
Source: J. Liebig, NOAA GLERL.

# CASE STUDY: WATERFLEAS—FISHHOOK WATERFLEA AND SPINY WATERFLEA (*Bythotrephes longimanus, Cercopagis pengoi*)

*The introduction and spread of aquatic invasive species (AIS) poses a threat to lakes, rivers, and other water bodies throughout North America. One pathway that has been shown to contribute to AIS spread is seaplanes. This case study illustrates the role seaplanes can play in the spread of AIS and the negative impacts AIS establishment can have on the environment as well as seaplane safety and operations. These case studies also illustrate the important role seaplane pilots can play to prevent the spread of AIS.*

## FAA Geographic Region: Great Lakes

Waterfleas are widespread and well-established in the Great Lakes. Likely introduced in the ballast water of large ships in the 1980s and 1990s, fishhook and spiny waterfleas are a concern to the region. Efforts to reduce their spread are focused on preventing their unintentional movement into and between inland lakes by human activities. Of particular concern are lake-hopping excursions that include visits to one or more lakes containing waterfleas.

## What are Waterfleas?

Misleadingly named, waterfleas are not aquatic insects, but rather tiny crustaceans that swim in the water columns of lakes with other organisms (collectively called zooplankton). Nearly invisible to the human eye, these tiny translucent animals can dominate native zooplankton communities. The spiny tails of waterfleas, making up more than 2/3 of their total length, can have one to four pairs of thorn-shaped barbs, often making them inedible. Female waterfleas produce offspring rapidly during the summer months but, in early fall, switch to producing eggs that can remain dormant, surviving the colder winter months on lake bottoms or being transported long distances on damp equipment.

## Why are Waterfleas a problem?

Although small, waterfleas can have a profound effect on waterbodies, out-competing native zooplankton species, disrupting food chains, and negatively impacting recreational fishing. Waterfleas cause a significant decline in zooplankton, leading to less food for small native fish, including young sport fish, such as bass, walleye, and yellow perch. Because waterfleas are largely inedible, reproduce rapidly, and consume native zooplankton, the more abundant waterfleas become in a waterbody, the less food there is for fish. In addition, the presence of waterfleas impacts both recreational angling and commercial fishing (including fish farms). Their tail spines get snagged on fishing equipment, such as lines, nets, and cables. The value of lakes known for recreational fishing can decline sharply with the establishment of waterfleas. Once introduced, there are no known techniques for controlling or eliminating them from an infested lake.

## How can Waterfleas be spread by seaplanes?

Waterfleas, snagged by their barbed tails, can easily be transported on seaplane floats, mooring lines, wires and cables, and rudders. Although adult waterfleas may not survive for long out of water, their dormant eggs are resilient, particularly if they remain in the female waterflea's body (the barbed tail spine staying attached to ropes, lines, vegetation, and mud), and can hatch whether or not the carrier waterflea is alive. If introduced to a new water body, the eggs can hatch and quickly multiply into a large population. Both live waterfleas and dormant eggs may also be successfully transported in trapped standing water.

Seaplane pilots that lake-hop can unintentionally spread both entrained live waterfleas or dormant eggs from lake to lake and facilitate the rapid expansion of these species.

**Seaplane pilots can help prevent the spread of aquatic invasive species.**

Examples of other aquatic invasive species you may encounter in your region:

- a microsporidian parasite (*Heterosporis sutherlandae*)
- Brittle Waternymph (*Najas minor*)
- Curly-leaf Pondweed (*Potamogeton crispus*)
- Largemouth Bass Virus (LMBV) (*Ranavirus* [*LMBV*])
- Lyngbya (*Lyngbya wollei*)
- New Zealand Mudsnail (*Potamopyrgus antipodarum*)
- Red-rim Melania (*Melanoides tuberculata*)
- Water Lettuce (*Pistia stratiotes*)
- Whirling Disease (*Myxobolus cerebralis*)
- Yellow Floating-heart (*Nymphoides peltata*)

# CASE STUDY: FEATHERED MOSQUITOFERN (*Azolla pinnata*)

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## FAA Geographic Region: Southern

Feathered mosquitofern has been found in (and removed from) numerous plant nurseries in the United States. It has a limited distribution to water bodies in Florida and Hawaii. Because of its limited distribution, seaplane pilots can prevent further spread of this plant to new water bodies.

## What is Feathered Mosquitofern?

Feathered mosquitofern is a small free-floating aquatic fern with roots that are suspended in the water column. Individual plants often clump together to form dense floating mats. Native to Australia, feathered mosquitofern grows in habitats of slow-moving freshwater ponds, swamps, and drainage canals, and thrives in temperate humid climates. The few populations that exist in the United States were spread by hitchhiking on other aquarium plants, and subsequently dumped into waterbodies. Both plant fragments and spores can produce new plants.

## Why is Feathered Mosquitofern a problem?

Feathered mosquitofern can grow rapidly and cover the surface of a waterbody. The species can grow very quickly and can double its population size every two to five days. Their dense mats can reduce water oxygen levels and deplete nutrients in the water column resulting in impeded native plant growth. Dense mats can also limit access to boating, fishing, and other activities. Feathered mosquitofern can spread on currents between connected waterbodies, and can attach to watercraft and equipment. Dense mats may also clog irrigation and flood control structures.

## How can Feathered Mosquitofern be spread by seaplanes?

Seaplanes that take on water in their floats may contain fragments or spores of feathered mosquitofern. Feathered mosquitofern can survive for days on moist soil out of water. Fragments can easily be transported on seaplane floats, mooring lines, wires and cables, and rudders.

**Seaplane pilots can help prevent the spread of aquatic invasive species.**

Examples of other aquatic invasive species you may encounter in your region:

- Alligatorweed (*Alternanthera philoxeroides*)
- Common Salvinia (*Salvinia minima*)
- Giant Salvinia (*Salvinia molesta*)
- Indian Swampweed (*Hygrophila polysperma*)
- Parrotfeather (*Myriophyllum aquaticum*)
- Water Hyacinth (*Eichhornia crassipes*)
- Water Lettuce (*Pistia stratiotes*)
- Waterflea (*Daphnia lumholtzi*)
- Yellow Floating-heart (*Nymphoides peltata*)

Source: Oklahoma Department of Wildlife Conservation.

# CASE STUDY: GOLDEN ALGAE (*Prymnesium parvum*)

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## FAA Geographic Region: Southwest

Golden algae have been found in more than 20 states, and blooms were first noted in Texas in the 1980s. During the early 2000's, algae blooms in reservoirs and rivers occurred across the southern United States. The alga occurs in brackish inland waters and coastal freshwater rivers, lakes, and estuaries. Seaplane-accessible water bodies across the Southwest may be at risk from golden algae introductions.

## What is Golden Algae?

Golden alga can be found suspended in the water column. The algae, suspected to originate from Europe, uses energy from the sun to grow. The algae produces chemicals toxic to other plankton and microscopic life. As other organisms die from these toxic chemicals, golden algae grow excessively, or bloom, creating a golden color in the water. Evidence suggests that the toxin production by golden algae can be triggered by increased salinity linked to periods of drought.

## Why is Golden Algae a problem?

The chemicals produced by golden algae are toxic to gill-breathing animals, such as fish and shellfish as well as plankton. The first observation of the algae in North America was linked to a massive fish kill of nearly 150,000 individual fish in Texas. A conservative estimate of more than 30 million fish deaths in Texas are directly linked to golden algae toxic blooms. Native mussel beds have also succumbed to toxins from algal blooms. Harmful algal blooms that cover the surface of the water block sunlight from reaching other organisms in deeper water, hindering their growth. To minimize their negative impacts and spread, algal blooms can trigger waterbody closures to all activities.

## How can Golden Algae be spread by seaplanes?

Algae may be transported within or on the floats of seaplanes. It is also possible that algae may hitchhike on other aquatic plants that attach to seaplane floats, mooring lines, wires and cables, and rudders. The resting, or dormant, stage of the algae may be one way that this species can survive and facilitate spread to new waters.

**Seaplane pilots can help prevent the spread of aquatic invasive species.**

Examples of other aquatic invasive species you may encounter in your region:

- Alligatorweed (*Alternanthera philoxeroides*)
- Brittle Waternymph (*Najas minor*)
- Common Salvinia (*Salvinia minima*)
- Feathered Mosquitofern (*Azolla pinnata*)
- Giant (or Island) Apple Snail (*Pomacea maculata*)
- Giant Salvinia (*Salvinia molesta*)
- Indian Swampweed (*Hygrophila polysperma*)
- Water Hyacinth (*Eichhornia crassipes*)
- Water Lettuce (*Pistia stratiotes*)
- Waterflea (*Daphnia lumholtzi*)

# CASE STUDY: HYDRILLA (*Hydrilla verticillata*)

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## FAA Geographic Region: Central

Hydrilla was first found in the United States in Florida in 1952 and has since spread to 27 states primarily in the South and East. In the Central Region, infestations of hydrilla are concentrated in Missouri and Oklahoma. Because of its limited distribution in the Central Region, it is possible that informed seaplane pilots can prevent further spread to other waterbodies.

## What is Hydrilla?

*Hydrilla verticillata*, and its numerous subspecies, is a rooted aquatic plant that grows long stems to reach the surface to form dense mats. It can be found in freshwater lakes, rivers, ponds, and canals. Native to the Indian subcontinent, it is a popular aquarium plant that was initially introduced to waters of the United States as discards from aquarium dumping. Hydrilla fragments, root stem pieces, and its tubers can generate new plants. The tubers can survive multiple days out of water.

## Why is Hydrilla a problem?

Once established, hydrilla can grow aggressively and spread in shallow areas forming thick mats. The thick growth can displace beneficial native plants and create anoxic conditions harming other species. Dense beds of hydrilla can also restrict boating, swimming, and general access to water. Recently, cyanobacteria—blue-green algae that can affect water quality and function—have been associated with hydrilla infestations, which has been linked to bald eagle, waterbird, and fish deaths.

## How can Hydrilla be spread by seaplanes?

Hydrilla can be moved to new waterbodies as fragments clinging to floats and other seaplane surfaces. Plant fragments or tubers can become entrained and easily be transported on seaplane floats, mooring lines, wires and cables, and rudders. Seaplanes that take on water in their floats may contain plant fragments that can be transported to new waters.

**Seaplane pilots can help prevent the spread of aquatic invasive species.**

Examples of other aquatic invasive species you may encounter in your region:

- Brazillian Waterweed (*Egeria densa*)
- Brittle Waternymph (*Najas minor*)
- Common Salvinia (*Salvinia minima*)
- Curly-leaf Pondweed (*Salvinia minima*)
- Eurasian Watermilfoil (*Myriophyllum spicatum*)
- Flowering Rush (*Butomus umbellatus*)
- Purple Loosestrife (*Lythrum salicaria*)
- Water Hyacinth (*Eichhornia crassipes*)
- Water Primrose (*Ludwigia spp.*)
- Whirling Disease (*Myxobolus cerebralis*)

Source: National Park Service.

# CASE STUDY: NEW ZEALAND MUD SNAILS (*Potamopyrgus antipodarum*)

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## FAA Geographic Region: Eastern

First reported in the United States near the Snake River in Idaho, New Zealand mudsnails have spread rapidly throughout the western states, in the Great Lakes, and in lakes and streams in parts of the East Coast, including Pennsylvania and New York. The physiology and biology of mudsnails make them well-suited for human-aided introduction and spread.

## What are New Zealand Mudsnails?

New Zealand mudsnails are tiny, brownish freshwater snails about ¼ inch long. These small snails are remarkably adaptable to a wide range of conditions and habitats ranging from cold flowing streams to warm water lakes and brackish water. Their broad tolerances for water temperature, flow rates, and salinity create significant potential for widespread establishment across much of the United States. Mudsnails have a flap (also known as an operculum) that allows them to withdraw into their shells, making it possible for them to survive out of water for days. Populations within the United States are almost exclusively female and produce live young through cloning—the introduction of a single snail can start a new population.

## Why are New Zealand Mudsnails a problem?

Once established, mudsnail densities can increase rapidly, sometimes carpeting the shallow portions of water bodies, crowding out native insects and invertebrates essential in the food webs of lakes and streams. Because of their small size and hard shell, mudsnails are not a good food source for fish, often remaining undigested and alive after a trip through a fish's digestive system. Once established, mudsnails are unlikely to be eradicated from natural systems even with targeted pesticides or water drawdowns.

## How can New Zealand Mudsnails be spread by seaplanes?

These tiny snails, easily mistaken for bits of gravel or mud, are natural hitchhikers. Because of their small size, they can wedge themselves into cracks and crevices. Mudsnails can also be transported on any entangled aquatic plants or standing water. In addition, any equipment, including anchors, lines, and cables, that come in contact with the sediment at the bottom of a lake can transport mudsnails.

Image Source: U.S. Geological Survey.

**Seaplane pilots can help prevent the spread of aquatic invasive species.**

Examples of other aquatic invasive species you may encounter in your region:

- Didymo (*Didymosphenia geminata*)
- European Frogbit (*Hydrocharis morsus-ranae*)
- Faucet Snail (*Bithynia tentaculata*)
- Fishhook Waterflea (*Cercopagis pengoi*)
- Mystery snails (*Cipangopaludina spp.*)
- Spiny Waterflea (*Bythotrephes longimanus*)
- Variable-leaf Watermilfoil (*Myriophyllum heterophyllum*)
- Water Primrose (*Ludwigia spp.*)
- Waterwheel Plant (*Aldrovanda vesiculosa*)
- Yellow Floating-heart (*Nymphoides peltata*)

## CASE STUDY: GIANT SALVINIA (*Salvinia molesta*)

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### FAA Geographic Region: Western Pacific

Giant salvinia is an invasive floating freshwater fern found in the lower Colorado River basin. It is associated with southern drainages, as well as San Luis Obispo County, California. Native to Brazil and introduced to the United States for use in aquariums and decorative ponds, giant salvinia is one of many similar species of invasive floating vegetation that blanket water bodies, choking out native plants and animals and eliminating recreational opportunities.

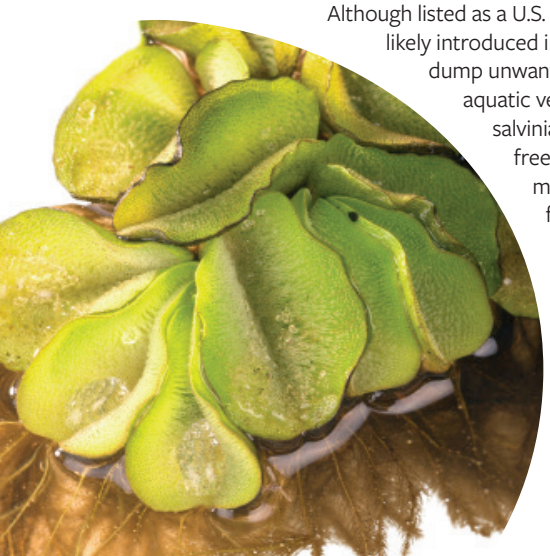
### What is Giant Salvinia?

Considered one of the most problematic aquatic plants in the southern United States, giant salvinia is a robust, fast-growing, floating aquatic fern. Originally imported from Brazil for sale in the pond and aquarium trade, it grows in dense mats that can double in size in just a week under ideal conditions. Giant salvinia grows best in warm, nutrient-rich, still or slow-moving water bodies, including ditches, ponds, lakes, slow-moving rivers, and canals.

### Why is Giant Salvinia a problem?

Thick mats of giant salvinia can eventually cover the entire surface of a water body, slowing water movement and dramatically decreasing available sunlight and oxygen for native plants and animals. Decaying plant matter falls to the bottom of these systems, further decreasing available oxygen. Mats of giant salvinia up to 3 feet thick have been reported, but even less dramatic densities of salvinia are known to impede navigation and eliminate recreational activities, such as swimming and fishing, while creating a beneficial habitat for mosquitos.

### How can Giant Salvinia be spread by seaplanes?



Although listed as a U.S. Federal Noxious Weed and thus illegal to sell, giant salvinia is likely introduced into new areas by uninformed aquarium or pond owners who dump unwanted vegetation. Recreational activities that entrain and transport aquatic vegetation are likely responsible for the further spreading of giant salvinia. Fragments of giant salvinia, which can tolerate short periods of freezing temperatures, can easily be transported on seaplane floats, mooring lines, wires and cables, and rudders. Once established, floating clumps of giant salvinia can spread independently through flowing water, wind, and currents.

**Seaplane pilots can help prevent the spread of aquatic invasive species.**

Examples of other aquatic invasive species you may encounter in your region:

- European Water-starwort (*Callitriche stagnalis*)
- Feathered Mosquitofern (*Azolla pinnata*)
- Hydrilla (*Hydrilla verticillata*)
- Quagga Mussel (*Dreissena bugensis*)
- Red-rim Melania (*Melanoides tuberculata*)
- Spongeplant (*Limnobium laevigatum*)
- Water Primrose (*Ludwigia spp.*)
- Waterflea (*Daphnia lumholtzi*)
- Yellow Floating-heart (*Nymphoides peltata*)
- Zebra Mussel (*Dreissena polymorpha*)

# CASE STUDY: DREISSENID MUSSELS—ZEBRA AND QUAGGA MUSSELS (*Dreissena polymorpha, D. rostriformis bugensis*)

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## FAA Geographic Region: Northwest Mountain

Dreissenid mussels were first found in the Great Lakes Region in 1997 where they were introduced via ballast water from global shipping. They have since spread across the United States via connected water systems, trailered watercraft, and other fouled equipment. Notable reservoirs within the Colorado River Basin are infested with quagga mussels, however invasive mussels have not been detected in most of the Pacific Northwest. The 2023 discovery of dreissenids in the Snake River, Idaho resulted in a prompt eradication attempt by the State of Idaho. Seaplane-accessible water bodies across the Northwest may be at-risk from the introduction of dreissenids by seaplanes.

## What are Dreissenid Mussels?

Dreissenid mussels, also known as zebra and quagga mussels, are freshwater bivalves that can live in lakes, rivers, and reservoirs. Native to Central and Eastern Europe, dreissenids are filter-feeding mussels that can colonize both soft and hard surfaces. Much like marine mussels (and unlike native freshwater mussels and clams), adult dreissenid mussels attach firmly to hard surfaces with byssal threads. Their microscopic larval form, or veliger, floats in the water and can survive in small amounts of water.

## Why are Dreissenid Mussels a problem?

Once established in a waterbody, dreissenids can colonize underwater surfaces and foul infrastructure, such as hydroelectric facility operations, water delivery systems, and submerged docks. The maintenance expenses to remove and dispose of mussels have been estimated at nearly $500,000 annually on multiple Colorado River hydroelectric facilities. Dreissenid mussels also attach and grow on aquatic invertebrates, such as native mussels and crayfish, hindering their growth and survival. Although mussels improve water clarity by filtering large amounts of water and removing suspended solids in the water column, the overall effects on a water body are negative because of increased plant growth and changes in how the water body functions (e.g., changes to fish populations).

## How can Dreissenid Mussels be spread by seaplanes?

Adults and veligers can attach to surfaces that are in contact with water, therefore seaplane floats and rudders are likely areas for mussel attachment. Seaplane floats that take on water can contain veligers or adults. Veligers are known to survive many days in very little water. Out of water and attached to various surfaces, adults can survive for multiple days.

**Seaplane pilots can help prevent the spread of aquatic invasive species.**

Examples of other aquatic invasive species you may encounter in your region:

- Brazillian Waterweed (*Egeria densa*)
- Carolina Fanwort (*Cabomba caroliniana*)
- Curly-leaf Pondweed (*Potamogeton crispus*)
- Flowering Rush (*Butomus umbellatus*)
- Infectious Haematopoietic Necrosis (*IHN Virus*)
- Parrotfeather (*Myriophyllum aquaticum*)
- Variable-leaf Watermilfoil (*Myriophyllum heterophyllum*)
- Water Primrose (*Ludwigia spp*)
- Whirling Disease (*Myxobolus cerebralis*)
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# SEAPLANE PILOT BEST PRACTICES TO REDUCE THE SPREAD OF AQUATIC INVASIVE SPECIES

**Follow these steps to improve your flying safety while preventing the spread of aquatic invasive species (AIS).**
**Why? AIS can take over waterbodies and crowd out native species, harming native fish and wildlife populations and potentially reducing seaplane access.**

## Planning a Flight

Familiarize yourself with AIS at destination water bodies, but recognize that not all water bodies are monitored for AIS— always assume a waterbody has AIS.

If you are departing from a waterbody that has confirmed high-risk AIS, before landing at another water body, consider landing at an airport first to fully inspect and clean your aircraft.

## Before Entering the Aircraft

Inspect and remove any visible vegetation or other debris from the aircraft. Remove any plant growth on mooring lines and dispose of any plants or identified AIS in a container, which can then be disposed of properly upon returning to the base location. Inspect the following for AIS:

- Floats
- Hulls
- Rudders
- Wires and Cables
- Mooring lines
- Wheel Wells
- Crossmembers
- Exterior paddle
- Your footwear and gear

Visually inspect submerged parts of the aircraft and run your hands, or use a brush, along the surfaces to check for any AIS that may be attached, especially if the aircraft has been moored on a waterbody for more than a few hours.

Pump as much water as possible out of bilge compartments using a pump with an invasive species filter (e.g., Turbo Pump) to limit the possibility of transporting microscopic AIS.

## Before Takeoff

Just prior to takeoff, **raise and lower your water rudders several times to remove aquatic hitchhikers**, which can cause cable stretch and affect steering.

Avoid taxiing through aquatic plants. If you must taxi through aquatic plants, stop once in open water and manually clear vegetation from floats, hull, and rudders.

## After Takeoff

After takeoff at a safe altitude, if conditions permit, **raise and lower your water rudders numerous times while flying over the water body you are departing** to clear aquatic plants from the water rudders and cables. If aquatic plants remain visible on the plane, return and remove them.

## Storage and Mooring

Thoroughly *Clean, Drain, Dry* the aircraft prior to flying to another waterbody. If the aircraft floats take on water, completely drain and dry if possible, and flush the floats with hot water. Allow to dry completely.

## Report Invasive Species

Report any invasive species you see to your state AIS reporting system.

## Spread the Word about Clean, Drain, Dry

Informed seaplane pilots can make a difference in preventing the spread of AIS. Talk with your colleagues and spread the word about the importance of *Clean, Drain, Dry* and the steps pilots can take to minimize the spread of AIS.

Expand your understanding of the types of AIS you might encounter in local and regional waterbodies by visiting https//nas.er.usgs.gov.

## Become a Certified AIS-Trained Seaplane Pilot!

Click on the QR code to watch a video created by the Washington Seaplane Pilot Association. After watching the video, take a short test, and earn your annual certificate to become an AIS-trained seaplane pilot. This certificate is recognized by all of the Pacific Northwest states.

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