From Tough Ruffe to Quagga

Intimidating invaders alter Earth's largest freshwater ecosystem

By JANET RALOFF

Waves of immigrants are colonizing the Great Lakes, threatening the harmony — and sometimes the very existence — of local residents. Arriving in trickles, their initial request may seem benign: to compete for a place to eat and sleep. But these newcomers aren't like the natives. They're exotic species.

"Exotic" usually connotes characters possessing traits at once unusual and desirable. In ecology, however, the term takes on a different, generally malignant connotation.

As aliens unchecked by the usual predator-and-prey balance that tends to develop in nature, exotics may quickly overwhelm their new environment, much like a cancer. And like a cancer, pioneering members of an exotic invasion often evade detection until their population swells to ungovernable proportions.

At a minimum, exotics may constitute a nuisance, like the alewives that washed up dead and stinking on the beaches of Lake Michigan in the 1970s. Other species have wreaked economic havoc, such as the zebra mussels that clogged pipes to power plants and water-treatment facilities. But to indigenous species, the introduction of each new exotic threatens not only a dramatic change in their way of life, but also extinction.

Natural resource managers also recognize keenly the threat that exotics pose. That may explain Dennis M. Pratt's initial reaction to learning an aggressive perch-like fish had just invaded an estuary he oversees: "It was like finding out that your wife has AIDS," the Wisconsin state fisheries biologist recalls.

No freshwater reservoir covers a greater surface — 94,560 square miles — than the five interconnected Great Lakes of Superior, Michigan, Huron, Erie, and Ontario. This waterway, which provides ocean-going vessels access to ports 1,300 miles inland, carries more shipping than any other freshwater system in the world.

While this traffic has brought commerce and prosperity to many North American ports, it has also served as a major conduit for introducing a host of living pollutants.

Since the 1800s, 136 exotic plants and animals have settled in the Great Lakes. According to a recent report issued by the Great Lakes Fishery Commission in Ann Arbor, Mich., 32 percent have been released by ship traffic. Indeed, the report notes, more than one-third of the Great Lakes' alien plants and animals have arrived over the past three decades, "a surge coinciding with the opening of the St. Lawrence Seaway."

The most notorious recent immigrant remains the zebra mussel, *Dreissena polymorpha* (SN: 5/4/91, p.282). Since entering the Great Lakes, probably in 1986, this proliferating mollusk has fanned into the Hudson, Susquehanna, and Mississippi rivers. To date, it's been spotted as far south as Tennessee, notes marine ecologist James T. Carlton of Williams College-Mystic (Conn.) Seaport.

Carlton cites U.S. Fish and Wildlife Service estimates indicating that a 10-year effort now underway to control the mussel's further spread — it has access to most remaining U.S. waterways — may cost $5 billion. Speaking at a Smithsonian Institution conference in Washington, D.C., last November, Carlton described this exotic's successful settlement in U.S. waters "as one of the outstanding invasions of North America in the past 200 years."

Several less well-known ecological "weeds" took up residence about the same time. One that's got more than a few biologists worried is the ruffe (*Gymnocephalus cernuus*), a fish whose common name rhymes with tough. They measure only about 5 inches long — significantly shorter than the minimum 7-inch perch that most anglers consider worth cleaning.

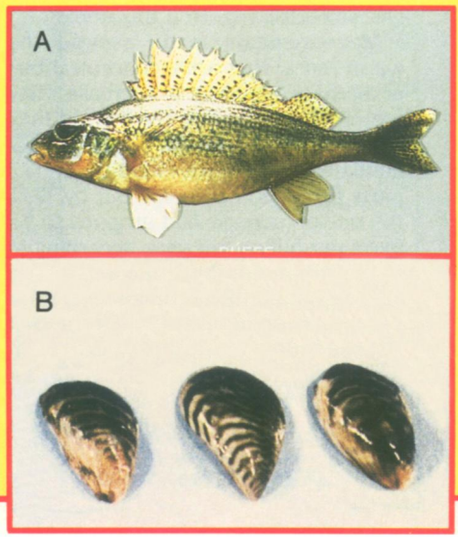
First spotted in western Lake Superior's St. Louis estuary in 1987, the ruffe, says Pratt, "is one invasion that started as far upstream as you could go" — a mere hop, skip, and splash away from the Duluth-Superior harbor, the Great Lakes' second busiest port. Within four years, an estimated 1.8 million were spawning in the 11,500-acre estuary and this European cousin of perch and walleyes had become the most abundant fish in the adjoining St. Louis River.

Its North American debut so far inland suggests that the ruffe stowed away aboard some European freighter, Pratt says, probably in the ballast water used to balance and stabilize a ship.

As large freighters unload their cargo, they fill ballast tanks and floodable cargo holds with water from the harbor. One or more ports of call later, as they prepare to take on new cargo, the crew will release that ballast — and any freeloading aquatic

Rogues' Gallery of Exotica

Biologists generally identify the purple loosestrife (on this week's cover), together with the exotics shown at right, as posing some of the biggest potential threats to Great Lakes natives. The ruffe (A), zebra-like "quagga" mussel (B), and spiny water flea (D) are among the newest villains. Since the 1830s, the sea lamprey has remained one of the most notorious. Originally salt-water denizens, these eels — seen here hanging from a fish (C1) — slowly adapted to freshwater. They extract blood and soft tissue from fish via a sucker-like mouth (C2). The Eurasian water milfoil (E), an aquarium plant, entered the Great Lakes around 1880. Today it is edging out native plants and clogging recreational waters.



life it may be carrying – into the local waters. Indeed, Carlton's analyses indicate, of all ship-related introductions of exotic species to the Great Lakes, an estimated 56 percent entered in ballast water, another 34 percent in solid ballast such as sand or rocks.

An aggressive competitor with a range that extends well north of the Arctic Circle, the ruffe tends to dominate whatever ecosystem it enters. How it conquers each new domain remains an open question, but its reproductive cycle certainly provides one major advantage.

Unlike most members of the perch family, the ruffe can mature early – by age 1. Females generally carry two batches of eggs, spawning them a week or two apart. And unlike many of their North American relatives, this fish "is very nonselective about where it spawns," Pratt says.

Since the ruffe appeared, he adds, "We've seen declines in the great majority of the other 20 to 30 species [of fish] common in the St. Louis estuary," including all age classes of walleyes, a particularly popular game fish.

Moreover, the ruffe is on the move. Some have already been caught about 180 miles north and east of Duluth-Superior, inside Thunder Bay, Ontario. And from there? "It's fairly easy to predict that in the future they'll spread to the rest of North America" – including northern Canada and Alaska, Pratt says. "There are just too many connections between the Great Lakes and the rest of our freshwater ecosystems."

For now, Wisconsin and Minnesota have outlawed possession of the ruffe, a move aimed at limiting the fish's further spread. (If people were allowed to take the fish home, they might clean them on the dock – a move that could inadvertently seed their home waters with viable eggs.) In addition, both states have reduced by two-thirds the allowable catch of potential predators – such as walleyes, muskies, northern pike, and large-mouth bass – that anglers can take from ruffe-infested waters. The states have also increased the rate at which they cooperatively stock predators in the St. Louis estuary – from 4.5 fish per acre in 1988 to 17 per acre last year.

"The good news is that the predators we have there do eat ruffe. The bad news is that they don't eat enough to have shown any impact yet," Pratt notes. In fact, his studies show, "Given a choice, these predators would eat anything else."

The spiny water flea, *Bythotrephes cederstroemi* (BC), represents another potential exotic threat to the Great Lakes. Zoologist W. Gary Sprules of the University of Toronto in Mississauga, Ontario, suspects the invader crossed the Atlantic in ballast water picked up in Leningrad by Soviet freighters dispatched to carry cargo home from North America. The flea made its North American debut in Lake Huron during December 1984. The next year, it showed up in lakes Erie and Ontario, entering lakes Michigan by 1986 and Superior by 1987.

Just 2 to 3 millimeters long (10 mm if you count its spine), BC preferentially dines on the even smaller *Daphnia*, a microscopic algae-feeding crustacean. Because small fish also consider *Daphnia* a popular dinner entree, aquatic biologists worry that BC's overgrazing could starve out some fish.

How likely is that? In laboratory studies, Sprules and his co-workers have shown that individual BC fleas consistently clean *Daphnia* out of 0.4 to 1.1 liters of water daily. But Sprules has found that *Daphnia* can double its population far quicker than BC – "in at most 10 days." This would seem to indicate, he says, that "the prey can grow much faster than BC can impose any kind of predation pressure on them."

So why worry about BC? Because field surveys by others in the Great Lakes have recorded sharp declines in the open-water populations of certain sizes of *Daphnia* and in their biodiversity following the spiny flea's arrival. For instance, Sprules observes, before BC entered Lake Michigan, surveys of deep, open waters recorded three *Daphnia* species. Two years after the water flea's arrival, surveys turned up just one *Daphnia* species. Moreover, he notes, the smallest *Daphnia* "actually disappeared during 1987, the year that BC numbers increased substantially."

Explains Sprules, this change in *Daphnia*'s size distribution is "consistent with predation by an invertebrate [such as the BC flea]." Fish, by contrast, would initially target the biggest *Daphnia*, leaving the smallest for last.

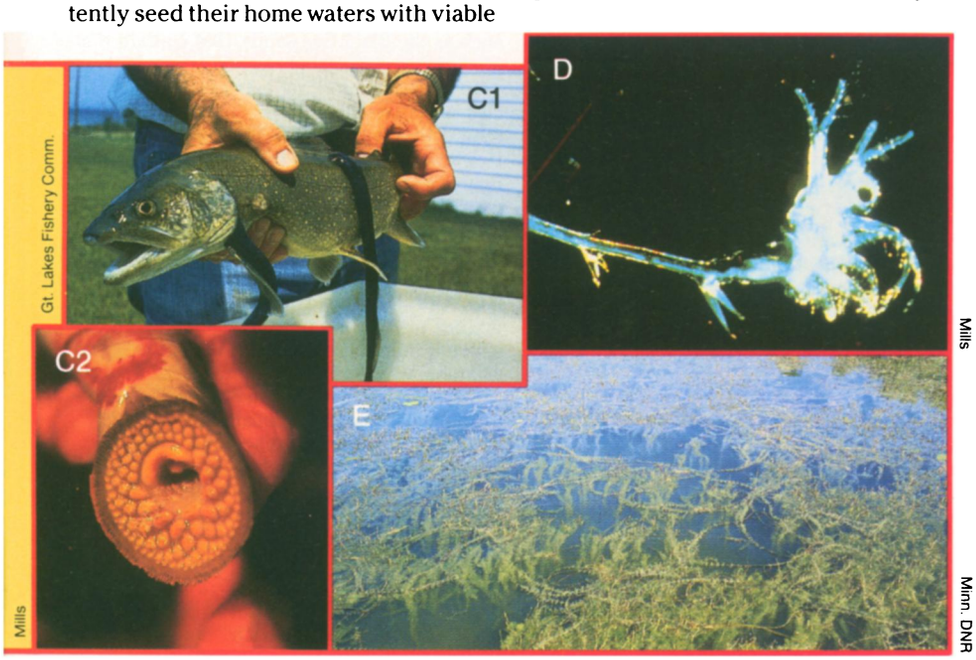
Clever biologists will keep a sharp eye out for still more exotic invasions, Carlton maintains. And that's just what it took – a sharp eye – to discern what may be the Great Lakes' newest invader.

At a glance, the new bivalves resemble the zebra mussel. Unlike the typical *D. polymorpha*, however, the new critters' ventral shell is not flat, but round, notes Edward L. Mills of Cornell University's biological field station in Bridgeport, N.Y. His colleague, Donna L. Dustin, spotted the new mussels in the fall of 1990 among specimens collected from trawls of deep waters in the southern basin of Lake Ontario. At the time, Mills recalls, "We didn't put too much credence on the [importance of those shells]." Small and found in deep water, he said, "They just appeared to be zebra mussels growing abnormally."

Last summer, his team discovered more in the Erie Canal and realized they probably signified a new animal – a suspicion that has just been confirmed by genetic studies.

Trawling runs by federal biologists along the southern shore of Lake Ontario last month have identified regions where this new "quagga" mussel – nicknamed after an extinct relative of the zebra (SN: 8/3/85, p.70) – constitutes roughly 50 percent of the zebra-like bivalves present. Up to 3 centimeters across, they tend to be 20 to 50 percent larger than true zebra mussels. Mills notes that Cornell geneticists have also just confirmed the presence of quaggas among zebra-like mussels collected in the Black Sea by colleagues in the former Soviet Union.

No one has yet established whether or how the quagga's habits differ from those of the true zebra mussel. It's something Mills wants to investigate.



Next on the exotics horizon? At the American Association for the Advancement of Science meeting in Chicago earlier this year, Carlton identified a crustacean 7 mm long and a snail 10 mm long as two of the most likely candidates to invade the Great Lakes – again through shipping. Initially hailing from the Caspian Sea and New Zealand, respectively, both creatures are now firmly established in western European ports frequented by Great Lakes haulers.

Biologists are laying out no welcome mats for either.

The tiny, shrimp-like crustacean, *Corophium curvispinum*, dwells in little tubes of mud it cements together with mucus. This amphipod has already gained notoriety throughout western Europe as a biofouling organism. Producing up to three generations a year, the animals quickly set up communities that coat underwater surfaces – from boat hulls and docks to zebra mussels – sometimes to densities reaching 100,000 animals per square meter.

Potamopyrgus antipodarum, the snail, also enjoys crowds, sometimes congregating in choking densities of up to 800,000 per square meter. And it's not very sensitive to temperature, surviving environments of 36° to 80°F.

Beginning this November, transoceanic shippers must exchange freshwater ballast for seawater before entering the Great Lakes – a move aimed at preventing the transport of freshwater exotics from one continent to another. This should slow the immigration of new species, Carlton notes: "If we had ballast exchange in place in 1980, my guess is that we would not have had the zebra-mussel invasion."

However, he warns, this new program is no panacea. Stowaways that can survive brief periods in salty or brackish water – as both *C. curvispinum* and *P. antipodarum* can – may still move in. Even more likely is their entry via a "back door," Carlton predicts.

The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 mandates ballast exchange only for ships entering the Great Lakes. Such vessels remain free to discharge millions of gallons of water – and any exotics they hold – into other U.S. freshwater systems. And once an exotic species "gets a toehold in North America," Carlton says, "it will eventually colonize the Great Lakes too."

Many exotics have already used that back door route: The Eurasian goldfish (*Carrassius auratus*) may have entered from residential ponds through seasonal streams feeding Great Lakes tributaries. The oriental weatherfish (*Misgurnus anguillicaudatus*) made its escape from an aquarium supply house through a river draining into Lake Huron. Anglers probably released the ghost shiner (*Notropis buchanani*), first observed in the Great Lakes 13 years ago, as discarded bait while fishing lake tributaries. And the purple loosestrife (*Lythrum salicaria*) – which has edged out cattails and other prime waterfowl habitat along much of the Great Lakes shoreline – may have arrived in the early 1800s with sheep from Europe or as a cultivated plant.

"As a result of the invasions that we've been seeing here at the end of the 20th century," Carlton says, "we're beginning to see clear, direct movement about trying to reduce the amount of ballast water – which acts as a major mediator of invasions." His lab, for example, has just begun the National Biological Invasions Shipping Study – an analysis requested by Congress – to gauge the amount and source of ballast water entering freshwater systems throughout the United States. "We will also examine in detail proposed control options for ballast water," he reports.

The Canadians and Australians "also are very interested in doing something about ballast water," Carlton adds, and the U.S. Coast Guard has formally called for the voluntary national adoption of ballast-water exchange for ships entering all U.S. ports from foreign waters.

"I think we are where we were many years ago with [the problem of ships discharging] oil into the ocean," Carlton observes: "There is a growing realization that things have to change." □

Letters continued from p.51

reading words would be constant and the language would be the variable.

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Why look back?

I think it is fair to assume that modern methods of astronomical observation and computation are significantly more precise in their measurement of stellar luminosity than those used 150 or even 50 years ago ("Astronomers Watch a Star Age," SN: 5/2/92, p.298). If that is so, a series of measurements taken even a few years apart could be used to extrapolate aging effects to longer periods.

Mart J. H. de Groot does not need to search through ancient records to recover data for testing models of stellar evolution; current data could serve as well.

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De Groot says P Cygni currently undergoes changes in brightness, even from night to night, that seem unrelated to aging. Thus, measurements of the star's luminosity must be averaged over a long period; even observations a few years apart may not be sufficient. In addition, he says, researchers must monitor the star over many years to see the true effects of aging. Using even highly accurate, modern measurements of the brightness of this star to infer its status 300 years ago could lead to erroneous results.

– R. Cowen

Stalking asthma relief

I read "Celery studies yield blood pressure boon" (SN: 5/9/92, p.319) just after suffering an asthma attack from walking through the smoking area at Houston Intercontinental Airport. Is there any evidence that the celery chemical 3-n-butyl phthalide would have the same relaxing effect on the smooth muscle in the *lungs?* This chemical, if it can relieve bronchial constriction, may offer a safer alternative to albuterol, in light of recent reports of higher death rates among asthmatics who use albuterol regularly.

I'm wondering if it's time to trade in my inhaler for a stalk of celery.

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Despite their similar-sounding names, the asthma drug albuterol and 3-n-butyl phthalide are very different compounds, says clinical pharmacologist William J. Elliott of the University of Chicago, who led the celery study. Albuterol is a fat-soluble drug, which helps it penetrate deep into the lungs when inhaled, whereas 3-n-butyl phthalide is water soluble. Elliott says he doubts that inhaled 3-n-butyl phthalide would reach an asthmatic's constricted bronchi.

Might eating more celery work? "We haven't tested it yet," says Elliott, mainly because there are no asthmatic rats. – C. Ezzell

Tin data 'incomplete'

I find it disturbing that SCIENCE NEWS carried such an unbalanced report concerning the possible tin sources in Anatolia ("Turkish tin mine revises Bronze Age history," SN: 5/9/92, p.309). Serious archaeological and metallurgical concerns still need to be addressed.

Your article gives no details on the tin content of the slag. Bronze melting and purifying operations can produce slags that contain appreciable amounts of tin; the presence of tin in a slag does not mean a tin smelting operation was occurring.

To date, the published chemical analyses of the ores from the Kestel and the Bolkardag region indicate that these ores contain less than 0.25 percent tin. There are plenty of other metalliferous ore sources in southwest Asia, such as the Black Sea sands, that contain this much tin or more.

To further complicate extraction, the particles of cassiterite in these ores are smaller than 2 millimeters. The question should be: How did Bronze Age miners and smelters ever figure out there was tin in these ores to begin with?

Your article also ignores the issue of the Old Assyrian trade with Anatolia. Cuneiform texts indicate that in the early second millennium B.C., Old Assyrian traders brought tin and textiles to Anatolia in exchange for gold and silver. If there is a tin source in southeastern Anatolia, why was it being imported?

It is hard to say what is going on at Goltepe and Kestel. Not until publication of a definitive site report, including publication of the scientific analyses of the finds, can claims for a major tin source be made. To date, the incomplete data that have trickled out about Goltepe and Kestel allow other interpretations to be forwarded.

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