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

Problems and Innovations in Controlling Brown Treesnakes on Guam

By Thomas H. Fritts

The arrival of the brown treesnake, *Bioga irregularis*, to the Island of Guam in post World War II ship traffic resulted in a colonization of a formerly snakeless ecosystem by an aggressive nocturnal predator. About 50 years have passed, but faunal perturbations and other ecological changes are still underway. Only recently are the complexities of the problems produced being fully documented. Although first documented in the 1950s, the brown treesnake population on Guam grew rapidly in the 1960s and continued to do so until the mid 1980s when the terrestrial vertebrate fauna collapsed to unprecedented levels.

The snake's success on Guam was likely due to differences in the ecological conditions encountered compared to its native range of eastern Indonesia, New Guinea, Solomon Islands and coastal areas of northern and eastern Australia. Guam presented exceptionally good prey resources. Guam's abundant lizards became food for the smallest snakes, and the high populations of introduced rodents, shrews, and birds as prey for the larger snakes. Guam also hosts a moderately diverse native bird fauna with no or limited evolutionary histories with snakes or comparable stealthy, nocturnal, arboreal predators.

Brown Treesnakes *continued on page 2*

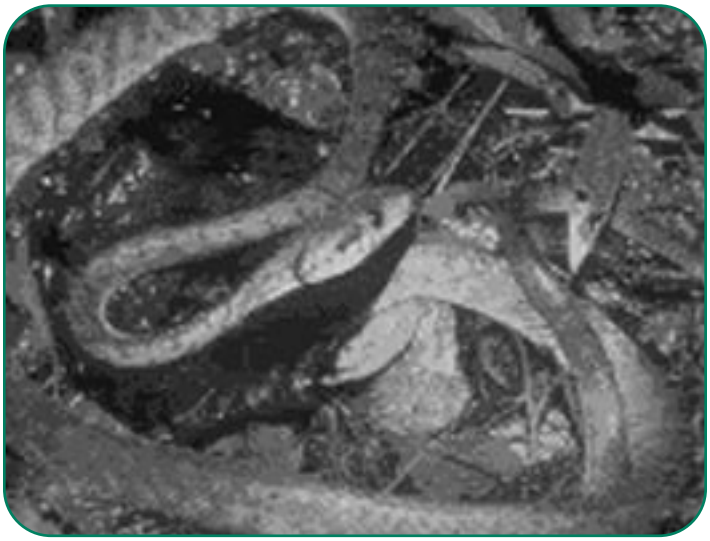

Figure 1. Brown Treesnake, *Bioga irregularis*.

ANS Prevention and Control Programs– CANADIAN PERSPECTIVES

Contributing Authors: Vic Cairns, Madhu Malhotra, Alan Dextrase amd Louise Lapierre

The prevention and control of nonindigenous aquatic nuisance species (ANS) in the Great Lakes-St. Lawrence ecosystem is a transboundary issue demanding binational management. Vectors of ANS introduction and spread revolve around interstate and international commerce. Activities such as ballast water discharge, horticulture, aquaculture, and baitfish and aquarium trades contribute to movement of invasive species across political and ecological boundaries.

Given these realities, the Great Lakes Panel on Aquatic Nuisance Species and the Great Lakes Commission, which staffs the Panel, recognize the importance of Canadian-United States partnerships in addressing challenges posed by ANS prevention and control. To complement past articles that have presented ANS issues from U.S. and state perspectives, this feature highlights the federal and provincial perspectives of our Canadian partners.

Federal Programs

The Canadian Department of Fisheries and Oceans (DFO) has a range of ANS-related activities occurring in the Great Lakes-St. Lawrence basin. Current research

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Brown Treesnakes *continued from page 1*

Snakes Cause Havoc

Seventeen species of vertebrates disappeared from Guam as a result of the eruption of snakes. Several bird species that remain are at dangerously low population levels and at risk of disappearing in the coming years. The snakes invaded agricultural areas, suburban housing areas, and commercial sites on Guam. Pets and poultry were killed and eaten; adults and children were left with life-threatening snake bites; and power outages became frequent, when snakes, climbing on power equipment and lines, simultaneously contacted charged conductors and grounded objects.

Guam's tourists and residents alike are traumatized occasionally by confrontations with snakes and inconvenienced frequently by the power outages that impact everything from traffic signals to nightclub lighting. When snakes emerged from overhanging foliage too frequently for the comfort of guests, "The Tree Bar", in one of Guam's largest hotels, was compelled to remove the large fig tree for which the poolside bar was named. The abundance of snakes even affected activities of the United States military bases on Guam including military traffic to other areas, construction projects, readiness training, management of wildlife on military lands, and even normal base operations.

The Threat Broadens

Snakes began showing up in ship and air traffic arriving to other snake-free islands and continents from Guam. The brown tree snake was identified as the cause of a wide range of ecological and economic problems on Guam. The realization of risks to Hawaii, the Northern Mariana Islands, and other American flag islands created an unprecedented justification for research and control strategies of snake populations on Guam. To combat risks of further dispersal and colonizations, United States Department of Agriculture's Wildlife Services (formerly Animal Damage Control) has worked since 1993 to limit snake emigration from Guam by interdicting snakes in and around ports, airports, and cargo centers.

Common reactions to the details of the brown treesnake's effect on Guam's native fauna, ecology, and socio-economics span a broad range of expectations: "Why don't you just get rid of the snake?" or . . . "Surely now that everything is gone the snake has run out of food and will die off on its own." But unfortunately neither expectation is compatible with the real situation. Detailed research by United States Geological Survey, its predecessor research agencies, and United States Department of Agriculture counterparts, has been underway since 1990. The USDA initiated intensive management efforts in 1993. Research has produced much knowledge of the snake's biology and population dynamics and has tested the utility of control tools and techniques such as traps, hand capture, detector dogs, barriers, fumigants, and toxic baiting. Traps suitable for capturing the snake have been developed and enhanced over time. Knowledge of the snakes' habits has led to visual search and hand capture protocols capable of harvesting quantities of snakes from fence-lines and other specialized situations. Detector dog technology was adapted to the snake problem and dog/handler teams were trained to detect snakes in specialized cargo situations.

It's potentially informative to consider trends in snake capture at Guam's International Airport since 1994, the first full year of control activities, and to evaluate present levels of dispersal risks from in and near Guam's civilian airport facility. These trends also show how snake barriers recently developed by the USGS could complement trapping, hand capture, and detector dog teams in reducing such risks. Over the five-year period 1994-1998, the total number of all captures from the area of Guam's civilian airport facility (Won Pat and Tiyan combined) was 5395 with an annual mean of 1079 (Fig. 2). The total number of snakes for 1994 was 1360 and 1214, 979, 742, and 1100 snakes were captured for 1995-1998, respectively. The total capture for 1998 was 81% of that in 1994 and the average take for 1995-1998 was 74% of that in 1994. Encouragingly, the total capture has declined in all years except for one since 1994. However, the harvest remains in excess of 70% of the original annual capture, suggesting that many snakes are re-invading the area or remaining un-captured each year. The year with the lowest yield from traps had the highest hand capture rate, suggesting increased emphasis on one

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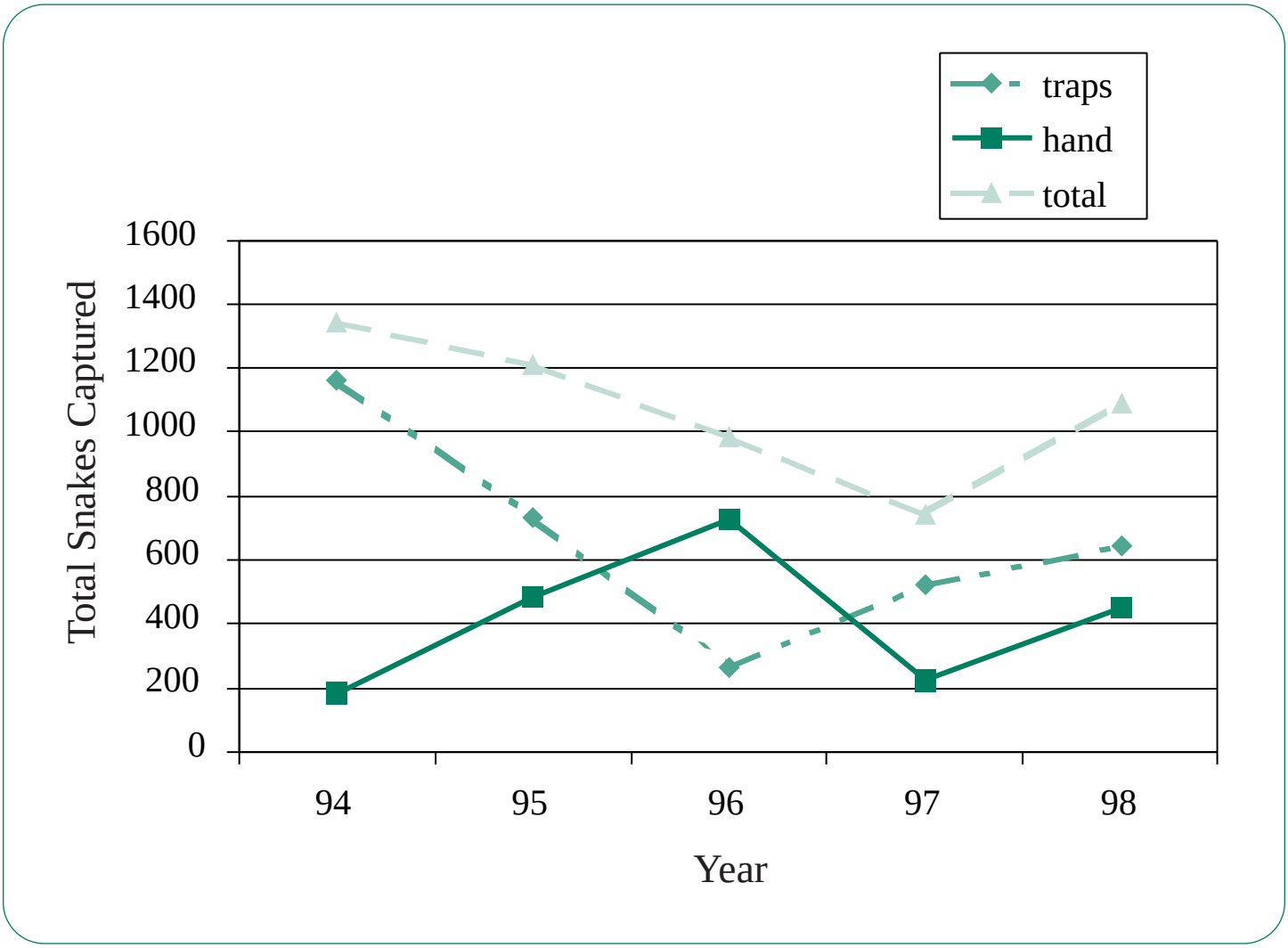

Figure 2. *Total captures from traps and hand efforts in and around Guam's Won Pat International Airport 1994-98.*

technique at the expense of the other (Fig. 2).

Detector dog teams are used to search cargo containers, vehicles, and airframes whereas trapping and hand capture efforts are largely focused on natural and artificial habitats at varying distances from developed airport facilities. The total capture rates for detector dog teams were 5 in 1994, and 0, 1, 2, and 7 for 1995-1998 respectively. Increasing captures by dogs probably reflect increased inspections with more dog teams and enhanced proficiency of the dog/handler teams. Most importantly, these captures evidence a persistence of snakes in and immediately adjacent to aircraft and cargo areas.

This data indirectly answers the two perspectives posed theoretically above: Why don't you get rid of them? and . . . Won't the snake disappear now that its so many prey species are gone? In brief, the magnitude of the task in controlling snakes on Guam is so great that getting rid of them is impossible with existing, and even developing, technologies. Just as importantly, the number of snakes has remained high even near Guam's airport, an urbanized area where snakes are taking advantage of abundant lizards as prey and are successful, even in the absence of several bird and mammal species.

The fact that many snakes are eluding capture or are moving into the control area is consistent with known limitations of the tools currently available. For example, traps are known to under-sample small snakes. This method of capture allows snakes in some size classes to remain in, and to be more likely to successfully enter, a trap-cordoned area. The brown treesnake is known to move over significant distances in its normal daily activity, moving on the order of 60 meters per day but sometimes up to 400 meters in a 24-hour period. They wander and only irregularly return to areas of previous activity. Such movements contribute greatly to the number of snakes that must be interdicted to protect transportation centers such as Guam's civilian airport. Untrapped snakes constitute an on-going threat of dispersal from Guam's airport as passive stowaways when they seek daytime refuge in cargo, airframes, and containers. Snakes allowed to mature and reproduce in transportation areas represent a source of additional snakes.

The data from Guam's civilian airport facility illustrates the magnitude of the task presented to Wildlife Services when considering the diversity of control areas in Guam's air and seaport facilities and both military and civilian situations. The efficacy of traps and other capture techniques could be magnified by the use of permanent barriers to prevent snake immigration into high priority areas. Most airport areas are open, mowed, artificial, or sparsely vegetated habitats where snakes would be quite accessible to control efforts if emigration from forested

Brown Treesnakes *continued on next page*

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and cliff-line habitats on the airport perimeter could be prevented. Priority sites for snake barriers would be areas along or parallel to the airport perimeter and especially near the adjacent forested cliff lines where snake populations are likely to be high.

At present, benefits of snake control are partially nullified because re-entry into the area results in predictable replacement of snakes from adjacent habitats where snakes abound. The potential for use of traps or hand capture in many of these perimeter areas is problematic because of karst substrates, vertical limestone cliff-lines, land ownership issues, the physical size of the bounding areas, and other factors. By excluding snakes from entering into the highest priority airport areas from unmanaged areas, appropriately positioned barriers could potentially reduce the need for captures by hand, dog teams, or traps. Modest increases in the United States Department of Interior's appropriations in 1999 and 2000 have allowed accelerated work on testing and the initiation of construction projects to place barriers in airport areas. Cooperative efforts are presently underway involving the United States Departments of Transportation, Interior, Defense, and Agriculture that are likely to lead to snake barriers being added to the control methods available in curbing the dispersal of brown treesnakes from transportation centers on Guam and within high priority sites in Hawaii and the Northern Mariana Islands.

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Brown Treesnake Annotated Bibliography and Overview
http://www.nbii.gov/invasive/browntreesnake

Brown Treesnake Fact Sheet (and other information on dispersal and electrical outages).
http://www.mesc.usgs.gov/research_briefs/bts/btree.htm

Overview of Problems Caused by Brown Treesnake on Guam
http://biology.usgs.gov/s+t/noframe/x181.htm

Biology in Focus Series Outlining Accomplishments and Scope of USGS Research Program
http://biology.usgs.gov/outreach/btspub.pdf

Upcoming Meetings

National ANS Task Force Meeting

November 28-29, 2000
Arlington Hilton and Towers
Arlington, Virginia
Contact: Joe Starinchak, USFWS, 703-358-2018
e-mail: Joe_Starinchak@fws.gov

2000 Midwest Fish and Wildlife Conference "Aquatic Exotics in the Mississippi River Basin"

December 3-6, 2000
Hyatt Regency Hotel
Minneapolis, Minnesota
Contact: Jack Wingate, 651-296-3327

The 5th Oregon Interagency Noxious Weed Symposium "Managing Noxious Weeds in a New Millennium"

December 5-7, 2000
Corvallis, Oregon
Contact: Dawn Zielinski, 503-986-4621
e-mail: dzielins@oda.state.or.us

National Conference "Control Strategies for Giant Salvinia"

March 14-16, 2001
Hotel Sofitel
Houston, Texas
More information to come.

11th International Conference on Aquatic Invasive Species

October 1-4, 2001
Hilton Alexandria Mark Center
Alexandria, Virginia
Call for Abstracts Deadline: December 17, 2000
Contact: Elizabeth Muckle-Jeffs,
800-868-8776 or 613-732-7068
e-mail: profedge@renc.igs.net

Send meeting announcements to:
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Deadline for the next issue is December 31, 2000.

Asian Swamp Eel Invasion Increases in Southeast

Compiled by Jeanne Prok

A new population of nonnative Asian swamp eels, *Monopterus albus*, was found earlier this year near the eastern border of Everglades National Park, in the area of Homestead, Florida. This new discovery places the eel within a mile of the ecologically fragile Everglades National Park. If the eels invade the park, there's a chance they could start causing disorder in one of the United State's most threatened ecosystems.

Asian swamp eel, *Monopterus albus*

On The Move

In late September 1994, Wayne Starnes, an icthyologist from the Smithsonian Institute, discovered the eel, originally collected by children studying at the Chattahoochee Nature Center in Georgia. Three years later, swamp eels were first discovered in Florida waters in two widely separated sites. In late summer 1997, U.S. Geological Survey researchers discovered a population of swamp eels while sampling fishes in ditches, canals, and streams flowing into Tampa Bay on Florida's Gulf Coast. At about the same time, students from Florida International University in Miami netted several small swamp eels while collecting aquatic plants from an artificial lake just north of Miami. Asian swamp eels, in these areas, are greatly increasing in number.

Upon discovery, biologists believed that the recent Homestead population represented an expansion of the population known to exist around the Miami-Dade/Broward County line. Genetic tests completed at Florida International University indicate that the Homestead population differs genetically from eels in northern Miami-Dade. The Homestead population is genetically closer to animals from populations originating in Southeast Asia, whereas the populations found previously in the Miami and the Tampa areas are nearly identical to samples from more northern parts of China.

Theories on the eel's entry to the United States are many. USGS scientists speculate they could be unwanted aquarium pets dumped into the wild or escapees from an aquarium fish farm. Another theory is that Asian immigrants intentionally introduced the eels, as the eel is a popular food fish in Asia.

Alarming Traits

Asian swamp eels thrive in shallow wetlands, marshes, swamps, streams, ditches, and ponds. The eel's biology makes it well suited for all types of habitats and extreme conditions. The species prefers freshwater, but can tolerate slight salinity and can also survive long dry spells. The eel breathes under water like a fish, but can slither across dry land, sucking air through a two-holed snout.

Swamp eels, which reach lengths of three feet or more, are predators, feeding on a diet of a variety of small aquatic organisms, including fishes and invertebrates. Yet, the eels are also able to survive weeks, and possibly months, without food. The eels are highly secretive, with most of their activities occurring at night. In the day, the fishes hide in thick aquatic vegetation or in small burrows and crevices along the water's edge.

The Asian swamp eels have a unique manner of reproduction. All young are hatched as females, and then, after spending part of their life as females, some eels transform into large males. This prolific species breeds year-round, with one eel laying as many as 1,000 eggs at a time.

The Asian swamp eel appears virtually unaffected to explosives and poisons, two techniques used to eradicate fish. Concussion sampling techniques, using detonating cord, did not work well on eels because they lack the large air bladder that makes fish susceptible to concussion blasts. In tests using rotenone, a poison that makes it impossible for fish to use oxygen, the eels simply raise their snouts above water and breathe air. Without natural predators, with its uncanny ability to survive extreme conditions, and its prolific growth rate, this fish is capable of having notable effects on other fish and bird populations as they compete for crayfish and small fish.

Control Efforts

A multi-agency workgroup, comprised of representatives from the USGS, U.S. Fish and Wildlife Service (USFWS), and Florida Game and Freshwater Fish Commission, has been formed to combat the spread of this exotic invader. Discussions of the working group center on research needs and development of a comprehensive strategy to eradicate or control the spread of the Asian swamp eel. Researchers and managers believe dispersal may be controlled through a combination of electric barriers, vegetation removal, and trapping. Since the discovery of the Homestead, Florida population, the agencies are collaborating on implementing an emergency response plan in an effort to eradicate the species or significantly reduce the population in areas adjacent to Everglades National Park.

To determine the abundance and more precise distribution of this population, USGS biologists are rapidly monitoring the Asian swamp eel. This program will help to determine resource managers' options for trying to contain or eradicate the eel before it can enter the Everglades National Park.

The USFWS has taken the lead in developing a draft Asian swamp eel management plan. The goal of the plan is to minimize environmental impacts caused by *M. albus*. Specific objectives include preventing further dispersal of species beyond present known distribution and minimizing impacts on water management needs and activities, particularly in south Florida.

For additional information on the Asian swamp eel, contact: Dr. James D. Williams, (Williams_Jim@usgs.gov), Dr. John L. Curnutt, (John_Curnutt@usgs.gov) or Dr. Leo Nico, (Leo_Nico@usgs.gov), at the USGS Florida Caribbean Science Center in Gainsville, Florida, or Pat Carter (Pat_Carter@fws.gov) at USFWS.

Another Successful Crab Invader:
The Asian Shore Crab *Hemigrapsus sanguineus*

By Nancy J. O'Connor

A recent marine bioinvader to the East Coast of the United States, the Asian shore crab *Hemigrapsus sanguineus*, is now receiving much attention both from scientists and the media. *Hemigrapsus sanguineus* is native to the western North Pacific Ocean, where it occurs from Russia to Hong Kong (Williams and McDermott 1990). The species was first found in 1988 near Cape May, New Jersey, and has since spread north to the northern Massachusetts coast and south to North Carolina (McDermott 1998), and probably will colonize northern New England. The crab was likely introduced in the mid 1980s as larval stages in ballast water (Carlton and Geller 1993; Williams and McDermott 1990). Although *Hemigrapsus sanguineus* is one of the most common crabs of Japan (Sakai 1976), it is not considered a nuisance species there.

Hemigrapsus sanguineus is not a large crab, males rarely reaching 40 mm in carapace width (Fukui 1988; McDermott 1998). Its carapace is squarish in shape, with three teeth on each side behind the eyes (Williams and McDermott 1990). The walking legs have a distinct banding pattern. Male crabs are somewhat larger than females and have more robust claws with a fleshy protuberance at the base of the movable "finger" of the claws (McDermott 1999). The species is highly fecund: females produce at least two broods of tens of thousands of embryos each in late spring and summer (Fukui 1988; McDermott 1998). The species has six planktonic larval stages that disperse for several weeks before settling and metamorphosing to juvenile crabs (Epifanio et al. 1998).

Hemigrapsus sanguineus primarily inhabits rocky intertidal zones in coastal areas and the lower reaches of estuaries (Ledesma and O'Connor in review). It has rapidly increased in abundance in areas it has successfully colonized. For instance, *H. sanguineus* densities in Falmouth, MA, on the south side of Cape Cod, averaged 0.1/m^2 in 1996 and 35/m^2 in 1998. In Sandwich, MA, on the north side of Cape Cod, average densities were 2/m^2 in 1996 and 29/m^2 in 1999. (O'Connor unpub. data). On parts of the Connecticut coast, the Asian shore crab occurs in densities of 90/m^2 (Lohrer pers. comm.). It will be interesting to see whether densities remain at this high level in the future.

Effects of Colonization

Naturally, crabs in these densities must be having some effect in their new ecosystem. Anecdotal reports and some data from the Connecticut coast (Lohrer pers. comm.) suggest that the Asian shore crab is displacing resident species of crabs, including the non-indigenous but very common green crab *Carcinus maenas*. To determine the magnitude of effects on other crab species, however, it is necessary to determine densities of crabs both at the beginning and well into the invasion. Such work is now being undertaken on the Massachusetts coast (O'Connor unpub. data).

Hemigrapsus sanguineus is an omnivore. Analyses of gut contents indicate it consumes macroalgae and benthic animals

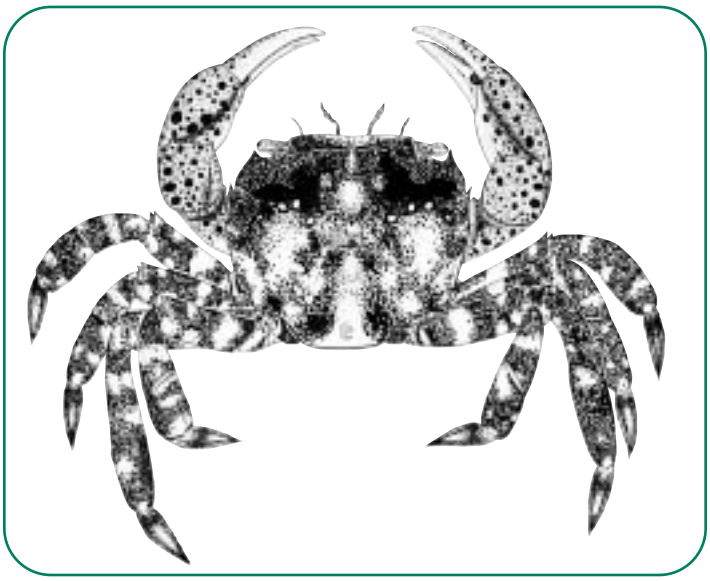

Figure 1. The Asian Shore Crab, *Hemigrapsus sanguineus.*

(Lohrer and Whitlatch 1997; McDermott 1999; Ledesma and O'Connor in review). In areas where it is very abundant, it may affect populations of prey species. In laboratory experiments, it eats bivalve molluscs such as juvenile blue mussels (*Mytilus edulis*), clams (*Mercenaria mercenaria* and *Mya arenaria*), and oysters (*Crassostrea virginica*) (Bourdeau and O'Connor 1999; Brousseau et al. 1999;McDermott 1999). The Asian shore crab may not affect natural populations of clams and oysters since those bivalves inhabit sedimentary environments not typically used by *H. sanguineus* (Ledesma and O'Connor in review). However, blue mussels are common members of rocky intertidal communities, and *H. sanguineus* might impact mussel populations, including those cultured commercially.

Basis for Success

Why has the Asian shore crab been successful so quickly in its new habitat along the east coast? Drew Lohrer suggests it was "pre-adapted" for colonization because its niche overlap with potential crab competitors is not high. Its high fecundity and long period of planktonic dispersal probably have contributed to its success and rapid range expansion. Predators of the crab are not known at present, but may include species of fishes, birds and mammals that feed in the intertidal zone. Yet predation may not be intense enough to greatly influence crab densities. In addition, parasites of United States populations of the crab appear to be few. In Japan, *H. sanguineus* is often parasitized by rhizocephalan barnacles (*Sacculina senta*) that interfere with molting and sexual functioning (Takahashi and Matsuura 1994). Similarly parasitized crabs have not been found in east coast populations (McDermott 1998a; O'Connor pers. obs.)

Asian Shore Crab *continued on next page*

Asian Shore Crab *continued from previous page*

A Teaching Tool

A positive byproduct of the invasion of the Asian shore crab is its usefulness as a teaching tool for the public, both through media coverage and its use by school teachers. *H. sanguineus* is a remarkably hardy crab, surviving well in classroom aquaria. Its habitat is readily accessible and the crabs are easy to collect and identify. These factors make it easy for children, even those of elementary school age, to study it on field trips and in classrooms. The Asian shore crab is an excellent tool for teachers to educate children about bioinvasions. Children can see, touch, and count the crabs while learning about species introductions and their consequent effects. The crab's use as an educational tool, however, also increases its chances of accidental release.

Hemigrapsus sanguineus is an established member of rocky intertidal communities throughout much of the east coast of the U.S. Although it may prove not to be a nuisance species with strong negative effects on coastal ecosystems, it has altered coastal food webs. However, the extent and magnitude of that alteration has yet to be determined.

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Genetic Sleuthing to Track Microscopic Weed Warriors

by Jan Suszkiw

Certain fungi and other microbes that attack invasive weeds offer an environmentally friendly method of controlling the pesky plants without resorting to traditional chemical herbicides, which may have harmful effects on our nation's water. The United States Department of Agriculture's Agricultural Research Service (ARS) scientists have developed molecular sleuthing techniques to monitor these biocontrol agents once released into the environment.

ARS plant physiologist Doug Luster says their approach can both detect and identify a weed pathogen's unique genetic "fingerprint" using polymerase chain reaction (PCR), amplified fragment length polymorphism (AFLP), DNA sequencing, molecular marking, and other sensitive technologies. These methods have already resulted in DNA fingerprints for several types of *Myrothecium verucarria*, a soil fungus that kills morning glories, a weed that plagues sugarcane and other crops.

In field studies, spraying redroot and small-flower morning glories with an oil-based carrier containing *Myrothecum* spores proved as lethal to these weeds as the herbicide Atrazine. Luster conducted the study with ARS plant pathologist Dana Berner and agronomist Rex Millhollon.

Though used in the lab, DNA fingerprinting is intended to help scientists keep close tabs on the spore growth and spread, host range and effectiveness of biocontrol pathogens like *Myrothecium* once they've been released to control weeds. The technology also allows researchers to pinpoint and analyze particular DNA regions that can differentiate strains of the same fungal family, such as *Puccinia carduorum* and *P.Jacea*, which attack musk thistle and yellow starthistle, respectively.

In weed-infested crop fields or pastures, for example, scientists hand-collect spore samples to identify weed pathogens and their whereabouts. They also examine the spores under a microscope, subject them to biochemical tests, and scrutinize infected plants for tell-tale disease symptoms.

DNA fingerprinting offers genetic evidence linking a specific microbial release to a specific disease seen in target weeds. It also reveals the spread of biocontrol microbes and demonstrates their effectiveness in reducing invasive weed populations.

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Canadian Perspectives *continued from page 1*

includes studies of food selectivity by round goby and the influence of the zooplankter, *Bythotrephes*, on energy cycling in Lake Erie, and the impact of zebra mussels on the trophic energy budget and the seasonal densities of the zooplankter, *Cercopagis*, in Lake Ontario. Continued involvement in the binational program to control sea lampreys includes the longstanding lampricide treatment program and the search for alternative control measures. More recent activities include proactive strategies to reduce future ANS introductions. Canada's National Code on Introductions and Transfer of Aquatic Organisms targets primary and secondary introductions from aquaculture-related activities. Ballast water management and associated treatment strategies are under development to reduce the risk of ANS introductions to the Great Lakes. Risk analysis, environmental impact, and socio-economic assessments are important in developing these strategies. These activities reflect DFO's intention to develop scientifically sound programs that are safe, enforceable, cost-effective, have limited impact on trade, and are consistent with international regulations.

Environment Canada is involved in research, monitoring, policy, and regulatory activities to advance ANS prevention and control. Current monitoring programs include implementing a suite of environmental indicators across Canada related to biodiversity and invasive species. These are aimed at early detection of potential problem species. Research efforts focus on zebra and quagga mussel impacts in Lake Erie, Hamilton Harbor, and the St. Lawrence River, as well as the species' impacts on water quality, phosphorus control, native mussels, and related taste and odor problems affecting Great Lakes drinking water supplies. Research into defining and reducing ecosystem vulnerability to invasive species is in its infancy. Discussions are underway toward a national strategy for nonindigenous invasive species and a framework for prevention of new introductions and control/eradication of established populations threatening ecosystems, habitats, and native species. A renewed Freshwater Strategy for water conservation and protection may also address ANS issues.

On the regulatory side, Environment Canada has authority under the Canadian Environmental Protection Act, the Wild Animal and Plant Protection, and Regulation in International and Interprovincial Trade Act to control the intentional importation of nonindigenous species posing environmental risks.

Ontario Programs

Bordering four of the five Great Lakes, Ontario has been affected by most Great Lakes ANS introductions. To prevent ANS introduction and spread in Great Lakes and inland waters, Ontario's program includes prevention initiatives, monitoring, awareness, control and containment, and liaison with other jurisdictions and agencies. The province has established a comprehensive Invading Species Awareness Program in partnership with the Ontario Federation of Anglers and Hunters. This program provides a province-wide, toll-free hotline to increase awareness of ANS materials around the province. The program also records ANS sightings in a central database. A survey of Ontario anglers conducted in 1998 revealed that effective awareness programs reduce the risk of ANS spread.

The lack of effective regulatory programs to control the discharge of ballast water has led to the introduction of a ballast water bill in Ontario, with recognition for more effective regulatory control at the regional level. Other pathways of introduction addressed by provincial programs include the release and escape of organisms from aquariums and water gardens in the Great Lakes basin. Fundamental to Ontario's prevention and control programs is raising awareness on ANS issues, as well as developing partnerships and cooperation between government agencies, the research community, industry, and nongovernmental agencies.

Québec Action Plan

The five-year Québec Action Plan for Aquatic Nuisance Species was established in 1998, resulting from a collaborative effort between the Société de la faune et des parcs du Québec and Québec's Ministère de l'Environnement. The plan's first priority is the prevention of ANS dispersal by vectors such as ballast water, boating, water transport, stocking, baitfish and aquaculture operations, and aquarium and ornamental pond release. It focuses on the production of outreach materials that target different water user groups to practice prevention measures. The second priority is to examine the need for regulatory changes to complete protection established under the Conservation and Development of Wildlife Act and Fisheries Act and their regulations.

Other priorities are investigations of damages to indigenous mussel populations of the St. Lawrence River resulting from zebra mussel invasions and the related effects on salmonids. The risks of ANS dispersal by the aquaculture industry and baitfish operators are being studied for the preparation of "Good Practices" guides. Early detection programs include goby and tench watches in collaboration with commercial fishermen, bait fish vendors, and sport fishers. Important to the Québec Action Plan is collaboration with other jurisdictions and departments in ANS prevention and control, such as those within St. Lawrence Vision 2000, a federal-provincial action plan for the protection of the St. Lawrence River. Collaborative efforts also occur with initiatives regarding species introductions (DFO), wildlife importation (Environment Canada), ballast water guidelines (DFO and Transport Canada, Environment Canada, Transport Québec), and partnerships with the Great Lakes community.

This article is a collaborative effort by:
Vic Cairns, Department of Fisheries and Oceans
Madhu Malhotra, Environment Canada
Alan Dextrase, Ontario Ministry of Natural Resources
Louise Lapierre, Société de la faune et des parcs du Québec

This article is taken from the quarterly newsletter, *ANS Update*, Volume 6. No. 3, published by the Great Lakes Panel on Aquatic Nuisance Species and the Great Lakes Commission. Contact: Katherine Glassner-Shwayder, Project Manager, Great Lakes Commission, 734-665-9135, shwayder@glc.org.

Cercopagis Invades the Great Lakes

By Patrice M. Charlebois

One of the most recent additions to the Great Lakes is a tiny ballast water stowaway native to the Black and Caspian Seas. *Cercopagis pengoi* is a small (< 2 mm body length) predatory crustacean that was first discovered in Lake Ontario in 1998. In the fall of 1999, researchers from Illinois Natural History Survey's Lake Michigan Biological Station found it in plankton samples from southwest Lake Michigan. In July 2000, University of Michigan researchers found that it had spread to several sites on the eastern side of the lake, and angler reports indicated that it has spread into Wisconsin.

Cercopagis, which has become known as the "fishhook flea," possesses a tail spine that can be up to five times as long as its body. In *Cercopagis*, the tail spine includes a predominate curve that resembles the curve in a fishhook. This curve separates it from the closely related *Bythotrephes cederstroemi*, known as the "spiny water flea", which invaded the Great Lakes in the 1980s. Mature *Cercopagis* individuals possess three pairs of lateral barbs on their tail spine. Because of this long, spiny appendage, *Cercopagis*, like *Bythotrephes*, is often found fouling fishing lines in the Great Lakes. The clogging of reels and fouling of nets makes this exotic species a potential nuisance in the aquatic systems that they invade.

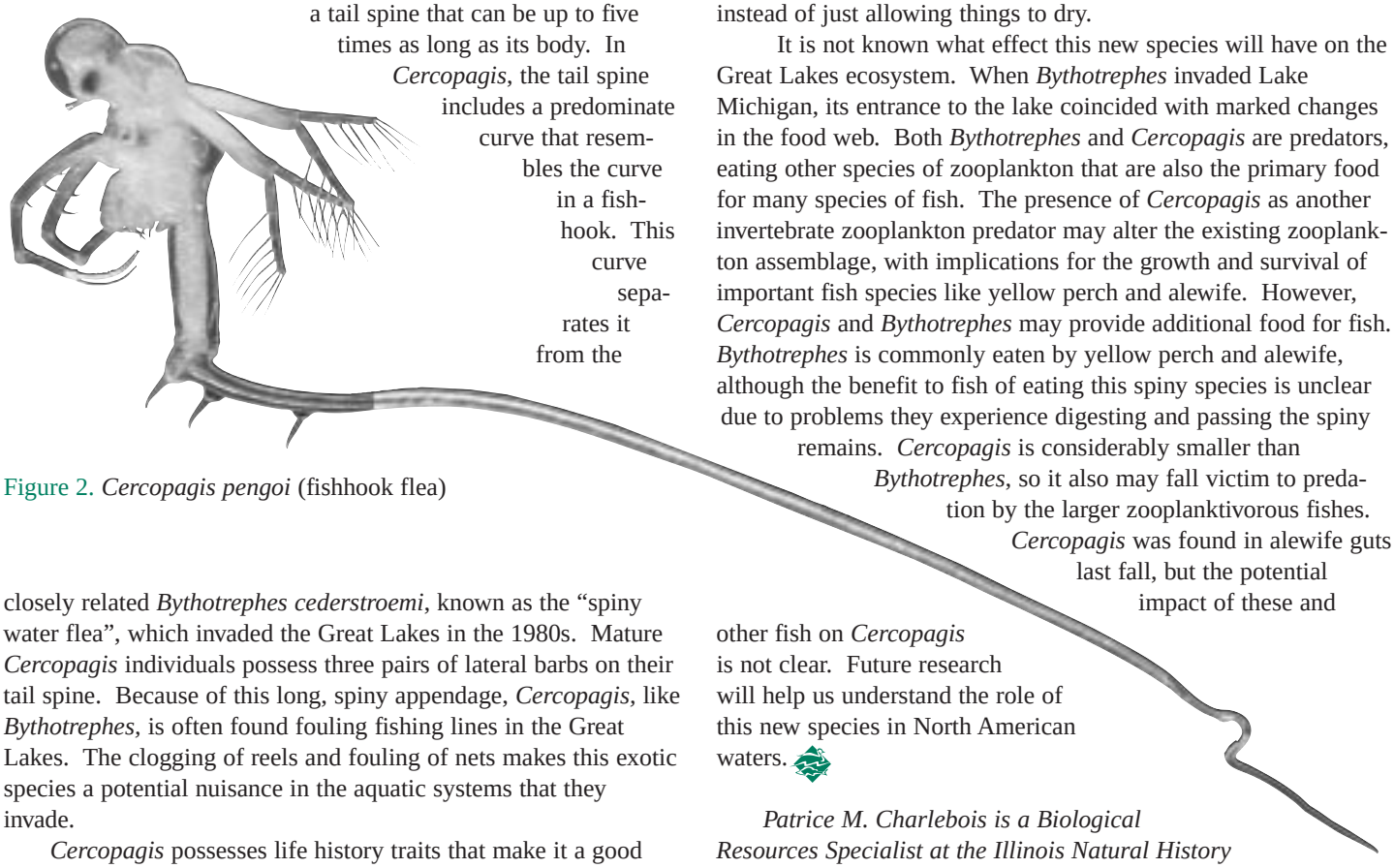

Figure 2. *Cercopagis pengoi* (fishhook flea)

Cercopagis possesses life history traits that make it a good invader. Like many other species of zooplankton, it reproduces by means of cyclic parthenogenesis, which means there is an alternation of reproductive mode. For most of the year, only females are present in the water. These females produce eggs asexually, which after a few days, are released as newborn daughters. With this mode of reproduction, a single introduced individual could potentially colonize an entire lake! When living conditions begin to deteriorate (not enough food, too many predators), something in the environment signals the females to begin producing sons instead of daughters. Once there are both males and females in the water, a different type of egg is produced. These eggs are known as "resting eggs" or "diapausing eggs" because, instead of hatching right away, they are capable of remaining dormant during the time when environmental conditions are bad. Once favorable conditions return, some of these eggs hatch and start a new population. Live animals require water to be transported from lake to lake. Therefore, the control measures used for other exotic aquatic species (e.g., emptying of bait buckets and live wells, washing and drying of all gear) will also help to reduce the spread of *Cercopagis*. The diapausing eggs are a different story. These eggs can hatch after they have dried up or frozen, even if it is several years later. Moreover, since females carrying these eggs can "stick" to fishing gear and other recreational equipment, care must be taken to thoroughly clean all equipment after leaving a lake, instead of just allowing things to dry.

It is not known what effect this new species will have on the Great Lakes ecosystem. When *Bythotrephes* invaded Lake Michigan, its entrance to the lake coincided with marked changes in the food web. Both *Bythotrephes* and *Cercopagis* are predators, eating other species of zooplankton that are also the primary food for many species of fish. The presence of *Cercopagis* as another invertebrate zooplankton predator may alter the existing zooplankton assemblage, with implications for the growth and survival of important fish species like yellow perch and alewife. However, *Cercopagis* and *Bythotrephes* may provide additional food for fish. *Bythotrephes* is commonly eaten by yellow perch and alewife, although the benefit to fish of eating this spiny species is unclear due to problems they experience digesting and passing the spiny remains. *Cercopagis* is considerably smaller than *Bythotrephes*, so it also may fall victim to predation by the larger zooplanktivorous fishes. *Cercopagis* was found in alewife guts last fall, but the potential impact of these and other fish on *Cercopagis* is not clear. Future research will help us understand the role of this new species in North American waters.

Patrice M. Charlebois is a Biological Resources Specialist at the Illinois Natural History Survey, Lake Michigan Biological Station, 400 17th Street, Zion, IL, 60099. Her major emphasis is nonindigenous species in Lake Michigan and inland surface waters of Illinois and Indiana.

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Nuisance Notes from the Western Regional Panel on ANS

State Updates

Alaska: Increase of interest in ANS issues by the public and a state legislator continues. Infestation of ANS populations of yellow perch on the Kenai Peninsula discovered and eliminated. No progress on state plan but support for full-time ANS contact soon looks promising. State ANS plan being developed in 2000. WRP State Contact: Bob Piorowski (907-465-6150).

Colorado: Personnel from the Colorado Division of Wildlife and the University of Colorado discovered a thriving population of escargot snails, *Helix promatia* on the west side of Pueblo, CO, along the Arkansas River in June, 2000. Specimens were collected and placed in the collection at the University of CO Museum, Boulder, CO. State WRP Contact: Chuck Loeffler CDOW (303-291-7451).

Guam: The Department of Agriculture and Division of Aquatic and Wildlife Resources has a policy in place banning the import of certain aquatic species, including nuisance species. DAWR also retrieves/accepts nuisance species when requested by the public. WRP Contact: Michael W. Kuhlmann (671-734-3942).

Kansas: Kansas Wildlife and Parks (KWP) is participating in a Minnesota Sea Grant Program boater education survey. The survey is part of nationwide survey to ascertain level of knowledge of recreational boaters on aquatic nuisance species. State WRP Contact: Tom Mosher (316-342-0658).

Montana: New Zealand Mudsnail monitoring and outreach efforts underway. WZMTF Contact: Tim Gallagher (406-444-2448).

Nevada: Exotic japanese freshwater crab Geothelphusa dehaani found in Lake Las Vegas. WRP Contact: Anita Cook NDW (702-486-5127).

North Dakota: Eurasian watermilfoil discovered in North Dakota State WRP Contact: Terry Steinwand ND Game and Fish Dept (701-328-6313).

Oklahoma: The Webbers Falls powerhouse (at L&D 16) had 36 zebra mussels /SM last April, compared to 688/SM in Feb 1999 and 1,255 in Nov 1997. It appears that the populations, first discovered in Feb 1993, peaked in 1997 & 1998. WZMTF Contact: Everett Laney, USACOE (9l8-669-7411).

South Dakota: l00th Meridian Boat Inspection stations were conducted in summer 2000. WRP Contact: Dennis Unkenholz (605-733-6770) SDGFP.

Washington: WA Dept of Fish and Wildlife received a grant to implement State Aquatic Nuisance Species Plan. WRP Contact: Scott Smith WDFW (360-902-2724).

PACIFIC STATES MARINE FISHERIES COMMISSION PSMFC conducted l00th Meridian boat survey work in MT,WY,ID, and OR in summer 2000. Results available indicating boat travel from zebra mussels infested states into western region. Contact: Stephen Phillips PSMFC (503-650-5400).

Tribal Contacts

Coastal Tribes:
Several western tribes are currently involved in exotic weed removal efforts through the Bureau of Indian Affairs. These eradication and control programs include exotic wetland and intertidal weeds on tribal reservations. Contact: Blaine Parker (503-731-1268).

Provincial Contacts

British Columbia: A 43' pleasure boat was trailered from Michigan to a boat broker in Vancouver, BC. At a zebra mussel check station in Spokane, WA, zebra mussels were seen on the trim tabs. This information eventually reached BC and the boat was inspected. Over 100 juvenile mussels still remained on the trim tabs which prohibited the boat from being launched into the Fraser River before treatment. The Coast Guard flushed the cooling system of the boat several times with very hot water, leaving it to sit for up to 40 minutes. This is the 1st official observation of zebra mussels in BC. Contact: Gary Caine, British Columbia Fisheries (250-897-7545) or Pat Lim (604-666-6529).

Saskatchewan: Saskatchewan is identifying high risk waterbodies for zebra mussels, A provincial stakeholders awareness committee is being considered. Contact: Rick Sanden, Saskatchewan Department of Environment and Resource Management (306-787-7812).

Federal Updates

U.S. Fish and Wildlife Service: ANS coordinators are available to provide technical assistance to state, federal, and private interests in regard to ANS. Region l (CA,OR,WA,ID, NE,HI) -Denny Lassey, (503-230-5973), Region 2 (TX,NM,OK,AZ) - Bob Pitman, (505-248-6471), and Region 6 (MT,WY,UT,CO,ND,SD,NE,KS) - Pat Dwyer (406-587-9265 X122). Sharon Gross is the National ANS Coordinator in Arlington, VA. (703-358-1718).

Bureau of Reclamation: The Bureau of Reclamation Western Zebra Mussel Task Force www.usbr.gov/zebra/wzmtf.html. The Western Regional Panel on Aquatic Nuisance Species Page can be accessed at: www.wrp-ans.org. Contact: Krista Doebbler (303-445-3639).

National Biological Services-Southeastern Biological Science Center: The Center maintains a nonindigneous aquatic species geographic information system and current zebra mussel location maps. Website: www.nfrcg.gov or contact: Amy Bensen (904-378-8181).

Sea Grant: OR and WA Sea Grant Programs produced a fact sheet on Chinese mitten crab and created an interactive ANS classroom game called "Alien Invaders". Contact: Paul Hemowitz with OR Sea Grant (503-722-6718) or Nancy Lerner with WA Sea Grant (206-616-8403). NY Sea Grant maintains an aquatic nuisance species information clearinghouse and publishes an information review, *Dreissena*. Contact: Charles O'Neill, Jr. (7l6-395-2638). MN Sea Grant has created a boat inspection video entitled *Stop Exotics, Clean Your Boat.* Contact: Doug Jensen (218-726-8712). CA Sea Grant continues to host series of ballast water education workshops throughout the west coast. The first volume of the biannual newsletter *Ballast Exchange* was distributed. Contact: Jodi Cassell, CA Sea Grant (650-871-7559).

U.S. Army Corps of Engineers: The Corps continued monitoring for zebra mussels at Columbia River Basin projects in 1999. Monitoring at the four lower Columbia River mainstem dams was expanded to include veliger sampling during the summer 2000. Contact: Jim Athern (503-808-3935). A density count last week while the R.S. Kerr powerhouse (at L&D 15) had one of their units dewatered for inspection produced 168 zebra mussels /SM. This compares to 126/SM March 2000, 1,300-5,200/SM in April of 1997, and 46/SM in March of 1995. Contact: Everett Laney (915-669-7411).

U.S. Coast Guard: The Interim Final Rule implementing NISA's Voluntary National Guidelines was published on May 17, l999 and took effect on July 1, 1999. Information on the Coast Guard's Ballast Water Program can be found at: www.uscg.mil/hq/g-m/mso4/First.htm. Contact: J. Koster (510-437-2956).

Western Regional Panel Meeting Held In Oakland, CA

The Western Regional Panel on Aquatic Nuisance Species held its annual meeting in Oakland, CA on September 26th and 27th, 2000. Representatives from provincial, state, federal, tribal agencies, and nongovermental organizations met to discuss western region invasive species issues. Presentations included; bait regulation, policy and risks (Mark Sherfy USFWS), interagency contol efforts for *Salvinia molesta* in the CO River (Bob Pitman, USFWS), The CA Ballast Water Program (Maurya Faulkner, CA Land Commission) and state activity reports. The WRP spent time in committee meetings developing the annual workplan. A number of ambitious projects are planned to improve regional coordination and response to ANS invasions. The WRP will be developing a protocol to aid state agencies to develop rapid response plans for individual species. The WRP has elected a new Executive Committee and Chair. The Chair is Scott Smith, Washington Department of Fish and Wildlife. He may be reached at (360-902-2724).

Publications

Stop Exotics, Clean Your Boat. This humorous 11-minute videotape, featuring John Ratzenberger (a.k.a. Cliff Clavin from the TV show *Cheers*), shows the simple steps boaters across the country can take to prevent the spread of invasive aquatic exotic species. With his likable know-it-all style, he teaches watercraft users how to take a couple extra minutes to clean their boat, sailboat, or personal watercraft based on the five basic principles for exotics-free boating. Cost: $10 each; $8 for 10 or more. Contact: Doug Jensen, Minnesota Sea Grant (218-726-8712).

Guide to Identification of Harmful or Potentially Harmful Fishes, Shellfishes and Aquatic Plants Prohibited in Texas (TPWD) Contact: Bob Howells (TPWD) at 210-866-3356.

The West Coast Ballast Water Outreach Project can be accessed at: http://ballast-outreach-ucsgep.ucdavis.edu.

The Western Regional Panel on Aquatic Nuisance Species Web Page can be found at: www.wrp-ans.org.

News from the Great Lakes Panel on Aquatic Nuisance Species

ANS UPDATE

Summer/Fall 2000 *Volume 6, No. 3*

Great Lakes Panel Update

The upcoming Panel meeting is scheduled for Dec. 12-13, 2000, in Ann Arbor, Michigan. The agenda will include final approval of the ballast water management policy statement and finalization of the information/education strategy for ANS prevention and control. The Great Lakes Action Plan has been circulated to the Great Lakes governors and premiers for signature. **Contact:** Katherine Glassner-Shwayder, Great Lakes Commission, 734-665-9135, shwayder@glc.org.

Washington Watch

Recommendations of the appropriations bills have fallen short of the administration's budget request for invasive species programs, making modest increases relative to FY2000 funding. The House approved level funding for the ANS Task Force and Ballast Water Demonstration Program ($1.65 million), while the Senate has approved an increase to $1.85 million. The U.S. Army Corps of Engineers' efforts on ANS control research are headed for cuts (zebra mussels by 30 percent and aquatic plant control by 25 percent in the House). ANS programs under the U.S. Fish and Wildlife Service (USFWS) and U.S. Geological Survey are generally level funded, though funds are provided ($2 million House, $3 million Senate) for the new USFWS Partners for Fish and Wildlife Invasive Species initiative. The Senate provided a $500,000 increase for U.S. Coast Guard research ($1 million) and implementation ($3.5 million) of National Ballast Water Guidelines. The House bill does not earmark funding levels for program research, but does provide $3.5 million for implementation. **Contact:** Rochelle Sturtevant, Senate Great Lakes Task Force, Northeast-Midwest Institute, 202-224-1211, rochelle_sturtevant@levin.senate.gov.

News from Around the Basin

ILLINOIS: Results from the Round Goby Roundup this June indicate that the goby's range has not extended farther down the Illinois waterway than last year. The DNR will receive its first grant from the USFWS to help implement the comprehensive state ANS management plan. The DNR supports USFWS efforts to re-register the bottom formulation of antimycin, with the objective of using this selective piscicide to treat ANS hot spots. **Contact:** Mike Conlin, IL DNR, 217-782-644, mconlin@dnrmail.state.il.us.

MICHIGAN: Under the comprehensive state ANS management plan, $109,000 was awarded from the USFWS, allowing implementation of the Council of Great Lakes Governors Ballast Water Initiative, management plan update, program coordination, and information/education activities. In preparation for a regional initiative under the auspices of the Council of Great Lakes Governors, the DEQ has conducted a series of meetings with international ship owners to discuss potential remedies for preventing ballast-mediated invasions in the Great Lakes. **Contact:** Mark Coscarelli, MI DEQ Office of the Great Lakes, 517-335-4227, coscarem@state.mi.us.

OHIO: The state revised its aquaculture related permitting process. Other initiatives include purple loosestrife control, development of a zebra mussel alert card for lake monitoring and ANS signs for boat ramps at state park lakes infested with zebra mussels. **Contact:** Contact: Randy Sanders, OH DNR, 614-265-6344, randy.sanders@dnr.state.oh.us.

QUEBEC: The Québec Action Plan on Aquatic Nuisance Species is in its third year of implementation. An Internet site on preventing ANS dispersal is online at www.fapaq.gouv.qc.ca/fr/faune/nuisibles/. In French, it includes a database on the evaluation of the colonization potential for over 2900 lakes and 250 sampling stations in rivers. Currently under study is the colonization of the Richelieu River by the tench (Tinca tinca), accidentally released by an ornamental fish vendor after an illegal importation. A two-year study began this summer to determine the response of native unionids to zebra mussel colonization in the St. Lawrence and Richelieu rivers. **Contact:** Serge Gonthier, Société de la faune et des parcs du Québec, 418-521-3875 (ext. 4498), serge.gonthier@fapaq.gouv.qc.ca.

WISCONSIN: Zebra mussels were discovered in Big Cedar Lake late this summer, bringing the total to 17 infested inland lakes. In August, reproducing populations of zebra mussels were found in the lower St. Croix River on the Wisconsin-Minnesota border. A new teaching tool, Attack Packs, was developed by University of Wisconsin Sea Grant Advisory Services and WDNR. Each Attack Pack is a teaching kit containing maps, overheads, background information, identification cards, activities, handouts, a PowerPoint slide presentation, specimens preserved in plastic and a video. **Contact:** Ron Martin, WDNR, 608-266-9270, martir@dnr.state.wi.us.

National ANS Task Force

The ANS Task Force held its summer meeting July 31- Aug. 2 in Burlington, VT. The Vermont Agency of Natural Resources hosted a field trip on southern Lake Champlain to view water chestnut harvesting operations. Also observed was a site invaded by purple loosestrife where state biologists were releasing beetles for biological control. The Task Force discussed the recent invasion of the Mediterranean strain of *Caulerpa taxifolia* in San Diego. Ways to assist in the eradication efforts were identified, as well as ongoing efforts to address the Asian swamp eel spread in the southeast. Task Force members provided updates on current initiatives regarding the National Invasive Species Council and ballast water management.

Presentations were provided by the Great Lakes Panel, Western Regional Panel and Gulf of Mexico Panel. Other activity updates included: the black carp injurious wildlife listing process, the giant salvinia control efforts in the southwest, a recent workshop on the brown tree snake, a bait pathway analysis, and a summary of grants for implementation of state ANS management plans. **Contact:** Sharon Gross, Executive Secretary, ANS Task Force, 703-358-2308, sharon_gross@fws.gov.

Upcoming Events

ANS Task Force Meeting. Nov. 28-30, 2000. Washington, D.C. **Contact:** Sharon Gross, Executive Secretary, ANS Task Force, 703-358-2308, sharon_gross@fws.gov.

62nd Midwest Fish and Wildlife Conference. Dec. 3-6, 2000. Minneapolis, Minn. **Contact:** Steve Kittelson, MN DNR, 651-296-9662, steve.kittelson@dnr.state.mn.us.

Meeting of the Great Lakes Panel on Aquatic Nuisance Species. Dec. 12-13, 2000. Ann Arbor, Mich. **Contact:** Katherine Glassner-Shwayder, 734-665-9135, shwayder@glc.org.

On The Bookshelf

Bibliography on Eurasian Ruffe (Gymnocephalus cernuus). 2000. **Contact:** Doug Jensen, MN Sea Grant, 218-726-8712, djensen1@d.umn.edu.

Proceedings for the 9th International Zebra Mussel and Aquatic Nuisance Species Conference. April 1999. **Contact:** Elizabeth Muckle-Jeffs, 800-868-8776.

Full copies of the ANS Update, a quarterly newsletter prepared by the Great Lakes Panel on Aquatic Nuisance Species, are available upon request from the Great Lakes Commission. The feature article of this issue (Vol. 6 No. 3), appearing on page 1 of the November 2000 issue of *ANS Digest*, is titled, *ANS Prevention and Control Programs– Canadian Perspectives*, authored by Vic Cairns, Department of Fisheries and Oceans; Madhu Malhotra, Environment Canada; Alan Dextrase, Ontario Ministry of Natural Resources; Louis Lapierre, Société de la faune et des parcs du Québec. **Contact:** Katherine Glassner-Shwayder, Great Lakes Commission, 734-665-9135, shwayder@glc.org.

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Aquatic Nuisance Species Digest

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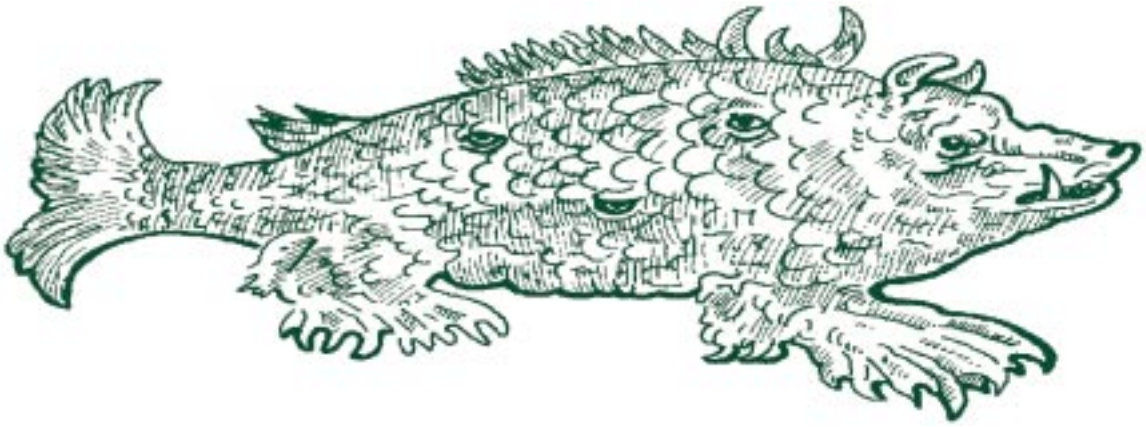

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