2015 Aquatic Invasive Species Program Final Report

Prepared for:
The Lower Hudson Partnership for Regional Invasive Species Management

Prepared by:
Samantha Epstein
Invasive Species Program Coordinator
Hudson River Sloop Clearwater, Inc.

December 2015

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This project was contracted by the Lower Hudson Partnership for Regional Invasive Species Management (PRISM) using funds from the Environmental Protection Fund as administered by the New York State Department of Environmental Conservation.

Introduction

Invasive species have become one of the biggest threats to our ecosystems, but many people are still unaware of the problem. People regularly plant bamboo, use non-local baitfish, or dump their aquariums into waterways without realizing that their actions can potentially spread a new invasive population. The first step in mitigating the spread of invasive species is to educate the public about them, including invasive species identification, impacts, management options, and spread prevention methods.

In 2005New York State took a tremendous step in invasive species management by creating the eight Partnerships for Regional Invasive Species Management (PRISMs). Each PRISM tends to focus its resources on one of the two sectors that is thought to be of the highest priority in their area – either terrestrial or aquatic invasive species. Until 2015, the Lower Hudson PRISM had primarily focused on terrestrial invasive species. The addition of the Aquatic Invasive Species Program helped the Lower Hudson PRISM broaden its focus from terrestrial invasive species to all invasive species, terrestrial and aquatic.

The Hudson River is an essential river for New York. Historically it has been a major mode of transportation of both goods and people, and it connects equally important bodies of water throughout the state including the Mohawk River and the Champlain Canal. These connections eventually lead to some of the nation's most important international ports – the Great Lakes.

The introduction of invasive species has become an expected consequence of International trade. Recently many regulations have been implemented to limit the number of new species, but it can be difficult to enforce them. When a new species is introduced into the Great Lakes, it is likely to spread throughout the state and beyond. The Hudson River is bound to get many of the invasive species that reach the Great Lakes because of how highly interconnected New York's waterways are.

Currently the Hudson River is home to over 100 aquatic invasive species (AIS), many of which could have been prevented through clean boating practices and proper aquarium disposal. Public education is vital to teach people about how their actions can impact the waterways that they use and love. Clearwater's Aquatic Invasive Species (AIS) Program aims to teach boaters, fisherman, children, students, teachers, and the general public how they can help prevent the spread of AIS. Some of these species, such as water chestnut, have been here for over 100 years. Others, including hydrilla, are new to the Hudson River Valley. It is our responsibility to contain these newly emerging species, and prevent those that have not yet entered the region from becoming established.

Importance of an AIS Program

The Hudson River has been a crucial body of water for New York for centuries, and over time it has faced various new and ongoing threats. It has been a dumping ground for sewage and chemicals, and continues to be impacted by Indian Point's water intakes and outputs. One of the ongoing threats that the Hudson River has faced over the centuries is from invasive species introductions, and this threat has been amplified by international trade. There have been numerous aquatic invasive species introductions to the Hudson River due to its connection to the Great Lakes, and these species have had a wide variety of impacts on the river and its surrounding tributaries. While some impacts are minimal, others can devastate large areas by changing the entire ecosystem.

Invasive species hitchhiking on boats are one of the biggest causes of spread. Many boaters have never heard of aquatic invasive species, or cannot grasp the severity of their potential impacts. In order to mitigate this pathway we need to properly educate our recreational boaters and fisherman about how they can help prevent AIS spread by properly cleaning their boats, using local bait, and properly disposing of unused bait and hitchhikers after leaving a body of water. It is also critical to keep boaters informed of any new/updated laws and regulations regarding invasive species and boating.

While the goals of this program are to help with early detection through surveying and to educate all kinds of audiences about aquatic invasive species, we also hope to get something deeper out of it. We want people to connect with their waterbodies in a way that makes them *want* to take protect them, rather than simply needing to abide by the new laws and regulations. This type of connection can be made anywhere, from a local farmers market to the city's boat launch to a classroom. Everybody connects to nature in different ways, so reaching people through different outlets including trainings, seminars, workshops, or tabling events is important.

The Aquatic Invasive Species Program helps cultivate this passion by teaching people the importance of taking spread prevention measures, while also providing them the opportunity to do some hands-on work in the field. The Watercraft Inspection Steward Program teaches boaters and fisherman the importance of clean-drain-dry while giving them a free boat inspection. The Invasive Species Program Coordinator, Samantha Epstein, has reached over 1,000 people through her trainings, workshops, seminars, and tabling events. She has taught children, high school students, college students, teachers, boaters, fisherman, County Park workers, the general public and others about AIS and how to prevent their spread. She also trained over 20 new Hydrilla Hunters how to identify common invasive species and how to survey for them in our Hudson Valley waterways.

This type of education is critical to prevent encroaching emerging species from becoming established. The more knowledgeable people we have looking for new populations, the earlier we catch them, and the earlier we catch new populations, the faster we can react and prevent their spread.

Watercraft Inspection Steward Pilot Program

(April 2015 – December 2015)

Over the past decade, Watercraft Inspection Steward (WIS) Programs have been created to help protect waters in the Great Lakes, Finger Lakes, and Adirondack regions. While Watercraft Inspection Steward Programs are becoming more common throughout the state, they are new to the Hudson Valley. The goal of these programs is to inspect boats for AIS before entering and after exiting the water, while also providing information to recreational boaters and fisherman about new launch laws/regulations and how they can help prevent the spread of AIS.

Clearwater created the first WIS Program in the Hudson Valley in 2015. Samantha Epstein, Clearwater's Invasive Species Program Coordinator, interviewed, hired, trained, and supervised the programs stewards. The stewards attended a training hosted by the Adirondack Watershed Institute in Paul Smith's College, which taught them basic plant identification, laws and regulations, and how to properly inspect boats. They began working at their boat launches on Memorial Day Weekend, and continued working two-8 days each weekend through Labor Day Weekend.

Aaron Wray, Norrie steward, inspecting a motor boat before it launches into the Hudson River

This year, Clearwater placed two stewards at boat launches along the east side of the Hudson River – at the Mills Norrie Marina, in Staatsburg, and the Echo Canoe and Kayak Launch, in Croton-on-Hudson. These locations were chosen for specific reasons. The DEC Environmental Center is located at the Mills Norrie Marina, which allowed us to talk to visitors that weren't necessarily at the marina to go boating. A steward was placed at the Croton Echo Launch because it is a highly used launch located at the edge of the Hudson Valley's largest hydrilla infestation.

Emily Bunyea, Croton steward, sets up her information table at the Croton Kayak and Canoe Launch

The WIS Pilot Program was very successful in 2015, and will be expanded to include more locations in 2016. Both stewards reached very different audiences due to the nature of their boat launch. Our steward at the Mills Norrie Marina launch primarily interacted with boaters and fisherman in large motorboats, many of which are already aware of the invasive species threat and spread prevention measures. This audience is very different from the audiences that the Croton Echo Launch steward reached. The launch prohibits motorboats from launching, so their main interactions were with kayakers and canoers. There is also a popular kayak and canoe rental shop at that launch, so even

though our steward did not inspect rented boats, she was able to interact with many people who passed by her inspection station.

While both stewards occasionally met boaters who were disinterested in the program, the overwhelming majority of public response was positive, ranging from polite interest to enthusiastic support. In general people were happy to see somebody advocating on behalf of the Hudson River and its users and enthusiasts. This positive feedback makes us believe that the program was quite successful and can be expanded to cover even more of the Hudson Valley.

Breakdown:

Croton Echo Launch:

- # Days Stewarded: 25
- # Boat Inspections: 500
    - # Boats that declined inspection: 3
- # Saves: 24
    - Species found: native pondweed, elodea, Eurasian watermilfoil, hydrilla
- % Knowledgeable about AIS: 26.5%
- % Taking Spread Prevention Methods: 50%
- Most Common Boat Launches Visited: Croton Echo Kayak and Canoe Launch (41.6%), Ossining boat launch (5%), Cold Spring boat launch (4.2%), and Adirondacks boat launches (2%)

Mills Norrie Marina Launch:

- # Days Stewarded: 24
- # Boats Inspected: 292
    - # Boats that declined inspection: 11
- # Saves: 14
    - Species found: brittle naiad, Eurasian watermilfoil, water chestnut, fish eggs
- % Knowledgeable about AIS: 74%
- % Taking Spread Prevention Methods: 76.9%
- Most Common Boat Launches Visited: Mills Norrie Marina Launch (70.1%), Hudson boat launch (1.7%), Adirondacks boat launches (1.3%)

Deliverables Met:

- Education and Outreach Materials
    - Steward's Field Guide to AIS In The Lower Hudson Region
    - Hydrilla WATCH Card
    - Didymo pamphlet
    - Water Chestnut Pamphlet
    - AVM/Hydrilla Pamphlet
    - Hydrilla Brochure

    - Spiny Water Flea Pamphlet
    - Laminated Species for Identification
- 2 Boat Steward Trainings
- Data Collected About Boater Habits and Potential Pathway Connections

Education and Outreach Program

(April 2015 – December 2015)

Clearwater has successfully integrated aquatic invasive species identification, spread prevention, surveying and management into their education and outreach programs. Clearwater taught over one thousand people about aquatic invasive species. Some of the audiences reached include boaters, fisherman, County Park staff, teachers, elementary, middle, high school, and college students, the general public, and many more. Samantha Epstein attended and held 43 events including trainings, Clearwater events, presentations, tabling events, surveying events, and invasive species removals.

Samantha Epstein created numerous informational materials ranging from pamphlets and brochures to field guides and WATCH cards. A list of all the informational materials can be found in the deliverables, and examples of each can be found in Appendix B.

Breakdown of Education and Outreach Events*

- # **Trainings**: 9
    - # People Trained: 33
- # **Clearwater Events**: 10
    - # People Reached: 245
- # **Presentations**: 5
    - # People Reached: 93
- # **Tabling Events**: 15
    - # People Reached: 675
- # **Surveying Events**: 3
    - # People Involved: 13
- # **Invasive Species Removals**: 1
    - # People Involved: 15

Total:

- **# Events**: 43
- **# People Reached:** 1,074

Samantha Epstein tabling at MWA's City of Water Day on Governors Island, NYC

*__Training__: event where individuals are taught AIS identification, management, and surveying protocol
Event: educational programs, workshops, or seminars held by Clearwater
Presentation: educational programs, workshops, or seminars given by Clearwater at another organization's event
Tabling: Outreach event where informational material was distributed
Surveying: Event held in the field (specifically Croton River) to survey for AIS
Removals: Invasive Species removal held by Clearwater

Samantha Epstein held and attended a wide variety of events to provide information about AIS, and provided seminars, workshops, and trainings to diverse audiences.

The Aquatic Invasive Species Program Coordinator held 9 seminars, 7 workshops, 8 trainings, held 3 surveying field days, tabled at 15 events, and participated in 1 aquatic invasive species removal project. Over one thousand people were reached, including children, elementary, high school, and college students, teachers, boaters, State Park Staff, different Associations, the general public, and others.

Samantha Epstein teaching Cary Institute students about aquatic invasive species

Deliverables Met:

- Education and outreach materials
    - Steward's Field Guide to AIS In The Lower Hudson Region
    - Surveyor's Field Guide
    - Hydrilla WATCH Card
    - Didymo pamphlet
    - Water Chestnut Pamphlet
    - AVM/Hydrilla Pamphlet
    - Hydrilla Pamphlet
    - Spiny Water Flea Pamphlet
    - Laminated Species for Identification
        - Invasive: Eurasian watermilfoil, water chestnut, brittle naiad, hydrilla, fanwort, curly-leaf pondweed
        - Native: hornwort, elodea, water celery
    - 3 AIS Information and Identification PowerPoint Presentations
    - 1 Hydrilla PowerPoint Presentations
- 2 Steward Trainings
- 6 AIS Identification and Survey Trainings
- 10 Clearwater Events
- 5 Presentations
- 15 Tabling Events
- 3 Surveying Days

Volunteer Surveying Program

(April 2015 – December 2015)

Volunteer surveying is an essential component of invasive species management. Often times, citizens are the ones who come across new infestations. For example, a student aboard the Floating Classroom was the first person to find hydrilla in the Cayuga Inlet near Cayuga Lake in upstate New York.

Surveying is a necessary to determine what species are in the area, where they are, and if the species is spreading. The earlier a new invasive plant population is found, the easier it is to manage.

Samantha Epstein trains new Hydrilla Hunters at Black Rock Park, Croton, NY

Our volunteer surveyors successful surveyed several bodies of water for eight (8) invasive species: water chestnut, hydrilla, Eurasian watermilfoil, fanwort, brittle naiad, curly-leaf pondweed, zebra mussels, and Chinese mystery snails. All volunteer surveyors were trained by Samantha Epstein before being sent into the field. Trainings took place at Black Rock Park in Croton, NY, where some of the Croton Rivers' densest hydrilla populations are found. These trainings consisted of an hour long discussion about invasive species in the Hudson Valley and identification practice, and another hour of surveying instruction and practice.

Samantha Epstein trained 23 people to identify and survey for AIS in 6 high priority areas, as well as other waterbodies throughout the Hudson Valley. The Croton River remained the top priority in order to see how quickly the hydrilla infestation has spread since last year. Unfortunately, many areas have gotten much denser, and the hydrilla has reached the surface at many spots near Black Rock Park.

Croton River Hydrilla Surveying

Clearwater partnered with the NYSDEC to survey for hydrilla in the Croton River. This surveying was done over the course of three days on September 24, October 12, and October 14. Eleven volunteers dedicated over 40 hours of their time. By the end of the season, we had surveyed over 120 points in the upper section of the Croton River. Some sections of the river were too rocky, shallow, or fast flowing to do the rake-toss surveys from a boat and were instead done from the shoreline.

The results of the survey showed how quickly the hydrilla is spreading in that section of the river. Many sections of the river around Black Rock Park that had no/minimal hydrilla last year were highly infested this year. Some patches of hydrilla were matting at the surface, creating dense monocultures that were easily outcompeting the Eurasian watermilfoil.

Deliverables Met:

- Surveyor's Field Guide
- Data Collection Sheets
- Plant laminates (fanwort, hydrilla, curly-leaf pondweed, Eurasian watermilfoil, water chestnut, brittle naiad, hornwort, elodea, Vallisneria)
- 5 Volunteer surveyor trainings
- 23 Volunteers surveying for AIS
- 120+ iMapInvasives entries

Summary

Invasive species have become an expected consequence of increased international trade and manmade canals that connect more waterways. New invasive species introductions have been and will continue to be a major threat to the Hudson River, its tributaries, and inland waterbodies. The first step to mitigate these pathways is to teach the public what they can do to help. Teaching people how to survey for and identify new populations, as well as how to prevent their spread, will help protect the Hudson Valley from future introductions. Clearwater's Aquatic Invasive Species Program has educated locals and got them engaged in invasive species projects.

Clearwater was able to teach thousands of people about aquatic invasive species through the combined efforts of the WIS Program, Education and Outreach Program, and Volunteer Surveying Program. While each program had its own goal and reached different audiences, they all shared the overarching goals of protecting the Hudson Valley through AIS education, identification training, and spread prevention. The Aquatic Invasive Species Program achieved these goals and will continue to develop in 2016.

This program brought attention to the formerly overlooked aquatic invasive species in the Hudson Valley, and broadened the focus of the PRISM from terrestrial invasive species to include aquatics. The Aquatic Invasive Species Program was very successful, and can be used as a starting point for a more expansive program. Over the coming years, Clearwater hopes to expand the WIS Program from two stewards to 5-10 stewards, both along the Hudson River and inland. The program will continue to expand, teaching more people how they can help protect their Hudson Valley from aquatic invasive species.

Appendix A:

Date	Location	Type	Event Name	# People Reached	Type of People
5/16/2015	Hudson, NY	Tabling	NY Rivers Boating Festival	25	Boaters
5/17/2015	Hudson, NY	Tabling	NY Rivers Boating Festival	30	Boaters
5/26/2015	Pier 40, NYC	Tabling	Meet the Fishes – Hudson River Project	40	General Public
6/2/2015	Cold Springs, NY	CW Event	Invasive Species Station on *Clearwater*	30	Children (5th Grade)
6/2/2015	Cold Springs, NY	CW Event	Invasive Species Station on *Clearwater*	15	Children (5th Grade)
6/3/2015	Cold Springs, NY	CW Event	Invasive Species Station on *Clearwater*	20	Children (5th Grade)
6/12/2015	Beacon, NY	Training	Steward Training	1	College Student
6/14/2015	Beacon, NY	Tabling	Strawberry Festival	45	General Public
6/20/2015	Croton, NY	Tabling	Clearwater Revival Festival	120	General Public
6/21/2015	Croton, NY	Tabling	Clearwater Revival Festival	80	General Public
6/27/2015	Croton, NY	Training	Steward Training	1	College Student
7/10/2015	Poughkeepsie, NY	CW Event	*Clearwater* Educator Sail	30	Teachers
7/12/2015	Poughkeepsie, NY	CW Event	*Clearwater* Public Sail – IS Focus	30	General Public
7/14/2015	Poughkeepsie, NY	CW Event	Invasive Species Station on *Clearwater*	40	Environmental Studies teachers and students
7/16/2015	Croton, NY	Training	ID and Survey Training	10	General Public
7/18/2015	Governors Island, NY	Tabling	MWA City of Water Day	60	General Public
7/25/2015	Poughkeepsie, NY	Tabling	Dutchess Dragon Boat Festival	40	General Public
7/25/2015	Verplanck, NY	CW Event	Invasive Species Station on *Clearwater*	20	National Maritime History Assoc
7/26/2015	Croton, NY	Training	ID and Survey Training	3	General Public
7/26/2015	Peekskill, NY	Training	ID Training	2	Westchester Park Staff
7/26/2015	Peekskill, NY	Training	ID training	4	General Public
8/2/2015	Eastchester, NY	IS Removal	*Trapa natans* Pull	15	Neighborhood
8/6/2015	Beacon, NY	CW Event	Invasive Species Station on *Clearwater* – part of YEP	20	Age 14-17
8/8/2015	Poughkeepsie, NY	Tabling	Upper Landing Community Day	25	General Public

8/29/2015	Croton, NY	Tabling	Croton Block Party	40	General Public
8/29/2015	Croton, NY	Training	ID and Survey Training	4	General Public
8/30/2015	Croton, NY	Training	ID and Survey Training	6	General Public
9/7/2015	Croton, NY	CW Event	Invasive Species Station on *Clearwater* – Marist Lifetime Studies	40	General Public
9/8/2015	Croton, NY	Training	ID and Surveying Training	2	General Public, Rockland SWD Staff
9/11/2015	New Paltz, NY	Tabling	SUNY New Paltz Volunteer Fair	40	General Public
9/12/2015	Croton, NY	Tabling	Croton Yacht Club-River Day	25	General Public
9/24/2015	Croton, NY	Surveying	Croton Hydrilla Surveying	3	General Public
9/26/2015	Tarrytown, NY	Tabling	Tarrytown Eco Fair	35	General Public
9/27/2015	Beacon, NY	Tabling	Spirit of Beacon Day	20	General Public
9/30/2015	Rye, NY	Presentation	LHPRISM Meeting	25	PRISM Partners
10/1/2015	Yorktown Heights, NY	Presentation	Hydrilla Toolbox Training	11	NYCDEP Staff
10/7/2015	Albany, NY	Presentation	STEM IS Seminar with 9th grade Tech Valley HS Students	30	9th Grade Students
10/12/2015	Croton, NY	Surveying	Croton Hydrilla Surveying	5	General Public
10/13/2015	Millbrook, NY	Presentation	Environmental Studies HS Club	15	High School Students
10/14/2015	Croton, NY	Surveying	Croton Hydrilla Surveying	5	General Public
10/19/2015	NYC, NY	Tabling	NYC Outdoors Expo	50	College Students and Teachers
10/24/2015	Bronx, NY	Presentation	Wildlife Conservation Society Class	12	High School Students

Appendix B:

Hydrilla: NOT WANTED

Hydrilla

Hydrilla (*Hydrilla verticillata*) is a submerged aquatic perennial plant that can quickly form dense mats in waters up to 25 feet deep. These mats interfere with recreational activities including swimming boating, and fishing. The mats can also break off and clog water intake pipes. When dense infestations die off, algae blooms can form and cause fish kills. Cyanobacteria linked to hydrilla infestations has been shown to cause Avian Vacuolar Myelinopathy (AVM), which has caused the death of thousands of American coots and at least 100 bald eagles.

Nicknamed the *world's worst aquatic invasive plant*, hydrilla was introduced to the United States in the 1950s, when it was infesting waterways in Florida. Since then, it has been found in many NY lakes and ponds, and in bigger waterbodies including the Cayuga Inlet, the Erie Canal, and most recently, the Croton River.

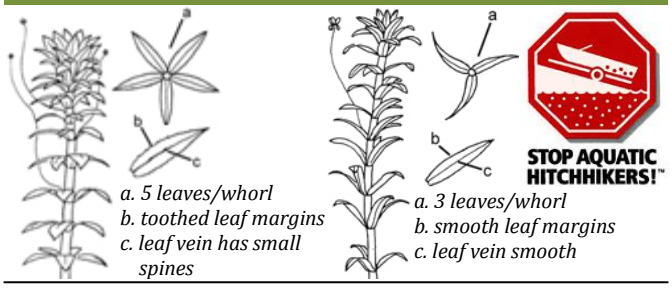
What You Can Do To Help

- **Learn** to identify hydrilla
- **Clean** any mud, plant, or animal material off boat and equipment before entering and after exiting a new body of water
- **Drain** water from all live wells, bilges, etc.
- **Dry** boat and all equipment that came into contact with the water (5 days in dry heat)
- **Report** new sightings to *iMapInvasives*. Note the exact location, take a sample (including tuber and turion if possible), place sample in zip-lock bag with damp paper towel (do not wrap sample in paper towel) and contact Hudson River Sloop Clearwater's Invasive Species Program Coordinator at (845) 265-8080 x7114.

Know the rules!

While specimens are required to confirm sightings, some jurisdictions prohibit possession/transport of invasive species. Learn the laws before transporting species, and **never** introduce them into the wild.

How to Identify Hydrilla v. Elodea (native)



- Whorls of 5, toothed leaf margins, tuber a few inches below sediment
- Grows horizontally like a "shag rug," then grows to surface as water warms
- Grows in up to 25 feet of water, and can grow several inches per day

Avian Vacuolar Myelinopathy & Hydrilla

Avian vacuolar myelinopathy (AVM) is an unusual neurological disease which has killed at least 99 bald eagles and thousands of American coots since 1994. While the cause of the disease is unknown, it has been linked to bodies of water with large infestations of hydrilla.

Birds affected with AVM lack muscle coordination and have difficulty flying and swimming. Birds that have died from AVM typically appear to be in good health, with the exception of a lesion on the brain and spinal cord.

Photo Credit: www.Wikipedia.com

AVM has been found in bald eagles and American coots from Texas to North Carolina. It is the cause of the largest undiagnosed eagle mortality in U.S. history, with a die-off of 30%-65% of all eagles wintering at DeGray Lake, Arkansas, the location of the first recognized cases. The disease has also afflicted numerous other waterbird species, including geese, mallards, killdeer, and ring-necked ducks.

Studies have shown that hydrilla and associated epiphytic cyanobacteria species are linked to AVM. The cyanobacteria thought to cause AVM grows densely on aquatic plant species (primarily hydrilla). Coots, mallards, geese, and other waterbird species consume the affected vegetation and become sick or die from ingesting the toxin. Eventually, the toxin works its way up the food chain and affects bald eagles.

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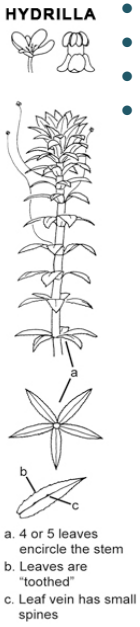
Photo Credit:

Hydrilla has been found covering a large percentage of the waterbodies surfaces at sites where AVM is present. Surveys of freshwater reservoirs, lakes, and ponds throughout the southeastern U.S. showed a potentially toxic cyanobacteria present on the hydrilla leaves and stems of hydrilla at all sites where AVM was found, but rare in areas where AVM was not observed. Fortunately, there have been **no** reports of AVM in the Lower Hudson Region.

What is Hydrilla?

Hydrilla is an invasive submerged perennial plant that is considered the world's worst aquatic invasive species. It was recently discovered in the Croton River (2013), which empties into the Hudson River. Hydrilla has been found in many NY lakes and ponds, as well as larger bodies of water including the Cayuga Inlet and the Erie Canal.

Hydrilla can be identified by these key characteristics:



- Leaves in a whorl around the main stem
- 3-8 (usually 5) leaves per whorl
- Leaves have visibly serrated/toothed edges
- Tubers (potato-like structures) found 3-12"below sediment

Hydrilla is easily fragmented, and each fragment can root and form its own population. These fragments also spread from waterbody to waterbody via hitchhiking on boats, which is why **clean boating practices** are so important. So remember, before entering and upon exiting a body of water: **clean** off all visible mud, plants, fish/animals from your boat, **drain** water from all equipment, and **dry** anything that comes into contact with water.

Photo Credit: University of Florida, Center for Aquatic and Invasive Plants

Photo Credit:
South Carolina DNR

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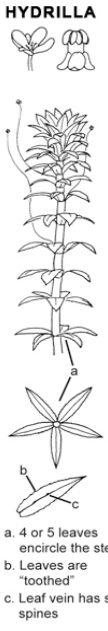
Hydrilla can be identified by these key characteristics:



- Leaves in a whorl around the main stem
- 3-8 (usually 5) leaves per whorl
- Leaves have visibly serrated/toothed edges
- Tubers (potato-like structures) found 3-12"below sediment

Hydrilla is easily fragmented, and each fragment can root and form its own population. These fragments also spread from waterbody to waterbody via hitchhiking on boats, which is why **clean boating practices** are so important. So remember, before entering and upon exiting a body of water: **clean** off all visible mud, plants, fish/animals from your boat, **drain** water from all equipment, and **dry** anything that comes into contact with water.

Photo Credit: University of Florida, Center for Aquatic and Invasive Plants

Didymo – Rock Snot

Didymosphenia geminata

(NOT) WANTED FOR:

- Growing thick mat-like growths (blooms) along stream beds
- Altering stream conditions and water quality
- Choking out native organisms living on the stream bottom
- Decreasing available food for native fish
- Impeding recreational activities

Didymo, commonly referred to as "rock snot," is an invasive microalgae that is capable of producing large amounts of stalk material that form thick brown mats on stream bottoms. Native to Northern North America and Europe, didymo is rapidly expanding its range.

Photo Credit: Tim Daley, Pennsylvania DEP

Identification

- Tan, brown, or white, possibly with long white "tails"
- Texture of wet wool (not slimy)
- Does not fall apart when rubbed between fingers, strong and firmly attached

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Control Options

While there are currently no known methods for controlling or eradicating didymo once it has infested a water body, we are still able to prevent it from spreading into other uninfested bodies of water.

Didymo is commonly spread unknowingly by recreational water users, including anglers, kayakers or canoeists, and other boaters. The algae is able to cling to waders, boots, boats, lures, hooks, fishing lines, and any other equipment that comes into contact with the water – even dogs! Didymo can remain viable for several weeks in dry conditions.

Photo Credit: Whitney Cranshaw, Bugwood.org

Prevention Is Key

In order to prevent didymo from spreading into uninfested waterways, we must remember to properly clean our equipment before entering a new body of water (pictured above). An effective way to limit the spread is using the Clean, Drain, Dry method:

- Clean: remove all visible animals, plants, and debris from boats, trailers and all equipment before entering and after exiting a body of water
- Drain: drain water from all live wells, bilges, etc.
- Dry: allow boats and equipment to dry before entering a new body of water (can take 5-7 days)

Clearwater LOWER HUDSON PRISM

References: http://www.dec.ny.gov/animals/54244.html

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HYDRILLA

The World's Worst Aquatic Invasive Plant, Now Found In Our Waters

Photo by Robert L. Johnson

History of Hydrilla verticillata

Hydrilla verticillata is an invasive submerged perennial plant, closely resembling the native waterweed elodea, and is considered the world's worst aquatic invasive plant. Hydrilla, which is native to Australia, Asia, and parts of Africa, was introduced to the United States in the 1950s, when it was found infesting waterways in Florida. Since then it has been discovered in many other states, including New York. Hydrilla can be found in many NY lakes and ponds, as well as bigger bodies of water including the Cayuga Inlet, the Erie Canal, and most recently, the Croton River.

Identification

- Leaves occur in whorls around main stem
- Whorls contain 3-8 leaves (usually 5)
- Leaf margins are visibly serrated
- Turions (overwintering buds) found along the stem of mature plants
- Tubers (small, potato-like structures) found 3-12 inches below the sediment at the end of the underground stem

Means of Spread

- Fragmentation – single fragments of hydrilla can root and form new populations
- Turion Production – overwintering buds flow downstream and start new populations
- Tuber Production – tubers can remain dormant for years until water conditions become favorable

Ecological Impacts

- Blocks sunlight and displaces native plants below its dense mats
- Stratifies the water column, decreasing dissolved oxygen levels – leads to fish kills
- Can cause algae blooms, leading to Avian Vascular Myelinopathy (AVM), a disease that attacks the nervous system of birds

Economic Impacts

- Dense mats impart boating, swimming, and fishing, which hampers the tourism economy
- Waterfront property values decrease significantly
- Weight and size of sportfish can be reduced when open water and natural vegetation are limited

Description

There are two types of hydrilla, monoecious (found in the northern states) and dioecious (found in the southern states). Hydrilla can tolerate a wide range of environmental conditions including nutrient deficit and nutrient rich waters, salinity, stagnant and running waters, and tidal waters. The monoecious biotype grows horizontally along the bottom of the waterbed. Once the water gets warm enough, it grows vertically and mats the entire surface of the water, blocking out sunlight for native species. Hydrilla can survive ice cover, freezing, drying, and ingestion.

Spread Prevention

One of the biggest pathways of aquatic invasive species is hitchhikers on boats. Using **clean boating practices** helps to mitigate this pathway. So remember to follow these steps before entering and after exiting any body of water:

- **Clean** – remove all visible mud, plants, fixh/animals to prevent transporting potential hitchhikers
- **Drain** – eliminate water from all equipment (motors, boats, waders, bilges, etc.)
- **Dry** – dry anything that came into contact with water (boats, trailers, equipment, etc.)

Management Options

- **Physical** – benthic barrier mats can be placed on the bottom of waterbodies to block out all light, killing plants beneath it
- **Mechanical** – dredging can be done to remove sediment (and tubers) from the waterbody. Hand-removing, as well as suction assisted diving is also an option if done carefully
- **Chemical** – herbicides (both contact and systemic) have been very successful in hydrilla eradication, but treatments need to be continued for up to 10 years to guarantee no tubers remain viable
- **Biological** – grass carp stocking has been used, but containment has proven difficult

Hydrilla in the Croton River

Hydrilla was discovered in the Croton Bay (Croton-on-Hudson, NY) in August 2013 during a rare plant survey conducted by David Werier. This past year, the Lower Hudson Partnership for Regional Invasive Species Management (PRISM) funded Allied Biological, Inc. to do a delineation survey of the entire Croton River to determine how far the plant has spread.

Hydrilla was found rooted as far north as the New Croton Dam, and as far south as the Croton Bay. Floating fragments were found past the railroad tracks, but no rooted plants were found.

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Spiny Water Flea
(*Bythotrephes longimanus*)

The spiny water flea, or *Bythotrephes longimanus*, is a tiny predatory crustacean native to Eurasia and was introduced into the United States and Canada via ballast water. First discovered in Lake Huron in 1984, the spiny water flea had established itself in all of the Great Lakes by 1987, and has since spread into many lakes including Lake George.

Identification

The spiny water flea is a tiny crustacean that can grow up to ½ inch in size. It has an elongated, barbed tail to protect against predation by small juvenile fish. Masses of the spiny water flea can be found in gelatinous clumps on fishing lines.

Photo Credit: Mass.gov – Office of Energy and Environmental Affairs

Impacts

While the spiny water flea is considered zooplankton, it feeds on the same native zooplankton (e.g. Daphnia) that native fish rely on for food. As the spiny water flea becomes more abundant, less food remains for juvenile fish. Unlike native species of water flea, the spiny water flea is not a viable food source for native juvenile fish because it has a long, barbed tail, making it difficult to eat.

The barbed tail of the spiny water flea allows it to catch on fishing gear, especially lines and downrigger cables. As stated above, masses of the water flea can accumulate on fishing gear, forming a gelatinous clump.

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Spread Prevention

As of now, the only effective strategy to control spiny water flea populations is to prevent its introduction into new bodies of water. The best way to prevent its spread is through clean boating practices. This includes three main concepts – Clean, Drain, Dry.

- Clean: inspect the boat, trailer, fishing gear, and any equipment that came into contact with the water. Remove all visible plant fragments, mud, debris, etc. above water line
- Drain: drain all water holding compartments including live wells, bait wells, and bilge areas
- Dry: make sure to dry boats, trailers, and all equipment before entering another waterbody (this can take 5-7 days in dry, warm weather).

Photo Credit: Mass.gov – Office of Energy and Environmental Affairs

While the female water fleas die out of water, their eggs can resist drying, freezing, and can establish new populations. Their eggs can also be transported in bilge water, bait buckets, and livewells. Proper cleaning of boats, trailers, fishing lines, and equipment is extremely important to stop the spread of the spiny water flea.

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References:

- www.Invasivespeciesinfo.gov
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What Is Water Chestnut

Water chestnut is an annual, rooted aquatic plant that was introduced to the Northeast in the 1800s. Since its introduction, it has spread throughout New York, clogging waterways and lakes. It spread to Lake Champlain in the 1940s, and now covers hundreds of acres of the lake. It can also be found over miles of the Hudson River.

How Did Water Chestnut Get Here

It was first introduced to North America in the 1870s, where it had been growing in a botanical garden at Harvard University. Soon it escaped cultivation and was found growing in the Charles River. It was then introduced into the Hudson River-Mohawk River drainage basin, possibly intentionally as waterfowl food or was a new plant for a water garden.

How Can Water Chestnut Spread

Water chestnut seeds grow directly beneath the parent plant's floating leaves and propagate the parent colony. Seeds can spread downstream through the currents. They can also be dispersed via ducks, geese, and other waterfowl.

Identification

Water chestnut has both submersed and floating leaves. The feather-like submerged leaves are found in whorls around the stem. The floating leaves are triangular with toothed edges, and can range in size from 2-4 cm. They form rosettes around the end of the stem, where a single, white flower with 4 petals sprouts.

Buoyant stems can reach up to 5 m and are anchored to the sediment bed by branched roots.

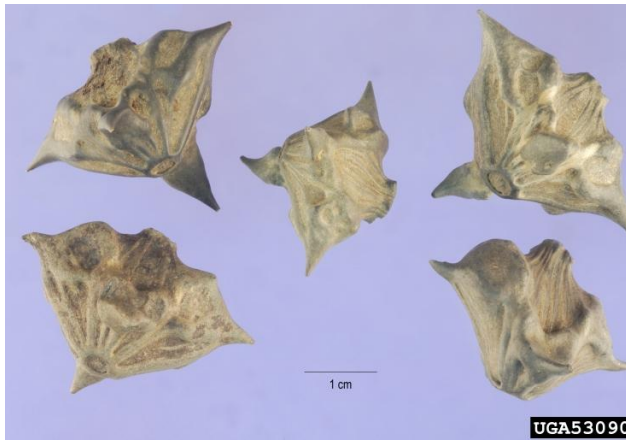

Photo Credit: Steve Hurst, USDA NRCS PLANTS Database, Bugwood.org

The seeds germinate in the spring, each producing 10-15 rosettes. Each of these rosettes is capable of producing 20 seeds. These hard, nut-like seeds can grow to about 2.5-4 cm with four very sharp spines.

Photo Credit: Leslie J. Mehrhoff, University of Connecticut, Bugwood.,org

Ecological and Economic Impacts

Water chestnut can quickly become a nuisance once it spreads into a new body of water. Once established, it can:

- Form dense mats, creating a monoculture, outcompeting natives
- Block light for native species below, displacing native vegetation
- Reduce dissolved oxygen levels, potentially leading to fish kills
- Provide little nutritional and habitat value for fish and waterfowl
- Impede recreational activities including swimming, boating, and fishing
- Harm people who step on the seeds

How Can We Prevent Water Chestnut from Spreading

The most important way to limit the spread of water chestnut and aquatic invasive species in general is through clean boating practices. This includes three main steps:

- **Clean**: remove any mud, plants, fish, animals, or debris from your boat, fishing gear, and any other equipment that came into contact with the water. *Discard items above high water or in provided disposal stations
- **Drain**: drain water from holding compartments including live wells, bait wells, and bilge areas
- **Dry**: dry boats, trailers, and all equipment before entering a new body of water (takes 5-7 days in dry, warm weather)

By following these steps, we reduce the biggest mode of spread – hitchhikers on boats. It is important to follow Clean Boating Practices in order to prevent spreading a new aquatic invasive species into the waterways that you love!

STOP AQUATIC HITCHHIKERS!™

How Can You Help?

Look for local water chestnut pulls in your area! There are always ways to volunteer and help stop the spread of aquatic invasive species. And always remember to properly clean your boat before entering a new body of water.

Photo Credit: Alfred Cofrancesco, US Army Corps of Engineers, Bugwood.org

Where can I find more information?

- www.NYIS.info
- www.LHPRISM.org
- www.seagrant.sunysb.edu

Clearwater

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What You Should Know About Water Chestnut

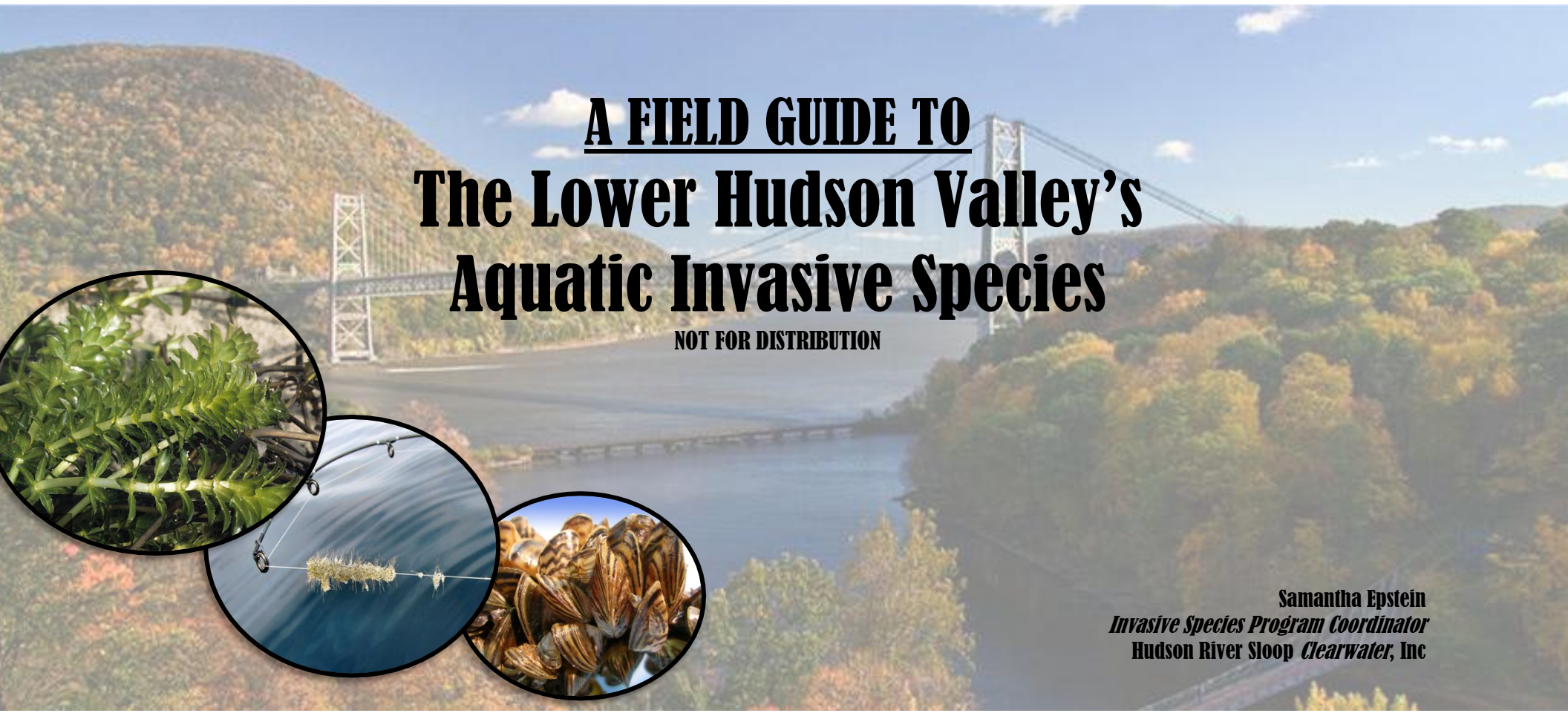
Trapa natans

Now PROHIBITED in New York, water chestnut is a highly invasive aquatic plant that has spread throughout the state. Inadvertently released into the Northeast in the 1800s, the plant has caused New York numerous ecological and economic hardships, including:

- **Hindering recreational activities**
- **Reducing native vegetation populations**
- **Lowering water quality**
- **Altering waterfowl, fish, and invertebrate populations**

Photo Credit: Leslie J. Mehrhoff, University of Connecticut, Bugwood.,org

Watercraft Inspection Steward
Field Guide



A FIELD GUIDE TO
The Lower Hudson Valley's Aquatic Invasive Species

NOT FOR DISTRIBUTION

Samantha Epstein
Invasive Species Program Coordinator
Hudson River Sloop *Clearwater*, Inc

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General Overview

An invasive species is defined as one that is non-native to the ecosystem, causes harm or has the potential to cause harm to the economy, ecology, or to human health, and the species' harmful impacts significantly outweighs its benefits. Some of the invasive species found in the Lower Hudson Region are already widespread, while others can be established, emerging, or still a threat. There are also species that are approaching the region, and can be found in neighboring regions.

This field guide does not list all of the species approaching or already in the region. It gives a general overview of the most common species found throughout the area (water chestnut), and species that we are on the lookout for (hydrilla).

New Regulations

A new amendment to Subdivision (i) of § 377.1 of Title 9 NYCRR has been approved by the New York Office of Parks, Recreation, and Historic Preservation that is designed to control the introduction and spread of aquatic invasive species at facilities under OPRHP jurisdiction. Under the newly amended legislation, one must take *reasonable precautions* to stop the spread of AIS:

- Summarized: Prior to launching and when leaving the site, the operator shall inspect for and remove any plant, aquatic life or animal, or parts thereof, and dispose in designated receptacles or in such a manner to avoid contact of the material with the waterbody. Measures must also be taken before arriving at a new site or leaving the current site to drain the watercraft (bilge area, livewells, bait wells, and ballast tanks) – Effective Nov. 12, 2014

NY Senate also amended the navigation law to include a section about universal AIS signage at launches.

- Summarized: The Department of Environmental Conservation will design and establish universal signage which will be posted at any access point to the navigable waters of the state relating to the threat and mitigation of AIS. Owners of each public boat launch shall conspicuously post the universal sign at each public boat launch in the state

Prohibited Species

New York State has listed numerous terrestrial and aquatic species as prohibited and regulated. These new regulations were published in September 2014, and became effective in March 2015. The new regulation (6 NYCRR Part 575 Prohibited and Regulated Invasive Species) prohibits 69 plants, 15 fish species, 17 aquatic invertebrates, 5 terrestrial and aquatic vertebrates 3 species of algae and cyanobacteria, and more. These prohibited species range from the mute swan to hydrilla to the spiny water flea.

Aquatic Invasive Species now prohibited in NY include:

- Killer Green Algae
- Didymo
- Golden Algae
- Fanwort
- Brazilian Waterweed
- Hydrilla, Water Thyme
- European Frogbit
- Yellow Iris
- Purple loosestrife
- Parrot-feather
- Broadleaf Water-milfoil
- Broadleaf water-milfoil hybrid
- Eurasian watermilfoil
- Yellow floating heart
- Curly leaf pondweed
- Water chestnut
- Northern Snakehead
- Bullseye Snakehead
- Giant Snakehead
- Walking Catfish
- Western Mosquitofish
- Eastern Mosquitofish
- Largescale Silver Carp
- Silver Carp
- Bighead Carp
- Oriental Weatherfish
- Black Carp
- Round Goby
- Sea Lamprey
- Tubenose Goby
- Tench
- Chinese Mystery Snail
- Japanese Mystery Snail
- Faucet Snail
- Spiny Water Flea
- Fishhook Water Flea
- Asian Clam
- Suminoe Oyster
- Carpet Tunicate
- Zebra Mussel
- Quagga Mussel
- Chinese Mitten Crab
- Asian Shore Crab
- Bloody Red Shrimp
- Rusty Crayfish
- New Zealand Mud Snail
- Vined Rapa Whelk
- Asian Sea Squirt
- Mute Swan

Stop Aquatic Hitchhikers

There are many pathways for spreading aquatic invasive species. An invasive species can be introduced for cultural reasons (e.g. food), through accidental introductions (e.g. hitchhiker on boat, ballast water, dumping aquaria species), through the pet and aquarium trade (releasing aquarium pets and plants into a waterbody), bait, waterfowl, and more. The best defense that we have against new introductions is **PREVENTION**. An important way to prevent one of the biggest AIS pathways – hitchhikers on boats – is by using clean boating practices when entering a new body of water and before leaving a body of water. The three key components to clean boating include:

Clean – Remove all visible mud, plants, fish, animal, organisms, and debris from your boat, trailer, and any equipment that came into contact with the water. Always clean your boat before leaving a body of water. Discard all potential hitchhikers in the proper disposal station when provided, or above the high water line.

Drain – Eliminate water from all equipment (motors, live wells, ballast, waders, etc.) before leaving the site.

Dry – Dry anything that came into contact with the water. If possible, decontaminate your boat and equipment with hot (<140°F), high pressure water. If this is not an option, allow your boat to dry for at least 5 days before entering new waters.

Chinese Mystery Snail

Cipangopaludina chinensis/Bellamya chinensis

Identification

The Chinese mystery snail has large, globose, smooth, and strong shells. The shell can grow 6.5 cm in height, usually has 6-7 convex whorls and the inner coloration is white to pale blue. It exhibits light coloration as a juvenile and olive green, greenish brown, brown, or reddish brown coloration as an adult. The shell has an oblong-shaped operculum ("trap door") that displays concentric growth rings. The operculum allows the snail to close the opening of the shell when water conditions become unfavorable or when being attacked by a predator

Impacts

Chinese mystery snail was found to cause declines in growth and abundance of native snail species, likely through competition for food. They are also less vulnerable to predation by the invasive rusty crayfish due to their larger size and thicker shells than native snails. The Chinese mystery snail can also reduce algal biomass, which changes the Nitrogen:Phosphorus ratio. They are also a nuisance to water intake pipelines, often clogging the screens and inhibiting the flow of water.

Chinese mystery snails can also serve as vectors for transmitting parasites and diseases, and host some parasites that can infect humans.

Native Range

The Chinese mystery snail is native to Eastern Russia, China, Japan, Korea, Philippines, Taiwan, and Vietnam.

Spread

Probably introduced through the aquarium trade or as an importation for food markets, the Chinese mystery snail spreads by recreational activities through bait buckets or water holding areas on boats (ballast, live well, etc.). It can still be introduced through accidental introductions from aquariums.

The Chinese mystery snail is **a threat** in the Lower Hudson Valley.

Asian Clam

Corbicula fluminea

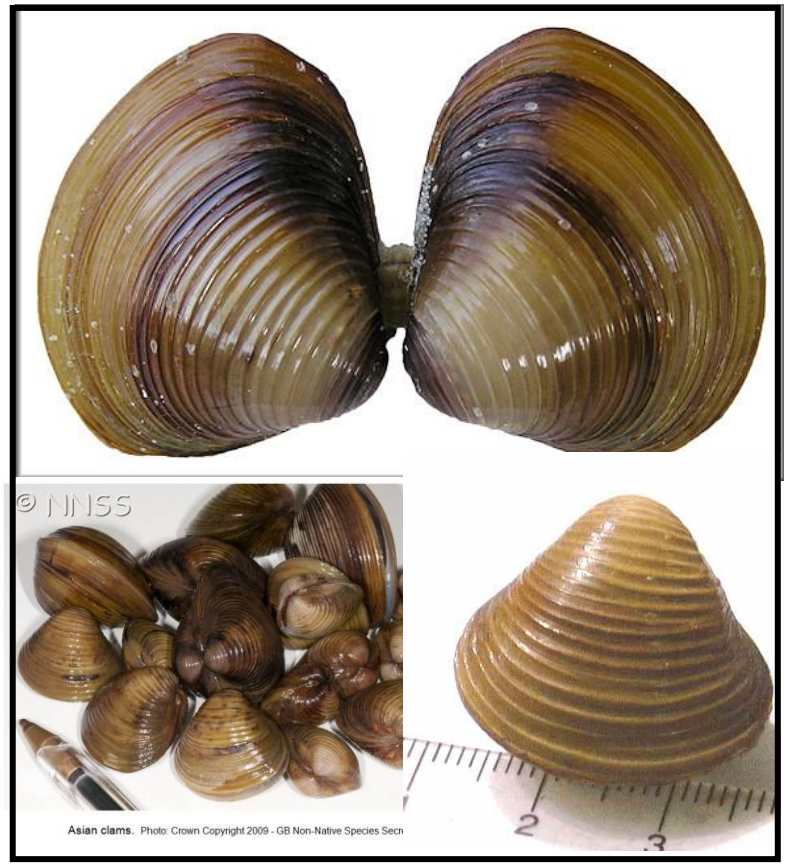
Identification

The Asian clam is a freshwater clam with a triangular yellowish brown to black shell with concentric, evenly spaced ridges on the shell surface. They are usually less than 25 mm but can grow up to 65 mm in length. It can be found on numerous substrates including silt, mud, sand, and gravel, and can tolerate sanities of up to 13 ppt for short periods of time.

Impacts

The Asian clam is highly successful coupling the nutrients in the water column and bottom sediments, filtering out phytoplankton and other particles suspended in the water that are also important food sources for filter-feeding organisms. They also excrete significant amounts of inorganic nutrients that can, in turn, stimulate algae and macrophyte growth. Asian clams have mass mortality events that occur in the summer, followed by the release of nutrients via decomposition, which can also lead to negative water quality effects. The shells create new habitat for species that prefer harder substrates (e.g. zebra mussels).

Asian clams are known to colonize intake pipes of water treatment systems and power stations. Unlike zebra mussels, the Asian clam does not attach to hard substrates. The juvenile clams pass through filter screens and settle on the floors of intake pipes where they reproduce and continue to accumulate in pipes while getting transported deeper into the system, eventually blocking structures with shells, altering flow, and increasing sedimentation rates.



Native Range

The Asian clam is native to eastern and southern Asia and was introduced as a food source.

Spread

The Asian Clam is hermaphroditic and capable of self-fertilization. It can spawn year round in warmer waters, and can release hundreds of thousands of veligers each day, which are then spread by water currents and human activity. The veligers and mature clams are able to attach themselves to boats, trailers, and equipment and can be transferred in bait buckets or water compartments including live wells and bilges.

The Asian Clam is **emerging** in the Lower Hudson Valley.

Zebra Mussel

Dreissena polymorpha

Identification

The zebra mussel has a triangular shell with a sharply pointed shell hinge end. The mussel can grow up to 5 centimeters, but most rarely exceed 4 cm. There is a prominent dark and light banding pattern on the shell. It is tan in color with broad, transverse color bands that are either smooth or zigzag in shape. The mussel attaches to hard surfaces using byssal threads, which distinguishes this mussel from other similar mussels in the region. The shell's "D-shape" gives it a straight midventral line and a prominent ridge that allows it to sit flat on its ventral side, unlike other mussel species.

Impact

Zebra mussels were first discovered in the Hudson River in 1991, and by 1992 their densities were reaching over 100,000 individuals per square meter. In such great densities, they were able to filter all of the water in the freshwater portion of the Hudson every 2-4 days, compared to the native mussels that filtered the water every 2-3 months. This causes a reduction in phytoplankton numbers and biomass which limits food for fish larvae, and eventually other consumers further up the food chain. Zebra mussel colonization can impede fish foraging and can affect spawning fishes.

Zebra mussels also clog intake pipes, ship hulls, and more, causing damage to boats and water treatment plants.

Native Range

The zebra mussel is native to Europe, Russia, Turkey, and Ukraine.

Spread

Female zebra mussels can produce up to one million eggs in a season. These free-floating veligers can be transported undetected in bait buckets, bilge water, and live wells. The mussels can also survive out of water for up to five days and can easily be transported to other waterbodies on boats, trailers, and other equipment.

The zebra mussel is **established** in the Lower Hudson Valley.

Spiny Water Flea

Bythotrephes longimanus (B. cederstroemi)

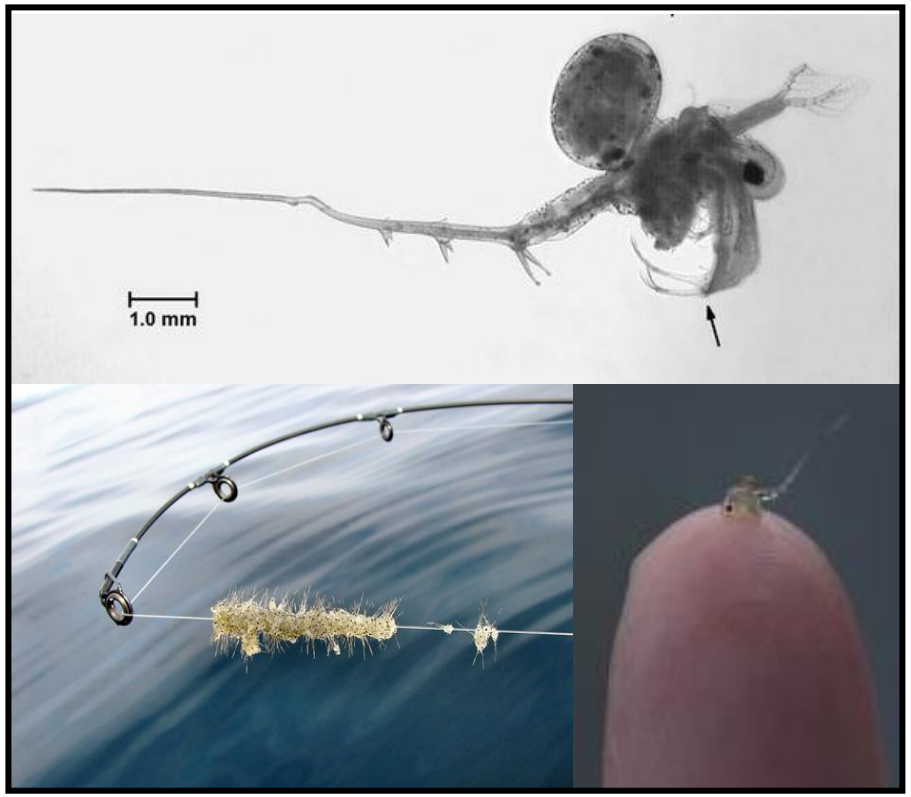
Identification

Spiny water flea is a carnivorous crustacean similar to the sea monkey, reaching 10-15 mm at maturity. Its long, spiny tail comprises about 2/3 of its body length. The head has one black eye and a pair of sickle-shaped mandibles. The spiny water flea has two swimming antenna behind its head and four pairs of legs used to catch their prey.

Impacts

The spiny water flea has directly impacted the native, herbivorous zooplankton including the species Daphnia, an important food for many native larval fish species. This makes the spiny water flea a direct competitor of the larval fish species. With its rapid reproduction, it is sometimes able to outcompete them.

The spiny water flea is also a nuisance for anglers and fisherman. They attach themselves in gelatinous globs on fishing lines, downriggers, anchor ropes, and fishing nets. The eggs are able to resist drying and freezing, and can establish a new infestation once entering another body of water. Eggs can also pass through the digestive tracts of fish. Females carrying eggs can be twice their normal weight, and their increased predation is another way for the eggs to disperse.



Native Range

Native to the Northern Europe and Asia

Spread

The spiny water flea collects on fishing lines and fishing gear, forming jelly-like globs. Eggs are able to survive being dried out and can survive on fishing gear for extended periods of time, which is why cleaning your boats and equipment is important. The spiny water flea can also spread in water containers on boats, so draining water from bilges, live wells, etc. is extremely important.

The spiny water flea is **approaching** the Lower Hudson Valley

Chinese mitten crab

Eriocheir sinensis

Identification

The Chinese mitten crab has a distinguished square shaped carapace that can reach 5-7 cm with a maximum carapace of 10 cm. Another distinguishing feature is the hair-like covering on the claws, resembling mittens. The color varies from yellow to brown, and is rarely purple.

Impact

The Chinese mitten crab is an opportunistic omnivore, consuming macroalgae, invertebrates, and fish which can diminish the food sources for the native crabs. Their burrowing activity can damage dikes and increase river embankment erosion, and can even cause bank collapses. Chinese mitten crabs have become a nuisance for recreational and commercial anglers by getting entangled in fishing gear, causing damage to fishing nets. They also reproduce and migrate in such high numbers that they can block water intakes and drainage systems

Native Range

The Chinese mitten crab is native to southeast Asia, southern China, and the Korean peninsula.

Spread

The Chinese mitten crab is spreading across the world in ballast water transfers, and by clinging to ship barges and hulls, which is why clean boating practices are so necessary. This species has also become popular in seafood markets.

The Chinese mitten crab is **widespread** in the Lower Hudson Valley.

Asian shore crab

Hemigrapsus sanguineus

Identification

The Asian shore crab has a somewhat square carapace with unusual patters and can range in color from brownish orange to greenish black to purple. Each side of the carapace has three distinct anterolateral teeth. The crab also has a light and dark banding pattern on the walking legs. Its claws have red spots. It can reach 2-3 inches in width. Females are capable of producing three to four clutches per season, each containing up to 50,000 eggs.

Impact

The Asian shore crab Is an opportunistic omnivore and has a very broad diet that can include macroalgae, salt marsh grass, larval and juvenile fish, and small invertebrates. This gives it the potential to affect populations of native crabs, fish, and shellfish by disrupting the food web. It has been known to out-compete native mud crabs, blue crabs, and lobsters. It occupies habitats very similar to our native mud crabs, overwhelming and dominating their habitat.

Native Range

The Asian shore crab is native to Russia, Korea, China and Japan.

Spread

Originally introduced by release of larvae in ballast water, the Asian shore crab continues to spread over great distances because their larvae are suspended in the water for approximately one month before developing into juvenile crabs, allowing the currents to move the larvae far away.

The Asian shore crab is **approaching** the Lower Hudson Valley.

Rusty crayfish

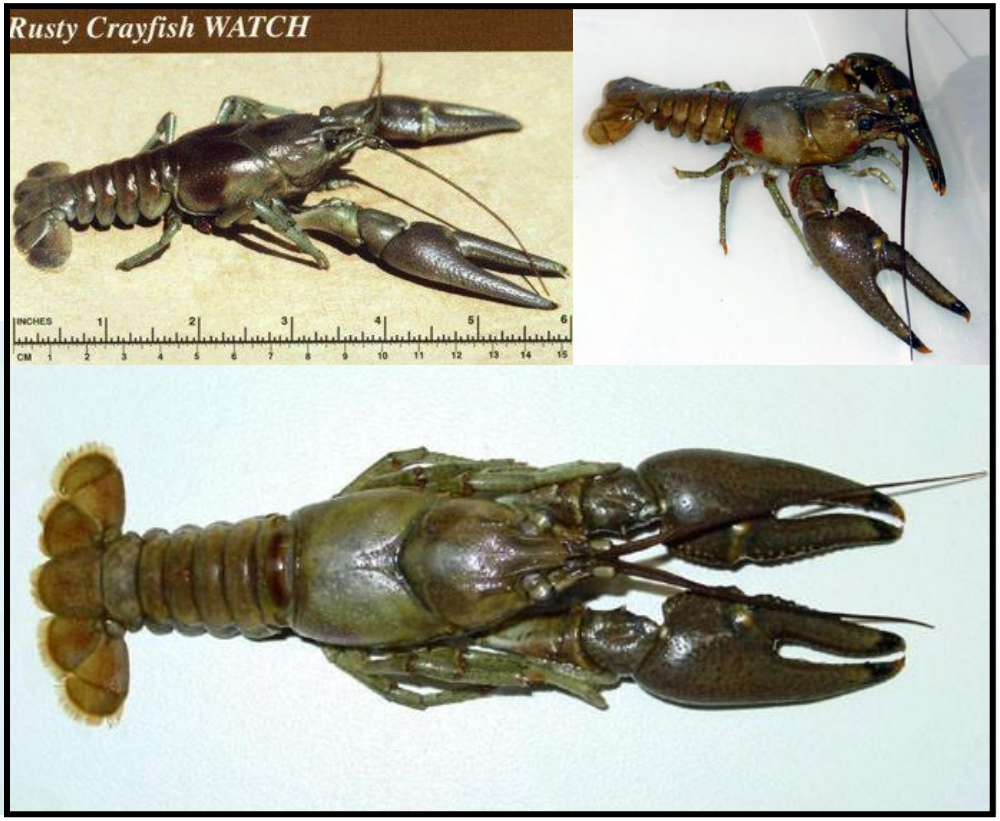
Orconectes rusticus

Identification

The rusty crayfish can reach up to 10 cm in length and has robust claws with dark, rusty spots on either side of its carapace. While usually prominent, the rusty colored spots do not develop well in some waters. A rust colored band also appears dorsally down the center of the abdomen. Its greenish color is most pronounced on its walking legs. Its claws are grayish green to reddish brown and have a black band at the tips.

Impact

The rusty crayfish has a range of ecological impacts on introduced environments that include competition and displacement of native crayfish, increased predation on snails, native and threatened bivalves, reduction of macrophyte abundance, reduction of sport fish abundance, reduction of macroinvertebrate abundance, and other cascading trophic interactions.
Rusty crayfish reduce sport fish populations by either egg predation or competition with juveniles. It also displaces native or existing crayfish species, which can result in less food for fish.



Native Range

The rusty crayfish is native to Ohio, Kentucky, and Michigan.

Spread

The most common mode of spread for the rusty crayfish is by anglers using them as bait, or are released by anglers, aquarium hobbyists, and commercial harvesters. Females can carry fertilized eggs or a male's sperm, so a single female can establish new populations.

The rusty crayfish is currently **established** in the Lower Hudson Valley.

Goldfish

Carassius auratus

Identification

Goldfish are small to moderately sized fish with an elongated, stocky body. Wild populations vary in color from gold to olive green to creamy white, and fades to silvery-white along the belly. They have long dorsal fins with 15-21 rays and a hard serrate spine at the origin of the dorsal and anal fins. Their life span is usually 6-7 years, but can live up to 30.

Impact

Cyanobacteria passing through the goldfish intestine stimulate cyanobacterial growth, which can result in algae blooms. The goldfish is a bottom-sucking feeder which causes the re-suspension of nutrients, leading to algae blooms. Goldfish also prey on the eggs, larvae, and adults of native fish species. Their feeding method increases water turbidity and decreases the native aquatic vegetation. Goldfish likely compete with native fish species for habitat and food, eventually displacing the natives.

Native Range

The goldfish is native to central Asia, China, and Japan.

Spread

Goldfish have been introduced into our waterways through many means. Wild populations have established through the release of pet goldfish. They are used for ornamental purposes and can escape confinement in outdoor ponds. It is thought that the first recorded goldfish release was the result of an intentional release by settlers wanting to add it to the North American fish fauna. For a period of time in the 1800s,the US Fish Commission raised the species and distributed it to many states for aquaria, fountains, and ornamental lakes. Since then it has been reported in nearly every state.

The goldfish is currently **established** in the Lower Hudson Valley.

Northern Snakehead

Channa argus

Identification

The northern snakehead has a torpedo-shaped body that tapers toward the tail. They have a single, long dorsal fin, long anal fin, and a small head with a large mouth. They can grow up to 85 cm in length. Resembling a fish with a large mouth and sharp teeth and a truncated, not rounded tail, the northern snakehead is easily identifiable by the dark irregular blotches on its sides that lay on top of a golden tan to pale brown body. It can also darken its color to the point of almost obscuring the blotches.

Impact

If left unchecked, the northern snakehead will expand its range and could potentially alter the balance of aquatic ecosystems. The northern snakehead is a voracious feeder of aquatic fauna and can eat prey up to 33% of their own body length. They are capable of surviving in waters with very low oxygen content, giving them a competitive advantage over native species that require more oxygen. The predatory fish eats numerous species of fish, crayfish, dragonfly larvae, beetles, and frogs.

Native Range

The northern snakehead is native to China, Russia, and Korea

Spread

The northern snakehead likely entered the United States via pet shops and live fish markets, where they were sold before their threat was realized. Pet owners often unknowingly released them into the wild when they grew too big for aquarium tanks, or as part of religious or cultural practices.

The northern snakehead is currently **emerging** in the Lower Hudson Valley.

Common Carp/Koi

Cyprinus carpio

Identification

Carp can grow up to 120 cm in length and weigh 60 kg. The common carp is recognized by its small eyes, thick lips, two barbells at each corner of the mouth, large scales outlined in black, and strongly serrated spines in the dorsal and anal fins. The head is short, with a rounded snout and toothless, sucker-like mouth. In the wild, common carp are usually olive green to bronze or silver with a pale underside. Koi carp are brightly colored with orange, yellow, white, or black markings.

Impact

Carp are known to damage aquatic macrophyte populations, which are integral to the ecosystem functioning. They pose a threat to wetlands that are used as spawning and nursing habitats by native species. They can stimulate algal blooms by increasing nutrient release from sediments and decreasing algal grazing by cladocerans. Carp negatively affect species abundance and diversity of macrophytes and some macroinvertebrates, which can lead to declines in biodiversity. Carp stir up sediment during feeding which results in siltation and bioturbidity. They can often drive native species out by overtaking their habitats and can outcompete native species and eat their eggs. They can also destroy the native vegetation.

Native Range

The common carp is native to Europe in rivers around the Black Sea and the Aegean basin.

Spread

Common carp were introduced to the United States both deliberately in an attempt to imitate the European environment, and accidentally through escaping ornamental or aquaculture fish. It has been introduced worldwide as a food fish in temperate freshwaters. Anglers sometimes use juvenile carp as bait.

The common carp is currently **widespread** to the Lower Hudson Valley.

Oriental Weatherfish

Misgurnus anguillicaudatus

Identification

The Oriental weatherfish varies in color from brown to yellow with greenish, grey-brown, or black marbling. The eel-like body is long, laterally compressed, reaching about 15 cm with a maximum length of 30 cm. Its small, narrow mouth is subinferior with 10 barbels. Four of these barbells are smaller and placed below the lip. It has thick, fleshy lips. Pectoral fins are triangular with a stout spine. It has a dark spot on the upper half of the base of the caudal fin. (9 dorsal rays, 6-7 pelvic rays, 7-8 anal rays).It gets its name as “weatherfish” because it becomes more active in response to changes in barometric pressure.

Impact

Oriental weatherfish can cause significant reductions in macroinvertebrate numbers and biomass. It has been associated with elevated ammonia, nitrate/nitrite, and turbidity levels – similar to the water quality impacts of carp. The Oriental weatherfish impacts native fisheries by reducing populations of their macroinvertebrate prey, by competing for shelter and spawning sites, and by preying on eggs and juveniles. It is a highly adaptive species with high competitive ability, high reproductive capacity, high survivorship, and high dispersal ability.

Native Range

Oriental weatherfish are native to Cambodia, China, Hong Kong, India, Japan, Korea, Russia, Taiwan, Thailand, and Vietnam.

Spread

The original means of introduction is through escaped fish farms. The Oriental weatherfish is a common aquarium fish and is popular in the aquarium trade. It is also spread through its use as live bait. Eggs are not guarded and scatter in open water, allowing currents to take the fish to new, previously uninvaded bodies of water.

The Oriental weatherfish is currently **emerging** in the Lower Hudson Valley.

Round Goby

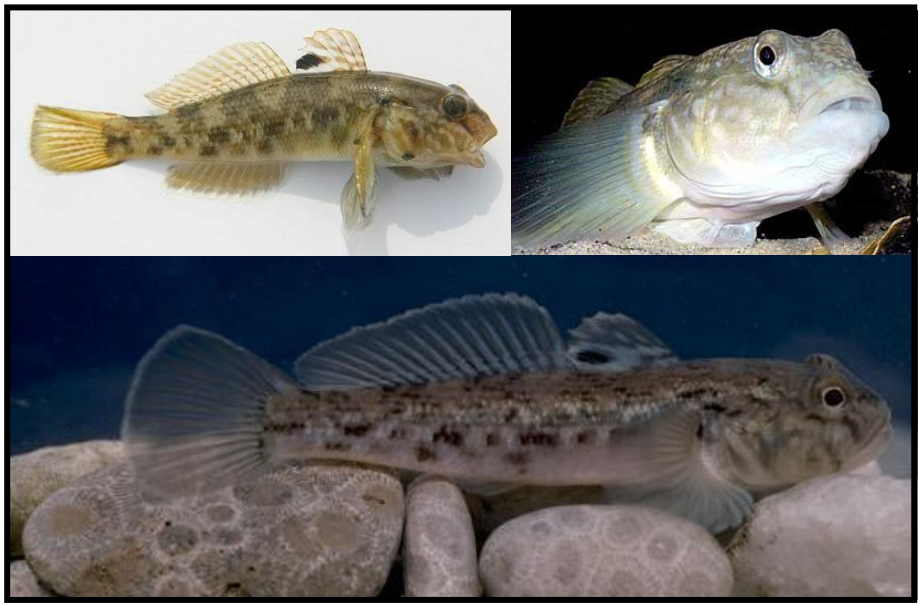
Neogobius melanostomus

Identification

The round goby is a small, soft-bodied fish readily distinguished from other freshwater fish in North America by the presence of a fused pelvic fin that forms a suction cup shaped fin on the ventral surface. It has a brownish gray body with dark brown lateral spots. There is usually a large, oblong black spot present at the end of the dorsal fin. The head length is about 23% of the total body length. Spawning males can turn almost solid black. Their soft body and large round head have frog-like raised eyes. This fish can grow 10-25 cm long.

Impact

The round goby is thriving and harming the native sport fish populations. It is able to outcompete the native species including lake trout, sculpin, and logperch for food sources, habitat, and spawning sites. It spawns more frequently than other species and feeds on their eggs and young juveniles.



Native Range

The round goby is native to Asia and parts of Europe.

Spread

The round goby was introduced to the Great Lakes through ballast water on cargo ships. They are mistaken with some common baitfish, so boaters and fisherman can unknowingly carry them from one body of water to another in bait buckets, bilge water, and more.

The round goby is currently **a threat** to the Lower Hudson Valley.

Sea Lamprey

Petromyzon marinus

Identification

The sea lamprey is eel-like and has long, flexible, cylindrical, scaleless bodies with a deeply notched dorsal fin that separates it into two distinct parts. It can reach 50 cm in length. It has no scales and no paired fins. Adult sea lampreys have a disc-like mouth that contains circular rows of over 100 sharp, hooked teeth. Adults can be olive-brown, yellow-brown, green, red, or blue mottled with darker shades of the same color, or nearly black. The underside is typically white or grey.

Impact

Sea lampreys attack and are parasite feeders on other fish, which often results in the death of the fish. They can destroy up to 40 pounds of fish during their adult lifetime. Typically, only one out of seven fish attacked by a sea lamprey will survive. The population explosion in the 1940s and 1950s contributed significantly to the collapse of economically important Great Lakes fish species.

Native Range

The sea lamprey is native to the east coast of North America, the Northeast Atlantic coast from Norway, Iceland, and the Barents Sea, to northern Africa, and the western Mediterranean Sea.

Spread

The sea lamprey appeared in Lake Erie in 1921 via the Welland canal, and took 25 years to spread to the remaining Great Lakes. Larval lampreys are used as bait in non-native areas. Adults can attach themselves to boats going through the canal systems, allowing it to travel to previously uninvaded areas. The sea lamprey also travels over long distances while attached to other fish.

The Sea lamprey is native to the Hudson River and has not been found to cause a problem. It is an ecological threat to non-native areas, including the Great Lakes and Lake Champlain.

Fanwort

Cabomba caroliniana

Identification

Fanwort is a submersed freshwater perennial plant. It can be found rooted or as floating fragments that can survive up to eight weeks. The branching stems have reddish-brown hair and can grow 6 meters or longer, growing from the rhizomes below the sediment. The submerged leaves are divided into fine branches, giving it a feathery appearance. Leaves are oppositely arranged, green, and about 5 cm in diameter. Floating leaves are narrow, small and oval or diamond shaped arranged in an alternating pattern. Flowers are small and range in color from white to pink to purple, with a diameter of less than 1.5 cm.

Impact

Fanwort is a very competitive plant, giving it the opportunity to form dense stands and reduce sunlight for and crowd out previously well-established, native species. These monocultures are bad for biodiversity and can affect the water quality. When large mats of the vegetation die off, their decomposition causes oxygen reductions. This plant can also clog drainage canals and freshwater streams, which impedes recreational and agricultural uses.

*Commonly mistaken for native Coontail (*Ceratophyllum demersum*)

Native Range

Fanwort is native to southern Brazil, Paraguay, Uruguay, and northeast Argentina.

Spread

Fanwort has spread through both intentional and unintentional releases in the aquarium trade. This species is capable of reproducing vegetatively through fragmentation, allowing it to spread via hitchhiking on boats, trailers, and other recreational equipment.

Fanwort is currently **emerging** in the Lower Hudson Valley.

Brazilian Waterweed

Egeria densa

Identification

Brazilian waterweed is a freshwater perennial with bright green stems and leaves with short internodes which gives the plant a leafy appearance. Leaves are minutely serrated and linear, 1-3 cm long, and up to 5 mm wide. The leaves are found in whorls of 4-8, but the lowest leaves are opposite or in whorls of 3. Stems are erect, cylindrical, simple or branched, and grow until they reach the surface of the water where they form dense mats.

Impact

This species forms monospecific stands that can restrict water movement, trap sediment, and cause fluctuations in water quality. The monospecific stands push out native species, reducing the biodiversity of the area. Introduced worldwide through the aquarium trade, even in its native range it becomes a nuisance species and causes economic impacts.
Dense beds can interfere with recreational water uses including boat navigation, swimming, fishing, etc. Fragments of the plant can also break off and clog intake structures of water treatment plants.

Native Range

Brazilian waterweed is native to South America.

Spread

Brazilian waterweed has spread via aquarium and water garden releases. It is only able to reproduce vegetatively by plant fragments which hitchhike on boats, trailers, and equipment and spread to new waterbodies. Brazilian waterweed has the ability to cover 100 acres of water per year.

Brazilian waterweed is currently **emerging** in the Lower Hudson Valley.

*Commonly mistaken for Hydrilla and native Elodea

Hydrilla

Hydrilla verticillata

Identification

Hydrilla is a submerged aquatic perennial with heavily branched stems towards the water surface. The plant can grow in depths of up to 30 feet, growing up to a foot per day. The northern biotype, monoecious hydrilla, mats the floor, creating a "shag rug" look. When the water is warm enough, the hydrilla grows vertically towards the surface, creating dense mats that block the sunlight for native species below. Leaves are strap-shaped with pointed tips and serrated edges, growing in whorls of 4-8 (usually 5). Leaf color can vary from green, translucent, yellow, to brown.

Impact

Hydrilla can impact the ecology and economy in numerous ways. When hydrilla mats the surface, it blocks sunlight for native species below it, displacing them and forming a monoculture. Hydrilla can grow up to a foot each day, easily overtaking large bodies of water. It can thrive in many water types, ranging from stagnant or moving, freshwater to brackish water, high or low sunlight, high or low nutrient levels, etc. It also creates tubers that remain viable under the sediment for up to 10 years, making treatments or removals more difficult. When large mats of hydrilla die later in the season, algae blooms can be created, causing fish kills. Hydrilla is also a host to a species of cyanobacteria that has caused deaths of at least 99 bald eagle and thousands of American coots.

Hydrilla can also devastate recreational activities including swimming, boating, fishing, and more, which can harm tourism industries. Hydrilla infestations also lower the value of waterfront

homes. Large mats of hydrilla can break off and clog water intakes at plants, which can be expensive to fix.

Native Range

The dioecious plant (found in the south) is native to southern India, and the monoecious plant is native to Korea. Both species are not found on every continent except Antarctica.

Spread

Hydrilla can spread vegetatively through fragmentation, making it a potential hitchhiker on boats, trailers, and other equipment. It can also spread via turions, or overwintering buds, that can flow downstream and start new populations. Hydrilla also produces tubers, which are potato-like structures that lay a few inches below the sediment. These can remain viable for up to 10 years, making hydrilla management projects more difficult.

Hydrilla is currently **emerging** in the Lower Hudson Valley.

*Commonly mistaken for Brazilian waterweed and native Elodea

Parrot-feather

Myriophyllum aquaticum

Identification

Parrot-feather is named for the feather-like leaves arranged around the stem in whorls of 4-6. It has both emergent and submerged aquatic leaves and can easily be mistaken for Eurasian watermilfoil. The submersed leaves are 1.5-3.5cm long with 20-30 divisions per leaf. Emergent leaves are 2-5 cm long with 6-18 divisions per leaf. The bright green emergent leaves are stiff and darker green than the submersed. The emergent stem and leaves can grow up to a foot above the water and look almost like a small fir tree. Submersed leaves are limp and appear to be decaying with very robust stems.

Impact

Parrot-feather has been introduced worldwide as an aquarium plant. It can spread vegetatively via fragmentation and can alter the physical and chemical characteristics of a lake or stream once established. Infestations can shade out the algae in the water column that serve as the basis of the aquatic food web. It is also good habitat for mosquito larvae. Parrot-feather can also restrict recreational opportunities and activities in the infested bodies of water.

Native Range

Parrot-feather is native to South America.

Spread

In the United States, there are only female parrot-feather plants, so it is restricted to spreading vegetatively through fragmentation. This means it can easily spread as a hitchhiker on boats, trailers, and other equipment that comes into contact with the water.

Parrot-feather is currently **a threat** in the Lower Hudson Valley.

Variable leaf/Broadleaf milfoil

Myriophyllum heterophyllum

Identification

Variable leaf milfoil is a submersed aquatic plant with emergent flowering spikes. Submerged leaves are feather-like, green, 2-5 cm long and 2-4 cm wide, dissected into 7-11 leaflets and whorls of 4-5. The emergent spike can reach 5-15 cm above the water surface. This species can be very difficult to differentiate from Eurasian watermilfoil and other milfoil species. The stem of the variable leaf milfoil is sturdier than others, and the submerged leaves are thicker and rougher. Unlike Eurasian watermilfoil, when you pull variable leaf milfoil from the water, it can hold its form.

Impact

Variable leaf milfoil is an aggressive plant that can grow up to one inch per day. It can form dense vegetative mats and reduce water movement. When decomposing, it reduces water quality and available oxygen which can harm fish and other aquatic organisms. The thick mats often outcompete native vegetation. It can also clog boat motors and deter people from water related activities.

Native Range

Variable leaf milfoil is native from southwestern Quebec and Ontario to North Dakota and southward to New Mexico and Florida.

Spread

This species of milfoil primarily spreads vegetatively through fragmentation, which are able to hitchhike on boats, trailers, and other equipment. Currents are also able to move fragments long distances.

Variable leaf milfoil is currently **emerging** in the Lower Hudson Valley.

Eurasian watermilfoil

Myriophyllum spicatum

Identification

Eurasian watermilfoil is an aquatic perennial, dicot herb with long branch stems and feather-like whorled leaves. Its small reddish flowers emerge from the water on a spike. Stems are slender and smooth, reaching up to 6 m long and range in color from reddish-brown to whitish-pink. The leaves are olive green and are typically less than 5cm long. Each leaf is soft, deeply divided and feather-like, and can be found in whorls of 3-6 (usually 4). A distinguishing feature of Eurasian watermilfoil is the end of each leaf, as the leaf divisions end in almost a straight, horizontal line rather than coming to a point (see top left picture).

Impact

Eurasian watermilfoil grows in dense patches, forming a monoculture which shades out native species. It is less of a food source than the natives that it replaces, and supports fewer insects that serve as the food resources for fish. Predatory fish lose foraging space and are less efficient at obtaining prey in infested areas. When large mats of the plant decay, oxygen levels drop, altering the ecosystem. Dense mats of Eurasian watermilfoil also impede water movement and limit recreational activities

Native Range

Eurasian watermilfoil is native to Europe, Asia, and northern Africa.

Spread

Eurasian watermilfoil does not rely on seeds for reproduction. Instead, it reproduces vegetatively via fragmentation. These fragments break off and float long distances with water currents. Fragments can also be transported long distances by hitchhiking on boats, trailers, and equipment.

Eurasian watermilfoil is current **widespread** in the Lower Hudson Valley.

Brittle Naiad

Najas minor

Identification

Brittle naiad is a submersed, annual herb with compact, bushy growth. Stems can reach up to 2.5 m long and are abundantly branched near their apex. Its leaves are opposite, but can appear to be in a whorl at the tip. The leaves can grow 1-2 inches long, and are toothed, stiff, curved, and pointed. Its flowers are inconspicuous. As stated in the name, this species is very brittle and easily breaks into pieces.

Impact

Brittle naiad is able to establish dense monocultures, excluding other native vegetation and affecting fish and waterfowl biodiversity. Unlike many other aquatic invasive plants, brittle naiad does not produce long stems that spread on the surface of the water. But its dense monocultures still capable of interfering with recreational activities like swimming, boating, and fishing, and can reduce the aesthetic appeal of the waterbody. Brittle naiad can also reduce the discharge capacity of channels as well.

Native Range

Brittle naiad is native to Austria, Belgium, Bulgaria, Czech Republic, France, Germany, Hungary, Italy, Poland, Portugal, Romania, Siberia, Ukraine, Morocco, India, Turkey, and Japan.

Spread

Brittle naiad can reproduce vegetatively through fragmentation. These fragments can hitchhike on boats or other equipment and be transported to a previously uninfested body of water and start new populations. Waterfowl also spread the species by ingesting the seeds and excreting them in new locations. Wind and currents can pull fragments of brittle naiad to new locations, where the viable fragments can establish new infestations.

While not prohibited, brittle naiad is considered invasive and is **established** in the Lower Hudson Region.

Curly-leaf pondweed

Potamogeton crispus

Identification

Curly-leaf pondweed is a submerged perennial plant with oblong, reddish-green to translucent, wavy, alternate leaves with finely toothed margins. Leaves are 0.5-1.5 cm wide and 3-10 cm long. Stems are branched and somewhat flat. The plant can reach 1 m in height. The plant flowers and fruits in late spring to early summer. When it dies off, it leaves fruits and turions to survive the summer. The turions produce new, small plants that overwinter.

Impact

This pondweed is able to tolerate low light levels and temperature conditions, allowing it to grow sooner than native plants. Curly-leaf pondweed can grow in very dense beds that can outcompete native plants, creating a monoculture. Dense surface mats can disrupt recreational activities. It can spread through fragmentation. Curly-leaf pondweed can increase algal blooms, decreasing the aesthetic value of waterfront properties. It can reduce the fetch of a lake and can stratify the water column in normally unstratified systems.

Native Range

Curly-leaf pondweed is native to Eurasia, Africa, and Australia.

Spread

This pondweed produces burr-like overwintering buds called turions that can spread long distances with the current, allowing it to reproduce vegetatively. Curly-leaf pondweed also produces seeds and can be spread by waterfowl ingesting them. Fragments can also spread on recreational equipment including boats and trailers.

Curly-leaf pondweed is currently **established** in the Lower Hudson Valley.

European Frogbit

Hydrocharis morsus-ranae

Identification

European frogbit is an herbaceous, annual aquatic that can reach 20 cm in length. It is a free-floating plant whose leaves are usually floating, but can be emergent if the vegetation is dense enough. The leathery, glabrous leaves are cordate-orbicular in shape measuring about 1-6 cm in length and width. The lower leaf circle is dark purple. European frogbit resembles a quarter-sized lily pad.

Impact

European frogbit can impede water flow in irrigation systems and canals, and lessen recreational and aesthetic values on waterfront properties. This can lead to a decrease in tourism.

Dense monocultures and mats of European frogbit block light penetration in the water column, reducing available light for native species. They can also deplete oxygen levels by limiting water circulation and increasing decomposition of dead plants, which changes the water quality and affects the ecosystem.

Native Range

European frogbit is native to Asia and Europe.

Spread

European frogbit can spread both vegetatively and by turions. Spreading vegetatively, or by fragmentation, allows frogbit to spread as a hitchhiker on boats and trailers. It also grows turions, which float to the surface and grow in the spring. A single plant can produce 150 turions each season.

European frogbit is currently **a threat** in the Lower Hudson Valley.

Yellow floating heart

Nymphoides peltata

Identification

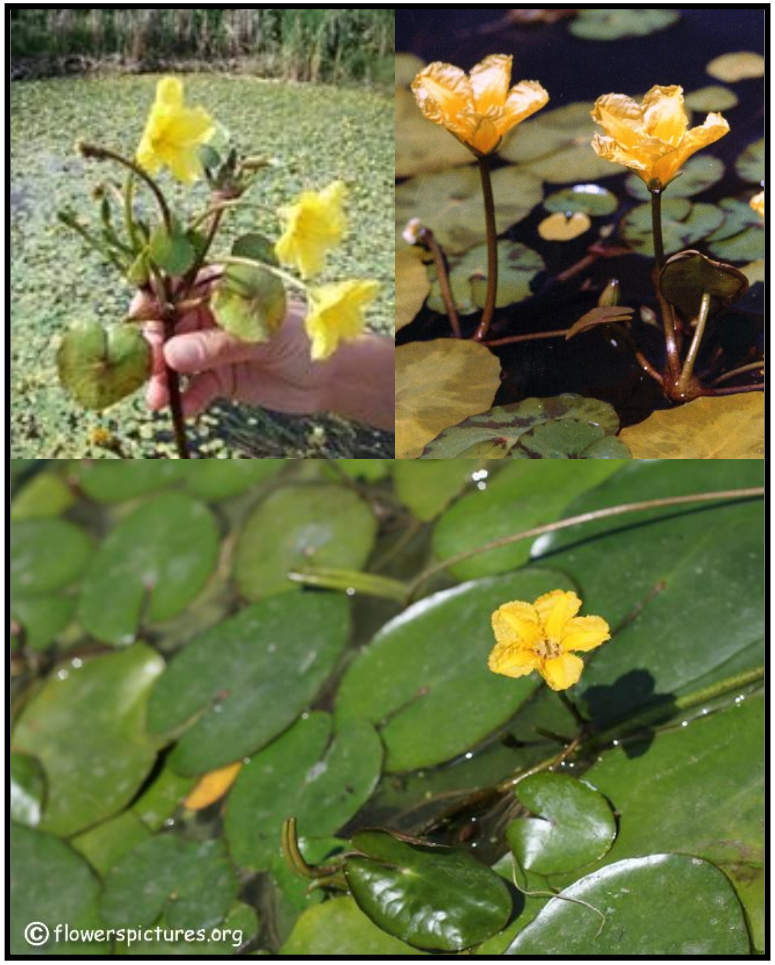
The yellow floating heart is a perennial, water lily-like plant that mats the surface of the water with long stalked, heart-shaped leaves. The leaves are 3-10 cm long, and are usually purple underneath. It has a showy, five petaled yellow flower growing on long stalks and rising a few inches out of the water. There can be multiple flowers per stalk. The flower edges are distinctively fringed.

Impact

The yellow floating heart can grow very dense patches and displace the native species. The plants can also limit movement in the water column, creating stagnant areas with low oxygen levels below the floating mats. Dense patches can hinder recreational activities including boating, swimming, and fishing.

Native Range

The yellow floating heart is native to Asia and Europe.



Spread

Originally introduced as an aquatic ornamental for outdoor water gardens, it continues to be spread accidentally through outside water gardens. The hairs on the seeds also allow the seeds to attach to waterfowl, which can also spread the plant.

Yellow floating heart is currently **a threat** in the Lower Hudson Valley.

Water chestnut

Trapa natans

Identification

Water chestnut is a rooted, floating plant. Its floating leaves are arranged in rosette. The individual leaves are 2-4 cm long and are sharply dentate along the leaf margins. The lower surface has conspicuous veins and short, stiff hairs. Submerged lower leaves are alternate and feather like and can reach 15 cm in length. The fruit is a four-horned nut-like structure about 3 cm wide and develop underwater.

Impact

Water chestnut can completely mat the surface, causing competition with native species for light, nutrients and space. When it decomposes, it can lower dissolved oxygen levels which can lead to fish kills. It has little value for waterfowl. The spiny fruit can hurt people and animals when stepped on. Big infestations can impede recreational activities and commercial navigation.

Native Range

Water chestnut is native to Europe, Asia, and Africa.

Spread

Water chestnut produces nut-like seeds that germinate in the spring, and each seed is capable of producing 10-15 rosettes. Each plant is capable of producing 20 seeds per season. These seeds sink to the bottom and are able to remain viable for up to 12 years. This plant also spreads vegetatively through fragmentation. Fragments are able to spread on boats, trailers, and other equipment.

Water chestnut is currently **established** in the Lower Hudson Valley.

Yellow Iris

Iris pseudacorus

Identification

Yellow iris is a perennial monocot that forms dense stands in waters up to 25 cm deep. It can grow between 40-150 cm tall. Its rhizomes are 1-4 cm in diameter with roots up to 30 cm long. The leaves are broad up to 100 cm long and 30 mm wide with a raised midrib, and comes to a fine point. Flowers are yellow and 8-10cm in diameter.

Impact

The yellow iris thick rhizomes create a sort of mat that prevent the germination and seedling growth of other plant species. This can also congest water flow. They also change the ecosystem by compacting soil and elevating the topography, creating a drier habitat with increased rates of siltation and sedimentation. It is a fast growing, fast spreading plant that can outcompete other native wetland species and form impenetrable thickets.
This species is poisonous, harming fish and animals that touch or eat it. It is capable of causing skin irritation to humans.

Native Range

Yellow iris is native to Africa, Asia, and Europe.

Spread

The yellow iris can reproduce vegetatively through underground stems, or rhizomes, which form into roots and allow it to re-grow new plants each season.

Yellow iris is currently **emerging** in the Lower Hudson Valley.

Purple loosestrife

Lythrum salicaria

Identification

Purple loosestrife is an erect perennial herb with a woody four-sided stem. Leaves are generally whorled and opposite, lance-shaped but heart-shaped or rounded at the base. Mature plants can have up to 50 stems emerging from a single rootstock. The plant can grow from 1.2-3 m. Showy, magenta-colored flowers with 5-7 petals.

Impact

Purple loosestrife can outcompete and replace native grasses, sedges, and other flowering plants that provide higher quality food sources and habitat. It forms dense monocultures that restrict native wetland plant species and can overrun wetlands to almost entirely eliminate open water habitat. Recreational and aesthetic values of wetlands and waterways are diminished when dense stands come in and decrease biodiversity. Purple loosestrife can also alter decomposition rates and nutrient cycling and water chemistry.

Native Range

Purple loosestrife is native to Eurasia, Britain, central and southern Europe, central Russia, Japan, China, southeast Asia and northern India.

Spread

Purple loosestrife has a very long flowering season, allowing it to produce two to three million seeds each year from its 30-50 flowering stems. It also produces vegetatively through underground stems, or rhizomes.

Purple loosestrife is current **widespread** in the Lower Hudson Valley.

Phragmites/Common Reed

Phragmites australis

Identification

Phragmites is a tall, perennial grass with erect, rigid, smooth, and hollow culms that can be 2.5 cm in diameter and up to 4 m tall. The culms terminate in dense, 30 cm long panicles. The leaves are typically 25-50 cm long and 1-4 cm wide. Phragmites has an extensive rhizome network and roots that grow at depths of 1 m. The feathery flower head is 13-40 cm long and is composed of many long branches that point upwards.

Impact

Phragmites is a vigorous growing plant capable of turning biodiversity rich habitats into dense monotypic stands that overtake available growing space and push out native species. It alters wetland hydrology and can increase the potential for fire. It also reduces and degrades wetland wildlife habitat because of its dense growth habit, which can reduce the biodiversity. It is capable of changing the marsh hydrology by decreasing salinity in brackish wetlands, changing the topography, and outcompeting other plant species.

Native Range

Originally from Europe, Phragmites is now found on every continent except Antarctica, and is even encouraged to grow in some regions, particularly in eastern Europe.

Spread

Phragmites spreads vegetatively through rhizome and stolon fragments. Rhizomes can break off and can be moved downstream through the currents, establishing in previously uninfested areas. Fragments can also spread via machinery. It also produces wind-dispersed seeds, but this seed viability is low.

Phragmites is currently **widespread** in the Lower Hudson Valley.

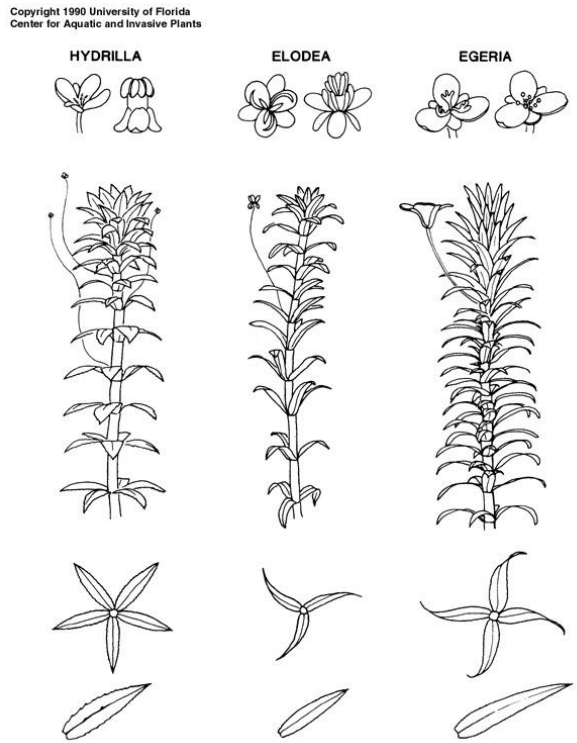
Native Lookalikes

American waterweed/Common Elodea
Elodea canadensis

Native elodea is commonly mistaken for hydrilla and Brazilian waterweed (and vice versa). While these species may look very similar, they have extremely different effects on the ecology. It is important to note the distinguishing differences between the species.

Elodea, often thought of as the typical aquarium plant, can be identified by its:

- 3 leaves/whorl (occasionally 4)
- Visibly smooth leaf margins (finely toothed under a microscope)
- Purple tint on stem below each whorl
- **NO** tubers



Coontail/Hornwort
Ceratophyllum demersum

Native coontail is a submersed plant found in all 50 states, including many New York lakes and ponds. It is commonly mistaken for the invasive plants Eurasian watermilfoil and fanwort. Its serrated, forked leaves are arranged in whorls around the stem, with 5-12 leaves per whorl. It is somewhat hard and crusty when held. When pulled out of the water, coontail holds its form pretty well, which is a distinguishing characteristic that allows us to differentiate it from fanwort and Eurasian watermilfoil

The Field Guide Sources

The following sources were used for multiple species:

1. *Pennsylvania's Field Guide To Aquatic Invasive Species.* Pennsylvania Sea Grant <http://www.anstaskforce.gov/Documents/AIS_Field_Guide_Finalweb.pdf>
2. Global Invasive Species Database < http://www.issg.org/database/welcome/>
3. *Common Aquatic Invasive Species of NY*. NYS DEC < http://www.dec.ny.gov/animals/50272.html>
4. *Lower Hudson Partnership for Regional Invasive Species Management (PRISM)* < http://lhprism.org/>

Additional sources listed below:

New Regulations

1. *New York State Regulations Target Aquatic Invasive Species*. NYS DEC <http://www.dec.ny.gov/press/97442.html>
2. *Bill A9927A-2013*. NY Senate <http://open.nysenate.gov/legislation/bill/A9927A-2013>

Prohibited Species

1. *6 NYCRR Part 575 Prohibited and Regulated Invasive Species Express Terms*. NYS DEC <http://www.dec.ny.gov/regulations/93848.html>

Stop Aquatic Hitchhikers

1. *Protect Your Waters* <http://www.protectyourwaters.net/>

Asian Clam

1. New York Invasive Species Information <http://www.nyis.info/index.php?action=invasive_detail&id=52>

Zebra Mussel

1. Cary Institute of Ecosystem Studies: Zebra Mussel Fact Sheet < http://www.caryinstitute.org/sites/default/files/public/downloads/curriculum-project/zebra_mussel_fact_sheet.pdf>

Spiny Water Flea

1. New York Invasive Species Information <http://www.nyis.info/index.php?action=invasive_detail&id=35>
2. Illinois-Indiana Sea Grant <http://www.iiseagrant.org/nabinvader/aitoolkit/ai_spiny_flea.pdf>

Asian Shore Crab

1. *Nonindigenous Species Information Bulletin*. USGS <http://fl.biology.usgs.gov/Nonindigenous_Species/Asian_shore_crab/asian_shore_crab.html>
2. New York Invasive Species Information <http://nyis.info/index.php?action=invasive_detail&id=21>

Rusty Crayfish

1. *Rusty Crayfish* (Orconectes rusticus), Minnesota Sea Grant <http://www.seagrant.umn.edu/ais/rustycrayfish>
2. Protect Your Waters <http://www.protectyourwaters.net/hitchhikers/crustaceans_rusty_crayfish.php>

Brazilian Elodea

1. *Egeria Densa* (Brazilian Elodea). Department of Ecology – State of Washington <http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua002.html>

Hydrilla

1. New York Invasive Species Information http://www.nyis.info/index.php?action=invasive_detail&id=16

Variable Leaf Milfoil

1. *Myriophyllum heterophyllum* (broadleaf watermilfoil). Invasive Species Compendium <http://www.cabi.org/isc/datasheet/34940>

The Field Guide Sources Cont.

Curly Leaf Pondweed

1. *Potamogeton crispus* (curlyleaf pondweed). Invasive Species Compendium <http://www.cabi.org/isc/datasheet/43664>

European Frogbit

1. Nault, M.E. and A. Mikulyuk. 2009. European Frog-bit (Hydrocharis morsus-ranae): A Technical Review of Distribution, Ecology, Impacts, and Management. Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1048 2009. Madison, Wisconsin, USA <http://dnr.wi.gov/files/PDF/pubs/ss/SS1048.pdf>

Yellow Floating Heart

1. *Yellow Floating Heart* (Nymphoides peltata). Department of Ecology – State of Washington <http://www.ecy.wa.gov/programs/wq/plants/weeds/FloatingHeart.html>

Water Chestnut

1. New York Invasive Species Information <http://www.nyis.info/index.php?action=invasive_detail&id=39>
2. *Water Chestnut* (Trapa natans) *in the Northeast.* New York Sea Grant <http://www.seagrant.sunysb.edu/ais/pdfs/WaterChestnutFactsheet.pdf>
3. *Water Chestnut.* National Park Service <*http*://www.nps.gov/plants/alien/pubs/midatlantic/trna.htm>
4. *Water Chestnut*. Invasive Plant Atlas of New England http://www.eddmaps.org/ipane/ipanespecies/aquatics/Trapa_natans.htm

Phragmites

1. New York Invasive Species Information < http://nyis.info/index.php?action=invasive_detail&id=42>
2. National Park Service < http://www.nps.gov/plants/ALIEn/pubs/midatlantic/phau.htm>

Image Credits

Overview

1. Main picture: https://www.pinterest.com/ridetheferry/hudson-river-valley/
2. Hydrilla: <http://plants.ifas.ufl.edu/node/183>
3. Spiny water flea: <http://usfoundation.net/wp-content/uploads/2013/07/SpinyWaterFlea1.jpg>
4. Zebra mussels: <http://www.100thmeridian.org/photobank/US_Fish_and_Wildlife_Service/Zebras/JustMussels.jpg>

Spread Prevention/Clean Boating Practices

1. Stop Aquatic Hitchhikers Logo: < http://www.protectyourwaters.net/>

Chinese Mystery Snail

1. <http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=1045>
2. <www.adirondackexpress.com>
3. <https://lakewicwas.files.wordpress.com/2010/07/cmsnail2.jpg>

Asian Clam

1. <http://www.nyis.info/user_uploads/images/Asian%20clams%20NNSS%202.JPG>
2. <http://www.jaxshells.org/p51.jpg>
3. <http://interactive.wxxi.org/files/images/highlights/asian_clam.jpg>

Zebra Mussel

1. <https://ferrebeekeeper.files.wordpress.com/2011/01/zebra_mussel.png>
2. <http://www.100thmeridian.org/photobank/US_Fish_and_Wildlife_Service/Zebras/JustMussels.jpg>
3. <http://sanctuarysimon.org/news/wp-content/uploads/2012/07/whats zebra mussels.jpg>

Image Credits Cont.

Spiny Water Flea

1. <http://usfoundation.net/wp-content/uploads/2013/07/SpinyWaterFlea1.jpg>
2. <http://www.extendonondaga.org/wp-content/uploads/2013/02/Spiny_waterflea-image.jpg>
3. <http://greatlakesecho.org/2013/04/23/spreading-the-invasive-spiny-water-flea-upsets-lake-ecosystems/>

Chinese Mitten Crab

1. <https://www.dfg.ca.gov/delta/mittencrab/images/crab9.jpg>
2. <http://www.issg.org/database/species/ecology.asp?si=38&fr=1&sts=sss&lang=EN>
3. <http://invasions.si.edu/SpImages/cbimages/ChineseMittenCrabSide2%20Edited_img_nolines.jpg>

Asian Shore Crab

1. <http://www.clarku.edu/departments/biology/biol201/2004/bwhitman/hemi7.jpg>
2. <http://nyis.info/index.php?action=invasive_detail&id=21>
3. <http://nas.er.usgs.gov/XIMAGESERVERX/2008/20080527103735.jpg>

Rusty Crayfish

1. <http://www.issg.org/database/species/ecology.asp?si=217&fr=1&sts=sss&lang=EN>
2. <http://www.macalester.edu/academics/environmentalstudies/threerivers/studentprojects/ENVI_194_LSR/Invasive_species/WEBSITE/Images/RustyCrayfish_Watch.jpg>
3. <http://www.issg.org/database/species/ecology.asp?si=217&fr=1&sts=sss&lang=EN>

Goldfish

1. <http://ffish.asia/?p=none&o=ss&id=94>
2. <http://www.invadingspecies.com/wp-content/gallery/goldfish/goldfish1-credit-wil-wegman-mnr.jpg>
3. <http://www.gbif.org/species/116853588>

Northern Snakehead

1. <http://dnr.maryland.gov/fisheries/news/story.asp?story_id=195>
2. <http://www.dfw.state.or.us/conservationstrategy/invasive_species/images/northern_snakehead_trammell.jpg>
3. <http://www.issg.org/database/image.asp?ii=878&ic=e>

Oriental Weatherfish

1. <http://nas.er.usgs.gov/XIMAGESERVERX/2009/20091002153036.jpg>
2. <http://www.seriouslyfish.com/wp-content/uploads/2012/03/Misgurnus-anguillicaudatus-1.jpg>
3. <http://nas.er.usgs.gov/XIMAGESERVERX/2010/20100524163145.jpg>

Round Goby

1. <http://www.nyis.info/user_uploads/files/Round_goby.jpg>
2. <http://www.cayugalake.org/img/large/gobe.jpg>
3. <http://84d1f3.medialib.glogster.com/media/7f/7f76414dcfac563bfdf9deee78a539ec90c09fa23fc17b49ecd7dd8ed9928ad6/round-goby-large.jpg>

Sea Lamprey

1. <http://www.invadingspecies.com/wp-content/gallery/sea-lamprey/profile-view-of-adult-sea-lamprey-credit-c-krueger-glfc.jpg>
2. <http://www.invadingspecies.com/invaders/fish/sea-lamprey/>
3. <http://techalive.mtu.edu/meec/module07/Exotics.htm>

Common Carp

1. <http://www.fcps.edu/islandcreekes/ecology/common_carp.htm>
2. <http://www.nps.gov/miss/learn/nature/carpintr.htm>
3. <http://upload.wikimedia.org/wikipedia/commons/9/9b/Cyprinus_carpio.jpeg>

Image Credits Cont.

Fanwort

1. <http://www.bio.brandeis.edu/fieldbio/Aquatic_Plants_Fishman_Kelly_Hankin/Images_Edited/Fanwort_underwater_edited.jpg>
2. <http://www.bio.umass.edu/biology/conn.river/plant_images/cabomba5.jpg>
3. <http://www.bio.umass.edu/biology/conn.river/plant_images/cabomba3.jpg>

Brazilian Elodea

1. <http://hyg.ipm.illinois.edu/article.php?id=46>
2. <http://www.ecy.wa.gov/programs/wq/plants/weeds/images/EgeriaDensa.jpg>
3. <http://www.connecticutvalleybiological.com/isotope/e/elodea-e7239757.jpg>

Hydrilla

1. <http://www.northeastans.org/online-guide/files/9wpCqMpA/F4-Hydrilla-verticillata.jpg>
2. <http://www.nyis.info/user_uploads/files/5345047.jpg>
3. <http://www.eattheweeds.com/wp-content/uploads/2013/02/Hydrilla-verticillata.jpg>

Parrot Feather

1. <http://www.aecos.com/CPIE/parrot.jpg>
2. <http://www.llwgs.org/images/Parrot_Feather.JPG>
3. <http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua003.html>

Variable Leaf Milfoil

1. <http://www.lakedoctors.com/images/weeds/submersed/variable-leaf.jpg>
2. <http://www.thompsonlake.org/promilrem1.jpg>
3. <http://2tubcd36xii712dhcv7zbw1a.wpengine.netdna-cdn.com/files/2010/06/variable-leaf_watermilfoil05.jpg>

Eurasian Water Milfoil

1. <http://dnr.wi.gov/org/caer/ce/eek/veg/plants/images/eurasianwatermilfoil.jpg>
2. <http://www.issg.org/database/image.asp?ii=560&ic=e>
3. <http://www.hrwc.org/wp-content/uploads/2011/10/eurasian-watermilfoil.jpg>

Brittle Naiad

1. <www.tneppc.org>
2. <www.iowadnr.gov>
3. <http://www.dec.ny.gov/animals/50272.html>

Curly Leaf Pondweed

1. <http://luirig.altervista.org/cpm/albums/bot-016/potamogeton-crispus2260.jpg>
2. <http://cdn.phys.org/newman/gfx/news/hires/curlyleafpon.jpg>
3. <http://blogs.reading.ac.uk/whiteknightsbiodiversity/files/2011/10/P.crips_1.jpg>

European Frogbit

1. <http://www.adirondackdailyenterprise.com/photos/news/md/532681_1.jpg>
2. <http://www.sleloinvasives.org/wp-content/uploads/2009/09/Eurfrogbit3.jpg>
3. <http://www.sleloinvasives.org/wp-content/uploads/2009/09/EurFrogbit2.jpg>

Yellow Floating Heart

1. <http://www.kingcounty.gov/~/media/environment/animalsAndPlants/noxious_weeds/thumbnails/newsletter/Vashon.ashx?w=169&h=225&as=1&la=en>
2. <http://www.issg.org/database/image.asp?ii=407&ic=e>
3. <http://www.flowerspictures.org/image/flowers/yellow-floating-heart/thumbs/yellow-floating-heart_16.jpg>

Water Chestnut

1. <http://www.nps.gov/plants/alien/pubs/midatlantic/img/trna-Mike_Naylor.jpg>
2. <http://estuarylive.pbworks.com/f/1239720123/1239720123/waterchestnutsbowser.jpg>
3. <http://www.reformrivers.eu/system/files/DSC_0089_LR.JPG>

Yellow Iris

1. <http://www.wildflowersofontario.ca/yellow_iris2.jpg>
2. <http://www.adirondackalmanack.com/wp-content/uploads/2012/06/IMGP1227.jpg>

Purple Loosestrife

1. <http://www.nps.gov/plants/ALIEn/fact/lysa1.htm>
2. <http://kboo.fm/content/theinvasionofinvasivespeciesinurbannaturalareas>
3. http://www.ecy.wa.gov/programs/wq/plants/weeds/images/PurpleLoosestrife.jpg

Phragmites

1. <http://nyis.info/index.php?action=invasive_detail&id=42>
2. <http://www.fs.fed.us/database/feis/plants/graminoid/phraus/all.html>
3. <http://www.invasiveplants.net/phragmites/>

Native Elodea

1. http://plants.ifas.ufl.edu/node/183

Coontail/Hornwort

1. http://www.illinoiswildflowers.info/wetland/plants/coontail.html

Aquatic Invasive Species Identification and Surveying Protocol

NOT FOR DISTRIBUTION

Samantha Epstein

Invasive Species Program Coordinator

Hudson River Sloop Clearwater

General Overview

An invasive species is defined as one that is non-native to the ecosystem, causes harm or has the potential to cause harm to the economy, ecology, or to human health, and the species' harmful impacts significantly outweighs its benefits. Some of the invasive species found in the Lower Hudson Region are already widespread, while others can be established, emerging, or still a threat. There are also species that are approaching the region, and can be found in neighboring regions.

This Field Guide is a tool to help volunteers identify common aquatic invasive species found in the Lower Hudson region, as well as species that are approaching from neighboring regions. It will also cover surveying and data collection protocol.

New Regulations

A new amendment to Subdivision (i) of § 377.1 of Title 9 NYCRR has been approved by the New York Office of Parks, Recreation, and Historic Preservation that is designed to control the introduction and spread of aquatic invasive species at facilities under OPRHP jurisdiction. Under the newly amended legislation, one must take *reasonable precautions* to stop the spread of AIS:

- Summarized: Prior to launching and when leaving the site, the operator shall inspect for and remove any plant, aquatic life or animal, or parts thereof, and dispose in designated receptacles or in such a manner to avoid contact of the material with the waterbody. Measures must also be taken before arriving at a new site or leaving the current site to drain the watercraft (bilge area, livewells, bait wells, and ballast tanks) – Effective Nov. 12, 2014

NY Senate also amended the navigation law to include a section about universal AIS signage at launches.

- Summarized: The Department of Environmental Conservation will design and establish universal signage which will be posted at any access point to the navigable waters of the state relating to the threat and mitigation of AIS. Owners of each public boat launch shall conspicuously post the universal sign at each public boat launch in the state

Prohibited Species

New York State has listed numerous terrestrial and aquatic species as prohibited and regulated. These new regulations were published in September 2014, and became effective in March 2015. The new regulation (6 NYCRR Part 575 Prohibited and Regulated Invasive Species) prohibits 69 plants, 15 fish species, 17 aquatic invertebrates, 5 terrestrial and aquatic vertebrates 3 species of algae and cyanobacteria, and more. These prohibited species range from the mute swan to hydrilla to the spiny water flea.

Aquatic Invasive Species now prohibited in NY include:

- Killer Green Algae
- Didymo
- Golden Algae
- Fanwort
- Brazilian Waterweed
- Hydrilla, Water Thyme
- European Frogbit
- Yellow Iris
- Purple loosestrife
- Parrot-feather
- Broadleaf Water-milfoil
- Broadleaf water-milfoil hybrid
- Eurasian watermilfoil
- Yellow floating heart
- Curly leaf pondweed
- Water chestnut
- Northern Snakehead
- Bullseye Snakehead
- Giant Snakehead
- Walking Catfish
- Western Mosquitofish
- Eastern Mosquitofish
- Largescale Silver Carp
- Silver Carp
- Bighead Carp
- Oriental Weatherfish
- Black Carp
- Round Goby
- Sea Lamprey
- Tubenose Goby
- Tench
- Chinese Mystery Snail
- Japanese Mystery Snail
- Faucet Snail
- Spiny Water Flea
- Fishhook Water Flea
- Asian Clam
- Suminoe Oyster
- Carpet Tunicate
- Zebra Mussel
- Quagga Mussel
- Chinese Mitten Crab
- Asian Shore Crab
- Bloody Red Shrimp
- Rusty Crayfish
- New Zealand Mud Snail
- Vined Rapa Whelk
- Asian Sea Squirt
- Mute Swan

Chinese Mystery Snail

Cipangopaludina chinensis/Bellamya chinensis

Identification:

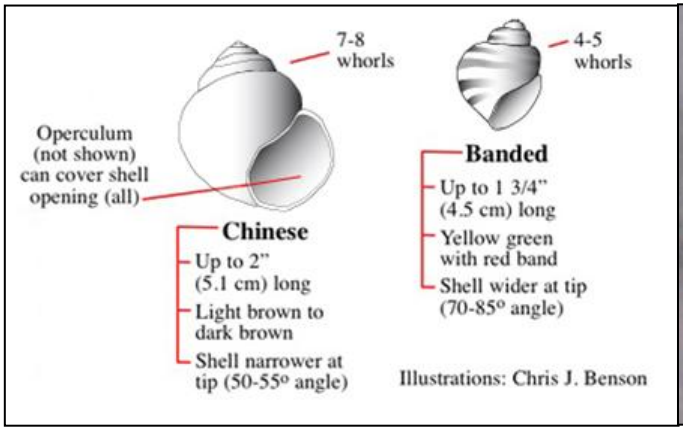
- Shell is large, spherical, smooth
- Coloring:
  - Outer shell is light as a juvenile and olive green, greenish brown, or reddish brown as an adult
  - Inner shell is white to pale blue
- Operculum (“trapdoor”) is concentrically marked with no banding
- Shells have 6-8 whorls that are strongly rounded and each suture where the whorls join is very indented
- Shell length can reach 2.5 inches
- Outer lip of shell is blackish and either round or oval

Habitat:

The Chinese mystery snail can be found in lakes, ponds, and slow moving rivers or streams.

Lookalike:

Banded Mystery Snail – has red bands that run parallel to the whorls of the shell. Shells can reach 1 ¾ inches long.



Banded mystery snail

Zebra Mussel

Dreissena polymorpha

Identification:

- Shell triangular with a sharply pointed shell hinge end
- Grows up to 5 cm but rarely exceeds 4 cm
- Prominent dark and light banding pattern on the shell
    - Tan with broad, transverse color bands that are either smooth or zigzag in shape
- Attached to hard surfaces using byssal threads – sometimes found on loose, individual mussels
    - Hair-like strands coming out of the hinge
- Shell has a D-shape, giving it a straight midventral line and a prominent ridge
- Sits flat on its ventral side, unlike other mussel species

Habitat:

Zebra mussels can tolerate a wide range of environmental conditions. They prefer temperatures between 68F and 77F, and water currents 0.15 – 0.5 m/s. The zebra mussel is a freshwater species but can adapt to brackish waters up to 2.5 ppt. They can be found in overly enriched lakes or those with high calcium content.

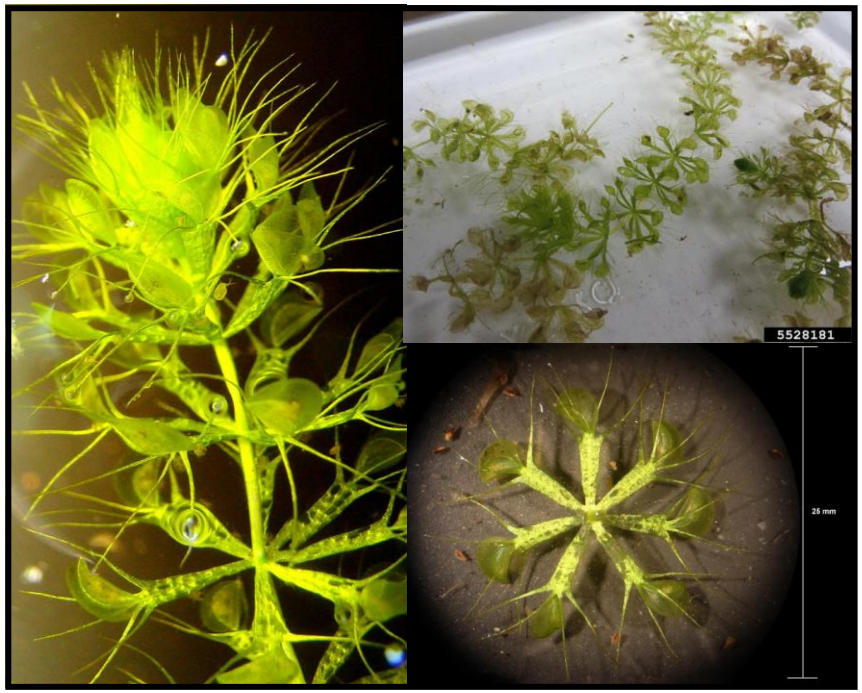
Lookalikes:

Quagga mussel – has rounded carina and a convex central side (determined by placing shells on ventral side – quagga mussels will topple over). Quaggas a rounder in shape. It has dark, concentric rings on its shell and is paler in overall color, especially near the hinge

Zebra mussel Quagga mussel

Aldrovanda/Waterwheel

Aldrovanda vesiculosa



Identification:

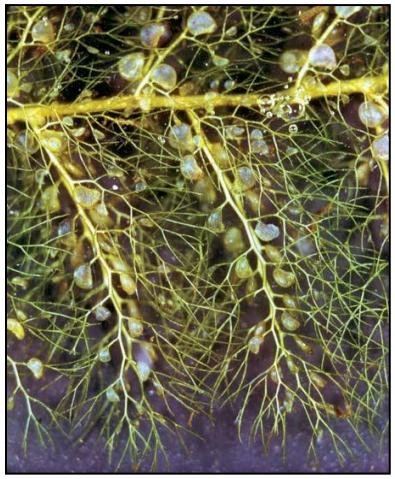
- Free-floating, rootless plant
- Carnivorous, capturing small aquatic invertebrates using small traps
- Leaves arranged in whorls of 4-9 around free-floating stem
- Clam-like traps, surrounded by 4-6 bristles
- Stem is air-filled to aid in floatation. Length depends on water quality, prey abundance, and irradiance
- Flowers are small, solitary 5-part white flowers that only opens for a few hours

Habitat:

Waterwheel grows in wetlands, streams, and lake littoral zones. It prefers clean, shallow, warm standing water with bright light and low nutrient levels.

Lookalikes:

Bladderwort – native, free-floating plants with tiny bladder-like structures on their branched underwater leaves. Their bladders are small vacuum traps that can catch tiny animals.



Bladderwort

Fanwort

Cabomba caroliniana

Identification:

- Multi-branched, submerged perennial plant with a few small, alternately arranged floating leaves
- Submerged leaves are oppositely arranged and attached by a single petiole
- Finely divided fan-shaped submerged leaves reach 5 cm across
- Small (up to 2 cm diameter) white/pink flowers rising from the tip of the stem and sand slightly above the water surface
- Stems can reach 10 meters and are covered with white or reddish-brown hairs

Habitat:

Fanwort is typically prefers shallow waters and can be found in ponds, lakes, and slow moving streams.

Lookalikes:

Watermilfoil (pictured below), coontail/hornwort, bladderwort

Bladderwort – native, free-floating plants with tiny bladder-like structures on their branched underwater leaves. Their bladders are small vacuum traps that can catch tiny animals.

Coontail/hornwort – native species with slender, densely branched stems. Compound leaves, forked into linear-flattened segments with fine teeth on one side of the leaf margin. Leaves are stiff/brittle and grow in whorls of 9-10 at each stem node.

Coontail/Hornwort Bladderwort

Didymo (rock snot)

Didymosphenia geminata

Identification:

- Microscopic algae that is tan, brown, or white
- Large stalk material forms thick mats on stream bottoms
- Forms long white “tails” coming off rocks
- Texture – feels like wet wool (not slimy)
- Strength – firmly attached, does not fall apart when rubbed between figures

Habitat:

Didymo likes cool, clear, nutrient poor waters but can be found in nutrient rich waters. It likes rivers with regulated, stable flows.

Lookalikes:

Filamentous algae – nicknamed “pond scum,” filamentous algae includes many types of algae that have a thread-like, stringy appearance. Filamentous algae is usually green and feels slimy, cottony, or coarse, compared to the “wet wool” texture of didymo.

Filamentous algae

Hydrilla

Hydrilla verticillata

Identification:

- Leaves pointed, bright green, about 5/8 inches long
- Ribbon/lance-shaped leaves
- Leaves grow in whorls of 3-8, but usually 5
- Margins of the leaves are serrated/toothed
- One or more sharp teeth along the length of the leaf mid-rib
- Turions (overwintering seeds) are ¼ inch long and grow at the leaf axils
- Tubers (potato-like energy storage) are white/yellowish, and grow 2-12 inches below the sediment at the end of the underground stems, and allow the hydrilla to overwinter
- When removed from the water, hydrilla holds its form

Habitat:

Hydrilla can grow in almost any freshwater (springs, lakes, marshes, ditches, rivers, tidal zones). It can grow in very shallow water or in waters more than 20 feet deep. It survives in oligotrophic and eutrophic conditions, salinity up to 7%, in cold temperatures, and only needs 1% of full sunlight.

Lookalikes:

Elodea – native submersed plant that typically has 3 leaves per whorl, with smooth margins and no teeth on the mid-rib. It also lacks tubers and turions. Elodea commonly has a purple hue below each whorl. When removed from the water, elodea loses its form.

Elodea canadensis

Eurasian watermilfoil

Myriophyllum spicatum

Identification:

- Soft, feather-like leaves arranged in whorls around the stem
- 12+ pairs of leaflets on each leaf, closely-spaced
- Leaves have a blunt tip (the leaflets do not come to a point)
- Tends to collapse around the stem when removed from the water
- Thin stem (compared to other species)
- Mature leaves are arranged in whorls of 4 around the stem
- Stem is reddish-brown to whitish-pink

Habitat:

This plant is found worldwide, but prefers lakes, ponds, and slow-moving rivers and streams. It can also grow in fast-moving waters. It can tolerate spring water to brackish water, up to 10 ppt salinity. It is able to overwinter in frozen lakes and ponds as well as survive in shallow, over-heated bays.

Lookalikes:

Native Northern Watermilfoil; Fanwort (pictured above), coontail/hornwort (pictured above)

Northern Watermilfoil – native species with 7-10 leaflet pairs per stem. Leaves feel more rigid, but are still feather-like in appearance. Lower leaflets can be very long. Leaves are arranged in whorls of 4-6 around the stem. Leaves typically stay rigid and hold their shape when out of water.

Northern Watermilfoil

Brittle Naiad

Najas minor

Identification:

- Leaves are opposite, but can appear to be in a whorl at the tip
- Leaves are 1-2 inches long, toothed, stiff, and pointed
- Leaves are recurved with noticeable teeth on edges
- The plant can seem very bushy due to internodes being very short near the growing tips of the stems
- Small, inconspicuous flowers found on leaf axils
- Holds its form when out of water
- Stem is highly branched and fragments easily

Habitat:

Brittle naiad likes to grow in shallow waters along lake shores, sheltered lake inlets, ponds, streams with slow currents, wetlands and drainage canals. It is very common in young ponds and other wetlands that have been created through human agency.

Lookalikes:

Thread-Leaf Naiad, Spiny Naiad

Thread-leaf naiad: branches occasionally, with slender stems that are medium green and flexible. Narrowly linear, and somewhat recurved leaves. Leaf margins have 10-20 minute, bristly teeth on each side

Spiny naiad: wide leaves (up to 2.5 mm across), and fewer, but larger teeth than brittle naiad.

Thread-leaf naiad Spiny naiad

Curly-leaf pondweed

Potamogeton crispus

Identification:

- Stiff, crinkled leaves approximately 2-3 inches long
- Green leaves arranged alternately around the stem and are directly attached to the stem
- Leaves become more dense toward the end of branches
- Leaf margins toothed
- Leaves appear translucent, olive green to red
- Produces overwintering buds (turions)
- Flower spikes emerge above the water surface
- Stems can grow up to 15 feet

Habitat:

Curly-leaf pondweed prefers soft sediment. It can grow in shallow or deep water, brackish or freshwater, and still or flowing water. It grows earlier than other plants, emerging in the spring and dying off mid-summer.

Lookalikes:

Clasping-leaf pondweed

Clasping-leaf pondweed has thin, oval shaped leaves that are wide with a broad base that ‘clasps’ the stem. It can look very similar to curly-leaf pondweed. A quick and easy differentiation is that curly-leaf pondweed’s leaf tips are blunt and rounded, while clasping-leaf pondweed tips come to a point

Clasping-leaf pondweed

Water chestnut

Trapa natans

Identification:

- Floating plant with leaves arranged in a rosette
- Individual leaves are triangular, and are 2-4 cm long with serrated margins
- Lower surface has conspicuous veins and short, stiff hairs
- Submerged, lower leaves are alternate and feather-like, reaching 15 cm long
- Fruit is a four-horned nut-like structure reaching 3cm wide and develop underwater
- Stems are cord-like, spongy, and buoyant, reaching lengths of up to 16 ft

Habitat:

Water chestnut likes to grow in freshwater lakes and ponds, and slow-moving streams and rivers.

Lookalikes:

White water lilies, spatterdock

White water lily: leaves arise on flexible stalks. Leaves are more round than heart-shaped, bright green, 6-12 inches in diameter, with a slit about 1/3 the length of the leaf. Flowers arise on separate stalks and have brilliant white petals with a yellow center
Spatterdock: leaves are large and heart-shaped. Flowers are yellow and ball-shaped. Stems are rigid enough to hold the leaves out of the water when water levels drop.

Spatterdock White water lily

Rake-Toss Surveying Protocol

- Find a **safe** access point to the water. Do NOT try to access the waterbody if you cannot find a location where you feel comfortable leaving your car or walking by yourself (due to traffic, steep slopes, unsteady terrain, etc.). Your safety is our top priority.
- Respect Private Property. Unless you get permission from the owner, always stay on public land.
- The goal is to survey as many locations as possible around the body of water. Surveying every 100 feet along the shore of the waterway is optimal. Shoreline surveys can be easily hampered due to access constraints, so if you are unable to survey every 100 feet, do as many as possible (one rake-toss is better than none!).
- Toss the rake twice at each location, once towards the left, and once towards the right. This is done to survey as much of the area as possible.
- Do a visual survey of the area – mark down if the **percent cover**. This refers to the amount of the bottom sediment obscured by vegetation. If you see that there is no plant material at the bottom, mark 0%. If you can't see the bottom floor at all due to the vegetation, mark 100%. Estimate all percentages in between. *If you cannot see the bottom because the water is too turbid, or because of the reflection on the water, mark with a dash (-).
- After you toss the rake (remember to hold on to the loose end of the rope), let it sink to the bottom and proceed to *s-l-o-w-l-y* pull the rake back towards you at a *steady pace*. When you lift the rake from the water, mark the **relative abundance** of plant material on the rake.
    - Z = zero (no plants)
    - T = trace (fingerful of plants on the rake)
    - S = sparse (handful of plants on the rake)
    - M = moderate (rake covered in plants)
    - D = dense (rake hard to pull out of water due to excess plants)
- When filling out the form:
    - write the name of the waterbody you are surveying and the town surveying in (if there is no name, give a description, location, and any other useful information so that others can determine what waterbody you surveyed later)
    - Mark down the time of the rake toss

Trace

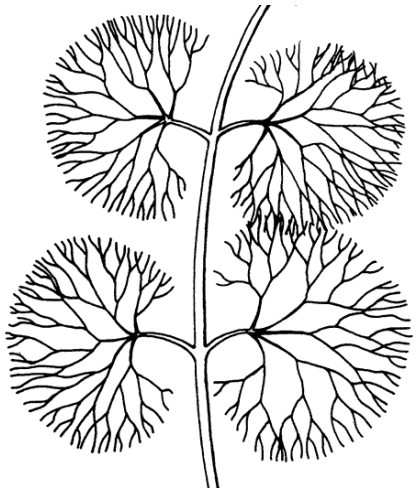
Sparse

Moderate

Dense

    - Include the GPS points for each location (the right/left rake toss can have the same GPS points)
    - Mark down what number rake toss is (restart the count at each new waterbody)
    - Write down what plants/animals you found
- Voucher Specimens
    - If you collect a sample and are unable to identify it but believe it is one of the species surveyed for:
        - Take pictures of the sample trying to include as many parts of the plant as possible (stem, leaf, leaf margin, flowers…). Take pictures with a white background when possible.
        - Put it in a plastic bag filled with water from the site. Label the bag with the time, location, and surveyor name.
        - **Always** collect a voucher specimen for hydrilla, didymo, and waterwheel unless sampling a location with a known infestation

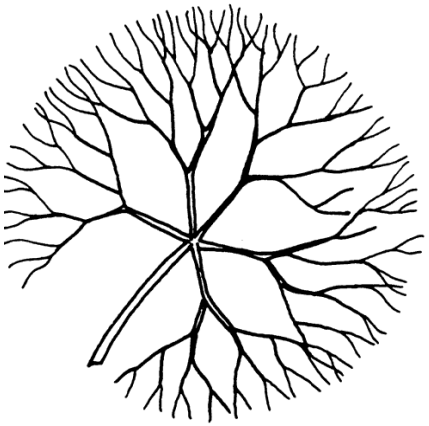
Opposite v. Alternate



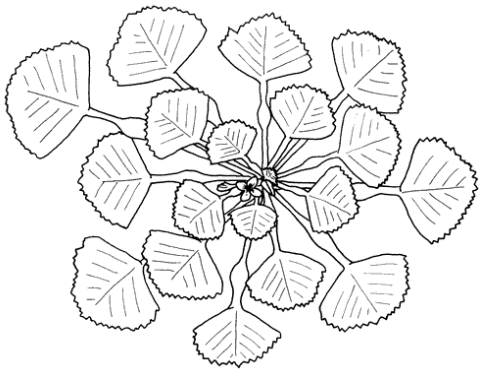
Serrated Leaf Margin

Spike (flowers)

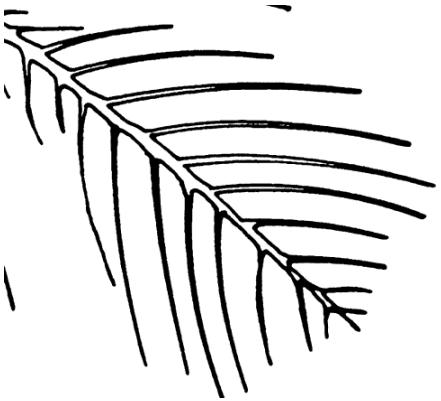
Branch-divided



Rosette



Feather Divided



Field Guide Sources

The following sources were used for multiple species:

1. *Pennsylvania's Field Guide To Aquatic Invasive Species.* Pennsylvania Sea Grant <http://www.anstaskforce.gov/Documents/AIS_Field_Guide_Finalweb.pdf>
2. Global Invasive Species Database < http://www.issg.org/database/welcome/>
3. *Common Aquatic Invasive Species of NY*. NYS DEC < http://www.dec.ny.gov/animals/50272.html>
4. *Lower Hudson Partnership for Regional Invasive Species Management (PRISM)* < http://lhprism.org/>

Additional sources listed below:

New Regulations

1. *New York State Regulations Target Aquatic Invasive Species*. NYS DEC <http://www.dec.ny.gov/press/97442.html>
2. *Bill A9927A-2013*. NY Senate <http://open.nysenate.gov/legislation/bill/A9927A-2013>

Prohibited Species

1. *6 NYCRR Part 575 Prohibited and Regulated Invasive Species Express Terms*. NYS DEC <http://www.dec.ny.gov/regulations/93848.html>

Stop Aquatic Hitchhikers

1. *Protect Your Waters* <http://www.protectyourwaters.net/

Zebra mussel:

1. *New Hampshire Dept. of Environmental Services: Zebra Mussels Environmental Fact Sheet* <http://des.nh.gov/organization/commissioner/pip/factsheets/bb/documents/bb-17.pdf>
2. *USGS:* Dreissena *species, FAQs, A Closer Look* <http://fl.biology.usgs.gov/Nonindigenous_Species/Zebra_mussel_FAQs/Dreissena_FAQs/dreissena_faqs.html>
3. *Cary Institute of Ecosystem Studies: Zebra Mussel Fact* Sheet < http://www.caryinstitute.org/sites/default/files/public/downloads/curriculum-project/zebra_mussel_fact_sheet.pdf>

Waterwheel:

1. *Bugwood: Aldrovanda vesiculosa/NJ* <http://wiki.bugwood.org/Aldrovanda_vesiculosa/NJ>

Fanwort:

1. *Massachusetts Dept. of Conservation and Recreation: Rapid Response Plan For Fanwort In Massachusetts* <http://www.mass.gov/eea/docs/dcr/watersupply/lakepond/downloads/rrp/fanwort.pdf>
2. *Pennsylvania Dept. of Conservation and Natural Resources: Invasive Plants in Pennsylvania – Carolina Fanwort* <http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_012345.pdf>

Field Guide Sources Cont.

Didymo:

1. *NYS DEC: Didymo (Rock Snot)* <http://www.dec.ny.gov/animals/54244.html>

Hydrilla:

1. New York Invasive Species Information http://www.nyis.info/index.php?action=invasive_detail&id=16

Brittle naiad:

1. *Wetland Wildflowers of Illinois: Brittle Naiad* <http://www.illinoiswildflowers.info/wetland/plants/br_naiad.html>

Curlyleaf pondweed:

1. *Aquatic Biologists: Weed Info – Clasping Leaf Pondweed* <http://www.aquaticbiologists.com/algae--weed-id-guide/submerged-weeds/clasping-leaf-pondweed>
2. *Potamogeton crispus* (curlyleaf pondweed). Invasive Species Compendium <http://www.cabi.org/isc/datasheet/43664>

Water chestnut:

1. *Texas A&M – Agrilife Extension: White Water Lily, Fragrant Water Lily* <http://aquaplant.tamu.edu/plant-identification/alphabetical-index/white-water-lily/>
2. New York Invasive Species Information <http://www.nyis.info/index.php?action=invasive_detail&id=39>

Water Chestnut Cont.:

3. *Water Chestnut* (Trapa natans) *in the Northeast.* New York Sea Grant <http://www.seagrant.sunysb.edu/ais/pdfs/WaterChestnutFactsheet.pdf>
4. *Water Chestnut.* National Park Service <*http*://www.nps.gov/plants/alien/pubs/midatlantic/trna.htm>
5. *Water Chestnut*. Invasive Plant Atlas of New England http://www.eddmaps.org/ipane/ipanespecies/aquatics/Trapa_natans.htm

Survey Protocol:

1. *Chris Doyle – Allied Biological: Rake Toss Aquatic Vegetation Survey* <http://nysfola.mylaketown.com/uploads/tinymce/nysfola/Rake%20Toss%20NYSFOLA2010%20(2).pdf>

Image Credits:

Chinese mystery snail:

1. <http://www.seagrant.umn.edu/ais/img/profile_identity_mysterySnail.jpg >
2. <https://adkwatershed.files.wordpress.com/2014/04/banded_mystery_snail.jpg>
3. <http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=1045>
4. <www.adirondackexpress.com>
5. <https://lakewicwas.files.wordpress.com/2010/07/cmsnail2.jpg>

Zebra mussel:

1. <https://ferrebeekeeper.files.wordpress.com/2011/01/zebra_mussel.png>
2. <http://www.100thmeridian.org/photobank/US_Fish_and_Wildlife_Service/Zebras/JustMussels.jpg>
3. <http://sanctuarysimon.org/news/wp-content/uploads/2012/07/whats_zebra_mussels.jpg>
4. <http://www.invadingspecies.com/invaders/invertebrates/zebra-and-quagga-mussels/>

Waterwheel:

1. <http://www.biolib.cz/cz/image/id102377/>
2. <http://plantsrescue.com/wp-content/uploads/2013/09/Aldrovanda-vesiculosa.jpg>
3. <http://bugwoodcloud.org/images/768x512/5528181.jpg>
4. <http://www.britannica.com/plant/bladderwort>

Fanwort:

1. <http://www.bio.brandeis.edu/fieldbio/Aquatic_Plants_Fishman_Kelly_Hankin/Images_Edited/Fanwort_underwater_edited.jpg>
2. <http://www.bio.umass.edu/biology/conn.river/plant_images/cabomba5.jpg>
3. <http://www.bio.umass.edu/biology/conn.river/plant_images/cabomba3.jpg>

Didymo:

1. <http://www.nuevomundopatagonia.cl/radio/wp-content/uploads/2013/03/didymonz.jpg>
2. <http://kootenairivernetwork.org/pics/kr-fishery/didymo.jpg>
3. <http://www.dec.ny.gov/animals/54244.html>
4. <http://aquaplant.tamu.edu/plant-identification/alphabetical-index/filamentous-algae/>
5. <http://www.aquaticbiologists.com/algae--weed-id-guide/problem-pond-and-lake-algae/weed-info---filamentous-algae>

Hydrilla:

1. <http://www.northeastans.org/online-guide/files/9wpCqMpA/F4-Hydrilla-verticillata.jpg>
2. <http://www.nyis.info/user_uploads/files/5345047.jpg>
3. <http://www.eattheweeds.com/wp-content/uploads/2013/02/Hydrilla-verticillata.jpg>

Image Credits Cont.:

Eurasian Water Milfoil

1. <http://dnr.wi.gov/org/caer/ce/eek/veg/plants/images/eurasianwatermilfoil.jpg>
2. <http://www.issg.org/database/image.asp?ii=560&ic=e>
3. <http://www.hrwc.org/wp-content/uploads/2011/10/eurasian-watermilfoil.jpg>

Brittle Naiad

1. <www.tneppc.org>
2. <www.iowadnr.gov>
3. <http://www.dec.ny.gov/animals/50272.html>

Curlyleaf pondweed:

1. <http://www.aquaticbiologists.com/algae--weed-id-guide/submerged-weeds/clasping-leaf-pondweed>
2. <http://luirig.altervista.org/cpm/albums/bot-016/potamogeton-crispus2260.jpg>
3. <http://cdn.phys.org/newman/gfx/news/hires/curlyleafpon.jpg>
4. <http://blogs.reading.ac.uk/whiteknightsbiodiversity/files/2011/10/P.crips_1.jpg>

Water chestnut:

3. <http://aquaplant.tamu.edu/plant-identification/alphabetical-index/white-water-lily/>
4. <http://www.nps.gov/common/uploads/photogallery/ncr/park/keaq/7C49C73A-1DD8-B71C-07B791DE7129B621/7C49C73A-1DD8-B71C-07B791DE7129B621-large.JPG>

Water Chestnut Cont.:

3. <http://www.nps.gov/plants/alien/pubs/midatlantic/img/trna-Mike_Naylor.jpg>
4. <http://estuarylive.pbworks.com/f/1239720123/1239720123/waterchestnutsbowser.jpg>
5. <http://www.reformrivers.eu/system/files/DSC_0089_LR.JPG>

Survey Protocol:

1. <http://nysfola.mylaketown.com/uploads/tinymce/nysfola/Rake%20Toss%20NYSFOLA2010%20(2).pdf>

Identification Key:

1. <http://www.mainevolunteerlakemonitors.org/mciap/herbarium/Glossary.php>