigation systems. Changes in water chemistry and/or increases in water temperature in power plant intakes at crucial stages in the life cycle of zebra mussels may reduce veliger settlement.

An important variation of cultural control involves protecting or creating environments where desired species or assemblages of species are not threatened by aquatic nuisance species. This may, for instance, entail establishing refugia in natural habitats or creating artificial habitats where invading nuisance species can be excluded or controlled and native species can be maintained and propagated over an extended period. Zebra mussels are believed to be a major threat to native bivalve mollusks and cannot be controlled in open ecosystems. Hence, protecting these species in natural refugia where the likelihood of excluding zebra mussels is high or, although very difficult, rearing and propagating them in artificial environments such as fish hatcheries is under active consideration.

CONCLUSION

Extensive, if somewhat anecdotal, literature exists on nonindigenous species. Although many such introductions have undoubtedly had neutral or beneficial net effects on their receiving ecosystems and on human society, it has long been recognized that some invaders escape control, with extremely damaging and costly consequences. The case of the sea lamprey is an example of one such introduction into the Great Lakes. The zebra mussel threatens to be an even more serious invader because it is likely to infest waterways nationwide and generate billions of dollars worth of damage. Virtually no type of control technique operates without some adverse environmental side-effects, and the general types of ecological risks each one can pose should be evaluated as carefully as possible before a chosen method is applied on any sort of scale. Generally, chemical controls pose more ecological risk than mechanical or carefully selected biological control methods. Realistically, however, a combination of techniques, monitored for effectiveness and ecological side-effects, is the best approach for control of any serious aquatic invader, including the zebra mussel.

Appendix B

Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990

Appendix C

MEMBERS OF THE AQUATIC NUISANCE SPECIES TASK FORCE AND ITS WORK GROUP INVOLVED IN DEVELOPING THE PROGRAM

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Jean Neitzke, Office of Canadian Affairs, U.S. Department of State -- Member, October 1991-Present

H. Stetson Tinkham, Office of Fishery Affairs, Bureau of Oceans and International Environmental and Scientific Affairs, U.S. Department of State -- Member, October 1991-January 1992

Steve Pruett, Office of Fishery Affairs, Bureau of Oceans and International Environmental and Scientific Affairs, U.S. Department of State -- Member, March 1991-October 1991

Jack Felt, Office of Canadian Affairs, U.S. Department of State -- Member, February 1991-August 1991

Appendix D

SCIENTIFIC NAMES OF SPECIES CITED IN THE PROGRAM AND ITS APPENDICES

Common Name	Scientific Name	Type of Organism
Alewife	Alosa pseudoharengus	Fish
Alligatorweed	Alternanthera philoxeroides	Plant
Alligatorweed flea beetle	Agasicles hygrophila	Insect
Alligatorweed stem borer	Vogtia malloi	Insect
Ambulia	Limnophila sessilifolia	Plant
American oyster	Crassostera virginica	Mollusc
Amphipod	Corophium curvispinum	Crustacean
Anchored [rooted] water hyacinth	Eichhornia azurea	Plant
Antipodes snail	Potamopyrgus antipodarum	Mollusc
Apache trout	Oncorhynchus apache	Fish
[Water] Arrowhead	Sagittaria stagnorum	Plant
Asian clam	Potamocorbula amurensis	Mollusc
Asian clam	Corbicula fluminea	Mollusc
Australian pine	Casuarina equisetifolia	Plant
Bald eagle	Haliaeetus leucocephalus	Bird
Barnacles	Order Cirripedia	Crustaceans
Blackchin tilapia	Tilapia melanotheron	Fish
Black-fronted dioch	See:Dioch	
Blue tilapia	Tilapia aurea	Fish
Bighead carp	Hypophthalmichthys nobilis	Fish
Benghal dayflower	Commelina benghalensis	Plant
Brown tree snake	Boiga irregularis	Reptile
Brown trout	Salmo trutta	Fish
Burbot	Lota lota	Fish
Catclaw mimosa	Mimosa pigra var. pigra	Plant
Cherry salmon	Oncorhynchus masou	Fish
Chinese mitten crab	Eriocheir sinensus	Crustacean
Cholera	Vibrio cholerae	Bacteria
Cichlids	Cichlidae Family	Fish

Chubs (Great Lakes)	Coregonus spp.	Fish
Cisco	See:Lake herring	
Common carp	Cyprinus carpio	Fish
Copepod	Eurytemora affinis	Crustacean
Copepod	Pseudodiatomous spp.	Crustacean
Copepod	Sinocalanus doeri	Crustacean
Curly[curled]leaf pondweed	Potamogeton crispus	Plant
Dhole	See:Indian wild dog	
Dioch	Quelea quelea	Bird
Eurasian watermilfoil	Myriophyllum spicatum	Plant
European flounder	Platichthys flesus	Fish
European rabbit	Oryctolagus spp.	Mammal
Exotic burreed	Sparganium erectum	Plant
Filamentous algae	Cladophora spp., Ulothrix spp., Stigeoclonium spp., Oedogonium spp.	Plant
Flowering rush	Butomus umbellatus	Plant
Flying fox	Pteroous spp.	Mammal
Fruit bat	See:Flying fox	
Giant salvinia	Salvinia auriculata, S. biloba, S. herzoggi, S. molesta	Plants
Giant water flea	Bythotrephes cederstroemi	Crustacean
Golden eagle	Aquila chrysaetos	Bird
Grass carp	Ctenopharyngodon idella	Fish
Gypsy moth	Porthetria dispar	Insect
Hollyleaf naiad	Najas marina	Plant
Humans	Homo sapiens	Mammal
Hydrilla	Hydrilla verticillata	Plant
Indian wild dog	Cuon spp.	Mammal
Infectious Hypodermal and Hematopoietic Necrosis (IHHN)	-----	Parvovirus
Infectious Hematopoietic Necrosis (IHN)	-----	Rhabdovirus
Infectious Pancreatic Necrosis (IPN)	-----	Birnavirus
Java sparrow	Padda oryzivora	Bird

Lake herring	Coregonus artedi	Fish
Lake trout	Salvelinus namaycush	Fish
Largemouth bass	Micropterus salmoides	Fish
Leafy spurge	Euphorbia esula	Plant
Macroalgae	Nilellopsis spp.	Plant
Malaria mosquitoes	Anopheles spp.	Insect
Meerkat	See:Mongoose	
Melaleuca	Melaleuca quinquenervia	Plant
Miramar weed	Hygrophila polysperma	Plant
Mitten crabs	Eriocheir spp.	Crusateans
Mongoose	Herpestes auropunctatus, Atilax spp, Cynictis spp., Helogale spp.,Heroestes spp., Ichneumia spp.,Munzos spp., Suricata spp.	Mammal
Mosquito fern	Azolla pinnata	Plant
Moss	Class Musci	Plants
Mozambique tilapia	Tilapia mossambica	Fish
Multimammate mouse	See:Multimammate rat	
Multimammate rat	Mastomys spp.	Mammal
Multinucleate Sphere X (MSX)	Haplospiridium nelsoni	Protozoa
Muskrat	Ondatra zibethicus	Mammal
Mussels	Various species of the Margaritiferidae, Mytilidae and Unionidae Families	Molluscs
Nile perch	Lates niloticus	Fish
Oncorhynchus masou virus	-----	Herpesvirus
Oyster (Chesapeake Bay)	Crassostrea virginica	Mollusc
Pacific salmon	Oncorhynchus spp.	Fish
Parasitic copepod	Mytilicola porrectus	Crustacean
Parrots	Order Psittaciformes	Birds
Phytoplankton	Dinoflagellates, various algae, etc.	Plants
Pink starling	Sturnus roseus	Bird
Purple loosestrife	Lythrum salicaria	Plant
Quagga mussel	Dreissena bugensis	Mollusc

Raccoon dog	Nyctereutes procyonoides	Mammal
Rainbow trout	Oncorhynchus mykiss	Fish
Redbelly tilapia	Tilapia zilli	Fish
Red-billed dioch	See:Dioch	
Red dog	See:Indian wild dog	
Red rice	Oryza longistaminata, O. punctata, O. rufipogon	Plants
Red-whiskered bul-bul	Pycnonotus jocosus	Bird
Rosy pastor	See:Pink starling	
Round Goby	Neogobius melanostomus	Fish
Rudd	Scardinius erythrophthalmus	Fish
Ruffe	Gymnocephalus cernuus	Fish
Russian olive	Elaeagnus augustifloia	Plant
Sago pondweed	Potamogeton pectinatus	Plant
Salmonid whirling disease	Myxobolus cerebralis	Protozoa
Salmonids	Salmonidae Family	Fish
Saltcedar	Tamarix pentandra	Plant
Sea lamprey	Petromyzon marinus	Fish
Shrimp	Penaeidae Family	Crustaceans
Smooth cordgrass	Spartina alterniflora	Plant
Spikerush	Eleocharis acicularis	Plant
Spiny[leaf] naiad	Najas marina	Plant
Spiny water flea	See:Giant water flea	
Sudan dioch	See:Dioch	
Tilapia	Tilapia spp.	Fish
Tubenose goby	Proterorhinus marmoratus	Fish
Viral Hemorrhagic Septicemia (VHS)	-----	Rhabdovirus
Walking cat	Clariidae Family	Fish
Walleye	Stizostedion vitreum	Fish
Water-aloe	Stratiotes aloides	Plant
Water hyacinth	Eichhornia crassipes	Plant
Water hyacinth weevil		Insect
Water-spinach	Ipomoea aquatica	Plant
White amur	See:Grass carp	

White Fish	Coregonus clupeaformis	Fish
Yellow perch	Perca flavescens	Fish
Zander	Stizostedion lucioperca	Fish
Zebra mussel	Dreissena polymorpha	Mollusc
-----	Monochoria hastata	Plant
-----	Monochoria vaginalis	Plant

Appendix E

SELECTED NONINDIGENOUS SPECIES AUTHORITIES AND ACTIVITIES

INTRODUCTION

Nonindigenous species have been imported into and transferred within North America since the beginning of European colonization. Spanish explorers introduced horses and burros when they first arrived. The introduction of exotic fish began three centuries ago (McCann 1984), continued sporadically into this century, accelerated substantially after World War II, and peaked in the early 1960s (Welcomme 1986). Interest in nonindigenous fish, shellfish, algae and plants for commercial purposes remains high. Because of the substantial adverse impacts of the zebra mussel infestation, the private sector has become deeply involved in control activities since 1989.

In response to this early interest and, more recently, concern about imports of nonindigenous and their transfer within the United States, several Federal and State programs were established during the past century to both facilitate and regulate such introductions. Most address problem infestations; a few promote or regulate introductions. An understanding of the nature and scope of existing programs and activities is essential if the Program is to effectively build on, rather than duplicate, on-going governmental efforts.

To provide a sense of the nature and scope of existing nonindigenous species activities and programs, a number are described in this appendix. However, Federal efforts to detect and monitor exotic fishes, ballast water and shipping activities, and the Public Facility Zebra Mussel Control Research and Development Program authorized by section 1202(i)(2) of the Act are described in the Program (pages 19, 40 to 45, and 46 to 47, respectively).

Estimates of Federal funding for selected nonindigenous species activities for fiscal years 1990 through 1993 are presented by agency and the principal elements of the Program and other requirements of the Act in Table E-2. Because the primary focus of the Program is on unintentional introductions, funding related to the culture of nonindigenous fish and other organisms is not included in Table E-1.

All Federal agencies with nonindigenous species activities may not be included in the table and all nonindigenous species activities of the agencies identified may not be displayed. Hence, the funding information presented in Table E-1 must be considered minimum estimates.

Table E-1

DEPARTMENT OF THE INTERIOR

U.S. FISH AND WILDLIFE SERVICE

Beginning with the establishment of the U.S. Fish Commission in 1871, the U.S. Fish and Wildlife Service (FWS) has been inextricably linked to nonindigenous species issues and activities. On-going FWS activities related to nonindigenous species are summarized in Table E-2 (page E-12) in terms of the elements of the Program and other responsibilities under the Act. Discussed in the remainder of this section is some historical FWS involvement with nonindigenous species as well as several current activities.

In the context of resource management philosophies prevalent in the late nineteenth century, FWS was instrumental in establishing populations of the brown trout and common carp in the 1870s and 1880s. Subsequently, FWS was involved intentionally or otherwise with the introduction of four other species of fish. As indicated by the enactment of the injurious wildlife provision in the Lacey Act of 1900 (18 U.S.C. 42), the need to consider potential adverse consequences began to be a focus of FWS dealings with nonindigenous species by the turn of the century. However, scientific and policy consensus regarding nonindigenous species has not been achieved. Hence, as late as the 1950s, FWS supported studies assessing the potential for introducing upland game birds.

Authority for FWS activities supporting the introduction of fish and other aquatic organisms is provided by several basic statutes. Authorities that have been used to introduce exotic fish and wildlife into the United States include the 1871 legislation establishing the U.S. Fish Commission (16 Stat. 593) and the Fish and Wildlife Act of 1956 (16 U.S.C. 742a-742j). FWS has substantially less authority to prevent or regulate the introduction of nonindigenous aquatic organisms.

FWS research and development responsibilities and activities were transferred to the National Biological Survey upon its establishment on November 11, 1993.1 The NBS is described subsequently (page E-26).

Fish Parasites and Diseases

Fish culture has been a central responsibility of FWS since its inception. Recognizing the presence of diseases and parasites and preventing outbreaks and their spread is a principal concern of all fish culturists. Consequently, FWS has been a leader and continues to play a crucial role in fish health research and management. Currently, FWS spends in excess of $500,000 annually to prevent or minimize the impacts of nonindigenous fish diseases and parasites in national fish hatcheries. This work is conducted through nine fish health centers. In addition, State, Tribal and private fish and shellfish culture activities devote substantial funds to nonindigenous disease problems.

Table E-2

Sea Lamprey Control in the Great Lakes

In the 1940s and 1950s, most native lake trout stocks in the Great Lakes collapsed due to overharvest compounded by predation from nonindigenous sea lampreys. In the early 1950s, FWS scientists discovered effective control techniques and were instrumental in

developing control strategies. To ensure a comprehensive, ecosystem-wide control program, the United States and Canada concluded the Great Lakes Fishery Convention (6 U.S.T. 2836) in 1954. The Great Lakes Fishery Act of 1956 (16 U.S.C. 931) implements the Convention in the United States. Under contract with the binational Great Lakes Fishery Commission established by the Convention, FWS became the agent for sea lamprey control research and operations in the U.S. portion of the Great Lakes. These activities continue to be a major FWS responsibility.

Regulation of Injurious Wildlife Imports

Prior to the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (16 U.S.C. 4701-4741), the injurious wildlife provision of the Lacey Act of 1900 was most comprehensive Federal authority for controlling the introduction of fish and wildlife. This authority specifically prohibits the import of the mongoose (Herpestes auropunctatus) and fruit bats of the genus Ptoropus into the United States and its territories and possessions, and their transport between the continental United States and those territories and possessions, including the District of Columbia. In addition, the Secretary of the Interior is authorized to regulate the import of wildlife deemed potentially injurious to human beings, the interests of forestry, agriculture and horticulture, and the wildlife of the United States. The terms wildlife and wildlife resources include: mammals, birds, fish, mollusks, crustaceans, amphibians and reptiles; their eggs and offspring; and the "aquatic and land vegetation upon which such wildlife resources are dependent."

From the beginning, implementation of this authority has involved prohibiting imports of a limited number of species known to be undesirable. Such an approach is reactive and has other significant shortcomings that are discussed later. Consequently, the potential for effectiveness of the injurious wildlife provision have not been realized.

FWS regulations implementing the injurious wildlife provision are included as Part 16 of Title 50, Code of Federal Regulations. The regulations prohibit the importation into the United States or its territories of dead fish or their eggs of the family Salmonidae and, if deemed potentially injurious to the health and welfare of human beings, the interests of forestry, agriculture and horticulture, or the welfare and survival of wildlife, live wildlife and their eggs, except Psittacine birds. Exceptions to this general prohibition are then provided that limit the effect of prohibitions to a few clearly undesirable species or taxa imported by entities other than Federal agencies.

Table E-3

Table E-4

More specifically, the regulations provide that:

o species or taxa of wildlife other than those listed in Table E-3 may be imported for scientific, medical, educational, exhibition, or propagation purposes without a permit merely by filing a written declaration with United States Customs at the point of entry;

o species or taxa listed in Table E-3 may be imported into, and shipped within, the United States for zoological, educational, medical, or scientific purposes under permits issued by FWS;

o imported wildlife can be released into the wild only by the State wildlife conservation agency with jurisdiction over the area of release or by persons with prior written permission from that agency;

o Federal agencies can import and transport live wildlife, except bald and golden eagles and migratory birds, solely for their own use upon filing a written declaration with United States Customs at the point of entry [However, such imports would be subject to Executive Order 11987--Exotic Organisms.];

o importation of dead specimens of wildlife, except migratory birds, game mammals from Mexico, and bald and golden eagles, is allowed without a permit for museum or scientific collection purposes upon the filing of a written declaration with United States Customs at the point of entry; and

o live or dead uneviscerated fish, live fertilized eggs, or gametes of the family Salmonidae may be imported by direct shipment if accompanied by certification that virus assays using specified methods had been conducted on samples from the fish lots from which the shipment originated and found free of the Oncorhynchus masou virus and the viruses causing viral hemorrhagic septicemia, infectious hematopoietic necrosis, and infectious pancreatic necrosis. In addition, all shipments must be disinfected less than 24 hours prior to shipping by a specified method and then maintained in pathogen free water. The certification must be in English, printed or typed in a specified format, contain specific information, and signed by a qualified fish pathologist designated by FWS' Director.

In addition to being reactionary, only a limited number of species and taxa are listed under this "exclusionary or dirty list" approach and rulemaking to add species is cumbersome and time consuming. Presently only one family of fish, one genus of crustaceans, one genus of mollusks, 11 genera of mammals, and 10 individual species are listed as injurious wildlife. The only listings since 1973 were the raccoon dog in 1982, mitten crabs in 1989, the brown tree snake in 1990, zebra mussels in 1991, and three viruses of fish in late 1993. Salmonid whirling disease was deleted by the 1993 rulemaking.

The Federal rulemaking process is intended to be transparent and provide notice of and opportunities for public involvement in decisions such as listing injurious wildlife. As a consequence, even normal rulemaking is a lengthy and involved process that is not conducive to responding to imminent importations. Most of recent injurious wildlife listings required at least three years during which time importations could continue.

Timing problems associated with the regulatory process are compounded by the lack of outside interest or pressure to add species or taxa, including petitions from non-Service

entities, and limited agency resources allocated to this task. Even with the present heightened concern about nonindigenous species introductions, no species are presently under consideration for listing as injurious.

Uncertainty about the timing of new imports is a significant disincentive to investing limited resources in listing efforts in anticipation of importations. During the 1980s, FWS' Gainesville, Florida, research facility began to develop information about potential nonindigenous fish imports and a general idea of their timing. This information was not formally compiled nor used as the basis for regulatory initiatives.

By the early 1970s, the shortcomings of the existing approach were obvious. Further, it became clear that effective application of the injurious wildlife provisions required a new approach that anticipated, rather than reacted, to pending imports. Thus began an ultimately unsuccessful attempt to shift to a proactive strategy for implementing the injurious wildlife provision of the Lacey Act of 1900.

On December 20, 1973, FWS proposed to modify its injurious wildlife regulations to allow the import of species or taxa determined to pose little threat to indigenous wildlife and their habitat, agricultural and forestry activities, and human health and welfare (38 FR 34970). Only a few hundred low risk species, predominantly freshwater fishes, were listed. Other species still could have been imported for scientific, educational, zoological or medical purposes under a permit system.

The fundamental change reflected in the proposal was that most nonindigenous wildlife, in the absence of reliable information to the contrary, were considered potentially injurious to the interests defined in the statute. Because of this changed philosophy, this proposal came to be referred to as the "clean list" approach. One of its important effects would have been to shift the burden of proving how injurious a species or other taxa might be from FWS to those proposing to import the species.

This fundamental shift in implementation strategy quickly became controversial. The public comment period on the initial proposed rule eventually totalled nearly nine months, during which four public hearings were held and more than 4,300 predominantly critical comments were received.

A revised proposal was prepared that retained the clean list strategy, but included many changes in response to specific concerns about the original proposal. In particular, a substantial number of additional species-- principally tropical fish--were included in the proposed list of low risk species. The revised proposal was republished on February 24, 1975 (40 FR 7935).

By the end of the comment period on April 10, 1975, nearly 1,200 comments were received on this revised proposal. Those comments identified a variety of adverse impacts. For instance, the pet industry and others contended proof that the importation of most wild animals is inherently injurious was insufficient. Opponents also asserted that the proposed regulations would have been particularly disruptive to the tropical fish

industry. Since past experience suggested that previously unknown tropical fish species would command high prices when they were discovered, they claimed exclusion of these taxa unless proven harmless would have an adverse effect on this segment of the pet industry.

Based on the predominantly adverse comments on the second iteration of the proposed rule, yet another proposal was published on March 7, 1977 (42 FR 12972). The preamble to the proposed rule reiterated that all wildlife outside its native habitat is potentially injurious to one or more of the interests designated in the injurious wildlife provision. Also acknowledged, however, was that the degree of risk varies from species to species. Based on nine criteria specified in the preamble, a number of additional species were determined to be injurious.

As with the earlier proposals, the numerous comments received on the 1977 version of the proposed regulations were mostly critical. As a consequence, attempts to modify FWS' injurious wildlife regulations to enhance their effectiveness were abandoned. Implementation of the injurious wildlife provision is still based on the dirty or exclusionary list strategy involving a limited number of prohibited species.

Executive Order 11987--Exotic Organisms

This Executive Order, signed by President Carter on May 24, 1977 (42 U.S.C. 4321), establishes Federal agency responsibilities regarding the import and export of exotic plants and animals. It requires Federal agencies, to the extent permitted by law, to restrict three activities:

o the introduction of exotic species into land and waters under their jurisdiction;

o the importation of exotic organisms for introduction into any natural ecosystem of the United States; and

o the export of native species for introduction into ecosystems outside the United States.

The Secretaries of Agriculture or the Interior may make exceptions to these restrictions if they find that such importations or exportations will have no adverse effect on natural ecosystems. Exotics were defined as "all species of plants and animals not naturally occurring, either presently or historically, in any ecosystem of the United States." In addition, the Secretary of the Interior, in consultation with the Secretary of Agriculture and the heads of other appropriate agencies, was directed to develop regulations implementing the Executive Order on a Government-wide basis.

In fulfillment of the Secretary's responsibility, FWS prepared a draft of the required regulations. The regulations were intended to be in addition to, not in lieu of, current Federal restrictions and conditions on the introduction or importation of exotic and native animal species, including endangered and threatened insects. Under the draft proposed

rule, executive agencies would be required to review all activities they conduct, fund or authorize and identify:

o all proposed introductions into natural ecosystems;

o any proposed importation for the purposes of introduction into a natural ecosystem; and

o any proposed export of native species for introductions into natural ecosystems outside the United States.

Whenever such proposed activities were identified, the draft regulations required that the agency request a biological opinion from FWS' Regional Director for the Region where the proposed activity would be carried out. Agencies were to be responsible for conducting appropriate studies and providing FWS with enough biological information to establish the effects of a proposed importation or exportation on natural ecosystems.

Within 90 days after the receipt of a written request for a biological opinion that provided all necessary biological information, FWS would analyze the proposed action and issue its biological opinion. The opinion could recommend modification of the proposed importation or exportation to ensure that such actions would not result in any adverse effects on a natural ecosystem. In rendering its biological opinion, FWS would have to ascertain whether receiving States or nations concurred with a proposed introduction and that such actions would be in compliance with all applicable laws and regulations. Upon receipt of FWS' biological opinion, the proposing agency would be responsible for satisfying the requirements of Executive Order 11987.

Although the draft regulations were not subjected to full public and peer review, limited internal review identified several concerns. Previously introduced exotic species that had become established as viable, self-sustaining populations in a natural ecosystem of the United States were considered "naturally occurring" and, therefore, not subject to the draft regulations. In addition, non-feral domesticated animals and plant cultivars were not covered.

The draft regulations were never published as a proposed rule, let alone made final and implemented. However, FWS adopted the proposed regulations as guidelines for discharging its responsibilities under Executive Order 11987 on December 14, 1978. Partly as a consequence of the Executive Order, FWS has not been involved in, nor funded or authorized, the introduction of exotics for nearly three decades. In addition, FWS now rejects most requests that it export fish or eggs.

Nonindigenous Species Research

One consequence of the 1970's debate regarding revision of FWS' injurious wildlife regulations was much broader recognition of the adverse effects of exotic fish and other nonindigenous species. Federal and State agencies, professional organizations and others became increasingly concerned about the lack of scientific studies as the basis for

corrective actions. In response, FWS established a National Fisheries Research Laboratory in Gainesville, Florida, in early 1977 with responsibility for exotic fish research. In 1987, the Laboratory's status was upgraded to that of a National Fisheries Research Center.1

The mission of the Center is to identify and determine the distribution, status, and impacts of exotic fish already established in the Nation's waters and to evaluate the exotic species under consideration for introduction or likely to be released into open waters. It serves as the major national center for information on exotic fish. Aspects of this role are described in the Detection and Monitoring Element of the Program (pages 19 and 20) and the following section. Working closely with other components of the Service and other Federal, State, and private organizations, the Center supports national policy prohibiting Federal actions that result in the introduction of additional exotic species without a full evaluation of their impact on the receiving environments. The Center is also responsible for promoting beneficial exotic species when they pose little or no threat to the Nation's waters.

Construction of a $5.5 million maximum security installation to house the Center at the University of Florida in Gainesville was completed in 1988. The facility is isolated from all major rivers and their drainage systems and there are no permanent bodies of standing surface water within five miles. The facility is double fenced and its 12 acres of ponds are enclosed by an earthen berm system that will retain up to three times the maximum recorded 24-hour rainfall in Gainesville (9? inches). The watershed in which the Center is located is small and drains into a sink hole 1.5 miles from the Center where surface water mixes with ground water with an oxygen level near zero. After flowing underground for 60 hours, this mixed water surfaces in the Santa Fe River system. All water exchanged between ponds and the laboratory building is double filtered and any water exchanged between ponds must pass through three screens and a 1OO? filter system. No live exotic fish can be moved out of the facility without the Center Director's approval.

The laboratory funded and participated in the publication of an Atlas of North American Freshwater Fishes (Lee et al. 1980) that provided summary accounts of the status and distribution of all native freshwater fish species. Exotic species that have become established in North American waters are highlighted. Laboratory staff also produced a manuscript summarizing published and unpublished data about the impacts of exotics species and an in-house manual providing detailed procedures for conducting research on nonindigenous fish.

In 1980, the laboratory contracted with the American Fisheries Society to identify the exotic fish species of economic importance to United States interests. That study eventually identified over 2,000 species of fish that were of particular interest or concern to North Americans. This information was summarized in World Fishes Important to North Americans, Exclusive of Species from Continental Waters of the United States and Canada (Robins et al. 1991).

Concerns in recent years about the import of several new exotic fish species and the expanded use of several others led to the development of biological synopses for the grass carp, bighead carp, and Mozambique tilapia. In addition, an in-Service review of the rudd has been prepared. Established and expanding populations of blue tilapia in the St. Johns River system and the blackchin tilapia in the Indian-Banana River system along the east coast of Florida have been investigated in the field to determine their distribution, status, biology, and impact on native fish populations. Studies in the laboratory have centered on determinations of critical environmental factors such as temperature and salinity, which control the survival and reproductive potential of exotic fish species.

The Southeastern Fish Cultural Laboratory, another substation of the Gainesville Center, conducted studies on the use of redbelly tilapia to control nuisance vegetation in striped bass production ponds. Two studies funded by the Center developed baseline data on the morphometric, meristic (Cichochi et al. 1989), and electrophoretic (Phelps 1989) characteristics of the same fish from most populations of tilapia now in the United States. Involved were detailed comparative analyses of 60 samples representing different tilapia populations from United States and foreign sources.

For a variety of reasons nonindigenous species research is also conducted at other FWS research centers. These considerations include physical proximity to an infestation, effects on species or ecosystems of primary concern to the center, or specific expertise.

At least 136 species of nonindigenous fish, plants and other organisms have become established in the Great Lakes since 1810 (Mills et al. 1991). Sea lamprey predation was a principal contributor to the collapse of lake trout populations in the Great Lakes. It is not surprising, then, that FWS' National Fisheries Research Center--Great Lakes in Ann Arbor, Michigan, has long been involved in research on nonindigenous species. Sea lampreys continue to be a focus of research at the Ann Arbor Center and FWS' National Fishery Research Center--La Crosse in La Crosse, Wisconsin.

Through the 1980s, limited studies of the Asiatic clam were also conducted by malacolgists on the staff of the Ann Arbor Center until that capability was redirected to zebra mussel research beginning in 1989. The Great Lakes and La Crosse Centers along with FWS' Northern Prairie Wildlife Research Center are involved with other Federal, Canadian, State and provincial agencies as well as private entities in a large, coordinated research effort in response the extensive, wide spread impacts of this recent invader. As discussed in more detail in the following section, FWS' zebra mussel research activities focus on determining its life history and impacts, developing control strategies and methods, and understanding interactions with waterfowl and native fish predators.

Researchers from the Ashland, Wisconsin, field station of the Ann Arbor Center led cooperative efforts to monitor the development of populations of the ruffe, another recent Great Lakes invader. That field station and the La Crosse Center continue to play a lead role in studies of the life history, population dynamics, impacts and control of this potentially very damaging nonindigenous fish.

Grass Carp Triploidy Certification Program

Ecological and laboratory studies on grass carp and its hybrid and triploid forms were also funded. The ecological studies have assisted local aquatic plant control agencies in developing appropriate stocking rates and management systems. Laboratory studies centered on the development of techniques to produce triploid grass carp. The Center's Fish Farming Experimental Laboratory substation in Stuttgart, Arkansas, conducted some of the earlier research on inducing the formation of triploid, in lieu of normal diploid, chromosomes as a means of sterilizing grass carp. Subsequently, the Stuttgart station developed a practical protocol for accurately determining whether grass carp in production facilities are functionally sterile.

With the development of an effective and inexpensive technique for sterilizing grass carp, State fish and game agencies began to relax prohibitions on its introduction by allowing the use of triploid animals. To encourage and facilitate the use of sterile grass carp, the Stuttgart station began inspections in September 1985 of grass carp shipped from large Arkansas producers as the basis for certifying that those fish were in fact triploid. As certification procedures became routine, responsibility for conducting the function was shifted to the FWS' Fishery Program on October 1, 1989.

At least 26 States allow only triploid grass carp to be imported and others are considering similar regulations. Many require inspection by FWS to ensure triploidy. Consequently, the number of triploidy inspections conducted by FWS increased from two in 1985 to 216 in 1988. In 1993, 381 inspections involving 555,000 fish were conducted.

Zebra Mussel Research and Management

Given available resources and congressional direction, the following activities have been identified as an appropriate FWS contribution to the cooperative North American response to the rapidly spreading zebra mussel infestation.

RESEARCH

a. Information Coordination. National Fisheries Research Center--Great Lakes, Ann Arbor, Michigan.

Information about zebra mussels and their impacts and control in North America has been expanding exponentially since 1989. One of the earliest zebra mussel activities of the Great Lakes Center was as a focal point coordinating information about zebra mussels for a variety of interest groups. With the rapidly growing involvement of others, particularly the development of other information networks, the Center's role changed. Links have been established to these other information networks to ensure Service research activities complement those of others, minimize duplicative research, identify new research needs, and facilitate early exchange of information.

b. Determination of Environmental Tolerances. National Fisheries Research Center--Great Lakes, Ann Arbor, Michigan.

Research is underway at the Great Lakes Center and several nearby field sites to better understand the growth and mortality of larval and adult zebra mussels in response to environmental conditions. Information about techniques for culturing, including reproducing, zebra mussels in the laboratory and relative tolerances of different life stages to environmental changes has been developed. Such information will be useful in predicting the ultimate distribution of zebra mussels in North America and in suggesting areas of emphasis for control oriented research.

c. Effect on Fishery Resources and Habitats. National Fisheries Research Center--Great Lakes, Ann Arbor, Michigan, and Sandusky, Ohio, Field Station.

Because of the extremely high densities of zebra mussels observed, a major concern is that existing fish and habitat resources will be adversely affected. The Great Lakes Center has focused on zebra mussel ecology and ecosystem effects, including effects on fish, fish spawning, native unionid clams, and other fish and wildlife resources. Early concerns that walleye would be adversely affected by dense colonization of spawning reefs in Western Lake Erie have abated somewhat based on preliminary laboratory findings and successful recruitment in 1990 and 1991. Of most immediate concern is the impact of zebra mussels on native unionids in the Great Lakes as well as elsewhere where many species are presently listed under the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.). Studies in the Great Lakes suggest survival of native unionid mussels may be threatened. The findings of these studies will allow evaluation of possible effects of mussels on fish and shellfish resources and the development of strategies to minimize likely impacts.

d. Effect on Wildlife Resources. Northern Prairie Wildlife Research Center Field Station, La Crosse, Wisconsin.

The anticipated spread of the exotic zebra mussel may have substantial effects on wildlife resources in North America. Preliminary information indicates that as populations of mussels expand, diving ducks in the upper midwest are altering their behavior to exploit this food resource. This is important because diving ducks are believed to be an important component in the "natural" control of zebra mussel densities in Europe. The extent to which waterfowl populations geographically respond to and prey on zebra mussels is being evaluated to determine the potential of North American waterfowl populations in controlling zebra mussels. Management recommendations concerning waterfowl-zebra mussel interactions will become input to the North American Waterfowl Management Plan.

e. Evaluation of Control Methods. National Fisheries Research Center--La Crosse, La Crosse, Wisconsin.

Measures that minimize the impacts of zebra mussel infestations in pipes are needed immediately. Control strategies and methods may be needed in the future to minimize impacts on indigenous fish and wildlife and the ecosystems on which they depend. The environmental safety of possible control measures is also of concern to FWS. With these needs and concerns in mind, the efficacy of chemical controls such as molluscicides and chlorination and mechanical controls such as water jets, will be evaluated. The principles of integrated pest management and biologically safe control methods will be stressed. This is consistent with the intent of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 which stresses the integration of biological principles and safe control strategies. Molluscicides effective against zebra mussels will be evaluated for potential registration for this use.

MANAGEMENT

a. Cooperative Detection and Monitoring. Fishery Field Offices.

Zebra mussels have spread throughout the Great Lakes and mush of the remainder of Eastern North America. They are expected to spread over much of North America in coming decades. Since further dispersal appears inevitable, coordination of the diverse detection and long-term monitoring efforts being initiated is essential to ensure useful information is widely available in a timely manner. With such information, potentially affected communities, industries, resource managers and others will be able to postpone substantial investments to combat the infestation until actually needed. This will also allow fine tuning of responses as circumstances change thereby avoiding costs and potential environmental affects. To this end, FWS' Fisheries Program is facilitating cooperative efforts to promptly detect the presence of zebra mussels in new areas and to monitor the status of established populations. As part of this involvement, the Service encourages the development and application of standard detection and monitoring methods and timely and standardized reporting of information obtained.

b. Integration of Distribution Data. National Fisheries Research Center--Gainesville, Florida.

The total number and occurrence of nonindigenous species in North America is not well-known. In particular, information about the rate of dispersal, geographical extent, and limits of specific nonindigenous species (including zebra mussels) is incomplete. Existing information about the presence and absence of nonindigenous species and the environmental parameters under which they occur have not been synthesized, primarily because of the volume of data for individual species. Computer systems for integrating geographic information and species environmental requirements, often referred to as Geographic Information Systems (GIS), are available for the complex tasks of integrating many data sets to evaluate the spread of exotic species. GIS capabilities are being used to integrate available data concerning exotic species, with emphasis on zebra mussels, thereby facilitating the timely evaluation of trends and patterns that exist. This information will be useful in preparing species-specific research, monitoring, and control plans as well as in exotic species policy and development.

c. Evaluation of Fish and Wildlife Facility Protection Strategies. Lamar Fish Technology Center, Lamar, Pennsylvania.

As with any other water use, zebra mussels are likely to adversely affect fish and wildlife facilities such as fish hatcheries and wildlife refuges by disrupting critical water flows and by changing ecosystems and the natural populations they support. At least 640 FWS field stations, as well as many State fish and wildlife and private aquaculture facilities, are at risk. In anticipation of such impacts, a study is underway to understand and assess the nature and scope of potential impacts on fish and wildlife facilities and to develop and evaluate possible protective strategies and actions.

A questionnaire designed to provide information for ranking Service installations and specific facilities into high, moderate, and low risk groups is being developed by a work group of zebra mussel specialists and project leaders. Experts from outside the Service will be consulted as needed. At risk field stations will be supplied with information on the most current prevention, detection and control methodologies and those at the most immediate risk will be required to develop contingency plans for preventing, detecting and controlling zebra mussel infestations. A policy committee will be formed to develop guidelines for transporting fish and eggs within or from areas where zebra mussels are present or suspected. Finally, disinfection procedures for facilities located, and equipment used, in infested areas will be developed, tested and implemented.

d. Evaluation of Native Mollusk Protection Strategies. Carterville Fishery Assistance Office, Carterville, Illinois.

Native mussel populations in rivers of the United States are at risk of being severely depleted or becoming extinct as the result of the rapidly spreading zebra mussel infestation. Experience in Europe and more recently in the Great Lakes suggest zebra mussel infestations cause the rapid decline of native unionids due to direct colonization, smothering, interspecific competition and other mechanisms. For native mussel species already considered endangered or threatened, the result could be extinction.

Needed is the development and implementation of approaches for avoiding the loss of these important components of the Nation's rivers and lakes. Approaches that might be considered include holding populations in hatcheries for reintroduction once the initial infestation crashes; preservation of sperm, eggs or other viable genetic material using cryogenic techniques; physically removing zebra mussels from native mussels in situ; transplanting populations in protected habitats; and establishing and protecting refugia containing natural populations in tributary streams.

In cooperation with State resource management agencies, the malacological community and the private sector, efforts are underway to address this problem. An ad hoc work group is seeking to identify short- and long-term protection strategies and actions, assemble available information related to those strategies and actions, develop pilot projects to evaluate the feasibility and desirability of the actions identified, suggest

priority research needs, and, ultimately, develop and implement a cooperative native mussel protection program.

e. Assessment of the Potential for Preventing the Spread of Zebra Mussels West of the Continental Divide. Regions 1, 2 and 6.

A few attempts such as in the St. Croix River Basin of Wisconsin and Minnesota and the reservoirs serving Baltimore, Maryland, are underway to exclude zebra mussels from specific ecosystems. However, no means has been found to prevent the rapid spread of zebra mussels into suitable habitat throughout virtually all of Eastern North America. Zebra mussels were recently introduced into eastern Oklahoma apparently by barge traffic up the Arkansas River. Although this sighting is the first west of the Mississippi River, the vast distances, arid climate, eastward flowing rivers, and other characteristics of the Great Plains may create a formidable natural barrier to rapid dispersal that provides the time to develop programs that might prevent the spread of zebra mussels west of the Continental Divide and, perhaps, into the Rio Grande River basin.

In response to this possibility, the Service conducted a study during 1993 assessing the feasibility for a cooperative program to prevent the dispersal of zebra mussels into the far West. This study was undertaken cooperatively by FWS' three Western Regions and the Bureau of Reclamation (BoR). A workshop was held in Denver, Colorado, to discuss the biological, social, fiscal and other feasibility of such an initiative and, if warranted, develop a strategy and plan to achieve that result.

The Western Spread Feasibility Study report describes the problem, including potential pathways responsible for dispersal and discusses the feasibility and effectiveness of possible containment actions and strategies. A strategy for addressing the problem and specific steps to implement that approach are recommended. Near-term actions recommended include: encouraging and assisting State and provincial governments and Indian Tribes to establish a system of inspection stations east of the Continental Divide; evaluating the potential impact of zebra mussels on western ecosystems; with other Federal agencies and the States and Tribes, cooperatively developing watershed plans that identify facilities and environments at risk from zebra mussel infestation; developing guidelines and policies regarding the transport of fish or water from hatcheries and other infested areas to areas that are free of zebra mussels; and developing an information and education program for nonindigenous species and encouraging and assisting States and other agencies to develop such programs.

NATIONAL BIOLOGICAL SURVEY

Under Secretarial Order No. 3173, the National Biological Survey (NBS) was established on November 11, 1993, upon enactment of the Fiscal Year 1994 Department of the Interior and Related Agencies Appropriations Act which authorized necessary funding.2 On October 26, 1993, the U.S. House of Representatives passed legislation to statutorily create NBS as a free-standing bureau within the Department of the Interior. That

legislation is expected to be considered by the U.S. Senate during the Second Session of the 103rd Congress.

NBS was created to provide the scientific knowledge needed to balance the goals of ecosystem protection and economic progress. Its mission is to gather, analyze and disseminate information necessary for the wise stewardship of our Nation's natural resources, and to foster an understanding of our biological systems and the benefits they provide to society. NBS will produce broad scale, scientifically valid biological information and assessments of the Nation's natural resources.

Science in the context of the NBS includes traditional research, inventorying and monitoring to identify status and trends, and information transfer. In addition to research and surveys conducted by NBS scientists, a portion of its work is carried out in cooperation with State agencies and universities.

Analogous to the U.S. Geological Survey (USGS), NBS is an independent science organization that does not advocate positions on resource management issues and has no regulatory or land and water development authorities. Organizationally, NBS reports to the Assistant Secretary for Fish and Wildlife and Parks.

NBS was created by consolidating most biological research and survey activities of Department of the Interior bureaus. This included combining substantial portions of FWS, the National Park Service and the Bureau of Land Management with smaller elements from the Minerals Management Service, the Office of Surface Mining Reclamation and Enforcement, the Bureau of Reclamation, USGS, and the Bureau of Mines.

Consistent with the Fiscal Year 1994 Appropriations Act, about $2 million for FWS nonindigenous species research and inventory activities identified on Table E-2 (page E-12) was transferred to NBS. Another $2 million for research on and surveys of non-native plants and plant pests, the effects of introduced fishes in Washington and Michigan national parks, feral animal control on national parks in Hawaii, and other activities was transferred from the remaining bureaus.

BUREAU OF RECLAMATION

BoR is responsible for the development and conservation of the Nation's water resources in the Western United States. Authorized by the Reclamation Act of 1902, BoR's original purpose "to provide for the reclamation of arid and semi-arid lands in the West" today covers a wide range of interrelated functions. These include providing municipal and industrial water supplies; hydroelectric power generation; irrigation water for agriculture; water quality improvement; flood control; river regulation and control; fish and wildlife enhancement; outdoor recreation; and research on water-related design, construction, materials, atmospheric management, and wind and solar power. Bureau programs most frequently are the result of close cooperation with the U.S. Congress, other Federal

agencies, States, local governments, academic institutions, water-user organizations, and other concerned groups.

BoR operates in 17 Western States and is divided into five regions by watershed areas. Each region has a Regional Director responsible for BoR activities in that region and a staff to perform administrative, planning, design, construction, and operation and maintenance activities. The main facilities constructed include water storage and diversion dams, pumping plants, canals, laterals (open and pipe) and hydroelectric power generators.

BoR also has offices in Washington, D.C., and Denver, Colorado. The Commissioner's Office in Washington develops and administers policy for BoR. The Denver Office is responsible for all technical aspects including design of all major facilities and projects, construction liaison, research coordination, overview planning, and operations and maintenance activities.

The Applied Sciences Branch of the Division of Research and Laboratory Services conducts a variety of scientific and technical investigations to provide information for many BoR applications. These investigations include activities such as determining the chemical and physical properties of engineering materials; studying the effects of construction and operation of project facilities on the water quality, ecology, and fisheries of lakes, rivers, and canals; conducting studies to determine the use and effects of herbicides, and biological and mechanical techniques to control nuisance plants on irrigation projects; and chemically analyzing such substances as water, cement, paint, soils, and crops.

Aquatic Pest Management Research Program

For many years, the Applied Sciences Branch has been involved in research into the control of problem aquatic plants and algae. Aquatic nuisances in and on water storage, conveyance, and distribution systems are a threat to irrigated agriculture and to other essential water uses, including municipal and industrial water supplies, water based recreation, and fish and wildlife habitats. Biologists at the Denver Laboratory are working to develop integrated management systems to control growth of undesirable aquatic vegetation. Such systems emphasize a balanced use of all appropriate control methods including chemical, mechanical, environmental, and biological which minimize adverse effects on the environment. Since 1980, BoR scientists have been involved in research to control serious aquatic nuisance plant problems including hydrilla and Eurasian watermilfoil. Other major pest species being addressed by the program are sago pondweed, filamentous algae, waterhyacinth, curlyleaf pondweed, hollyleaf naiad, saltcedar, Russian olive, purple loosestrife, flowering rush, zebra mussel, and Asiatic clam.

Chemical control of aquatic nuisance plants is conducted with the following objectives: (1) to study the uptake and movement of herbicides through the plant, (2) to determine the fate of herbicides related to their dissipation, degradation and accumulation in the

aquatic ecosystem, (3) to develop new and more efficient methods of applying herbicides to water, (4) to investigate new methods for formulating herbicides, especially controlled release granules, and (5) to evaluate new herbicides for their potential to kill aquatic plants. Potential benefits of this research include new, more effective and safer aquatic herbicides and more efficient use of present herbicides.

Biological control of aquatic nuisance plants includes the use of fish, insect, plant pathogens, and competitive vegetation. Major objectives are: (1) to develop methods for implementation and utilization of natural enemies of aquatic nuisance plants, (2) to conduct surveys to identify organisms with potential value as biocontrol agents, and (3) to investigate modes of action, environmental requirements, and the impact of introduced natural enemies of aquatic nuisance plants on the environment. Considerable research has been conducted on the use of grass carp to control aquatic weeds and algae. A desirable aquatic plant known as spikerush has been shown to eliminate stands of troublesome aquatic nuisance plants in irrigation systems through competition and possible chemical interaction. Various insect species are being considered for testing to control plant species which grow along the wetted perimeter of delivery channels.

Research for mechanical control of aquatic nuisance plants is conducted to determine the optimum timing of control to provide rapid and long-term reduction of plant biomass. These investigations also involve evaluation of various techniques and equipment available to perform the process.

Investigations also are conducted on environmental factors and the effect of manipulation of these factors as a tool to control aquatic nuisance plants. The major objectives of such studies are to: (1) investigate stress factors as related to growth and development of nuisance plants; (2) learn why nuisance plant problems occur; (3) study ecological relationships of aquatic plants in mixed communities; and (4) determine relationships between environmental factors and the control of aquatic nuisance plants.

Aquatic Pest Control Program

Current operations and maintenance programs utilize methods in all the above categories. A common method of nuisance plant control in BoR irrigation systems is the use of various mechanical removal techniques such as mechanical excavators, chaining, and screening. These methods are generally very expensive and are mainly used when some restriction (environmental regulation, etc.) precludes other alternatives. High equipment, fuel, and labor costs contribute heavily to the expense of this method. Finding a disposal site for sediments and removed nuisance plant materials is a common constraint in this type of operation.

Chemical methods are sometimes preferred by water system operators because of their ease of application and labor saving characteristics. Water quality, expense, water use, and environmental restrictions are frequent limitations of this category of control. Environmental or cultural methods such as drawdown and linings are frequently incorporated as a supplementary method integrated with other techniques. Biological

control of aquatic pests in irrigation systems is becoming increasingly important. Use of competitive vegetation to suppress undesirable weed types is becoming more common. In recent years, the grass carp, an aquatic weed consuming fish, has been successfully used in many western irrigation system weed management programs. More frequently, combinations of the above methods are being incorporated in integrated practices to attain maximum benefits of both economy and effectiveness.

Federal Aquatic Plant Management Working Group

BoR participates in the Federal Aquatic Plant Management Working Group (FAPMWG) with other Federal agencies involved with aquatic plant issues.

National Marine Fisheries Service

National Marine Fisheries Service (NMFS) nonindigenous aquatic species efforts focus primarily on pathogens of shellfish. Aquatic shellfish disease research programs were first established in 1960 at the NMFS Cooperative Laboratory in Oxford, Maryland, to conduct research on marine animal health and to assess management issues associated with the impact of diseases, parasites, pests, and predators on American marine and estuarine resources. The laboratory is currently developing rapid diagnostic methods of studying diseases of marine invertebrates. Efforts have been made with various state fishery commissions to develop uniform guidelines and to coordinate activities between the existing commissions; thus minimizing risks of undesirable introductions into other regional interjurisdictional fisheries. During 1990-1992, program funds were made available to state fishery management agencies and universities in Maryland, New Jersey, South Carolina, and Virginia. This program funded research projects that include studies of the life cycles of oyster parasites, disease transmission and resistance, environmental effects on disease transmission, resistance and prevalence, and genetic composition of American oyster stocks and possible hybrids.

Researchers at the Oxford laboratory are also monitoring the presence of pathogens in imported seafood. NMFS currently has an MOU with the Food and Drug Administration (FDA) to inspect live oysters from Australia and Chile, shipped to this country under the authority of the National Shellfish Sanitation Program. NMFS inspects for disease and associated organisms that might become established in US waters.

In addition, Interjurisdictional Fisheries Coordination Act funds have been provided to the Great Lakes Commission to support the Great Lakes Panel on Nonindigenous Species. The Panel is a regional coordination mechanism established by section 1203 of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (P.L. 101-646).

National Ocean Service

The National Ocean Service's nonindigenous species activities has focused on research projects on introduced seagrasses and copepods as part of its National Estuarine and Research Reserve System (NERRS). NERRS has existing monitoring programs for

baseline parameters and the sites are well integrated with State agencies and the academic communities around them.

Office of Oceanic and Atmospheric Research

National Sea Grant College Program

The zebra mussel program of the National Sea Grant College Program (NSGCP) combines outreach and public education activities with research into the effects of zebra mussels on both infrastructure and the environment and development and evaluation of control methods. Carried out primarily by academic researchers supported through the Great Lakes Sea Grant College Programs, the Zebra Mussel Program represents the largest single expenditure of funds on the problem by the Federal government. The result has been the development of a closely integrated network of academic and Federal researchers and marine advisory personnel focused on developing methods for dealing with the invasion, communicating those results to the user community, and increasing public involvement in the issue. This capability was expanded into the Northeast and mid-Atlantic States in 1992 in response to the spred of the mussel. Forty-three zebra mussel research projects were funded for up to three years with appropriations provided for fiscal years 1991 through 1993.

In addition, the NSGCP also supports research on a variety of other nonindigenous species that impact Great Lakes and marine ecosystems including the spiny water flea (Bythotrephes spp.), the ruffe, and the sea lamprey, and on general aspects of the aquatic nuisance species (ANS) issue such as the role of ballast water in introductions.

Sea Grant Aquaculture Research Program

The Sea Grant Aquaculture Research Program funds a variety of projects related to nonindigenous species, including the diagnosis and control of pathogenic organisms such as viruses in shrimp or protozoans in oysters. Several candidate aquaculture species are nonindigenous and Sea Grant Aquaculture Research Program funds research on the appropriate culture and safeguards for their use as well as policy and regulations regarding their culture. Other research on nonindigenous species involves the role they play in culture ecosystems.

Great Lakes Environmental Research Laboratory

The ANS research program at the Great Lakes Environmental Research Laboratory (GLERL) is primarily focused on the zebra mussel. The program has projects dealing with a variety of mussel-related topics. The ecosystem research project is a major, multi-agency effort assessing changes in the food web of Saginaw Bay, Lake Huron. Initial efforts documented conditions in the bay prior to infestation by the zebra mussel, and monitoring efforts are being continued as mussel populations increase. The program is a cooperative effort with the Michigan Department of Natural Resources, U.S. Environmental Protection Agency (EPA), FWS, and regional Great Lakes universities. In

addition, GLERL is conducting laboratory studies of toxic contaminant interactions with zebra mussels and is evaluating the impacts of zebra mussels on native unionid mussels in Lake St. Clair.

GLERL also hosted a series of workshops in 1993, on behalf of NOAA and the EPA, to develop Zebra Mussel Containment Protocols. These protocols currently are used in conjunction with the Research Protocol to ensure zebra mussels are not spread through research activities. The Ballast Exchange Study mandated by the Act will also be conducted at and administered through GLERL. In addition, GLERL provides funding to the Great Lakes Commission for operation of the Great Lakes Panel on Nonindigenous Species.

U.S. DEPARTMENT OF TRANSPORTATION

UNITED STATES COAST GUARD

The United States Coast Guard (USCG) is currently researching methods for countering zebra mussel infestations. Coating systems to prevent the adherence of zebra mussels for hull and sea-chest applications are being tested. Additionally, the USCG Naval Engineering Support Unit--Cleveland, Ohio, in cooperation with the Maintenance and Logistics Command--Atlantic Area, and the Research and Development Center in Groton, Connecticut, is investigating vessel engineering modifications and vessel redesigns that will inhibit the survival of nonindigenous species in water taken on by vessels.

The Ninth District, which oversees USCG activities in the Great Lakes region, has established a zebra mussel reporting system in conjunction with its aids to navigation and vessel inspection programs. Twice each year, USCG crews service buoys and other aids to navigation on the Great Lakes. When this maintenance takes place, maintenance crews record the quantity, size, and depth of any zebra mussel infestation observed. This information is also recorded for any infestations observed on USCG vessels when they are inspected. All of the information gathered is distributed to concerned industries and research programs, and is available to anyone.

USCG and other ballast water and shipping activities related to nonindigenous species are discussed in the Program (pages 40 to 45).

DEPARTMENT OF DEFENSE

U.S. ARMY CORPS OF ENGINEERS

Aquatic Plant Control Research Program

Infestations of invasive aquatic plants in many navigable waterways in this country create major problems in maintaining this important component of the Nation's infrastructure. Over the past century, the build-up of unwanted plant populations has prevented or

seriously hindered navigation and recreation and adversely affected flood control and water supplies. All of these adverse effects result in loss of revenue, higher prices for goods, an increase in tax dollars spent for aquatic plant control operations, and inefficient flood control. In response, section 302 of the Rivers and Harbors Act of 1965 (33 U.S.C. 610) authorized the U.S. Army Corps of Engineers (USACE) to undertake aquatic plant control research and development activities.

The Aquatic Plant Control Research Program (APCRP) program established by USACE deals primarily with nonindigenous aquatic plant infestations of major economic significance in navigable waters, tributaries, streams, connecting channels and allied waters. Its purpose is to provide environmentally compatible, cost effective methods for identification, assessment, and management of problems caused by alligatorweed, water hyacinth, hydrilla and Eurasian watermilfoil. Due to successful control of the two emergent species (i.e., alligatorweed and water hyacinths) the APCRP now concentrates on the two submersed species (i.e., hydrilla and Eurasian watermilfoil).

The APCRP is organized into five technology development areas--biological, chemical, ecological, bio-engineering, and mathematical modeling--under which related research studies are conducted.

BIOLOGICAL CONTROL TECHNOLOGY. This major research area develops operational capability to use host-specific biological agents for long-term management of problem aquatic plants. Through domestic and overseas searches, agents are tested, quarantined, and released. These agents include insects, pathogens, herbivorous fish and the genetic engineering of microorganisms. This research presently is concentrating on the development of agents for control of two submersed problem species: Hydrilla and Eurasian Watermilfoil. A large portion of this research is conducted through a Cooperative Agreement with the Science and Education Administration of the U.S. Department of Agriculture (USDA).

CHEMICAL CONTROL TECHNOLOGY. This area of research involves the development of improved herbicides for aquatic plant control. Specifically, the development of adjuvant-herbicide combinations, controlled-release forms of already labelled herbicides, and application techniques in flowing water systems. In addition, a cooperative association is maintained with the chemical industry to aid the progress of registration of new compounds for aquatic uses by providing EPA with research data acquired through this program.

ECOLOGICAL TECHNOLOGY DEVELOPMENT. This research is designed to develop the relationships necessary to describe and understand the establishment, growth and spread of these problem plants under various environmental conditions. This involves light, temperature, water chemistry, sediment chemistry, and interactions within a plant community. These relationships provide the basic understanding necessary to anticipate new problem areas and implement preventive measures, and to properly manage existing problem areas in an environmentally compatible manner. Recently, research was initiated

to study the beneficial role of these plants in the aquatic ecosystem, to better manage their populations in multi-use water bodies.

INTEGRATED TECHNOLOGY DEVELOPMENT. Integrated technology research is designed to determine if combinations of existing methods can produce a synergistic effect, or produce the same effect with less potential for environmental damage. Presently, the combinations of insects-herbicides on two different plant species, and water drawdown-herbicide treatments are being conducted. Other combinations such as herbicide-mechanical, insect pathogens, and re-establishment of treated areas with non-problem species are planned for the future.

SIMULATION TECHNOLOGY DEVELOPMENT. The objective of this research is to develop user-friendly simulation capabilities for use on personal computers as an aid in decision making and planning. To a lesser extent, they also provide a method for identifying technology gaps for future research. Two models have been completed and are operational. Two additional simulation models are under development and others are planned. All of these simulation models will be assembled into an overall operational planning capability 1993 or 1994.

The APCRP has accomplished much in the nearly 30 years since its inception. Since 1974, technology in the form of on-the-shelf capability for managing aquatic plant problems has been developed. Insect agents have been a major contributor to successful efforts to reduce problems with alligatorweed and water hyacinth to maintenance level management in the Southeastern United States. Through field evaluations and cooperative efforts with industry, two new herbicide compounds have been registered for aquatic use. Prototype quantities of two controlled-release formulations have been produced for large-scale field evaluations.

Three simulation models are operational and have been transferred to approximately 12 State agencies, four universities, and several USACE Districts. Three private companies have also requested and received the models through the Stevenson-Wydler Technology Innovation Act of 1980 (15 U.S.C. 3701-3714) as amended by the Federal Technology Transfer Act of 1986 (P.L. 99-502).

Five Instruction Manuals have been produced for field users, including The Use of Insects to Control Alligatorweed, The Use of Insects to Control Water Hyacinths, The Use of White Amur for Control of Hydrilla, and Herbicide Users Guide. Over 5,000 copies of the Herbicide Users Guide, which is in its fourth printing, have been distributed. In addition, six major field demonstrations have been conducted throughout the United States in new problem areas, to demonstrate and transfer current technology in support of developing Federal/State cost-sharing programs.

Coordination of research is continual with USACE Districts, and their cost-sharing State agencies. In addition, coordination through formal agreements is maintained with USDA's Science and Education Administration, BoR, TVA, and EPA. Coordination is also maintained with FWS. An annual review meeting is attended by approximately 120

people representing Federal, State, local, private, and university organizations. The manager of the research program serves as a member of the Federal Interagency Research Coordinating Council, and is the Corps expert on aquatic plant control.

Estimated Federal funding for USACE aquatic plant control research activities for Fiscal Years 1990 through 1993 is as follows:

FY 1990	FY 1991	FY 1992	FY 1993
$4,413,000	$3,500,000	$4,000,000	$4,000,000

Public Facility Zebra Mussel Control Research and Development Program

This new activity authorized by section 1202(i)(2) of the Act is described in the Program (pages 46 to 47).

Aquatic Plant Control Program

In the late 1880s and early 1890s, populations of waterhyacinth expanded, and problems associated with this plant increased. Commercial river traffic was impeded. Faced with mounting problems, the citizens of Florida and Louisiana petitioned Congress for assistance. The effect was that certain aquatic plant management operation directives, known as the Removal of Aquatic Growths (RAG) Project, were included in the Rivers and Harbors Act of 1899 (33 U.S.C. 401-687) since many affected waterways were Federal navigation projects. The RAG Project was limited to such projects in Florida, Alabama, Mississippi, Louisiana, and Texas.

The Rivers and Harbors Act of 1899 was amended by the Rivers and Harbors Act of 1902 (33 U.S.C. 418), which allowed for the extermination and removal of waterhyacinths by mechanical, chemical, or other means, and by the Rivers and Harbors Act of 1905, which prohibited the use, only in Florida, of any chemical process injurious to cattle. Cattle were apparently attracted by the saltpeter on the treated waterhyacinth, ate the plants, and died.

In 1945, the Committee on Rivers and Harbors of the U.S. House of Representatives adopted a resolution charging the Board of Engineers for Rivers and Harbors with the responsibility of determining if an expansion of the original authorization was advisable. This review called for "control and progressive eradication of the waterhyacinth, alligatorweed and other detrimental aquatic plant growths from the watercourses." It was published in a 1956 U.S. House of Representatives document entitled Water-Hyacinth Obstructions in the Waters of the Gulf and South Atlantic States. The review resulted in the enactment of Section 104 of the Rivers and Harbors Act of 1958 (P.L. 85-500) which provided for a five-year pilot project, referred to as The Expanded Project for Aquatic Plant Control, with an annual funding authorization of $1.5 million. The Expanded Project extended control operations from Federal navigation project waters to those

tributary areas beyond the limits of navigation, and added Georgia, South Carolina, and North Carolina.

In addition, P.L. 85-500 required that "local interests agree to hold and save the United States free from claims that may occur from such operations and participate to the extent of 30 percent of the cost of the additional research program." Also included was a requirement that State contributions account for 30 percent of operation costs.

Results of the Expanded Project were later forwarded by the Chief of Engineers to the Secretary of the Army and, subsequently, to Congress. The report recommended that a "project" approach was no longer desirable, and that "a continuing nationwide program" should be authorized "for the control of obnoxious aquatic plants wherever infestations of such plants constitute a serious threat to navigation, agriculture, public health, the efficient operation of drainage and flood control works, or the use of the Nation's waterways."

The current Aquatic Plant Control Program (APCP) was created in 1965 when P.L. 85-500 was amended by Section 302 of P.L. 89-298. This amendment authorized "a comprehensive program to provide for control and progressive eradication of waterhyacinth, alligatorweed, Eurasian watermilfoil, and other obnoxious aquatic plant growths, from the navigable waters, tributary streams, connecting channels, and other allied waters of the United States" with an annual funding authorization of $5 million. The amendment also provided that "costs for research and planning undertaken pursuant to the authorities of this section shall be borne fully by the Federal Government."

In response to increasing problems and needs, the APCP's funding authorization was increased to $10 million in 1983 by P.L. 98-63. The Water Resources Development Act of 1986 (P.L. 99-662) changed the non-Federal share of APCP operations from 30 to 50 percent and increased the annual funding authorization to $12 million. Local sponsors can, however, contribute more than 50 percent of APCP costs.

Aquatic plant control activities are also conducted within the boundaries of USACE managed water resource development projects as an operations and maintenance activity. The goals and objectives of these operations and maintenance programs are basically the same as those of the APCP.

Under its longstanding authorities, USACE has official management programs for four species of introduced aquatic plants in 11 States, the District of Columbia, and Puerto Rico as indicated in Table E-4.

U.S. DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

The National Oceanic and Atmospheric Administration's (NOAA) co-chair responsibilities are administered out of the Office of the Under Secretary for Oceans and

Atmosphere. Activities include Program development and implementation, nonindigenous species policy development, international negotiations, program coordination, and information dissemination. NOAA also actively supports the heightened interest in biological diversity as this will raise the awareness of and increase attention toward the nonindigenous species issue.

To determine appropriate management and research activities for marine nonindigenous species, NOAA sponsored an international workshop on Nonindigenous Estuarine and Marine Organisms (NEMO) in April 1993, in Seattle, Washington. NOAA also convened a Nonindigenous Aquatic Species panel session at the November 1993 Environmental Management of Enclosed Coastal Seas Conference. Additional efforts include participation in the 1992 United Nations Conference on Environment and Development (UNCED). The NOAA co-chair was a member of the U.S. delegation to the UNCED and strongly supported the U.S. proposal to the UNCED Secretariat which included language urging the international community to adopt the FAO/ICES guidelines for the transfer and introduction of marine and freshwater organisms and appropriate safeguards for ballast water discharge and the aquaculture industry.

Estimated Federal funding for USACE aquatic plant management activities for Fiscal Years 1990 through 1993 is as follows:

FY 1990	FY 1991	FY 1992	FY 1993
$4,625,000	$5,000,000	$5,000,000	$5,000,000

This funding represents slightly more than 50 percent of the total cost of the APCP. Involved States and local interests provide at least half of direct project costs while USACE assumes some administrative costs.

Federal Aquatic Plant Management Working Group

The USACE participates in the FAPMWG with other Federal agencies involved with aquatic plant issues.

U.S. ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF RESEARCH AND DEVELOPMENT

Since Fiscal Year 1990, EPA has initiated a number of projects related to nonindigenous species. One of the first was to organize and conduct an October 1990 workshop in Saginaw, Michigan, entitled: Ecology and Management of the Zebra Mussel and Other Introduced Aquatic Nuisance Species. A summary of and conclusions from that workshop were published in early 1991 (Yount 1990). During 1990, planning and design

of a containment room at Environmental Research Laboratory-Duluth, Minnesota, for conducting research on exotic species was also initiated.

In Fiscal Year 1991, a containment room was constructed at EPA's Environmental Research Laboratory in Duluth, Minnesota. Inhouse research on bioaccumulation of toxic organic chemicals by zebra mussels was initiated and the process of modifying nutrient cycling (eutrophication) models of Saginaw Bay to account for the new recycling pathway provided by zebra mussels began. To compliment this work, EPA agreed to partially fund two proposals that had been solicited by the NSGCP as cooperative research projects. The cooperative projects, both of which were submitted by Ohio State University researchers, were: Zebra Mussel-Fish Relations and Their Effects on Nutrient/Energy and Contaminant Dynamics and Accumulation and Trophic Transfer of Organic Xenobiotics by the Zebra Mussel, Dreissena polymorpha: The Role of Exposure and Lipid Content.

In addition, development of laboratory cultures of zebra mussels began in preparation for inhouse work on the environmental requirements and limits of zebra mussels. In support of that work, another proposal from the Sea Grant solicitation (Genetics of Zebra Mussels: Critical Data for Ecological Studies and Development of Long-term Control Strategies submitted by the University of Illinois-Champaign) was partially funded as a cooperative project. A cooperative project was developed with the EPA Laboratory at Gulf Breeze, Florida, on microbiological control of zebra mussels. Another cooperative agreement was developed with the Institute for the Biology of Inland Waters, Russian Academy of Sciences, on the Biology and Ecology of Nonindigenous Aquatic Species in order to benefit from the extensive Russian experience with the zebra mussel. At the request of EPA Region 5, tests were conducted on the effectiveness of chloramines, a proposed agent for controlling zebra mussels.

A major increase in funding in Fiscal Year 1992 allowed EPA to fully fund the extramural cooperative projects initiated in Fiscal Year 1991. Laboratory work on the environmental requirements and limits of zebra mussels and a cooperative project with FWS to investigate the biology and ecology of the ruffe in the St. Louis River, Minnesota and Wisconsin, were begun.

A major cooperative effort to determine the factors influencing the distribution and effects of zebra mussels and other introduced species in rivers and streams throughout the United States was initiated. A request for preliminary proposals produced 37 pre-proposals, which were reviewed and ranked by a peer panel. Six of the top 10 pre-proposals were selected for development into full proposals and are currently being reviewed by the peer panel; if acceptable, the six projects will be funded through Fiscal Year 1994. As the zebra mussel spreads from the Great Lakes Basin into other river basins, this work will be crucial in characterizing successful invaders and riverine habitats at risk from introduced species.

Results, to date, of these efforts include:

o Data have been obtained on the accumulation of toxic organic chemicals by zebra mussels in the Great Lakes.

o Bioassays have provided data on action levels of chloramines against zebra mussels.

o Research on the genetics of zebra mussels has revealed that a second species of zebra mussel is present in the Great Lakes.

U.S. DEPARTMENT OF AGRICULTURE

A number of USDA agencies have responsibilites for or are involved with nonindigenous species.

ANIMAL AND PLANT HEALTH INSPECTION SERVICE

The mission of the Animal and Plant Health Inspection Service (APHIS) is to provide leadership in ensuring the health and care of animals and plants, to improve agricultural productivity and competitiveness, and to contribute to the national economy and the public health.

APHIS' involvement with nonindigenous aquatic species is a part of this broad mission and is focused primarily in two areas--plants (including noxious weeds) and aquaculture. In addition, the Agency's Import-Export Program protects against the introduction of nonindigenous animal diseases or disease vectors. APHIS also participates on the FAPMWG.

Plants and Noxious Weeds

APHIS is responsible for excluding harmful exotic plants, animals and diseases from the United States through agricultural inspections at ports-of-entry to and controlling or eradicating those that become established. The primary authorities for APHIS inspections of exotic plants and plant products for diseases, parasites, and predators are the Federal Plant Pest Act (7 U.S.C. 147a-150jj) and the Nursery Stock Quarantine Act (7 U.S.C. 151-167). With respect to inspections for noxious weeds, APHIS' primary authority is the Federal Noxious Weed Act (FNWA, 7 U.S.C. 2801-2813) as amended by section 1453 of the Food, Agriculture, Conservation and Trade Act of 1990 (P.L. 101-624).

Regulations implementing the FNWA (7 CFR Part 360) define noxious weeds via lists of specific terrestrial weeds, parasitic weeds, and the following 17 nonindigenous aquatic nuisance plants:

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Mosquito fern        Anchored water hyacinth
Hydrilla             Miramar weed
Water-spinach        Moss
Ambulia              Monochoria hastata
Monochoria vaginalis Arrowhead
Giant salvinia
  (four species)          Exotic burreed
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Water-aloe Melaleuca

In addition, five nonindigenous plants (i.e., three species of red rice, catclaw mimosa and the Benghal dayflower) listed as terrestrial nuisance plants in 7 CFR 360.200(c) are generally considered to be wetland plants.

The FNWA authorizes a regulatory system designed to prevent the introduction into the United States of nonindigenous noxious weeds from foreign countries through inspection activities at United States ports-of-entry. One of the most common nonindigenous aquatic nuisance plant species intercepted at ports-of-entry in the last few years is water-spinach.

APHIS is also authorized under the FNWA to control and eradicate incipient infestations of noxious weeds in the United States. Once a control or eradication program is established for a particular nuisance plant, APHIS may establish quarantines and regulate interstate movements of that nuisance plant.

The 1990 amendments to the FNWA address "undesirable plants" which are defined as:

"...plant species that are classified as undesirable, noxious, harmful, exotic, injurious, or poisonous, pursuant to State or Federal law."

This new, broader definition includes, but is not limited to, the earlier definition (and list) of noxious weeds.

The amendments require each Federal agency to:

o designate an office or person to develop and coordinate an undesirable plants management program on Federal lands under the agency's jurisdiction;

o establish and fund such a program;

o implement cooperative agreements with State agencies for the management of undesirable plant species; and

o establish integrated management systems to control or contain undesirable plant species targeted under cooperative agreements.

Among the nonindigenous aquatic nuisance plants that have entered the United States (despite APHIS' efforts to exclude them), the Agency has so far limited its domestic involvement (e.g., survey, control, containment, eradication, methods development, State assistance) primarily to hydrilla, melaleuca, miramar weed, and water-spinach.

The longest-standing Agency involvement with an exotic aquatic nuisance plant has been with hydrilla. A 1979 hydrilla demonstration project in Florida was APHIS' first funded noxious weed program activity. Since then, APHIS has conducted hydrilla control programs in Florida, the Imperial County of California, and the Mexicali Valley of

Mexico. APHIS is currently providing technical advice and assistance with maintenance of a hatchery for triploid grass carp in California. Grass carp, augmented with chemical and mechanical means, control hydrilla in infested waterways in the West.

APHIS maintains two plant biocontrol advisory groups that interact with USDA's Agricultural Research Service (ARS) and other agencies: the Technical Advisory Group on Biological Control of Weeds; and the User Advisory Panel for APHIS' National Biocontrol Institute.

Aquaculture

The statutory and regulatory authority over United States aquaculture is divided among various departments and agencies, including APHIS, FDA, Commerce, and Interior. Under existing statutes and regulations, APHIS has clear authority to:

o License and regulate veterinary biologics used in prevention, diagnosis, and treatment of diseases of fish or other aquatic animals. Several killed bacterial fish vaccines are presently licensed by APHIS.

o Regulate the importation of aquatic plants into the United States.

o Assist the aquaculture industry with control of bird depredation and damage to aquaculture facilities due to predation; assist aquaculture producers in obtaining (and completing) permits from FWS.

o Produce reagents and references for the aquaculture industry.

APHIS also participates on two Task Forces formed by the Joint Subcommittee on Aquaculture (JSA). The JSA is a subcommittee of the Federal Coordinating Council on Science, Engineering, and Technology. It was created to increase the overall effectiveness and productivity of Federal aquaculture programs by improving coordination and communication among approximately 23 Federal agencies involved in these programs. Several Task Forces are associated with the JSA, two of which are co-chaired by APHIS and FWS:

o Aquatic Animal Health Task Force; and

o A Task Force which has evolved into a legislative watch group and forum for discussing problem areas (originally, the Protective Statutes Task Force).

Import-Export Program

The purpose of APHIS' import inspection program is to prevent the introduction and dissemination of animal diseases (or disease vectors) of foreign origin to animals and poultry in the United States. The program protects the animal and poultry population of the United States against the introduction of animal diseases or disease vectors by:

evaluating requests for import permits; issuing import permits; and conducting port-of-entry inspections and quarantines, certifications, tests, and precautionary treatments of certain animals, animal embryos and semen, birds, and meat and other animal and poultry products.

APHIS maintains control over importation, as well as domestic interstate movement of organisms and vectors, to ensure that their movement does not constitute a threat to the livestock industry. Applications for import permits are reviewed to determine the characteristics of the organism and the security of the research facility to prevent their escape. APHIS Veterinary Services has approved over 400 establishments in the United States for the receipt and handling of a wide variety of restricted animal products, byproducts, and related materials. These establishments are under continuing surveillance to ensure that the restricted imports do not constitute a disease risk for the livestock population.

APHIS does not currently include any aquatic species in its import inspection program. However, this program could be a model for new programs to prevent unwanted introductions of nonindigenous aquatic species or could be modified in the future to include aquatic species. **Federal Aquatic Plant Management Working Group**

APHIS participates in the FAPMWG with other Federal agencies involved with aquatic plant issues.

AGRICULTURAL MARKETING SERVICE

The primary objective of the Agricultural Marketing Service (AMS) is to enhance the marketing and distribution of agricultural products from the Nation's farms. AMS' limited involvement with nonindigenous aquatic species is authorized by the Federal Seed Act (FSA, 7 U.S.C. 1551-1610) and the Plant Variety Protection Act (PVPA, 7 U.S.C. 1562-2583 and 28 U.S.C. 1338-2353).

Under the interstate commerce provisions of the FSA, AMS regulates noxious weed seeds (which could include nonindigenous aquatic nuisance plant seeds). That part of the law covers agricultural and vegetable seed shipped in interstate commerce for planting purposes. The law is basically a truth-in-labeling law; quality factors must be labeled and labeled truthfully. Enforcement of the interstate commerce provisions of the FSA is implemented via Memoranda of Understanding between AMS and each of the 50 States. If State officials (or farmers or private organizations) submit complaints of FSA violations to AMS, the complaint will be investigated and, if a violation is confirmed, a letter of warning will be issued or a penalty imposed.

The PVPA encourages the development of novel varieties of sexually reproduced plants by providing patent-like protection to developers. Oversight and direction is provided to several industry-funded research and promotion programs.3

In addition, AMS provides marketing assistance to aquaculture (which could involve nonindigenous species) via the Federal-State Marketing Improvement Program and the AMS Transportation and Marketing Division.

AGRICULTURAL RESEARCH SERVICE

ARS is USDA's in-house agricultural research agency, with major responsibilities for conducting and leading national agricultural research efforts. ARS' mission is to develop new knowledge and technology that will ensure the United States an abundance of high quality agricultural commodities and products at reasonable prices.

In fulfilling its mission, ARS conducts research on aquaculture and a variety of animal and plant topics involving nonindigenous species. ARS plays a key role in identifying and evaluating potential nonindigenous biological control agents for possible use for biological control of plant and animal pests and diseases in North America. This includes evaluating the risks of any proposed release of nonindigenous insects or diseases in the United States and ensuring that such actions will be safe. ARS also has ongoing research programs on several nuisance nonindigenous aquatic plants in Fort Lauderdale, Florida, and Davis, California. In addition, ARS interacts with other agencies on two biocontrol advisory groups maintained by APHIS: the Technical Advisory Group on Biological Control of Weeds; and the User Advisory Panel for APHIS' National Biocontrol Institute.

COOPERATIVE STATE RESEARCH SERVICE

The Cooperative State Research Service (CSRS) links USDA to U.S. universities for the purpose of conducting agricultural research. CSRS participates with States and other sources of funding to encourage and assist State institutions in conducting agricultural research through: the State Agricultural Experiment Stations of the 50 States and the territories; approved Schools of Forestry; the 1890 Land-Grant Institutions and Tuskegee University; Colleges of Veterinary Medicine; and other eligible institutions.

CSRS funds research, which could include research related to nonindigenous aquatic species, via non-competitive and competitive grants. Non-competitive funds are granted to States according to established formulas authorized by the Hatch Act of 1887 (7 U.S.C. 361a-379). States may use these funds on any research topics, as long as the proposed research accords with broad guidelines from CSRS. CSRS has significantly fewer funds for competitive grants (versus non-competitive grants). These competitive research grants could include topics related to nonindigenous aquatic species. CSRS awards competitive grants in aquaculture through the Aquaculture Special Grant Program and the National Research Initiative.

In cooperation with the Extension Service, CSRS also administers five Regional Aquaculture Centers, which are consortiums of universities and industry groups. These centers conduct research, undertake demonstration projects, and transfer technology for the benefit of aquaculture.

CSRS houses the Office of Aquaculture, which is responsible for coordination of all USDA aquaculture programs. CSRS' Office of Aquaculture provides leadership for the Federal-wide Joint Subcommittee on Aquaculture and coordinates the operations and activities of the Regional Aquaculture Research, Development, and Demonstration Centers.

U.S. FOREST SERVICE

The U.S. Forest Service (USFS) is responsible for Federal leadership in forestry. It carries out this role through four main activities:

1. Protection and management of resources on 191 million acres of National Forest System lands.

2. Research on all aspects of forestry, rangeland management, and forest resources utilization.

3. Cooperation with State and local governments, forest industries, and private landowners.

4. Participation with other agencies in human resource and community assistance programs in rural areas.

The USFS manages 191 million acres of National Forest System land in 44 States, including 156 national forests, 19 national grasslands, and 71 experimental forests. Over 50 percent of the surface water supply in the Western United States originates in National Forest System lands. These waters include 300,000 miles of perennial streams, 2.2 million acres of lakes/reservoirs, and 42 million acres of municipal watersheds.4

The USFS seeks to maintain the great diversity of wildlife, fish, and plant species that exist in the National Forest System, and to help endangered species to recover. Most of these species are probably native, but some of USFS research (e.g., on threatened, endangered, and sensitive species) may indirectly involve nonindigenous aquatic species.

EXTENSION SERVICE

Through the land-grant colleges, the Extension Service (ES) provides the Nation's farmers and aquaculturists with cooperative extension assistance which consists of:

o Developing practical applications of research knowledge;

o Utilizing non-land grant educational programs to give instruction about and demonstrate existing or improved agricultural and aquacultural technologies; and

o Encouraging the application of such information by persons not attending land grant colleges, using demonstrations, publications, and other means.

The ES provides national leadership and represents the USDA within the Cooperative Extension System, which includes the Federal Extension Service, about 21,000 State and local extension system employees, and 2.9 million program volunteers.

The role of the ES is primarily educational, spanning a broad range of issues, which could include those related to nonindigenous aquatic species. Specifically, the Cooperative Extension System employs aquaculture specialists, located in several States, who assist aquaculturists with information, including the transfer of technology relevant to that industry. For example, State aquaculture extension programs include workshops for new fish farms, short courses in management of fish diseases, aquaculture demonstrations, farm visits, field days, etc.

ECONOMIC RESEARCH SERVICE

The mission of the Economic Research Service (ERS) is to provide the general public, Congress, and the Administration with economic and other social science information and analysis for improving the performance of U.S. agriculture and rural America. This Agency:

o Monitors, analyses, and forecasts U.S. and world agricultural production and demand for production resources, agricultural commodities, and food and fiber products;

o Measures the costs of and returns to agricultural production and marketing;

o Estimates the effects of Government policies and programs on farmers, rural residents and communities, natural resources, and the public; and

o Produces information about the organization and institutions of the United States and world agricultural production and marketing systems, natural resources, and rural communities.

ERS could conduct analyses directly or indirectly related to nonindigenous aquatic species. For example, ERS' "Aquaculture Situation and Outlook Report" provides information on the supply, demand, pricing, and trade for aquacultural and related wild-harvested fisheries products.

NATIONAL AGRICULTURAL LIBRARY

The National Agricultural Library (NAL) is one of the most heavily used and largest agricultural libraries and information services in the world, serving as the national center for the collection and dissemination of information on all aspects of agriculture. As one of three national libraries, together with the Library of Congress and the National Library of Medicine, NAL fulfills national and international responsibilities, as well as its USDA role.

Information on nonindigenous aquatic species is likely to be a part of the vast resources of the library. For example, NAL has established an Aquaculture Information Center, which was mandated by the National Aquaculture Improvement Act of 1985 (Title XVII, P.L. 99-198) to serve as a repository for national aquaculture information. The Center networks with States, Regional Aquaculture Centers, libraries, and the public and private sectors to enhance information exchange in the Nation. Staff of the Aquaculture Information Center at NAL are members of the Federal-wide Joint Subcommittee on Aquaculture and the supporting Information Task Force.

One of the products of this Center is the Regional Information System for African Aquaculture II, an integrated hypermedia/expert system on African aquaculture developed in April 1990 and funded by the Food and Agriculture Organization of the United Nations.

TENNESSEE VALLEY AUTHORITY

The Tennessee Valley Authority (TVA) is an independent corporate agency of the Federal Government; that is, it is not part of any cabinet department, and in some ways it operates more like a private corporation than a Government agency, especially in regard to its self-supporting power program. However, electric power generation is only one of TVA's functions. Congress charged TVA to develop, conserve, and manage the full range of the Tennessee Valley region's resources--natural, economic, and social. One of TVA's primary responsibilities is managing the water resources of the Tennessee River and its tributaries and the series of dams and reservoirs that now comprise the TVA water control system. That includes managing aquatic vegetation, which--depending upon where it grows and in what quantities--can either increase or decrease the usefulness of those water resources for various purposes.

For more than 50 years, TVA has acted as a catalyst for improvements in resource use and conservation, productivity, economic growth, and overall quality of life. As a regional development agency, TVA has been able to transcend State and local political boundaries within the seven-state region to help accomplish some resource development and management goals that otherwise might never have been realized. TVA works in concert with other Federal agencies, State and local agencies, cities and industries, and the people of the Valley. It is this cooperative effort that deserves much of the credit for the good things that have happened in the Tennessee Valley during the last half century.

TVA has long enjoyed a partnership with the Nashville District of the USACE. The Interconnected Inland Waterway extends 650 miles up the Tennessee River and 380 miles up the Cumberland River. The Tennessee and Cumberland river systems have operated as a unit since 1966, when a navigation canal was opened connecting TVA's Kentucky Reservoir and the USACE's Lake Barkley. Both drainages now have aquatic plant problems. Although those in the TVA system are more extensive than those in the USACE system, the presence of Eurasian watermilfoil and the threat of hydrilla are reasons for mutual concern.

Aquatic Plant Management Program

From its beginning, TVA has been involved with nonindigenous organisms, including control of aquatic plants. During initial planning for the agency, it was realized that the proposed series of impoundments could increase breeding habitat for the malaria mosquito. Early cooperative research by TVA, the U.S. Public Health Service, the USACE, and State health agencies indicated the malaria mosquito could be effectively and economically controlled by managing aquatic plants--primarily native emergent species at that time--through a combination of water-level management and supplemental chemical or mechanical techniques.

TVA entered a new era of aquatic plant problems when Eurasian watermilfoil was introduced into the Tennessee River Basin in the late 1950s. As sometimes happens when non-native species are introduced into a new ecosystem, it spread rapidly. By 1968, 25,000 acres in eight TVA reservoirs from east Tennessee to north Alabama had been colonized. This infestation has now spread to all nine mainstream reservoirs and two tributary reservoirs. With no practical or environmentally acceptable eradication strategy presently available, it is considered inextricable. Under these circumstances, TVA's management strategy is to reduce overly abundant populations in priority areas where they interfere with one or more uses of water resources.

Introductions of nonindigenous species is a pervasive and difficult issue confronting TVA and other water resource managers. Controlling undesirable species that are spread through a variety of pathways has become an urgent priority. In the Tennessee Valley, this problem is exemplified by the introduction of the spinyleaf naiad and, most recently, hydrilla. Since it was detected in 1982, hydrilla has spread to more than 3,000 acres in four reservoirs in the Tennessee River basin. This infestation is likely to get worse since TVA's reservoir system contains more than 100,000 acres of potential habitat.

Although aquatic plant control has been practiced for several hundred years, aquatic plant management is a relatively new concept. It requires integrating information from several traditional disciplines. An understanding the relationships among the various components of the water resource and the various uses of those components that must be accommodated is also required. Both data bases and the understanding of the relationships among water resources and their uses is essential to effectively manage--not just control--aquatic plants. This need is exacerbated because some introductions such as zebra mussels are so recent that life history and ecological requirements are poorly understood, making management difficult, if possible at all.

Controversy exists about how much vegetation growth is necessary for effective management and recreational use of waterfowl and fishery resources as opposed to that needed to effectively manage other reservoir resources and uses, including other types of recreation. A better understanding of how aquatic plants influence and interact with the waterfowl and fishery resources is needed to resolve those issues and is being developed. Improved management plans and techniques to provide optimum compatibility and

balance among the various uses of these and other reservoir resource components must be developed based on such information.

Another issue is the controversy over the use of aquatic herbicides and other pesticides. Scientific evidence supports continued, careful use of a number of aquatic herbicides. Aquatic plant management would be greatly hampered if this key control technology was unduly restricted. However, this control method should continue to be closely scrutinized to ensure human and environmental safety.

TVA comprehensively addressed these and other issues in a recent supplemental environmental impact statement for its Aquatic Plant Management Program. A range of alternative management strategies, including no control, were evaluated and several opportunities for public involvement and comment provided. Based on this record, TVA determined continuation of the integrated program that has evolved since the original environmental impact statement was released in 1972 was the preferred alternative (58 FR 46667).

Cooperative Applied Aquatic Plant Research and Demonstration Project

Controlling aquatic plants with grass carp and other biological methods has stimulated extensive press coverage and public interest, especially among fishermen. In response, Congress directed TVA and the USACE, through its Aquatic Plant Control Research Program at the Waterways Experiment Station in Vicksburg, Mississippi, and its Nashville District, to cooperatively test and demonstrate innovative management techniques and control technologies, including use of the grass carp. This has been accomplished by developing and implementing a comprehensive aquatic plant management plan for Guntersville Reservoir in northeast Alabama that incorporates the most effective biological control methods available. Aquatic plant management technology developed and refined by this joint project is expected to be applicable to other reservoir systems in the Southeast and elsewhere in the United States.

Federal Aquatic Plant Management Working Group

TVA participates in the FAPMWG with other Federal agencies involved with aquatic plant issues.

FEDERAL AQUATIC PLANT MANAGEMENT WORKING GROUP

The FAPMWG is organized and chaired jointly by the USACE, TVA, and BoR. The FAPMWG acts as a coordinating and communication body for Federal agencies involved with aquatic plant issues. Recent issues of concern include the zebra mussel threat and the purple loosestrife problem. The FAPMWG also provides leadership in the development of aquatic plant control technology, and coordinates Federal dealings with States on aquatic plant issues. The FAPMWG usually meets annually; a subgroup on aquatic research meets more frequently.

NON-FEDERAL ACTIVITIES

Municipal and industrial plants that rely on raw water drawn from lakes and rivers have become increasingly aware and concerned about the zebra mussel infestation. Water intakes are highly desirable environments for zebra mussels because these filter feeding organisms are provided a steady flow of water and, therefore, food. If not managed properly, mussels grow in layers in intake pipes and rapidly reduce their capacity to transport water. Clusters of mussels also slough off and may clog small inlets and cause other problems. Pumping may have to cease periodically so the system can be dewatered and accumulations of zebra mussels removed.

To date, the greatest impact of zebra mussels on water users has been in the Great Lakes, especially on Lakes Erie, Ontario and St. Clair. Many, if not most, raw water users on the Great Lakes fund or conduct research to develop zebra mussel control programs because the nature and effectiveness of control efforts vary significantly from facility to facility. Hence, those entities threatened by zebra mussels must find the best solution for their individiual facility. The cost of such research and development has been quite variable.

A range of non-Federal zebra mussel research and other activities underway in 1991 are summarized in this section to illustrate the scope of such efforts. Described as well are several non-Federal projects related to the management of other ANS, including purple loosestrife, ruffe, sea lamprey and common carp.

The information presented in this section is for illustrative purposes only. It is not an endorsement of the Task Force, its member agencies or the Federal Government of any of the products, services or organizations mentioned.

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Acres is a full service engineering, planning and environmental consulting firm founded over 60 years ago. As a result of the company's long and project-extensive association with the zebra mussel issue, Acres has established a highly qualified staff of engineers and scientists with extensive experience in mussel monitoring and control investigations. Acres personnel are proud of their unique ability to integrate the scientific and engineering disciplines required to design and implement zebra mussel control strategies to protect water users' equipment and conduits. A team of Acres staff has been fully committed to the zebra mussel problem through:

o presenting papers at international technical conferences and speaking at technical workshops;

o participating in regional task forces planning multi-state monitoring programs;

o assisting in development of state zebra mussel management plans;

o producing zebra mussel training videos and speaking at training programs;

o conducting several research and development projects for zebra mussel control;

o conducting large-scale zebra mussel monitoring programs; and

o developing engineering designs to control infestations at individual facilities.

Acres has worked on the zebra mussel problem with every major New York State utility directly or through projects with the Empire State Electric Energy Research Corporation (ESEERCO). The company also works with water suppliers, electric utilities, and State and Federal agencies in Pennsylvania, Ohio, Maryland, Connecticut, Tennessee, and the District of Columbia through planning committee meetings or projects. The company is currently assessing system vulnerabilities, including potential impacts, for the water supplies of Baltimore, Maryland, and New York, New York. Zebra mussel management programs for these two water supply systems will ultimately be designed and implemented based on these studies.

Acres' biological staff began monitoring programs for Asiatic clams in the mid-1970s. Monitoring for zebra mussels was initiated in 1989 at two Cleveland Electric Illuminating Company facilities on Lake Erie. In 1990 and 1991, Acres conducted a large zebra mussel monitoring program in New York for ESEERCO that encompassed 28 monitoring sites on 14 waterbodies. Acres is currently conducting the largest single monitoring program in the United States for the New York City Department of Environmental Protection.

From this experience, Acres believes effective management of zebra mussels requires potential vulnerable installations to plan for an infestation before zebra mussels are detected as prepartion for prompt systematic action once the species is present. To accomplish this, a structured approach for zebra mussel management at individual facilities or systems such as reservoirs, water intakes, conduits and valves has been developed. This approach involves from one to four phases depending on the outcome of the initial phase.

Phase I is a simplified facility infestation risk analysis that is designed to provide an estimate of the vulnerability of a facility to mussel fouling. If vulnerability is estimated to be high, and infestation imminent (based on monitoring), conceptual engineering design of control options is recommended to be completed. Phase II involves final engineering design for zebra mussel control(s) as prescribed in Phase I (if indicated). Phase III includes system installation and Phase IV involves post-installation testing of the control(s). This phased approach provides a convenient place to pause between Phases I and II where technical information and/or costs for controls (if controls are required) can be evaluated by facility managers. Scheduling of detailed design and implementation can then be set based on Acres' recommendations and as directed by the facility managers.

The first phase, System Vulnerability Assessments, is perhaps the most important phase in the control program and is normally divided into the following tasks:

o assess the probability of entry of zebra mussels into the various components of the water systems;

o investigate the various dispersal mechanisms that may be used to transfer zebra mussels into the water supply system(s);

o determine any water quality factors that may limit the degree of infestation;

o evaluate the sensitivity of various components of the water supply system(s) to fouling;

o determine the control options that may be feasible;

o determine how Federal and state regulations may affect the promising control options;

o select only the option(s) that have been proven and shown to be a sound biological, engineering, and environmental method(s) for the design phase; and

o depending on the facility and urgency, complete conceptual engineering design(s) and cost estimates.

The remaining three phases of this approach leading to a successful management of a zebra mussel infestation include:

o design the control option(s);

o implement the control option(s); and

o conduct post-installation field testing.

Concurrent with the first phase of the control program, however, it may be appropriate to initiate a monitoring program to determine if and when the zebra mussel has reached the facility location. Those who are first implementing a monitoring program must consider sample collection, sample analysis, and reporting methods that are appropriate for their situation. They must also consider how to train their technicians in the correct field and laboratory sample techniques as well as QA/QC programs.

A zebra mussel monitoring program should consist of three types of sampling:

o collection of water samples to determine the presence and density of veligers;

o the use of standardized substrates to determine the timing and extent of settlement; and

o direct inspection of system components to determine actual fouling in the system.

Collection of water samples for determination of the presence and density of veligers should be standardized. In areas where mussels have not been documented or are expected to be present in low numbers, Acres suggests filtering a minimum of 1,000 liters of raw water through a plankton net with 63-micron mesh. Methods of collection differ somewhat depending on the water source. If mortality is a concern, the collection methods again are slightly different. Samples may be analyzed live or preserved. Density estimates should be made by veliger morphological type. This will assist in the determination of when settlement is likely to occur.

Determination of settlement can be assessed using two general types of samples; a suspended standard substrate or a sidestream biological monitor. The sidestream monitor is an enclosed box that contains standardized substrates. The monitor is plumbed into the raw water flow. The most appropriate method to use is dependent on the sampling locations. The standardized substrates are periodically retrieved and replaced. The substrates are then examined for the presence of recently settled zebra mussels.

The third type of sampling that cannot be overlooked is direct inspection. Accessible surfaces should be inspected periodically for settlement. The facility personnel should be aware of zebra mussels and be trained to inspect for them whenever maintenance efforts allow them access to surfaces contacted by untreated raw water.

Monitoring at a facility has a variety of purposes. As noted above, it can determine when zebra mussels have reached the area for the first time. In addition, after the mussel has reached the area, monitoring can be used to determine the life stages/density of veligers present, and when settlement is about to occur. This information can be used to time the application of the desired control. A well thought out monitoring program can also be adapted to a program to assess the success of any control that has been instituted (e.g., a Phase IV effort).

Alvord, Burdick, and Howson Engineers
20 North Wacker Drive, Suite 401
Chicago, Illinois 60606

Contact: Pete Templeton (312) 236-9147

Alvord, Burdick, and Howson Engineers has been involved with zebra mussel research for approximately two years. Their research has consisted of studies of zebra mussel habitat, food sources, and method of attachment; chemical applications consisting of approximately 22 different chemicals; a study of various materials that would be able to transport the different types of chemicals researched; predation of the zebra mussel; desiccation; ultrasonic vibration; and heat treatment. The firm analyzes control methods and determines which ones are the most realistic and effective. Clients and respective activities include the following:

o Greenbay Water Utility (Greenbay, Wisconsin): Prepared feasibility report on zebra mussel control and completed design of chlorination system.

o City of Port Washington (Port Washington, Wisconsin): Feasibility report on zebra mussel control in progress.

o City of Cudahy (Cudahy, Wisconsin): Prepared feasibility report on zebra mussel control.

o City of Racine (Racine, Wisconsin): Prepared feasibility report on zebra mussel control.

o City of Lake Forest (Lake Forest, Illinois): Prepared feasibility report on zebra mussel control.

o City of Evanston Water Works (Evanston, Illinois): Prepared feasibility report on zebra mussel control.

o Northwestern University (Evanston, Illinois): Prepared feasibility report on zebra mussel control.

o Commonwealth Edison Stateline Generation Station (Hammond, Indiana): Feasibility report on zebra mussel control in progress.

o Lever Brothers Company (Hammond, Indiana): Prepared feasibility report on zebra mussel control and completed design of chlorination system, which is under construction.

o Hammond Water Works Department (Hammond, Indiana): Prepared feasibility report on zebra mussel control.

o City of East Chicago (East Chicago, Indiana): Prepared feasibility report on zebra mussel control.

o Michigan City Water Works (Michigan City, Indiana): Prepared feasibility report on zebra mussel control.

o Saginaw-Midland Municipal Water Supply Corporation (Saginaw-Midland, Michigan): Completed and bid chlorination system design.

American Water Works Association Research Foundation
6666 West Quincy Avenue
Denver, Colorado 80235

Contact: Emerson Lomaquahu (303) 794-7711

American Water Works Association Research Foundation (AWWARF) is currently overseeing a research project titled Controlling Zebra Mussels at Water Treatment Plant Intakes. This research is a collaborative effort of the cities of Toledo and Cleveland, Ohio, the Case Western Reserve University, the University of Toledo, and the consulting firm Finkbeiner, Pettis & Strout, Ltd. The total project budget is $368,438; the

AWWARF portion of this project is $150,000. Research objectives include determining the impact of six chemical additives on zebra mussel veliger mortality and on veliger settling inactivation. The candidate chemicals include sodium hypochlorite, iron plus hydrogen peroxide, potassium permanganate, chlorine dioxide, ammonia, and chloramine. The project goal is to determine the most cost effective chemical treatment at the water intakes. A report of the results is expected to be published. Whit Van Cott, Commissioner of Water, Toledo, Ohio (Telephone: (419) 321-6672) is the principal contact for this project.

The American Water Works Association has produced the following publications: Utilities Install New Facilities to Clean Clogged Intakes, by Judi Buehrer (Mainstream, March 1990, Volume 34, No. 3, page 6); and Utilities Coping with European Import, by Mary Parmelee (Mainstream, October 1989, Volume 33, No. 10, page 1).

Bio-Electrics, Inc.
1215 West 12th Street
Kansas City, Missouri 64104

Contact: Erich Sarapuu (816) 474-4895

Bio-Electrics develops and markets proprietary technology of electrical pest eradication in agriculture, horticulture, aquatic environments, and areas in which hazardous chemicals are expensive, ineffective, or prohibited. Electrical systems have been designed to eliminate zebra mussels from infested waters. For each site, a feasibility and demonstration study are performed, and an appropriate electrical system is designed.

Bollyke Associates, Inc.
83 Oakwood Avenue
Norwalk, Connecticut 06850

Contact: Joe Bollyke (203) 847-1506

Bollyke Associates is an engineering consulting firm that has developed a patented sidestream ozonation treatment process for controlling zebra mussel infestation in raw water intake pipelines.

Centerior Energy
P.O. Box 94661
Cleveland, Ohio 44101-4661

Contacts: Joseph C. Szwejkowski or Louise Barton (216) 447-3201.

Zebra mussels were first collected at Centerior at the Perry Nuclear Power Plant (PNPP) in September 1988. PNPP has developed a three-part zebra mussel program that includes monitoring, a chemical treatment program for the 1990 mussel season, and several research projects.

Monitoring methods include the use of artificial substrates, sidestream monitors, plankton nets, and scuba divers in addition to visually inspecting raw water system components when open for maintenance or repair.

PNPP adopted a chemical treatment program in 1990. It required the use of a proprietary chemical for two treatments during the season, in mid-July and late October. PNPP has conducted studies on the effectiveness of various applications of chlorine using the plant chlorination and dechlorination systems. An additional study on the effectiveness of intermittent chlorination for control of veligers was conducted during the summer of 1990, as well as a study of the effectiveness of pressure to control zebra mussels.

PNPP is also working with the Electric Power Research Institute (EPRI) to evaluate the performance of three proprietary chemicals. The chemicals are being evaluated in a sidestream testing apparatus designed to simulate plant conditions. The objectives of this project are focused on optimizing applications toward demonstrating environmental stewardship and cost effectiveness. Several of Centerior's other facilities have also used a proprietary chemical to treat infested service water systems. These fossil plants are also permitted to use chlorine intermittently as a biofoulant treatment. Because intermittent chlorination appears to be lethal to veligers, it is being investigated as a method of keeping raw water systems free from future infestation, once they have been cleared with the proprietary chemical.

Centerior Energy, in cooperation with Niagara Mohawk Power Corporation and Wisconsin Electric Power, is also conducting long-term fate analyses of various molluscicides. The project is nearing completion and the results should be available during the summer of 1991.

Commonwealth Edison
One First National Plaza
P.O. Box 767
Chicago, Illinois 60690

Contact: Harry Bernhard (312) 294-4447

In cooperation with EPRI and New York, Lake Erie, and Ontario plants, Commonwealth Edison is sampling and monitoring for zebra mussels as well as investigating control methods such as thermal treatment.

Detroit Edison
200 Second Avenue
Room H-133, WSC
Detroit, Michigan 48226

Contact: Bill Kovalak (313) 897-1394

Detroit Edison has conducted efficacy studies of various chemicals and methods for zebra mussel control. They are also involved with trying to determine the critical density for cluster formation.

Donahue and Associates, Inc.
4738 North 40th Street
Sheboygan, Wisconsin 53083

Contact: Loren Trick (414) 458-8711

Donahue and Associates was instrumental in organizing water and power utilities with intakes in Lake Michigan and Lake Superior to conduct a study to monitor their intakes for the presence of zebra mussel larvae during the summer of 1990. This study was conducted in association with the University of Wisconsin Sea Grant staff. Donahue worked with Sea Grant staff to develop sampling protocols, then trained the various utility personnel in proper sampling technique. Samples were analyzed by Sea Grant laboratory staff and the results were tabulated and distributed to study participants.

Donahue is presently conducting research to evaluate the effectiveness of various chemicals for the control of zebra mussels. Live adult mussels were obtained from Lake Erie in early May 1991; tests have been conducted on these mussels at both the Donahue laboratory and at a nearby water treatment facility participating in the study. Lake Michigan water is being used for all the tests, and the data is being correlated to toxicity data reported by researchers using other lake water and laboratory grade water.

Prior to starting research, Donahue met with researchers from other institutions such as Ohio State University, FWS, Wisconsin Sea Grant, and Illinois Geological Survey for assistance in formulating test protocols. Donahue formally applied for a permit from the Wisconsin Department of Natural Resources to bring live zebra mussels into the state. After conducting several series of 120-hour static acute toxicity tests in the laboratory, flow-through aquaria were used to evaluate the effect of continuous low dosage rates of the same chemicals.

A goal of this study is to determine a possible means to treat for zebra mussel infestations from the shore well end of intakes. This could eliminate the need for lengthy chemical piping, but may require some repiping inside the water treatment facility to provide sufficient water for backflushing.

Electric Power Research Institute
3412 Hillview Avenue
P.O. Box 10412
Palo Alto, California 94303

Contacts: Tony Armor or John Tsou (415) 855-2000

The Electric Power Research Institute (EPRI) has produced a technical report, The Zebra Mussel: U.S. Utility Implications. Published in 1990, The report (No. GS-6995) was prepared by Macrofouling Consultants and is available from EPRI. EPRI has also produced a video tape, Zebra Mussels: The Silent Invaders (order code: EA91-03), which describes the zebra mussel invasion and how it is affecting electric power plant operations. In addition, EPRI has formed an internal zebra mussel task force and utility advisory group.

EPRI has an agreement with Centerior Energy Corporation to conduct a study entitled Application of Chemical Control for Zebra Mussel Infestation. An interim report and final report should be available in November 1990 and November 1991, respectively. The work, to be performed by Centerior Energy, with EPRI technical support, is described as follows:

a. Full Flow System Treatment: The detailed research protocol will be finalized by Centerior Energy, EPRI, and its contractors. The initial chemical screening test by EPRI will be considered in the selection of treatments for control, both full flow and sidestream.

Chemical control methods will be implemented for zebra mussels at both Davis-Besse and Perry Nuclear Stations service water systems. Chlorination is currently planned for both Davis-Besse and Perry. In addition, Perry plans to use low level non-oxidizing biocides. Depending on the results of EPRI screening tests and regulatory approval, one of these plants will conduct full flow demonstration of at least one non-toxic dispersal type treatment. The most likely candidate to demonstrate independent and/or synergistic efficacy with the non-toxic and chlorine treatments is Davis-Besse. Perry will demonstrate independent and/or synergistic efficacy with the non-oxidizing and chlorine treatments.

b. Sidestream Testing System: Centerior will construct a low flow rate sidestream test system of PVC for field testing of biocides and dispersants for control of zebra mussels. The system will include piping, valves, flow meters, settlement sections, and chemical injection capabilities. The settlement or test sections will be designed for inspection, insertion, and removal of test animals. Transparent materials will be used in this section for on-line visual observation of attachment and release. Removable substrates for attachment will be representative of system materials.

The sidestream test capability will consist of at least three parallel sections to facilitate comparison of two treatment regimes and one control section. Corrosion coupons for mild steel and copper alloys will be inserted in these streams to determine any impact, positive or negative, on system materials. Simple biofilm test devices will be used to monitor the effect of the treatments on sessile microorganisms.

Chemical injection to the sidestream test system will be multi-head, low flow rate, metering pump(s). The system inlet will be monitored for temperature and periodic analysis will determine appropriate chemical parameters of the water. These will include

pH, dissolved oxygen, suspended solids, and chemical treatment concentrations as a minimum.

A test protocol for this system will include comparison of treatment efficacy for selected chemicals, including synergistic effects. Subsequently, this system will be used to optimize treatment level toward cost-effectiveness and environmental stewardship.

Other ongoing research projects include the following:

o developing a zebra mussel monitoring and control guide;

o developing interim control guidelines for electric power companies;

o investigating thermal treatment as a control method; and

o evaluating zebra mussel shells for heavy metal contamination and developing shell disposal methods.

Empire State Electric Energy Research Corporation
c/o New York Power Pool
5172 Western Turnpike
R.D. Route 3, Box 59
Altamont, New York 12009

Contact: John Holsapple (518) 356-6122

ESEERCO, a consortium of electric utilities within New York State, as well as its individual member utilities sponsor zebra mussel research and related activities. Some of this research is listed in Table E-5.

One of ESEERCO's early accomplishments was the development of a Zebra Mussel Sampling Protocol that is being used by member utilities statewide to monitor veliger concentrations and settling rates in power plant water intakes. In addition, Acres International used the protocol as the basis for monitoring programs for other raw water users in the State of New York. ESEERCO also funded studies by Sonalysts, Inc., on nonchemical zebra mussel control methods and by Aquatic Sciences, Inc., on zebra mussel dispersal by floating vegetation and the effectiveness of native predators such as muskrats.

Table E-5. ESEERCO Zebra Mussel Research

Sponsor/Contact	Amount	Investigator/Title
ESEERCO/J. Holsapple	$234,480	D. Molloy/Screening for Biological Contaminants of Zebra Mussels
ESEERCO/J. Holsapple	$248,900	Sonalysts/Acoustic Control of

		Zebra Mussels
ESEERCO/J. Holsapple	$ 39,987	Acres International/Second Year Monitoring of New York Inland Waters
ESEERCO/J. Holsapple Clearinghouse	$ 99,393	Zebra Mussel Information (For information, contact the Clearinghouse at (716) 395-2516)
Eastman Kodak Clearinghouse	$ 5,183	Zebra Mussel Information
Monroe City Water Clearinghouse Authority	$ 2,024	Zebra Mussel Information

Ferro Corporation
4150 East 56th Street
Cleveland, Ohio 44101

Contact: Pat Knack (216) 641-8580

Ferro Corporation developed the antifoulant coating, Crystic CopperClad, in 1988. CopperClad is a metal coating (70% copper particles by weight) that can be applied like a gelcoat. The copper particles are in a thermoset resin vehicle (non-conductive), which has anti-fouling properties without the environmental hazards of tributyltin. Beyond its use on boat hulls, CopperClad is being marketed for use in water treatment plants, power plants (cooling water inlets, etc.), sewage treatment plants, off shore oil rigs, weirs, buoys, fish traps, and submersibles.

Ferro Corporation has conducted seawater exposure tests on CopperClad over steel and fiberglass-reinforced plastic substrates in Biscayne Bay, Florida. The treated substrates exhibited resistance to permanent attachment of marine fouling organisms and have also demonstrated self-cleaning properties when fouled. In static conditions with no little velocity, a slime layer will attach and gradually thicken, allowing the attachment of biofouling organisms. With CopperClad, slime and organisms cannot securely attach and under dynamic conditions, the flowing water tends to "self-clean" the surface.

Great Lakes Chemical Corporation
P.O. Box 2200
West Lafayette, Indiana 47906

Contact: Gerald Walter (317) 497-6100

Great Lakes Chemical Corporation is supporting studies, at independent laboratories, to control zebra mussels with commercially available and developmental biocides. These biocides are bromine derivatives and the results to date have been encouraging.

Great Lakes Indian Fish and Wildlife Commission
P.O. Box 9
Odanah, Wisconsin

Contact: James H. Schlender, Executive Administrator (715) 682-6619

The Great Lakes Indian Fish and Wildlife Commission (GLIFWC) is involved in management and research of purple loosestrife, sea lamprey, and ruffe.

The GLIFWC has been investigating purple loosestrife control efforts since 1988. Their studies have led to a specific loosestrife control strategy in Fish Creek Sloughs and a general loosestrife control strategy for implementation in northern Wisconsin. Both strategies involve containment, control, and cleanup. The cleanup phase involves a continued effort of hand pulling seedlings that will undoubtedly germinate after the control phase. The Wisconsin Department of Transportation and the Wisconsin Conservation Corps (WCC) have provided funds for these GLIFWC efforts.

Since 1986 the GLIFWC has conducted a cooperative project with FWS' Sea Lamprey Control Station in Marquette, Michigan. This project gathers information on adult spawning-phase sea lamprey ascending various tributaries of Lake Superior. Objectives of this project are to: (l) monitor upstream spawning movements of the sea lamprey; (2) collect data on biological characteristics of the spawning lamprey; (3) estimate the number of lamprey spawning in each tributary using mark-recapture methods; and (4) reduce the spawning potential of lampreys by removing a portion of the run. The information is used to estimate absolute abundance of adult lamprey in the United States waters of Lake Superior and to estimate the effectiveness of regional control efforts.

The GLIFWC has provided field crews in support of FWS's research on ruffe in western Lake Superior. In 1991, GLIFWC will conduct sampling of fish predator stomachs to evaluate the effectiveness of a build-up of predators in controlling ruffe. Recently, the Council of Lake Committees, part of the Great Lakes Fishery Commission, wrote to chairmen of the appropriate committees in Congress and requested $1 million for research on biology and control of the ruffe. Fishery managers on the Great Lakes view the ruffe as the greatest looming threat to the fisheries of the Great Lakes.

Harza Engineering Company
150 South Wacker Drive
Chicago, Illinois 60606-4288

Contact: Suzanne Boltz (312) 855-7000

The Village of Wilmette, Illinois, has contracted with the Harza Engineering Company (Harza) to: 1) evaluate the vulnerability of their water plant to zebra mussel infestation; 2) evaluate methods to prevent and remove zebra mussel infestations in their plant; and 3) develop an action plan to respond to any infestation. A component-by-component assessment of zebra mussel impacts was made for each water supply, treatment, and

distribution system in Wilmette. The action plan developed for the Wilmette Water Plant recommended monitoring zebra mussel occurrence at several locations in the system, and immediate construction of protection measures for land-based system components at risk. Future actions will be determined based on the extent and rate of zebra mussel infestation. The recommendations were summarized and associated costs for the actions were developed. Harza is assisting Wilmette with a monitoring program and is providing design services for a chlorine system for land-based components. The development of a detailed long-term plan to protect off-shore facilities will begin soon.

Hi-Tek Chemical Corporation
Marine Division
106 Taft Avenue
Hempstead, New York 11550

Contact: Richard J. Spera (516) 538-0400

Hi-Tek Chemical Corporation has developed Epco-tek 2000, an epoxy coating containing copper powder available in a sprayable liquid form and as laminated fiberglass sheathing. Several years of testing in Lake St. Clair by Gerry Mackie has demonstrated that this compound reduces settlement by zebra mussel veligers. Results to date also suggest that this formulation is non-ablative once it stabilizes shortly after application.

Illinois Natural History Survey
Center for Aquatic Ecology
Lake Michigan Biological Station
P.O. Box 634
Zion, Illinois 60099

Contact: Dr. J. Ellen Marsden (708) 872-8676

Dr. Marsden has prepared a report entitled Standard Protocols for Monitoring and Sampling Zebra Mussels which was published in April 1992 as Illinois Natural History Survey Biological Notes 138. The methods described in the report were compiled using information from over 40 researchers and agency personnel involved in zebra mussel monitoring. The urgent need for zebra mussel sampling guidelines prompted the release of a working draft of the report in March 1991 (Illinois Natural History Survey Aquatic Ecology Technical Report 91/4). Several researchers compared different sampling methods described in the working draft during the 1991 field season. In addition, the working draft was circulated widely for review and comment. The methods described in the report are being used by many power plants and others in the Great Lakes region. Funding for the development of the report was provided by the Great Lakes Research Consortium.

Midstates Marine Group
550 North Greenbay Road
Waukegan, Illinois 60085

Contact: Charlie Moberly (708) 263-7117

Midstates Marine Group is a national distribution corporation for the marine industry. Their primary products consist of OMNI-GEL, a line of marine cleaners, and other chemicals. OMNI-GEL, an HCL-based formulation, cleans surfaces infested with zebra mussels, algae, mineral deposits, barnacles, and other salt and freshwater parasites. It removes zebra mussels and other organisms from surfaces by dissolving them and their shells. Although microscopic tests have not been conducted, it has been suggested that the cleaner effectively dissolves the byssal threads as well.

Midstates Marine Group has provided a small colony of zebra mussels to Dr. Ellen Marsden of Illinois Natural History Survey. Dr. Marsden's work will include performing microscopic studies to verify OMNI-GEL's efficacy at zebra mussel removal.

Midwest Marine Contractors, Inc.
149 Gregory Street
Mt. Prospect, Illinois 60056

Contact: Sandy Goranson (708) 296-1574

Midwest Marine Contractors provides divers to do troubleshooting on underwater pipes. Their zebra mussel program currently consists of three systems: l) preventative maintenance for underwater pipes (patented); 2) using divers to install machinery to clear out infested pipes; and 3) videotaping the inside of pipes up to five miles long.

Monroe Water Treatment Plant
915 East Front Street
Monroe, Michigan 48161

Contact: Wil LePage, Superintendent (313) 241-5947

The Monroe Water Treatment Plant has chlorinated water at its intakes since late 1989 to prevent infestation by zebra mussels and is investigating other control methods. Studies have been funded on ozone treatment and biocides to determine their efficacy. The ozone treatment work is being conducted under contract by Bollyke Associates of Norwalk, Connecticut.

Nalco Chemical Company
One Nalco Center
Naperville, Illinois 60563-1198

Contact: Edward Ekis, Jr. (708) 305-1000

Nalco Chemical Company (Nalco) has been active in developing chemical strategies for preventing and controlling macrofouling in nuclear and fossil fired power plants. Where

chlorine alone cannot be used to preclude micro- and macrofouling, chlorine activated bromide-surfactant technology developed by Nalco has provided a cost-effective solution in preventing plant infestations by a variety of macrofouling species. Nalco researchers have demonstrated that: 1) the addition of bromide salts to a chlorinated water stream converts hypochlorous acid to hypobromous acid; and 2) the proportion of each acid could be changed intentionally by varying the molar ratios of chlorine to bromine being fed to the system. It was also found that the inclusion of penetrating surfactants in the formulation was helpful in the prevention of biofilm formation on heat transfer surfaces. The resulting bromide-surfactant technology when coupled with chlorine (as a gas or as the safer, liquid hypochlorite) is expected to provide significant benefits to the utility industry over the use of chlorine alone. Marketed under the name Acti-Brom, Nalco has three patents for its biocide treatment products: Multi-Functional Hypobromide Precursors, May 1984; Biocide Water Treatment Having Reduced Copper Corrosion, April 1989; and Mixture of Halides Such as NaOCl and Bromide Salt for Removal of Mussels and Barnacles from Salt or Brackish Water, October 1989.

New York State Electric and Gas
4500 Vestal Parkway East
P.O. Box 3607
Binghamton, New York 13902-3607

Contact: Ray Tuttle (607) 729-2551

New York State Electric and Gas (NYSEG) funds a significant amount of zebra mussel research. One such study investigating whether electric barriers can exclude veligers from water intakes found that with the substantial volumes of water involved too much power is required to create an effective barrier for this technology to be a practical solution. Monitoring for zebra mussel veligers following the ESEERCO protocol began at NYSEG' Somerset Station on Lake Ontario in April 1990. NYSEG has obtained underwater videos that show progressive zebra mussel colonization of walls and pump housings in power plant cooling systems. Other NYSEG sponsored zebra mussel research is listed in Table E-6.

Table E-6. Zebra Mussel Research Sponsored By NYSEG

Title	Amount
Monitoring at the Kintigh Station	$ 80,000
Chlorination Control Parameters	$ 60,000
Acti-Brom Control Optimization	$ 60,000
Use of Clam-Trol for Zebra Mussel Control	$ 40,000
Evaluation of the Feasibility of a Particle Separator	$100,000

Niagara Mohawk Power Corporation
300 Erie Boulevard West, Building A2

Syracuse, New York 13202

Contact: Dr. Ed Neuhauser (315) 428-3355

The Niagara Mohawk Power Corporation currently has two zebra mussel research projects. One project is on the effect of oxidant type and application method on the inactivation of zebra mussel veliger larvae. This research will evaluate the effectiveness of ozone, hydrogen peroxide, and chlorine to control zebra mussels, and determine the effect of oxidant dose and application method (continuous vs. pulsed) on the inactivation of zebra mussel larvae. In addition to controlled variables (oxidant, concentration, application method), water temperature, pH, and incoming veliger concentrations are being monitored as well. Investigators are Drs. John Van Benschoten and James N. Jensen, Department of Civil Engineering, State University of New York at Buffalo, and Aquatic Sciences, Inc.

Niagara Mohawk is also evaluating selected molluscicides for environmental effects and fate. This project will analyze the relative value of a number of chemical agents for controlling macrofouling by the zebra mussel. The environmental fate, toxicity, and mechanism of action of the substances studied will be assessed in order to determine the most efficacious and environmentally sound treatment for the control of the mussel in power plant and industrial raw water intakes. Chemical agents considered for assessment include Clam-Trol CT-l (Betz), Acti-Brom 1338 (Nalco), Macro-Trol 7326 (Nalco), Bulab 6002 (Buckman), and Bulab 6009 (Buckman). Investigators will also determine the mechanism of toxicity to both the mussel and non-target species (including humans).

Ohio State University
Department of Entomology
103 Botany and Zoology
1735 Neil Avenue
Columbus, Ohio 43210

Contact: Dr. Susan Fisher (614) 292-2133

Ohio State University is currently involved in two projects that have been funded by the private sector:

1. Evaluation of chemicals, substrates, and devices for zebra mussel control:

Company	Product	Product Type
Fibertron	fibertron	substrate
Inorganic Coatings	silicon	substrate
Atochem	hydrothol	chemical
ISK Bioteck	chlorothalonil	chemical

2. Use of potassium chloride for zebra mussel control. This project is designed to assess the ability of low levels of potassium chloride, continuously delivered, to deter

attachment of zebra mussel veligers. Sponsored by the Potash Corporation of Saskatchewan. The use of potassium for zebra mussel control is currently in the process of being patented.

Paape Technologies

Paape Technologies has developed a mobile test laboratory that can be used to treat a specific infested area for a given period of time. The unit can also be used to demonstrate the viability of the use of ozone through a limited "pilot project" or demonstration of the equipment and techniques that would be used to treat the mussel in a larger more comprehensive treatment program.

A three-pound per day ozonator (i.e., an ozone generator), manufactured by the Ozone Research and Equipment Corporation (OREC) of Phoenix, Arizona, has been installed in a fourteen foot Chevrolet Cube Van. Auxiliary power is available through a diesel engine powered generator installed in the van. This provides the capability to operate in a remote or isolated location where electrical power may not be available. The van is equipped with three six foot tall, sixteen-inch diameter columns that act as contractor towers to provide the retention time needed for the ozone to percolate through the water being treated.

Potomac Electric Power Company
1900 Pennsylvania Avenue, N.W.
Washington, D.C. 20068

Baltimore Gas and Electric Company
1000 Brandon Shores Road
Baltimore, Maryland 21226

Contact:
F. Edward Kreuger, Potomac Electric Power Company (202) 331-6539
Melissa Weiland, Baltimore Gas and Electric Company (301) 787-5114

The Maryland Department of Natural Resources held a meeting with public utility, university, state, and neighboring state management agencies to discuss the environmental and economic threat posed by zebra mussels. Representatives from each of these areas comprise the Department's Zebra Mussel Work Group. The Work Group has focused on research, monitoring, control, and funding.

The Work Group agreed that it would be unwise and unnecessary to allow importation of live organisms for research. The group has recommended that this understanding be communicated to neighboring states. Maryland utilities are keeping abreast of the experiences of plant in infested areas, but have not yet formulated specific strategies for prevention or control. The Work Group is developing a plan that will identify industries, habitat, and species at risk, control strategies, research needs, and risk factors.

Pettit Paint Company
36 Pine Street
Rockaway, New Jersey 07866

Contact: (201) 625-3100

Pettit Paint Company has developed a paint used to deter zebra mussel settling and infestation. The Unepoxy formulation comes in three strengths: standard, plus, and tropic, which vary from 55 to 65 percent in copper content.

RJF International Corporation
6900 W. Snowville Road
Brecksville, Ohio 44141

Contact: Dick Varga (216) 526-2555

The Polymeric Protective Linings Company is a division of the RJF International Corporation that manufactures and markets a line of rubber and plastic linings to meet a broad range of environmental needs. These linings are widely used throughout industry to protect equipment, piping, fans, blowers, and scrubbers from corrosive chemicals and abrasive materials.

RJF International has expanded their lining technology to include slow-release additives to rubber that can deter the growth of water-spawned larvae, trematodes, and mollusks. This technology can be adapted to retard growth and spread of the zebra mussel in municipal water inlet systems in the Great Lakes. Research is continuing with the City of Cleveland and Case Western Reserve University to verify the concentration and release rates of the active ingredient to retard growth of the zebra mussel.

Superior Water Systems
P.O. Box 192
Griffith, Indiana 46319

Contact: Al Griffin (219) 865-1155

Superior Water Systems installs ozone equipment around raw water intake pipes according to specifications designed for each site.

Toledo Water
P.O. Box 786
Toledo, Ohio 43697

Contact: Bob Stevenson (419) 693-6277

In addition to research conducted with the American Water Works Research Foundation (described above), Toledo Water monitors directly for zebra mussel presence and

indirectly by measuring indicators such as phytoplankton abundance, flow rates, and draw down. Toledo water has conducted research on the effects of hydrogen peroxide with iron, potassium permanganate, and oxidants on veligers.

University of Guelph
Department of Zoology
Guelph, Ontario N1G 2W1
CANADA

Contact: Dr. Gerald L. Mackie (519) 824-4120

Dr. Mackie monitors zebra mussel control programs at pulp and paper, petroleum, chemical, cement and steel plants. He also conducts bio-assays on confidential products for ESEERCO, Niagara Mohawk, and Ontario Hydro.

Wildlife Forever
12301 Whitewater Drive
P.O. Box 3404
Minnetonka, Minnesota 55343

Contact: David Garton, Indiana University at Kokomo (317) 455-9244

Wildlife Forever is a non-profit organization concerned with maintaining wildlife heritage. Dr. David Garton has received $2,000 from Wildlife Forever for his research on the impact on native fauna by the introduced zebra mussel in North America. The primary objectives of this research are to determine if the introduction of the zebra mussel has resulted in significant diversion of algal production from the pelagic food web and if the effects that an increase in biomass and production of the zebra mussel might have on zooplankton abundance and production.

Winous Point Shooting Club
3500 South Lattimore Road
Port Clinton, Ohio 43452

Contact: Roy Kroll (419) 734-1188

The Winous Point Research Committee (WPRC) is the organization within Winous Point Shooting Club through which research projects are conducted. Current research on non-indigenous species is limited to two species associated with freshwater marshes: a plant, purple loosestrife, and a fish, common carp.

Studies on purple loosestrife focus on controlling its establishment within Ohio's Lake Erie marshes. More research on purple loosestrife has been conducted through Winous Point than through any other Ohio research entity. These studies, which began in 1979, include the development of successful control techniques and long-term monitoring of their effectiveness. Researchers have investigated the techniques of hand-pulling, water

level control, burning, mowing, mechanical tillage, and environmentally safe herbicide application. Effective management techniques have been documented to prevent the establishment of purple loosestrife in the managed marshes of Lake Erie's southwest shore. Annual wetland management scenarios have been developed to suppress existing infestations of loosestrife in managed marshes. Several technical publications and presentations have been generated from these investigations.

The common carp degrades wetlands by uprooting marsh vegetation and increasing the turbidity of the water. The most desirable and sensitive wetland plants occur in clear waters. Winous Point is exploring methods to suppress common carp and reestablish desired underwater vegetation in order to increase the habitat quality for wetland wildlife. Researchers are measuring the response to this increased quality by documenting numbers of breeding marsh bird species.

Appendix F

COORDINATED PROGRAM OF RESEARCH ON NON-INDIGENOUS SPECIES IN THE GREAT LAKES

Prepared by the United States Great Lakes Non-Indigenous Species Coordinating Committee

August 1990

BACKGROUND

Recently, three new organisms have established populations in the Great Lakes: the zebra mussel (Dreissena polymorpha), a small bivalve; the spiny water flea (Bythotrephes cederstroemi), a large cladoceran zooplankter; and the ruffe (Gymnocephalus cernuum), a medium-sized fish related to yellow perch. The first two species are undergoing rapid population explosion in the Great Lakes and are expected to become widespread in North America. These two species may dramatically alter existing trophic level relationships in the ecosystem, not only in the Great Lakes, but potentially across large portions of the United States. The third species is currently confined to Duluth Harbor in western Lake Superior but is undergoing a rapid population increase.

Non-indigenous species (also known as exotic species) which establish themselves within an environment are not new to the Great Lakes ecosystem. Humans have introduced many species of plants and animals over the past 150 years through both planned and accidental activities. Some introduced species have been considered beneficial (e.g. brown trout, rainbow trout, Pacific salmon) although there is relatively little understanding of the effects they have had on native biota. Other species, such as the Chinese mitten crab (Eriocheir sinensis), Asiatic clam (Corbicula fluminea), European flounder (Platichthys flesus), and macroalgae (Nitellopsis spp.), have not attained great abundances, nor have they become widely distributed. Non-indigenous species continue to gain access to the Great Lakes. Most recently, the tubenose goby (Proterorhinus marmoratus), a fish which lives in the Black and Caspian Sea Basins, was captured in the St. Clair River.

Unfortunately, several non-indigenous species have adversely affected important habitats and associated biota. The sea lamprey (Petromyzon marinus) has had catastrophic consequences for native species of coregonid fishes, commonly called chubs, and lake trout. The lamprey, which caused millions of dollars in damages and losses to commercial Great Lakes fisheries, was not brought under control until the late 1950's with the implementation of a costly and continuing control program. In the late 1960's, the build-up of huge populations of alewife (Alosa pseudoharengus), accelerated the collapse of coregonid populations, adversely affected yellow perch and other native species, and caused economic hardships for communities across the region by necessitating the costly clean-up of dead alewives littering the beaches each year. Subsequently, the alewife became an important prey fish for a considerable number of

recreational fishes, including the Pacific salmon, and the system has come into a fragile balance.

Since its recent introduction, the zebra mussel population also has caused significant problems. Like the spiny water flea, the prolific zebra mussel may have disrupted natural food chain processes in the lakes. In addition, zebra mussels have been clogging municipal and industrial water intake structures, attaching themselves to and hastening the deterioration of nautical and littoral structures, and littering and fouling recreational beaches.

The zebra mussel and spiny water flea have already spread into all five of the Great Lakes. Because the Great Lakes are directly and indirectly connected to other major waterways (e.g., the Hudson River via the Erie Canal; the Mississippi River via the Chicago Sanitary and Shipping Canal), it is expected that zebra mussels and spiny water fleas can and will ultimately spread into freshwater lakes, rivers, and streams in many areas of the United States. In addition, mussels attached to the hulls of pleasure boats that are moved by trailer from one body of water to another can survive out of water for up to 14 days. This is more than enough time for a boat from Lake Erie to be moved and placed in lakes, rivers, or streams anywhere in the United States. Although zebra mussels do not proliferate in waters that are either too warm or cold, their range could include all of the temperate region of the United States (about 60% of the country) as well as southern Canada.

UNITED STATES GREAT LAKES NON-INDIGENOUS SPECIES COORDINATING COMMITTEE

Recognizing the importance and urgency of the problems surrounding nonindigenous species in the Great Lakes, the Great Lakes research community highly advocates the development of a coordinated research program. To facilitate this concept, a meeting was held on June 6, 1990, in Detroit, Michigan, with the primary purpose of beginning to develop a coordinated research program. Participating in the meeting were representatives from the Great Lakes Environmental Research Laboratory of NOAA, the National Fisheries Research Center -- Great Lakes of the U.S. Fish and Wildlife Service, each of the six Great Lakes Region Sea Grant Programs, the Cooperative Institute for Limnology and Ecosystems Research, and the U.S. Environmental Protection Agency. The group established the U.S. Great Lakes Non-Indigenous Species Coordinating Committee, with representation suggested from the following fourteen organizations:

Great Lakes Environmental Research Laboratory of NOAA

National Fisheries Research Center -- Great Lakes of the U.S. Fish and Wildlife Service

Illinois-Indiana Sea Grant Program

Michigan Sea Grant College Program

Minnesota Sea Grant College Program

New York Sea Grant Institute

Ohio Sea Grant College Program

University of Wisconsin Sea Grant Institute

Institute Cooperative Institute for Limnology and Ecosystems Research

U.S. Environmental Protection Agency

Great Lakes Commission

Great Lakes Fishery Commission

U.S. Coast Guard

U.S. Army Corps of Engineers

Coordination with Canadian counterpart agencies and committees will be sought and encouraged.

The overall goal of the U.S. Great Lakes Non-Indigenous Species Coordinating Committee is to establish a coordinated research program to provide the scientific basis for sound policy formulation. Toward this end, the Committee has developed a multi-level framework of objectives and activities for focusing and integrating program and project development (see attached figure) and guiding the review of proposals and budgets. The framework includes six major research areas and a number of high priority research topics with each area. The mix of activities within and among areas will be determined by a variety of processes involving many participants, including, as necessary, interested and qualified individuals and organizations not represented on the committee.

This committee will facilitate the coordination of research, education, and technology transfer regarding non-indigenous species within the Great Lakes Basin. The process will include exchanging information on proposed research, establishing and maintaining a non-indigenous species database, and developing communication with state and local governments and the private sector.

NON-INDIGENOUS SPECIES RESEARCH AREAS AND TOPICS

Biology/Life History of Non-Indigenous Species

A basic understanding of the life history and population dynamics of recently introduced species is required to predict the response of the ecosystem to invasion, and to determine

biological characteristics that may guide research to the discovery of effective, ecologically safe, and economically feasible control measures. Review of existing research literature in conjunction with primary biological research to consider the areas of life history, population dynamics, physiology and behavior, genetics, parasites, and diseases may be especially pertinent for determining an organism's vulnerability to particular control alternatives. Information on the ecological and environmental tolerances of non-indigenous species is necessary to determine the potential geographic limits of infestation and to predict which indigenous species and their habitats are most likely to be affected by the invasion.

Ecosystem Effects of Non-Indigenous Species

Any new organism introduced to an existing ecosystem has the potential to alter or disrupt existing ecosystem relationships and environmental processes. The implications of a non-indigenous species invasion to the ecosystem, especially in relation to competition for food with other species ranging from zooplankton and benthos to juvenile fish, may be far-reaching. The invasion of non-indigenous species can significantly affect the populations of other organisms that are important components of the existing food web, ultimately leading to either overpopulation or demise of important existing species. In addition, some nonindigenous organisms can influence, and possibly significantly change, environmental processes that determine water quality, such as the distribution and cycling of particulates and toxic contaminants, and the productivity of the affected water bodies.

Therefore, a high priority of any non-indigenous species research program must be to identify and evaluate the likely ecosystem and environmental effects and changes that the new organism, at each stage of its life history, is likely to produce. Such information will assist natural resource managers in making decisions that will minimize and/or accommodate as much as practical, the ecological and environmental impacts that invading organisms have on established biota and their habitats.

Socio-Economic Analyses: Costs and Benefits of Non-Indigenous Species

Natural resource managers need to be cognizant of the potential effects of non-indigenous species on the economy and society so that they can adjust their management strategies to control and direct the impacts. Experience with most non-indigenous species indicates that negative impacts usually predominate over positive ones; nonetheless, research should address both aspects for the benefit of society. Research should focus on the potential impacts on human health in terms of spread of disease, concentrations of pollutants, and contamination or purification of drinking water sources. Economic impact investigations should broadly examine effects on all productive uses of aquatic resources including the sport, commercial, and tribal fishing industry; the recreation and tourism industry; shipping and navigation needs; and municipal and industrial water users. Economic use of non-indigenous species, such as food for domestic animals or fertilizer for gardens and crops, should be evaluated. Finally, research results should be used to

provide a scientific basis for developing sound policy and environmental law and for education and technology transfer on socio-economic effects.

Control and Mitigation of Non-Indigenous Species

While temporary measures may mitigate the effects of invading organisms, the only truly effective means of control will be identified through long-term research. An example of this approach is the successful control of sea lamprey populations in the Great Lakes. Future success in controlling the damage from newly invading non-indigenous species must be predicated on the same research strategy which investigates the entire suite of physical, chemical, and biological requirements of each non-indigenous species. Innovative and effective control techniques specifically targeted to non-indigenous invaders can only be determined through knowledge of the organisms' behavior, physiology, genetic and immunochemical characteristics. Thus, a well-balanced research program on control and mitigation requires, as a point of departure, information regarding these factors.

From this base of information acquired under the Biology/Life History research area, the research program in control and mitigation can move into the investigation of a variety of control measures: engineering (redesign of water-intake pipes, etc.), physical (scraping, filtering, etc.), chemical (antifoulants, biocides, etc.), biological (parasites, predators, etc.) and physio-chemical (heat, Ph, etc.). These lines of investigation should be paralleled and include both short-term and long-term means of control and mitigation of non-indigenous species. Finally, any and all proposed control strategies for each particular non-indigenous species must be ecologically acceptable and responsible. In particular, research on proposed biocides would include consideration of their toxicity to other organisms, persistence in the environment, and bioaccumulation.

Prevention of Introduction of Non-Indigenous Species

Once introduced and established in an open aquatic system, non-indigenous species have proven impossible to eliminate. While effective means may be found to control these organisms at some ecological or socio-economic level of acceptance, in most cases little can be done to minimize ecosystem impacts and resulting resource losses. Emphasis, therefore, should be placed on preventing the introduction of new non-indigenous species into the system.

First, the means of introduction must be identified. Then, research should focus on establishing cost-effective, realistic methods of prevention. For example, ballast water discharge is an important vector for non-indigenous species introductions in the Great Lakes. Strategies must be developed to effectively eliminate this source of introduction without imposing undue hardships on the shipping industry. Strategies for eliminating other means of non-indigenous species introductions, such as intentional release, opening of canals, accidental release, etc. must be examined in a similar fashion.

In addition, not all introduced species become widespread and abundant. An examination of life history characteristics and past dispersal patterns in other aquatic environments worldwide can identify those species most likely to spread into and colonize the Great Lakes.

Reducing the Spread of Established Non-Indigenous Species

The scientific ability to predict the spread of an established non-indigenous species (i.e., a viable reproducing population) is dependent on knowledge of the species' environmental requirements and its dispersal mechanisms, which allow it to reach new areas where environmental conditions are favorable for growth and reproduction. Most non-indigenous species have been introduced and spread by anthropogenic activities (ship ballast, boats, pet industry, etc.). However, the mechanism by which dispersal occurs is often unique to each species and is usually determined after geographic range extensions occur.

Basic understanding of non-indigenous species biology, and documentation of past modes of dispersal can be used to establish likely future dispersal mechanisms. Once dispersal mechanisms are identified for individual established non-indigenous species, proper safeguards and international protocols can be developed to prevent and/or slow the spread to uninfected areas. Such safeguards and protocols may also be applicable to preventing the spread of new, not-yet-established non-indigenous species. Analysis and identification of past and possible future dispersal mechanisms of non-indigenous species will enhance the ability to control and mitigate the impact these species may impose on the ecosystem.

Appendix G

PROTOCOL FOR EVALUATING RESEARCH PROPOSALS CONCERNING NONINDIGENOUS AQUATIC SPECIES

AQUATIC NUISANCE SPECIES TASK FORCE
JULY 1994

Introduction

The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (Act; Public Law 101-646, 104 STAT. 4671, 16 U.S.C. 4701-4741 approved Nov. 29, 1990) requires that an intergovernmental Aquatic Nuisance Species Task Force (Task Force) develop and implement a protocol to ensure that research carried out under Subtitle C of the Act does not result in the introduction or dispersal of nonindigenous aquatic nuisance species to the waters of the United States. This protocol fulfills the requirements of the Act. The Task Force intends to develop the research protocol further based on experience gained through implementation of this protocol. This protocol will supplement other existing Federal protocols established to control activities with specific major classes of organisms, such as those already established for plants and insects under the Plant Quarantine Act of 1912 and the Federal Plant Pest Act of 1952, and for research involving recombinant DNA molecules under the Public Health Service Act of 1944.

This protocol must be used when research is carried out under Subtitle C of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990. Individuals, states, corporations, and institutions not required by the Act to follow this protocol are encouraged to do so to prevent introductions and dispersal of nonindigenous aquatic nuisance species through research activities. Prevention of unintentional introductions through means other than research is addressed in the Task Force's proposed Aquatic Nuisance Species Program (which addresses prevention, detection, monitoring, and control of nonindigenous aquatic nuisance species). Intentional introductions are addressed in the Task Force's Report to Congress entitled "Findings, Conclusions, and Recommendations of the Intentional Introductions Policy Review".

A Research Protocol Committee (Appendix III) composed of representatives from the Task Force members was established to develop the required research protocol. The committee met in Gainesville, Florida, on June 25, 26, and 27, 1991, drafted the protocol, and prepared policy recommendations to the Task Force concerning implementation of the protocol. The draft protocol was circulated to all Task Force agencies for review. A second draft was presented to the Task Force on September 27, 1991. Following a meeting of the Research Protocol Committee on April 1 and 2, 1992, and receipt of additional comments from Federal and non-Federal sources, a final draft was prepared and presented for Task Force approval on April 21, 1992. The research protocol was adopted by the Task Force on April 22, 1992 as an interim working protocol until the protocol had completed a public review. The availability of the Research Protocol for public review was announced in the Federal Register on September 24, 1992.

Research Protocol

The research protocol consists of two parts: a risk assessment (Part I) and a set of guidelines outlining preventative containment and confinement procedures (Part II). The risk assessment requires the Principal Investigator and the Research Institution to evaluate the risk that the species, if it escapes or is released, will be a nuisance, and to determine if preventative measures must be taken to prevent the species from escaping or being released. Research may be conducted with minimal special preventative measures if 1) the research site is within the present established or historic range of the species, 2) the species is free of nonindigenous diseases, parasites or other extraneous viable material, 3) the species is not likely to be a nuisance if released, and 4) the species cannot survive in the waters adjacent to the research location, or 5) only non-viable forms are used, or 6) the research does not involve actual handling or transfer of the species (e.g. computer modelling and in situ data collection). The evaluation of the proposal by the risk assessment will determine if preventative measures must be taken.

The second part of the protocol is a detailed set of preventative containment and confinement guidelines that the Principal Investigator may be required to follow to prevent the escape or release of any research species that fails to meet one or more of the conditions listed above. If directed by the risk assessment, the Principal Investigator must develop preventative measures that will contain or confine the species to the research facility or location(s).

Appendix I is a list of some of the presently existing guidelines and protocols that may be used as resources by investigators to identify the types of precautions that can be taken to prevent unintentional releases of organisms used in research or to guide research on aquatic nonindigenous species. The specific precautions needed (which include procedural and facility design and use elements) will depend on the species to be studied, its life stage and size (e.g. macroscopic and/or microscopic, and size range within each), the scope of the project, the characteristics of the research location(s) with regard to the species' critical environmental factors, and the potential of the species to survive in that locale(s) and to be a nuisance. If the species is a disease-causing organism or a parasite, or the species or the source of the species under consideration is not free of nonindigenous diseases or parasites, extra precautions may be necessary. Most of the guidelines listed require that test species be contained or confined by some combination of physical, biological, chemical, and/or environmental barriers, or by limiting the scope of the research. The number and types of barriers needed depends on the species and the potential problems the species could create if it escapes or is released from the research site(s).

Procedures to Process Research Proposals

1. The Principal Investigator

The Principal Investigator shall determine that the research proposal complies with all applicable local, state, and national laws and regulations. The Principal Investigator will

submit all research proposals concerning nonindigenous aquatic species to their Research Institution for review -- usually the Research Institution will establish a committee similar in membership, roles and responsibilities to the Institutional Biosafety Committee (IBC) described in the National Institutes of Health (NIH) Guidelines for Research Involving Recombinant DNA Molecules (Federal Register 51, Number 88, page 16959 (51 FR 16959)). In the proposal the Principal Investigator must demonstrate a knowledge of the life history and biology of the species, provide all information necessary for preparation of a risk assessment, and provide citations for all supporting data. If the species is found to present any possibility of being a nuisance, as determined by the risk assessment, the proposal must clearly demonstrate that 1) adequate confinement and containment procedures will be in place during research and throughout the time that the species is held, and 2) the Principal Investigator has incorporated into the study plan procedures, facility design elements, and other preventative measures analogous to those in guidelines developed by NIH for research within recombinant DNA molecules, and the U.S. Department of Agriculture for research in agricultural biotechnology (49 FR 50856, 51 FR 23302, and 56 FR 4134), which are adequate to contain and confine the species and any pathogens or parasites it may contain or be infested with. Within 30 days of being notified by a Funding Agency that a nonindigenous species research proposal will be funded, the Principal Investigator must notify the appropriate state authorities in writing that the research is going to be carried out, and must submit a copy of that written notification to the Funding Agency by the end of the thirty day period. The Funding Agency will be responsible for sending a copy of the state notification document to the Research Protocol Committee before the research is initiated.

2. The Research Institution

The Research Institution accepts and reviews the research proposal, reviews and approves the risk assessment and preventative measures, agrees to support the research and signs a statement that it will ensure that the research will be conducted as planned and the preventative measures will be carried out. The Research Institution may establish an Institutional Biosafety Committee (IBC) and a Biosafety Officer (BO) position to assist it to meet its obligations. The use of an IBC or a BO is optional but the Principal Investigator and the Research Institution should have a system in place to demonstrate that the proposal has been reviewed by a qualified independent group before submitting it to the Funding Agency. The Research Institution must determine that the proposal is complete, and that it includes an accurately completed risk assessment, all required life history and biological data, and adequate and detailed containment and confinement measures, if needed. The Research Institution should also determine that the proposal complies with all applicable local, state, and national laws and regulations. The Research Institution should determine if a species-specific containment/confinement protocol has been approved by the Research Protocol Committee for the species and if so, whether the proposal fully meets all requirements of that approved species-specific protocol (ASSP). If an ASSP exists and the Principal Investigator is proposing to deviate from that ASSP, the Research Institution should ensure that the differences and the substituted preventative measures are clearly described, since further review and approval of the proposal by the Research Protocol Committee will be required. If no ASSP exists, the

Research Institution must be assured that the Principal Investigator has conducted a thorough literature review on the species, is knowledgeable of its life history, biology and ecology, and has developed and described preventative measures to adequately contain and confine the species if necessary. Proposals not conforming to an ASSP or for which no ASSP exists will require a full review by the Research Protocol Committee, and should follow guidelines similar to that outlined in Appendix I. The proposal, with the appropriate findings and a certification of compliance statement signed by the Principal Investigator and the Research Institution that states that the Principal Investigator and the Research Institution will adhere to the proposed containment and confinement procedures, must be transmitted to the Funding Agency. If the Research Institution or the IBC does not have the expertise to evaluate a particular proposal, the proposal should be transmitted to the Funding Agency accompanied by a request for a review by the Research Protocol Committee. The Principal Investigator is still responsible for providing all the information needed to fully evaluate the species.

3. The Funding Agency

The Funding Agency provides technical and programmatic review, determines if the proposal is complete and that it complies with the requirements of the National Environmental Policy Act (NEPA) and other applicable laws and regulations (Appendix IV). The Funding Agency makes all funding decisions; prioritizes and selects proposals for funding, submits the proposals to be funded to the Research Protocol Committee, and after receipt of the Research Protocol Committee's review, determines what steps must be taken, if any, before the proposals will be funded. The Funding Agency may require that the Principal Investigator make changes in the proposal before submittal to the Research Protocol Committee for initial or re-review. All proposals selected for funding will be transmitted to the Research Protocol Committee within 15 days after the proposal has been selected for funding, either for review, if the Research Institution has not already certified that the proposal is in compliance with an ASSP, or for informational purposes, if the Research Institution has certified compliance with an ASSP. The Research Protocol Committee will eventually review all proposals, but proposals following an ASSP do not have to be reviewed prior to funding.

4. The Research Protocol Committee

All proposals concerning nonindigenous aquatic species (including the risk assessment and preventative measures to be used to prevent escape or inadvertent release) selected for funding by a Funding Agency will be submitted to the Research Protocol Committee within 15 days of selection for funding. Research proposals requiring preventive/containment measures and for which the Principal Investigator and Research Institution have certified that one or more ASSPs will be followed without modification, will not have to be reviewed by the Research Protocol Committee prior to funding. However, such proposals will still be sent to the Research Protocol Committee by the Funding Agency for review to verify the risk assessment and ASSP(s), to verify compliance with the intent and provision of the Research Protocol, to obtain information that may be used to revise the Research Protocol or the ASSP(s) as appropriate, and to

obtain information necessary for reporting purposes. For all other proposals, the Research Protocol Committee will review in detail the completed risk assessment, the research proposal, and the proposed containment and confinement procedures to insure that the proposed procedures are adequate to prevent the species from escaping or being released during the research. The Research Protocol Committee will review and provide comments and recommendations to the Funding agency within 90 days of receipt of the research proposals from the Funding Agency. Proposals requiring major changes must be resubmitted to the Research Protocol Committee for review. The Research Protocol Committee may call on outside expertise when necessary or may establish subcommittees to review multiple proposals for work on the same species. The Research Protocol Committee will advise the Funding Agency and make recommendations: (1) the proposal (including the completed risk assessment and preventative measures) appears to be adequate and thus funding is appropriate; (2) the proposal is not adequate in all aspects and needs to be resubmitted to the Research Protocol Committee after deficiencies identified are addressed and appropriate changes made to the proposal; or (3) the proposal has serious inadequacies that require major changes, and should not be funded until these changes are made and the proposal has been resubmitted to the Research Protocol Committee and the Research Protocol Committee has deemed the revised proposal to be adequate.

All proposals (both those complying with an ASSP and those with individualized containment and confinement plans) will be reviewed by the Research Protocol Committee to determine if there are problems in the use of the risk assessment and to improve both this research protocol and the ASSP. The Research Protocol Committee will provide an annual report to the Task Force detailing the proposals reviewed, the species involved, the number of proposals needing detailed confinement and containment procedures, the location of the research sites by species, the problems encountered, and announce the availability of ASSP's and recommend changes to the Task Force as needed.

The Research Protocol Committee will serve as an advisor to the Funding Agencies, providing comments and recommendations on the risk assessment and adequacy of preventative measures being taken by the researcher. The responsibility of ensuring NEPA compliance, and of selecting and funding the research belongs entirely to the Funding Agency.

At every level of the processing of the proposals every effort will be taken to protect the confidentiality of the research. Genetically altered species, unless they are also nonindigenous species, should not be processed through this protocol. Research involving genetically altered species should be processed through other appropriate protocols (See Appendix I).

PART I

Risk Assessment

Completed risk assessments must be submitted in narrative form to the Funding Agency along with the preventative measures, if needed. The reasoning behind each answer must be stated. The submittal of the complete research proposal to the Research Protocol Committee is not necessary, however, the Principal Investigator is responsible for providing enough information to enable the Research Protocol Committee to understand the research, and to evaluate the risk assessment and the effectiveness of the preventative measures, if needed.

I. Does the research concern a nonindigenous aquatic species as defined by the Nonindigenous Aquatic Nuisance Species Prevention and Control Act of 1990 (Act)? Nonindigenous aquatic species means any species or other viable biological material that enters an ecosystem beyond its presently established or historical range, including transfers from both domestic and foreign sources. [Historical range is the territory occupied by a species at the time of European colonization of North America.]

ALL ANSWERS: go to II.

II. Does the species carry any known nonindigenous diseases, parasites or any other nonindigenous species or viable biological material? Unless there is knowledge or evidence to the contrary (e.g., oysters being transferred from an area where MSX or dermo or imported oyster drills exist, salmonid transfers from areas where IHN and VHS viruses occur, or warmwater species transfers from areas where the Asian tapeworm occurs) species transfers within the continental U.S. can be considered free of nonindigenous diseases or parasites. Any species recently imported directly or indirectly into the continental U.S., Hawaii, Alaska or a territory of the U.S. from a foreign country, or from Alaska, Hawaii, or a territory of the U.S. into the continental U.S. or the reciprocal should be considered to have nonindigenous diseases or parasites unless proven otherwise; appropriate preventative measures must be taken (see Part II, Guideline of Preventative Measures).

YES or NOT SURE: go directly to Part II (Guideline of Preventative Measures) and to III.

NO: go to III.

III. Do or could transportation waters, media or sediments or sampling equipment carry any nonindigenous diseases, parasites, or other viable material (study or extraneous organisms)?

YES or NOT SURE: transfer species to clean water and container, treat waste water to kill all organisms, disinfect original container. If this is sufficient to rid the shipment (transfer) of all extraneous organisms, go to IV; if not, go to Part II (Guideline of Preventative Measures).

NO: go to IV.

IV. If the research does not concern a nonindigenous aquatic species under the Act and the research could not spread nonindigenous diseases, parasites or other viable material, this protocol does not apply, however, some precautions may be necessary to avoid the spread of nonindigenous species by incidental means such as contaminated equipment. If the species falls under the Act, continue on to V.

If answers to I, II, and III are all NO: the protocol does not apply to your research organism.

If any answer to I, II, and/or III above is YES or NOT SURE: the species falls under the Act; go to V.

V. Will live, viable, or fresh specimens be required?

NO (specimens must be preserved in a manner to kill the organisms immediately to assure no possibility of infestation if the specimens are released): no additional procedures may be necessary.

YES: go to VI.

VI. Will the species be transferred away from the site where collected?

NO: The spread of the organism is unlikely therefore environmental concerns are minimal. Some precautions to avoid the incidental spread of the organism by contaminated sampling equipment may be needed. If the research will not result in the spread of live organisms the remainder of the protocol does not apply.

YES: go to VII.

VII. Will the species be transported through areas which are free of the infestation?

YES: adequate preventative measures must be taken to prevent escape or release during transportation; go to VIII.

NO or NOT SURE: go to VIII.

VIII. Is the species under investigation presently established within one mile of any facility which will receive live nonindigenous species or other nonpreserved field material which may be contaminated with a nonindigenous species? Studies may be conducted in more than one research laboratory (including field laboratories). List each laboratory in which the research will be conducted, and discuss and document for each laboratory.

YES (The species is found within one mile of a research facility or its effluent discharge point): the study may not require more

than minimal measures at this facility to prevent the species' introduction. It may however require precautionary measures to ensure that nonindigenous species are not spread between collection sites, from one facility to another facility, or from a facility to noninfested sites by means of equipment or supplies used at more than one study site or used for more than one study.

NO (the species is not found within one mile of a research facility which will receive live nonindigenous species or other nonpreserved field material which may be contaminated with a nonindigenous species, or within one mile of the facility's effluent discharge point): the researcher should report the nearest known population of the species from each facility and go to IX.

IX. Can the species survive in the surrounding waters?

NO: only minimum preventative measures may be needed.

YES or NOT SURE: go to X.

X. Is it absolutely certain that the species will not be a nuisance if it escapes or is released into surrounding waters? [Note: A nuisance species threatens 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.]

YES: only minimum preventative measures may be needed.

NO or NOT SURE: go to XI.

XI. Have you previously been approved for research with this species at your present location(s) using the same facilities?

YES: explain the changes, if any, between this proposal and previous funded studies and attach a copy of previous approval letter and submit to the Funding Agency for review by the Research Protocol Committee. Explain any changes in detail.

If major changes exist from earlier funded study or the answer is NO: go to XII.

XII. Is there a Research Protocol Committee approved species-specific protocol (ASSP) for the nonindigenous species that is (are) the subject(s) of your research proposal, and will this ASSP be used by you for this proposal?

YES (an ASSP exists and will be adhered to in every particular): attach the ASSP and list specifics (e.g. options to be used) that are to be used in your research. Submit to Funding Agency for review by Research Protocol Committee.

NO (no ASSP exists, or an ASSP exists but will not be used): go to XIII.

NO (An ASSP exists but will not be exactly adhered to, i.e. additional or different methods will be used, or parts of the ASSP will not be used): describe in detail any deviation from the ASSP, specify if any part of the ASSP will be used, and describe preventative methods to be used that differ from those in the ASSP. If any part of the ASSP is to be used, attach the ASSP: go to XIII.

XIII. If the proposal has reached this point in the risk assessment, a preventative containment/confinement plan must be developed and described in detail which will ensure that the species or any diseases or parasites it might carry cannot escape or be released into the surrounding waters. The species under consideration is a live or viable nonindigenous aquatic species, a nonindigenous pathogen or parasite of aquatic species, or might be carrying nonindigenous diseases or parasites of aquatic species, is not present in the waters surrounding the research site, could survive if released, and could be a nuisance. The researcher must document knowledge of the literature concerning the species and the problems which could result if released. A plan must be developed to ensure that the research does not result in the release, escape, or dispersal of the species. The investigator will be required to develop a preventative plan (PART II) and submit it with the risk assessment to the Funding Agency who will forward it to the Research Protocol Committee for review. The investigator and the supporting Research Institution must agree to comply with the preventative plan, and this protocol or an approved species-specific protocol. The Funding Agency and the Research Institution will ensure compliance.

Every investigator conducting research on a live or viable nonindigenous aquatic species which could be a nuisance, and is conducting the research outside the species' present established or historic range, is required to develop containment and confinement procedures and have a secure facility. Reference to guidelines already available (Appendix I) can be of assistance in developing a containment and confinement plan. Table I is an outline of the information and containment and confinement procedures required in most existing guidelines. In the future species-specific protocols may be developed for high visibility species (like the zebra mussel) whose life history, biology, and impacts are known and for which there are multiple studies under consideration. When reviewed and approved by the Research Protocol Committee, ASSPs may be used by investigators, however, compliance to all points of the ASSP will be mandatory if the Investigator elects to use an ASSP. Any or all protocols may be changed by the Research Protocol Committee as new knowledge is accumulated. Deviations from an ASSP will require case by case approval of research proposals and their preventative plans. Research on nonindigenous species which may also have nonindigenous diseases and parasites will require maximum security for the species and for any diseases or parasites the species may carry. Every effort should be made to conduct research on nonindigenous species in facilities located within the existing established range of the species; in this case only one level of preventative measures may be required.

PART II

Guideline of Preventative Measures

The Research Protocol Committee cannot develop a detailed set of guidelines for every nonindigenous species under research. Investigators and Research Institutions must develop containment and confinement plans taking into consideration the species, its characteristics, diseases and parasites, and critical environmental factors, its capabilities to be a nuisance, the design of the research facilities, and the location of the test site in relationship to the species' present range. Appendix I lists guidelines which have already been developed for groups of organisms. Table I is an outline of the informational needs and preventative measures to contain or confine test species found in most guidelines. The appendix and table are included as reference materials for investigators.

If the investigator determines that live specimens must be used, that the research must be conducted in an area where the species is not already present, that the species could survive if released into surrounding waters, and that the species or its diseases or parasites could be a nuisance, major preventative measures would be required to prevent escape or release.

The preventative plan should use a combination of physical, biological, environmental, and/or chemical barriers to contain or confine all life stages of the organism. Reducing the scope of the research should also increase the safety of the research.

For containment of diseases, parasites, small species, or the early life stages of larger species, the procedures outlined in the NIH guidelines (FR 51 No. 88, May 7, 1986, pg. 16959) or guidelines developed by the U.S. Department of Health and Human Services (see references) are the most comprehensive.

For containment or confinement of larger forms, the guidelines developed for whole plants or animals by the Office of Agricultural Biotechnology, USDA, are the most appropriate, especially if the research is to be conducted outside the laboratory (see Appendix I).

Preventative measures should address all life stages present or possible during the research phase. Where feasible, use of juvenile specimens, monosex populations, or sterile individuals is recommended.

Species-Specific Confinement and Containment Protocols

The Research Protocol Committee expects to receive many research proposals on a few high profile, high risk species, such as zebra mussels. A subcommittee of the Research Protocol Committee or one of the Funding Agencies may submit a species-specific confinement/containment protocol for review by the Research Protocol Committee. When such a proposed species-specific protocol is submitted, the Research Protocol Committee will review the adequacy of proposed containment procedures to insure that the species or any associated diseases, parasites, or any other nonindigenous species or viable biological materials cannot escape or be released during research. The Research Protocol Committee will complete its review and provide a response to the appropriate Funding Agency or subcommittee within 90 days. The form of the Research Protocol

Committee's response will be either: 1) the species-specific protocol is adequate as proposed and is approved for general use by the research community (i.e., the protocol has become an ASSP); or 2) the species-specific protocol is not adequate as proposed and is not approved. If the proposed species-specific protocol is not approved, the Research Protocol Committee will state reasons and may suggest modifications to correct problems seen. Since these protocols will only be prepared for species which are considered nuisance species, the risk assessment section can be reduced and the preventative plan can be standardized. Research proposals adhering to an ASSP will not need to be reviewed by the Research Protocol Committee prior to funding.

Compliance with all provisions of an ASSP must be fully accepted in writing by the Principal Investigator and the Research Institution by submitting a signed statement (certification of compliance) to that effect. Specific preventative measures to be used by the Principal Investigator must be documented in the research proposal. If all aspects of the ASSP are accepted, the Research Institution can approve confinement and containment procedures and monitor the research. All documentation, including the proposal, completed risk assessment, and preventative measures to be used, will be forwarded to the Research Protocol Committee by the Funding Agency. Any deviations from the requirements of an ASSP will require that the research proposal and confinement and containment plan be reviewed by the Research Protocol Committee before funding is approved.

The Research Protocol Committee will use the information in all research proposals (using both species-specific and non-standard protocols), to improve future protocols and to establish the location of research on nonindigenous aquatic species.

The Research Protocol Committee will report annually to the Task Force the number of proposals requiring confinement/containment measures, the species involved, and the location of research sites. Problems will be identified and recommendations for correcting them provided to the Task Force.

Until a research proposal is funded and becomes public property the confidentiality of the contents of the proposal must be maintained at all levels. All levels of review before funding must be made aware of the legal and ethical responsibilities not to discuss, copy, or share proposals with anyone not directly involved or authorized to assist in the review.

Compliance, Inspection, Reporting

All proposals which are required to follow a confinement and containment protocol must include certification by the Principal Investigator and the Research Institution that they will comply with the requirements of the protocol, and within the proposal must document the specific containment and confinement measures to be used. The Research Institution or The Institutional Biosafety Committee and/or the Biological Safety Officer, if appointed by the Research Institution (see NIH guidelines 51 FR 16963 for specific duties), will monitor the conduct of the research and verify compliance with the

containment and confinement procedures agreed to by the Principal Investigator and the Research Institution.

The Funding Agency, the Research Protocol Committee, and appropriate state agencies may inspect the facilities and containment and confinement procedures at any time. The Research Institution should inspect its research at least twice yearly.

Failure to comply with the protocol, or the escape or release of a nonindigenous aquatic species must be reported to the Funding Agency, the appropriate State agencies and the Research Protocol Committee immediately. Penalties for noncompliance with the protocol will be administered by the Funding Agency and could include suspension of research funding. The major responsibility for compliance with the protocol falls to the Principal Investigator and the Research Institution.

APPENDIX I

Existing Guidelines and Protocols

Guidelines for Recombinant DNA Molecule Research:

The following is a list of guidelines and protocols used to confine or contain nonindigenous species or organisms involved in recombinant DNA research. These can also be applied to nonindigenous aquatic species proposals. Consulting one or more of these will help investigators to identify physical, biological, chemical, and/or environmental preventative measures that may be used to confine or contain the nonindigenous aquatic species during research, transportation and storage. (Federal Register 51 No. 8, pg. 16958; FR 51 No. 123, pg. 23367; FR 52 No. 154, pg. 29800; FR 56 No. 22, pg. 4134; FR 51 No. 88, pg. 16959)

Guidelines for Microorganisms

National Institutes of Health (NIH). 1968. Guidelines for Research Involving Recombinant DNA Molecules. Published in Federal Register May 7, 1986 (51FR 16958-16961) with additional major actions August 24, 1987 (52F 31838); July 29, 1988 (53FR 28819); October 26, 1988 (53FR 43410); March 13, 1989 (54FR 10508); March 1, 1990 (55FR 7438); and August 11, 1987 (52FR 29800) with appendix P for plants and Q for animals.

Guidelines for Whole Plants and Animals

U.S. Department of Agriculture (USDA). 1984. Coordinated Framework for Regulation of Biotechnology. Federal Register December 31, 1984 (49FR 50856) and June 26, 1986 (51FR 23302+).

USDA. 1986. Advance Notice of Proposed USDA Guidelines for Biotechnology Research. Federal Register June 26, 1986 (51FR 23367-23393) and February 1, 1991 (56FR 4134-4149).

USDA. 1986. Introduction of Organisms and Products Altered or Produced Through Genetic Engineering Which are Plant Pests or for Which There is Reason to Believe are Plant Pests. Federal Register June 26, 1986 (51FR 23352-23366) and June 16, 1987 (52FR 22892-22915).

Coulson, J. R., and R. S. Soper. 1989. Protocols for the Introduction of Biological Control Agents in the U.S. Chapter I, pages 2-35 In: Kahn, R. P. (ed.). Plant Protection and Quarantine. Volume III Special Topics. CRC Press, Inc., Boca Raton, Florida.

USDA, Office of Agricultural Biotechnology. 1988. USDA Guidelines for Research Outside the Laboratory Involving Biotechnology, also Federal Register June 26, 1986 (51FR 23367-23313) and February 1, 1991 (56FR 4134-4149).

International Guidelines and Protocols:

European Inland Fisheries Advisory Commission. 1988. Code of Practice and Manual of Procedures for Consideration of Introductions and Transfers of Marine and Freshwater Organisms. FAO. EIFAC. Occasional paper No. 23. 52 pages.

International Council for the Exploration of the Sea. 1982. Proposed Guidelines for Implementing the ICES Code of Practice Concerning Introduction and Transfer of Marine Species. 23-page manuscript.

Disease Related Guidelines and Protocols:

Anonymous. 1989. Operating Procedures for the Alma Quarantine Facility. Prepared for the Alma Research Station, Guelph, Ontario, Canada. 16 pages typewritten.

Horner, R. W., and R. L. Eschenroder. 1991. Protocols to Minimize the Risk of Introducing Salmonid Disease Agents with Importation of Salmonid Fishes. Draft manuscript. 11 pages. Prepared for Great Lakes Fish Disease Control Committee. Pages 27-37.

U.S. Department of Health and Human Services. 1984. Biosafety in Microbiological and Biomedical Laboratories. 1st Edition (March 1984). U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, Atlanta, Georgia 30333, and National Institutes of Health, Bethesda, Maryland 20892.

An additional 17 references on laboratory disease and pathogen control methods can be found listed in the Federal Register, May 7, 1986 (51FR 16965).

Other Guidelines and Protocols:

Klingman, D. L., and J. R. Coulson. 1983. Guidelines for Introducing Foreign Organisms into the United States for Biological Control of Weeds. Bulletin of Entomological Society of America. Fall 1983:55-61.

Guidelines for the Importation, Interstate Movement, and Field Release of Foreign Arthropod-Parasitic Nematodes into the United States for Biological Control of Arthropod Pests of Plants, Man, and Domestic Animals, and Vectors of Plant, Human, and Animal Pathogens, and for the Interstate Movement and Export of Foreign and Native Arthropod-Parasitic Nematodes for Research on Biological Control of Such Pests.

Guidelines for the Importation, Interstate Movement, and Field Release of Foreign Microbial Pathogens (Fungi, Bacteria, Rickettsia Viruses, Protozoa) into the United States for Biological Control of Arthropod Pests of Plants, Man, and Domestic Animals, and Vectors of Plant, Human, and Animal Pathogens, and for the Export of Foreign and Native Arthropod Pathogens for Research.

Guidelines for the Importation, Interstate Movement, and Field Release of Foreign Arthropods and Nematodes into the United States for Biological Control of Weeds, and for the Interstate Movement and Export of Foreign and Native Arthropod and Nematode Natural Enemies of Weeds.

Guidelines for the Importation, Interstate Movement, and Field Release in the United States of Foreign Microbial Pathogens for Biological Control of Weeds, and for the Interstate Movement and Export of Foreign and Native Pathogens of Weeds for Research.

Guidelines for the Importation, Interstate Movement, and Field Release of Foreign Beneficial Organisms (Microbial Pathogens and Antagonists) into the United States for Biological Control of Plant Nematodes and Plant Pathogens, and for the Export of Such Organisms (Foreign and Native) for Research.

Southeastern Cooperative Wildlife Disease Study. 1985. Model for State Regulations Pertaining to Captive Wild and Exotic Animals. University of Georgia, Athens, Georgia. 48-page manuscript. Prepared in response to Resolution #9. U.S. Animal Health Association, Milwaukee, Wisconsin 10/27-11/1/85.

Jennings, D. P., and J. A. McCann. 1991. Research Protocol for Handling Nonindigenous Aquatic Species. National Fisheries Research Center, U.S. Fish and Wildlife Service, Gainesville, Florida. 43-page manuscript.

Brown Tree Snake Protocol:

Pacific Basin Development Council. 1991. Recommended Protocol for Transport of Live Brown Tree Snakes (Boiga irregularis). Prepared for Plant Quarantine Branch, State of Hawaii Department of Agriculture and Biological Survey, and the U.S. Fish and Wildlife Service.

Guidelines for Animal Care and Welfare:

Guidelines for Use of Live Amphibians and Reptiles in Field Research. American Society of Ichthyologists and Herpetologists (ASIH), The Herpetologists' League (HL), and the Society for the Study of Amphibian and Reptiles (SSAR). 1987.

Interagency Research Animal Committee's Report. U.S. Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training. Published in the Federal Register. May 20, 1985.

Guidelines for the Use of Fishes in Field Research. American Society of Ichthyologists and Herpetologists (ASIH), American Fisheries Society (AFS), and American Institute of Fisheries Research Biologists (AIFRB).

APPENDIX II

Definitions

Aquatic Nuisance Species - a nonindigenous species that threatens 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. Aquatic nuisance species include nonindigenous species that may occur in inland, estuarine and marine waters and that presently or potentially threaten ecological processes and natural resources. In addition to adversely affecting activities dependant on waters of the United States, aquatic nuisance species adversely affect individuals, including health effects.

Biological Safety Officer (BSO) - an individual who is a member of the IBC who has the direct responsibility (after the PI) to ensure the activities and precautions stated in the research proposal are followed. See NIH guideline FR 51 No. 88, pg. 16963, for other roles and responsibilities.

Confinement - a term used primarily in the USDA guidelines meaning organisms restricted to research field facilities such as outside experimental pond areas and involving whole plants and animals.

Containment - a term used primarily in the NIH guidelines to mean restricted to laboratory environments and is usually in reference to micro-organisms, recombinant DNA molecules, or whole plants (Appendix P) or whole animals (Appendix Q).

Established - when used in reference to a species, this term means occurring as a reproducing, self-sustaining population in an open ecosystem, i.e. in waters where the organisms are able to migrate or be transported to other waters.

Institutional Biosafety Committee (IBC) - see NIH guidelines FR 51 No. 88, pg. 16962, for membership, roles, and responsibilities.

Nonindigenous Species - any species or other viable biological material that enters an ecosystem beyond its historic range, including any such organisms transferred from one country to another. Nonindigenous species include both exotics and transplants. [Note: Historic range is interpreted to mean the territory occupied by a species at the time of European colonization of North America.]

Pathogen - as defined in USDA guidelines, is a virus or micro-organism (including its viruses and plasmids, if any) that has the ability to cause disease in another living organism.

Principal Investigator (PI) - see FR 51 No. 88, pg. 16963, for roles and responsibilities.

Research Institution - means any public or private entity (including Federal, state, or local government agencies) conducting the research.

Research Protocol Committee (RPC) will be comprised of one or more representatives from each Federal Task Force agency who are qualified to evaluate nonindigenous species research proposals. Knowledgeable experts from other Federal, state, or private groups with different areas of expertise might be asked to assist the committee.

Surrounding Waters - means any free flowing or standing waters in the immediate vicinity of the research facility that are connected with public waters either directly or indirectly.

Survival - organism able to live in an ecosystem during its normal life span but not necessarily able to reproduce itself.

Unintentional Introduction - an introduction of nonindigenous species that occurs as a result of activities other than the purposeful or intentional introduction of the species involved, such as the transport of nonindigenous species in ballast or in water used to transport fish, mollusks or crustaceans for aquaculture or other purpose. Involved is the release, often unknowingly, of nonindigenous organisms without any specific purpose. The virtually inevitable escapement, accidental release, improper disposal (e.g., "aquarium dumping") or similar releases of intentionally introduced nonindigenous species do not constitute unintentional introductions.

Waters of the United States - the navigable waters and the territorial sea of the United States. Since aquatic nuisance species can move or be transported by currents into navigable waters, all internal waters of the United States, including its territories and possessions, are included. The Territorial Sea of the United States is that established by Presidential Proclamation Number 5928 of December 27, 1988.

APPENDIX III

Membership of the Research Protocol Committee

Dr. James A. McCann, National Fisheries Research Center-Gainesville, U.S. Fish and Wildlife Service - Chairman, May 1991-Present

Dr. Althaea Langston, Animal and Plant Health Inspection Service - Policy and Program Development, U.S. Department of Agriculture - Member, May 1991-Present

Dr. David F. Reid, Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration - Member, May 1991-Present

Dr. Edwin A. Theriot, Environmental Laboratory, Waterways Experiment Station, U.S. Army Corps of Engineers - Member, August 1991-Present

Dr. J. David Yount, Environmental Research Laboratory-Duluth, U.S. Environmental Protection Agency - Member, March 1993-Present

APPENDIX IV

Other Legislation or Executive Orders Related to the Nonindigenous Aquatic Species Act

Applicable State Laws, Regulations, Permit and Notification Requirements - Must be determined on an individual basis by Principal Investigators and Research Institutions.

Lacey Act of 1900 - 16 USC 3371-3378 and 18 USC 42 Item 2,58

Endangered Species Conservation Act of 1973-16 USC 1531-1543 plus Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)-16 USC 1531-1543.

Executive Order #11987 dated March 1977 - Exotic Organisms

Plant Quarantine Act of 1912 (7 USC 151 et seq.)

Federal Plant Pest Act of 1957 (7 USC 150aa et seq.)

Federal Noxious Weed Act of 1974 (Public Law 93-629-Jan. 3, 1975) (7 USC 2801 et seq. + 21 USC 111 et seq.)

National Environmental Policy Act of 1969 (NEPA)

Occupational Safety and Health Act of 1970 - Federal Register April 12, 1984 (50FR 14468) (29 USC et seq.)

Animal Welfare Act. 7 USC 2131-2155; 80 STAT.350, 84 STAT.1560, 90 STAT.417, 99 STAT.1645.

TABLE I

Outline of Information Required by Reference Guidelines

Identification of Principal Investigator and Research Institution

Identification of Species and Source of Research Specimens Justification for Research

Complete Description and Exact Location of Research Facility

Discussion of the Life History, Biology, Critical Environmental Factors, Ecology, Performance in Areas where Previously Introduced, Present Distribution and Status of the Study Species

Biosafety Level Based on Risk Assessment and Possible Impacts if Species Escapes or is Released

Diseases and Parasites

Identification List of All Known Diseases and Parasites Found in Waters Where Species Were Taken Quarantine Facilities/Procedures

Complete Description of Methods used for Physical, Biological, Chemical,and Environmental Containment and/or Scope Limitations

Fate of Surviving Specimens - Close Out Procedures

Required Permits and Related Laws and Regulations

Shipping and Transportation Precautions

Training and Qualifications of Personnel

Security

Emergency Plan and Procedures for Termination of Study

Administrative Control, Roles, Responsibilities

Frequency of Inspections, Monitoring, Compliance Evaluations and Reporting