United States Environmental Protection Agency

NONINDIGENOUS SPECIES - AN EMERGING ISSUE FOR THE EPA

Volume 1:
Region/ORD Nonindigenous Species Workshop Reports

and

Volume 2:
A Landscape in Transition: Effects of Invasive Species on Ecosystems, Human Health, and EPA Goals

May 2001

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FOREWORD

This two volume report on *Nonindigenous Species - An Emerging Issue for EPA* contains a set of EPA workshop reports and an expert paper on high priority Regional science issues related to nonindigenous species in the U.S Together, the regional and national workshops on this topic are a fourth in a series of Regional Science Topic Workshops sponsored by the Office of Science Policy in the Office of Research and Development (ORD) at EPA. Others in this series include:

Asthma: The Regional Science Issues
Communicating Science: Waves of the Future Info Fair
FIELDS

The objectives of the Regional Science Topic Workshops are to: (1) establish a better cross-Agency understanding of the science applicable to specific Region-selected human health and/or ecological topics, and (2) develop a network of EPA scientists who will continue to exchange information on these science topics as the Agency moves forward in planning education, research, and risk management programs.

Each year the EPA Regions identify priority science topics on which to conduct workshops. The workshops address the science issues of greatest interest to the Regions on the selected topic area. Each workshop is planned and conducted by a team of Regional, ORD, and interested Program Office scientists, led by a Regional chairperson and facilitated by one or more Regional Science Liaisons to ORD. Participants maintain the cross-Agency science networks they established at the workshops through planned post-workshop projects and activities. An example of such an activity is the continued involvement of informal workshop planning groups, such as the EPA Nonindigenous Species Work Group (NISWG) which has helped develop research initiatives and provided input to a federal invasive species management plan.

Volume 1: *Region/ORD Nonindigenous Species Workshop Reports* summarizes the presentations and discussions from five Regional nonindigenous species workshops conducted during 1999 and 2000, and a national nonindigenous species workshop held in Washington, DC on July 12 and 13, 2000.Based on the issues raised in the Regional workshops, the National Workshop focused on ballast water, wetlands, TMDLs, and pesticides.

Volume 2: *A Landscape in Transition: Effects of Invasive Species on Ecosystems, Human Health, and EPA Goals* is a post-workshop paper authored by Drs. Henry Lee and John Chapman. One goal of this paper is to provide an overview of the types of impacts invasive species have on ecosystem services, human health, and economics. Another goal is to explore how invasive species can impact the implementation of EPA's goals and mandates, and how EPA's regulations relate to the management of invasive species.

For additional information on any of the specific workshops or on the Regional Science Topic Workshop series in general, contact David Klauder in ORD’s Office of Science Policy (202 564 - 6496).

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United States Environmental Protection Agency

NONINDIGENOUS SPECIES - AN EMERGING ISSUE FOR THE EPA

Volume 1: Region/ORD Nonindigenous Species Workshops Reports

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May 2001

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DISCLAIMER

This document is the final product from the series of Regional and National Nonindigenous Species Workshops, which were funded by the Office of Science Policy. The objective of this workshop series was to bring together EPA scientists from the Regions, Program Offices, and ORD laboratories to discuss science issues related to nonindigenous species of high interest to the Regions. The focus of the workshop series was discussion among scientists and managers from different parts of the Agency, each with their individual and office-specific information and viewpoints. The statements in this document do not necessarily reflect the views or policy of the EPA and no official endorsement should be inferred.

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EXECUTIVE SUMMARY

This report (*Volume 1: Region/ORD Nonindigenous Species Workshop Reports*) summarizes the results of a series of Regional and National EPA workshops on nonindigenous species sponsored by the Office of Science Policy (OSP) in ORD. Nonindigenous species, also referred to as exotic, non-native, or introduced species, are now generally recognized as the second most important ecological threat, only behind habitat destruction. In 1998 the Regions, through the National Regional Science Council (NRSC), identified nonindigenous species as a high priority topic for OSP's Regional Science Topic Workshop series. To plan the workshop, an informal Nonindigenous Species Work Group (NISWG) was formed consisting of Regional, Program Office, and ORD members.

Because many of the nonindigenous species issues were directly affecting the Regions, it was decided to initially hold a series of regional workshops throughout the country to identify the high priority issues for a national workshop. Four such workshops were sponsored under the OSP Regional Science Topic Workshop series, with the Region 9 workshop consisting of two sessions. Additionally, Region 3 sponsored its own workshop on this topic. The Regional Workshops are summarized in Table 1.

TABLE 1.REGIONAL NONINDIGENOUS SPECIES WORKSHOPS

PRIMARY TOPICS	DATE	LEAD REGION AND LOCATION	PARTICIPANTS
Noxious Weeds and Whirling Disease in Trout	September 21, 1999	Region 8, Denver, CO	ORD, Region 9, State of Colorado, Trout Unlimited (16 participants)
Ballast Waters (Great Lakes)	October 20-21, 1999	Great Lakes Program, Chicago, IL	ORD, Region 5, Great Lakes Commission, NOAA, USGS, Dept. Agriculture, U.S. Fish & Wildlife, municipal and state governments, academia
Ballast Waters (Coastal and Marine)	November 9-10, 1999	Region 4, Tampa, FL	ORD, Region 4, USGS, academia, municipal and state governments, private industry (72 participants)
Review *Impacts of Nonindigenous Species On Subtidal Benthic Assemblages In the San Francisco Estuary*	December 14, 1999	Region 9, Richmond, CA	ORD, Regions 8, 9, & 10, San Francisco Estuary Inst., Navy, USGS, State of California, Oregon State Univ. (15 participants)
Wetlands & Riparian Zones	December 14, 1999	Region 9, Richmond, CA	Region 9, San Francisco Estuary Inst., municipal and state governments, academia, NGOs
Mid-Atlantic Perspectives on Issues and Mitigation	June 7-8, 2000	Region 3, Ft. Meade, MD	Region 3, ORD, NPS, FWS, USGS, Delaware, DoD, USDA, NOAA, Smithsonian, USCG, USFS, academia

A National Nonindigenous Species Workshop was then held in Washington, DC on July 12 and 13, 2000.Based on the issues raised in the Regional workshops, the National Workshop focused on ballast water, wetlands, TMDLs, and pesticides. In contrast to the Regional

workshops, an “EPA only” format was used to focus the discussion on aspects directly relevant to the Agency. There was broad representation at the Workshop, with representatives from ORD (OSP, NCEA, NCER, NRMRL, and NHEERL), the Regions (Regions 1, 3, 4, 5, 8, 9, 10), Program Offices (OW, OPPTS, Great Lakes Program, Office of Science and Technology, Office of Policy and Reinvention, Office of International Environmental Policy), Science Advisory Board, and the National Estuary Programs (NEPs).

This document contains summaries of each of these Regional workshops and the National Workshop prepared by Environmental Management Support, Inc. and Dr. Henry Lee (ORD). An additional report from the Great Lakes Workshop produced by the Great Lakes Commission is not included in this document (Glassner-Shwayder, K. 2000.*Briefing Paper: Great Lakes Nonindigenous Invasive Species: A Product of the Great Lakes Nonindigenous Invasive Species Workshop*. Prepared by the Great Lakes Commission Ann Arbor, Michigan. 71 pages). As a follow-up to the National Workshop, a technical report was produced that is the companion to this document (Lee, H. and J. Chapman, 2001. *Nonindigenous Species - An Emerging Issue for EPA. Volume 2. A Landscape in Transition: Effects of Invasive Species on Ecosystems, Human Health, and EPA Goals.*).

Region 8, Noxious Weeds and Whirling Disease

EPA Region 8 hosted the initial workshop, where invited specialists discussed noxious weeds and “whirling disease,” a parasitic disease of trout. The Colorado State Weed Coordinator pointed out that the annual economic impacts in North Dakota stemming from a single weed - leafy spurge - are estimated to be $87.3 million, equivalent to about 1,000 jobs in a state whose entire population is under 1 million. Whirling disease, an introduced parasite, has decimated rainbow trout populations in many areas of the West. The parasite continues to spread even though states have spent considerable resources on attempting to limit its spread in hatcheries. Whirling disease is also an example of how management of point and non-point sources might be an approach to controlling an invasive species. The intermediate host for whirling disease is a pollutant-tolerant worm commonly found in organically enriched fine sediments. By controlling inputs of sediment and organic matter it might be possible to reduce the intermediate worm host and hence the spread of the disease. This led to a discussion of using TMDLs to regulate exotic species. The representative from Trout Unlimited stated that they plan to petition the states to list streams with whirling disease as “impaired” under EPA’s Total Maximum Daily Load (TMDL) program.

Great Lakes Program (Region 5), Ballast Waters and Great Lakes Basin

EPA’s Great Lakes National Program Office and the Great Lakes Commission jointly hosted invited specialists to discuss the ecological and economic effects of nonindigenous invasive species on the Great Lakes Basin. Approximately 10 percent of 140 nonindigenous species introduced into the Great Lakes Basin have had significant economic and ecological impacts. It is estimated that the current rate of invasion into the Great Lakes is one new organism each year. Ballast water exchange before entering the Great Lakes is the present approach to reducing new introductions but onboard and offboard treatment of ballast water also needs to be evaluated as potentially more effective options. Although most of the focus in the Great Lakes Basin has been on aquatic nuisance species, terrestrial ecosystems are also being invaded. In Wisconsin, 24percent of the plants are nonindigenous and of those 50 percent are “invasive” to some extent. Workshop participants agreed that prevention is the best approach to managing nonindigenous

species. For new invasions, the best strategy is to attempt to eliminate the satellite populations while they are still limited in range. Several participants noted the importance of monitoring and detection as part of any management strategy and the need for funding taxonomists and taxonomic infrastructure. There was a consensus that education and public outreach were key components of invasive species management strategies, especially with species potentially transported through recreational activities (e.g., on boats, as bait).

Region 4, Aquatic Invasive Species and Shipping in the Eastern Gulf of Mexico

The Region 4 workshop included scientists, state and federal managers, and representatives from the shipping industry. The first day focused on ballast water management. Representatives for the shipping industry acknowledged the environmental issues associated with introductions through ballast water, but also expressed concern that any ballast water regulations must be practical and safe. They also expressed a desire for uniform rules rather than a suite of individual state or local regulations. There was a general consensus among the researchers that ballast water exchange is not sufficiently protective and that some type of ballast water treatment would be needed. While several different ballast water treatment technologies are being evaluated, such as filtration and UV radiation, none of them are sufficiently advanced to treat the volume of ballast water in a timely fashion. The second day focused on the science issues related to ballast water and invasions. A number of exotic invertebrates and fish are established in Tampa Bay but the available evidence suggests that the Bay is not highly invaded. However, the recent finding of the mussel *Perna* demonstrates the potential vulnerability of the system. The aquarium trade may be an important route in Florida. A major impediment to the study of invasions is the lack of trained taxonomists and the lack of regional taxonomic centers.

Region 9, Benthic Assemblages

The purpose of this workshop, hosted by EPA Region 9 and the San Francisco Estuary Institute (SFEI), was to elicit comments on the report entitled *Impacts of Nonindigenous Species On Subtidal Benthic Assemblages In the San Francisco Estuary*. This analysis quantified the nature and extent of nonindigenous species in the subtidal benthic communities of San Francisco Bay, with the most heavily invaded communities consisting of more than 90 percent nonindigenous species. However, the study did not find negative correlations between nonindigenous and native species. Nor did the study find that sediment contamination increased the abundance of nonindigenous species. In terms of the area altered, nonindigenous species are having a much greater impact than contaminated sediments. One concern raised by the participants was the quality of the previous taxonomy when making historical comparisons. Another concern was that since the correlations used recent data (1994-1997), the study is evaluating the structure of a community that has already responded to invasions and sediment contamination. This might explain why no negative relationship between nonindigenous and native taxa was found in this study. Participants emphasized the need for better taxonomy in all studies and recommended requiring strict taxonomic QA/QC in federal and state regulatory programs. To convince decision makers as to the importance of these changes in benthic communities, researchers must demonstrate a connection between the health of the benthic community and higher trophic levels.

Region 9, Wetlands and Riparian Zones

The EPA Region 9 workshop also included a session on invasive species in wetlands and riparian zones. The two goals of this session were to 1) prioritize lists of invasive plant and animal species as ecological stressors for California and 2) for the habitats selected, compare biological invasions to other major stressors. The exotic plants species of highest concern in tidal wetlands are exotic *Spartina* species, Brazilian waterweed (*Egeria densa*), pepperweed (*Lepidium latifolium*), purple loosetrife (*Lythrum salicaria*). The animals of greatest in tidal wetlands are red fox, Chinese mitten crab, green crab, Norway rat, and feral cats and dogs. In riparian habitats the plant species of highest concern are Cape ivy (*Delairea odorata*), giant reed (*Arundo donax*), and tamarisk or saltcedar (*Tamarix* spp.), while bullfrogs and Chinese mitten crab are the high priority animals. For most habitats, the group consensus was that nonindigenous species rank as one of the most important threats to wetland/riparian ecosystems, along with habitat loss and hydromodification. Several of the participants made the case that construction of estuarine wetlands in San Francisco Bay should be halted, or at least reconsidered, until methods are developed to limit invasion by *Spartina*.

Region 3, Mid-Atlantic

The sixth workshop, sponsored by U.S. Environmental Protection Agency and Department of Defense (DoD), focused on the Mid-Atlantic region and management and mitigation strategies. The workshop reviewed federal programs by DoD, U.S. Forest Service's Forest Health Monitoring program, USDA's Animal and Public Health Inspection Service (APHIS) program, National Park Service, U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. Coast Guard, EPA, and the National Oceanic and Atmospheric Administration. In addition, the states in the Mid-Atlantic region, The Nature Conservancy, Anne Arundel Community College, the Smithsonian Environmental Research Center, and the National Fish and Wildlife Foundation presented overviews of their programs. Workshop participants generally agreed that prevention is the most cost-effective approach to managing exotic species. Prevention strategies are hindered by inadequate funding for rapid assessment and response, and education and outreach to increase voluntary participation of private landowners and compliance with ballast water control programs. Prevention is further hindered by inadequate funding for APHIS, which can only inspect about 2 percent of materials that enter the United States. Managing invasives requires close coordination among federal, state, and local organizations; an understanding of the direct and indirect costs of invasive species to agriculture and the ecology; and an effective approach for conveying the importance of the invasive species issues to Congress.

National Workshop, Ballast Water, Wetlands, TMDLs, and Pesticides

The National Workshop was a two-day "EPA only" workshop held in Washington, D.C. On the first day, three outside experts provided an overview of invasive species issues. All three experts emphasized the ecological threat posed by invasive species and that invasives endanger ecosystems and crop production more than chemical pollution and any other stressor other than habitat destruction. The experts also emphasized the need for rapid response to new invasive species. Representatives from the National Estuary Program (NEP) estuaries presented an "on the ground" view and also emphasized the ecological and economic damage from invasive species at the local scale. Representatives from each of the Regional Nonindigenous Species Workshops then summarized their workshops.

Results from a survey of EPA employees sent out before the workshop indicated that awareness as to how nonindigenous species relate to EPA's mission was limited. Based on breakout sessions, the workshop participants concluded that nonindigenous species will have a direct impact on the implementation of EPA's programs. The participants also concluded that various EPA regulations, such as the CWA and FIFRA, provide the Agency with regulatory authority concerning certain nonindigenous species issues.

On day 2, Diane Regas, Deputy Assistant Administrator for the Office of Water, presented an overview of their concerns and activities. Specific areas mentioned included ballast water regulation and treatment, the National Estuary Programs, wetlands restoration, development of biocriteria, discharges from aquaculture, TMDLs for exotic species, and water diversions. She emphasized that the Office of Water needs good science to do its job in addressing these issues and identified the following research needs: 1) investigation into new methods of ballast water treatment; 2) understanding nonindigenous species vector sources; 3) evaluating habitat vulnerability; and 4) determining the efficacy and cost of nonindigenous species prevention options and monitoring activities.

The participants then divided into four groups to address high priority topics. One of the main conclusions from the ballast water group was the need to develop performance standards to allow the comparison of mid-ocean ballast water exchange with various ballast water treatment alternatives (e.g., UV, biocides, filtration). The wetland/riparian group urged caution in restoration projects because these areas often provide a place for nonindigenous species to proliferate. The TMDL group reached consensus that invasive species could indirectly affect TMDLs for toxic pollutants, nutrients and sediments by altering erosion, runoff, and pollutant fate. The use of TMDLs for regulating exotic species was discussed but no consensus was reached. The pesticides group identified two action items to address invasive species: 1) promote more education and outreach _ both within and outside EPA and 2) determine ways that it can more quickly generate the data needed for registration of new pesticides for invasive species.

Mike Slimak summarized the workshop with three main points: 1) EPA and other federal agencies have a role to play to address nonindigenous species; 2) since EPA's current regulations do not provide the Agency with clear direction on how to deal with the nonindigenous species issue, EPA will need to figure out its role in addressing these issues, and 3) EPA needs to commit resources to the nonindigenous species issue.

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REGION 8 NONINDIGENOUS SPECIES WORKSHOP

September 21, 1999
Denver, Colorado

Abstract

EPA Region 8 hosted the first of a series of regional workshops to help identify the key policy-relevant science issues related to nonindigenous species. President Clinton issued an Executive Order in 1999 that established a cabinet-level executive council to oversee an interagency program intended to detect, monitor, and control invasive species and to restore native species and habitats. This initial workshop invited specialists to discuss noxious weeds and "whirling disease," a parasitic disease of native trout, two major nonindigenous species issues in Region 8.

Russell Jones of EPA described the Federal Interagency Committee on the Management of Noxious and Exotic Weeds (FICMNEW), an interagency committee organized to coordinate weed management and control practices and research among federal land management agencies.

Eric Lane, Colorado's State Weed Coordinator, discussed the environmental and economic impacts of noxious weeds in Colorado and other Rocky Mountain States. Direct and secondary annual economic impacts in North Dakota stemming from a single weed—leafy spurge—are estimated to be $87.3 million, equivalent to about 1,000 jobs in a state whose entire population is under 1 million. Preventative action is far more cost-effective than control once the weed becomes established. On a national scale, a Cornell University study estimates that economic impacts associated with invasive species cost the U.S. economy $138 billion per year.

Eric Hughes, Colorado Department of Fish and Wildlife's Hatcheries Director, and David Nickum, Conservation Director for Trout Unlimited, discussed the ecological and economic impacts of whirling disease on rainbow trout. Management objectives now are strongly oriented towards protecting against further exposure of protected habitats. There are no known strains of disease-resistant rainbow trout, despite extensive searching. Whirling disease is a very complicated problem that will require significant funding from state and federal governments. Whirling disease is a good cautionary tale against the introduction of any non-native species, since wildlife managers at the time did not know enough to recognize the severity of the threat, based upon the best knowledge of the time. It is also a potential example of how management of point and/or non-point sources might be an approach to controlling a nonindigenous species since the intermediate host for whirling disease are tubifex worms, a pollutant-tolerant species most commonly found in organically-enriched fine sediments. Trout Unlimited plans to petition the states to list streams with whirling disease as "impaired" under EPA's Total Maximum Daily Load (TMDL) program.

EPA's Office of General Counsel (OGC) should be asked how existing laws such as FIFRA, FQPA, Endangered Species Act, and NEPA may be used to address invasive species. EPA can conduct research to consider alternatives to pesticides and give grants to states and other organizations on biocontrol. EPA's EMAP program may offer remote sensing techniques that can be applied to identify current and vulnerable areas of nonindigenous species using hyperspectral mapping. Finally, EPA should investigate whether water bodies degraded by invasive species may be considered "impaired" under the TMDL provisions of the Clean Water Act.

Welcome and Introductions

Cindy Schaffer, Region 8's Invasive Species Coordinator, welcomed participants to the first of a series of four workshops to help EPA identify the key nonindigenous species research issues potentially related to the EPA's and Region's mission. The workshop series is partly in response to an Executive Order (E. O. 13112) issued by President Clinton in February 1999, which established an interagency Invasive Species Council (ISC). The ISC is co-chaired by the Departments of Agriculture, Commerce, and Interior and is comprised of eleven federal agencies, including EPA, as charter members. The Executive Order directed agencies to:

- Identify funding that might be available to address invasive species;
- Prevent the introduction of new invasive species;
- Detect and control populations in an environmentally sound manner;
- Monitor invasive populations;
- Provide for the restoration of native species and habitat conditions;
- Conduct research on new control techniques; and
- Promote public education.

Bill Yellowtail, EPA's Region 8 Regional Administrator, noted that many federal and state agencies are engaged in combating invasive species, and strongly encouraged the workshop to identify appropriate opportunities for EPA to contribute its scientific, management, or partnership capabilities to help address this very significant ecological problem.

The United States has been faced with invasive weeds since before the Revolutionary War. "Dyer's woad" has been found in the eastern part of the country since the Seventeenth Century and is now on Utah's noxious weed list; spotted knapweed, first discovered on the West Coast in 1893, now is choking out 46 million acres of native meadows in Montana alone, with an estimated economic impact of $42 million. Leafy spurge has infested the riparian edge of many lakes and streams, displacing native grasses and plants. The estimated economic impact of leafy spurge in Montana, Wyoming, North Dakota, and part of South Dakota is $129 million, primarily in declining forage value. Whirling disease, which first appeared in the Rocky Mountain states in the 1950s, has devastated the native rainbow trout populations throughout the Madison River system in Montana.

Yellowtail asked the participants for their honest appraisal of EPA's potential roles—if any—and offered to carry their recommendations forward to the Administrator.

Federal Interagency Committee on the Management of Noxious and Exotic Weeds (FICMNEW) Russell Jones, EPA Office of Pesticide Programs

Fourteen federal agencies* convened the Federal Interagency Committee on the Management of Noxious and Exotic Weeds (FICMNEW) via a Memorandum of Understanding in 1994, and EPA has been a participant since 1996. FICMNEW was established by federal land-management agencies to coordinate their respective programs to manage invasive weeds on their lands and to share scientific and technical information. The committee has no legislative mandate or

*Now 17 agencies, mainly in the Departments of Agriculture, Interior, and Commerce, plus EPA and DoD.

jurisdiction. FICMNEW developed the *National Strategy for the Management of Invasive Plants*, which defines three goals: effective prevention (including detection and monitoring), effective control (including integrated pest management and rapid response), and effective restoration of habitats once the invasive species has been controlled or eradicated. FICMNEW is implementing its strategy in collaboration with the National Fish and Wildlife Foundation (NFWF)—a federally chartered nonprofit organization that encourages private funding to improve fish and wildlife habitat. The FICMNEW/NFWF collaboration (known as the "Pulling Together Initiative," or PTI) has provided over $2 million in seed money to fund 100 control, prevention, and restoration activities across the country. This seed money has generated an additional $4 million in leveraged funds for these projects. One of these activities, the *Invasive Weeds Fact Book*, provides an excellent, non-technical introduction to the invasive weeds problem across the country. Additionally, FICMNEW, NFWF, and Vermeer Productions are collaborating on a public television documentary on invasive weeds, tentatively scheduled for completion in 2001. The documentary will depict selected habitats throughout the United States that have been infested and degraded by noxious, invasive plant species, as well as success stories, wherein local, state, and federal resources have been marshaled to control the invaders and restore the degraded habitats. FICMNEW has sponsored a number of workshops, including one on standardized databases that contain information on the geographic extent of plant species, including invasives, in North America. FICMNEW has sponsored field trips for policy makers and legislators to increase their awareness of the problems. FICMNEW is also developing public service announcements to raise public awareness of the problems associated with invasive weeds. A public relations firm is donating much of the talent for this initiative. Several scripts are under review. Gary Johnson (DOI/NPS) and Deborah Hayes (USFS) are current co-chairs. FICMNEW's web site is located at http://bluegoose.arw.r9.fws.gov/ficmnewfiles/ficmnewhomepage.html.

> **Q**: Do agencies have GIS data and maps on invasive species?
> **A**: Yes, but they are spotty and not coordinated. One goal of the workshops has been to recommend common data formats.

Norine Noonan, ORD's Assistant Administrator, is EPA's representative on the Executive Council on Invasive Species, which was created by the Executive Order. Mike Slimak of ORD/NCEA is her technical advisor. The Council, which has 11 member agencies, is co-chaired by the Departments of Agriculture, Interior, and Commerce. The Council provides national leadership to implement the Executive Order. The Department of Interior will provide permanent staff and an executive director for the Council. The first meeting was held in July, and established several subcommittees. They will coordinate the preparation of a National Plan (by August 2000), which will be a composite of all the individual agency plans. Council representation remained a contentious issue after the first meeting. It is unclear whether the representatives will be political appointees or career professionals. The size of agency delegations also is contentious. These issues are being considered now; the next meeting has not yet been scheduled.

> **Q**: To what extent will off-road vehicle use encourage or affect the invasion of non-native species?

A: Not aware of any research in this area. Each agency should address this in its own management plan.

Q: Off-road vehicles do distribute seeds. Some landowners have stopped inviting people to enter their land to fish because of fear that their vehicles will carry spotted knapweed seeds. Is there an opportunity for private landowners to participate?
A: Yes. There will be a federal advisory committee of outside stakeholders to participate and advise.

Q: Purple loosestrife, on the federal noxious weed list, is still commonly planted as an ornamental.
A: There is federal legislation pending to give APHIS more authority to prevent this.

Q: What is the best source of information on aquatic invasive species, especially in boundary areas between the United States and Canada?
A: There is no single comprehensive database, but most of the individual databases are available online. The FICMNEW home page has links to many of these databases.

Q: Why is FICMNEW only concerned with plants?
A: Originally, FICMNEW was established by federal land-management agencies, and in 1994, weeds were the principal concern. A separate interagency committee, the Aquatic Nuisance Species Task Force (ANSTF), was formed in 1990 to implement the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990. The ANSTF is co-chaired by the U. S. Fish & Wildlife Service (USFWS) and the National Oceanographic & Atmospheric Administration (NOAA), and includes EPA.

Environmental and Economic Impacts of Noxious Weeds on the Prairies — Eric Lane, Colorado State Weed Coordinator

The Colorado Legislature established the position of State Weed Coordinator in 1996 with an annual budget of about $250,000 to address the state's weed management problems (compared to Montana's $1.8 million budget). Colorado and Montana are the only two states with grant programs in the West.

Lane discussed the environmental and economic impacts of noxious weeds on grazing citing a study on leafy spurge in North Dakota and on crop lands using statistics from Colorado's wheat production. Weeds are defined in legislation—often as "nuisance" or "noxious" plants—usually as being non-native plants that result in ecological or economical harm. The "problem" is not so much the introduction of species, which is a natural ecological function, but the rate of these introductions as facilitated by human activity. Purple loosestrife was introduced not only intentionally as an ornamental, but unintentionally through contaminated ship ballast. The rate of introductions has accelerated; it is estimated that a new species is introduced into San Francisco Bay every 14 days.

Introduced species affect native plant communities in several ways. They compete successfully for sunlight by creating a new canopy (such as the kudzu vine) and competing for nutrients (for example, cheat grass greens up much earlier than native grasses), alter site and soil characteristics in ways that harm native plant communities and cause erosion and water runoff,

which harm water quality, and accelerate native plant mortality through natural herbicides (Russian knapweed exudes a potent herbicide). Introduced species result in changes to the entire native plant community, not just to one or two native species. These changes in plant communities directly result in significant changes to wildlife habitat, and represent a leading threat to wildlife communities and the structure and function of an ecosystem. Introduced plants have affected nutrient cycling in Hawaii, which resulted in plant successions skipping entire species.

Yellow star thistle now dominates more than 10 million acres of northern California grasslands, rendering them essentially worthless. Sheep grass is the dominant species on over 100 million acres in the intermountain West; 42 percent of threatened and endangered species are at risk from nonindigenous species (especially those found in Hawaii). Twenty-seven percent of the plants in Great Smokey Mountains National Park are exotic, and ten of those exotics are causing very serious problems. Twenty-one percent of the plants in Indiana Dunes National Seashore are exotic, and 14 of them are posing severe threats to the park's resources. Hawaii has almost 2,700 plants, one-third of which are nonindigenous. Hawaii is a unique biological treasure, with insufficient funding to protect it.

Nonindigenous species have changed our conservation paradigm. The invasion of non-native species will destroy native ecosystems and fragment landscapes without active management. In the past, conservation implied fencing off land without thought given to future management. Additionally, weeds and other nonindigenous species can have major economic impacts both nationally and locally. In 1993, the Office of Technology Assessment issued an assessment of nonindigenous species and reported that farmers have suffered between $3.6-5.4 billion in crop losses from nonindigenous weeds. About $2 billion per year is spent on herbicides. Nonindigenous species comprise the majority of noxious weeds. A recent Cornell University study estimates that economic impacts associated with invasive species cost the U.S. economy $138 billion per year. This figure includes costs associated with public health, fires, lost productivity from farmers and ranchers, and recreation.

Lane discussed the economic losses from diminished grazing capacity and impacted wild lands caused by leafy spurge in South Dakota. Leafy spurge is a deep-rooted perennial that reproduces by seed and root. Its seeds spread through water. Its white sap is toxic to horses and cattle (although not to sheep and goats). Most economic impacts result from lost grazing. Direct and secondary annual economic impacts in North Dakota stemming from leafy spurge are estimated to be $87.3 million. This translates to about 1,000 jobs, a severe impact from just one invasive species when compared to North Dakota's total population of less than 1 million. A study completed 10 years ago in Colorado examined the impacts of just three weed species on wheat production (jointed goatgrass, volunteer rye, and cheat grass). These three species mimic wheat, so it is very difficult to eradicate the weeds once you are in wheat production. Wheat producers may be hurt more than other agricultural producers because there is no fix. Colorado loses 7 million bushels per year, or about $24.4 million in lost revenues. Secondary losses annually amounted to $36 million in Colorado. This is just from three weed species affecting one crop. This has been a major impact on Colorado's economy, and it is getting worse.

Prevention is perhaps the most important aspect of weed control, and we are not doing enough. We need to interdict weed seeds and spores before they arrive in this country. Preventative action is far more cost-effective than control once the weed becomes established. Absolute prevention is not a practical goal, however, so the next level is to find the exotic

species quickly while it is still possible to eradicate it. This means that there must be a public awareness program to enable people to recognize the weed. Remote sensing may be an important new tool for weed control, and FICMNEW must encourage the Department of Defense to help in this regard. Integrated pest management will help with containment and management. Restoration must be a part of any weed control/eradication program, but restoration consumes an enormous amount of resources, which are simply not available. Education of the public, legislators, and policy makers is very important. However, before resources are committed to education, consider what behavior you want to change. The PBS documentary may be a very interesting experiment in this regard.

In conclusion, the fact that we have $138 billion in economic impacts attributed to invasive species shows that we have a tremendous national problem. We need to identify those problems and figure out a strategy to address them. One suggestion might be to focus on what EPA does particularly well as compared to other agencies and programs, and apply this to weed management. Don't worry about turf or stepping on toes. Any organization that claims exclusive attention to any part of the weed problem is not being honest.

Q: Is the population growth in Colorado's Front Range contributing to the spread of exotic species?
A: Definitely. Construction equipment may be the single most important vector for spreading weeds, but there are some best management practices that could be applied. Another problem is the lack of maintenance on land locked up for speculation. Colorado counties are exploring the use of bonds and other economic incentives to get owners and investors to better mange their lands.

Q: Does leafy spurge kill horses?
A: No. The horses eat everything else, which creates a weed monoculture.

Q: A lot of satellite imagery is commercially available, but it can be quite expense. The real problem is obtaining adequate resolution.
A: Satellite imagery interpretation is a major target for assistance. We suspect that the Department of Defense and others have the technology and skill, but we need to get it applied.

Q: Please elaborate on the strategies for interdicting weeds; you would need a microscope and the expertise to use it.
A: We will need the research to narrow the field and figure out what we need to focus on. Only about 1 or 2 percent of non-native species become a problem. Once we know that, we need to consider the primary vectors for those noxious species, and then manage those vectors. I have been surprised by the tremendous technical expertise out there, but not enough resources are being applied to figuring out what to look for. For example, shipments of "artificial" Christmas trees from China harbored invasive species in internal wood components. We need to know where to look.

Economic Impacts of Whirling Disease —
Eric Hughes, Colorado Dept of Fish and Wildlife

This presentation centered on a videotape about whirling disease. Whirling disease is a very serious disease in Montana and Colorado, causing declines in wild trout populations in some of their best rivers. Particularly disturbing is its tendency to infest the most productive trout streams, such as the Madison and Upper Colorado. In the Madison River in Montana, more than 90 percent of the rainbow trout population has been eradicated by whirling disease. Whirling disease was first seen in the United States in Pennsylvania in 1956, and has since been confirmed in 21 states across the country. It may have been imported accidentally as frozen fish food from Europe. The first instance of whirling disease in Colorado was discovered in 1987.

The whirling disease parasite feeds exclusively on cartilage. Consequently, when the parasite attacks a juvenile fish, the fish may never develop a proper bony skeleton. An adult fish, which has already developed its bony skeleton, may survive parasitization. Parasite spores are released from a decomposed, infected fish, and they can survive in the environment for 30 years before they are ingested by the common *Tubifex tubifex* worm, an intermediate host. After a few months, the parasite changes into the free-swimming infective stage, which is then released into the water. When it finds a fish host, it attaches itself to the skin and then injects itself into the fish's mucous cells, and travels along the fish's nerves to cartilage. It digests cartilage and multiplies, ultimately killing the fish. In severe infections, inflammation around the damaged cartilage places pressure on the nervous system, causing the fish to "whirl." Whirling disease has no known human health effects.

Whirling disease has a significant potential to decimate native trout populations. In 1991, rainbow trout populations in the upper Madison River were 3,300 fish per mile. These populations have since dropped to about 300 per mile. The recreational fishing industry in Montana alone generates close to $500 million annually, and the Madison accounts for about half of that value. In 1993, Barry Niering of the Colorado Department of Fish and Wildlife first suggested that whirling disease was the cause of the catastrophic loss of young rainbow trout in the upper Colorado River.

We know very little of the biology and ecology of the tubifex worm, or even if there are other species capable of serving as the intermediate host. We don't know much about the factors that cause susceptibility of individual fish, either in the wild or in hatcheries. We know little about the seasonality of the infection, either in the worm or in the trout, or whether fish can develop any immunity. The brown trout seems to be immune from the disease, even though they may be infected. Much research is going on, but there are too many questions, such as the duration of exposure that causes infection: just 10 days of exposure will result in an 85 percent infection rate in exposed populations. Experiments have shown that the brook trout and cutthroat trout seem to be more susceptible to whirling disease than are brown trout or rainbows. However, the fact that wild brook and cutthroat are not impacted in the wild may imply another factor—such as spawning season or water temperatures—may be significant.

Management objectives now are strongly oriented towards protecting against further exposure of protected habitats that are useful for recovery of Greenback, Rio Grande, or Colorado River cutthroat trout. We will have to live with the existence of whirling disease in the Colorado River. There will be no "silver bullet" that will solve this problem in the short term. There are a few management practices that can limit the damage, however. One is to rear fish in clean hatchery conditions and stock them at an appropriate life stage that reduces their

vulnerability. We will learn techniques that will prevent contamination in hatcheries, but the answer for wild species probably will lie with finding resistant strains. Fishermen are being advised to wash mud from boots and trailers, to prevent the transfer of spores from one body of water to another. Whirling disease is a very complicated problem that will require significant funding from state and federal governments. It may be five to ten years before research starts providing answers. The University of California (Davis) has developed a DNA-based test to detect the presence of the parasite, once a costly and time-consuming process. Collaborative efforts among public and private stakeholders are essential to attack this national problem. For the most recent information, visit the whirling disease research homepage at http://www.montana.edu/wwwrc/docs/whirling/centerpage/whirling.html.

David Nickum, Conservation Director, Trout Unlimited

Whirling disease was first identified in 1903 in Europe in rainbow trout. It first was reported in the United States in Pennsylvania, to great consternation. Several states took extreme actions—Michigan, for example, eradicated whole populations of aquatic life in a futile attempt to halt the disease. The disease was first discovered in the Rocky Mountains in the early 1980s, but the initial reactions were muted, assuming that there were only limited impacts. This attitude changed in the early 1990s following the recognition of population-level impacts from the disease and the recognition that there was much more to the problem than originally assumed. Whirling disease is a good cautionary tale against the introduction of any non-native species, since wildlife managers at the time did not know enough to recognize the severity of the threat, based upon the best knowledge of the time.

Whirling disease is caused by a microscopic parasite (*Myxobolus cerebralis*) with a complicated, two-host life cycle: fish and worms. While the parasitic spores are persistent, the infective-stage spores produced inside the tubifex worm are short lived—perhaps two or three days. This may be a weakness that can be attacked. There are four factors that must be considered: 1) whirling disease is thought to infect only salmonid fish; 2) whirling disease spores require the tubifex intermediate host; 3) the parasite itself, in both its forms; and 4) the environment.

There had been much hope that a disease-resistant fish— a "silver bullet"—might be found. So far, only the brown trout is resistant. Rainbow and cutthroat trout are highly vulnerable. The timing and location of fish spawning may be significant, and there is some indication that some fish may become resistant. Unfortunately, individual resistance is not genetic and therefore not passed along. Whirling disease has really affected rainbow trout at the recruitment stage—in Colorado, it has decimated rainbow populations in numerous rivers—because juvenile fish have more cartilage. In some rivers, brown trout have increased, but not everywhere.

Tubifex has long been recognized as an indicator species for water quality—it is pollution tolerant, and tubifex worms are found mostly in disturbed ecosystems. This may indicate that many of the great trout rivers were not as pristine as once thought. Perhaps cleaner rivers and healthier systems may reduce tubifex populations.

> **Q**: Are there any river characteristics—such as water temperature or elevation—that might characterize good tubifex habitat?
> **A**: Generally, tubifex worms like siltation and fine sediments. Tubifex worms are not strong competitors, so they are found where the natural species are reduced. They

prefer colder waters. There has been a lot of research, but with little demonstrated relations between worm populations and physical characteristics. Water temperatures of about 14EC seem to be optimal for spore production. Consequently, a seasonal cycle of infectivity is observed. Flushing flow also seems to be significant. Whirling disease seems to be most prevalent on regulated streams. Another factor in Colorado seems to be "point sources" within a stream where whirling disease is significant.

Some new research deals directly with management practices. Stocking with infected fish is causing increased incidence of the disease in the wild. Colorado has scaled back stocking dramatically, and has demonstrated a consequent drop in spores. Other management controls that are being considered include re-routing some reaches of infected streams, such as around Windy Gap Reservoir, to trap infected sediments off channel.

Q: Would eliminating some dams help?
A: Some people have considered that option, but except for the few dams that are generally accepted to be unnecessary, there are political difficulties that make such a course impractical. There are better engineering solutions that could be considered for future diversions, however.

With respect to a potential role for EPA, two areas to consider are: 1) examining its water quality monitoring data to identify the current occurrence of tubifex worms, which may indicate areas of future vulnerability for the disease; and 2) whether there are Clean Water Act implications to whirling disease—are point sources contributing to water quality conditions that favor tubifex worms and resulting whirling disease?

Q: Will a state list a water body as "impaired" under TMDL because of whirling disease?
A: Trout Unlimited will petition states to do just that once they get enough water quality data, arguing that "rainbow trout fishery" is a designated use that is no longer being achieved. There may be some resistance to listing, however.

Q: California listed San Francisco Bay as impaired under TMDL due to invasion of exotic species. Consequently, the TMDL process may be a suitable process to address a problem at the watershed scale that otherwise might not be addressed. There would need to be some evidence, however, of significant problems, since there are always some tubifex worms present everywhere.
A: Yes. More research is needed. There are areas in the Intermountain West where one might expect infestations of whirling disease but there are none. It may be quicker to address hatcheries and private ponds that may be releasing spores.

Q: What is the status of the DNA testing?
A: It is beyond research. There are competing tests on the market, one from UC-Davis and one from a lab in Colorado. Colorado Fish and Wildlife has begun to use DNA testing in its own laboratories and hatcheries. Cost was a big factor. Other states have not yet picked it up, perhaps because it is not yet accepted by the American

Fisheries Society. There may be some political aversion as well. The cost is $15 per sample (fish or worm or pooled samples).

Q: Whirling disease is associated with juveniles, but the video pointed out that trout are carriers even if they do not exhibit symptoms.
A: Colorado classifies waters according to vulnerability. Waters must pass different levels of water quality screening before fish may be stocked. Trout Unlimited is concerned primarily with impacts to wild fish. Trout Unlimited opposes stocking infected fish if it increases the likelihood of disease among wild fish.

Q: The Bureau of Reclamation has major diversion programs that might be pumping infected water across basins. Is whirling disease a consideration, and should EPA become involved?
A: There is not any good information. It seems that the question would be what is the receiving ecosystem? If the fish are dominantly pike, there is no immediate issue. If there are trout, it may be a problem. If there are no trout present (presumably for 30 years), the spores will probably die out on their own. We just don't know.

Q: Is there any monitoring program that is required of hatcheries to ensure that spores are not released?
A: There is no required monitoring. Colorado monitors its own facilities to identify spore problems. There is no requirement for private facilities. Research indicates that any place with high sediment loads is susceptible to spore infestation.

Q: Most small hatcheries are exempted from NPDES permits, because traditional concerns were nutrient levels. Whirling disease may be a new factor.
A: None of the private hatcheries in Colorado have NPDES permits. A couple of state hatcheries have them, but only for sediments, nitrites, and other nutrients and chemicals.

Eric Hughes discussed some economic impacts of whirling disease. Angling generates between $1.2 and 1.3 billion per year in Colorado—second only to skiing. Fishing license sales have remained level over the past few years despite increases in population, which indicates a proportional drop in recreational fishing. Colorado's stocking program has reflected this decrease, now stocking about 3.5 million fry per year compared to 5 million in the past. Colorado has noted a shift in the past 20 years from catching and keeping fish to catch and release, and there are fewer fishing opportunities for people (due to crowding and fewer fish). People go fishing now not to catch the fish but for the change of pace. There are still lots of good fisheries in Colorado, but more publicity about whirling disease is keeping people away.

Q: Is loss of habitat a factor in why people don't go fishing any more?
A: Not a significant factor based upon Colorado's survey.

Streams on the west slope of the Rockies are no longer stocked because of disease, with a consequent drop in west slope fisheries. However, the west slope anglers are still fishing somewhere, and evidence points to increases in east slope fishing—Front Range fishing has almost doubled.

There are no known strains of disease-resistant rainbow trout, despite extensive searching. Wyoming does have a native strain of cutthroat trout that is far less vulnerable to whirling disease, and Colorado is trying to develop a brood stock of cutthroat trout and convert the rainbow fisheries to cutthroat trout. By shifting to cutthroat, we will stem the distribution of spores. Unfortunately, brown trout grow much more slowly and therefore are much more expensive to stock. Additional research is examining drug therapy. A French firm has developed a broad-spectrum antibiotic that seems to be effective in Japan and Europe. Colorado has tried to get licensing for the U.S., but the French company is not interested enough. There has been interest in a vaccine, but that is years away. A biocide successfully applied to lampreys in the Great Lakes also kills tubifex worms. A small dose may be an economical way of reducing the worm population, and research is continuing.

Colorado has built all of its hatcheries on open waters, and they are not secured against whirling disease. That has proven to be an expensive oversight. If you can avoid the parasite by switching from open streams to groundwater, that is the way to go. Colorado Department of Fish and Wildlife has requested $13 million from the legislature to install prevention facilities within its hatcheries. The best technique now is to bring in cutthroat trout eggs, disinfect them, raise them in isolation, and release them. Colorado is using single-round-amplification DNA testing in its hatcheries. It is not as effective as UC-Davis's double-round technique, but because Colorado tests so many fish, they consider it adequate.

> **Q**: When you switched to groundwater, did you first need to disinfect the existing equipment?
> **A**: Yes. Everything was thoroughly disinfected or discarded. Cleanliness has become a significant part of hatchery management to avoid contamination from surface sources, including covered raceways.

Discussion: Where do We Go From Here, and What Should EPA Do? — Jim Stemmle, ORD/Region 8 Regional Scientist

- "Regional Geographic Initiative" grants to local communities to prevent spreading of noxious weeds (purple loosestrife). Need authority to give grants. Need a direct connection to a specific program. Perhaps if EPA Regions collectively approached Headquarters, and demonstrated a collection of activities, Headquarters might get involved. Region 8 has funded a number of biocontrol projects. There may be relevant projects.
- The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) may be the Office of Pesticide Programs' (OPP) primary authority to get involved, even though it doesn't directly address invasive species. The Clean Water Act (CWA) may be the avenue whereby the Office of Water can manage problems associated with NIS (ballast water issues). Need to consult with FIFRA and FQPA legal specialists in the Office of General Counsel to see how these laws may be interpreted to address invasive species.
- EPA can conduct programs [such as the Pesticides Environmental Stewardship Program (PESP)]. that promote pesticide risk reduction and safer alternatives.

- NEPA review process to enforce land management practices (such as off-road vehicle use). NEPA is a powerful tool. EPA does have authority to comment on other federal agencies' actions under NEPA.
- EPA's EMAP program is characterizing environmental health at large scales, including use of landscape and remote sensing approaches. Can these remote sensing techniques be applied to weed control? May need hyperspectral data, which may be beyond civilian capabilities. It may be ripe for research and does fall within EPA's mandate.
- What is EPA's potential authority under the Endangered Species Act, insofar as invasive species may contribute to the decline of listed species? This may be a legal question for OGC.
- Can point sources (hatcheries) and nonpoint sources of whirling disease be regulated under TMDL? If species are under stress from reduced water quality (from sedimentation, for example), as well as from pesticides, TMDL may offer an indirect benefit as well. Use TMDL to restore optimal conditions for native species
- Involve volunteers from such organizations as Trout Unlimited with some EPA funding to identify monitoring sites or to destroy invasives.

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GREAT LAKES NONINDIGENOUS INVASIVE SPECIES WORKSHOP

October 20-21, 1999
Chicago, Illinois

Abstract

On October 20_21 1999, EPA's Great Lakes National Program Office and the Great Lakes Commission hosted the second of a series of EPA Regional workshops to evaluate the research and management issues associated with nonindigenous species. This workshop invited specialists to discuss the ecological and economic effects of nonindigenous invasive species on the Great Lakes Basin. The impacts of existing nonindigenous species, such as zebra mussels, and the threat of additional invasions is particularly serious in the Great Lakes and efforts to prevent and control the introduction and spread of these species can serve as useful examples to the rest of the nation.

More than 140 aquatic nuisance species have been identified in the Great Lakes Basin. Approximately 10 percent of nonindigenous species introduced into the Great Lakes, the world's largest surface freshwater system, have had significant economic and ecological impacts. Cumulative costs due to zebra mussels alone totaled $120 million between 1989 and 1994. It is estimated that the current rate of invasion into the Great Lakes is one new organism each year. The single largest source of unintentional introductions has been through maritime commerce. Organisms will either attach themselves to the hulls of oceangoing ships or are carried in ballast water that was historically discharged into the Great Lakes. Ballast water exchange before entering the Great Lakes is the present approach to reducing new introductions but onboard and offboard treatment of ballast water also needs to be evaluated as potentially more effective options.

Although most of the focus in the Great Lakes Basin has been on aquatic nuisance species, terrestrial ecosystems are also being invaded. In Wisconsin, 24percent of the plants are nonindigenous and of those 50percent are "invasive" to some extent. Invasives reduce the native flora both through competition and through hybridization, as is occurring with the native broad leaf cattail. On a global scale, invasions will reduce biodiversity and homogenize the fauna and flora.

Workshop participants agreed that prevention is the best approach to managing nonindigenous species because of the difficulty of controlling invasives once established. The sea lamprey is one of the few cases of control of an aquatic nuisance species. With the zebra mussel and ruffe, management actions appear to have slowed their spread but have not controlled their populations in infested areas. There are more options for the control of terrestrial weeds, such a fire, species-specific pesticides, and biocontrols, but in many cases these are prohibitively expensive, cause their own impacts, or are ineffective. For new invasions, the best strategy is to attempt to eliminate the satellite populations while they are still limited in range. Several of the participants noted the importance of monitoring and detection as part of any management strategy and the need for funding taxonomists and taxonomic infrastructure.

Management of invasive species requires close coordination among federal, state, and local organizations, which is often not the case. Effective management is also hindered by the patchwork of state and federal legislation and programs. Some of the participants argued that a

lead agency needs to be charged with managing invasive species. There was a consensus that education and public outreach were key components of invasive species management strategies, especially with species potentially transported through recreational activities (e.g., on boats, as bait). Several states, such as Minnesota and New York, have such programs and believe they have been successful in slowing the spread of invasive species.

Welcome and Introductions

Gary Gulezian, Director of EPA's Great Lakes National Program Office, welcomed participants to the second of a series of four workshops to help define EPA's role in combating invasive species. The workshop series is being conducted partly in response to an Executive Order establishing an executive council, consisting of several cabinet officials and EPA Administrator Carol Browner, to oversee an interagency program to detect, monitor, and control invasive species and to restore native species and habitats. Mr. Gulezian asked participants to consider how best to identify national needs in combating nonindigenous invasive species and to array efforts spread across international, federal, state, and local agencies. He stressed the need to consider both aquatic and terrestrial species. The Great Lakes Basin forms the largest surface freshwater system in the world and is a particularly significant ecosystem. The Region serves as an example of the damaging effects of aquatic nuisance species (ANS) and highlights efforts and approaches to combat nonindigenous invasive species. Although this topic is recognized as a serious problem at the local level, upper levels of management remain either unaware or unconvinced of the gravity of the situation. Mr. Gulezian hoped that this workshop would provide ideas for conveying the growing danger of nonindigenous invasive species to the environment and the economy. Ultimately, Mr. Gulezian would like to see a powerful statement drafted to move this issue to the national agenda.

Workshop Overview and Objectives —
Marc Tuchman and Karen Rodriguez, EPA Great Lakes National Program Office

Marc Tuchman, EPA Great Lakes National Program Office, reiterated that these four workshops on nonindigenous species are aimed at drawing higher-level attention to this growing problem. He encouraged participants to consider what roles EPA and other agencies should have in efforts to prevent the introduction of and limit the damage due to these species. Karen Rodriguez, EPA Great Lakes National Program Office, pointed out that the problem encompasses both aquatic and terrestrial species. From an ecosystem view, the two are closely related and efforts must consider this connection. The workshop focused on four primary means of addressing the problem of nonindigenous invasive species: prevention, control, monitoring and protection, and outreach and education. Presentations covered current work within the Great Lakes Region for each of these topics.[**]

[**]Questions and answers following each presentation generally clarified or reiterated points made earlier. For this reason, questions and answers were incorporated into the presentation summary, as appropriate.

Overview of Briefing Paper for Great Lakes Nonindigenous Invasive Species Workshop — Kathe Glassner-Shwayder, Great Lakes Commission

Kathe Glassner-Shwayder, Great Lakes Commission, began the day's presentations with an overview of a briefing paper prepared in advance of the Great Lakes Nonindigenous Invasive Species Workshop. This document, which summarized the state of affairs on nonindigenous invasive species in the Great Lakes Basin, was distributed to participants prior to the meeting. In addition to providing an overview, the paper aims to promote support for the prevention and control of invasive species. The document addresses the scope of the problem in the Region, assesses current management structures for the prevention and control of nuisance species, identifies prevention and control strategies, discusses approaches to education and outreach, and presents case studies on several particularly serious invasions in the Region. Glassner-Shwayder added that the conclusion section of the briefing paper would be finalized based on the ideas generated from workshop discussions.

The general state of knowledge in the Great Lakes Basin, with regard to nuisance species, is geared toward aquatic species. More work is needed for terrestrial species in general. Existing knowledge covers the assessment of the ecological and economic effects of nonindigenous invasive species and their pathways of spread. The ecological effects of aquatic nuisance species are well documented in the Great Lakes Region. However, less information is available to assess the ecological effects of terrestrial nuisance species in the Region. Such information may exist but has not been integrated into the overall picture because of a lack of coordinated effort among relevant agencies. Both aquatic and terrestrial species pose serious threats to the biodiversity of the Region.

Nonindigenous invasive species can be thought of as biological pollutants. Pathways of introduction can be intentional and unintentional. Generally, intentional introductions of nuisance species are meant to be beneficial. However, either the possible deleterious effects of introducing the species are not fully considered or the species escapes from a controlled use into the wild. Unintentional introductions generally come from the unknowing transport of nuisance species. The unintentional introduction of the zebra mussel through ballast water in transoceanic shipping is a prime example.

While the ecological effects of invasive species are identifiable, it is difficult to account for the economic costs to the Region. Assessments of economic costs are nationally based. A 1993 Office of Technology Assessment (OTA) Report to Congress on the subject estimated that costs resulting from just 79 species averaged $1.1 billion per year. A 1999 Cornell University study counted costs of $138 billion annually due to more than 50,000 nonindigenous species.

Coordination among all levels of management is necessary to adequately confront problems caused by nuisance species. The briefing paper catalogs prevention and control programs at the federal, regional, and state levels. At the federal level, there are a few tools in place to combat nonindigenous invasive species. These include the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA), the Aquatic Nuisance Species (ANS) Task Force, the National Invasive Species Act of 1996 (NISA), and the Executive Order on Invasive Species (1999). The provisions of the NANPCA were initiated largely because of the zebra mussel invasion of the Great Lakes. Regulations established a regime that targeted the prevention of aquatic nuisance species carried in ballast water. The Aquatic Nuisance Species Task Force is an intergovernmental body charged with the prevention and control of aquatic nuisance species and with implementing NANPCA. Part of this effort is the cooperative Aquatic Nuisance Species

Program, which addresses all such activities funded by the federal government. The National Invasive Species Act of 1996 reauthorized and expanded NANPCA to a national level. NISA also enhanced other national monitoring and control programs. The Executive Order on Invasive Species can potentially provide greater control and prevention in the Great Lakes Region by requiring all relevant federal agencies to use and coordinate their authority and programs to prevent, detect, monitor and control the introduction of nuisance species. Many efforts are also under way at the Great Lakes Regional level, such as the Great Lakes Panel on Aquatic Nuisance Species, the Great Lakes Action Plan for the Prevention and Control of Aquatic Nuisance Species, and a Symposium on Ballast Water Management and Aquatic Nuisance Species. Additionally, Great Lakes State Programs for ANS Prevention and Control and Comprehensive State Management Plans provide another layer in the management structure. The challenge is to integrate prevention and control measures across agencies and among the various management layers.

In terms of steps to ameliorate the nuisance species problem in the United States, and the Great Lakes Region in general, preventing the introduction of new species must target high-risk pathways, such as ballast water. Control measures must involve developing one approach that integrates biological, chemical, and physical means. Control also requires quick response to the detection of new invasions. Finally, an informed public is the cornerstone of all of these measures. To achieve this, agencies must convey accurate facts to appropriately targeted audiences in a consistent message.

Group discussion of the paper centered on the geographic scope of the Great Lakes Basin. While the lakes and contributing water bodies are easy to define, there was some debate about the terrestrial boundaries of the Region. Ms. Glassner-Shwayder noted that while this term implies the watershed basin along the water/land interface, it is difficult not to discuss more inland areas, as these are being invaded as well. The group also discussed how much, if any, effort should be made at this point to address the costs to human health. A study done on Mobile Bay may have taken this into consideration, but not much is currently being done to integrate human health impacts into nonindigenous invasive species research.

Nonindigenous Aquatic Nuisance Species —
John Gannon, Great Lakes Science Center (USGS)

With more than 140 species identified, aquatic nuisance species constitute a serious problem in the Great Lakes Basin. Two species in particular, the sea lamprey (*Petromyzon marinus*) and the zebra mussel (*Dreissena polymorpha*), provide prime examples of the lessons learned, not only in terms of the effects of introducing nonindigenous invasive species, but also in terms of the efforts to control these invasions. The sea lamprey, native to the coastal regions of the Atlantic Ocean, preys on other fish. It was introduced to the upper Great Lakes Region through the Hudson River and Erie Canal systems. By the 1950s, the population of this fish in the upper Great Lakes had reached a crisis level, threatening the lake system with the collapse of several fish populations. At that time, the United States and Canada began working jointly through the Great Lakes Fishery Commission to reduce the impacts of the sea lamprey. One chemical compound was finally identified that was toxic to the lampreys but not to other aquatic species in the lakes. Other control methods in use or under investigation include mechanical barriers to prevent spawning and the release of sterile males. Such solutions are more desirable than the intentional introduction of toxins into the ecosystem. The cost of these efforts was estimated at $10 million annually in a 1993 OTA report.

The zebra mussel is perhaps the premier aquatic invader in the Great Lakes Region. Colonization fouls intake pipes, navigation locks, and other pieces of the aquatic infrastructure. It is believed that zebra mussels entered the Great Lakes through ballast-water discharge, a process through which cargo ships release or take in water to counterbalance the loading and unloading of cargo. First identified in the Region in 1986, the species has rapidly spread throughout all of the Great Lakes and even to several inland lakes. Zebra mussels are reducing phytoplankton, a major food source in the food chain. They also have a damaging effect on the spawning habits of certain fish species and will kill native mussel species. It is postulated that the invader can also cause the spread of nuisance aquatic plant species. Finally, by colonizing pipes and underwater intakes and outputs, zebra mussels have cost industries millions of dollars in damage. Between 1989 and 1994, documented cumulative losses to major users of untreated surface water in the Region amounted to more than $120 million. Zebra mussels originated in the Caspian Sea and infested European waters prior to arriving in the United States. Europeans adapted to the infestation by including filters, intakes, and other features to reduce fouling. Cooperation with other nations could lead to better tools for combating this invader. The Great Lakes have been particularly vulnerable to this rapidly reproducing species because of the water system's size, location, and connectivity.

These two cases serve as examples of the need to target efforts to prevent and control nuisance species. Prevention needs to be a priority. It is easier and more cost-effective to prevent the introduction of nonindigenous invasive species than it is to control invasions once they occur. These species cannot really be controlled in environments that allow them to reproduce and that are devoid of natural predators. It is more realistic to aim for containment of these species by studying life cycles and identifying species weaknesses. Any containment strategy needs to be flexible and adaptive, given the uncertainty of dealing with nonindigenous invasive species. Also, strategies need to be more attuned to early detection of and response to possible invasions by nuisance species. Right now, the best efforts made are in response to infestations already underway. Involved agencies need to do a better job of anticipating potential threats. There are five objectives for improving current efforts: prevention, coordination of monitoring, better and faster transfer of information, rearrangement of institutional authority, and building public support to take advantage of teachable moments when the public's attention is focused on an incident.

Discussion echoed the sentiment that it is critical to contain nuisance species. In the case of the zebra mussel, further spread could be reduced through interstate initiatives, watercraft inspections, and better education and outreach. Some participants noted that signs of the spread are slowing and believed this to be attributable to education and outreach. The group agreed that prevention is key.

Nonindigenous Terrestrial Noxious Species —
Randy Westbrooks, USDA, Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW)

Randy Westbrooks noted two problems facing those working against terrestrial nuisance species: the lack of management focus and the lack of a good organizational structure to combat invasive species. The USDA's Animal and Plant Health Inspection Service (APHIS) has been operating as a first line of defense against nonindigenous invasive terrestrial species, but was not originally configured for this role. APHIS works primarily to protect agriculture from nuisance weeds and pests. This effort is linked to agricultural production and is therefore commodity-based. Without any one agency having a clear lead in preventing the introduction of nuisance species, relevant

agencies must work together. To that end, Mr. Westbrooks posed the question of how EPA fits into the control of biological pollutants, such as nonindigenous invasive species. He suggested that involved agencies may be able to draw upon EPA's experience overseeing chemical pollutants like pesticides and its experience in creating and implementing environmental policy. In the case of pesticide safety, the burden of proof is on the industry. Perhaps a similar approach could be used for the intentional introduction of nonindigenous invasive species.

The problem with nuisance species is that they have been put outside of their natural habitats, where they were managed by natural predators. Unlike chemical pollutants that breakdown over time, biological pollutants multiply. In new habitats and those lacking natural predators, invasive species pose a serious threat to biodiversity. Prevention and outreach are crucial tools. Based on his own work with APHIS and FICMNEW, Mr. Westbrooks noted that detection techniques are currently not advanced enough to be an effective first line of defense. Work needs to be done to strengthen this element of prevention. He did point out, however, several cases in which agencies had been tipped off to the presence of an invasive species by a citizen, who had seen it on the Internet and recognized it in his or her neighborhood. In terms of changing the institutional environment, a lead agency needs to be charged with the prevention and control of the introduction of nuisance species. Work needs to move across agencies, so that money and expertise can be pooled and efforts are not duplicated. Finally, a need exists for a mobilized constituency to press for resources and partnering among all levels of government and private groups. Mr. Westbrooks cited the Federal Interagency Weed Committee's National Weed Strategy as an example of a partnering and outreach tool currently available. Likewise, the ANS panel was set up to foster cooperation, develop a strategic plan, and provide oversight to federal agencies. A national strategic plan could be used as a model for regional and state plans.

Discussion touched upon the use of genetic modification as a means of control, with the understanding that much further research would be needed before it was a practical option. The group noted that there is a public perception that species available at nursery suppliers are controlled by some level of government. This is not currently true, but, if it were, it could provide a means of control.

Prevention of Nonindigenous Species Introductions and Spread —
Allegra Cangelosi, Northeast Midwest Institute, and Doug Jensen, Minnesota Sea Grant

Allegra Cangelosi focused on the unintentional introduction of nonindigenous invasive species via ballast water. Once the zebra mussel problem was identified and attributed to shipping ballast water in the late 1980s, concerns were raised in the Great Lakes Region about preventing new introductions from ships. Federal legislation was initiated to require mandatory inspection of ships entering Great Lakes ports. Based on the impacts of nonindigenous invasive species elsewhere and on a rough study of national ballast-discharge practices, ballast-water exchange was identified as a high-risk pathway for nuisance species. A trial period of unenforced compliance was set up to gauge compliance with ballast-water discharge procedures. The International Maritime Organization (IMO) was initially slow to respond to concerns about the transport of nonindigenous invasive species through ballast water. However, when the United States stepped up monitoring and regulatory efforts, the IMO took the initiative to establish some uniformity in international efforts to regulate ballast-water discharge.

Currently, studies are taking place to assess the effectiveness of various technologies for ballast-water control. Open ocean exchange, in which ships empty and fill ballast water in near

coastal waters, provides the best measure for ensuring that nuisance species are not transported. These waters are sufficiently different from inland waters to assure that any transported species do not survive. However, in practice, this is a potentially dangerous technique for the ship and crew. Another alternative is near shore alternate exchange zones, although this does not work for all ship designs. Currently, the Gulf of St. Lawrence is the only one in operation. Here, ballast water is exchanged closer to shore, but still outside of freshwater. This technique is believed to be less effective. The retention of ballast on board is another control technique and requires moving ballast water to different areas of the ship while loading and unloading. Shipping interests are resistant to this technique. There are other, less-effective techniques available. These include avoiding the intake of ballast water near red algal blooms and visible sewage discharge, when possible. Despite these techniques, the problem of unpumpable residuals in which invasive species can be resuspended and later discharged remains. Future ballast-management goals should aim at a more comprehensive array of tools, including coastal and transoceanic shipping, and near shore alternate exchange zones and pumping facilities.

Ms. Cangelosi concluded her presentation by relating a number of exciting opportunities to better manage ballast-water introduction of invasive species. NISA provides the opportunity to implement the monitoring of ballast water through Coast Guard compliance checks. There is growing support for research and development for onboard and offboard treatment options, along with retrofitting and new design possibilities. This may also be the time to create new requirements for new ships, ensuring better ballast-management practices. Finally, studies need to be carried out on the effectiveness of ballast-exchange techniques. The techniques must be not only effective but also monitorable, economically feasible, safe, and applicable to non-transoceanic shipping. Current research covers the use of heat, backwash filtration, biocides, shoreside treatment, cyclonic separation, and ultraviolet light, ozonation and ultrasonics.

Doug Jensen, Minnesota Sea Grant, focused on existing programs and legislation to prevent the introduction and spread of nonindigenous invasive species, particularly those in the Great Lakes Region. The OTA report highlighted a patchwork of state and federal legislation and programs to address this problem. These efforts do not always match up with existing problems. In terms of state laws, those pertaining to agriculture in general are fairly comprehensive. However, coverage of nuisance species under state agriculture laws is somewhat sporadic. Several resources are available for states to use in drafting legislation and policy to deal with nonindigenous invasive species. The Great Lakes panel has developed a model that could be used by states for regulatory purposes. The State of Minnesota has several well-developed programs to prevent and minimize the introduction of nuisance species. These programs, as well as the state's experiences, could serve as models for other states as well. Originally, Minnesota attempted to develop species-specific plans. Along the way, it was decided that a more comprehensive approach was needed. Regulations were developed to prevent both the overland and water-to-water spread of nonindigenous invasive species. Key components include the granting of authority to state agencies to regulate nonindigenous species and the requirement of permits. Lists could also be established that either list plants that are safe to include or list plants that must be excluded. Minnesota's species-specific plans also distinguish between intentional and unintentional introductions.

Several components of these plans that address intentional introductions include an evaluation of the potential environmental impacts, studies of long-term effects, a statement of the purpose for a particular introduction, an assessment of the potential use of native species to meet the same purpose, and a review of information about the pathogen status of proposed species.

Similarly, several ways in which to address unintentional introductions were suggested. These include regulating the transport of harmful species (specifically addressing infested waters) and regulating activities that might be potential pathways for unintentional introductions. Minnesota regulates the transportation of aquatic macrophytes on public roads, requires that water craft must be drained before being moved from infested waters, prohibits moving infested waters or animals from their original location (for example, live bait), and requires drying or freezing of commercial fishing equipment. In addition, Minnesota does more than 20,000 hours of road inspections related to watercraft. Voluntary guidelines also play a role in Minnesota's efforts. These apply to many recreational activities, such as scuba diving, angling, and boating. Mr. Jensen suggested some generic guidelines for these types of activities, which include always inspecting equipment, removing visible plants from equipment and craft, and cleaning and draining.

Mr. Jensen noted several important ideas discussed at the workshop. The group pointed out several times that once nuisance species are introduced, it is virtually impossible to eradicate them. This is in part because there are often no acceptable controls available. Practically speaking, introductions are forever. The idea that prevention is a much more important goal was another common theme throughout the workshop. The group noted the importance of addressing both main pathways of introduction: water-to-water transport, such as ballast exchange, and overland transport, such as moving recreational watercraft. Another key area is education and outreach.

Following this presentation, the group expressed concerns about the feasibility and costs of ballast-exchange techniques. Ms. Cangelosi noted that these concerns depend largely on the type of ships and voyages.

Control of Nonindigenous Species —
Kelly Kearns, Wisconsin Department of Natural Resources

Kelly Kearns discussed the control of nonindigenous terrestrial plant species, focusing on the scope of the problem, prioritization, general control methods, and unmet needs. While nonindigenous aquatic species, such as the goby (*Neogobius melanostomus),* seem to get the headlines, nonindigenous plant and insect species are far more numerous. In 1993, OTA reported that about 2,000 of the over 4,000 species of foreign origin in the United States are plant species. In Wisconsin, 24 percent of the plants are non-native and 50 percent of these are invasive to varying degrees. New plant species are adapting and invading.

Ms. Kearns stated that perhaps the largest known impact of nonindigenous plant species in Wisconsin is their tendency to exclude native species. This can happen in two ways. Non-native species can produce chemicals that prevent other plants from growing near them. Non-native species can also hybridize with a native species. For example, the narrow leaf cattail is moving from the Atlantic coast and hybridizing with Wisconsin's native broad leaf cattail. These hybrids are then out-competing the native species. Economic costs approaching hundreds of millions of dollars can be associated with species loss. Ms. Kearns also discussed human health issues related to nonindigenous species invasion. For example, parsnip is toxic to the skin and can cause a painful rash. Ms. Kearns emphasized that state property managers faced with non-native species invasion will likely need to prioritize which species to manage first. Prevention is vital. Managers should focus on satellite populations that are just being established so that potential impacts never materialize. Natural areas infested with nonindigenous species should also receive priority. Checking and monitoring bordering areas for invading nonindigenous species is also important.

A number of methods are commonly used in the Midwest to control the spread of nonindigenous species. Fire is used to kill Eurasian grasses that often overrun native species. However, fire can kill wildlife, so it must be used judiciously. Pulling is another control method. It is simple and less damaging than fire, but it is an ineffective defense against plants that have already spread broadly. It can also pose risks to humans. Cutting and mowing are also good alternatives, if done at the right time. Digging is generally ineffective because the disturbance it creates causes more problems than it addresses. Foliar spray and biocontrol are methods occasionally used to control nonindigenous species spread. Some pesticides are species-specific pesticides, i.e., ones that target specific plant families. Companies are still working on developing more species-specific pesticides. Several states, including Wisconsin, Missouri, and Illinois, have put together manuals that recommend control methods that can be used with various species. Monitoring nonindigenous species and managing existing native species are also important components in controlling nonindigenous invasive species.

Unmet needs of the state of Wisconsin include staffing, funding, and enforcement limitations. Federal laws are not considered strong enough. Examples of situations in which federal laws need to be strengthened include expanding federal weed laws, controlling federal agency introduction of nonindigenous species (including invasive species in federal land use plans), and developing laws limiting interstate transfer of non-native species. States and localities also need to strengthen their own invasive species policies and laws, while improving outreach to the public.

Control of Nonindigenous Species —
Tom Busiahn, U.S. Fish and Wildlife Service

Mr. Busiahn spoke next about the control of aquatic indigenous invasive species. He focused on the ruffe, originally native to Europe and Asia, but now abundant in upper Lake Superior. The release of ballast water from ships introduced ruffes into western Lake Superior. Since then, the ruffe has spread along the southern and northern shores of Lake Superior. The ruffe has also spread to Alpena, Michigan in Lake Huron due to ballast-water transport, but has not been sighted in other places since 1995. However, peripheral populations on the northern and southern shores of Lake Superior are increasing so further movement of the ruffe across the Great Lakes is likely. The ruffe is a threat to local fisheries in these regions.

The ruffe has characteristics that make it an especially effective invader. These include its prolific spawning and survival success in a variety of habitats. The ruffe, along with the zebra mussel, was the prime impetus for the passage of the Nonindigenous Aquatic Nuisance Prevention and Control Act in 1990. The ruffe is still a problem today, but impacts on the ecosystem are difficult to measure. Its impacts may appear decades in the future. Since 1995, the Ruffe Control Program, authorized in 1992, has met its goal of preventing or delaying the spread of ruffe. Mr. Busiahn discussed the eight components of the Ruffe Control Program, including prognoses for future success.

- *Population Reduction*
  - Objective: Eliminate or reduce reproducing populations, using appropriate technologies where feasible.

- Prognosis: Poor. Technologies do not exist. Pesticides are controversial and likely to be ineffective. Physical removal may be useful in very limited situations. Use of pheromones to reduce ruffe populations is only in development stages.

- *Ballast-Water Management*
  - Objective: Minimize the transport of ruffe from western Lake Superior through ballast-water management and support the development of technologies to prevent transport.
  - Prognosis: Good for western Lake Superior ports, because most ships coming from Duluth (except cement ships) do not use ballast water. The prognosis is poor when ruffe colonize other Great Lakes. Technology development is in very early stages.

- *Population Investigation*
  - Objective: Continue and expand investigations of ruffe populations to evaluate the impact on affected fish communities and to provide information necessary to plan, implement, and evaluate control activities.
  - Prognosis: Mixed. Investigations continue at reduced intensity. Integration of agencies' data has not been completed.

- *Surveillance*
  - Objective: Conduct surveillance sampling in likely locations to find newly established populations of ruffe and designate a single office to compile collections of ruffe.
  - Prognosis: Good. Field sampling and angler reports have detected ruffe colonization in a timely manner. Surveillance results for all Great Lakes are compiled into one annual report.

- *Fish Community Management*
  - Objective: Recommend fish-management practices that will improve resilience of fish communities against invasion or dominance by ruffe.
  - Prognosis: Mixed. No recommendations specifically for ruffe. General recovery of Great Lakes fish communities and habitats will increase resilience.

- *Education*
  - Objective: Develop and promote information and education programs to identify ruffe so that they will not be transported alive but rather killed and their presence reported.
  - Prognosis: Good. Excellent educational materials are available. Public awareness is high.

- *Bait Fish Management*
  - Objective: Assist jurisdictions in developing model language for regulation of bait harvest and possession.

- Prognosis: Good. Model language now available through Great Lakes Panel on Aquatic Nuisance Species. Bait industry working to improve quality control.

- *Chicago Sanitary and Ship Canal*

  - Objective: Consider options to prevent the movement of ruffe from the Great Lakes to the Mississippi watershed via the Chicago, Des Plaines, and Illinois Rivers.
  - Prognosis: Mixed. Electrical barrier is to be installed in 2000. Effectiveness is unknown, and other technologies are poorly developed.

OVERALL PROGNOSIS

Activities conducted under the Program have delayed the spread of ruffe in the Great Lakes. It is projected that, even in the absence of human-assisted transport to new locations, the ruffe will eventually colonize new locations throughout the Great Lakes and connected waters by their own movements. However, assistance by humans will likely be necessary for ruffe to colonize new locations beyond the Great Lakes and connected waters. Measures are being developed to prevent ruffe from being transported to waters not connected to the Great Lakes.

Based on his experience, Mr. Busiahn made several observations. First, a need exists to integrate management and research early in the process; management decisions cannot wait for peer-reviewed literature. It is of little use to fund researchers but then not obtain results from them for years. Second, planning teams should be inclusive because decisions are best informed by considering diverse viewpoints. A variety of interest groups need to be represented, not just scientists. Third, technical and policy roles should be separated in planning. Policy people need to be able to speak for their agency with authority; technical people should avoid speaking for policy people. Mr. Busiahn added several general conclusions. First, control technologies and integrated pest management strategies are not effective for aquatic species; the control technology toolbox is practically empty for these organisms. The sea lamprey control program is an exception to this. Use of toxicants is unlikely to succeed in open systems like the Great Lakes unless they are species-specific. Second, preventing future invasions is preferable to controlling them once they become established. Third, Mr. Busiahn noted that, although biocontrol has been explored as a way to control ruffe populations, studies show that predator stocking was not effective. Predators have tended to kill species other than ruffe.

Detection and Monitoring of Nonindigenous Species —
Don Schloesser, U.S. Geological Survey's Great Lakes Science Center

Don Schloesser believes that research on detecting and monitoring exotic, nonindigenous species has been overwhelmed by research on preventing and controlling them. In this instance, detection is defined as finding an organism in an environment where it did not previously exist. Monitoring is defined as keeping track of the population of a species. Exotic species have historically been discovered in one of two ways: randomly, by researchers already out in the field, or intentionally, by individuals or agencies actively searching. Without funding, most discoveries will continue to be made accidentally. Mr. Schloesser had several recommendations about how to improve detection and monitoring of nonindigenous species:

- Develop regional and watershed lists for indigenous species.
- Develop incentives for taxonomic experts to look for or report nonindigenous species.
- Decrease the time between detection and reporting of nonindigenous species.
- Include more evaluation of the impacts of nonindigenous species.
- Develop a quick-response team to address reports of nonindigenous species -- this may allow satellite populations to be eliminated. It is important to ensure that objective teams that are free from vested interests are used to evaluate impacts on nonindigenous species.
- Nonindigenous species legislation needs to be strengthened considerably, as suggested in a recent Congressional Research Service (CRS) report on nonindigenous species.
- Hitchhiking on biodiversity programs may be an inexpensive way to quickly identify invasive species.

Detection and Monitoring of Nonindigenous Species —
Tom Nalepa, Great Lakes Environmental Research Lab, NOAA

Tom Nalepa argued that in order to effectively monitor invasive species in the Great Lakes, it is essential to monitor measures of ecological change. Invasive species create an unstable ecosystem in which specific changes are difficult to predict. For instance, nothing in European scientific literature suggests the impact that zebra mussels have had on water quality in the Great Lakes. Some scientists believe that zebra mussels might be promoting the spread of plants such as the *Microcystis*, a nuisance bloom of blue-green algae, because they feed on types of phytoplankton other than *Microcystis*. This preferential feeding allows the *Microcystis* to proliferate. This nuisance algae may create taste and odor problems in water, such as those experienced throughout the summer of 1994 at Michigan's Saginaw-Bay City Water Intake.

Mr. Nalepa is studying the impact of the zebra mussel on populations of the amphipod *Diporeia*, which have declined precipitously since the arrival of the zebra mussel. *Diporeia* may very well be gone within the next 10-20 years. It is likely that this will cause major changes in Great Lakes fish populations. Mr. Nalepa made two suggestions regarding the future direction of monitoring. First, it is important for interested parties to form partnerships to allow as many variables as possible to be monitored, because it is difficult to predict which ones will reveal the presence or impact of invasive species. Invasive species seem to impact all biological components. Creation of a strong baseline data set will allow comparison of changes in specific variables over time. Second, experimental studies should be integrated with monitoring activities.

Detection and Monitoring of Nonindigenous Species —
Noel Pavlovic, U.S. Geological Survey

Noel Pavlovic's current research focuses on monitoring and detection systems for invasive plants. Mr. Pavlovic explained that there are generally four phases of species invasion: the lag phase, the permanent phase, the colonization phase, and the infiltration phase. The lag phase occurs when a species is repeatedly introduced to a new ecosystem; sometimes the species survives and sometimes it does not. The permanent established phase occurs when populations become established and are reproducing, but these populations remain small. The colonization phase occurs as a species disperses and populations become larger. The infiltration phase occurs

when an organism infiltrates or penetrates an entire ecosystem. These phases highlight the importance of detecting invasive organisms early, before invasion becomes massive.

Mr. Pavlovic is currently monitoring exotic species in four national parks: Indiana Dunes, Sleeping Bear Dunes, Pictured Rocks, and Fossil Islands. He is sampling vegetation in each of the parks to assess native plants, detect common exotics within parks, identify trends in parks, and provide information to the public about how to control invasive species on their property. The intention of Mr. Pavlovic's research is to identify mechanisms that enable early detection of invasive organisms.

Detection and Monitoring of Nonindigenous Species —
Miles Falk, Great Lakes Indian Fish & Wildlife Commission

Miles Falk began by describing the purple loosestrife (*Lythrum salicaria)* invasion over the past 10-12 years in northern Wisconsin. The purple loosestrife has devastating ecological effects on wetlands areas. The Great Lakes Indian Fish & Wildlife Commission has created an inventory of monitoring data by targeting sites, such as boat docks, where purple loosestrife is likely to be found, and counting the number of plants found. Through this inventory of monitoring data, the Commission has been able to generate a distribution map that allows it to prioritize the protection of wetlands sites and to develop a strategy to predict where the loosestrife is likely to move next. Mr. Falk also mentioned the Commission's evaluation of the effects of chemical control and biocontrol on purple loosestrife.

Mr. Falk identified three Commission needs. First, a need exists for alternative control methods to deal with the demands of different property owners. For instance, the Forest Service is not allowed to use any herbicides on its property. Second, there is a need for better survey technology to identify points of introduction for terrestrial plants. Third, there is a need to receive input from other agencies and to tap into their insights.

Education/Outreach on Nonindigenous Species Issues —
Doug Jensen, Minnesota Sea Grant Program

Doug Jensen talked about the education and outreach activities undertaken by the Minnesota Sea Grant Program. This program supports research and public education programs related to Lake Superior and Minnesota's inland waters, including information on aquatic nuisance species. It is part of the National Sea Grant Program, which sponsors research in 31 coastal and Great Lakes states. Mr. Jensen stressed prevention as the key to the fight against nonindigenous species and noted that education is a key component of prevention. Public knowledge about a particular nuisance species is directly related to the level of effort put forth by a particular agency and the number of education methods used to disseminate information. The most effective educational methods include television public service announcements, radio advertisements, newspaper advertisements, signs at boat launches, billboards, brochures, information booklets, and information cards. Information needs to kept simple and to the point. While it is difficult to show that public education has directly contributed to limiting the spread of aquatic nuisance species, it is argued that the zebra mussel, for instance, could be spreading much faster, given the mechanisms that are available for it to do so. In conclusion, the Minnesota Sea Grant Program needs to continue to enhance partnerships with public and private sectors, as well as increase its funding.

Education/Outreach on Nonindigenous Species Issues —
Tim Sinnott, New York Department of Environmental Conservation (DEC)

Tim Sinnott's focus was on educating the public about aquatic nuisance species in New York. His primary message was that in order to have a successful education program, it is essential to get the audience you are trying to educate motivated to take action. Public awareness without action accomplishes very little. In the DEC's Aquatic Nuisance Species Management Plan, education is part of the plan's goals because it is considered essential to the plan's success. Education can replace regulation to some extent. For example, letting New York anglers know that taking bass out of their nest can reduce future bass populations significantly helped to reduce that problem. Obstacles to a successful education program include lack of time, staff, and money. Emphasis on the importance of the issue is often the best way overcome these limitations.

Discussion on Prevention, Control, Detection and Monitoring, and Education/Outreach —
Kathe Glassner-Shwayder, Great Lakes Commission

The major points made by workshop participants during the wrap-up discussion session are given below.

- The research component was missing from the workshop's agenda. While it is certainly part of prevention and control, it is important for research to be considered separately as its own category.
- Federal and state agencies should get together early in the process to address aquatic nuisance species issues.
- Invasive aquatic species seem to have received the most attention, but it is important for federal and state agencies to realize that invasive terrestrial plants are extremely problematic as well.
- It is important to gather economic information on the costs of taking no action and the benefits of taking action to control terrestrial and aquatic nonindigenous species. This information takes some time to produce, but is a great aid to decision-makers.
- There is a need to develop an inter-agency stakeholder strategy for assessing the environmental impacts of various technologies, such as biocontrol and chemical control. It is important to be aware of the environmental risks associated with each type of control. Otherwise, it is possible to cause serious problems with control methods, such as ballast-water management and terrestrial pesticide use.
- Effective partnerships with national conservation groups are lacking.
- Some invasive species controls, particularly pesticide use, should be reduced. However, it is important not to make biocontrol versus chemical control a competition; such an approach could be quite damaging.
- Attempts to prioritize on which invasive species to focus and which natural areas to protect first should be continued. There are too few resources to protect everything, so the most sensitive or valuable ecological areas should be protected first.
- There is a need to get more volunteers involved in prevention, control, monitoring, and education activities.

- Prevention is the most important action that a state or federal agency can take and cannot be over-emphasized. Once an organism is successfully introduced into a new environment, its spread can be slowed, but it is almost impossible to eradicate. Ballast water management is a key prevention area, but other areas must not be overlooked. Agencies react rather than thinking ahead. Since many invasive species have originated from the Baltic ships, perhaps emphasis should be placed on coordinating with Europeans to better address this problem.
- It was suggested that a letter with multiple agency sign-off would spur action at state agencies.
- Invasive species are a national issue, as well as a Great Lakes problem. Emphasis on the national aspect of the problem may make federal funding more likely.
- Perhaps more focus should be placed on the public health impacts, rather than the ecological impacts, of invasive species. Public health issues are frequently higher on the priority list of elected officials.
- In order to make an effective case for why elected officials should focus on indigenous invasive species issues, arguments need to center around comparative risk. In other words, it is necessary to emphasize the aspects of this issue that make it more important than competing issues.
- State funding to address invasive species issues is often limited. States need to receive federal money to have a significant impact.
- There is a need to determine out how to close major exposure pathways. Some consider this problem to be intractable, but everyone should keep thinking about it.
- Although EPA is not specifically responsible by statute for addressing the issue of nonindigenous species, the Agency can have an indirect but important impact through the setting of Total Maximum Daily Loads (TMDLs) and the development of guidance for water quality standards.

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REGION 4 NONINDIGENOUS SPECIES WORKSHOP

AQUATIC INVASIVE SPECIES AND SHIPPING
IN THE EASTERN GULF OF MEXICO
November 9 -10, 1999
Tampa, Florida

Abstract

EPA and several other federal agencies and state organizations held a workshop "Aquatic Invasive Species and Shipping in the Eastern Gulf of Mexico: A Workshop for the Maritime and Scientific Communities" in Tampa, Florida on November 9 _ 10, 1999. The discovery in Tampa Bay of an exotic mussel native to Asia provided a timely focus for scientists and shippers who attended the November workshop in Tampa. Prior to the workshop, Tampa Bay managers were unaware of any inadvertent introductions of aquatic invasive animals into the bay via ballast water. The presence of the Asian green mussel *Perna viridis* came to light during planning for the workshop and provided for lively discussions among participants regarding its arrival and potential economic and environmental impact.

The first day of the workshop, sponsored by EPA Region 4, focused on ballast water management. Increasingly, control efforts related to invasive species nationwide are focusing on ballast water for two major reasons: it is a known transport medium for nonindigenous species; and it is one of the few avenues of aquatic introduction that can be identified and managed to reduce risk. Thus, despite the fact that many methods of exotic species dispersal exist, ports and the shipping industry are presently bearing the brunt of the responsibility for the problem. Representatives for the shipping industry acknowledged the environmental issues associated with introductions through ballast water, but also expressed concern that any ballast water regulations must be practical and safe. They also expressed a desire for uniform rules. There was a general consensus among the researchers that ballast water exchange is not sufficiently protective. While several different ballast water treatment technologies are being evaluated, such as filtration and UV radiation, none of them are sufficiently advanced to treat the volume of ballast water in a timely fashion.

The second day of the workshop was part of ORD's New Directions effort with the Region and focused on the science issues related to ballast water and invasions. A number of exotic invertebrates and fish are established in Tampa Bay but the available evidence suggests that the Bay is not highly invaded, especially in comparison to San Francisco Bay where some of the benthic communities are composed of more than 90percent nonindigenous species. However, the recent finding of the mussel *Perna* demonstrates the potential vulnerability of the system. Aquatic species can be introduced from a variety of vectors, including ballast water, fouling of ship hulls, and intentional releases. The aquarium trade may be an important route in Florida. A major impediment to the study of invasions is the lack of trained taxonomists and the lack of regional taxonomic centers. Other researchers discussed forensic methods of evaluating whether a ship had exchanged ballast water, the inadequacy of ballast water exchange in altering phytoplankton composition, a model to predict the suitability of Florida waters to invasion by zebra mussels, and the impact of exotics species on biodiversity.

A general and unanimous conclusion of the participants was that the exotic species problem is here to stay and, although the costs and impacts to society may change, the environmental challenges posed by these interlopers will continue. Although not all exotic species pose a threat

to native biota (as with the Mexican saber crab), the risk to ecological biodiversity from those species that do usurp native plants and animals remains high.

POLICY AND MANAGEMENT PERSPECTIVES

Introduction and Overview — Holly Greening, Tampa Bay Estuary Program

Holly Greening (Tampa Bay Estuary Program) and Dave Parsche (Tampa Port Authority) opened the meeting with a brief welcome and general introductory remarks. Until recently, marine and estuarine aquatic invasive species were not thought to be a major problem in the Tampa Bay area. The discovery of high concentrations of the Asian green mussel *Perna viridis* in several local electric utility intakes this past summer raised concerns among the scientific community in the Eastern Gulf of Mexico and forced the issue of aquatic invasive species to the public eye.

Nanette Holland (Tampa Bay Estuary Program) showed a short video news release that was produced by the Gulf of Mexico Program as part of a public education campaign designed to present some of the common issues, including invasive species, that are relevant throughout the Gulf of Mexico region.

Invasive Science and Non-Native Species in the Eastern Gulf of Mexico — Dr. James Williams, U.S. Geological Survey

The west coast of Florida has a broad continental shelf that has been shaped by continuous changes in sea level over the past 5 million years. This area is ringed by shallow water marshes, mangroves, and the constructs of human beings. The perturbations that humans have wrought on native habitats have facilitated the invasion of exotic species. Water hyacinths, hydrilla, walking catfish, Tilapia, and the swamp eel are a few examples of the numerous freshwater exotics that have been introduced into Florida's water bodies, mainly because there were no laws or policies prohibiting their release. Common carp were intentionally released into rivers and lakes throughout the United States in the 1800s in order to provide additional protein to a growing population. Today, the government spends hundreds of thousands of dollars trying to control this species.

The highest number of introduced freshwater species in Florida are found in Miami, Tampa, and Jacksonville, which correspond to the state's highest population centers and the cities with the most number of tropical fish dealers. There are over 262 introduced freshwater fish species in the 10 Southeastern states, the majority of which are North American species that were purposefully introduced for stock enhancement, bait release, sport fish stocking, and aquiculture. A number of these exotics also come from South America, Asia, and Africa. We can expect the exotics found in estuarine systems to mimic these trends.

Terminology is important in this field. "Exotic" has been widely used to describe species that did not come from the United States. The term "nonindigenous" is a more recent term that is more comprehensive in that it suggests that a species does not have to come from another country to be non-native. Any species that is not native to a particular ecosystem is nonindigenous and therefore a potential problem. "Cryptogenic" refers to a species whose origin is uncertain. "Unintentional" introductions may result from such occurrences as the dumping of ballast water from ships, the release of organisms that have attached themselves to hulls, or the escape of organisms from enclosed containment systems. "Intentional" releases occur when a

nonindigenous organism is purposefully introduced to combat an indigenous organism, or when an organism is released with the intention of increasing its numbers, as in the case of stocking water bodies with sport fish.

The following nonindigenous species issues are crucial to understanding the problem and must be determined:

- The place of origin of cryptogenic marine invertebrates and algae
- The location and date of arrival
- How and why a nonindigenous species was introduced
- How far and how fast an organism has spread
- The impacts of the nonindigenous organism on native communities and ecosystems
- The detrimental effects of human activities on the spread of invasive species
- The success of the nonindigenous organism in adapting to a new environment
- Possible behavioral changes in a species once it has been transplanted to a new environment
- Methods for controlling introduced pests.

Many successful nonindigenous species share the same biological characteristics. Not every characteristic will apply to all species, but in general, the chances that a nonindigenous species will successfully adapt to a foreign environment increase when the invading species exhibits:

- A high reproductive rate
- A long life span
- A good method of dispersion
- Genetic variation and phenotypic plasticity.

Likewise, communities that exhibit the following characteristics are more susceptible to invasion by nonindigenous species:

- Climatically matched to the invasive species' native ecosystem
- Low diversity of native species (providing more niches for the nonindigenous species)
- Absence of traditional predators
- Anthropogenic disturbance.

The most common negative impacts of aquatic nonindigenous species on native ecosystems include:

- Displacement of native species (decreasing biodiversity)
- Altering of hydrologic regimes
- Transmission of disease
- Modification of nutrient cycling throughout the ecosystem.

Many nonindigenous species are introduced to the Gulf of Mexico through major ports of entry, including Miami (FL), Jacksonville (FL), Tampa (FL), Houston (TX), Corpus Christi (TX), New Orleans (LA), and Mobile (AL). These organisms can be hidden in ballast water, attached to the bottoms of ships' hulls, or contained in cargo and later released (either intentionally or accidentally). The Intercoastal Waterway allows estuarine species to navigate the coastline of the United States with relative ease. International airports may serve as entry-points for nonindigenous species (which are usually imported for aquiculture and escape or are accidentally released). Land-based cargo routes and the interstate highway system are also common pathways for transporting nonindigenous species across regional boundaries.

Similar water quality characteristics throughout most Gulf states facilitates the rapid spread of many nonindigenous species. In the warm summer months, most Gulf ports have similar water temperatures, a characteristic that makes it easy for an alien organism to reestablish itself in other regions of the Gulf. Although salinity varies from port to port throughout the year, most estuarine organisms are by nature versatile when adapting to varying salinities.

Most ships that exchange ballast water in the port of New Orleans come from the West-Central Atlantic, Northeast Atlantic, and Mediterranean Sea regions. The same holds true for Tampa. Examples of nonindigenous species that are known to have traveled via ballast water include a comb jelly common to the Western Atlantic (which made its way in ballast water from the Western Atlantic to the Eastern Mediterranean and Black Seas, wreaking havoc on European fisheries), and the zebra mussel in the Great Lakes region. Representatives of the shipping industry often complain that the costs associated with refitting ballast water systems and related mid-ocean transfer strategies are very high. On the other hand, attempts to halt the spread of the zebra mussel in the Great Lakes have cost billions of dollars.

Shipping and Ballast Exchange in Gulf Ports (The Battelle Report) — William Holland, Gulf of Mexico Program

There are approximately 2 million gallons of ballast water released in U.S. waters each day. Few comprehensive studies have been conducted that examine the issue of nonindigenous species in ballast water. This report, which was a collaborative project with Battelle, was an attempt to identify the problems associated with shipping and ballast exchange in Gulf ports. This project investigated one port in each Gulf state, except Louisiana, where three ports were examined. There was not much data available for this study. The quantity of ballast water was identified as a function of cargo volume and ship type. An indirect analysis was conducted to quantify ballast water discharges. Information for this report was gathered from a shipping study authored by Dr. Jim Carlton and a U.S. Army Corps of Engineers (USACE) waterway experiment. This information was supplemented by interviews with the U.S. Coast Guard and the individual port authorities.

The three types of ships that were examined in this study are bulkers, general cargo, and tankers. The Louisiana ports had the largest volume of ballast water discharge (as expected),

followed by the Houston ship channel, Tampa, Mobile, and Gulfport, respectively. Bulkers exchange the largest volume of ballast water. In the Tampa area alone, more than 2.1 million metric tons of ballast water are discharged per year. There is a high risk that this ballast water will contain invasive species. In conclusion, the Gulf is understudied and more research needs to be done. The report is available at: www.gmpo.gov.

Development of Performance Criteria for Alternate Ballast Water Management Strategies — Roland Ferry, U.S. EPA, Region 4

In 1990, Congress passed the national Aquatic Nuisance Prevention and Control Act, primarily in response to the controversy surrounding the introduction of the zebra mussel to the Great Lakes. The Act called for the creation of an intergovernmental body whose tasks were to prevent introductions of aquatic nonindigenous species and control those that were already established. This intergovernmental body became known as the Aquatic Nuisance Species (ANS) Task Force. The ANS Task Force spawned a number of different working groups and committees to address specific noninvasive issues, including the Ballast Water and Shipping Committee (BWSC), whose task is to help the ANS Task Force develop an integrated ballast water strategy for the United States.

Currently, open ocean ballast water exchange is being used to combat aquatic nonindigenous species introductions. This method does not require the retrofitting of ballast water exchange system on ships or the construction of port facilities to treat ballast water. In the future, ballast water management strategies must incorporate several technologies, as open ocean exchange is not a foolproof method of preventing nonindigenous invasions.

BWSC is considering two main types of preventative measures for combating invasive aquatic species. The first method involves techniques that keep organisms from entering the ballast water in the first place (*e.g.*, shipboard filtration techniques, using clean ballast water). The second method entails using different treatment techniques to kill organisms once they have entered the ballast water (*e.g.*, oxidative and non-oxidative biocides, ultraviolet radiation, heating the water). Ballast water could also be treated at portside facilities or on barges specifically designed for that purpose.

BWSC is responsible for developing protocols and guidelines for testing and evaluating the different practices and engineering technologies that are proposed for treating ballast water. BWSC must also take regional differences into consideration when evaluating methods of ballast water treatment.

BWSC will examine several basic performance criteria when evaluating new technologies, including:

- Effectiveness at preventing the contamination of ballast water
- Cost
- Environmental soundness
- Universality of equipment
- Vessel safety
- Ease of use.

Proposed methods must be at least as effective as oceanic ballast water exchange. The environmental soundness of proposed treatment technologies is also of paramount concern; we do not want to harm the outside marine or freshwater environment with biocides or poisons. Any new technologies must comply with local, state, and federal laws governing water and air quality.

Offshore ballast water exchange flushes most small organisms from the hold, but larger organisms may be able to swim against the current or attach themselves to the hull. The effectiveness of offshore exchange decreases with increasing organism size and relationship with the benthos. Osmotic shock also helps kill any remaining organisms that may not have flushed out of the vessel. Ballast water volume and rate of exchange are variables that must be considered when determining appropriate means of treatment. Safety concerns are also critical when evaluating technologies and proposed policies.

Port Limitations and Concerns —
Tom Chase, American Association of Port Authorities

Every major port in the U.S. consists of a public port and a collection of private terminals. The percentage of port facilities that are public as opposed to private varies greatly throughout the country. Public ports are primarily divided into "landlord ports" and "operating ports." Most ports are landlord ports, where a company constructs the facility, maintains it, and leases it to stevedore companies, who in turn contract with shipping companies to load and unload ships. Operating ports do the stevedoring themselves and have a direct relationship with shipping companies. Operating ports are more common in the South where labor laws are less strict than in the Northeast or Northwest. Public ports tend to focus on general cargo, while bulk terminals (handling one type of commodity such as oil or grain) tend to be highly specialized and privately owned and operated.

The greatest ballast water threat comes from bulk terminals where large empty ships (filled with ballast water) jettison ballast water as they take on cargo. Both international trade and domestic trade are major concerns when examining ballast water issues. Ships involved in domestic trade are mainly barges, which do not have the same ballast water issues as oceanic vessels. Most of the movement of nonindigenous species in domestic trade occurs when organisms foul ships' hulls. All ports are non-federal, as the U.S. Constitution bars the federal government from owning or operating ports. Ninety-five percent (by weight) of U.S. foreign trade is transported by ships. The growth rate in bulk commodities is increasing by approximately 1 percent per year, while containerized cargo trade is growing at 5-6 percent per year. It is important to note that container ships release much less ballast water than bulk carriers.

The American Association of Port Authorities (AAPA) was founded in 1912 as a trade association for deep draft ports. The two main goals of the AAPA were to advocate port issues before the U.S. government and to educate and provide networking opportunities to port managers.

An Executive Order signed by the President last February requires all agencies to develop guidelines for assessing their activities that have the potential to increase aquatic invasions. U.S. Army Corps of Engineers' (USACE) permits for deepening projects have the potential for increasing ballast discharges, so the AAPA hopes to work with USACE on this issue.

Coastwise movement of organisms is another area that AAPA would like address. The U.S. Coast Guard's program does not address coastwise movements. The Coast Guard currently

encourages voluntary mid-ocean exchange of ballast water, coupled with mandatory reporting of these activities.

Ports can assist with the development of technologies to help curb the spread of nonindigenous species and the AAPA is looking forward to working with state and federal agencies to preserve the integrity of native ecosystems.

Q: What are your main concerns with individual state and port efforts in ballast water management?
A: We represent 84 U.S. ports and 150 ports throughout the hemisphere, and these ports as a group get nervous when one port creates a potentially competitive advantage. AAPA aims to get uniform standards to prevent such advantages. The Port of Oakland (CA) applied for a permit to deepen their port, and the permit was granted with the stipulation that ships exchange their ballast water at sea before entering the port. The City of Oakland passed a local ordinance requiring the oceanic exchange of ballast water (except in those instances where safety was is concern), and the State of California ultimately adopted this ordinance as a state law.

Q: Is there a consensus among AAPA members that the potential actions mentioned are doable?
A: I hope to find that out over the next 4 months. We want to make sure that our proposals and action plan are realistic. We hope to have an action plan in place by March.

Q: Is your association broken into regional groups?
A: Yes, we have six regional caucuses in the U.S.: North Atlantic, South Atlantic, Gulf, South Pacific, North Pacific, and Great Lakes.

Ballast Water Exchange Methods —
Dr. Thomas Waite, University of Miami

The ballast water issue is incredibly complex and can be viewed as a classic industrial waste problem. The industry is being regulated by various agencies that desperately need information and are under pressure from the public to effect change. The industry is not keen on solving the problems without clear guidelines and regulations. The option of handling ballast at shoreside treatment facilities is unrealistic and probably will never happen in this country and most certainly will not happen abroad. In general, shippers favor shipboard treatment of ballast water, mainly because they cannot be assured that domestic and foreign ports will have the proper shoreside treatment facilities.

The International Maritime Organization (IMO) is the United Nations' specialized agency responsible for improving maritime safety and preventing pollution from ships. IMO has been examining invasive species issues since 1990 and has established guidelines for ballast water treatment. They understand that current procedures are ineffective at preventing nonindigenous species invasions by means of ballast water. Many individual ports and states are developing their own guidelines and regulations governing the treatment of ballast water, much to the chagrin of shipping companies. Australia has been a leader on ballast water issues in recent years, mainly because they are determined to protect their abundant and unique marine flora and fauna. Oceanic ballast water exchange and monitoring is mandatory, and vessels are frequently

boarded to ensure that proper records are kept. The U.S. has a voluntary ballast water exchange policy, with the exception of California, where it is mandatory. Internationally, Australia, New Zealand, Israel, and Chile all have mandatory, enforceable ballast water management regulations. The typical cost for turning a ship away from port is $80,000 to $100,000, so the economic consequences of these regulations are important. Ports need to be concerned not only with what is coming in, but also what is going out. Ships coming from ports with notoriously bad water conditions or a high number of exotics may not be allowed access to certain foreign ports.

The National Research Council (NRC) conducted a study to evaluate different ballast water treatment options. The NRC had two primary concerns: 1) ship safety and 2) efficacy of the treatment. Cost, environmental soundness, and other considerations were secondary to these main issues.

The NRC's primary recommendation called for filtration or screening as the preferred method of onboard treatment. Dinoflagellates, which cause red tides, and their cysts are the target organisms for filtration standards. Their cysts are approximately 20 microns, which means that the filtration screen cells must be at least that small. However, this small screen size makes it difficult to filter large volumes of water in a short period of time. Smaller microorganisms, such as viruses, can only be killed using biocides.

> **Q**: What rates of waste generation were seen during filtration backwash?
> **A**: As the screens became plugged, a backwash cycle would activate, washing the collected organisms and debris back overboard into the harbor.
>
> **Q**: Are the filters made for a different application or are they specifically designed for ships?
> **A**: Self-cleaning screens have been around for years. The screens are commercially produced, then specially fitted for these systems.
>
> **Q**: What was the maximum flow rate that you encountered in your tests?
> **A**: For the pilot scale, the system was running at 300 gallons/minute.

Status of Research and Development for Alternatives to Ballast Water Exchange — Allegra Cangelosi, Northeast Midwest Institute

In the late 1980s, invasive species issues, spurred by the problems associated with the zebra mussel, began to get the attention of biologists and engineers who deal with Great Lakes issues. In the early 1990s, people began investigating the possibility of placing technologies on ships. In 1990, Congress enacted the Nonindigenous Aquatic Nuisance Prevention and Control Act, which was intended to create a national ballast management program. Several new studies, including a biological study and shipping study, were conducted to increase our knowledge of nonindigenous species issues. Due to the increased awareness and understanding of invasive species issues, Congress passed the National Invasive Species Act (NISA) in 1996. After the NISA was enacted, people began investigating alternate means of treating ballast water. In 1999, several scientists, non-profit groups, and other interested citizens wrote letters to Vice President Gore, the Coast Guard, and EPA requesting that more aggressive action be taken by the federal government.

California's new state law making ballast water exchange mandatory was also enacted in 1999. Ballast water treatment technology, however, has been lagging behind the policy.

NISA addresses nonindigenous species transfer via ships (which are the leading known vector of unintentional transfers of aquatic organisms into U.S. waters), as well as via other means. The U.S. has a voluntary national program that, if examined, is essentially a mandatory unenforced national program. If the industry does not actively participate, then the program will become mandatory.

Ballast exchange is the standard for curbing invasive species introductions. Any effective and environmentally sound method (as defined in NISA) can be used to treat ballast water. Current ballast water exchange methods include:

- High seas ballast water exchange (exchanging coastal ballast water with oceanic water while in transit)
- Alternate exchange zone (exchanging ballast in area where prevailing currents force organisms out to sea)
- Shoreside treatment facilities (very expensive, so not really feasible given current technologies)
- Retention of ballast water (no exchange)
- General precautionary measures (marginal protection from good housekeeping).

Some suggestions for preventing the spread of invasive species through ballast water include:

- Using our resources to investigate new technologies for onboard and shoreside treatment of ballast water
- Developing an integrated pest management system within a ship, across ships, and from country to country
- Supporting research and development of management strategies
- Developing backup systems to work in conjunction with ballast water exchange
- Learning from mistakes and move toward full enactment of NISA
- Moving from theory to action
- Investigating the designation of more alternate exchange zones
- Instigating a strong and timely Marine Pollution Convention (MARPOL) annex
- Contemplating financial incentives in the U.S. to help ships move toward new treatment technologies.

An experiment was conducted aboard the *Algo North*, a Great Lakes cargo ship operated by Algoma Steel. The experiment tested the effectiveness of a 250-micron filtration screen used to filter ballast water. They used 20-micron plankton nets to trap organisms in the ballast tanks and examined the organisms that they captured. The filters were effective at removing most organisms.

Other areas of emerging research for treatment of ballast water:

- Biocides
- UV radiation
- Cyclonic separation
- Heat
- Ultrasonics.

POLICY PANEL

The IMO's Approach — Kathy Metcalf, Chamber of Shipping of America

The International Maritime Organization (IMO) has been discussing the issue of marine invasive species for over 10 years. There are two mandatory vehicles at IMO–conventions and protocols. Recommendations must be incorporated into one of these two instruments in order to attain the force of international law. Most conventions and protocols are well enforced internationally. The Marine Pollution Convention (MARPOL) and Safety of Life at Sea (SOLAS) are examples of internationally enforceable conventions. The IMO may consider adding ballast water regulations as Annex VII to MARPOL, but Ms. Metcalf argued against this course of action. She believes that the ballast water regulations should stand on their own. A Marine Environment Protection Committee (MEPC) working group has been established to prepare draft guidelines for an internationally enforceable ballast water management program. Funds for examining ballast water issues will probably not be budgeted until IMO's 2002/2003 budget cycle. The two main applicability and exception issues are: 1) what types and sizes of ships will be regulated; and 2) where will the regulations apply. Most IMO instruments have a tonnage floor applied to them (*e.g.*, regulations only apply to ships over 1,000 gross tons), but individual countries can enforce stricter standards.

Many current ballast water exchange policies are ineffective because they are based on arbitrary, non-scientific parameters such as distance from land or water depth. Under the existing text of the MEPC guidelines, every ship must have a ballast water plan. They must also document their activities and demonstrate their compliance with the treaty.

The most important concept being discussed internationally is that ballast water exchange is not the best means of preventing invasive species introductions. There must be a mechanism or clause in the MEPC's document that allows a port-state to have a test period for new technologies. The information gathered from onboard experiments could then be incorporated into the instrument or future amendments to the document. Because we cannot test all ships at all times, we need to establish standardized test protocols. Individual solutions will not work in all ships throughout the world–there must be room for flexibility and innovation.

The U.S. Coast Guard's Approach —
Commander Scott Newsham, U.S. Coast Guard

How we manage the threat posed by the introduction and spread of nonindigenous species is clearly the most pressing marine ecological problem that we are facing in the United States. Ballast water from commercial ships, which are regulated by the U.S. Coast Guard, remains the primary vector for the movement of nonindigenous species. The Coast Guard leadership is committed to minimizing the threat posed by invasive species.

A central element of the Nonindigenous Aquatic Nuisance Prevention and Control Act (1990) was the establishment of the Aquatic Nuisance Species Task Force that is co-chaired by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Fish and Wildlife Service, with the Coast Guard, EPA, U.S. Army Corps of Engineers and U.S. Department of Agriculture as other voting members. Com. Newsham is the Coast Guard representative for the Task Force. In the Great Lakes, there is a mandatory ballast water exchange regulation for ships that have entered the area from outside the Exclusive Economic Zone (EEZ), which extends seaward some 200 miles from shore. Ships entering the Great Lakes must exchange their ballast water in an area outside the EEZ, where the water depth is at least 2000 meters, or retain the ballast water onboard while operating in the area. The National Invasive Species Act of 1996 (NISA) extended ballast water management regulations to encompass all U.S. waters. NISA lays out a regime of voluntary ballast water exchange for all ships carrying ballast water and originating from outside the EEZ, and for whom Great Lakes regulations do not apply. On February 3, 1999, President Clinton signed Executive Order 13112, which raises the visibility of nonindigenous species issues and directs each federal agency to use relevant programs and authorities to prevent the introduction of invasive species. This order also established the National Invasive Species Council (NISC) that is concerned with both aquatic and terrestrial species. One of the key roles of NISC is to prepare an invasive species management plan that details and recommends performance-oriented goals and objectives and specific measures of success for federal agency efforts. NISC is in the process of appointing an advisory committee that will provide advice to the council on a broad array of invasive species issues. NISC's key deliverable will be a management plan due late in the summer of 2000. The Executive Order directs NISC to rely on existing organizations, such as the Aquatic Nuisance Species Task Force, in accomplishing its mission.

The mandatory Great Lakes ballast water exchange program, which was begun in 1993, is mature and well established. The voluntary guidelines for all remaining U.S. waters took effect on July 1, 1999, and are still in their infancy. The voluntary regime is exactly what NISA called for. The intent was to allow the industry the opportunity to prove that it can be a good citizen without the punitive stick of civil and criminal penalties hanging over them. With a few exceptions, all vessels entering the United States from outside the EEZ are requested to conduct a mid-ocean ballast water exchange before entering U.S. waters. These same vessels are required to submit a ballast water management report to the Coast Guard which details how, where, and when ballast water is discharged. Ships are also asked to abide by several voluntary operational precautions to minimize the uptake of aquatic species. Domestic vessels operating solely within U.S. waters are also asked to abide by these precautionary measures. Coast Guard, Department of Defense (DOD), and other public vessels are excluded from these voluntary national guidelines. They are directed to develop their own ballast water management strategies to meet NISA's intent. Coast Guard vessels conduct ballast water exchanges at least 12 miles from shore.

The Coast Guard, in conjunction with DOD and EPA, is developing a new program called the Uniform National Discharge Standards.

NISA requires the Coast Guard to report to Congress by January 1, 2002, an assessment of vessel compliance with the voluntary guidelines, along with an appraisal of the effectiveness of these guidelines in reducing incidences of invasive species introductions. If this review demonstrates that the voluntary guidelines are ineffective, then they will be made mandatory, with civil and criminal penalties for vessels that are not in compliance.

Education and outreach materials are being used to convey the magnitude of the problem to the commercial and recreational seafaring communities. A full range of age groups and backgrounds are being targeted.

The Coast Guard is collecting and analyzing the data gathered from vessel reports at the National Ballast Water Information Clearinghouse in Edgewater, Maryland. In addition, the Coast Guard has been conducting ballast water tests, interviewing mariners, and examining ships' logs through the Random Survey Program.

The Coast Guard accepts that ballast water exchange is only an interim solution. They are working with a variety of interests to explore promising new technologies. The Coast Guard ballast water management program has a $4 million budget that includes 39 field billets, three headquarter billets, and a Civilian Ballast Water Management Program Coordinator (Dr. Richard Everett). Key Coast Guard activities in the near future include:

- Remaining an active member of the Aquatic Nuisance Species Task Force
- Tracking the activities of the NISC as they relate to ballast water management
- Chairing the Task Force's Ballast Water and Shipping Committee
- Pushing the development of a protocol for testing and approving new ballast water management technologies
- Pursuing ballast water management research, using cooperative agreements with other agencies
- Maintaining the National Ballast Water Information Clearinghouse, making the data available to the public
- Playing a leading role in the development of the IMO's national ballast water regulations.

U.S. Law and Nonindigenous Species Introductions —
Erinn Neyrey, Louisiana Sea Grant Legal Program

Federal acts or regulations that address (directly or indirectly) invasive species:

- National Invasive Species Act of 1996
- Clean Water Act (Section 402–National Pollution Discharge Elimination System (NPDES); and Section 303–Total Maximum Daily Load)

- Lacey Act of 1900 (prohibits import, export, transportation, sale, receipt, acquisition, or purchase of fish, wildlife, or plants that are taken, possessed, transported or sold in violation of any federal, state, tribal, or foreign law)
- Marine Protection Research and Sanctuary Act
- Endangered Species Act
- Executive Order 13112.

State acts or regulations that address (directly or indirectly) invasive species:

[Note: State laws cannot be in opposition to federal laws or violate interstate commerce rules.]

- Alaska: Passed a law asking the Coast Guard to prohibit foreign ballast water exchange
- Maryland, Pennsylvania and Virginia: Asked Congress for programs, research and funding to combat invasive species
- Hawaii: Has program that allows for inspection of foreign ballast water
- Washington State: Considering a mandatory inspection of foreign ballast water
- California (Assembly Bill 703): Mandatory ballast water exchange for vessels entering U.S. waters from outside the EEZ, in addition to a fee and civil penalties collected and placed into a research fund.

Individual ports' attempts at regulation:

- Alabama State Docks Ordinance: Regulates oily waste
- Vancouver (BC): mandatory mid-ocean ballast exchange for all vessels discharging more than 1000 metric tons of ballast water, along with reporting form
- Oakland (CA): No vessel can discharge into San Francisco Bay without ballast exchange.

Policy Roundtable Question and Answer Period**Q**: How will Coast Guard personnel be trained in ballast water management?
A: A guidance document has been published and a training program has been established at Yorktown. Each marine safety office has an individual who is assigned to deal with ballast water management issues. The material is not complicated and can be learned locally.

Q: Are any European or Asian countries establishing their own regulations?
A: I'm not really sure what other countries are doing, although I do know that there is lots of research being conducted internationally. Many foreign nations have expressed a desire for internationally standards. The United States is extremely wealthy and we have resources to spend on technology development; other nations look to us for research and development.

Follow-up: The number of countries going unilateral is increasing. Australia, New Zealand, Argentina, and Canada have announced mandatory programs, which is sending a strong message

to other flag states. Follow-up: There are a few flag states at IMO that will oppose any regulations that require new equipment or additions to a vessel's operations. The culture has to change. The Australian program would be unacceptable in the United States; they get samples from a vessel and make decisions based on what they find in the ballast water. The scientific community cannot make those determinations yet.

> **Q**: What are the costs associated with ballast water exchange?
> **A**: To retrofit a ship with a filtration system costs about $1 million. To design these filters into a ship would be less expensive and could be amortized back pretty readily (approximately $500,000).

SUMMARY OF LUNCH DISCUSSIONS–DAY 1

1. What are viable alternatives for ballast exchange?

The tables noted many viable alternatives (including the following) as outlined by the morning speakers, but also noted that *all* alternatives needed additional development.

- Provide clean ballast water;
- Filtration
- Biocides;
- UV exposure
- Heat (using waste heat from engines)
- Shoreside treatment.

Several groups noted that ballast exchange was the *current* best option/policy. Several also noted that the development of a risk assessment process was needed, because some ships or ballast may require more treatment than others. However, it was also noted that shippers need certainty to plan, and would not want a "testing" system which may not provide that certainty.

Other alternatives noted were:

- Retrofit older ships and design new ships to keep and treat ballast on-board;
- Educate policy-makers; and
- Educate recreation boaters.

Four of the eight groups noted that treating water *as* or *before it enters the ship* was the most effective—however, one table noted that shipboard treatment was most effective. The need to know potential costs of alternatives was noted by several groups, as was the need for international cooperation on policies. One solution is not applicable to every area; solutions should be tailored to the needs of a region.

Other ideas noted in response to identification of viable alternatives for ballast exchange included the following:

- Virus/bacteria health problems should be first concern
- More research is needed to identify on-board treatment
- Viable alternatives must not interrupt ship operation schedules
- One group recommended loading drinking water as an alternative, another recommended against this potential option
- Provide financial incentives to retrofit ships
- New ship construction should include on-board ballast treatment systems
- Need for either economic incentives and/or regulatory "club"
- Viable alternatives must be affordable
- To be viable, a treatment must be able to treat 5,000 tons/hour
- Examine whether ports can provide ballast water (groundwater?)
- Treating ballast water before it gets into the tank will reduce sediment loading and weight
- Ports cannot provide adequate reception facilities; the U.S. charges too much
- Not all ports use docks, so shoreside treatment may not be viable
- Shipboard installations would be economically viable
- The Great Lakes mandatory exchange is less than 20 percent effective
- Difficult identifying any near-term viable options- need a standardized test program to test alternatives fairly
- Shipping industry would like to have ballast exchange happen shoreside, but it is not realistic in many cases
- Ozone treatment is tremendously expensive- $20 million per ship for outfitting
- Chlorination is required in Brazil
- Some ships can choose not to discharge ballast as a viable management option
- Consider a "treatment train" approach; *i.e.*, filtration pretreatment to remove large particles followed by UV
- Cascade ballast is an option
- Ballast exchange can take a long time (up to 48 hours) — need to be concerned about the ship integrity and stability during this time;
- Using clean water as ballast is difficult and expensive
- Port to port competition is very important- federal intervention may be needed
- There are problems with species that are long-lived or tolerant of wide salinity ranges
- Additional research is needed on all alternatives
- Treated wastewater may be a source of "clean" ballast water
- The U.S. is an exporter of exotic species, as well as a receiver
- The IMO is the best organization to coordinate these efforts globally, but IMO is currently behind the curve on ballast water

- International players need to agree on criteria; for example, how much chlorine is acceptable in treated ballast water.

2. What policies would need to be in place to encourage a non-regulatory approach to ballast water exchange?

All tables noted the need for a regulatory driver, and none thought that a non-regulatory approach without this driver would be effective for large ships. However, non-regulatory (*i.e.*, educational) approach may work for recreational boaters. Several groups noted the need for coordinated or consistent international policy.

Providing tax or other economic incentives may be helpful in implementing controls/prevention. Some tables noted that providing regulatory standards, not requiring techniques, would be most effective: however, standards will be difficult to develop. The need for a monitoring network between ports was noted by several groups.

One group suggested that ballast water treatment requirements should be a condition of membership in the World Trade Organization.

Additional comments addressing this question included:

- Regulation will drive the technology needed to meet regulations
- Port-enforced monitoring is important: if a port monitoring network was in place, a ranking of "clean" ballast water would mean a more competitive port
- One group noted that this issue should not be included in EPA's point source control, but should remain under non-indigenous species rule
- Public education and opinion should be included in this issue
- Use tax incentives to ship builders and private ports to implement treatment
- Policies must apply world-wide–U.S. cannot bear the brunt of regulations
- One group expressed concern that a blanket approach may be mandated, regardless of costs/risks/application
- An environmental tax or port fee based on the "pro-activeness" of a ship would provide incentives. Consider a variable scale of regulation to apply more heavily to vessels that don't comply.

Scientific Perspectives: Introduction and Overview —
Roland Ferry, U.S. EPA, Region 4

The invasive species issue is somewhat new to the Environmental Protection Agency (EPA). EPA has representation on the Aquatic Nuisance Species Task Force and occasionally responds to public inquiries on nonindigenous species issues. In 1998, EPA's Office of Research and Development (ORD) asked EPA's Regional scientists which emerging issues they are most interested in. Nonindigenous species issues were at the top of their list. As a result of this survey, ORD created a New Directions Program that addressed the top three or four recommendations for future Agency involvement. In response, ORD and the Regions decided to hold a series of workshops around the country, including this one in Tampa, that are designed to examine

nonindigenous species issues more closely. In the year 2000, EPA will hold a national nonindigenous species workshop that will address all of the relevant issues that emerge from these Regional meetings.

Status of Aquatic Nuisance Species in Tampa Bay and the Eastern Gulf of Mexico — Amy Benson, U.S. Geological Survey

Introductions of nonindigenous species in the Americas likely began over 500 years ago with the arrival of European explorers, who transported hull-fouling and wood-boring organisms across the Atlantic Ocean. Unintentional introductions can result when organisms:

- Foul ships' hulls
- Bore into wooden hulls or components
- Discharge in ballast water
- Escape from aquiculture
- Are used in packing material (seaweed and other sea plants are sometimes used as packaging material for aquiculture products)
- Escape from aquariums.

Intentional introductions can result when organisms:

- Are used for mariculture (cultured for food or other purposes)
- Are used as fish bait
- Outgrow aquariums and are dumped by humans.

Nonindigenous organisms that are most often introduced include:

- Mollusks
- Crustaceans
- Fish species
- Plants (mostly algae)
- Invertebrates (*e.g.*, sponges, hydroids, flatworms).

There are no known nonindigenous species of marine plants that have become established in Florida. Several species of fish have been introduced into the Tampa Bay region, including the panther grouper (from South Pacific), scat (from Asia), and threadfin shad (freshwater fish from northern Florida).

There is some documentation that a few species of barnacles, a species of crab, and some isopods have arrived in the area. The green mussel (*Perna viridis*) has been found only at three power plants in the Tampa area. The mussel is native to Asia and the Indo-Pacific region and

was probably transported in ballast water, although it can be purchased over the Internet as a food source. In the juvenile stage, their small size (smaller than a penny) can create serious problems for power plants or other utilities with water intakes.

Research is still needed on community levels, genetic and ecological characteristics of invasive species, temporal and spacial patterns of human mediated dispersal mechanisms, ecological impacts, changes in species composition over time, and sources of current and future invasions.

The Tampa Bay region, unlike San Francisco Bay, has not had a major ecological disaster resulting from nonindigenous species introductions, although the recent discovery of the green mussel may be a portent of things to come. We must be proactive instead of reactive when dealing with nonindigenous species introductions.

Q: What are the minimum salinity requirements for the green mussel?
A: They can live down to about 20 ppt.

Q: How big can the Green Mussel get?
A: They can grow to 5-6 inches.

Q: Can they occur in high densities like zebra mussels?
A: Yes, they have been found in high densities in Trinidad.

Q: How important are sources other than ballast water when examining invasive species introductions?
A: Things like mariculture are very important because they can be grown as a food source for profit.

Q: Can we identify the larvae?
A: The larvae are very difficult to identify, although there are some genetic tests that can be done.

Q: Are there regulations preventing people from importing exotics and growing them for food?
A: Florida is in the process of developing best management practices for aquiculture that will address those issues. You can find current regulations in Chapter 370 of Florida Statues.

Dan Roberts, Florida Marine Research Institute, gave a brief presentation on Florida's state plan for addressing nonindigenous species invasions.

Q: Have any guidelines or outlines been developed for state programs?
A: The Aquatic Nuisance Species Task Force has developed a plan, as have several states; these plans could be used as a template for other states. A draft of the Ohio plan can be found at http://www.anstaskforce.gov/ohiomgt.htm.
Q: Is there a common characteristic that successful invasive species share?
A: The science of predicting which species may be successful is not well developed. All organisms have the potential, but those that are long-lived have a high

reproductive rate, mature quickly, or filter feed have a high potential to become established.
Q: What do green mussels eat?
A: Most bivalves consume bacteria.

Q: Can the green mussel and the brown mussel interbreed?
A: Mollusc taxonomy is not an exact science. The chromosome difference would probably prevent interspecies breeding.

Wayne Price (University of Tampa) spoke briefly about another nonindigenous species, the saber crab, which was brought to the area between 1915 and 1930 on a barge from the Western Gulf. They are semi-terrestrial and mostly nocturnal. The females are dark brown and the males are light tan.

Status and Trends Monitoring in San Francisco Bay —
Henry Lee, U.S. EPA, Office of Research and Development (ORD), Region 9

The San Francisco Bay delta is the most invaded aquatic system in the United States. There are 212 known nonindigenous species in the Bay, the majority (69 percent) of which are invertebrates. Fish and other vertebrates make up 15 percent of the Bay's nonindigenous species, while vascular plants and protists account for the majority of the remainder. In part, these numbers reflect the skills of the researchers, who mostly specialize in benthic ecology. In 1995, there were 123 cryptogenic species, species of unknown origin. The rate of introduction appears to be increasing, with an estimated introduction once every 14 weeks. Most nonindigenous species found in the bay are originally from the Atlantic Ocean and Asian waters.

Nonindigenous species were introduced by several means, including (in order of prevalence):

1) Hull fouling (includes wood-boring organisms)
2) Ballast water
3) Shipment of oysters (15 percent of introductions)
4) Intentional stocking of fish or shellfish (9 percent)
5) Releases by individuals (7 percent).

There are several potential reasons why more nonindigenous species have been found in San Francisco Bay than in any other water body in the United States:

- The Bay area has been heavily researched
- Invasion is a highly stochastic process, but the Bay has simply had some bad luck
- There may be more exposure (partly due to a high volume of trade with Asia)
- Water diversion may have harmed native species, creating niches for invasive species
- The Mediterranean climate creates mild winters, which may be conducive to many species

- The system is "ecologically young," with no native species in some taxonomic groups or trophic guilds
- The spacial patterns allow for noninvasive species to occupy regions partially or wholly upstream from their apparent native counterparts.

The San Francisco Estuary Institute (SFEI) and EPA/ORD are conducting a pilot risk assessment that compares the impacts of nonindigenous species with the stressors that EPA normally regulates. One aim of this assessment is to demonstrate to EPA that nonindigenous species introductions are related to some issues that the Agency in involved with, including sediment contamination. The pilot seeks to answer two main questions: 1) is there a relationship between sediment contamination and the incidence of nonindigenous species (NIS); and 2) what is the relative impact of NIS versus sediment contamination on benthic structure. The study is only examining soft bottom benthos. The Bay has been divided into three assemblages: freshwater brackish, estuarine, and central bay marine.

The percentages of nonindigenous species by number of total individuals per assemblage and subassemblage were as follows:

- Freshwater brackish assemblage/muddy subassemblage: *Potamocorbula* (Asiatic clam) 1.6 percent; other NIS 44 percent
- Estuarine muddy subassemblage: *Potamocorbula* 43 percent; other NIS 48 percent
- Estuarine disturbed subassemblage: *Potamocorbula* 0.2 percent; other NIS 48 percent
- Central bay marine assemblage/sandy subassemblage: *Potamocorbula* 6 percent; other NIS 1 percent.

In the estuarine assemblage, there was no significant correlation between the measure of sediment contamination and the number of nonindigenous taxa. There was a significant negative correlation between the proportion of nonnative individuals and sediment contamination, indicating that, in this system, the NIS were more sensitive to chemical contamination than the natives. The other assemblages still need to be examined before conclusions can be drawn.

Taxonomic Identification of Exotic Invertebrates —
Stuart Poss, University of Southern Mississippi

Many fishes, which are released either intentionally or unintentionally, are making their way from marine systems into estuarine and freshwater systems, creating problems. The amount of research in the area of nonindigenous invertebrates is lacking, which makes taxonomic identification difficult. Differences in many species of marine invertebrates are qualitative and difficult to discern, and species may have been incorrectly identified. Working backwards from historical literature is difficult because very few records pertaining to marine invertebrates have been archived. A specimen in hand is often needed to confirm an identification. Many viruses and parasites are introduced while unknowingly hidden inside the host organisms. When examining biotic change, you need an assessment of the baseline variability. Knowing what is there and how long it has been there is absolutely critical. We also need to know the full ranges of the species that are found in a particular ecosystem.

There is also a lack of professional taxidermists. The Internet can be used as a tool to train students and scientists to identify different species. In the short term, structured systems for accessing information over the Internet must be developed. With Geographic Information Systems (GIS), biologists and ecologists have the ability to map species and their habitats. These technologies will aid in the identification and dissemination of information on nonindigenous species.

Q: Who should take responsibility for maintaining a comprehensive collection of specimen?
A: One would have to rely on existing collections and those individuals who maintain them. We also need more institutional support. Museum budgets for taxonomy are meager. Networking among scientists and other professionals needs to be greatly increased.

Q: How can we be sure that organisms were correctly identified in the past?
A: There is no way to be sure, and we may never know, but we cannot simply discount the evidence that we have because errors may have occurred.

Q: Because of costs and staffing issues, there is some appeal to maintaining a large collection of specimen at a central location. Would your lab be willing to take on that responsibility for specimen in the Gulf of Mexico region?
A: We've talked about that possibility, but we don't have the resources.

Q: We should also make the information that you've mentioned accessible to the public by including common names.
A: That is a good idea and something we need to work on. We also need good illustrators who can accurately capture the details and differences that assist in identifying different species.

Effects of Nonindigenous Species on Biodiversity —
Robert Doren, Florida International University

Invasive species are a form of biological pollution that threatens our economy and natural system. Invasive species are like chemicals that grow, spread, and mutate. There are 30,000 species of foreign origin in the United States. Twenty-five thousand of them are cultivated plants that are the mainstays of agriculture and horticulture. About one percent of these species cause severe harm, but you only need one zebra mussel to cause billions of dollars in damage. Every ecosystem we know of has invasive species, including Antarctica. Invasive species are more common in warmer climates and in island-type systems. Travel and trade are increasing the efficiency of transport. The total cost of invasive species in the U.S. is about $123 billion annually. Thirty-five percent of weeds in the U.S. are native, 65 percent are nonnative. In Florida, 69 percent of plant species are native, while 31 percent (and growing) are nonnative. Sixty-seven percent of plants are imported for ornamental horticulture; 11 percent are imported for agriculture products; 15 percent for unknown reasons; 5 percent are forage crops; and 2 percent are used for packaging material. Eighty percent are introduced purposefully. Between 1994 and 1998, exotic plants brought through Miami International Airport increased from 290

million plants to nearly 500 million. Less than 2 percent of these plants are inspected by the USDA. Two million tons of cargo enter the U.S. through Miami Airport.

Traditionally, oceans and mountains prevented species from traveling around the world. In the modern world, airplanes can transport organisms to the other side of the planet in less than a day. The only means of preventing the movement of these species are prevention, clearance, exclusion, eradication, and control, and these methods are not always effective.

Speciation occurs at a faster rate in isolation. Hawaii is an excellent example of this; it is the most isolated island chain in the world, and has some of the most diverse flora and fauna. There is evidence that Paleoexterminations occur when landforms are rejoined. By introducing species throughout the world, we will reduce biodiversity. The major threats to biodiversity worldwide include habitat loss and degradation; introduction of invasive species; habitat fragmentation; spread of disease; and exploitation of natural resource.

Australia has a black list and a white list that contain the names of exotic species that have been brought into the country. Organisms on the black list cannot be brought into the country. If an item is not on the list, it must first be cleared by an expert.

Many of our agricultural products are nonindigenous, and diseases that are brought to this country in plants can infect native species as well as nonindigenous ones. The gypsy moth, fire ant, Cuban tree frog, nutria, feral pig, zebra mussel, pollen apple, brown tree snake, fountain grass, Argentine ant, and sea lamprey are all examples of invasive species that have devastated natural ecosystems. Many plant species were introduced for erosion control, vegetable oil, and medicine.

There are approximately 125 exotic species listed as threats by the Florida Exotic Pest Plant Council, 24 of which are grown commercially in Florida. Exotic plants grown commercially for more than 20 years are 66 percent more likely to become invasive than those grown for less time. Roughly $100 million per year is spent on controlling weeds in Florida's natural areas. Worldwide estimated annual losses due to plants alone is estimated at $1 trillion, while all invasive species cost between $3 and $5 trillion per year.

Prevention is the best solution. The ballast water issue is relatively simple because prevention can be absolute and is completely achievable through technological means. There is a national strategy for dealing with invasive plant species, but not much has been done to implement it. Most control efforts are piecemeal when they exist at all. Partnerships need to be the norm for future control efforts. We need to work at all levels of government and internationally to be effective. The biggest problem is the lack of awareness.

> **Q**: Are researchers using biological control to prevent the spread of invasive plant species?
> **A**: Yes, with varying degrees of success. Species introduced for biological control may have very serious consequences to the ecosystem and the economy.

Suitability of Florida Waters to Invasion by the Zebra Mussel *Dreissena polymorpha* — Ernest Estevez, Mote Marine Laboratory

Two years ago, we completed a study examining the suitability of Florida waters to invasion by the zebra mussel. The full study can be found at http://www.mote.org. "Risk" is the chance or likelihood that a species will be introduced, while "vulnerability" is the ability of the

environment to support a population if an introduction occurs. We examined if Florida waters are suitable for zebra mussels. We considered environmental variables and interpreted the data using a habitat suitability index. We reviewed the world literature for several environmental parameters, including temperature, salinity, dissolved oxygen, pH, calcium, sediment size, and transparency, to find which values of these variables were lethal, tolerable, optimal, and intermediate. We produced a habitat suitability index model for zebra mussels on an annual life cycle basis. Lowest salinities have the best suitability for zebra mussels, while salinities above 15 parts per thousand (ppt) are unsuitable. More dissolved oxygen created a more suitable habitat for the zebra mussel. After the data were aggregated using median values, we found that the majority of sample stations in Florida had low suitability values. There were some with medium suitability values, and a few with high suitability values. We also studied the data on a watershed basis.

Most of Florida's waters provide an unsuitable environment for zebra mussels. Areas with high suitability in the domain of medium values for watersheds included hot spots in the Suwannee, Lower St. John, Hillsborough, Manatee, Myakka, Caloosahatchee, and Big Cyprus Rivers. We are not sure why this is the case. Some of these rivers are fed by spring water, which drives up suitability. Others are near phosphate mines. Lake Okeechobee was also found to be suitable. There are numerous deficiencies with the suitability curves, including the annualized life cycle and the lack of interaction terms. The database was not uniform, and certain areas lacked data. We may have neglected some parameters that are important to the success of zebra mussels. Springs have the highest suitability. Another assumption is that zebra mussels have an equal chance of getting to every water body in the state.

It is difficult to know which animals to model; if it has not been studied previously, you cannot build a suitability index. We have good databases for Gulf Coast estuaries, but we may not have variables that are crucial to certain nonindigenous organisms. We have good information on traffic in oceanic waters, but we have poor information on ship traffic on inland waterways throughout the state. Monitoring for these plants and animals should be examined, but for many species, including zebra mussels, monitoring may not be entirely accurate or exhaustive. A protocol for rapid assessment that works for a number of species would be useful.

Ballast Water Exchange Verification Technologies and Measurement Techniques — Robert Hiltabrand, U.S. Coast Guard Research and Development Center

The U.S. Coast Guard is developing forensic science techniques that can be used in a court of law to determine whether or not ballast water management techniques were employed by a particular vessel. Measuring ballast exchange will not be easy. The Newcastle method uses ships' logs to determine how much power was used to open and close the ballast tanks for verification. California went mandatory August 1, 1999, but they do not know how to determine whether ballast exchange actually occurred.

The number used to confirm mid-ocean exchange is a salinity of 30 ppt, a number the Coast Guard checks with refractometers. A more appropriate value or standard would be closer to 34 ppt. Salinities in the near coastal zone (within 200 nautical miles) can be greater than 30 ppt. Some Mediterranean ports have salinities approaching 36 ppt, so there must some other way to determine whether or not an oceanic ballast exchange has taken place.

The Coast Guard also examined PAHs as a possible means of determining if oceanic ballast exchange had taken place, but many vessels' hulls are lined with chemicals that can leach PAHs into the ballast water. There are two ways to verify samples: 1) compare sample to sample; or 2)

compare sample to database. There is a comprehensive database of oceanic salinities and temperatures that could be used. Sample-to-sample techniques would provide more accurate results, but sample to database would be more universally accepted.

Reducing Marine Biological Invasions Due to Ballast Water Discharges — Heather Walton, Duke University Marine Laboratory

The port of Morehead City, North Carolina is particularly susceptible to marine invasion for a number of reasons, including:

- It is location inside North Carolina's string of barrier islands, which prevents flushing back to sea
- The 45-foot draft is one of the deepest on the East Coast, allowing ships to enter the port, get safely berthed, and begin discharging ballast water
- Increased human disturbance of the natural habitat
- The port's top exports are phosphate and wood chips.

Ten-liter samples of ballast water were sampled from one tanker, one container ship, one refrigerated vessel, and six bulk carriers. The temperature and salinity of each sample was tested, and the water was run though a series of sieves, ranging in size from 330 microns to 35 microns. The organisms were preserved and cultured for 21 days. The average ship contained 7,000 metric tons of ballast water, with the bulk carriers containing 20,000 metric tons per ship. The temperature ranged from 24-33EC, while the salinities ranged from 0 to 38 practical salinity units (psu). Ballast water source regions included Morehead City, New Orleans, Dominican Republic, Belgium, Spain and Japan. Four of nine ship captains claimed to have performed a mid ocean exchange. From the nine ships, we isolated 342 distinct species of phytoplankton, and identified 106 of these across 70 genera. Species richness was high. We found that there was no relationship between the age of ballast water and the number of species. Fresh ballast water from Morehead City contained similar numbers and types of phytoplankton.

Scientists and policy makers should pay careful attention to phytoplankton and should increase biogeographic data on phytoplankton. The results challenge the efficacy of ballast water exchange. Phytoplankton abundance and diversity did not seem to be affected by the occurrence of ballast water exchange. In addition, many of the freshwater species of phytoplankton picked up in New Orleans (0 psu) survived in a culture at 35 psu. The chance that a single phytoplankton will have a great impact on an ecosystem is low, but the effects of a single introduction could be devastating. Scientists should not overlook phytoplankton when evaluating or determining ballast water treatment options.

SUMMARY OF LUNCH DISCUSSIONS–DAY 2

1. What elements of a monitoring program are necessary to effectively assess the current status of invasive species in estuarine/marine waters?

Almost all groups responded with recommendations to rely on users and people on the bay (power plants, fishermen, researchers, existing monitoring programs) to provide an early warning

system, rather than to initiative new monitoring programs. Several elements which would support this strategy which were suggested included:

- Ask users to be aware and look for potential animals or plants which “look different”
- Develop and implement an outreach campaign to provide outreach/education (especially pictures or drawings) at boat ramps/bait shops, general information to newsletters, etc.
- Provide a website or CD with pictures and descriptions of potential invasives
- Work with existing monitoring programs to enlist their help- provide pictures, descriptions, drawings
- A major requirement of this approach is the need to identify a local person/group that will act as the point of contact, to which users can report anything “different”, and who can provide identifications.

Several groups identified the following in response to this question:

- An inventory of existing and historic species is needed
- Conduct “walk-around surveys” on a regular basis, using experts to look for invasives
- Develop consistent protocols and guidelines if a more intensive monitoring program is needed.

Other issues raised during discussion of this question included:

- Examine outbreaks in nearby areas as possible early warnings
- Deploy settling platforms as a collection method
- Need periodic updates of baseline surveys- if baseline surveys aren’t available, this is an important first step
- Need coordination and communication between taxonomists
- Habitat and water quality variables are important to monitor
- Estimate the probability of establishment and/or vulnerability
- Measure the survival of invasives, not just presence
- Monitor pathogens and disease as well as invasive species.

2. What are the primary research needs necessary to develop prevention/management options for ballast water?

Several noted that understanding the life history/ecology/taxonomy of invasive species was needed. Genetic variability was also noted. The economic impacts of invasive species and treatment costs were noted by several groups. Other research needs noted by several groups included:

- A critical review of options for treatment, including technology for ships
- Establishment of a clearinghouse for research/information
- Establishment of a research facility.

Additional research needs noted included the following:

- Assessment of range of conditions for survival and tolerance levels of exotic species
- Transport mechanisms
- The need for a critical review of engineering methods for managing ballast water
- Look at point of origin of ships to estimate what species might be next
- Biological control should be examined as an option
- Document past conditions where exotic species have exploded
- Taxonomists need adequate funding and pay—difficult to lure new scientists into taxonomy.

3. What are the next steps for aquatic invasive species in the Eastern Gulf of Mexico?

Those responses noted by two or more tables included:

- Establish an information clearinghouse
- Form regional (*i.e.*, Tampa Bay area) working groups to further develop management to invasion strategies
- Establish baseline database of species in coastal waters
- Establish facility to perform research
- Develop an outreach program (noted by several tables)
- Enforce existing regulations
- Encourage implementation of Coast Guard recommendations.

Additional "next steps" identified by the groups included the following:

- Preventative research- how to keep invasives out
- Incorporate invasive species awareness into existing public programs, such as Lakewatch, Streamwatch, and Baywatch.

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REGION 9 NONINDIGENOUS SPECIES BENTHIC WORKSHOP

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Richmond, California

Abstract

The workshop on benthic nonindigenous species was hosted by EPA Region 9 and the San Francisco Estuary Institute (SFEI) to elicit comments on the draft report ("White Paper") entitled *Impacts of Nonindigenous Species On Subtidal Benthic Assemblages In the San Francisco Estuary* (Lee, H., B. Thompson, and S. Lowe. 1999) and to recommend research and program actions for EPA. The workshop was one of a series of regional workshops to explore how EPA may participate more strongly in a federal initiative against nonindigenous species.

Jean Circiello of EPA facilitated the discussion, and Bruce Thompson, SFEI, and Henry Lee, EPA, summarized the EPA-SFEI analysis, which shows that there is a pervasive and widespread alteration in subtidal benthic community structure due to the invasion of nonindigenous species throughout the Bay. Using correlation and regression approaches, the study did not find that nonindigenous species reduced the abundance or number of native taxa and in some cases they were positively correlated. Nor did the study find that sediment contamination increased the abundance of nonindigenous species. In terms of the area altered, nonindigenous species are having a much greater impact on the San Francisco Bay benthos than contaminated sediments. Similarity analysis using historical data showed major changes in benthic community structure since 1986, though the cause for the changes are not clear.

Participants critiqued the study. One particular concern was the quality of the taxonomy used in the historical studies, making the temporal trends suspect. Another concern was that since the correlations and regressions used recent data (1994-1997), the study is evaluating the structure of a community that has already responded to invasions and sediment contamination. This might explain, for example, why the study did not find any indication that nonindigenous species are reducing native taxa. The authors agreed that a temporal analysis could show some different results, nonetheless the study shows how the present community is responding. The lack of functional analysis is also a limitation of the present study.

The participants discussed various science and infrastructure gaps. Participants emphasized the need for better taxonomy in all benthic studies and recommended requiring strict taxonomic QA/QC in federal and state regulatory programs. They recommended creating regional centers of taxonomy. These centers would serve as storage sites for voucher specimens and storing pictures of specimens on computers for quality assurance purposes. Participants recognized the need for dependable funding for these centers and proposed instituting a national program. Since dredging could have a significant impact on the balance between native and nonindigenous species, they suggested that the EPA and other agencies require routine benthic studies before and after dredging.

The participants identified a number of research needs. Research related to San Francisco Bay included: 1) comparisons of benthic community structure in San Francisco Bay with other West Coast estuaries; 2) learning more about the long-term changes in the Bay beginning with the earliest available samples that stored in museums or universities; 3) reconstructing the spatial distribution of the impacts on the Bay over time and determining if diversity is increasing or decreasing; 4) studies comparing the functional structure of the benthic community in the Bay with other estuaries on the West Coast; and 5) comparison of San Francisco Bay with the

geographical areas that ship to the Bay area. Other research areas included: 1) studies on extinction rates of native and nonindigenous species and 2) research on cross-breading genetics to recognize introduced species.

To convince decision makers as to the importance of these changes in benthic communities, researchers must demonstrate a connection (even anecdotally) between the health of the benthic community and higher trophic levels, such as sea mammals or economically valuable fish. To help derive better management strategies, studies are needed to determine which species should be kept out of the Bay and their likely routes of introduction. This information will help determine the level of protection that may be needed against organisms in ballast water or other sources of species introduction. The changes that nonindigenous species, such as the Asian clam (*Potamocorbula*), may be having on phytoplankton and other carbon sources of food for fish should be investigated, as this is a likely example of an introduced species having an impact on an entire food web. Finally, because nonindigenous species are an international problem, EPA should promote international research and cooperation.

Welcome and Introductions

Jean Circiello, EPA Region 9 facilitator, welcomed participants of the benthic subgroup to the workshop on benthic nonindigenous species in the San Francisco Estuary. Circiello asked participants to: (1) evaluate the data and approaches used in a draft report ("White Paper") produced by ORD and the San Francisco Estuary Institute (SFEI) entitled *Impacts of Nonindigenous Species On Subtidal Benthic Assemblages In the San Francisco Estuary*; (2) identify the major sources of uncertainty and corresponding research needs in assessing the ecological risks of nonindigenous species; (3) identify the potential approaches to assessing the ecological risks associated with nonindigenous species in estuarine ecosystems; and (4) identify the overarching issues that should be carried forward to a national discussion on EPA's response to nonindigenous species.

Overview of *Impacts of Nonindigenous Species On Subtidal Benthic Assemblages In the San Francisco Estuary* —
Bruce Thompson, San Francisco Estuary Institute, and Henry Lee, U.S. EPA, ORD Regional Scientist, Region 9

EPA and SFEI produced a pilot risk assessment evaluating the impacts of nonindigenous species on benthic community structure in the San Francisco Estuary. The study attempted to: 1) quantify the spatial and temporal patterns of nonindigenous species in the subtidal benthic assemblages; 2) evaluate the relationship between nonindigenous species and the number and abundance of native taxa; 3) evaluate the relationship between the abundance and diversity of nonindigenous species and sediment contamination; and 4) identify conceptual issues and sources of uncertainty limiting the ability to conduct a comparative risk assessment on nonindigenous species. Benthic community structure was chosen as the endpoint because it is a traditional measure of ecosystem condition used by regulators in making risk management decisions and because benthic ecosystems are valued in their own right (i.e, an assessment endpoint).

The EPA-SFEI analysis focused on subtidal assemblages because of the availability of subtidal data from the 1994-1997 Regional Monitoring Program (RMP) Benthic Pilot Study conducted by SFEI. Previous work by Bruce Thompson delineated seven subtidal macrobenthic assemblages from the RMP benthic data using an ordination and classification scheme. Each

macrobenthic assemblages had a characteristic species composition and abundance. While the boundaries of these assemblages varied among years with changes in freshwater inflow, the species composition within each assemblage was consistent over time. The changes in the suite of organisms at a particular site in response to salinity changes generally occurred over a 2 to 16 month period but could occur instantaneously in response to large freshwater inflows. Because of the relative year-to-year stability of the species composition within an assemblage, they were used as the framework for analyzing the spatial patterns of invasions and the relationship of the abundance of nonindigenous species to sediment contamination. Using the assemblages as the framework reduced the variation due to year-to-year variations in species composition at a particular site and allowed an evaluation of how nonindigenous species varied among biotic communities. The EPA-SFEI analysis of spatial patterns revealed some uncertainties associated with assigning sites within the Bay to specific assemblages. These uncertainties can affect mean values for an assemblage but not the overall percentage of nonindigenous species.

To evaluate temporal changes in the extent of invasions, data from eight different benthic sampling programs in the San Francisco Bay Delta conducted between 1962 and 1997 were compared. These studies all used 0.5 mm mesh screens. However, they used different sampling methods, had different number of replicates, and, in some cases, reported numbers on the basis of volume rather than area. Therefore, the temporal changes could be compared only on a relative basis and not with absolute densities.

The pilot risk assessment had several recognized limitations. One is that by focusing on macrobenthic community structure the analysis did not attempt an evaluation of the impacts on function nor did the analysis include larger, mobile species such as the mitten crab. All the studies used were subtidal so the analysis cannot be extrapolated to the intertidal. Lastly, the analysis did not attempt to review or include every benthic study conducted in San Francisco Bay estuary.

> **Q**: A standardized list of terms would be useful.
> **A**: Yes, the terms “exotics” and “aliens” have been used in the past, but they have been replaced by the term “nonindigenous species,” which may be the best term.
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> **Q**: If more fresh water is diverted into Southern California, could the benthic assemblage approach be used to predict the changes that will occur in the Bay’s benthic assemblages?
> **A**: The benthic assemblages should allow general predictions as to the types of changes and the general boundaries of such changes. However, more research is needed on the time required for such changes to occur.
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> **Q**: You will need to track the life history of the organisms, especially those that are most abundant.
> **A**: Agreed.

Taxonomy, Benthic Assemblages in the Bay Delta, and Spatial Patterns of Introduced Species —
Henry Lee, U.S. EPA Region 9

The EPA-SFEI analysis used the excellent work by Cohen and Carlton for identifying nonindigenous species. However, this is not an exact science. The current approach to identifying nonindigenous species depends on the weight of evidence. Genetic approaches may replace or at least augment the current methods.

Sources of uncertainty in the taxonomy data used for the present analysis, and any similar analysis, include 1) native species identified as nonindigenous species; 2) identifying nonindigenous species as natives; 3) uncertainty from cryptogenic species (species suspected of being nonindigenous but for which there is insufficient evidence) 4) not recognizing taxonomic synonyms; and 5) not identifying the taxa to a species level so that it is not possible to determine whether the species is native or introduced. In regards to the last source of error, the percent of taxa not identified to species was 21-40percent in the RMP studies. This range appears typical of other studies and is largely due to the inability of taxonomist to identify "difficult" groups (*e.g.*, oligochaetes), early life stages, and/or incomplete specimens. The lack of regional lists of nonindigenous species, as found in Cohen and Carlton, would limit similar analyses in many other estuaries.

Q: Nonindigenous species are an international problem. More funding is needed for studying nonindigenous species in their native habitats.
A: International research and collaboration should be promoted.

Q: If one could stop nonindigenous species in San Francisco Bay, how would it be done?
A: This is a difficult problem especially in aquatic ecosystems. Ballast water exchange or treatment could reduce the number of new introductions. It might be possible to control some existing nonindigenous species in the Bay by altering flow regimes or by trapping and fishing. In other cases we will have to live with the introductions.

Q: How can you identify nonindigenous species without long-term data?
A: While the historical record is important, there are many other ways to determine whether a species is nonindigenous. The biogeography of the organism is one such method, such as a disjunct distribution along a coastline. Genetics is another potential method that can be used to evaluate the similarity of a suspected nonindigenous species with those in the potential source. Basic research is needed to determine how to recognize introduced species through cross-breading genetics

Q: Biomass measurements on major taxa are an important measure because one cannot analyze function without it.
A: Many aspects of function can be determined without biomass since we know the approximate size of most of the organisms. Nonetheless, wet-weight biomass is useful especially over 10-20 years. The RMP analysis contains biomass data for a large number of samples, though it was not used in the present analysis. It is also

important to recognize that measuring biomass involves a lot of work and is most useful for a limited number of species. Basic wet-weight biomass is also variable. However, it could be measured a few times to understand the dynamics.

Q: Voucher specimens should be archived for future researchers to study. Vouchers should be photographed and stored on micrographs or compact disks, and a program needs to be instituted for saving voucher samples and replicates—typically in museums. The group recommended that the government require archiving, taxonomy, and quality assurance programs. Funding has to be institutionalized (funded on a regular basis) to maintain the collections.
A: This is a critical need. We agree that there needs to be some mechanism to fund these collections since maintenance of historical collections is often one of the first things to be cut by state and federal agencies.

Q: We can do a much better job of identifying species.
A: This is another critical need. Quality assurance of taxonomy data should involve inter- and intra-laboratory calibrations among laboratories, and pictures of benthic organisms can be put on the web. Because this country is losing a generation of taxonomists and is not replacing them, funding is needed for students or museum apprentices to learn taxonomy and biogeography. There also must be jobs for the students after they graduate. Because few nonindigenous species are initially found by experts, who are usually not in the field looking for them, regional centers on taxonomy should be created. If taxonomy carried the same QA/QC requirements that regulatory programs impose on other types of measurements, such as pollutant concentrations, there would be better funding for taxonomy. Regulatory agencies, especially state agencies, could require better taxonomy. The Corps of Engineers, Navy, and EPA should require benthic studies of dredgers. That alone would trigger some quality assurance planning.

Q: What is the cost per biogeographic region of determining nonindigenous species?
A: One could do a good study of San Francisco Bay for about $100,000, which is not a large amount of money for most federal agencies.

Q: The EMAP data for the West Coast will have to be analyzed to ensure its quality. If East Coast EMAP contractors are used to study the West Coast, their taxonomists may not be familiar with Asian nonindigenous species.
A: Agreed, that is a concern that we have especially for San Francisco Bay.

Lee and Thompson continued to discuss the White Paper, including 1) the correlation between the abundance of nonindigenous species and native species; 2) the relationship between sediment contamination and the abundance of nonindigenous species; and 3) the temporal trends in the extent of invasion as determined by comparisons to earlier benthic studies. The present study did not find negative correlations between the abundance of nonindigenous species and the abundance of native species or the number of species of natives. Although the present analysis did not evaluate changes in function, the large changes in benthic structure due to nonindigenous species suggest functional impacts. Abundances of the introduced clam *Potamocorbula amurensis* are likely to have had large functional affects, and according to one study, this clam

has displaced many native clams. Nonetheless, the present analysis did not demonstrate a negative correlation between *Potamocorbula* and the abundance of native species.

In a pilot comparison of the impacts of nonindigenous species verus sediment contamination, essentially all sites (all except 3 out of 675) have fairly high levels of invasions. Therefore, introductions are widespread in the Bay, and they contribute substantially to community composition and structure—endpoints that EPA considers important. In comparison, severely contaminated sediments are very localized. And there was either no or a negative relationship between sediment contamination and the abundance of nonindigenous species. It seems that nonindigenous species respond to contamination in a manner similar to native species and that sediment contamination does not promote invasion. We can say that 95percent of the Bay is impacted by nonindigenous species and that extensive sediment contamination is limited to hot spots. We can also say that contamination does not discriminate between native and nonindigenous species, but we want to avoid the implication that contamination is not a problem in the Bay.

Q: You should collate your data with Cohen and Carlton's work and see if there are differences in terms of the types of species and when they were first reported. You want to be able to identify the key species that have been introduced since 1994 or earlier if possible. It may take a day or more to collate, but it is important.
A: In our analysis, we found about 60 exotic species, but we have not yet collated with Cohen and Carlton data in regards to their biogeographic source or likely date of introduction. We can determine if the community pattern (e.g., percent amphipods, mollusks, etc.) is different from that found in Cohen and Carlton's list. Also, Carlton reported an exponential increase in the number of introductions. However, this is the cumulative number of recorded introductions and it does not account for introduced species that have disappeared. We might be able to analyze the RMP data to determine if any of the previously common introduced species are rare.

Q: Can you analyze shell fragments and other physical parameters in the core samples to determine when a species was first introduced?
A: A lot of that work has been done, and it has shown that shell fragments are scarce.

Q: Under existing laws, you could attempt to confirm or disprove the statement that large-scale disturbances, such as alterations in flow, give invading species an opportunity to invade or expand their population. But you would also have to explain why this is important. Although it would be better to do these types of studies under dredging mandates rather than endangered species acts, you could take a multiple approach.
A: Agreed.

Q: Why do you need to know the biogeographic source of a nonindigenous species?
A: Understanding the biogeographic distribution of a species is important in that it can help determine management strategies. For example, if we know that a lot of species are coming from Asia, we could recommend ballast-water control. And if you understand processes and mechanisms of introductions (replacement, exclusion) you might be able to develop an intervention strategy. This, however, is another level of analysis that requires a lot of work. Right now we can say that major changes have

been occurring in the Bay, probably since 1900, and we still do not know what it all means in terms of function or ecosystem goods and services or how to predict the future.

Q: You need to sprinkle the term "significant impact" throughout the White Paper because dredgers pay attention to that term. In NEPA the term does not necessarily mean statistical significance; it can also mean a substantial impact. If there is enough data to suggest that there might be a significant impact, standard NEPA programs could require dredgers to sample the benthic communities they dredge. Planning is underway for the construction of three large airports, which will require significant dredging and filling along the Bay. As scientists, we need to raise reasonable scientific questions whether such disturbances could promote introduced species. Taking samples of benthic communities before and after dredging should be part of every program to evaluate this. The data in the White Paper demonstrates that nonindigenous species are impacting benthic communities; over half of the species examined are nonindigenous. But more evidence is needed to convince managers of national programs that this is a problem.
A: The question of whether the dredge and fill associated with the construction of the airports will promote invasions is an important point.

Q: The White Paper never says that there is a problem that someone should do something about. To convince the decision makers, you have to demonstrate connections between the benthic alterations and species, such as aquatic mammals, that politicians value. Can you say that the benthic nonindigenous species serve as a contaminated food source for aquatic mammals?
A: Because of their abundance, it highly likely that benthic nonindigenous species are serving as a mechanism for the trophic transport of contaminants to higher trophic levels. However, it is not clear that there is more transport than with the native species. One possible case where exotics may enhance the transport of contaminants is with *Potamocorbula*, which appears to be a major source of selenium for diving ducks.

Q: The authors of the White Paper expressed concern about the different number of replicates used in the historical surveys (*i.e.*, non-RMP studies) they analyzed for temporal trends. They asked participants if there is any bias in taking a species list with three replications versus more?
A: There are standard rarefaction studies to test this. Alternatively, you can take the first three replications from each of the studies, take all possible combinations or run it both ways. You can also run it three times and take the mean. You should not see many differences with mean values or proportions of nonindigenous species. However, when comparing species lists, the more replicates the more rare species you add to the list.

Q: We have to recognize that many of impacts at the benthic assemblage and community levels in the Bay have already been done before the RMP study. This may be one of the reasons you did not find a negative correlation between the abundance of nonindigenous species and native species or a positive correlation between nonindigenous species and sediment contamination.

A: It is possible that a long-term data set may have shown different relationships. Nonetheless, the correlations in present system do not demonstrate a relationship between chemical stress and the abundance of nonindigenous species under present conditions.

Q: Stressing a system in certain ways may make it more prone to invasion, and although species may have been introduced many times before, they only take hold when the conditions are right. The present Bay system may not be stable.
A: It is likely that the Bay will continue to change in response to further invasions, changes in forcing functions such as inflow, and perhaps the increase of an existing nonindigenous species. Nonetheless, the similarity of the benthic assemblages across years in the RMP study suggests that there predictability in species composition at least in the three to five year time frame.

Q: Does the correlation coefficient between nonindigenous species and the number of natives include *Potamocorbula*?
A: Yes. We used regression and proportions for these correlations in two of the benthic assemblages. We took a straightforward approach to determine which of the independent variable listed in table 6 of the White Paper has the most influence on the native taxa or total abundances of native organisms. This approach has limitations. For instance, the biotic response to contaminants may be nonlinear. Also, because some of the variables are not independent, some coefficients add up to more than 100percent. Although there are limitations, this analysis is useful in determining the relative importance of nonindigenous species versus other variables. But as a correlation, it does not identify mechanisms or cause and effect.

Q: What order were the variables entered into the correlation coefficients? The order is important unless the variables are entirely independent.
A: It did not matter in this analysis as long as two or three of them were used. You can also change the order and it does not change the correlation coefficient.

Q: Does the regression analysis show that *Potamocorbula* abundances account for little variability in the native taxa?
A: The correlations show that contamination does not account for very much of the variability in native taxa, but the number or abundance of taxa of nonindigenous species does. We did correlations with individual nonindigenous species, including, *Potamocorbula*, but they did not provide useful information.

Q: Because your variables are cross-correlated, it is difficult to interpret your correlation coefficients. Would a correlation matrix be better? You should try to relate the dependent variable (e.g., abundance of native taxa) with the factors that it may be related to naturally, like salinity, water depth, and grain size. That way you can get rid of any nuisance variables. Enter these variables first, and then introduce the independent variable you are especially interested in, such as contamination or introduced species, and determine if there is anything left that can be explained by the variable you are interested in. This is called higher order regression analysis, and it creates a structural model that makes sense.

A: The nuisance variables are largely controlled for by calculating the correlations for each assemblage independently, since the assemblages are determined by factors such as salinity and grain size. I also question the use of linear assumptions when we know that a lot of the relationships are nonlinear. Again, the correlations and regressions were used as a method to gain an indication of relative strength of the relationship.

Q: You can use a squared value—transform them or test the linear function first. The absolute numbers are not critical and are imprecise, so it is difficult to identify artifacts. You should qualify your results. There are so few natives anyway that you may not be asking the right question.
A: There are native species with a very wide salinity tolerance, and there are areas of the Bay where these species could thrive because of the salinity but they are not in the samples.

Q: What will you get out of EMAP? Will you be able to address the Bay with any more precision? A: One of the benefits from EMAP is that it establishes a statistically sound baseline for the Bay. The lack of good baseline information is one of the factors that have limited our ability to evaluate the extent of impact on the Bay. We know that there have been some major changes. For instance, we know that at one time, the Bay used to support huge oyster and waterfowl populations. Yet in most cases, the specific changes are unknown or at least cannot be quantified.

Q: What do you mean when you say community structure has been altered by nonindigenous species over time?
A: Using the similarity index, the 1988 samples are only 50percent similar to the 1986 samples and the similarity continues to decline with time. That says that there has been a significant change in community structure in a short time. However, that could be due to other factors, in particular changes in salinity. The EPA-SFEI analysis does not address the cause of the change; that is a subject for another study. The important point is that different assemblages have different proportions of introduced taxa.

Q: Several of the participants were familiar with the quality of the taxonomy in the earlier studies (pre-RMP) used in this temporal analysis of changes in the benthic community structure. They strongly cautioned against trusting many of the identifications and felt that this uncertainty made it very tenuous to say much about temporal changes. They suggested other potential sources for historical data in the Bay.
A: We will have to decide whether to drop this section because of these concerns or, at least, raise this caution.

Q: What do you mean when you say that the invaded communities did not resemble disturbed communities?
A: We compared the number of taxa and species composition in the invaded assemblages to the highly contaminated sites and the invaded communities were not dominated by characteristically pollution tolerant species. However, we did not run a full suite of benthic metrics (e.g., diversity measures).

Q: How does the functional structure of the community compare with other estuaries on the West Coast of the United States and with the geographical areas that ship to the Bay area? One might not be able to compare species, but one might possibly compare filter feeders and arthropods, for instance, in several estuaries.
A: No one has looked at that.

Q: You do not know what the extinction rates are for the introduced or native species. For instance, you do not know if the arrivals of nonindigenous species are correlated with extinctions of native species. However, you can compare which species were present and which were not at certain times. It would also be interesting to find out how many species reported in Cohen and Carlton can actually be found in the Bay now.
A: Agreed.

Q: The EPA-SFEI analysis has a bias problem because the sampling stations were not randomly placed. Also, the analysis may understate the potential contaminant effect by simply indicating only hot spots, when there could be low levels of contamination throughout the Bay.
A: It might be true that low levels of contamination throughout the Bay have facilitated the introduction of nonindigenous species, which would confound the correlation between sediment contamination and the abundance of nonindigenous species. We know there is a substantial amount of background contamination in the Bay, and we know there is a relationship between abundance and contaminant concentration, but when compared to other stressors, like salinity, contamination effects appear to be minimal. Amphipods appear to be among the most sensitive groups in the Bay.

Q: In addition to contamination, you should look at other kinds of stress, which could be quite subtle, such as the space and time-scales of suspended sediment.
A: We will not solve these problems without more research. EMAP should help. Also, the role of water quality in the interstitial water and water just above the surface cannot be overlooked. But if you compare community data with toxicity data from standard bioassays using sediment collected from the field, you have a confounding problem because the animals in the community are not exposed to the same contaminants as animals in the bioassay. There are methods for exposing organisms to undisturbed sediments, which minimizes some of these problems, but they are more costly.

Q: There have been a lot of improvements in the Bay Delta since the 1950s when a few studies found no life in the bottom of the Bay. Has anyone canvassed the old universities around the Bay for archived samples that might contain benthic organisms?
A: This has been done to some extent. Some of the first specimens of species have been found by college students who routinely sampled the Bay as part of their course requirements.

Additional Approaches, Key Ideas from the White Paper, and Research Recommendations — Jean Circiello, Region 9 Facilitator

Q: What percent of species are known?
A: Resolution (taxonomy) at spatial and temporal scales has always been a problem. There are many unknowns.

Q: Research is needed to compare San Francisco Bay with other estuaries on the West Coast.
A: Agreed. Last year, EMAP took samples from the Mexican to the Canadian boarders, which may be helpful. However, they took only 50 to 80 samples per state.

Q: We have no information on extinction rates of native or nonindigenous species.
A: Such a study must be done well because it will become a benchmark.

Q: We need to reconstruct the spatial distribution of the impacts on the Bay over time and determine if the diversity of the Bay is increasing, staying the same, or decreasing. The California Department of Water Resources' data could be used to evaluate temporal change. At the very least, we should be able to evaluate effects on oysters.
A: Agreed.

Q: You will have to show a connection between the health of the benthic community and some higher trophic level organism (with scales, fur, or feathers). For example, dioxin load in the food chain is a major concern for environmental justice communities and California's large Asian population. A: *Potamocorbula* is a good example of a species that has shown a significant increase in biomass in the northern Bay, and *Potamocorbula* accumulates contaminants. As a result, bottom feeders, including fish and diving ducks that eat *Potamocorbula*, are consuming higher doses of contaminants. Reproduction will soon be reduced in bottom feeders. There are other examples of benthic organisms affecting endangered species at higher trophic levels.
A: Agreed.

Q: One of the big stories is the effect that the Asian clam may be having on phytoplankton and the carbon cycle in the Bay. These in turn may be having economic effect on the local fisheries. Therefore, some future research should be focused on function.
A: Agreed.

Q: Function studies are needed in three different areas: bioaccumulation of pollutants, such as selenium, and pollutant transport; changes in trophic dynamic structure; and the autocology of the population dynamics of key species like the mitten crab, green crab, and others. We have to be able to show that nonindigenous species have caused serious problems if nonindigenous species research programs are to compete successfully for limited resources.
A: Agreed.

Q: Based on what is published in the literature, is it possible to make a case that *Potamocorbula* has functionally changed the northern part of the Bay?
A: No, but there are suggestions. For instance, a recent paper has shown an apparent reduction of small fish populations in the northern Bay. This reduction could be due to changes in the carbon sources that limit the fishes' food options, which in turn might be due to *Potamocorbula*. Laboratory studies could be used to determine whether these populations can utilize other sources of carbon. Studies should be designed to investigate why there have been changes in trophic dynamics in north Bay and which of the changes may be due to quality and quantity of food availability. Another question is why no major changes in the fisheries of the northern Bay have been reported. One possibility is that the fish are using other sources of carbon. Someone needs to determine why one species can thrive and another cannot.

Q: The White Paper should emphasize that the Bay no longer has a native benthic structure, and introduced species are still entering the Bay at a rate that is out of control. That should be enough to trigger the research.
A: Agreed.

Q: Can we draw any conclusions from other places around the world to use as references? Juvenile salmon, who thrive on amphipods during their two week stay in the Bay, transfer contaminants up the food chain, but we do not know if amphipods, or which amphipods, might be contaminated.
A: Agreed.

Q: We want to determine if the mitten crab, for which there is a lot of historical data, is having an impact on certain benthic species. For instance, we want to know what the crabs eat. We know they are true omnivores.
A: Agreed.

Q: We have to make the case that the impact of nonindigenous species is important over long time scales. We could compile anecdotal information about the disastrous impacts nonindigenous species are having. Nonindigenous species impacts have put several billion dollar regulatory programs in jeopardy. The selenium problem and mitten crabs, which have foundered efforts to protect endangered species, are good examples of such impacts. Although the situation in the Bay has reached a low level due to nonindigenous species, the situation is not stable.
A: Agreed.

Q: Questions remain unanswered about whether the situation in the Bay will get much worse and what, if anything, can be done about it. We can show that undesirable events have occurred and the potential exists for more events to occur. Even if we could stop all new species introductions, the situation in the Bay will be unstable. We cannot restore the Bay, but it may be possible to destroy some nonindigenous species or minimize introductions of new species. An important research question is, how do we apply adaptive management to the current condition of the Bay? We should compile anecdotal information about nonindigenous species

impacts and urge completion of feasibility studies and cost studies to the maritime industry to try to stop further introductions of nonindigenous species.
A: Agreed.

Q: Another research question is to determine which species should be kept out of the Bay. This will help determine the level of protection and the size of ballast-water filters. At this point, we do not know what should be done to protect against further species introductions. We cannot even state for sure that ballast water is a problem.
A: Agreed.

Q: Research is needed to analyze and validate the phytoplankton taxonomic data that are available today. The zooplankton data also should be analyzed, but some zooplankton analyses are already underway.
A: Agreed.

The authors and Circiello asked participants to e-mail their comments on the White Paper and any further discussion points to the authors.

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REGION 9 WETLAND/RIPARIAN NONINDIGENOUS SPECIES WORKSHOP

December 14, 1999
Richmond, California

Abstract
Concurrent with the benthic workshop, EPA Region 9 and the San Francisco Estuary Institute (SFEI) hosted a workshop on the effects of nonindigenous species on California wetlands and riparian zones. Participants included experts from EPA, SFEI, other state and federal agencies, and academia. One goal of the workshop was to develop prioritized lists of invasive plant and animal species as ecological stressors for wetlands and riparian zones. The exotic plants species of highest concern in tidal wetlands are exotic *Spartina* species, Brazilian waterweed (*Egeria densa*), pepperweed (*Lepidium latifolium*), and purple loosestrife (*Lythrum salicaria*). The animals of greatest concern in tidal wetlands are the red fox, Chinese mitten crab, green crab, Norway rat, and feral cats & dogs. In riparian habitats, the most deleterious invasive plant species are Cape ivy (*Delairea odorata*), giant reed (*Arundo donax*), and tamarisk or saltcedar (*Tamarix* spp.).The invasive animal species posing the greatest threat are bullfrogs and the Chinese mitten crab.

The second goal of the workshop was to compare the impacts of biological invasions to other stressors for selected habitats. The habitat types selected were intertidal, riparian, palustrine, lacustrine or riverine, and vernal pools. (Palustrine refers to inland marshes and swamps, while lacustrine refers to marshes and aquatic beds associated with lakes. Vernal pools are shallow, seasonal wetlands usually found in grasslands.) Among the stressors identified impacting these habitats were nonindigenous species, contaminants, global climate change, habitat loss, and hydromodifications (e.g., water diversion). Approximately 70 nonindigenous plant species and 35 nonindigenous animal species were found to be problems in these habitats in Region 9.Using an expert opinion approach, the relative importance of each stressor was evaluated for each habitat (Table 1). While there are many data gaps, nonindigenous species were ranked high as an overall stressor in these habitats, along with habitat loss and hydrological modifications. Only vernal pools seem to be relatively unimpacted by invasive species.

An issue raised during the workshop was the invasion of newly constructed or remediated wetlands by exotic weeds. Such newly constructed habitats are especially vulnerable to invasions. Of particular concern is the invasion of constructed tidal wetlands in San Francisco Bay by exotic species of Spartina. Besides the loss of a functioning native wetland at the remediated site, these invaded habitats could serve as seed sources for the invasion of surrounding habitats. Several of the participants suggested that the construction of new estuarine wetlands in San Francisco Bay should be halted, or at least reconsidered, until methods are developed to limit invasion by Spartina.

TABLE 1: RELATIVE RANKING OF STRESSORS IN WETLAND/RIPARIAN HABITATS TYPES

	STRESSORS (RESULTING FROM AGRICULTURE, FORESTRY, MINING, URBAN DEVELOPMENT, INDUSTRY, AND RECREATION)					
HABITAT TYPES	**NIS**	**CONTAMI-NANTS**	**HARVEST**	**HABITAT LOSS***	**HYDROMODI FICATION**	**GLOBAL CLIMATE CHANGE****
INTERTIDAL	H	M	L	H	H	Research needed
RIPARIAN	H	L-M	L	H	H	Research needed
PALUSTRINE	M	L-M	L	H	H	Research needed
LACUSTRINE OR RIVERINE	H	H	L	L	H	Research needed
VERNAL POOL	L	L-M	L	H	M	Research needed
ALL COMBINED	H	M	L	H	H	?

* considers loss of both quality and quantity of habitat changes

** refer to recent report on global climate change predictions for CA

REGION 3 NONINDIGENOUS SPECIES WORKSHOP IN THE MID-ATLANTIC

June 7-8, 2000
Ft. Meade, Maryland

The U.S. Environmental Protection Agency and Department of Defense (DoD) sponsored the sixth and final regional workshop on nonindigenous species (NIS). The workshop focused on federal and state agency perspectives, major nonindigenous species in the Mid-Atlantic region, and management and mitigation strategies. Many NIS have come into the United States through the Mid-Atlantic world trade routes that run through coastal estuaries. Numerous NIS aquatic and terrestrial organisms are established in the Mid-Atlantic.

DoD is one of 16 federal agencies that participate on the National Invasive Species Council and the Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW). In 1998, FICMNEW completed a national strategy, called *Pulling Together*, for managing invasive plants. Six federal agencies including the U.S. Army Corps of Engineers participate on the Aquatic Nuisance Species Task Force, which has regional panels. DoD has a policy memorandum on NIS and produces a wide variety of guidance to help military installations plan, budget, and manage their plant NIS problems.

The U.S. Forest Service's Forest Health Monitoring program is conducting a three-year project to evaluate the health and sustainability of the forests in the Mid-Atlantic region and is helping fund methods development for economic impact analyses at the University of Maryland. The USDA's Animal and Public Health Inspection Service (APHIS) uses port inspections, quarantine treatments, detection surveys, and eradication procedures to prevent new, harmful introductions of invasive species, but with only 3,000 port inspectors worldwide and the increasing amount of international trade, pressures on the system are mounting.

The National Park Service, U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. Coast Guard, EPA, and the National Oceanic and Atmospheric Administration have programs to address NIS. In addition, the states in the Mid-Atlantic region, the Nature Conservancy, Anne Arundel Community College, and the Smithsonian Environmental Research Center have NIS programs. The National Fish and Wildlife Foundation creates partnerships with private organizations, state and local agencies, academia, and federal, interstate, and tribal agencies to fund NIS projects.

Workshop participants generally agreed that prevention is the most cost-effective approach to managing NIS because of the difficulty of controlling NIS once established. Prevention strategies are hindered by inadequate funding for rapid assessment and response, and education and outreach to increase voluntary participation of private landowners and compliance with ballast water control programs. Prevention is further hindered by inadequate funding for APHIS, which can only inspect about 2 percent of materials that enter the United States. Managing invasives requires close coordination among federal, state, and local organizations; an understanding of the direct and indirect costs of NIS to agriculture and the ecology; and an effective approach for conveying the importance of the NIS prevention, research, and management to Congress.

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NATIONAL NONINDIGENOUS SPECIES WORKSHOP

July 12-13, 2000
Washington, DC

Welcome —
Henry Lee, U.S. EPA, Office of Research and Development (ORD)

Henry Lee (ORD) welcomed participants to the Nonindigenous Species Workshop. The goals of the meeting were to raise awareness about nonindigenous species (NIS) and to discuss the impact they may have on EPA's mandate to protect human health and the environment. This national workshop built upon five Regional workshops held over the last year to discuss the extent and magnitude of health, ecological, economic, and social impacts associated with the presence of nonindigenous species in various locations across the country.

The working definition of "nonindigenous species" is species beyond their historic range, taken at the time of European colonization of North America, and presumably introduced through human intervention. Other frequently used terms are exotic, introduced, non-native, and alien species. Only a fraction of the nonindigenous species is nuisance or invasive species, meaning that they are causing unacceptable ecological or economic damage or are affecting human health.

Dealing with nonindigenous species is very different from dealing with conventional or toxic pollutants, because the impacts of chemical stressors dilute over time, but the impacts of nonindigenous species can increase over time as their populations increase and they spread into uninvaded habitats. Contrary to reasons sometimes given why EPA should not be involved with nonindigenous species, invasions are still occurring, it is possible to control aquatic invasives (at least in some cases), and nonindigenous species appear to fall within the Agency's purview as indicated by the ballast water petition to the Administrator and pesticide applications for exotic pests. Because of the prevalence of nonindigenous species in the environment, few ecological decisions made by the Agency will not be affected in some way by nonindigenous species. While control is possible in some cases, the key to slowing invasions is prevention through, for example, ballast water discharge requirements or pesticide applications upon first notice of an invasive species.

Overview of Environmental Risks Associated with Nonindigenous Species —
Daniel Simberloff, University of Tennessee

The world biota is being homogenized by nonindigenous species, which has an impact on species diversity and the economy—an increase in travel and trade has exacerbated the problem. According to various surveys, nonindigenous species pose the second largest threat to endangered species (two times the threat of pollution and second only to habitat degradation).

Different nonindigenous species pose different problems. For example, some can eliminate native species. Examples include: the Australian Paper Bark Tree, which has taken over 400,000 acres in South Florida, and can easily catch on fire, destroying other species living in its vicinity; the water hyacinth, which is growing out of control in Louisiana, Texas, Lake Victoria, and Asia, and poses water quality problems that can wipe out other species living nearby; the brown tree snake, which has wiped out most bird species on Guam, and has been found eight times on the Island of Oahu, and once on Corpus Christi; and the Giant African Snail, which has wiped out all other species of snails on Hawaii. Other examples include: *Myrica faya*, which makes the soil

inhospitable to other plants; cheat grass, which fosters frequent fires and reduces range productivity by 75 percent; red mangrove, which was taken to Hawaii by a sugar company in a failed attempt to build land; and the salt cedar, whose roots take up all the water in the areas where it grows, thereby killing native plants.

Some nonindigenous species can completely change the nature of communities. For example, the zebra mussel has changed the ecosystems of the areas in which it lives and has eliminated some species. Nutria have destroyed land in Louisiana and have begun to do so in the Chesapeake Bay region. Chestnut Blight entirely eliminated the American Chestnut, which used to be the dominant species in the Northeast of the United States. The Nile perch was introduced into the bailiwicks of Lake Victoria, and has wiped out over 200 species of fish. The brown rat has caused the global extinction of 30 species of birds. The small Indian mongoose was introduced to North America in a futile attempt to kill rats, but instead preyed upon reptiles, amphibians, birds, and other mammal species, and poses a great threat to biodiversity. Non-native goats on the Island of St. Helena in the Atlantic have wiped out 100-150 native plant species over a 50-year period and have reduced the endemic flora by 50 percent. Many Hawaiian birds have been made extinct or endangered by avian malaria and avian pox.

Some nonindigenous species are successful because they are better at competing for resources. For example, the Red Squirrel, which is a nonindigenous species, has proliferated because it is better at collecting nuts than the native gray squirrel. Other examples include the ladybug and the red fire ant.

Some nonindigenous species have driven other species extinct or endangered them through hybridization. For example, non-native mallards are able to bear offspring with the grey duck of New Zealand, but their hybridized offspring are unable to reproduce. Other examples include the red deer, which has hybridized successfully with the secca deer, and the rainbow trout, which has hybridized with five listed species.

Other nonindigenous species have posed problems without hybridization. For example, the male American mink can breed with female European minks earlier in the season than the male European mink. The resulting embryos are not viable and abort earlier. However, despite the aborted fetus, the female European mink is no longer available to breed for the rest of the season, making extinction a real possibility.

Some animal behavior has exacerbating effects. For example, the water buffalo often tramples wetlands, which provides the perfect habitat to *Mimosa pigru*. Feral pigs spread exotic weeds, the Asian mina bird disperses weeds to pasture land, and the zebra mussel excessively filters the water it lives in, resulting in the perfect habitat for Eurasian watermilfoil. The successful Eurasian watermilfoil in turn provides a perfect habitat for zebra mussels.

Evolution also plays a role with nonindigenous species. A nonindigenous species of *Spartina* was brought into the United Kingdom by accident and established itself, but was harmless. However, at some point the exotic *Spartina* bred with a native species producing a hybrid species, but these did not pose a problem until the hybrid mutated and became fertile, creating a new nuisance species.

In response to a question, Simberloff explained that Alligator weed can be successfully controlled with a nonindigenous species of beetle without other nontarget impacts.

Overview of Pesticide Usage on Nonindigenous Invasive Species—
Robert Eplee, Weed Scientist Consultant

Invasive species endanger ecosystems and crop production more than chemical pollution, because chemicals dissipate over time, while biological pollution grows, adapts, multiplies, and spreads forever. Rapid response is key to the efficient eradication of new invasive species - "weeds won't wait." The use of targeted pesticides seems to have the best effect on reducing or eliminating invasive plant species, while minimizing the impact on affected ecosystems. In many cases, a suite of registered pesticides is available, however, in some cases, the effective control of a new exotic pest will require the use of pesticides outside of their present registered use or the use of newly developed pesticides. For example, triclopyr is effective on the invasions of tropical soda apple in pastures, while 2,4-D (registered use); paraquat (expanded use); oxyfluoven (new); or ethylene (new paradigm) seem to be effective on witchweed, which can devastate corn. Flurodone has been effective in the eradication of Giant Salvinia, and glyphosate is 77 percent effective, and sodium 2,2,3,3-tetra fluropropinate is greater than 95 percent effective on eradicating Serrated Tussock. EPA should be involved in the process of developing a national system to deal with biological pollution as well as chemical pollution and to develop legislation that will protect crops and pastures from invasive species.

Overview of Impacts on Aquatic Systems —
John Chapman, Oregon State University

Nonindigenous species are a major public concern that poses significant economic and ecological impacts on aquatic systems. Aquatic nonindigenous species are spreading at an accelerating rate that currently is unknown; donor and recipient countries are located around the world, and the cost to control these invasions are great.

Examples of aquatic nonindigenous species include: the European green crab, which is usually transported in ballast water; the Chinese mitten crab, which is a problem species in San Francisco Bay; *Caulerpa taxiflora,* which is an aquarium plant that recently invaded a bay in San Diego; *Undaria pinntifida*, which is a seaweed used by the Japanese to make miso soup, but is considered a nuisance species by other countries; *Mnemiopsis leidyi*, which is a problem species in the Black Sea that has caused a loss of $250 million per year to the local fisheries; and *Corophium alienense,* which is a problem species in the U.S., but whose origins are unknown.

Aquatic nonindigenous species can be introduced through several vectors. There are five major routes of nonindigenous species introductions into San Francisco Bay: ship fouling (26percent); ballast water (23percent); Atlantic and Pacific Ocean oyster shipments (15percent); stocked fish or shellfish (9percent); and releases by individuals (7percent). An additional 20percent of introductions come from unknown routes.

Climate appears to control the distribution of nonindigenous species because the relative importance of nonindigenous species declines from San Francisco Bay to Puget Sound to Prince William Sound. Also, the prevalence of nonindigenous species is higher the eastern side of oceans (e.g., the Pacific coast of the United States). We need to acknowledge that current nonindigenous species management efforts are limited, and we must ask whether voluntary ballast water exchange is working, what ecosystems are at risk, and how can we manage nonindigenous species over a biogeographical region. We need to promote and coordinate nonindigenous species control efforts at the federal and state levels through the development of ecological safety protocols for nonagricultural nonindigenous species and assist the development

of control methods. We also need to promote development of a federal registry of nonindigenous species. State and local registries are difficult to implement and local rules create unfair competitive advantages such as among ports. Nonindigenous species are posing a national and international problem, and we need an international program to address them.

Impacts of Nonindigenous species on the National Estuary Program (NEP) Watersheds — Holly Greening, Tampa Bay Estuary Program, John Dohrmann, Puget Sound Action Team, and Judith Pederson, Massachusetts Bay Program

Nonindigenous species are an emerging issue, and have become a serious management issue. Among the 28 estuaries addressed by the National Estuary Program (NEP), each has unique problems, and there is no cookie cutter solution for these sites. The National Estuary Program has three research priorities: address the viability, economic, and ecological costs of prevention and control of nonindigenous species; identify and rank the importance of vectors; and understand the life history and ecology of nonindigenous species and what triggers outbreaks.

In Puget Sound, a rapid assessment identified 39 nonindigenous species; however, the latest list reports that there are actually 52 nonindigenous species in Puget Sound. Sources of these nonindigenous species include intentional introductions, ship fouling, ballast water discharge, and aquaculture.

Nonindigenous species were largely ignored in the Puget Sound region until a 1994 transboundary science panel was held. This prompted a Region 10 effort to form a Regional committee to prepare a background paper and develop actions to address nonindigenous species. NEP participates on this Regional Panel, and partly-funded a State Coordinator position to prepare a State Aquatic Nuisance Species (ANS) Management Plan. The Puget Sound NEP is proposing to add an ANS program to the Comprehensive Conservation and Management Plan (CCMP) for Puget Sound in the fall of 2000.

To address nonindigenous species in Puget Sound, we need to focus on the following research needs:

- How should we treat ballast water?
- How should we monitor treated ballast water for compliance?
- How should we treat ballast water when it is taken aboard rather than at the port of discharge?
- How adequate are existing methods to limit organisms from traveling attached to vessel hulls?
- What cleaning or treatment should be used for vessels hauled overland? What about float planes?
- What chemical, biological, and mechanical methods to control or eliminate non-native species are safe and effective?
- Are we controlling eggs and larvae from liquid discharges from laboratories, aquaria, pet stores, and live seafood stores?

We also need to ask the following policy questions:

- If EPA regulates discharges of parasites, bacteria, and viruses, why not aquatic nuisance species?
- How can EPA inspectors help prevent introductions of non-native species?
- Is EPA monitoring designed to detect previously unreported species?

The Massachusetts Bay Program is working with the MIT Sea Grant Program, the Massachusetts NEP, Massachusetts Coastal Zone Management, the Massachusetts Port Authority, and the Massachusetts Audubon Society to develop a Rapid Assessment Survey on floating docks in Massachusetts. The purpose of this survey is to develop a database and management plan to address nonindigenous species. Ten to 12 taxonomic experts are working on this study to assess up to five historical-use sites a day. Follow-up activities to this effort include: supporting monitoring and research activities; using the information to prepare management plans; encouraging surveys in other habitats; and initiating efforts to quantify and delineate the areal extent of these invaders. However, these follow-up efforts will require coordination and international collaboration. For additional information on this effort, check out MIT's Sea Grant College Program Exotic Species Web Pages at http://massbay.mit.edu/exoticspecies

In response to a question about ballast water exchange, John Dohrmann indicated that ballast water regulations require ballast water exchange 50 miles offshore. A new Washington state law regarding ballast water exchange has strong industry support. In response to a question about coordination with Canada, Chapman reported that they have good coordination with the Port of Vancouver, and that Canada serves on the Nonindigenous Species Committee. In response to a question about whether NEP has made efforts to look at vessels and vectors of the nonindigenous species problem, Dohrmann reported that no data are available on this issue, but there is concern of overland transport by pleasure vessels.

Panel Discussion with Invited Speakers and a NEP representative — Eplee, Greening, Simberloff, and Chapman

Eplee opened up the panel discussion by recognizing that EPA needs to decide what its long-term objectives are for ecosystems and needs to develop an information management system for nonindigenous species. Chapman added that now is the time to address nonindigenous species invasions, because nonindigenous species are proliferating, are degrading existing habitats, and causing global change—all at a great cost. Greening said that monitoring programs need to be developed to better recognize nonindigenous species outbreaks in the future.

Simberloff indicated that nonindigenous species invasions are equal in magnitude to pollution problems. Eradication of nonindigenous species can work, but the biggest impediment to eradication and maintenance controls is the failure to commit resources. Eplee added that as we contemplate prevention, we need to recognize that we seldom reward people for preventing problems because the results of prevention are not as clear as the results of control or eradication efforts.

A participant reported that EPA Region 4 classifies its wetlands by function, which is often not affected by nonindigenous species invasions. He then asked whether nonindigenous species should be considered when classifying these wetlands. Simberloff said that it depends on what

definition of function is being used. Most invaded ecosystems still function as a healthy ecosystem. However, some invaders can have negative impacts that should be considered.

In response to a question about nonindigenous species in Willapa Bay, Chapman noted that there is concern that the Bay's ecosystem is changing, and that this could affect existing species, such as the Coho salmon. Simberloff added that development of a risk assessment tool for nonindigenous species could be helpful to determine potential problems. However, no risk assessment tool currently exists for aquatic species, and since most introductions of aquatic nonindigenous species are accidental, the predictions of invasions and potential problems are more difficult. Greening added that it is difficult to put nonindigenous species into a risk perspective since we do not know the potential impacts at this time. Chapman added that it is worth the energy, however, to determine if something will or will not become a pest. Simberloff cautioned that we need to think first before we act so we do not implement an eradication scheme that causes more harm than good.

Introduction to Regional Nonindigenous Species Workshops —
David Klauder, U.S. EPA, Office of Research and Development (ORD)

In 1998, ORD initiated a "New Directions" program to conduct workshops with the EPA Regions on some of their high priority science issues. Nonindigenous species ranked high on the Region's list of science priorities. A nonindigenous species workgroup, under the direction of Henry Lee (ORD), decided to conduct a series of workshops throughout the country to examine regional nonindigenous species issues and provide a basis for a national workshop in Washington, DC. This workgroup also has been utilized to provide Agency input to other federal activities, such as to the National Invasive Species Council. Over the course of the last year, ORD, the Regions, and the Great Lakes Program, along with several other federal, state, and local agencies and NGOs, sponsored Regional nonindigenous species workshops in Denver (CO), Chicago (IL), Tampa (FL), Richmond (CA), and Fort Meade (MD). Participants at these Regional workshops included representatives from other federal, state, and local agencies, and from NGOs. The Regional representatives from each of these Regional workshops were invited to present a brief overview of their workshop conclusions.

Region 8: Regional Issues Including Pesticide Usage to Control Nonindigenous Species in Natural Environments —
Cindy Schaffer, U.S. EPA, Region 8

The primary objective of the Denver nonindigenous species workshop, which was held September 22, 1999, was to heighten awareness of nonindigenous species in the Region. This workshop, the first of the Regional workshops, focused on efforts to control noxious weeds and "whirling disease," a nonindigenous parasitic malady that affects native trout. A third invasive nonindigenous species, the hobo spider, was omitted from the agenda because the invited expert was unavailable. Among the sponsors of the Region 8 workshop were ORD, the State of Colorado Fish and Wildlife Service, Colorado Department of Agriculture, U.S. EPA's Region 8 office, and Trout Unlimited (TU).

Noxious weeds, including spotted knapweed and leafy spurge, and whirling disease are devastating the ecology and economy of the Rocky Mountain states. Spotted knapweed covers over 46 million acres in Montana alone, costing the state an estimated $42 million annually. Leafy spurge is invading cattle grazing grounds, costing the livestock industry approximately $129 million per year in Montana, Wyoming, North Dakota, and South Dakota combined. The

whirling disease parasite has spread to numerous freshwater rivers in 22 states, including Montana's Madison River, where certain stretches have experienced a 77percent decrease in trout numbers. Trout Unlimited plans to distribute a petition to each state to include whirling disease as a part of their TMDL mandate.

According to some estimates, the economic and environmental damages associated with nonindigenous species cost the US economy a total of $137 billion per year. The costs associated with pesticide application alone are estimated to be $7.1 billion per year (based on 1992 figures). Indirect costs of nonindigenous species, including those associated with human health, animal poisoning, destruction of natural predators, pesticide resistance, fishery and crop losses, and government regulations, are estimated to be in excess of $8.1 billion per year. According to Region 8, the biggest issue is the cost of nonindigenous species control in natural forests, lakes, streams, rivers, and recreation areas. The total cost of controlling nonindigenous species is growing rapidly throughout the region and the world.

One participant asked how the indirect cost of nonindigenous species on human health, which were reported at $787 million per year, was determined. Schaffer indicated that the number reflects the costs associated with documented exposure to pesticides and other biocides or toxins. Another participant asked whether the data used to determine costs were general (i.e., pesticides used to control both indigenous and nonindigenous species) or related only to nonindigenous species. Schaffer answered that the data is general and not adjusted for nonindigenous species.

Great Lakes National Program Office: Impacts on the Great Lakes and Role of Ballast Water as a Vector —
Karen Rodriguez, U.S. EPA, Great Lakes National Program Office (GLNPO)

More than 140 aquatic nuisance species have been identified in the Great Lakes Basin, of which approximately 10percent have caused significant ecological and economic effects. Most of these nonindigenous species have been transported to the Great Lakes region by way of ships from Eurasia. At stake are biological and physical processes, such as the food web and nutrient dynamics, as well as economic considerations, such as the sportfishing industry and power plant intake systems.

The zebra mussel was first discovered in Lake St. Clair in 1988; since then, the cumulative costs to the region have been estimated at between $3.1 and $5 billion. The round goby is another nonindigenous species that is quickly spreading throughout the Great Lakes. This goby is an aggressive bottom-dwelling fish that is outcompeting native species; it was likely transported to the region in ballast water. The fishhook waterflea, another nonindigenous species that was probably introduced via ballast water, displaces native zooplankton species, and cannot be fed upon by smaller fish due to its long spiny tail. It has been estimated that 30 percent of all aquatic nonindigenous species introductions have occurred via ballast water from transoceanic vessels.

The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 was the first major legislation passed in this country that was specifically designed to curb the influx of nonindigenous species. This act, which was amended in 1996 as the National Invasive Species Act (NISA), gave ships entering the Great Lakes three options: 1) they could perform ballast water exchange; 2) they could retain their ballast water while in the region; or 3) they could treat their ballast water using a method other than ballast water exchange. These regulations are

enforced by the U.S. Coast Guard. Several ships claim “no ballast water on board” (NOBOB), but nonindigenous species may still be contained in sediments in the ballast tanks.

Three projects illustrate the status of nonindigenous species in the Great Lakes. A technology demonstration project involving filtration mechanisms is being conducted aboard the vessel *Algo North*; a second phase of this experiment will examine other technologies, such as UV light exposure. A management and research agenda is examining treatment options for NOBOB vessels, including the use of biocides to treat ballast water tanks. Finally, a standards and guidelines initiative for ballast water treatment is examining variable ship designs, ballasting operations, and trade routes. Aquatic nonindigenous species in the Great Lakes region continue to harm the native environment and the economy; nonindigenous species are a global problem that requires a global solution.

In response to questions from the participants, Rodriguez answered that shippers do not have the option to select the treatment they use (ballast water exchange versus other innovative technologies), and that the Great Lakes are less susceptible to nonindigenous species invasions than oceanic ports or regions, because: 1) many oceanic creatures cannot survive in the low salinity of the Great Lakes; and 2) most ships entering the lakes must pass through the St. Lawrence River, making it easier for the Coast Guard to monitor shipping.

Region 4: Regional Issues Including Risks to Tampa Bay —
Roland Ferry, U.S. EPA, Region 4

In terms of nonindigenous species, the Southeastern U.S. is the most invaded region of the country. Florida has the second-most number of nonindigenous species in the nation (only Hawaii has more). Some 2000 known species of nonindigenous species can be found in Florida alone. The costs associated with plant and insect control are extremely burdensome to the Gulf states. The Formosan subterranean termite eats 37 species of living trees and is quickly destroying many historic buildings in New Orleans, Louisiana. Florida spends $23 million per year trying to control floating plants, such as the hydrilla and the water hyacinth. The Brazilian pepper, melaleuca, Asian tiger mosquito, Mediterranean fruit fly, and Asian swamp eel also have been discovered in the southeastern states.

The first day of the Gulf of Mexico Regional workshop focused on ballast water policy and management. The Gulf ports, which are among the largest in the United States, receive billions of gallons of ballast water discharges each year. Many workshop participants agreed that regional solutions work best for ballast water issues—what works in the Great Lakes may not work in the Gulf. Viable alternatives to open ocean ballast water exchange are needed. Managers and policy makers must evaluate all proposed methods before dictating regulations. There was also a consensus that human health should be a priority in the Gulf. Finally, most participants agreed that a regulatory approach is best for combating the nonindigenous species problem.

From a scientific perspective, prevention, assessment, control, and restoration should be the guiding principles. Researchers need to work with taxonomists to create an inventory of desirable and undesirable species. The development of a user-based early warning system will greatly increase response time and may prevent newly introduced species from gaining a foothold in the Gulf. More research is needed on the life histories and biology of nonindigenous species. Cost/benefit analyses need to be performed to determine the appropriate trade-offs in the control of nonindigenous species. Most importantly, coastal managers, policy makers, scientists, and the public must focus their energies on prevention.

In Region 4, EPA is working on several nonindigenous species initiatives, including:

- Developing a Gulf of Mexico ballast water profile
- Characterizing nonindigenous species
- Assisting states with their nonindigenous species management plans
- Funding nonindigenous species restoration projects.

In response to a question about why there so few exotics in Tampa Bay, Ferry said that researchers are not sure how many nonindigenous species are in Tampa Bay; just because nothing has "jumped out" at us yet does not mean that there are not a number of problem species lurking beneath the waves. In response to another question, Ferry said that "users" of the Gulf include anyone who works on or near the waters of the Gulf. When asked whether Region 4 is coordinating its efforts with Mexico, Ferry said that the Region is coordinating to some extent with Mexico, and is hoping that Mexico will attend some of EPA's Regional workshops.

Region 9: Relative Risk to Wetlands and Riparian Zones in California — Paul Jones, U.S. EPA, Region 9

The goals of the wetland and riparian session of the Region 9- San Francisco Estuary Institute (SFEI) nonindigenous species workshop, which was held in Richmond, California, in December 1999, were to prioritize the lists of invasive plant and animal species and, for select aquatic habitats, to compare biological invasions to other major stressors. The invasive plant species of greatest concern in tidal wetlands are exotic *Spartina* species, Brazilian waterweed, pepperweed, and purple loosestrife. In riparian habitats, Cape ivy, giant reed, and tamarisk are the nonindigenous species of greatest concern.

The animal species that present the greatest ecological and economic concern in tidal wetlands include the red fox, Chinese mitten crab, green crab, Norway rat, and feral dogs and cats. The bullfrog and mitten crab threaten riparian areas. The wetland and riparian habitats considered were intertidal zones, riparian zones, emergent marshes, lakes, open water, and vernal pools. Among the stressors identified in these habitats were nonindigenous species, contaminants, climate change, habitat loss, and hydrologic modification. Approximately 70 nonindigenous plant species and 35 nonindigenous animal species were found to be problems in these habitats in Region 9.

Region 9: Alterations in Benthic Community Structure in San Francisco Bay — Henry Lee, U.S. EPA, Office of Research and Development (ORD)

As part of the Region 9 nonindigenous species workshop, the San Francisco Estuary Institute (SFEI) and EPA/ORD conducted a pilot risk assessment comparing the impacts of nonindigenous species with the stressors that EPA normally regulates. The project sought to answer two main questions: 1) is there a relationship between sediment contamination and the incidence of nonindigenous species; and 2) what is the relative impact of nonindigenous species versus sediment contamination on benthic structure. The study only examined structural changes in the subtidal soft-bottom benthos. For purposes of the study, the Bay was divided into three assemblages: freshwater brackish waters, estuarine waters, and central bay marine waters. These assemblages were further divided into several subassemblages.

The percentages of nonindigenous species by number of total individuals and by total number of species per subassemblage were as follows:

- Estuarine assemblage/muddy subassemblage (most highly invaded subassemblage): 68percent percent of the total species were nonindigenous species; 91percent of individuals were nonindigenous species (43percent of these nonindigenous species individuals were *Potamocorbula* (Asian clam)).
- Estuarine disturbed subassemblage (stressed subassemblage): 50percent of the total species were nonindigenous species; 48percent of individuals were nonindigenous species (0.2percent of which were Asian clam).
- Central bay marine assemblage/sandy subassemblage (least invaded subassemblage): 11percent of the total species were nonindigenous species; 7percent of individuals were nonindigenous species (6.2percent of which were Asian clam).

Native taxa were not negatively associated with nonindigenous species, and in fact a number of positive correlations between nonindigenous species and native taxa were found. Nonindigenous species were not found to be associated with sediment contaminants. Rather native taxa and nonindigenous species responded similarly to contamination. Nonindigenous species were found to have a greater effect on community structure than sediment contamination. Nonindigenous species were ubiquitous whereas sediment contamination was localized to "hot spots." One of the lessons learned from this study is that determining the impacts of nonindigenous species may depend on the temporal and spatial scales of the study. Finally, teasing out impacts of nonindigenous species versus other stressors in highly invaded systems raises the number of conceptual issues that must be addressed.

In response to questions from the participants, Lee said that historic native conditions are determined by looking at structural changes, and that the disturbed subassemblage was identified using multivariant analysis using species distribution patterns and was characterized by such characteristics as low diversity as is found near sewage outfalls.

Mid-Atlantic Integrated Assessment (MAIA)/Region 3: Regional Perspectives and Management Strategies in the Mid-Atlantic —
Jim Andreasen, U.S. EPA, Office of Research and Development (ORD)

The MAIA/Region 3 nonindigenous species workshop was held in June, 2000, at Ft. Meade, Maryland. Over 125 individuals attended the two-day workshop, which was co-sponsored by EPA and Department of Defense (DoD). Representatives from numerous federal, state, and local agencies, as well as several NGOs, attended the workshop. The various organizations represented at the meeting found that they are dealing with similar nonindigenous species issues. Participants agreed that cooperation and coordination among different levels of government and other organizations needs to be improved. Workshop participants also generally agreed that prevention is the most cost-effective approach to managing nonindigenous species because of the difficulty of controlling nonindigenous species once they become established. Inadequate funding hinders efforts to control and prevent nonindigenous species; funding agencies must be convinced that nonindigenous species present a real threat to the environment and the economy.

EPA is sponsoring several regional attempts to quantify and address the nonindigenous species issue, including the Regional Vulnerability Assessment (ReVA) and MAIA. EPA's ReVA program is an approach to regional-scale, priority-setting assessment being developed by ORD. MAIA is an interagency, multi-disciplinary program that is integrating and assessing research and monitoring information to provide answers to policy and management questions.

In response to a question about whether nonindigenous species will become the economic generator of the new millennium, Andreasen said that when you factor in lost wages and the amount that the government spends trying to control nonindigenous species, the costs will outweigh the benefits associated with new jobs that are created. One participant added that the economic costs by Pimental *et. al.* quoted in many of the presentations today were arrived at through standard economic analysis. Pimental did not subtract secondary benefits (e.g., the jobs that control and prevention would create) from the total estimated cost of nonindigenous species just as economists would not subtract doctors wages from the estimated cost of cancer in this country.

Overview of the Pre-workshop Survey and Instructions for the Day 1 Breakout Sessions — Mike Slimak, U.S. EPA, Office of Research and Development (ORD)

The nonindigenous species survey was sent to the Regions, Program Offices, and ORD. Additional surveys were available at this meeting. The purpose of the survey was three-fold: 1) to evaluate EPA's awareness of nonindigenous species issues; 2) to identify how the ecological and/or human health impacts of nonindigenous species are affecting EPA's ability to accomplish its mission; and 3) to identify the relevant science issues related to nonindigenous species.

It is sometimes difficult to lump all nonindigenous species into one category and classify them as a problem, especially considering that the economic benefits of four nonindigenous species (corn, wheat, soybeans, and cotton) account for $185 billion in revenue each year in the U.S. alone. Nonetheless, managers need to be made aware of the threats that problem nonindigenous species pose to the environment and the economy.

The results of the survey thus far demonstrate that participants moderately agree that they are aware of the impacts of nonindigenous species in general. Participants barely agree that they understand how nonindigenous species relate to EPA's mission or a specific program. Respondents barely agree that technical staff and management are aware of nonindigenous species issues. According to the survey, 37percent of respondents claimed that their office has funded research on nonindigenous species issues. The average funding amount was $212,712. The mean number of work years spent on nonindigenous species issues was 2.9. The final survey results will be available after all questionnaires from this meeting have been tallied.

BREAKOUT SESSION – DAY ONE

The participants were divided into four groups and asked to answer two questions:

1) Based on what you have learned, how great an impact will nonindigenous species have on EPA's ability to meet its specific regulatory mandates and broader environmental goals of protecting human health and the environment?

2) What EPA mandates and activities are most likely to be impacted by nonindigenous species invasions?

Green Group—
Marilyn Katz, U.S. EPA, Office of Water, moderator

Breakout session participants from the green group generally agreed that nonindigenous species are an important issue that EPA should become involved with. The Agency has some authority under the Clean Water Act's (CWA) National Pollutant Discharge Elimination System (NPDES) and regulations governing clean water conditions. The National Estuary Program (NEP) offers a non-regulatory, ecosystem-based approach through which the Agency can investigate and manage nonindigenous species. EPA must also pursue partnerships with other federal agencies and NGOs, such as the Department of Agriculture, Fish and Wildlife Service, and San Francisco Estuary Institute. A cooperating group of organizations will be better able to address the nonindigenous species problem by combining funds, expertise, and human resources. EPA should act as a catalyst to the process, fostering collaboration among these organizations.

The Agency should develop a Government Performance and Results Act (GPRA) goal of no new introductions. The Science Advisory Board should become involved in the nonindigenous species issue and assist with determining what EPA's role should be. More research is needed to determine the actual and potential threats that nonindigenous species pose to ecosystems. Finally, the pesticides program should become more involved in the nonindigenous species problem. In terms of ballast water, EPA should do everything it can to protect aquatic ecosystems from nonindigenous species invasions.

Orange Group—
Roland Ferry, U.S. EPA, Region 4, moderator

The orange group began by listing Agency mandates that may be applicable to nonindigenous species. For the most part, the Clean Air Act does not specifically address issues related to nonindigenous species. Connections between Superfund, the Resource Conservation and Recovery Act (RCRA), and Toxic Substances Control Act (TSCA) and nonindigenous species also were not readily apparent, although the use of native species for phytoremediation could be mandated by the Agency. The CWA is more directly related to issues surrounding aquatic nonindigenous species and their affect on the environment. Total Maximum Daily Loads (TMDLs) were mentioned as a potential regulatory mechanism for addressing nonindigenous species in waterbodies, although the details would be difficult to work out. The orange group also discussed the applicability of NPDES permits as they relate to nonindigenous species and discharges from ballast water and point sources. The Safe Drinking Water Act (SDWA) was another possible mechanism that could be used to address nonindigenous species pathogens in drinking water systems. One goal of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) is to reduce the use of pesticides to control noxious species. The control of nonindigenous species often requires an increase in pesticide application. The Food Quality Protection Act (FQPA) is also related to the use of pesticides. The Pollution Prevention Act (PPA) may facilitate the development of new technologies to combat nonindigenous species from point sources, such as ships and aquaculture farms.

The EPA mandates and activities that are most likely to be impacted by nonindigenous species are ecological assessments, risk assessments, socio-economic and comprehensive watershed management plans, and ORD programs.

Blue Group —
Dave Klauder, U.S. EPA, Office of Research and Development, moderator

The blue group began by asking themselves how nonindigenous species frustrate EPA in meeting its mandates and goals. The FIFRA rapid approval was the first point of contention that was mentioned. Most group members agreed that the CWA was the most directly related to nonindigenous species. Permit discharges, water quality issues (including low dissolved oxygen), individual state criteria, and biocriteria were all mentioned as issues that could be affected by nonindigenous species. Nonindigenous species also pose a possible health threat to humans by way of pathogens in drinking water. In terms of the Clean Air Act, acid rain is often a stressor to forests, which could make them more susceptible to nonindigenous species. Estuary management plans could be changed to include nonindigenous species. If nonindigenous species are classified as pollutants , it would change the way the Agency conducts ecological and health risk assessments. There also will be an increase in litigation if nonindigenous species are classified as pollutants.

Red Group —
Russ Jones, U.S. EPA, Office of Pesticide Programs, moderator

The red group also went through different EPA regulatory vehicles to determine which ones may have an impact on the Agency's response to nonindigenous species. CWA Sections 404 (wetlands remediation) and 319 (Nonpoint Source Management Program, with its objective of a balanced indigenous population) were mentioned as regulations that may be used to address nonindigenous species. The Clean Water Action Plan would have to incorporate nonindigenous species if they are determined to be pollutants. TMDLs and regulations governing the treatment and disposal of dredged material are also Agency-regulated issues that could be used to address nonindigenous species problems. FIFRA's goal to reduce the risks associated with pesticide usage could be used to justify the prevention and management of nonindigenous species. Secondary impacts of EPA's programs and activities, such as phytoremediation, monitoring programs, and investigations into disease vectors, also address relevant nonindigenous species concerns. The Endangered Species Act also may be used as a mechanism for regulating nonindigenous species.

SUMMARY OF BREAKOUT SESSIONS

Nonindigenous species will have a direct impact on EPA's programs. The CWA, FIFRA, and other statutes can be used to provide the Agency with regulatory authority concerning certain nonindigenous species issues. EPA needs to determine what role it should play in the management, control, and prevention of nonindigenous species invasions. This workshop will help summarize the information management needs to evaluate the nature of the problem and their potential options.

Introduction to Day 2 —
Mike Slimak, U.S. EPA, Office of Research and Development

Mike Slimak presented an overview of EPA's nonindigenous species activities. Nonindigenous species are considered to be the second greatest threat to ecosystems after habitat loss. Although

nonindigenous species invasions have occurred throughout history, it appears as though the rate of invasions is on the rise. Researchers often site Williamson's "10 rule;" approximately 10percent of nonindigenous species become established outside their natural environment, and 10percent of these perpetuate, posing a threat to the native ecosystem. Hence, only one percent of all introduced nonindigenous species ever become a problem. Many scientists believe that number is increasing.

Many people do not realize that several of our cultivated crops, range animals, and commercially and recreationally harvested fish are nonindigenous species. A species becomes invasive when population levels become unchecked and the organism begins to do harm to the native habitat. There are many pathways by which nonindigenous species enter our environments, including aquaculture, the aquarium trade, biological control, channels, locks and canals, the live bait industry, nurseries, scientific research, ballast water and hull fouling on boats, recreational sport fishing, and restaurants and retail seafood operations. One of the most damaging consequences of invasive nonindigenous species are their potential to dominate the native ecosystem, causing the decline or extinction of native species. Among the numerous examples of the damaging affects of nonindigenous species on ecosystems are the loss of the American chestnut from blight, defoliation of the eastern forests by gypsy moths, reductions in lake trout from the sea lamprey, and the loss of benthic diversity from the zebra mussel. Knowledgeable scientists and researchers must educate the EPA, other agencies and organizations, the public, and Congress about the threats posed by nonindigenous species.

There are many indirect and manifold effects of nonindigenous species that are rarely addressed. Nonindigenous species and climate change are inextricably linked; some invasive weeds now have time to flower and set seeds due to changing climate. Nonindigenous species have a profound impact on co-evolution of ecosystems. Most agree that there are definite human health endpoints, although there is little agreement on ecological endpoints. The key is convincing management that this issue is worthy of their time and money. Legal authorities are fragmented, underfunded, and often unenforced. Executive Order 13122, which was signed by President Clinton, represents an attempt to get federal agencies to work together to address nonindigenous species issues.

One participant asked whether EPA has a niche when it comes to nonindigenous species. Slimak noted that examples include the Aquatic Nuisance Species Taskforce, the Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW), the National Invasive Species Council, numerous research and monitoring efforts (including EMAP, regional assessments, MAIA, and ReVA), international activities (IJC), uniform national discharge standards, pesticides control (FIFRA), Clean Water Act regulations, and NEPA. EPA representatives are currently serving on the National Invasive Species Council workgroups. A draft of the interagency invasive species Management Plan has just become available. The five Regional nonindigenous species workshops, in conjunction with this national workshop, were designed to disseminate knowledge about nonindigenous species while at the same time increasing awareness. ORD's Integrated Science for Ecosystem Challenges (ISEC) initiative and the STAR grant program are further examples of EPA programs designed to address nonindigenous species issues.

Slimak left participants with several questions to consider:

- How does the nonindigenous species crisis compare to other ecological threats (such as habitat loss, climate change, acid rain, and ozone depletion)?
- Is the nonindigenous species problem really a crisis, or are human-mediated range expansions any more troublesome than natural movements?
- What is at risk when species become invasive?
- What can be done to limit invasions?
- Given the rapid pace of globalization, is it futile to try to control nonindigenous species?
- What role should the government play in managing nonindigenous species? The private sector?

An Overview of the Office of Water's Activities and Concerns —
Diane Regas, Deputy, Assistant Administrator, U.S. EPA, Office of Water (OW)

Nonindigenous species have the potential to impede the overall goals of the Agency. The Office of Water (OW) takes nonindigenous species seriously and uses several tools to deal with them, including regulations, grants, interagency coordination, and partnerships with the private sector. OW's activities include prevention of nonindigenous species, and restoration of habitats that have been impacted by them. OW needs good science to do its job.

Uniform National Discharge Standards (UNDS), CWA, and Sec. 312: OW is currently writing regulations on standards for Armed Forces vessel discharges, including ballast water discharges, hull cleaning, and antifouling paint. Although UNDS applies only to Armed Forces vessels, the technology could be transferred to commercial and recreational vessels.

Ballast Water Regulation: In response to a petition to regulate ballast water, OW has been studying implications, chances of success, "slide effects," technological limitations, gaps in knowledge, and gaps in regulations. Early areas of consensus include the agreement that the threat is real, that EPA has a role to play in this issue, that the CWA does provide EPA with authority, that the biggest impediment is the lack of treatment technologies, and that EPA should encourage the development of new technologies. EPA is also working with the Coast Guard and the ANS Taskforce to develop standards for ballast water treatment. EPA is working with the International Maritime Organization (IMO) to develop an international ballast water treaty. In addition, several states, including California, recently passed their own ballast water standards.

National Invasive Species Council: Under an Executive Order, EPA is assisting with the development of a National Invasive Species Management Plan. An Aquatic Nuisance Species Taskforce has been established to coordinate nonindigenous species efforts among government agencies. The ballast water management focus is shifting from research to action.

National Estuary Program (NEP): The 28 NEPs are national watershed management models. In 1997, nine NEPs identified nonindigenous species as a high or medium priority in their watershed. In addition, NEPs designated nonindigenous species as one of seven key management issues that need to be addressed. The NEPs have been instrumental in funding research on the local impacts of nonindigenous species. In the San Francisco Estuary, between 95percent and 99percent of all organisms are non-native. In the Indian River Lagoon in Florida, three exotic

plant species, namely the Brazilian pepper, Australian pine, and melaleuca tree, have wreaked havoc on the native ecosystem. Control of these species is costly, but, thanks to the efforts of citizen volunteers, progress is being made in the management of these nonindigenous species.

Wetlands Restoration: EPA is fully committed to fulfilling the goals of the Clean Water Action Plan (CWAP). OW supports the Five-Star Restoration Grant Program, which brings together citizen groups, corporations, youth conservation corps, students, landowners and government agencies to undertake projects that restore streambanks and wetlands. The program provides challenge grants, technical support, and peer information exchange to enable community-based restoration projects. Grants have recently been awarded to the Caddo Native American Tribe, and communities in Colorado, Arizona, Texas, Idaho, and Oregon.

Biocriteria: OW strongly supports state biocriteria development. Biocriteria provide states with water quality standards and benchmarks against which they can measure progress. On average, it takes three to four years for a state to develop a biocriteria program. EPA probably will not mandate the development of biocriteria by states.

Aquaculture: OW has begun preparing aquaculture effluent guidelines that will address nonindigenous species. OW sought input from stakeholders regarding how nonindigenous species should be addressed in these guidelines. Two consensus points regarding nonindigenous species and aquaculture emerged: 1) all aquaculture facilities have the potential for nonindigenous species escapes; and 2) nonindigenous species problems stemming from aquaculture operations exist in freshwater as well as marine systems.

Total Maximum Daily Loads (TMDLs): Twenty-six waterbodies in five states are considered impaired because of nonindigenous species. More than 800 waterbodies are listed as impaired because of invasive aquatic plants (both native and nonindigenous). California recently listed some portions of San Francisco Bay as impaired because of nonindigenous species.

Water Diversions: Anthropogenic water diversions provide a potential pathway for nonindigenous species introduction and spread. EPA is diligently working to address the threats posed by water diversions that have the potential to transfer chemical pollutants. Some proposed water diversions may provide new nonindigenous species pathways and should be reevaluated given this potential threat.

Major Research Needs:

- Investigation into new methods of ballast water treatment
- Understanding nonindigenous species vector sources
- Evaluating habitat vulnerability
- Determining the efficacy and cost of nonindigenous species prevention options and monitoring activities.

In conclusion, nonindigenous species are major environmental problem. OW is devoting significant resources and attention to nonindigenous species prevention and restoration. Research will play a vital role in nonindigenous species prevention and control activities. OW welcomes the opportunity to work closely with ORD in developing a nonindigenous species research agenda to guide future Agency management decisions and actions.

One participant asked why EPA is dealing with ballast water. Regas explained that EPA is not a "species" agency. EPA can play an important advocacy role and bring nonindigenous species issues, including those associated with ballast water, into the national spotlight. The Agency must work to restore impaired waterbodies and foster a watershed approach to nonindigenous species management. In addition, EPA must continue to address the use of pesticides and biocides to control nuisance species.

Another participant noted that research and development provides the knowledge that is necessary to make informed decisions. Agency scientists have been making technical recommendations to management, but management has not been able to determine how to transfer this knowledge to the Agency's goals. Regas responded by noting that scientists must understand management tools and the limitations of these tools. Budget constraints and existing commitments are a problem, but we are working on getting more money to address nonindigenous species issues.

PEPCO's Integrated Vegetation Management Program/Pesticide Reduction — Steven, Genua, PEPCO

The Potomac Electric Power Company (PEPCO) serves the electrical energy needs of the Washington, DC, metropolitan area. The service area is supplied by a network of transmission lines along 330 miles of rights-of-way, which covers approximately 10,000 acres. PEPCO utilizes various management tools to control and maintain the vegetation on the rights-of-way. Many factors affect the prescriptive analysis for taking care of these rights-of-way, including: aerial inspections; use of barricades and debris removal; brush control; removal of conflict trees; and tractor mowing.

In 1998, PEPCO experienced an electrical outage on one of its circuits due to a single tree that grew into the wires. Upon further inspection, PEPCO found 350 other undesirable trees that were too close to the wires. To address this problem PEPCO developed a meadow management program, which required a one-time mow to remove all vegetation and an application of herbicides to remove undesirable woody species from resprouting. This management method, however, resulted in the introduction of some non-native plants, which has required work on four fronts: prevention of additional introductions; early detection and eradication of new pests; control and management of established problem species; and protection and recovery of native species and ecosystems.

In response to questions from the participants, Genua indicated that while other power companies have used sheep to control the invasions of nonindigenous species, PEPCO has not. PEPCO is trying to work with EPA's Pesticide Stewardship Program to reduce its use of pesticides, and has worked with its neighboring communities to receive feedback on how it should deal with land maintenance issues. PEPCO is working with the Fish and Wildlife Service to address migratory birds, and is looking to other groups to collaborate with as well.

Science Area 1: Ballast Water–Science Issues Related to Environmental Impacts and Management of Ballast Water— Mike Slimak, U.S. EPA, Office of Research and Development (ORD)

Ships can be considered "biological islands." As the nature of ships and shipping has changed, so too has the nature of organisms in ballast water. Modern vessels can cross oceans in a matter of days, allowing organisms to survive the trip inside ballast tanks before they are emptied into

coastal or inland waterways. Ballast water is the primary vector for aquatic nonindigenous species. There are a number of ballast water management methods that have emerged in recent years, the most common of which is mid-ocean ballast water exchange. In the Great Lakes, ballast water exchange is mandatory due to the sensitivity of the region to nonindigenous species. To date, ballast water exchange has proven to be moderately successful. Pockets of un-exchanged water and sediment containing nonindigenous species can remain in the hull during and after mid-ocean exchange. In addition, mid-ocean exchange does not work for ships that travel the inter-coastal waterways.

Shore ballast water reception and treatment facilities are other options being explored, although this method of treatment is extremely costly. Other innovative treatments under consideration include *in-situ* chlorine treatment, physical separation technologies, filtration, thermal treatment, biocides, cyclonic technologies, and UV treatment. Research is the key to developing new technologies that are effective.

Science Area 2: Wetland/Riparian Protection and Restoration—
Paul Jones, U.S. EPA Region 9

Wetland and riparian areas are being threatened by nonindigenous species. Exotic cordgrass species (*Spartina*), for example, are altering wetland and riparian habitats, which can affect endangered species. Herbicide control of these cordgrasses may have negative impacts on these habitats, and may lead to potential lawsuits, causing a slowdown of the pace of wetlands restoration. Other problem species in wetland and riparian habitats include Giant Reed and Cape Ivy. Hawaii's wetlands and riparian areas also are being threatened by nonindigenous species. Some noxious weeds that were introduced to Hawaii with the best of intentions have dried up wetlands. Research needs to be conducted to better understand the life histories and growth control measures of these species before we can properly and effectively act to control the problem.

Science Area 3: TMDLs–Science issues related to listing and implementation of TMDLs—
Henry Lee, U.S. EPA, Office of Research and Development (ORD)

There are at least three ways in which nonindigenous species are related to TMDLs. One is to implement a TMDL to control an existing exotic species. For example, in the Rocky Mountain States, a TMDL could be implemented to combat the nonindigenous parasite that causes whirling disease. This parasite, *Myxobolus cerebralis*, must be ingested by tubifex worms before it can infect trout. Tubifex worms are pollution indicators that are found in sediments that are high in organic material, such as those near sewage treatment plants. It may be possible to reduce the parasite load by issuing a TMDL that will decrease organic loading, thereby reducing the number of tubifex worms that can act as hosts for the metazoan parasite. Another type of TMDL would be for the prevention of the introduction of new nonindigenous species, as was proposed for San Francisco Bay by the Regional Water Control Board. In this case, the load of new nonindigenous species was set at zero. Discharges of ballast water was assumed to be the major vector, so the TMDL would manage ballast water discharges through mid-ocean exchange or treatment. Finally, nonindigenous species can indirectly affect TMDLs for chemical pollutants, nutrients, or clean sediments by altering the fate and flux of these pollutants. For example, dense populations of filter-feeding bivalves, such as zebra mussels, can strip contaminants from the water column and deposit them in the sediments, altering both their bioavailability and the species exposed.

Several questions must be answered before we can address the nonindigenous species issue by using TMDLs, including:

- How do we define impairment with nonindigenous species?
- Is an ecosystem impaired if it retains similar ecological functions?
- How do we address biotic changes from stocked fish?
- How do we define the acceptable loading for nonindigenous species?
- What are feasible ballast water treatments?
- How do we balance the direct impacts of nonindigenous species versus the impacts resulting from their control?

Science Area 4: Pesticides —
Dan Rosenblatt, U.S. EPA, Office of Pesticides

Currently, there are 30 major pesticide producers and 100 small pesticide producers that are regulated by EPA. There are 2,500 pesticide formulators, 600 active ingredients, 20,000 pesticide products, and one million farmers that use pesticides on their crops. In 1999, EPA registered 26 new active ingredients, and made 1,000 decisions on old chemicals being used in new products, 3,500 decisions on labeling and formulation amendments, 350 decisions on tolerances, and 109 decisions on inerts. Before a new pesticide makes it to the U.S. market, it usually takes up to four years to develop the appropriate data needed to bring it to market, and another two to three years to register it through EPA.

In 1996, Congress passed the Food Quality Protection Act (FQPA), which required new safety factors to protect infants and children and made new labeling requirements. Section 18 of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) allows EPA to exempt state and federal agencies from provisions of FIFRA if emergency conditions exist. Emergency conditions are met when an urgent, non-routine situation arises that requires the use of a pesticide that is not registered, and when no economic or environmentally feasible alternative practice is available. This kind of situation could arise when a new pest is introduced, or when there is a threat to human health, endangered species, beneficial organisms, or the environment. Types of emergency exemptions include specific exemptions, quarantine exemptions to control the spread of introductions, public health exemptions, or crisis exemptions. Existing quarantine programs being implemented for nonnative pests by Section 18 include those for: olive fruit fly; Mediterranean and Oriental fruit flies; brown tree snake; exotic ticks or imported reptiles; and karnal bunt. Special provisions included in the Mediterranean fruit fly eradication program are: door-to-door advance notices; multi-lingual fact sheets; public meetings and citizen hotlines; outreach to public health and veterinary clinics; special notices to chemically-sensitive persons; and non-target protections for bees, water body buffers, and endangered species.

BREAKOUT SESSION—DAY 2

The participants were divided into four groups to discuss actions EPA can take to address the four science areas previously discussed. The report-outs from these breakout groups follow.

Ballast Water Breakout Group Report

The ballast water breakout group focused its discussion on performance standards, assessment, and research. In the area of performance standards, the breakout group suggested that EPA focus on the following:

- Performance standards versus technical-based standards
- What do we really mean when we say that a particular method is 90percent effective
- Regional versus national standards and the role that the states and federal government would play
- What organisms really need to be controlled (e.g., is it necessary to develop techniques to eliminate dinoflagellates and viruses or is it sufficient to control fish and invertebrate larvae).

In the area of assessment the breakout group suggested that EPA focus on the following:

- Comparison of technologies as they relate to risk, efficacy, cost, and treatment
- Testing of basic assumptions (e.g., are 30percent of nonindigenous species really coming from ballast water; how certain must EPA be to act)
- Vulnerability assessments to define "risk zones" and types of ships posing the greatest risk (this may require collaboration with the shipping industry to redesign ships).

In the area of research the breakout group indicated that research is critical for setting standards for treatment options and ballast water discharge locations.

Wetland/Riparian Restoration and Protection Breakout Group Report

During this breakout session, the group identified a list of things that EPA should consider in the area of nonindigenous species invasions in wetlands and riparian areas:

- Educate the U.S. Army Corps of Engineers regarding the introduction of new species to wetland areas
- Take caution in restoration areas (e.g., disturbed areas) because these areas often provide a place for nonindigenous species to proliferate
- Conduct research on disturbed species.

The group also identified a list of things that EPA should achieve in the area of nonindigenous species:

- Restore and maintain the understory of wetland and riparian areas to decrease runoff.
- Maintain recreational enjoyment.
- Prepare case studies on areas that municipalities have designated as "no pest" areas to see what has worked and what has not.
- Conduct an inventory of what is being done to improve communication and foster communication (e.g., list of web sites, available tools, and technologies to address nonindigenous species).

- Conduct further work on the EPA management strategy to better "frame" the nonindigenous species issue to management.
- Focus on protection and prevention.
- Conduct research and make investments to develop better detection tools to determine when we have a problem.
- Identify ways to identify and characterize the direct and indirect impacts of nonindigenous species.
- Prioritize the issues related to nonindigenous species (e.g., by ecoregion and waterbody type).
- Make sure that all plant species used to restore wetlands are acceptable; develop a list of preferred and non-preferred species.
- Train in-house staff about the issues related to nonindigenous species.

The group also identified a list of science questions that need to be answered before EPA should begin to address nonindigenous species:

- How much do we need to know before starting to address nonindigenous species?
- What do we need to know in the areas of hydrology, biocriteria?
- If we start too soon, will we create more problems?
- What are the methods?
- What are the desirable species?
- Are diverse communities really better than monoculture communities; do we need to mirror natural processes?
- What are the reference conditions?
- How will the evolution of infrastructure changes, climate change, sea level rise, stress/responses, and innovative technologies, such as bioengineering, affect decisions?

The group then specifically recommended that EPA resolve its legislative authority in the area of nonindigenous species before acting on some of the nonindigenous species problems. In addition, it suggested that EPA and its partners evaluate and revise existing policies and guidance to properly address nonindigenous species and native species; promote nonindigenous species concerns and issues within EPA and beyond; provide better mechanisms for coordination and integration; improve fundamental understanding of the condition of the nation's ecosystems; and improve tools and processes for early detection of nonindigenous species.

TMDLs Breakout Group Report

The TMDLs breakout group first reported on the issues for which they had consensus. First, the group recognized that by definition, a TMDL only can be assigned if loadings of a pollutant reduces water quality or impairs a water body. Given that, the group decided that TMDLs could be assigned for introductions of new nonindigenous species from ballast water discharges and for discharges from the aquarium trade and aquaculture. In these cases, there are identifiable discharges that could be regulated. Although there was not complete consensus, it was mentioned that it might be possible to implement TMDLs to control existing populations of

nonindigenous species by regulating the loadings of "ecosystem drivers," such as fine sediments or water flow in streams. In such cases, it was not clear whether the TMDL would be for nonindigenous species or for the sediment or water flow, for example. There was general agreement that invasions of nonindigenous species could indirectly affect TMDLs for toxic pollutants, nutrients and sediments by altering runoff and pollutant fate.

The group also raised several other issues:

- There is a close relationship between nonindigenous species and the use of biocriteria; use of biocriteria will be driven by or modified by nonindigenous species.
- The next sleeping giant for nonindigenous species is the anti-degradation clause in the Clean Water Act.
- EPA's guidance on nonindigenous species in relations to TMDLs needs to be clarified.
- The Regions and states need to be better educated on ways to address nonindigenous species.
- Research is needed to define impairment by nonindigenous species, but this will not be done unless it is driven by policy and guidance.
- It may be possible to develop holistic TMDLs that do not violate state standards, but address the issue of "balanced indigenous populations."

Pesticides Breakout Group Report

The pesticides breakout group focused its discussion on what EPA's Office of Pesticide Programs, other EPA Program Offices, and the Agency as a whole can do to address the nonindigenous species issue and to interact with the private sector. The following action items were identified:

- EPA needs to promote more education and outreach—both within and outside EPA.
- EPA needs to determine ways that it can more quickly generate the data needed for registration of new pesticides that may be effective on nonindigenous species.

Other issues of concern that were identified included the use of pesticides in nonindigenous species eradication efforts. For example, in the case of small nonindigenous species infestations, the use of pesticides to eradicate a species may be fairly straightforward. However, in the case that an nonindigenous species infestation covers several thousands of acres, the Endangered Species Act may preclude pesticide application and alternative mechanisms to eradicate the nonindigenous species may need to be identified.

Wrap Up —
Mike Slimak, U.S. EPA, Office of Research and Development (ORD)

Mike Slimak (ORD) thanked Henry Lee (ORD) for being so passionate about the nonindigenous species issue and for taking the lead to plan this workshop. He also thanked the speakers and all participants for attending the meeting.

He then recapped the main issues that were heard during the workshop:

- EPA and other federal agencies have a role to play to address nonindigenous species.
- While EPA's current regulations do not provide EPA with clear direction on how to deal with the nonindigenous species issue, EPA will need to figure out its role in addressing these issues.
- EPA needs to commit resources to the nonindigenous species issue.

Slimak encouraged participants to brief their colleagues about this meeting at their next staff meeting or by holding a briefing with their Program Offices or Regions. He then agreed to send the Invasive Species Draft Management Plan to all attendees who request a copy. The draft also is available on the Internet at http://www.invasivespecies.gov.

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U.S. EPA Nonindigenous Species Workshop

Radisson Barcelo Hotel•Washington, DC• July 12-13, 2000

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