ANS
Aquatic Nuisance Species
DIGEST

Volume 2, No. 1 March 1997

FRESHWATER FOUNDATION

Providing current information on monitoring and controlling the spread of harmful nonindigenous species.

NISA Passes!

by Allegra Cangelosi

Just minutes before adjourning for the national elections this past autumn, Congress acted to reauthorize and expand the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990. The new legislation, titled the National Invasive Species Act of 1996 (PL 104-332) (NISA), assures continuation of the successful Great Lakes ballast management requirements, establishes a national ballast management program, and expands invasive species management programs within the Department of Interior and the National Oceanic and Atmospheric Administration.

NISA was introduced in the Senate (S. 1660) by Senator John Glenn, and in the House of Representatives (H.R. 3217) by Congressman Steve LaTourette on 29 March 1996. Introduction of the bill followed a National Forum on Nonindigenous Species Invasions of U.S. Marine and Fresh Waters held in the U.S. Capitol (see "Experts from around the Country Gather for a National Forum" in *ANS Digest*, Volume 1, No. 4), and a lengthy process of consensus building among key stakeholders. Both these early efforts helped the bill attract solid bipartisan support throughout the Great Lakes and other coastal regions.

The House of Representatives was the first to devote formal attention to NISA. The House Resource Committee and the Committee on Transportation and Infrastructure held hearings over the summer. The Senate began its work in September with a hearing in the Environment and Public Works Committee.

NISA establishes a national ballast management program which will be mandatory after three years if the shipping industry record of compliance under a voluntary system is poor. Compliance records will be established via a mandatory reporting system which the U.S. Coast Guard will establish and actively monitor. Criteria for how much compliance is enough to protect coastal resources (and preempt an enforcement regime) will be developed by the national Aquatic Nuisance Species Task Force over the next year and a half. The Great Lakes ballast program remains unchanged (and mandatory) except that the scope of the program is clarified to include vessels which may enter the lakes reporting no ballast on board.

NISA Passes! *continued on page 6*

ANS Task Force Meets in California

by Nils C. Halker

The national Aquatic Nuisance Species (ANS) Task Force met on 14 November 1996 at the San Francisco Bay National Wildlife Refuge near Fremont, California. The meeting, which covered many topics, was preceded by a Forum on Coastal and Marine ANS and by field trips to sites on San Francisco Bay to highlight nonindigenous marine species problems.

The first new business on the agenda was a report by Allegra Cangelosi (Northeast-Midwest Institute) on the recent passage of the National Invasive Species Act of 1996 (NISA), the reauthorization of and amendments to the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA) (see "NISA Passes!" in this issue).

In light of the expanded scope of the Task Force under the amendments, there was discussion of the need to re-examine the Task Force's membership, including broadening *ex-officio* membership. Some of the interest groups that need to be represented include the shipping industry, bait industry, recreational anglers, and boaters. Task Force members will identify additional interests that should be represented and organizations that represent those interests for possible *ex-officio* membership. The Task Force will also contact other groups involved or interested in nonindigenous species to improve coordination and to increase the attention given to ANS issues.

Meeting *continued on page 2*

In This Issue:

Aquatic Nuisance Species Digest

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FRESHWATER FOUNDATION

ANS Task Force Meets in California

Continued from page 1

Dr. Jim Carlton discusses marine invasives in San Francisco Bay with Forum participants and a local television crew

Ballast Water Issues

Ballast water carried by ships is one of the major vectors for the introduction of nonindigenous species to North American waters. Several reports were presented on projects and studies currently underway or recently completed.

The Great Lakes Ballast Water Demonstration Project is being undertaken to improve upon ballast exchange, the current primary means of preventing unintentional transfer of nonindigenous organisms. The alternative treatment being tested is double filtration of ballast water, which is being compared to untreated ballast water. Water will be sampled in study and in control tanks and in piping immediately before and after filtration to ascertain the effectiveness of the treatment. Secondary treatment technology, such as ultraviolet irradiation, will be tested in the future to kill small organisms that pass through a filtration system.

The National Research Council Marine Board Ballast Water Technology Study was recently completed, and the final report, *Stemming the Tide: Controlling Introductions of Nonindigenous Species by Ship's Ballast Operations*, is now available from the National Academy Press in Washington, DC.

A Ballast Exchange Study, led by Al Beeton (National Oceanic and Atmospheric Administration) and Jim Carlton (Williams College—Mystic Seaport), also recently has been completed. The study focused on near-shore sites adjacent to port systems in the Atlantic, the Gulf of Mexico, the Pacific,

Meeting *continued on next page*

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Alaska, and Hawaii, to identify potential alternative off-shore ballast water release sites to minimize the chances for nonindigenous organisms to become established. The final report will be available in spring 1997.

Researchers at the Smithsonian Environmental Research Center (SERC) have conducted several studies related to shipping and to ballast water. They have found that there are many species present in ballast water and that the survivorship of these organisms making transoceanic voyages is high. Their research has also shown that high-seas ballast water exchange is effective in reducing the number of organisms that survive. SERC will be working with the U.S. Coast Guard in developing and maintaining the Ballast Water Information Clearinghouse mandated under the 1996 amendments to NANPCA.

The U.S. Coast Guard is mandated under the 1996 amendments to put many of these research findings into practice; some of these responsibilities include:

- Develop and issue ballast water guidelines for all vessels entering U.S. waters.
- Establish reporting and sampling procedures to monitor compliance.
- Develop a mariner education and technical assistance program.
- Conduct ecological and ballast water surveys of the Columbia River system.
- Report to Congress by 1999 on progress on ballast water programs and on any intent to make regulations mandatory in any region.

Regional Issues

The Task Force heard reports of work being done in many locations around the country.

The Prince William Sound Regional Citizens Advisory Council (PWS RCAC), Alaska, has organized a Nonindigenous Species Working Group to address concerns related to increased oil-tanker traffic in Prince William Sound and in Valdez Harbor (see "Preventing Nonindigenous Species Invasions in Prince William Sound" in *ANS Digest*, Vol. 1, No. 4). The PWS RCAC is holding a workshop on 25 March 1997 in Anchorage, Alaska, to discuss ANS issues in Prince William Sound and to raise public awareness in the region.

NISA requires the establishment of a Western Regional Panel on ANS, similar to the existing Great Lakes Panel. The Western Regional Panel is planned to include representatives from Alaska, Hawaii, and from the 17 western states and four western Canadian provinces involved in the Western Zebra Mussel Task Force (see "Western States and Provinces Join Forces" in *ANS Digest*, Vol. 1, No. 2). The Western Zebra Mussel Task Force will become the basis for the Western Regional Panel, which will probably designate a working group to address coastal-specific issues.

Under the amended NANPCA, individual states continue to be and now interstate organizations are encouraged to develop Comprehensive ANS Management Programs (see "State Management Plans on ANS" in *ANS Digest*, Vol. 1, No. 1). Once a program is approved by the Task Force, federal money is made available to aid in the implementation of the program. The State of Ohio submitted its Comprehensive Management Program to the Task Force at this meeting. The Program has three major elements; prevention, control, and abatement. Task Force members subsequently reviewed the Ohio Program and have approved it.

Species Issues

The Task Force heard reports on the status of efforts to control several nonindigenous species, including the brown tree snake (see "Trouble in Paradise: The Brown Tree Snake in the Western Pacific" in *ANS Digest*, Vol. 1, No. 3), the Eurasian ruffe (see "The Battle to Control Ruffe" in *ANS Digest*, Vol. 1, No. 2), and the round goby (see "Round Goby Roundup" in this issue). Pertaining to the ruffe and to the round goby, a team was established to determine the feasibility of a dispersal barrier on the Chicago Waterways to prevent new downstream spread of these and other species from Lake Michigan into the Mississippi River basin.

The Task Force also heard from individuals proposing the authorization of control programs for purple loosestrife (see "Biological Control of Purple Loosestrife" in *ANS Digest*, Vol. 1, No. 4), and green crabs. A draft report, *Pulling Together: A National Strategy for Invasive Plant Management*, was presented and the Task Force was asked to support and endorse the strategy, which it subsequently did endorse.

The next meeting of the

ANS Task Force

is scheduled for
13 March 1997
in the Washington, DC area

For more information
about this past meeting
or about the upcoming meeting
contact Bob Peoples
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Nils C. Halker is editor of the ANS Digest *at the Freshwater Foundation in Navarre, MN. Additional material for this article was provided by Bob Peoples.*

NUTRIA

Another Threat to Louisiana's Vanishing Coastal Wetlands

by Irene D. Hesse, William H. Conner, and Jenneke M. Visser

Although nutria (*Myocastor coypus*) have not been recognized by Congress as a pest species, they have caused serious problems since their introduction as a fur-bearing animal. These large (12 to 16 pounds, 37 to 42 inches long), semi-aquatic rodents are found in all marsh types (fresh, intermediate, brackish, and salt) and in freshwater forested wetlands. They are extremely prolific animals, reaching sexual maturity at four to six months and breeding year-round with average litters of four to five offspring. In Louisiana they are responsible for damage to marshes, forested wetlands, bald cypress restoration efforts, agricultural crops, and levees, and are also thought to be responsible for displacing portions of an indigenous muskrat (*Ondatra zibethicus*) population. However, sales of nutria pelts have generated millions of dollars of revenue since the 1950s.

Historical Overview

Nutria are indigenous to South America; their original range covered Argentina, Bolivia, Brazil, Chile, Paraguay, and Uruguay. Fur-farming introductions extended that range to include the United States, Europe, the former Soviet Union, the Middle East, Africa, and Japan. Nutria were introduced into the U.S. between the 1899 and the 1940, but fur-farming attempts failed due to high mortality rates and low reproductive success in captivity. Subsequent accidental and intentional releases led to the establishment of **feral*** populations in at least 15 other states, and to reports of sightings in at least 40 states and three Canadian provinces. A once small captive group of nutria became one of the largest feral populations in the world. Thirteen nutria were brought to south Louisiana in 1937; by the late 1950s the population in Louisiana was estimated to exceed 20 million animals.

In South America nutria populations are controlled by trapping and by major predators such as caymans (*Caiman latirostris, C. sclerops,* and *C. niger*), jaguars (*Felis onza*), pumas (*Felis concolor*), ocelots (*Felis pardalis*), and little spotted cats *(Felis tigrina*). Trapping pressures during the late 1800s and early 1900s in South America were so great that legislation was enacted to protect the population. In the United States nutria have only one major predator, the American alligator (*Alligator mississipiensis*), and present day trapping efforts do not keep the population in check. The number of pelts taken annually in the 1960s and 1970s was in the millions and subsequently helped to control the nutria population in Louisiana. Since then fur has become less fashionable to wear, pelt prices have declined, and trapping efforts have diminished. By the 1980s fewer than 800,000 pelts were sold and, by the 1990s, that average reached an all-time low of 180,000 pelts per year.

words in **bold type are defined in the glossary on page 11.*

An Adult Nutria *(Myocastor coypus)*

Effects on Marshes in Coastal Louisiana

For many years wetlands were thought to be of little use, but recent decades have brought about considerable change in our understanding of their functions. Wetlands control erosion and flood waters, improve water quality, and provide habitat for timber, fish, and wildlife. Louisiana wetlands, **deltaic** in origin and cut off from their sediment source (the Mississippi River), are threatened by land subsidence and by rising sea levels. As total acreage decreases, successful regeneration of remaining wetlands becomes more critical.

Marsh types in coastal Louisiana include fresh, intermediate, brackish, and salt (with salinities of 0 to 5 parts-per-thousand (ppt), 5 to 8 ppt, 8 to 15 ppt, and 15 to 35 ppt, respectively). Nutria damage in Louisiana's coastal wetlands is most apparent in the low salinity marshes of the upper estuaries, as well as in the developing delta of the Atchafalaya River. Studies in the Atchafalaya Delta were the first to show the significant effects of grazing by nutria on the establishment of vegetation on newly created mudflats (Fuller et al. 1985). Exclosure experiments showed that grazing by nutria was largely responsible for turning extensive sagittaria marshes into bare mudflats. The destruction of vegetation results in the loss of habitat for native wildlife and waterfowl, and in increased soil erosion. Food preference studies have shown that nutria are not very discriminating, they eat all but a few unpalatable species such as elephants-ear (*Colocasia esquelenta*) and water-willow (*Justicia lanceolata*) (Shirley et al. 1981).

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Nutria grazing is suspected to have caused the decline of maidencane (*Panicum hemitomon*)-dominated floating marshes, which are being converted into spikerush (*Eleocharis baldvinii*)-dominated floating marshes and into open water. Preliminary studies have shown that nutria grazing significantly reduces the biomass in the spikerush marshes, but to date no studies of nutria grazing have been performed in maidencane marshes. The appearance of a spikerush marsh is very similar to a mowed lawn (especially during the spring and summer) and signs of grazing as well as nutria droppings and sightings are widespread.

Nutria also can significantly damage intermediate salinity marshes; nutria "eatouts" (areas where only sparse vegetation remains) are common. After one growing season of excluding nutria from several eatout areas, recovery was dramatic. After Hurricane Andrew (August of 1992) scraped vegetation off the underlying substrate, creating shallow ponds with mudflats, nutria have prevented vegetative recolonization of these mudflats (where recolonization is slow even in the absence of grazing). Two years after construction, exclosures in these scrape areas have started to support some vegetation, while the adjacent grazed areas remain bare.

Little is known about the effects of nutria in the saline marshes; it is assumed that relatively few nutria live in this habitat type.

Effects on Forested Wetlands in the Mississippi River Floodplain

Nutria have affected forested wetlands, of which there are two main types in Louisiana; deep-water swamps, characterized by bald cypress-tupelo (*Taxodium distichum-Nyssa aquatica*) associations, and bottom land hardwood swamps that include bald cypress, tupelo, willow (*Salix nigra*), maple (*Acer rubrum*), ash (*Fraxinus sp.*), oak (*Quercus sp.*), elm (*Ulmus americana*), and palmetto (*Sabal minor*).

Bald cypress, a prominent, long-lived tree species existing in both types of wetlands, faces an uncertain future. Although regeneration did occur in many places throughout the state following logging during the late 1800s and early 1900s, conditions today are not as conducive for successful natural regeneration. Increased flooding due to natural changes (subsidence, sea level rise, etc.) and human-made changes (levees, channelization, impoundments, etc.) means that many wetland areas do not dry out long enough for seeds to germinate and to become established. Concerted planting efforts to restore portions of the bald cypress population that began in the 1950s have been unsuccessful due mainly to nutria damage. Numerous protection methods have been tried in recent years, but none have proven entirely successful.

Recent investigations have begun to examine the effect of nutria on forested wetlands in the state. Examination of stomach contents in one study showed that duckweeds (*Lemna minor* and *Spirodela polyrhiza*) constituted the majority (55%) of their diets (Wilsey et al. 1991). Although not identified by species, woody tissue represented a significant 7%. In another investigation, mature trees in a forested wetland area being used for wastewater treatment were examined for evidence of nutria damage (Hesse et al. 1996). Nutria girdled 92% of the willows, while strips of bark were removed from 67% of the cypress and from 16% of the maple.

Control Strategies

Different strategies used to control populations include such direct techniques as chemicals (zinc phosphide is the only chemical registered for controlling nutria), shooting, live-trapping, and leg-hold trapping. Indirect methods include planting practices that minimize nutria damage through the use of exclosures around areas of planting, individual tree shelters, sleeves, or seedling protectors, and rodent repellents such as Ropel. These methods have met with varying degrees of success, but the one control strategy that has proven most effective and benefits both the economy and the environment is trapping. The total revenue brought into Louisiana between 1951 and 1993 from the sale of nutria pelts was $129 million (an average of approximately $3 million annually). Simple economics (as well as past experience) show that an increase in pelt prices will increase trapping efforts, so the demand for fur has to increase for this endeavor to succeed. The Louisiana Department of Wildlife and Fisheries has recently worked on increasing the international market of nutria fur and leather as well as the local market for nutria meat.

Irene Hesse recently moved to Boulder, CO, but did relevant work as a Research Associate at Louisiana State University's Coastal Ecology Institute. William Conner is Associate Professor of Forestry at Clemson University's Baruch Forest Science Institute, and Jenneke Visser is Assistant Professor of Research at Louisiana State University's Coastal Ecology Institute. All three researchers have been actively involved in research into the ecology and management of coastal wetlands for several years.

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NISA Passes! Continued from page 1

Some highlights of the legislation include:

- Creation of an enforceable national ballast management program targeted to all U.S. coastal regions.
- Requirement of detailed ballast exchange reporting by all vessels.
- Reauthorization of the mandatory Great Lakes ballast management program.
- Authorization of a Ballast Technology Development Program which will bring many more resources to the search for technological and management practice tools to replace ballast exchange. This program is especially important for regions which experience a great deal of coastwise trade, like Alaska and the Great Lakes.
- Continuation and expansion of the State Management Plans program to include an aquatic plants program.
- Authorization of funding for research and development of a dispersal barrier for the Chicago Ship and Sanitary Canal. This provision will help prevent transfers of organisms between the Great Lakes region and the Mississippi River basin.
- Creation of voluntary national guidelines for recreational vessels to help prevent spread of alien species overland via trailered vessels.
- Region-specific research on effects of invasive species in the Gulf of Mexico, Narragansett Bay, Chesapeake Bay, Lake Champlain, the Great Lakes, California and the Pacific Coast, and Hawaii, and other regions yet to be determined.

While achieving a great deal, the legislation also left much work to be done. First and foremost is the work involved in promoting effective implementation of the NISA's programs. Second, NISA does not require ballast exchange of vessels engaged coastwise trade (where it is of little or of no use) and it exempts vessels which pass through the exclusive economic zone (EEZ) in coastwise crude oil trade between California and Alaska. Improved ballast management technologies and practices are needed to address coastwise and NOBOB (no ballast on board) situations. In the meantime, alternative exchange sites should be identified along U.S. coastlines for vessels to use when they are unable to conduct high-seas exchange for safety reasons. Finally, NISA does not address planned introductions or terrestrial invasions.

Passage of the National Invasive Species Act of 1996 is a real achievement for the exotic species network which led the national effort. NISA became law only because of the willingness of so many to take an active role in promoting this program to protect the environment. Each action taken to support the legislation from every corner was critical to the success of NISA. As Congress turns its attention to implementation of NISA and to legislation for planned introductions of exotic species and for terrestrial invasions, the involvement of the *ANS Digest* readership will be equally important.

To obtain copies of NISA or of the proceedings of the National Forum on Nonindigenous Species Invasions of U.S. Marine and Fresh Waters, contact the Northeast-Midwest Institute at: (202) 544-5200.

Allegra Cangelosi is Senior Policy Analyst and Great lakes Ecosystem Director at the Northeast-Midwest Institute in Washington, D.C.

New ANS Web Site

Information on zebra mussels and other nonindigenous species is now available on the World Wide Web through:

The Great Lakes Sea Grant Network

The Sea Grant Zebra Mussel and Nonindigenous Species World Wide Web Site (SGNIS) contains a comprehensive collection of research publications and education materials produced by Sea Grant programs across the country.

The site can be accessed through the World Wide Web, Telnet, or directly through a modem.

The address is:

http://www.ansc.purdue.edu/sgnis/

A CD-ROM version will soon be available for those who do not have Internet access.

This site is useful for:

~ industrial and municipal water users
~ shoreland property owners
~ boaters
~ resource management agencies
~ students and teachers
~ outreach professionals
~ researchers.

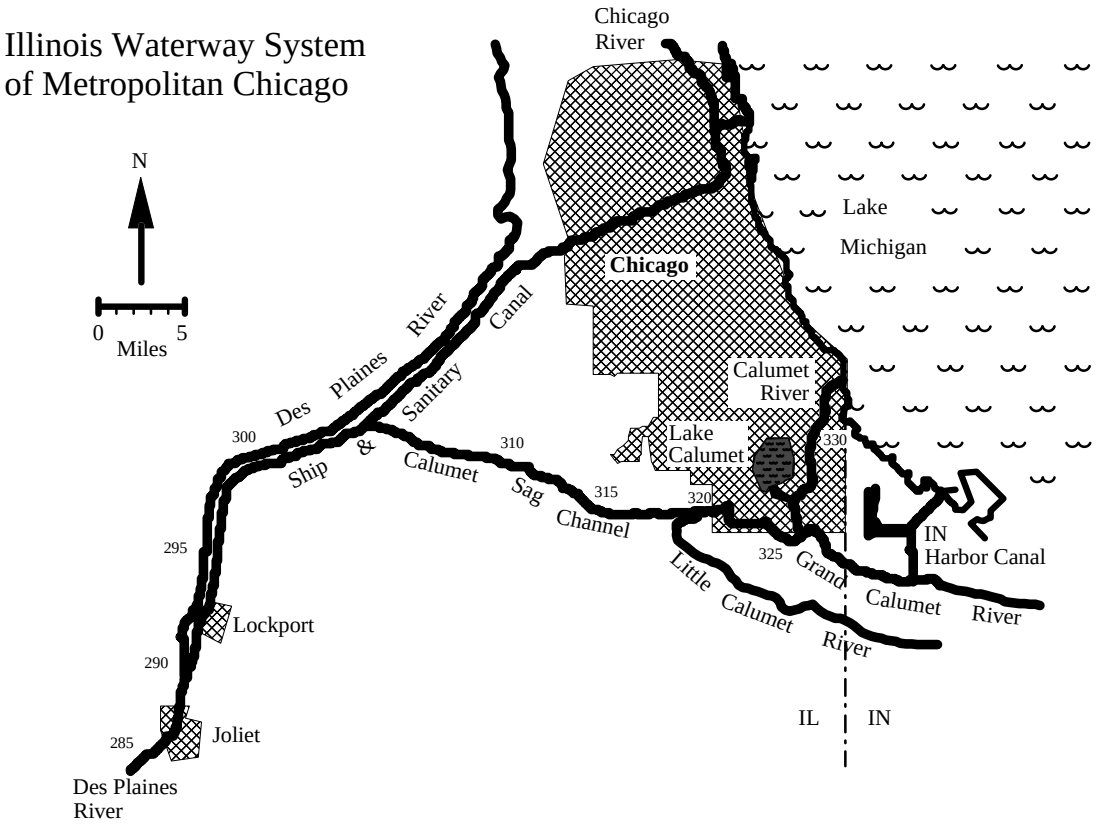
The site currently contains information on:

~ zebra mussels
~ Eurasian ruffe
~ round goby
~ sea lamprey
~ spiny water flea

More than 150 research reports and 60 educational items are housed at the site, including four newsletters, conference proceedings, and a slide library. It also provides linkages to the National Biological Service's Nonindigenous Aquatic Species Geographic Information System, the Great Lakes Information Network, as well as to the nonindigenous species homepages of individual Sea Grant programs.

Round Goby Roundup

by Mark Steingraeber and Joan Guilfoyle



Not many people would fish on a river lined with sewage treatment plants, steel mills, and oil refineries. Even fewer would do so during a week of high winds, rain, cold temperatures, and power outages. Yet 25 biologists recently did just that, in pursuit of an aggressive little fish that could cause big problems in North America's rivers. The anglers were in search of the round goby (*Neogobius melanostomus*), a Eurasian fish probably introduced into the Great Lakes in ballast water of transoceanic vessels.

The round goby is a sedentary benthic fish that resembles a sculpin, and is displacing sculpin at some Great Lakes locations. The round goby can be readily identified by its fused pelvic fins. They are aggressive and known to feed on a variety of small native fishes as well as on zebra mussels that can concentrate certain biocontaminants. Round gobies are themselves preyed upon by several sport fish species and may therefore represent a new link in the transfer of contaminants to higher **trophic** levels.

The team of biologists from eight federal, state, and municipal government agencies, one university, and two nonprofit organizations gathered near Chicago in October 1996 to determine how far down the Illinois Waterway System round gobies had expanded. The information will be used to determine whether effective action can be taken to prevent the spread of round gobies from the Illinois Waterway System into the Mississippi River, and into other vulnerable drainage basins between the Appalachian and Rocky mountain ranges.

Researchers took samples as far downstream as Joliet, IL (at river mile 286—see map), which is more than 35 miles downstream from the last known sighting of round gobies. Researchers found round gobies only in the Little Calumet River, with the farthest downstream sighting 12 miles inland from Lake Michigan, just above river mile 321. Round gobies prefer rocky substrate, which is less common over a one-mile stretch of the river downstream of river mile 321. This lack of preferred substrate may temporarily restrict the downstream distribution of round gobies until increased numbers promote downstream movements or the fish are moved by deliberate or unintended human intervention.

The national Aquatic Nuisance Species Task Force has appointed a committee to develop a proposed emergency response to prevent the spread of round gobies into the Mississippi River basin.

Mark Steinbraeber is a Fishery Biologist at the Fishery Resources Office of the U.S. Fish and Wildlife Service, Onalaska, WI, and Joan Guilfoyle is the Regional Outreach Coordinator in the Division of Fisheries of the U.S. Fish and Wildlife Service, Minneapolis, MN.

The United Nations Conference on Alien Species

by Randy G. Westbrooks

Article 8(h) of the Convention on Biological Diversity (CBD), signed at the UN Conference on Biodiversity in Rio de Janeiro, Brazil in 1993, calls on each signatory nation, as far as possible and as appropriate, to prevent the introduction of, control, or eradicate those nonindigenous species which threaten ecosystems, habitats, or species. To date 140 nations have signed the CBD (the U.S. has not become a signatory, although U.S. researchers continue to participate). Following the Brazil Conference, the Trondheim Conferences on Biodiversity were initiated to provide input from recognized experts on various aspects of biodiversity to the signatories of the CBD.

In July 1996 more than 200 scientists, managers, policy advisors from 80 countries, and representatives from several UN bodies, institutions, and organizations gathered in Trondheim, Norway, for the UN Conference on Alien Species. The Conference, one of the ongoing series of Trondheim Conferences, was hosted by the Norwegian Ministry of the Environment and the UN Environment Program and its Convention on Biological Diversity. The Conference was called to discuss the challenges related to the implementation of provisions of Article 8 of the CBD related to nonindigenous species.

The Conference was organized around eight themes: human dimensions of the problem; ecology and effects of invasions; aquatic invasives; agricultural and forestry invasions; vectors; effects on oceanic islands; management measures; and future issues and follow-up. Several official conclusions and recommendations from the Conference will be provided to the Conference of the Parties to the CBD:

Introductions of nonindigenous species can be accidental or deliberate, and these may require different policy and management responses. The most important vectors for accidental introductions of invasive species are related to international transport, such as trade, commerce, travel, and tourism; the most important vectors for deliberate introductions are related to economic activities, such as agriculture, forestry, and fisheries. When a nonindigenous species is deliberately introduced, there is a need to undertake pre-introduction screening and to strike the proper balance between the benefits of using a species with the costs involved, including long term effects and to take due concern for unforeseeable circumstances.

Nonindigenous (or alien) species are species that occur in places different from their area of natural distribution and that may become invasive, meaning that they threaten ecosystems, habitats, or species. Several factors affect the potential for nonindigenous species to become established and to become invasive. The growing physical and chemical influence of humans on ecosystems increases the opportunities for nonindigenous species to become invasive. There are nonindigenous species, such as many sport fish and most agricultural plants and animals, that do provide economic benefits and arguably have a low likelihood of becoming invasive.

Invasive species were identified as a serious global threat to biological diversity, and in some countries the most important threat. Such species threaten the natural and productive systems that they invade, and may cause disruption of ecological systems, homogenization of biota, and extinctions. This may again result in significant environmental, economic, health, and social problems, imposing costs in the billions of dollars and seriously affecting large numbers of people.

The environmental problems resulting from invasive species need to be addressed at the genetic, species, and ecosystem levels. Important areas for management follow-up include development of governmental infrastructures and programs, quarantine measures, risk analysis, and review and development of legal and economic policies. More focus is needed on the economic costs of invasive species, while at the same time taking into consideration conflicting interests and distribution effects.

Information and education strategies on invasive species are needed urgently at the national level.

International compilation of information on invasive species (comparable to that available for agricultural pests and infectious diseases), and the dissemination of this information, is a high priority.

Networks of specialists providing expertise relating to prevention and management of invasive species should be strengthened.

***UN Conference** continued on next page*

UN Conference *continued from previous page*

All sectors involved in activities related to invasive species must have a role in implementing preventive and corrective action. This includes the private sector, such as relevant industries related to transport (shipping and tourism, for example) and to primary production (agriculture, forestry, and fisheries, for example). Technical and practical cooperation, both nationally and internationally, is needed between environment, **phytosanitary**, and health authorities working with alien species, in such a way that prompt and appropriate action can be taken when needed.

Developing countries will need various types of assistance, especially to develop programs and infrastructure, that will enable them to respond effectively to invasive species.

A global strategy and action plan to deal with the problem of invasive species is urgently needed.

The Trondheim Conference urges national governments and international organizations and institutions to seriously address the issues of invasive species in their ongoing deliberations related to biological diversity.

The Trondheim Conference on Alien Species offers its conclusions to the Conference of the Parties to the CBD to assist in the implementation of Article 8. It also offers its conclusions to other relevant and appropriate international organizations and agreements working with issues related to alien species. Conference speakers from the United States included:

Michael Soul (University of CA)
Marcel Rajmanek (University of CA)
Peter Moyle (University of CA)
James Carlton (Williams College)
Peter Jenkins (University of NM)
Randy Westbrooks (USDA)
Alan Holt (Nature Conservancy)
Michael Bean (Environmental Defense Fund)

Abstracts from each speaker are available by e-mail from Randy Westbrooks at rwestbrooks@weblnk.net.

Randy Westbrooks is a weed scientist with the U.S. Department of Agriculture who has worked with the Weed Science Society of America, the Exotic Pest Plant Council, and federal and state regulatory agencies. He has written and spoken extensively on the threat posed by the homogenization of the world's flora and fauna.

Upcoming Meetings

West Coast Zebra Mussel Information and Monitoring Workshop
10-11 March

Meeting of the Western Zebra Mussel Task Force
12 March, Portland, OR
Contact: Linda Drees, (913) 539-3474;
email: Linda_Drees@FWS.GOV; or Debra Eberts,
(303) 236-6007

Aquatic Nuisance Species Task Force Meeting
13 March, Washington, DC
Contact: Bob Peoples, (703) 358-2025
email: robert_peoples@mail.fws.gov.

Second International Symposium on Biology and Management of Ruffe
21-23 March, Ann Arbor, MI.
Contact: Michael Klepinger, Michigan Sea Grant
334 Natural Resources Building, East Lansing, MI
48824-1222
(517) 353-5508
email: klep@pilot.msu.edu.

Aquatic Nuisance Species in Prince William Sound: A First Look
25 March, Anchorage, AK
Contact: Joel Kopp, PWS RCAC
154 Fairbanks Drive, PO Box 3089, Valdez, AK
(907) 835-5957; email rcac@alaska.net

Second Northeast Conference on Nonindigenous Aquatic Species
18-19 April, Burlington, VT
Contact: Nancy Balcom, Sea Grant Advisory Program
1084 Shennecossett Road, Groton, CT 06340-6097
(860) 405-9127.

Marine/Aquatic Introduced Species in the Pacific Symposium of the VIII Pacific Science Inter-Congress
13-19 July, Suva, Fiji
Contact: L.G. Eldredge, 1525 Bernice St., PO Box 17801
Honolulu, HI, 96817-0801
(808) 848-4139; email: psa@bishop.bishop.hawaii.org

Integrated North American/World Web Site on All Nonindigenous Species Planning Workshop
proposed autumn 1997
Contact: Ian Efford, (613) 526-4427, fax: (613) 526-0081
email: avocet.intl@sympatico.ca.

Send meeting announcements to: Editor, ANS Digest
2500 Shadywood Rd., Navarre, MN 55331
email: freshwater@freshwater.org
Deadline for the next issue is 25 April 1997

A New Pest for American Aquaculture: The Zebra Mussel

by Rick Kastner and John Guyton

In addition to the many other problems facing the North American aquaculture industry, zebra mussels now threaten to be another pest for fish farmers. In less than a decade zebra mussels have cost industries in the Great Lakes basin millions of dollars in monitoring, removal, and control activities, have changed Great Lakes ecosystems, and now threaten to invade the growing aquaculture industry. Although no aquaculture facility has reported zebra mussel infestations to date, given the zebra mussel's history, it is only a matter of time before they are found.

Unfortunately, American aquaculture is in a less than advantageous position to take on a new foe. Although the industry has experienced, for the most part, consistent growth and profitability over the last decade (in 1993 the U.S. aquacultural crop was estimated at 715 million pounds and valued at $810 million), like most agricultural endeavors aquaculture operators are often plagued by cash flow constraints. Extreme off-flavor conditions, bird predation problems, and high feed and fuel costs are typical factors that can result in economic disaster, especially for small farms. Conditions associated with zebra mussel infestation and eradication could have similar consequences.

It is in light of these facts that the Nationwide Zebra Mussel Training Initiative (a program of Sea Grant Extension and Marine Advisory Services and the U.S. Department of Agriculture Cooperative Extension Service; see "Nationwide Zebra Mussel Training Initiative" in *ANS Digest*, Vol. 1, No. 3) has chosen to target aquaculture interests as one of its priority audiences. Sea Grant Extension has been given the lead responsibility in providing education materials to the aquaculture community, focusing on three measures:

- to provide relevant information about zebra mussels and their effects on aquaculture;
- to keep aquaculture operations zebra-mussel-free, and;
- to prevent the inadvertent spread of zebra mussels with aquaculture products.

Figure 1
Zebra musssels attached to pipe
(C. Czarnecki, Michigan Sea Grant)

Zebra mussels will affect aquaculture in three major ways. First, they will clog pipes, screens, and filters in hatcheries, raceways, intensive recirculating systems, and at holding and processing facilities (Figure 1); mussel densities approaching 100,000 animals per square foot have formed masses up to 10 inches thick in industrial intake pipes and canals (O'Neill 1993). Second, zebra mussels are the intermediate host for the parasitic **trematodes*** *Phyllodistomum folium* and *Bucephalus polymorphus* that have caused fish kills in Europe (Kinklein et al. 1968). Russian researchers have linked zebra mussels with other species of **digenetic** trematodes as well (Davids and Kraak 1993). Third, because of the zebra mussel's highly efficient filter feeding habits, they could compete for food with fry, fingerlings, and **planktivorous** fish if they were to invade fish-rearing ponds.

Perhaps the most devastating effect that zebra mussels will have on the industry will be on the perceptions of fish buyers and the public that some farm-raised products may carry zebra mussels, which could place the industry in a very precarious and awkward position. This already has been experienced by the baitfish industry in Arkansas. In 1994 Maryland, New York, and New Hampshire placed restrictions on shipments of farm-raised baitfish until they were certified zebra-mussel free. Aquaculturists must be proactive to prevent zebra mussels from invading their facilities or from spreading to others, and to prevent negative public perceptions. There are several steps fish farmers can take to keep their operations zebra-mussel free:

Keep contaminated equipment and fish out of aquaculture facilities. Zebra mussels can enter an aquaculture facility either as veligers transported in water or as adults attached to nets, traps, buoys, boat hulls, motors, and trailers. Strictly prohibiting from fish farms boats and other equipment that have been in contaminated waters can eliminate most sources of zebra mussels. Fingerlings and brood stock should be purchased from suppliers that are certified zebra-mussel free.

Aquaculture *continued on next page*

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All contaminated equipment, including seines, buckets, boats, motors, trailers, and pumps should be steam cleaned, dried, and quarantined. Contaminated containers, such as hauling tanks, live wells, and minnow buckets should be drained and cleaned. Cleaning should be done in an area where runoff will not contaminate other water bodies. When cleaning equipment with hot water, a sustained heat treatment of 140°F (60°C) of three to four minutes is necessary to kill adult zebra mussels. Bulky equipment like seines should be spread and dried for 10 days or frozen for two days because adult zebra mussels can live more than a week out of water in warm, moist areas.

Zebra mussels can attach to aquatic plants (Figure 2), so any plants on equipment that are inadvertently carried into a facility should be removed and properly disposed of.

Because most surface waters are at risk of being invaded by zebra mussels, aquaculturists should use ground water where feasible. In cases where water is taken from rivers or creeks, the water should be filtered (40 micron mesh filter) or taken in through a system of intakes buried in filtration beds or sand filters followed by mechanical filters. This will eliminate unwanted fish and other aquatic organisms as well a zebra mussels. Filters should be properly maintained and regularly changed or back-washed.

In extreme cases, a constant-flow treatment of chlorine/sodium thiosulfate can be used to treat contaminated waters. Continuous applications of chlorine at concentrations from 0.25 to 0.50 milligrams per liter have been shown to be effective in preventing settlement and growth of mussels (Chagnard 1995). Keeping zebra mussels out of aquaculture systems in the first place will eliminate future problems and expenses.

For more information on prevention, monitoring, and control of zebra mussels at aquaculture facilities, contact:
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Rick Kastner, Ph.D., is a professional aquaculturist and works as a technical writer for Mississippi Sea Grant Advisory Services. John Guyton, Ed.D., is an Environmental Specialist at the Mississippi Cooperative Extension Service at the Coastal Research and Extension Center, Biloxi, MS.

Figure 2
Zebra mussels attached to aquatic plants. (C. Ramcharan)

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Glossary

Deltaic

Formed by the alluvial deposits (silt and sediment) near the mouth of a river.

Digenetic

An organism that has alternations in its life cycle of forms produced in a different manner, especially the alternation of sexual with asexual generations.

Feral

Domesticated animals or plants that have reverted to the wild.

Phytosanitary

Relating to the handling and quarantine of plants.

Planktivorous

An organism that eats plankton.

Trematodes

A parasitic flatworm of the class Trematoda, having one or more external suckers.

Trophic

Related to levels in a food chain; for example, an eagle that feeds on a trout is at a higher trophic level than the mayflies eaten by the trout.

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