INVADERS
of the Great Lakes

Produced in cooperation with Wildlife Forever
by Karen R. Hollingsworth

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DEDICATION

To our waters and those who work tirelessly to protect them.

– *Karen Hollingsworth*

Acknowledgments

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ABOUT WILDLIFE FOREVER

Wildlife Forever is America's leading all-species nonprofit conservation organization. Working with private conservation groups, state game and fish departments and federal agencies, Wildlife Forever has been involved in more than 1,000 projects, covering every state in the nation.

Wildlife Forever's conservation projects fall into four categories: habitat, fish and wildlife management, research, and conservation education. Award-winning programs include the Threat Campaign™, which provides anglers, hunters and all recreational users with the information they need to stop the spread of invasive species, and THE ART OF CONSERVATION® State-Fish Art™ Program, a K-12 nationwide competition teaching children aquatic education through the arts.

America is truly blessed. It is a land rich in natural resources. Much of our identity and culture can be attributed to our natural world. We believe conservation education is the key that will ultimately determine the very future of our country's fish and wildlife heritage.

Conserving America's fisheries, by preventing the introduction and spread of invasive species, is more critical than ever before. Anglers and recreationists need to know the risks and what to do when they encounter invasive species in the wild. These silent invaders are serious threats, and they are damaging fishing, destroying habitat, devastating the aquatic food chain, impeding navigation, and costing the American public millions of dollars annually. This guide describes the top invasive threats to the Great Lakes and highlights the steps everyone can take to help prevent their spread.

Thank you for doing your part to ensure the healthy future of our lakes and streams . . .

Douglas H. Grann
President & CEO

To learn more, contact us at (763) 253-0222, 2700 Freeway Blvd., Suite 1000, Brooklyn Center, MN 55430 or check out our website at www.WildlifeForever.org.

ABOUT SEA GRANT

Sea Grant—a unique partnership of public and private sectors that combines research, education and technology transfer for public service—is a national network of universities meeting the changing environmental and economic needs of Americans in coastal ocean and Great Lakes regions.

Sea Grant has an outstanding record of achievement in transferring the results of university research to a wide range of audiences and giving special assistance to coastal communities, businesses and individual citizens.

Congressional committees have repeatedly cited Sea Grant as one of the most efficient and cost-effective programs funded by the U.S. Government. A 1981 analysis, for example, estimated that the annual benefits to the national economy from Sea Grant-sponsored research and outreach surpassed the federal government's total investment in the program over the preceding 12 years, and the program's benefits continue to grow exponentially.

Through its network of Advisory Service (Extension) agents and its use of modern communications and education techniques, the Great Lakes Sea Grant Network plays a central role in supplying the region and the nation with usable solutions to pressing problems and providing the basic information needed to better manage Great Lakes resources for present and future generations of Americans.

For more information, visit www.seagrant.noaa.gov.

FOREWORD

Aquatic invasive species are hitchhikers, and their spread is not inevitable. Those of us who do business or spend time on or around the water can unintentionally help aquatic invasive species spread. They can be visible as plant fragments or adult organisms clinging to a boat or trailer, or they can be microscopic and float in bilge water, a livewell or a bait bucket. By learning about how these organisms live, grow and reproduce—and how they spread—boaters and anglers can learn how to stop aquatic hitchhikers!

Reducing their spread is vitally important. Prevention saves money and jobs, and protects lakes and rivers and the outdoor heritage that we all enjoy. It helps give researchers time to discover and develop ways to manage, control or possibly eradicate these unwanted visitors. We all have a responsibility to care for and manage our nation's waters and to help educate others about the importance of preventing the spread of aquatic invasive species.

This guide is the product of a partnership among the programs of the Great Lakes Sea Grant Network, Wildlife Forever, the U.S. Forest Service, the U.S. Fish and Wildlife Service and the National Professional Anglers Association. Working together, we strive to help the boating and angling public learn about the threat aquatic invasive species pose to our environment and economy, and what we can do to prevent their spread.

Join me and our partners in the fight to protect our treasured fishing and boating waters so we can ensure they are here for this generation and those that follow.

Philip B. Moy, Ph.D.

Assistant Director for Research and Outreach
Fisheries and Invasive Species Specialist
University of Wisconsin Sea Grant Institute

ENDORSEMENT

For the past 18 years I have been truly blessed to make my living as a professional angler. I get to travel the country and enjoy the great fishing we have literally coast to coast. There is nothing better. At this time, we are very fortunate. I have never seen fishing as good as it is today, nationwide.

From time to time, things come along that threaten the opportunities we have to enjoy this incredible fishing. In the past few decades, aquatic invasive species have become a major concern. These undesirable plants and animals are brought to our waters unintentionally and threaten to destroy the pastime we all love so dearly.

The Great Lakes were the first areas devastated by them, but now many inland waterways are threatened. From zebra mussels and Eurasian watermilfoil to many fish species, there seems to be no end. No one knows what the next threat will be or where it will come from.

There is hope, however. The spread of these species can be controlled, and it starts with us—the anglers—because we care. By learning to recognize aquatic invasive species, inspecting our boats and trailers, and draining our livewells and bilges, we can help prevent the spread of these threats.

As a member of the National Professional Anglers Association, I am proud to join forces with the Great Lakes Sea Grant Network, Wildlife Forever, the U.S. Forest Service and the U.S. Fish and Wildlife Service in the creation of this guide. Carry it with you and keep a lookout for these species, which threaten our favorite pastime. Please report invasives when you see them and pass the word on stopping their spread.

I personally thank you and hope to see you on the water.

Johnnie Candle
Professional Angler
2010 World Walleye Champion

AQUATIC INVASIVE SPECIES: THREATS TO THE GREAT LAKES

The Great Lakes and our inland lakes, rivers and streams are being invaded. Since the 1800s, more than 180 non-native aquatic organisms of all types—including plants, fish, invertebrates and pathogens—have become established in the Great Lakes region. Some, such as coho salmon, were purposely stocked, while others were inadvertently introduced after hitching rides in freshwater ballast of ocean-going ships, anglers' bait-buckets or on recreational watercraft.

When a non-native species is introduced to a new ecosystem and causes, or is likely to cause, economic or environmental harm or harm to human health, it's considered invasive. Because non-native species are adept at surviving in different ecosystems, some have advantages for outcompeting our native species for food and habitat. Without predators, diseases and competitors to keep these species in check, they rapidly grow, reproduce and spread. This can lead to significant damage to the entire ecosystem. When such species reproduce unchecked, this can lead to significant changes to the native food web, which is in a fragile balance. When a new species is introduced, it can disrupt that balance, causing a cascade of problems for all the interconnected species.

Unfortunately, over the past two centuries, a whole host of invasive species has ravaged the Great Lakes, profoundly harming the region's economy, recreational opportunities and biodiversity. Native fish species that were once economically

important, such as the lake trout, have been decimated, costing commercial fishermen millions and denying recreational anglers a prized target. Once-tidy boats and harbors are now littered with thousands upon thousands of zebra mussels, which are almost impossible to control. Water-intake pipes at power plants and factories are choked with quagga mussels. Pristine lakes are now matted with invasive species, such as Eurasian watermilfoil or elodea, reducing property values and making fishing and enjoying time on the water difficult, if not impossible.

Hitching a Ride: How They Got Here

Many of the aquatic invasive species in the region "hitch-hiked" here. Completion of the St. Lawrence Seaway in the 1950s connected the Great Lakes to the Atlantic Ocean, enabling immature fish and invertebrates to "stow away" in

ballast tanks of ocean-going ships or attach to hull surfaces. A number of species made their way here in this fashion. Examples include the round goby (page 101), tubenose goby (page 103), spiny waterflea (page 67), fishhook waterflea (page 65), bloody red shrimp (page 55) and a host of other invertebrates and plants. In addition, the completion of shipping canals allowed saltwater and salt-tolerant species, such as alewife (page 91), to enter the Great Lakes. For example, the sea lamprey (page 107), which is native to the Atlantic Coast, entered the upper Great Lakes through the Welland Canal, devastating the fisheries in all of the Great Lakes.

Thankfully, we've made progress in preventing new species from entering the region. In 1993, the U.S. Coast Guard began requiring all ocean-going ships bound for the Great Lakes carrying ballast water to perform an open-ocean ballast exchange. They do this because salty ocean water kills freshwater organisms taken on in European harbors. Later, in 2008, ships carrying cargo were likewise required to do a "swish and spit" with ocean water. These regulations and policies have greatly reduced the threat, and no new Great Lake invasive species attributable to ballast discharge have been discovered since 2006.

A Danger to Inland Waters

While we've made progress in preventing additional species from entering the region, the species that are already here pose a serious threat to our inland lakes, rivers and streams. Just as they invaded the Great Lakes, they could easily invade thousands of inland water bodies across the region.

Instead of hitching a ride in ballast water or swimming up a man-made waterway, invasive species, such as Eurasian watermilfoil, could easily be introduced inadvertently by anglers, boaters and any people enjoying time on the water. Unless proper inspection and washing steps are taken (see page 20), it's easy to accidentally transport an invasive species. They can hitch a ride on (or in) trailers, boats, motors, livewells or other angling or boating equipment that comes into contact with invasive-infested water. Unfortunately, this isn't simply a threat. Many inland bodies of water have already been infested with aquatic invasives, and it's up to us to prevent them from spreading even more.

Natural Treasures to Protect

When we protect our aquatic environments, we're actually putting our own interests first. After all, the Great Lakes and our inland lakes have contributed a great deal to our region. The region became a major population center and the industrial core of the United States and Canada in large part because of the region's vast forests and its agricultural and mineral resources.

Today, the Great Lakes region is as important as ever, but aquatic invasive species pose a serious threat to the lakes and to our inland waterways. Unfortunately, when it comes to invaders (such as zebra mussels and Asian carp), it's often an all-or-nothing game. Once the invaders are established, they are likely here to stay. That's why it's so important to spread the word about stopping aquatic invasive species.

Here are just a few reasons to join the fight:

Economic Impact

The Great Lakes have a profound economic impact on the region. A 2011 analysis by the University of Michigan Sea Grant Program concluded that the Great Lakes generate $62 billion in wages each year and that more than 1.5 million jobs are directly connected to the waterways. That economic impact is hard to miss; commercial ports, fishing ports and recreational harbors are common sights. Not surprisingly, the lakes are also a major water source in the region and provide water for about 30 million people.

Recreational and Commercial Fishing on the Great Lakes

Several Great Lakes boast thriving recreational fisheries that are based on salmon, which were introduced to the lakes in the 1960s to control alewives. Today, the fisheries of the Great Lakes have an estimated value of $7 billion. Salmon continue to be stocked, but they have also begun to spawn on their own in rivers and streams that flow into the Great Lakes.

The Great Lakes are also home to a commercial fishery that is mainly supported by whitefish, yellow perch and lake herring. It harvested more than $18 million worth of fish in 2009, according to a report from the U.S. Geological Survey's Great Lakes Science Center.

Fishing on Inland Lakes, Regional Tourism, and Biodiversity

The fight against aquatic invasives isn't just about the Great Lakes, however. The Great Lakes are a case study in aquatic invasive species introduction and impact, and the Great Lakes are often a source of invasive species that can spread to inland lakes. Our treasured inland lakes, rivers and streams are very much at risk, and when invasives are introduced, they can have a profound impact. Iconic fish and waterfowl species can be adversely affected, the chemistry of the water can be irreparably changed, and even enjoying time on the water can be difficult due to mats of vegetation. Infested waters can harm tourism, fishing, property values and the economy of communities that depend upon those water resources.

THREE PRIMARY AQUATIC THREATS: INVERTEBRATES, PLANTS AND FISH

Three types of aquatic invasive species pose the greatest threat to the Great Lakes and our inland waterways: Invertebrates, Plants and Fish. As each type of invasive can be introduced in a different way, each type poses a different threat. For instance, invasive fish species can be introduced when they are accidentally used for bait, while invasive invertebrates, such as spiny waterfleas, can be moved when improperly cleaned gear is used in uninfested waters. It's therefore important to know what to look for, where to look and what to do to help stop the spread of aquatic invasive species.

Aquatic Invertebrates

Invertebrates are some of the most abundant creatures on earth—about 97 percent of all known living animal species—yet they are often inconspicuous and few people are aware of their presence, much less their importance.

Wildly diverse creatures, the only thing they all have in common is what they lack—a backbone. They are everywhere, and they outnumber us. In fact, the combined body mass of just the insects and spiders in the United States, it would be more than twice that of humans.

Aquatic invertebrates are threatened, yet they play critical roles in healthy ecosystems. In the United States an estimated 50 percent or more of crayfish, freshwater mussel and stonefly species are imperiled, near extinction or already extinct.

There is a critical need to protect native aquatic invertebrates from the effects of habitat destruction and displacement by invasive species. Impacts on such important food resources have serious repercussions throughout the aquatic food web.

Aquatic Plants

Thousands of species of aquatic plants are native to the United States. As an essential part of a healthy ecosystem, their presence in a body of water is one of the best indicators that it will be a good fishery. These plants produce the oxygen vital for life, help reduce erosion and provide nutrients. Most aquatic life also depends upon plants for food. They also provide fish with cover, nursery areas and protection.

When aquatic plants are introduced into a new environment, they can become invasive. Invasive aquatic plants often grow very quickly, and a population can go from just a few plants, or even fragments, to potentially cover hundreds of acres in a short time. This chokes out native plants, eliminates useful habitat for fish and other wildlife, disrupts recreational activities, reduces tourism and lowers property values.

Once an invasive is established, attempts to eradicate it often fail and management is very expensive. That is why preventing their spread is critically important.

Fish

More than 32,000 species of fish live in the world's water and roughly 2,000 species live in North America alone.

Unfortunately in the United States, approximately 37 percent of freshwater fish species are threatened or even extinct. The worst invasive species have caused substantial damage to Great Lakes fisheries and ecosystem health by taking over the habitat and food that native fish species need to survive.

In addition, invasive species, such as zebra mussels (page 53) and quagga mussels (page 51), are in danger of unraveling the food web because they consume huge amounts of phytoplankton, the base of the food web. This essentially starves native fish and other aquatic wildlife. So while the Great Lakes seem cleaner and clearer than ever before, cleaner is good, but clearer isn't. The water looks clear because it is becoming less productive.

EDUCATION IS THE KEY

The most important weapon in the fight against aquatic invasive species is education—informing the public how to prevent them from spreading. Studies show that anglers, boaters and other people who enjoy time on the water will take the time to clean, drain and dry their boats, trailers, tackle and gear if they know the threats, what to look for and what to do. It is equally important to show anglers, boaters and all who spend time on the water that proactive prevention is the most effective method of stopping the spread of aquatic invasives.

Tournament Anglers Need to Be Aware

Tournament anglers need to be especially careful about inadvertent transport of aquatic invasives. Professional tournament anglers may visit dozens of waters in multiple states each year as they pre-fish, compete, then quickly travel long distances to the next tournament site. While most competitive anglers strive for clean gear, the sheer number of anglers and lakes visited raises concern about the potential for accidental spread to uninfested waters.

Thankfully, tournament anglers are willing to be part of the solution by taking action at accesses and teaching fellow anglers about the risks posed by aquatic invasive species. Professional anglers are familiar with our native aquatic plants and animals, and they often have a keen eye for that weed or fish that looks a bit out of the ordinary.

Keep a Lookout

But it's not just anglers who need to take care. Invasive species can enter our aquatic ecosystems in a variety of other ways. Any human activity that potentially moves water, soil, mud, sand, weeds or animals could possibly transport aquatic invasive species. Potential pathways include aquarium releases, bait harvesting, boating, hunting, scuba diving, sea-planes and personal watercraft. We all have a responsibility to protect our natural waters from the threat of aquatic invasive species.

HOW YOU CAN HELP

1. **CLEAN • DRAIN • DRY!** Don't let invasives hitchhike on your watercraft or equipment.
2. Know state and federal regulations (see page 22)
3. Identify–learn what aquatic invasives look like by using this guide
4. Keep up to date on where invasives are by referencing the QR codes (page 31) and websites (page 124) in this book
5. Report any suspected new sightings

1. CLEAN • DRAIN • DRY

BE A PART OF THE SOLUTION!
You can help stop the invasion.

Boaters, anglers and other outdoor recreationists can help prevent the spread of aquatic invasive species by taking three simple actions—**CLEAN • DRAIN • DRY**—every time they are at the water access. If drying is not possible before reuse, rinsing or washing watercraft and equipment is the right thing to do. Rinsing removes small organisms that may not be visible. Washing with hot water kills small organisms that may not be visible. By taking these actions whether the water is infested or not, you are part of the solution and helping ensure that our lakes and rivers will be healthy for future generations.

BEFORE launching . . . BEFORE leaving:

CLEAN your watercraft, trailer, motor, equipment, clothing, boots, buckets. Remove all visible mud, aquatic plants and animals before leaving any water access.

DRAIN water from your boat, bilge, motor, jet drives and livewell by removing the drain plug and opening all water-draining devices away from the boat ramp. In many states and provinces, this is required when leaving water accesses. Remove water from any bait buckets, diving gear, boots/waders, floats and any other gear.

DRY everything at least five days before going to other waters or spray/rinse recreational equipment with high pressure and/or hot water.

All three of these steps are equally important, as it's what you might not see that counts! The larvae of zebra mussels (veligers) and many other species are often microscopic or easy to overlook. These tiny organisms can live for days in water left in boat hulls, livewells and bait buckets. If transported to new waters, they can grow into adults, reproduce, and spread, threatening our favorite fishing spots.

2. Know the Regulations

Because aquatic invasive species are such a prominent threat, laws specifically pertaining to invasive species exist at the state, federal, provincial and sometimes local levels prohibiting possession, transport and spread. So it's about doing the right thing to help protect our lakes and rivers while being in compliance with the laws. Not taking appropriate action can result in citations and fines. Transporting invasives, even inadvertently, is often against the law.

For details and a list of prohibited aquatic invasive species in your area, check with your state natural resource department and local authorities. Also visit the following websites for more information. Also be mindful of Canadian regulations when fishing on or near the border, or when in Canada.

State:

Laws and regulations vary state-by-state. For specific information about your state, we have provided a list of Sea Grant and state websites on page 124.

Federal:

National Invasive Species Information Center
www.invasivespeciesinfo.gov/laws/federal.shtml

U.S. Fish and Wildlife Service
www.fws.gov/invasives/laws.html

Provincial:
If you are on or near Canadian waters, be sure to check these websites:

Ontario Ministry of Natural Resources
www.mnr.gov.on.ca/en

Ontario Federation of Anglers and Hunters
www.ofah.org

3. Identifying Invasives

This guide describes 39 aquatic invaders of concern in the Great Lakes region. These invaders could spread by hitching a ride on a boat motor, trailer or hull, when inadvertently transported in water, in contaminated bait or on angling equipment. All of these species pose threats to your favorite lakes and rivers. Each species page describes where each invader lives, grows, reproduces and spreads. In turn, this knowledge will help you understand how important it is to follow the three steps to Stop Aquatic Hitchhikers on page 20.

4. Keep Up to Date with QR (Quick Response) Codes

Quick and easy access to basic information about aquatic invasive species is just a click away. For smartphones, scan the QR code (the funny-looking square) on the lower left corner of each species page. For barcode applications, open the application and slowly pass the phone over the barcode, which will link to a webpage with up-to-date information about the aquatic invasive species.

5. Reporting . . . What Should You Do?

If you suspect a new sighting, report it. Reporting invasive species allows authorities to step up enforcement, outreach and communication efforts to help contain the spread and, if necessary, it can help scientists develop a plan to contain or control invaders. It also helps other boaters, anglers and folks who enjoy time on the water to stay up-to-date.

To help you report a sighting, we've included a "How You Can Help" section for each of the invaders in this book. This section provides species-specific steps for you to follow when reporting a find, as well as instructions about how to preserve a specimen. We have also included a "Template for Noting Sighting Details" on page 128 with fill-in-the-blank forms for you to easily jot down information to report to your local or state's natural resource agency. You will find a contact list for each state's natural resource agency on page 124.

For your convenience, you can also report a sighting online from anywhere in the United States at this link:

Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS):
https://nas.er.usgs.gov/SightingReport.aspx

To find out more about aquatic invasive species and how you can help, visit the GLANSIS definitive database of non-native invaders. You can visit their website here:
www.glerl.noaa.gov/res/Programs/glansis/glansis.html

To discover what Wildlife Forever's Stop Aquatic Hitchhikers!-Threat Campaign™ has done to educate people and help prevent the spread of aquatic invasive species, visit: www.WildlifeForever.org.

WHAT'S NEXT? ARE MORE INVADERS ON THE WAY?

Our aggressive prevention and control efforts have been effective in keeping some aquatic invasive species at bay. What we do know is that if we do nothing, aquatic invasive species will spread and have a devastating impact. If we do all that we can, we will be able to continue to prevent and slow their spread. Being vigilant as good stewards will prevent existing aquatic invasive species from spreading to nearby lakes and rivers, and will prevent them from entering our region. Every water body that is protected helps our society, environment and economy.

Using information about life cycles of foreign species, living requirements, potential for range expansion, and how closely their home habitat resembles our native waterways, scientists predict that about two dozen additional non-native fish could arrive and thrive in our lakes, rivers and streams. At least nine of these could spread quickly, and five would likely harm native species. The wild card here is their ability to hitch a ride to North America; they could arrive via ship ballast, release by aquarists, escape from water gardens, or release of unwanted bait. If you find or catch something you don't recognize, report it.

Here Are the "Dangerous 5" Potential Invaders

In addition to Asian carp, we don't know for sure whether these "Dangerous 5" will make it into the Great Lakes region or not. Nevertheless, they have successfully invaded other countries and caused a great deal of damage in invaded territories, so we must continue to take every precaution to keep them out. These are the species to be on the lookout for; to that end, we're including a little information about each. If you think you've spotted one, report it!

Kilka (*Clupeonella cultriventris*): A potential ballast invader and a member of the herring family, it lives in rivers, lakes and the ocean. About 5½ inches long, it forms schools, eats zooplankton, and may compete with larval fish. Upon introduction, it would likely take over lakes and rivers, crowding out native fish.

Black-striped pipefish (*Syngnathus abaster*): Related to seahorses, they have slender bodies with bony rings. Males rear the young in pouches. They can live in both fresh and salt water and feed heavily on small benthic invertebrates and are capable of producing several broods of young over the year.

Black Sea silverside (*Atherina boyeri*): Also called bigscale sand smelt, it is found in slow-flowing or still water. It can survive in brackish water, as well as salt water and fresh water. It forms dense schools, feeding on crustaceans, worms, mollusks and fish larvae. It can grow to more than 7 inches long.

Monkey goby (*Neogobius fluviatalis*): Sold in the aquarium trade, it lives on sandy bottoms in near-shore areas of lakes

and rivers. It also lives in brackish waters. Infestations can double each year, often becoming the most numerous fish in rivers. Growing only up to 8 inches long, it feeds on small clams, mussels and snails.

Caspian bighead goby (*Ponticola gorlap*): This species inhabits both fresh and brackish habitats in rivers, tributaries and inshore areas of lakes and coastal areas. It lives in a variety of habitats, including rocky, sandy-bottomed areas, reeds and aquatic vegetation. It eats invertebrates and small fish, including the young of other goby species. It can live 2–3 years and can reach 3–6 inches in length.

For images and information about these species, visit www.fishbase.org.

FISH DISEASES AND PARASITES AND HOW WE CAN HELP PREVENT THEIR SPREAD

Invasive fish, plants and invertebrates aren't the only organisms that can spread and invade a new environment. Like people, fish are vulnerable to a variety of diseases and parasites. Fish diseases are usually caused by organisms (pathogens), such as bacteria, viruses and fungi. Like aquatic invasive species, diseases and parasites can be transported from one body of water to another. This often happens via bait-bucket transfer. Putting bait in a body of water where a virus is present exposes the bait to that virus. Simply moving the fish to clean water does not remove the pathogen from the bait; on the contrary, that could transfer it to a new body of water. Aquatic plants can also carry diseases or pathogens. Likewise, invasive invertebrates, such as crayfish and snails, can carry diseases (such as crayfish plague) or be intermediate hosts for harmful parasites for native invertebrates. Anglers must be aware of the risks associated with moving fish, bait bucket water and invertebrates.

When fish are exposed to new pathogens, the disease often spreads quickly. Like human maladies, fish diseases are infectious: once a few fish get sick, the pathogens can spread rapidly from fish to fish, causing large die-offs. Examples of common fish diseases are the largemouth bass virus, bacterial kidney disease, *Heterosporis* and whirling disease. New diseases of concern in our waterways include viral hemorrhagic septicemia (VHS), spring viremia of carp, and koi herpes virus.

Diseases may affect fish in different ways, but many have similar symptoms that are easy to recognize. Here are a few common warning signs:

- Abnormal swimming in circles or upside down
- Gasping, rapid gill movement, bleeding, eroded or pale gills
- Skinny body, hollow belly
- Pale body colors
- External cysts, sores, blood stains, bloody or bulging eyes
- Fungus, often resembling white or yellow fuzz on body

Parasites are a problem, too. Generally, parasites don't kill the fish, but feed from them instead. When fish are stressed, parasites can further weaken the fish, making it more vulnerable to disease. Typical fish parasites include flukes, round worms, tapeworms and *Heterosporis*. Sometimes fish exhibit external signs that parasites are present, such as black flecks on the skin and fins or wormy threads inside the body, especially on internal organs.

To protect our waters from fish diseases and pathogens, be on the watch for fish that appear sick and report any suspicious sightings to your local fisheries manager. In some cases, humans can contract fish parasites by eating undercooked fish.

Rusty crayfish

Orconectes rusticus

OTHER COMMON NAMES: rusty crawfish, rusty crawdads, rusties

DESCRIPTION: up to 6 inches (with claws); brown body; males often with dark rusty spots on each side (as though you picked it up with paint on your fingers); large, smooth grayish-green to reddish-brown claws with a black band at the tips, claws have an oval gap when closed; "S"-shaped movable claw

HABITAT: lakes, ponds, rivers, streams; bottom areas with rocks, logs or other debris for cover; needs permanent water

ORIGIN: native to Ohio River Basin; first discovered in 1960s in Wisconsin and Minnesota

SPREAD BY: likely bait bucket releases by anglers; home aquarium releases; study specimen release; females with stored sperm may be able to establish new populations

HOW YOU CAN HELP:

The best method to control rusty crayfish is to prevent new introductions, as eradicating established infestations is impossible. Do not use as bait outside the Ohio River drainage.

- **CLEAN • DRAIN • DRY** page 20
- **REPORT** your catch or new sightings to your state's natural resource agency (page 124); note date, exact location (page 128) and include a photograph, if possible
- If you catch a rusty crayfish—**do not release it!**
- Keep the entire carcass (freeze if necessary) and report

When threatened, it often takes an aggressive defensive posture with claws raised, so not eaten as often as native crayfish.

IMPACT ON YOU!

Rusty crayfish eliminate vegetation that provides cover for fish and habitat for invertebrates, an important food for fish and waterfowl. They also can harm native fish populations by eating their eggs and young.

- Competes aggressively with native crayfish for food . . . can eat up to twice as much
- Can **hybridize** with native crayfish

For more information go to www.usgs.gov or scan this code with your smart phone. See page 31 for details.

Quagga mussel

Dreissena bugensis

OTHER COMMON NAMES: none

DESCRIPTION: thumbnail-size, laterally compressed shell is pale colored or has alternating brown to brownish stripes; pale near **hinge**

COMPARE: topples over if you try to set it on its ventral (lower) surface; zebra mussels (page 53) can sit flat and are "D" shaped

HABITAT: surfaces (rocks, boats, docks, etc.) from shallow to deep water in lakes, rivers, canals, ponds; more tolerant of deeper and cooler water than their zebra mussel cousin; blankets soft-bottomed areas to depths of 400 feet

ORIGIN: native to Eurasia; first discovered in Lake Erie in 1989; likely transported via **ballast** water; now in parts of all Great Lakes

SPREAD BY: attaches to boats, motors, lifts, aquatic plants; can reproduce in water near freezing; microscopic **veligers** (larvae) can be present in bait buckets and livewells even in late fall or early winter

HOW YOU CAN HELP:

The primary way quagga mussels spread to inland waters is on trailered boats. It is critical to inspect and remove all plants, animals and mud before leaving the water access area.

- **CLEAN • DRAIN • DRY** page 20
- **REPORT** new sightings to your state's natural resource agency (page 124); note date, exact location (page 128) and include a photograph, if possible
- Place specimen in a sealed plastic bag (or in rubbing alcohol) and report

In areas of the Great Lakes, they are displacing zebra mussels.

IMPACT ON YOU!

Extensive mats of quagga mussels filter **plankton** from the water, altering the **food web** from the bottom up, ultimately threatening commercial/sport fishing in the Great Lakes.

- Colonizes soft and hard substrates covering fish spawning areas
- Colonizes docks; pollutes swimming areas with sharp shells
- Linked to fish/wildlife die-offs due to **botulism**

For more information go to www.usgs.gov or scan this code with your smart phone. See page 31 for details.

Zebra mussel

Dreissena polymorpha

OTHER COMMON NAMES: none

DESCRIPTION: under 1 inch (up to 2); black to brownish "D"-shaped shell, generally with alternating dark and light stripes (zebra-like); usually in clusters of individuals; on smooth surfaces, young feel like fine sandpaper, juveniles are peppercorn-size

COMPARE: zebra mussels can sit flat on their ventral (lower) surface, quagga mussels (page 51) cannot

HABITAT: attaches to hard surfaces (rocks, logs, boats, docks, etc.); generally in shallow (6–30 feet) algae-rich water of lakes, rivers, canals, ponds

ORIGIN: native to Eastern Europe; introduced to Great Lakes in late 1980s by **ballast** water; spread to the Mississippi River, its tributaries and inland lakes

SPREAD BY: recreationists transporting mussels attached to aquatic plants, boats, nets, fishing equipment and in water; produces several hundred thousand microscopic eggs per season

HOW YOU CAN HELP:

Zebra mussels are now found in all the Great Lakes and many U.S. states. The cost of prevention and control is estimated to exceed $500 million annually.

- **CLEAN • DRAIN • DRY** page 20
- **REPORT** new sightings to your state's natural resource agency (page 124); note date, exact location (page 128) and include a photograph, if possible
- Place specimen in a sealed plastic bag (or in rubbing alcohol) and report

Strains the microscopic food of fish larvae (up to 1 quart water per mussel per day), making water clearer . . . but less productive!

IMPACT ON YOU!

Zebra mussels are a serious problem and can encrust boat hulls, piers and moorings. Larvae drawn into boat engine intakes can colonize the interiors of engine cooling systems.

- Disrupts aquatic **food web**
- Facilitates nuisance plant growth
- Sharp shells littering beaches can make a stroll hazardous
- Smothers native clams/mussels (many are rare) and crayfish

For more information go to www.usgs.gov or scan this code with your smart phone. See page 31 for details.

New Zealand mudsnail

Potamopyrgus antipodarum

OTHER COMMON NAMES: Jenkin's spire shell, pond snail, mudsnail

DESCRIPTION: very tiny, up to 3/16 inch; dark gray, light to dark brown shell; cone-shaped with 7–8 right-handed **whorls**, separated by deep grooves; possesses an **operculum**

COMPARE: difficult to distinguish from native snails, but shell more elongate

HABITAT: from flowing freshwater with silt/sand sediment to very **brackish** rivers; lives in water as deep as 60 feet in freshwater lakes and reservoirs

ORIGIN: native to New Zealand; found in Idaho in 1987, introduced with stocked rainbow trout; established in Lake Ontario in 1991; spreading in the Great Lakes

SPREAD BY: clings to anything from floating leaves to wading anglers; can reproduce by **parthenogenesis,** which allows them to spread easily

HOW YOU CAN HELP:

Anglers pose a risk for spread because snails can easily be moved on felt-soled waders or fishing gear.

- **CLEAN • DRAIN • DRY** page 20
- **REPORT** new sightings to your state's natural resource agency (page 124); note date, exact location (page 128) and include a photograph, if possible
- Place specimen in a sealed plastic bag (or in rubbing alcohol) and report

New Zealand mudsnails can survive out of water for days!

IMPACT ON YOU!

New Zealand mudsnails may affect critical **food webs** in trout streams and other waters. They also may compete for food with native bottom-dwellers.

- Lacks predators and reproduces at an alarmingly high rate
- Colonizes quickly; can reach densities of 500,000 individuals per square meter!

For more information go to www.usgs.gov or scan this code with your smart phone. See page 31 for details.

Fishhook waterflea

Cercopagis pengoi

OTHER COMMON NAMES: fish-hook water flea

DESCRIPTION: ¼–⅝ inch; long tail spine ending in a "hook"; prominent dark eyespot; can form clumps (with black spots) that look and feel like gelatin or wet cotton

HABITAT: brackish to freshwater; deep lakes, shallow water bodies

ORIGIN: native to Northern Europe; reported in Lake Ontario in 1998, likely introduced in ballast water; spread to Lakes Michigan and Erie

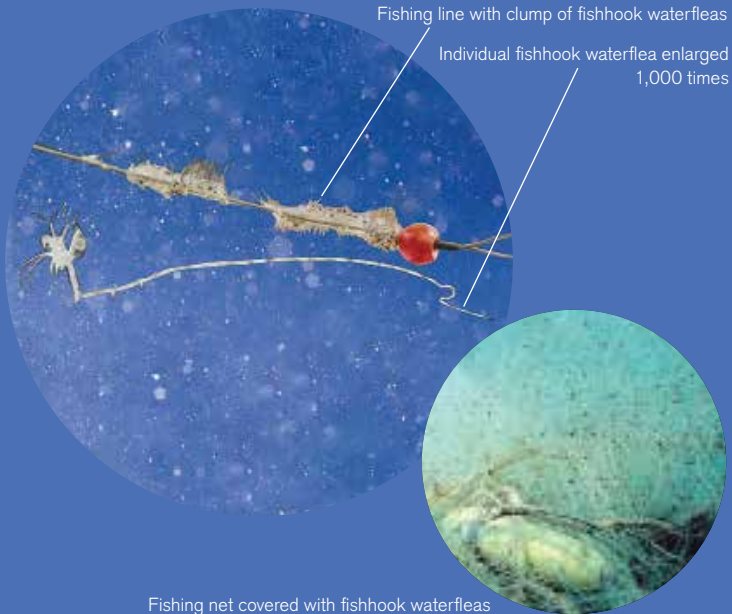
SPREAD BY: angling and boating equipment; eggs can be transported between lakes in early spring in sediment stuck to anchors and downrigger cables

HOW YOU CAN HELP:

Anglers often discover new infestations. Fishhook waterfleas can accumulate on gear and spread when that gear is used in a new body of water.

- **CLEAN • DRAIN • DRY** page 20
- **REPORT** new sightings to your state's natural resource agency (page 124); note date, exact location (page 128) and include a photograph, if possible
- Do not transport waterfleas alive; preserve them in ethanol (grain alcohol) or rubbing alcohol
- Drain water from specimens; place in alcohol-filled glass or plastic container and report
- Remove gelatinous blobs or cotton-like material from gear (to do this, pluck the line like a guitar string)
- Examine line at swivel, lure and downrigger connections, and inspect nets and anchor ropes

New populations can even start from eggs in dead females.



IMPACT ON YOU!

The fishhook waterflea's "hook" catches on fishing lines and nets, fouling gear and lowering the quality of recreational fishing and charter trips.

- Jams the first eyelet of fishing rods, often resulting in the loss of a hooked fish
- Devours **plankton**, essential to the diet of larval native fish
- Can coat commercial fishing nets

For more information go to www.usgs.gov or scan this code with your smart phone. See page 31 for details.

Spiny waterflea

Bythotrephes longimanus

OTHER COMMON NAMES: Eurasian spiny waterflea

DESCRIPTION: tiny (½ inch) and translucent with a long, sharply barbed tail spine; dark eyespot is prominent; large numbers form clumps (with black spots) that look/feel like gelatin or wet cotton

HABITAT: deep lakes, reservoirs, shallow water, large rivers, oxbows

ORIGIN: native to Northern Europe; likely introduced in **ballast** water; discovered in Lake Ontario in 1982; spread to all Great Lakes and some inland lakes

SPREAD BY: angling and boating gear contaminated with adults carrying eggs

HOW YOU CAN HELP:

Anglers often discover new infestations of spiny waterfleas accumulating on fishing gear. If not removed from all equipment, waterfleas can infest another body of water.

- **CLEAN • DRAIN • DRY** (page 20)
- **REPORT** new sightings to your state's natural resource agency (page 124); note date, exact location (page 128) and include a photograph, if possible
- Do not transport waterfleas alive; preserve them in ethanol (grain alcohol) or rubbing alcohol
- Drain water from specimens; place in alcohol-filled glass or plastic container and report
- Remove gelatinous blobs or cotton-like material from gear (to do this, pluck the line like a guitar string)
- Examine line at swivel, lure and downrigger connections, and inspect fishing nets and anchor ropes

Don't let their small size fool you; spiny waterfleas can have as serious an effect on aquatic food webs as larger invaders!

IMPACT ON YOU!

Spiny waterfleas collect on fishing gear, especially lines and downrigger cables, lowering the quality of recreational fishing and charter trips.

- Jams the first eyelet of fishing rods, often resulting in the loss of a hooked fish
- Clumps can damage the drag on some reels
- Disrupts **food web** of the aquatic **ecosystem**

For more information go to www.usgs.gov or scan this code with your smart phone. See page 31 for details.

Brazilian elodea

Egeria densa

OTHER COMMON NAMES: Brazilian waterweed

DESCRIPTION: very bushy; rooted in water (up to 20 feet deep) or drifting in open water; can form dense mats visible at surface; bright green leaves with 4–8 **whorls** that are close together along the **stem** (looks bushy); white flowers are present about 1 inch above the water in spring or early summer

COMPARE: a native look-alike, American elodea (*Elodea canadensis*), has smaller leaves in whorls of 2–3; also confused with Hydrilla (page 77)

HABITAT: slow-moving or still water in lakes, ponds and rivers; streams, ponds, springs, ditches

ORIGIN: native to South America; likely introduced by aquarium releases or accidentally shipped with aquatic plants

SPREAD BY: plant **fragments** easily tangle on boats, boat trailers, motors, equipment, fishing and diving gear

HOW YOU CAN HELP:

Dispose of unwanted aquarium or water garden plants in the trash. Be sure to rinse plant purchases to remove mud, unwanted plant fragments and other "hitchhikers."

- **CLEAN • DRAIN • DRY** page 20
- **REPORT** new sightings to your state's natural resource agency (page 124); note date, exact location (page 128) and include a photograph, if possible
- Wrap specimen in a wet paper towel, place in sealed plastic bag and report

Can survive periods of unfavorable conditions, such as flooding, and then rapidly spread during more favorable conditions.

IMPACT ON YOU!

Dense stands of Brazilian elodea can interfere with water-based recreation, such as fishing, boating and swimming, dramatically impacting tourism on infested lakes.

- Crowds out important native aquatic plants
- Degrades fish and waterfowl habitat
- Creates breeding ground for mosquitoes

For more information go to www.usgs.gov or scan this code with your smart phone. See page 31 for details.

Eurasian watermilfoil

Myriophyllum spicatum

OTHER COMMON NAMES: spike, spiked watermilfoil

DESCRIPTION: submerged, feathery; long stems branch near surface, forming thick mats in shallow water; green leaves with 12–21 threadlike leaflet pairs; 3–5 feathery leaves in **whorls** around the **stem**; small, reddish flowers above water midsummer

COMPARE: the leaf of the native look-alike, northern watermilfoil (*Myriophyllum sibiricum*) has only 5–10 leaflet pairs

HABITAT: shallow freshwater less than 20 feet deep; highly disturbed lakebeds; heavily used lakes and ponds; nutrient-rich areas; ponds; slow-moving areas of rivers and streams

ORIGIN: native to Eurasia and North Africa; accidentally introduced in the 1940s (possibly as early as the 1800s), most likely as a released aquarium plant

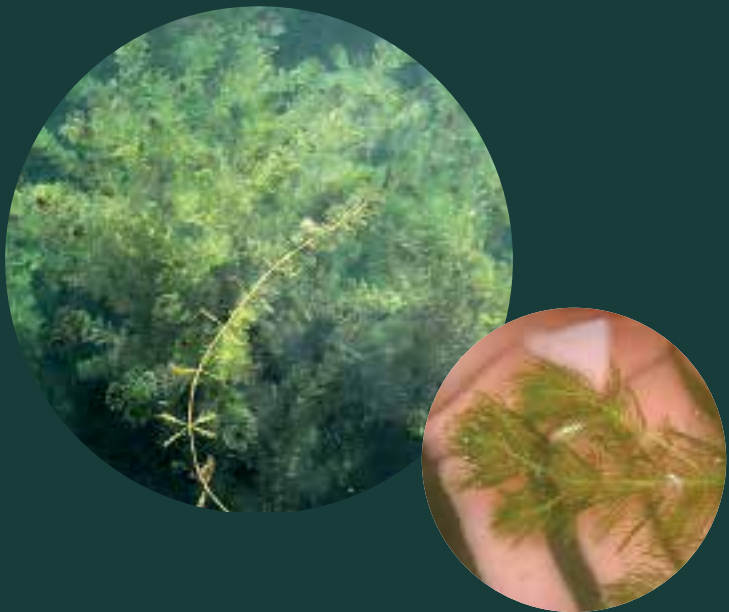
SPREAD BY: **fragmentation**; clinging to boats, trailers, motors, personal watercraft, fishing and diving gear; fragments break off and float with water currents; mechanical clearing can create thousands of fragments

HOW YOU CAN HELP:

Eradicating established infestations is nearly impossible, so detecting and reporting new infestations is vital.

- **CLEAN • DRAIN • DRY** page 20
- **REPORT** new sightings to your state's natural resource agency (page 124); note date, exact location (page 128) and include a photograph, if possible
- Wrap specimen in a wet paper towel, place in a sealed plastic bag and report

Threadlike pairs of leaflets resemble bones on a fish spine.



IMPACT ON YOU!

Infestations of Eurasian watermilfoil essentially take over shallow areas of lakes and can interfere with swimming, fishing, waterfowl hunting, and even boating, as plant **fragments** tangle on propellers.

- Can crowd out important native aquatic plants for waterfowl
- Impairs ability of some fish to spawn
- Reduces local property values
- Creates breeding grounds for mosquitoes

For more information go to www.usgs.gov or scan this code with your smart phone. See page 31 for details.

Bighead carp

Hypophthalmichthys nobilis

OTHER COMMON NAMES: Asian carp, noble fish, lake fish

DESCRIPTION: up to 60 inches, 130 pounds; dark gray dorsally, paling to silver-white sides with scattered dark blotches; big scaleless head with upturned mouth, no barbels; eyes set forward below the midline of body, eyes look downward

COMPARE: similar in appearance to silver carp (page 99) but has dark blotches on body

HABITAT: backwaters of large rivers, lakes and ponds; spawns in flowing water

ORIGIN: native to China; introduced to Arkansas in 1972 for water quality management in fish culture ponds; flooding resulted in its escape (as it did for the silver and black carp) into the Mississippi River Basin

SPREAD BY: range expansion via connected waterways and flooding; possible bait bucket transfers as young carp resemble shad; intentional releases

HOW YOU CAN HELP:

In March 2011, the U.S. Fish and Wildlife Service included bighead carp on the list of injurious fish species.

- **CLEAN • DRAIN • DRY** page 20
- **REPORT** sightings in new areas *immediately* to your state's natural resource agency (page 124)
- Note date, exact location (page 128) and include a photograph, if possible
- Freeze specimen (or preserve in rubbing alcohol) and report

Bigheads grow rapidly; they can gain a pound or more per month.

IMPACT ON YOU!

Bighead carp consume 5–20 percent of their body weight daily, competing for food with larvae of native fish, paddlefish and bigmouth buffalo in the upper Mississippi River system.

- Can load the nets of commercial fishermen to the point they are forced to abandon the fishing spot
- Each female produces millions of eggs annually and can live more than 30 years

For more information go to www.usgs.gov or scan this code with your smart phone. See page 31 for details.

Black carp

Mylopharyngodon piceus

OTHER COMMON NAMES: Asian carp, snail carp, Chinese black carp, black amur, Chinese roach, black Chinese roach

DESCRIPTION: up to 60 inches, 150 pounds; blackish brown to dark olive with a white belly, blackish gray **fins**; broad, blunt head, slightly downturned mouth, no **barbels**; no **keel**; large "chain-link" scales

HABITAT: large rivers, lakes and ponds

ORIGIN: native to Eastern Asia; imported for snail control in catfish farms in early 1970s; escaped in Missouri in 1994 when holding ponds flooded; black carp still are used by fish farmers to control snails that host a catfish parasite

SPREAD BY: flooding of fish farms; mistakenly included in grass carp (page 97) introductions; inclusion in bait shipments

HOW YOU CAN HELP:

Although not officially established in the United States, many fishermen from the Gulf Coast to Illinois and Missouri have reported catching them.

- **CLEAN • DRAIN • DRY** page 20
- **REPORT** new sightings to your state's natural resource agency (page 124); note date, exact location (page 128) and include a photograph, if possible
- Freeze specimen (or preserve in rubbing alcohol) and report

Because they eat a lot and reproduce rapidly, they're called "river rabbits" in Australia.

IMPACT ON YOU!

Black carp stay near or on the bottom and feed heavily on snails and mussels, posing a risk to native mollusks, many of which are endangered or threatened.

- Life span exceeds 15 years; even sterile black carp in the wild have the potential for harm

For more information go to www.usgs.gov or scan this code with your smart phone. See page 31 for details.

Grass carp

Ctenopharyngodon idella

OTHER COMMON NAMES: Asian carp, white amur

DESCRIPTION: large (up to 49 inches, 99 pounds); silvery dark gray, sides with gold sheen, white belly; broad blunt head, slight downturned mouth, no **barbels**; no **keel**; pointed **dorsal fin** with 8–10 soft rays; large "chain-link" scales

HABITAT: large standing or slow-flowing water with vegetation; lakes, ponds, pools, backwaters of large rivers; tolerates temperatures from freezing to over 100°F, as well as low oxygen levels and **brackish** water

ORIGIN: native to Eastern Asia; introduced in the United States in 1963 to control aquatic plants in fish farms and escaped due to flooding; escapees from stocking by federal and state agencies contributed to their rapid range expansion

SPREAD BY: legal stocking of fertile and sterile fish occurs in many states; escape from stocking locations, natural reproduction

HOW YOU CAN HELP:

Grass carp can now be found in 45 states. If you catch one from a body of water where it was not stocked, do not release the fish alive.

- **CLEAN • DRAIN • DRY** page 20
- **REPORT** new sightings to your state's natural resource agency (page 124); note date, exact location (page 128) and include a photograph, if possible
- Freeze specimen (or preserve in rubbing alcohol) and report

Can eat up to 100 percent of its body weight per day in aquatic plants and live up to 21 years.

IMPACT ON YOU!

Grass carp are widely established. In large numbers, they can potentially reduce native fish and waterfowl populations and adversely affect their habitat.

- Eliminates vast areas of aquatic plants that are important fish spawning and nursery habitat
- Consumes important aquatic **forage** for waterfowl

For more information go to www.usgs.gov or scan this code with your smart phone. See page 31 for details.

Silver carp

Hypophthalmichthys molitrix

OTHER COMMON NAMES: Asian carp, Asian leaping carp, flying carp, silver fin

DESCRIPTION: large (up to 41 inches, 60 lb.); olive green dorsally with bright silver sides; scaleless head, large upturned mouth, no **barbels**; eyes set forward below the midline of body, looking downward; sharp ventral **keel** from **anal fin** to throat; known for its leaping prowess (up to 10 feet out of the water)

COMPARE: similar in appearance to bighead carp (page 93), but lacks the dark blotches on body

HABITAT: near the surface of calm, slow-moving waters; lakes and backwaters of large rivers

ORIGIN: native to Eastern Asia; introduced in 1973 in Arkansas with bighead carp shipments; like bighead carp (page 93) and black carp (page 95), accidentally escaped by flooding; now present throughout much of the Mississippi River Basin

SPREAD BY: range expansion; potential bait bucket transfers

HOW YOU CAN HELP:

Silver carp are a danger to native fish species. They are spreading rapidly in the United States, and they are on the federal list of injurious species.

- **CLEAN • DRAIN • DRY** (page 20)
- **REPORT** sightings in new areas *immediately* to your state's natural resource agency (page 124)
- Note date, exact location (page 128) and include a photograph, if possible
- Freeze specimen (or preserve in rubbing alcohol) and report

In an effort to popularize them as a food in the United States, some restaurants call them "silver fin."

IMPACT ON YOU!

Silver carp leap in response to the noise and vibration of boat motors, posing a threat of serious injury to anglers and boaters.

- Can reach high densities following invasion, often dominating fish communities
- Feeds mostly on **plankton**, reducing food for larval fish and **filter-feeding** fish, such as native paddlefish

For more information go to www.usgs.gov or scan this code with your smart phone. See page 31 for details.

Round goby

Neogobius melanostomus

OTHER COMMON NAMES: goby

DESCRIPTION: rarely more than 7 inches long; mottled gray and brown; a single suction cup-like **pelvic fin**; frog-like, bulging eyes; black spot on rear margin of front **dorsal fin**

COMPARE: sculpin appear similar, but these and other native species have paired pelvic fins; the invasive tubenose goby (page 103) also has a single fused pelvic fin

HABITAT: nearshore, rock, cobble or **riprap**; bottom-dwelling; tolerates a wide range of conditions, including low oxygen and polluted waters

ORIGIN: native to Eastern Europe; introduced in **ballast** water; first discovered in 1990 near Detroit; in all Great Lakes by 1995

SPREAD BY: bait bucket transfers; high reproductive capacity; can spawn up to 6 times per summer

HOW YOU CAN HELP:

Gobies will often try to steal bait from anglers fishing near the bottom for perch or walleye. As a consequence, anglers are often the first to encounter gobies in a new habitat. Do not use them as bait!

- **CLEAN • DRAIN • DRY** page 20
- **REPORT** new inland sightings to your state's natural resource agency (page 124); note date, exact location (page 128) and include a photograph, if possible
- Freeze specimen (or preserve in rubbing alcohol) and report

One of the more annoying ways they impact anglers is by stealing bait from hooks!

IMPACT ON YOU!

Round gobies eat fish eggs, and may contribute to the decline of sport fish populations, such as smallmouth bass.

- Links in the transfer of **botulism** to waterfowl
- Aggressively competes with native bottom-dwelling fish
- Highly territorial for food, shelter and optimal spawning sites

For more information go to www.usgs.gov or scan this code with your smart phone. See page 31 for details.

Sea lamprey

Petromyzon marinus

OTHER COMMON NAMES: green lamprey, lamper, lake lamprey, eel sucker, lamprey eel, nine eyes, shad lamprey, spotted lamprey

DESCRIPTION: 12–20 inches; jawless, parasitic, eel-like fish; gray-blue back, metallic violet sides, silver-white belly; suction-cup mouth, hook-like teeth, rasping tongue

COMPARE: native freshwater lamprey species are smaller and mostly found in rivers and streams; they live in balance with the **food chain** and don't deplete fish populations

HABITAT: adults spawn in streams and die in spring; larvae burrow into the stream bottoms, feeding on debris and **algae** for 3–17 years, then transform into parasitic adults; they then migrate back into the lake for 12–20 months, feeding on fish

ORIGIN: native to North Atlantic Ocean; entered Lake Erie via the **Welland Canal** in 1921; spread to all Great Lakes by 1938

SPREAD BY: one adult lays more than 100,000 eggs; despite a 90 percent population reduction in most areas, sea lampreys remain a threat

HOW YOU CAN HELP:

Sea lampreys caused disastrous declines in Great Lakes trout and whitefish in the 1940–50s, resulting in hundreds of millions of dollars in damage to commercial/sport fisheries. Since 1956, the United States and Canada have led a successful control program, but it costs more than $18 million annually.

- Support legislation that maintains the sea lamprey control program
- If you catch fish with lamprey attached, kill the lamprey

Sea lampreys bore into fish to feed on their blood and body fluids; under some conditions, only 1 out of 7 victims survives.

IMPACT ON YOU!

Anglers who fish for lake trout, salmon, steelhead, brown trout, whitefish, yellow perch, burbot, walleye and catfish are affected by this parasitic invader; each lamprey kills an estimated 40 pounds of fish in its lifetime.

- One of the most devastating aquatic invasive species in the Great Lakes
- Contributed to the **extirpation** of lake trout in all of the Great Lakes, except Lake Superior

For more information go to www.usgs.gov or scan this code with your smart phone. See page 31 for details.

Rainbow smelt

Osmerus mordax

OTHER COMMON NAMES: smelt, freshwater smelt, American smelt

DESCRIPTION: up to 12 inches; shimmers colorfully in water but out of water fades quickly and smells like cucumbers; has an adipose fin; large teeth on jaws and tongue; large mouth, protruding lower jaw, upper jaw extends to middle of eye or beyond

HABITAT: landlocked in clear, cool, deep lakes; spawns in early spring along shorelines, rivers, streams; often schools in open water in summer

ORIGIN: native to Atlantic Coast and Lake Champlain; introduced into Crystal Lake, Michigan, as prey species in 1912; escaped and invaded the Great Lakes

SPREAD BY: use and release of live bait; illegal stocking

HOW YOU CAN HELP:

Its spread to inland lakes may be partly the result of anglers putting live smelt into bait buckets, where eggs and milt can mix, then unintentionally introducing them by dumping the mix into the water. Such disposal is illegal.

- **CLEAN • DRAIN • DRY** (page 20)
- **REPORT** new sightings to your state's natural resource agency (page 124); note date, exact location (page 128) and include a photograph, if possible
- Freeze specimen (or preserve in rubbing alcohol) and report
- States have differing laws regarding smelt (dead or alive)

Spawns in both streams and deep waters of the Great Lakes.

IMPACT ON YOU!

Evidence shows that after rainbow smelt move into a lake, they can decimate walleye populations. They are also known to negatively impact other native game fish.

- Eats the young of lake trout, cisco, whitefish, walleye . . . and their own!
- Implicated in the decline of native Great Lakes fish due to predation and **early life mortality syndrome**

For more information go to www.usgs.gov or scan this code with your smart phone. See page 31 for details.

Northern snakehead

Channa argus

OTHER COMMON NAMES: snakehead

DESCRIPTION: cylindrical body (up to 47 inches) is dark brown to tan with irregular blotches; long single **dorsal fin** and long **anal fin**; large scales on head give a "snakehead" appearance; jaws have canine-like teeth

COMPARE: the native bowfin (*Amia calva*) has a short anal fin and no scales on its head; native burbot (*Lota lota*) has 2 dorsal fins, a single **barbel** on the middle of chin and very tiny scales

HABITAT: muddy or vegetated ponds, swamps, slow-moving streams

ORIGIN: native to China; introduced by consumers after purchase from live-food markets or as released pets; first discovered in Crofton, Maryland, in 2002

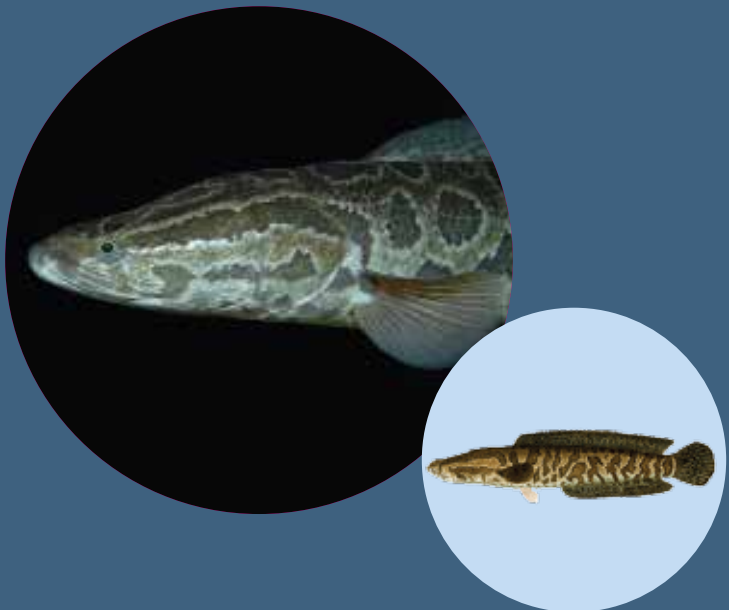
SPREAD BY: aquarium releases; live-food release

HOW YOU CAN HELP:

All species of snakeheads have recently been given "injurious wildlife" status. If you think you've caught a snakehead—**do not release it alive!**

- **REPORT** your catch or a sighting to your state's natural resource agency (page 124)
- Note date, exact location (page 128) and photograph, if possible
- Freeze specimen (or preserve in rubbing alcohol) and report

Can breathe air, survive for three days out of water and can crawl overland.



IMPACT ON YOU!

The northern snakehead is a voracious top-level predator with few natural enemies that reduces populations of native fish.

- Survives in water with very low oxygen, an advantage over trout, pike and bass
- Adapted to a wide range of environmental conditions
- Once established, very difficult to eradicate

For more information go to www.usgs.gov or scan this code with your smart phone. See page 31 for details.

ABOUT THE THREAT CAMPAIGN™

Invasive Species are one of the greatest conservation challenges facing our natural resources. They destroy habitat and are one of the leading causes for fish and wildlife to be added to threatened and endangered species lists.

The Threat Campaign is an award-winning national partnership of state, federal, tribal and non-governmental organizations and ordinary citizens working together to educate the public on awareness and prevention of invasive species. Using numerous multimedia tools, the Threat Campaign includes public service announcements, grassroots education and outreach events to inform those who play and work outdoors.

CLEAN • DRAIN • DRY are the most important steps you can take to ensure healthy fish and wildlife. Learn more at: www.CleanDrainDry.org

Help stop invasive species from ruining your favorite fishing spot or outdoor location. Join Wildlife Forever today.

ABOUT THE STOP AQUATIC HITCHHIKERS! CAMPAIGN

A National Public Awareness and Partnership Campaign on Aquatic Invasive Species

Stop Aquatic Hitchhikers! is a national public awareness campaign focused on education and prevention of aquatic invasive species. Designed by the U.S. Fish and Wildlife Service in partnership with many state, federal and various organizations, the multi-faceted campaign raises awareness with aquatic recreational users. Promoting environmentally friendly behaviors of **CLEAN • DRAIN • DRY**, consistent messaging and brand awareness reinforces prevention steps individuals can take to protect water resources from the damaging effects of invasive species.

Join the campaign!

Anyone can join the campaign and become an active prevention partner. By signing up, you will receive marketing tools and materials that will allow you to take the branded campaign message to your community. Help inform and educate others on aquatic invasive species prevention. Join Stop Aquatic Hitchhikers! today.

Visit www.CleanDrainDry.net to learn more.

WILDLIFE FOREVER
2700 Freeway Blvd., #1000
Brooklyn Center, MN 55430
(763) 253-0222
www.WildlifeForever.org

GLOSSARY

adaptation particular characteristic developed that makes it better suited to its environment

adipose fin a fin on many fish located behind the dorsal fin; often clipped on hatchery fish so that people can tell them from wild fish NOTE: not shown on the picture diagram (page 87)

algae plants that are usually aquatic, ranging in size from single cells to large seaweeds, and lack true stems, roots and leaves

algal bloom occurs in both marine and freshwater during suitable environmental conditions when algae responds to nutrients in the water and reproduces rapidly; some produce potent chemical toxins

amphibian cold-blooded, smooth-skinned vertebrates that spend part of their life on land and part of their life in the water, including frogs, toads, newts and salamanders

anadromous fish that spend most of their life in salt water but migrate to freshwater to spawn

angler person who catches fish or attempts to catch fish for food or recreation

annual plant that completes its life cycle in one year or less

anterior situated forward, toward the head end

aperture the hole at the base of a snail's shell through which the body comes out

aquaculture cultivation of freshwater and marine resources, both plant and animal, for human consumption or use

aquatic of, in or pertaining to water

aquatic insect insects that spend all or part of their lives in water (e.g., mayflies)

aquatic plant plant that grows partly or wholly in water, whether rooted in the mud or floating

axis the main stem or central part around which plant parts, such as branches, are arranged

bait natural, processed and artificial objects used to catch fish

ballast material (rocks or water) taken onboard ships to help maintain stability when the cargo hold is empty

barb sharp, spur-like projection

barbel slender, fleshy, flexible projection near the mouth of certain fish, including catfish and carp; used for smell and taste

basal pertaining to the base of a plant or stem

behavior way an organism responds to its environment

benthic relating or pertaining to the bottom or lowermost levels of a sea or lake

bilge the area in the bottom of a boat, usually near the stern, where water collects

biodiversity the variety of lifeforms within an ecosystem and a measure of its health

biofoul attachment of an organism or organisms to a surface in contact with water for a period of time; can eventually cause corrosion (e.g., hulls of ships, fishing equipment, water cooling systems)

biologist person who studies the science of living organisms and life processes

bivalve second-most diverse group of mollusks, easily recognized by its two-halved shell, including mussels, oysters and scallops

bottom-dwelling living on or in sea, lake or river bottoms

botulism poisoning by botulinum toxin, one of the most potent toxins known

brackish slightly salty or briny water

brood (verb) to hatch, protect and warm the young, usually done instinctively by the female

burrow (verb) to dig underground

byssal thread strong, silky fiber made from proteins that is used by mussels to attach to rocks, pilings or other surfaces

camouflage protective adaptation that enables an organism to disguise itself or blend with its surroundings

carapace the part of the shell covering the head and thorax of a crab or crayfish

carnivore eats only meat

catch-and-release practice of catching game fish using sporting methods and releasing them alive and unharmed; catch-and-release is used as a wildlife management tool designed to increase fish populations by restricting the number of fish caught and kept by anglers, as well as regulating the size and type of the fish caught

cluster (noun) number of things of the same kind, growing or held together; (verb) to gather into a cluster

clutch nest of eggs

colony group of organisms that prefers to live together

communication sound, scent or behavior recognized by members of the same species (see also "pheromone" and "courtship")

competition the struggle between different species that use the same source for food or shelter

conchologist person who studies mollusks and shells

conservation care, wise use and management of a resource

courtship behavior or series of actions a fish displays to indicate to the opposite sex that it is ready to mate in order to reproduce

cover naturally occurring sheltered areas that provide concealment and shelter for wildlife, such as a dead tree, fallen log, rock outcrops or dense areas of plants

crustacean group of mostly aquatic animals that have an exterior skeleton and antennae; some examples of crustaceans include shrimps, lobsters, crabs and water fleas

cylindrical long, roller-shaped body with circles at the two ends, with straight sides between

detritus the broken-down remains of dead plants and animals, and the bacteria living in or on it

diatom a unicellular organism and one of the most common types of phytoplankton; both abundant and of vital importance, thought to produce at least a quarter of our oxygen

die-off when a large number of organisms (plants or animals) die suddenly in a short timeframe; a common cause of summer fish kills occurs when a dense growth of submerged aquatic plants or algae dies suddenly from natural causes and decomposes, using up all the oxygen in the water; this leaves none for other aquatic organisms, such as fish

diurnal active during the day

dorsal upper surface of an organism; the top

early life mortality syndrome a thiamin deficiency in young fish, primarily lake trout, caused by a maternal diet high in smelt or alewife

ecology study of the relationships between living things and the environment in which they live

ecosystem interacting system of plants, animals, soil and climactic conditions in a self-contained environment (e.g., pond, marsh, swamp, lake or stream)

emergent aquatic plants which have some portion of the plant extended out of the water

endangered species in danger of becoming extinct due to declining population numbers

environment entire surroundings of an organism or group of organisms

eradicate completely eliminate from an area

Erie Canal a 363-mile-long waterway in New York that runs from the Atlantic Ocean to the Great Lakes; opened in 1825, now part of the New York State Canal System

estuary area where freshwater and salt water meet, and the area where rivers dump into lakes

ethics principles of good conduct; a sense of right and wrong

exotic an organism from another region or ecosystem that may be considered undesirable as it competes with native species for habitat and food (see “invasive species”)

extinct species that no longer exists or has died out

extirpation to remove totally from an area

face a flat side

filter-feed feed by straining suspended matter and food particles from water, typically by passing the water over a specialized filtering structure

fin membranous appendage extending from the body of a fish or other aquatic animal, used for propelling, steering or balancing the body in the water (see page 87)

fin thread long, threadlike last ray of the dorsal fin

fishery biologist person who manages aquatic and wetland habitats and fish reproduction and health

fishing line cord used or made for angling

food chain plants and animals linked together as sources and consumers of food; typically an organism higher in the food chain eats the one lower in the food chain, so the health of one is dependent on the health of another

food web the many possible feeding relationships found within a given ecosystem

forage (noun) plant material; (verb) to eat plant material

foul make foul or dirty; pollute

fragment small plant piece broken off (often by boat propellers) or detached naturally

fragmentation one method by which an aquatic plant spreads; a single tiny fragment that contains at least one node is capable of rooting and growing into a new plant

freshwater body of water that contains little salt (e.g., pond, lake or stream)

fruit plant structure that bears the seeds

fry newly hatched young fish

game fish fish that can be caught according to legal seasons and limits

gill respiratory organ in mollusks, crustaceans and fish that obtains oxygen from the water and releases carbon dioxide

habitat local environment in which one lives; includes food, water, cover (shelter) and space

herbivore eats only plant material

hermaphroditic having reproductive organs of both sexes

hibernation period of winter dormancy during which body processes slow dramatically, reducing the amount of energy required for survival

home range area over which an animal repeatedly travels in order to locate food, water and cover

host animal or plant in or on which another organism lives

hybridize sexual reproduction between two different recognized species

ichthyology study of fish

immersed beneath the surface of the water

immune system body system made up of many organs and cells that defends against infection, disease and foreign substances

incubate the time for an embryo to develop in an egg prior to hatching

instinct inherited or unlearned behavior

invasive species plants, animals, fish or diseases brought from another region, often another continent, either intentionally or by accident, that have a negative effect on the native species as they compete for habitat and food (also referred to as exotic, non-native or introduced species)

invertebrates animals without backbones, including insects, earthworms, spiders and mollusks

keel sharp, longitudinal fold or ridge, usually on the ventral side of a fish

landlocked living in waters shut off from the sea, as in some fish

larva (singular) **larvae** (plural) newly hatched, earliest stage that differs greatly from the appearance and form of an adult

lateral line system of sensory nerves in the skin, extending from head to tail on either side of a fish, that detects movement of water and other fish

leaf blade-like organ attached to the stem, commonly functioning as a principal organ in photosynthesis

leaflet one of many leaf-like structures that make up a leaf

leafstalk (petiole) stem-like structure that attaches a leaf to the main stem

limiting factor environmental component, such as drought, extreme cold and shortage of food or cover, that negatively impacts wildlife and plant populations

lip wall of the opening made by the last complete turn of the shell in snails

littoral zone (freshwater) region close to shore. Sunlight reaches all the way to the bottom, allowing rooted aquatic plants to grow, creating a habitat for fish and other organisms that is very different from open water.

livewell compartment in a boat designed to hold water (typically recirculating) and keep fish alive

lure artificial object used to catch fish

macrofoul clogging of screens and other hard-surfaced components in raw water systems because of living organisms

margin edge or border of a leaf

marine aquatic habitat in salt water

migration seasonal movements of fish and wildlife from one area to another that are usually triggered by environmental cues, such as day length, temperature or water flow

milt semen of a male fish that fertilizes the female's eggs during spawning

Mississippi River Basin the fourth-largest watershed in the world covering much of the central United States; drained by the Mississippi River System from its origin in Minnesota, east to the Appalachian Mountains, west to the Rocky Mountains and emptying into the Gulf of Mexico in Louisiana

mollusk or **mollusc** invertebrates with smooth, soft bodies, including clams, snails, oysters, slugs, octopuses and squid

multiple-use using and managing an area to provide more than one benefit simultaneously

nacreous, **nacre** pertaining to the pearly lining of a mussel shell

native indigenous or naturally occurring species

natural resource material found in nature to which people have assigned value

New York State Canal System (NYSCS) a 524-mile canal system across New York State linking the Great Lakes with the Hudson River

nocturnal active at night

node point along a stem which gives rise to leaves, branches or flowers

nongame species the fish and wildlife not often sought for sport by humans

nonrenewable natural resource nonliving natural resources that, for all practical purposes, cannot be replaced, including metallic minerals and fossil fuels

noxious weed any plant designated by a federal, state or county government as injurious to public health, agriculture, recreation, wildlife or property

nut hard, one-seeded fruit, typically with an outer shell

omnivore eats both plants and meat

operculum (mollusks) covering or lid that closes the opening; (fish) the cover protecting the gills

parasite organism, plant or animal, feeding on another

parthenogenesis form of reproduction in which an unfertilized egg develops into a new individual

pathogen a germ (such as a bacterium or virus) that causes disease

pathway way that serves as a path for something to move or spread

pelvic of, relating to, or located in or near the pelvis

perennial plant that lives for more than two years

pharyngeal teeth teeth composed of hard, movable plates located in the throat of certain fish and used for crushing or grinding food

pheromone chemical scent secreted as a means of communication among members of the same species

photosynthesis process by which plant cells convert light, water and carbon dioxide into energy and nutrients while simultaneously releasing oxygen

phytoplankton plants and plantlike organisms in plankton; the very foundation of the aquatic food web; they are also responsible for consuming carbon dioxide from the atmosphere and releasing oxygen into the water

plankton group of passively floating or drifting organisms occurring in a body of water, primarily microscopic algae and protozoa; it is important as the base food source and all aquatic life is dependent upon the energy and oxygen it provides

pollution toxic (poisonous) substances deposited in the air, water or soil, creating an unhealthy environment

population collection of individuals of the same species in a given area whose members can breed with one another

posterior the rear; at the tail end

predator one that hunts and feeds on others (prey)

prey one that is hunted or killed for food by others (predators)

range particular geographic region in which a species is found

ray flexible support for a fin

recreation activity undertaken for enjoyment; entertainment often associated with natural resources, such as fishing, boating, bird watching, hiking and hunting

redd nest-like depression made by a male or female fish to contain eggs

renewable natural resource natural resource that can be replenished and harvested, including trees and wildlife

resting egg egg that has entered a phase of slowed or stopped development, sometimes over winter

rhizome stem that grows horizontally at or just below the soil surface, producing roots below and sending up shoots above

riparian area lands adjacent to streams, rivers, lakes and other wetlands where the vegetation is influenced by the great availability of water

riprap rock or other material used to protect shorelines, streambeds, bridge abutments, pilings and other shoreline structures against water or ice erosion

rosette dense cluster of leaves that are all at a single height, such as petals of a rose

salt water body of water with a high concentration of salt

scales small, flat plates that fit together to form the external body covering of a fish

school group of fish

scute modified, thickened scale that often is keeled or spiny

season pertaining to the window of time in which females are reproductively active to produce offspring

serrated (plant) leaf with sharp, typically forward-pointing, teeth

sinker small metal weight used by anglers designed to sink bait or lures

spawn process of fish reproduction; involves females laying eggs and males fertilizing them to produce young fish

species group that has a similar structure, common ancestors and characteristics that are maintained through breeding

sport fish certain species of fish that are actively pursued by anglers because they are considered challenging and/or fun to catch or they are desirable to eat (also called game fish)

stem principal shoot of a plant

stewardship responsible care of natural resources for future generations

stocking adding fish (usually game fish) to a body of water, such as a lake, pond or stream

stolon flat-lying or creeping plant structure that lies along the top of the ground, from which erect branches grow (a runner is a type of stolon)

stress factor that may negatively affect health, such as lack of food and/or habitat, disease or overpopulation

substrate surface or material on or from which an organism lives, grows or obtains its nourishment

suture spiral line marking the junction between whorls in mollusks

tackle fishing equipment (e.g., rods, reels, poles, lines, sinkers, hooks, bobbers and lures)

territory area defended, usually during breeding season, typically against members of its own species

threatened classification for species whose population is in great decline and approaching the endangered classification

tooth (plant) points or lobes along a leaf edge

toxic poisonous

transfer movement of live bait and water from one body of water to another

trematode parasitic flatworms having external suckers for attaching to a host

trolling to fish in by trailing a baited line or lines behind a boat

tuber potato-like or pealike swellings forming at the end of roots or on rhizomes that overwinter and sprout into new plants in the spring

turion hardy plant bud found on the stem of certain aquatic plants that detach, fall or drift on currents to the bottom, overwinter and grow into a new plant the following spring

valve half the shell of a bivalve

vector spreads infection by transporting pathogens from one host or place to another, but does not itself cause disease

veliger microscopic, free-swimming larva of some mollusks, such as zebra and quagga mussels

ventral lower surface of an organism; the bottom

vertebrate having a backbone, including fish, birds, mammals, reptiles and amphibians

viable (plant) able to begin to grow and put out shoots after a period of dormancy

Welland Canal built to go around Niagara Falls and connect Lake Ontario to Lake Erie, providing a man-made deep waterway to access the Great Lakes; the first Welland Canal opened in 1829; the present canal officially opened in 1932

whorl (plant) three or more leaves, forming a ringlike arrangement around the stem; (invertebrate) one turn of a spiral shell

wildlife non-domesticated animals (including mammals, birds, fish, reptiles, amphibians and insects)

wildlife agency state or federal organization responsible for managing wildlife

wildlife management combination of techniques, scientific knowledge and technical skills used to protect, conserve and manage wildlife and habitat

winterkill death during winter resulting from lack of oxygen due to deep snow cover and low oxygen production

zooplankton the animal constituent of plankton; mainly small crustaceans and fish larvae; populations of zooplankton feed on phytoplankton, and then, in turn, they provide nourishment for fish and crustaceans

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