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University of Maryland, 2113 Animal Science Building
College Park, Maryland 20742-2317
Telephone: 301-405-6085, FAX: 301-314-9412
E-mail: nrac@umd.edu Web: http://www.nrac.umd.edu

Freshwater Aquaculture Species for the Northeast

Joe Buttner, Salem State College
Gef Flimlin, Rutgers Cooperative Extension
Don Webster, Maryland Cooperative Extension

Introduction

Many aquatic animals and plants are cultured commercially in the northeastern United States, while others have been grown for restoration or for use in research. Finfish, shellfish, aquatic plants, and other organisms are cultured commercially and recreationally for food, bait, stocking, research, bioassay tests, ornamental markets, and classroom use. Table 1 lists 56 species or varieties of freshwater animals and plants cultured in the region. No one species dominates production: an animal or plant cultured successfully in one system or location may prove impractical or unprofitable in another.

This fact sheet describes major species currently in commercial production, those that have shown potential, and others now under experimental investigation. The descriptions summarize culture methods and regulatory considerations. Applicable regulations for proposed operations, particularly those that would employ non-native species or culture in public waters, can be obtained from extension agents and specialists in your state. For a list of aquaculture extension contacts by state and current State Situation and Outlook Reports, consult the NRAC website (http://nrac.umd.edu).

Current Commercial Production

1. Species and hybrids of trout, including rainbow (*Oncorhynchus mykiss*), brown *Salmo trutta*), and brook trout (*Salvelinus fontinalis*) — All are cold-water fish, which require well-oxygenated water below 65°F. Pennsylvania and New York are the leading producers in the region.

While most trout are grown in flow-through systems, some culturists reuse their water and a few use cages or ponds. Rainbow trout are marketed for stocking and as food fish. Brown, brook, and hybrid trout are most frequently stocked for recreational fishing, though some are also sold as food.

Brown trout (*Salmo trutta*) (Photograph by Joe Buttner)

2. Atlantic salmon (*Salmo salar*) — Native to the eastern United States and better suited to aquaculture conditions than their Pacific coast relatives, the Atlantic salmon has become an important aquaculture species in the region with most aquaculture located in New England, particularly Maine.

Juvenile Atlantic salmon are grown in freshwater, usually raceways or recirculating systems, and released as smolts in streams to enhance natural populations or stocked in net pens floated in coastal waters with substantial flushing where they are grown to market-size. Smolts may be produced in freshwater hatcheries as part of an integrated operation or purchased from approved suppliers. (See Marine Aquaculture Species for the Northeast, Fact Sheet 103-2008.)

Atlantic salmon (*Salmo salar*) (Photograph by Chris Bartlett, Maine Sea Grant College Program/University of Maine Cooperative Extension)

3. Several species of minnows, including fathead minnow (*Pimephales promelas*), bluntnose minnow (*P. notatus*), golden shiner (*Notemigonus crysoleucas*), emerald shiner (*Notropis atherinoides*), creek chub, (*Semotilus atromaculatus*) — Widely grown in the region, minnows are usually raised in ponds. Ponds are typically fertilized with an organic material such as soybean meal or wheat sorts, which stimulates the growth of algae. The resulting plankton bloom is eaten by the fish. Some growers use a low protein, commercial fish feed, which minnows feed on and which indirectly serves as a fertilizer when uneaten or excreted as feces. Potential markets exist for minnows as live-bait or as bioassay and research animals. They are also useful in ponds for control of mosquito larvae. Since minnows are not destined for direct human consumption, culturists have fewer regulations.

Fathead minnows are the most commonly cultured live-bait in the region. Golden shiners are larger and more attractive to anglers, but less hardy. In much of the Northeast, they require two growing seasons to attain market-size and reproduce, unlike fathead minnows which grow to market-size and reproduce in one season.

4. Channel catfish (*Ictalurus punctatus*), blue catfish (*Ictalurus furcatus*), and brown bullhead (*Ameiurus nebulosus*) — Cultured widely in the region, the channel catfish is the most important aquaculture species in the U.S. Most channel and blue catfish are raised in the southern U.S. in ponds five to twenty acres in size. Cage culture is also practiced to a lesser extent. Catfish can survive a wide range of temperatures and will tolerate brackish water. Commercial culture in the Northeast may be limited to the mid-Atlantic region because catfish grow best above 80°F. Throughout much of the Northeast, the culture season is too short for commercial success.

Brown bullheads are a popular recreational and food fish in the Great Lakes basin. They grow well at temperatures encountered in the Northeast and do best in turbid waters. Farmers in the Northeast grow and market bullhead for direct consumption, as research and instructional aids, and for stocking in private ponds. Fingerlings and feeds are commercially available for both catfish and bullheads.

Channel catfish (*Ictalurus punctatus*) (Photograph by Joe Buttner)

5. Striped bass (*Morone saxatilis*), white bass (*M. chrysops*), and hybrid striped bass (*M. saxatilis x M.* spp.) — Hybrid striped bass aquaculture is a growing industry in the Northeast. Most commonly cultured are crosses of hybrid striped bass with other fish in the genus *Morone* such as the white bass, white perch (*M. americana*), or yellow bass (*M. mississippiensis*). Hybrid striped bass usually have a deeper body, shorter tail, and more sloped head than the striped bass.

Striped bass (*Morone saxatilis*) (Photograph by Joe Buttner)

Striped bass, hybrids, and relatives tolerate a wide range of temperatures and salinities, from fresh to salt water. As warm water fish, they grow best at 75-80° F; they are cultured commercially in ponds, flow-through systems, and cages, with some production in recirculating systems. Length of growing season is one factor that determines where they can be raised profitably.

6. Comet or goldfish (*Crassius auratus*), koi (*Cyprinus carpio*), and ornamentals such as discus (*Symphysodon* sp.) — These ornamentals are commonly cultured in small ponds, tanks, and recirculating systems. Outdoor culture units may be covered in winter to protect fish from the cold. Production of ornamental fish for the aquarium trade is substantial, but diffuse and modest-scale with much occurring in basements and garages.

Koi (*Cyprinus carpio*) (Photograph from www.ag.auburn.edu/fish)

Ornamentals are marketed live so survival during harvest, handling, and shipping is very important. Because appearance is critical, care must be taken to ensure fish are not only healthy, but aesthetically appealing. The market is highly competitive and well established, with large-scale production centered in wholesale companies; niche marketing that provides services as well as fish locally is also profitable.

7. Yellow perch (*Perca flavescens*) — An extremely popular food fish in the northern U.S., this species is hardy and can be trained to accept pelleted feeds. Yellow perch are grown for direct human consumption and for stocking in ponds. Production occurs mainly in small ponds. Perch may also be grown in cages, tanks, and recirculating systems.

Yellow perch (*Perca flavescens*) (Photograph by James Haynes, SUNY Brockport)

Economics of perch culture should be assessed carefully, particularly if fingerlings are purchased rather than produced.

8. Several species of gamefish, including panfish (*Lepomis* spp., *Pomoxis* spp.), largemouth and smallmouth bass (*Micropterus* spp.), and walleye (*Sander vitreus*) — Culture methods vary among species. In most cases, fish farmers purchase or hatch eggs and rear fry to fingerling size. Fingerlings are then sold and stocked for recreational fishing. Some fingerlings may be retained and reared to an advanced fingerling size or to market-size for direct human consumption in niche markets (e.g., sportsmen clubs and ethnic markets that pay premium prices for live fish of preferred species).

Largemouth bass (*Micropterus salmoides*) (Photograph by Joe Buttner)

Fingerling sunfish, bass, and walleye are normally produced in fertilized ponds where they feed on zooplankton. At one to two inches in length, fingerlings are routinely harvested for sale or habituated to prepared feed. Once trained to accept pelleted feed, fingerlings may be grown to larger size in tanks, ponds, cages, or recirculating systems. Culture procedures for most of these gamefish are relatively well defined.

9. Nile tilapia (*Oreochromis niloticus*) and other tilapia (e.g., *Sarotherodon* sp.) — Cultured commercially throughout the U.S., tilapia are hardy, grow rapidly, and are readily accepted by consumers. All tilapia are cichlids, tropical fish that require warm water to survive. If water temperatures fall below 50 to 55°F, tilapia will die.

Nile tilapia (*Oreochromis niloticus*) (Photograph from www.ag.auburn.edu/fish)

In the Northeast, most tilapia culture is done in recirculating systems. Harvested fish are usually marketed live in Asian areas, where they command a premium price.

10. Crayfish (*Orconectes* spp. and *Procambarus* spp.) — These crustaceans represent a significant aquaculture industry with growth potential in the Northeast. Most culture occurs in small, shallow ponds where the crayfish feed on natural vegetation; this natural food may be supplemented with hay or other grain by-products. Crayfish are harvested with traps or a seine.

Orconectes are often grown with fathead minnows in a polyculture system (two or more species grown in one system) and marketed as bait. *Procambarus* are cultured in the mid-Atlantic region for direct consumption in local markets.

11. Aquatic plants — A variety of aquatic plants are cultured commercially and used widely for garden ponds, restoration efforts, and direct human consumption. Many species are produced in the Northeast, typically in small ponds, shallow raceways, or as part of integrated recirculating systems. Often growers provide their clientele with technical assistance, service, and other organisms (e.g., ornamental fish) in addition to plants.

The personalized attention provided by growers of aquatic plants to their customers allows for success of small to modest size operations. Prospective growers must carefully assess their markets, work ethic, and interpersonal skills.

Potential Commercial Species

1. Barramundi (*Lates calcarifer*) — This exotic euryhaline fish inhabits waters from Australia to southeast Asia. One company in Massachusetts has cultured it commercially since 2004. Fingerlings at 0.5 g each are imported from Australia and reared in recirculating systems supplied with freshwater that is kept above 100 mg/L hardness and alkalinity. Fish require approximately a year to attain market-size of 1.5 lb. While commercially viable, the likelihood of securing a dependable supply of fingerlings and duplicating the setup employed in Massachusetts is unlikely.

2. White sucker (*Castostomus commersonii*) — Fish are captured during their spring spawning run by some live-bait producers in the north central U.S.; eggs are then stripped, fertilized, and incubated, with hatched fry reared in ponds. Suckers grow faster than golden shiners and in one growing season attain a size desired by bass and pike anglers. Market size and culture methods require further research.

White sucker (*Castostomus commersonii*) (Photograph by James Haynes, SUNY Brockport)

3. Common carp (*Cyprinus carpio*) — Carp are an important foodfish in Asia and around the world, though with minimal demand in the U.S. Technology to culture carp in ponds is available and the fish is well-suited to conditions throughout the Northeast. The principal obstacle is poor consumer acceptance. Carp could provide a dependable supply of fish for use in value-added products such as surimi and fish sausage, although these products require inputs which could adversely affect profitable culture.

Common carp (*Cyprinus carpio*) (Photograph from www.ag.auburn.edu/fish)

4. Grass carp (triploid), or white amur (*Ctenopharyngodon idella*) — Occasionally stocked in ponds to control aquatic vegetation, grass carp survives well and grows rapidly. Only sterile triploids should be used. Laws regulating its importation and use vary among states. Culturists should consult their Department of Natural Resources or its equivalent before importing or stocking fish, as interstate transport in violation of state law could be a federal offense.

Grass carp (*Ctenopharyngodon idella*) (Photograph from ww.ag.auburn.edu/fish)

Experimental Species

1. Walleye (*Sander vitreus*) — Prized throughout the northern U.S. as a premier food fish, walleye are generally marketed as advanced fingerlings, although some are sold as food fish. Fingerlings can be trained to accept pelleted food and a few growers are producing walleye in ponds and cages. Growers in the Northeast could benefit from advances in walleye culture.

Walleye (*Sander vitreus*) (Photograph by James Haynes, SUNY Brockport)

2. Shovelnose sturgeon (*Scaphirhynchus platorynchus*), and paddlefish (*Polydon spathula*) — Shovelnose sturgeon and paddlefish are being cultured by the West Virginia Department of Natural Resources to enhance natural populations. In other regions of the U.S., sturgeon and paddlefish are cultured commercially as food, for roe as caviar, and fingerlings for the aquarium trades. Many regulatory hurdles preclude commercial production of these fish in the Northeast.

3. Prawns (*Macrobrachium* spp.) — These subtropical crustaceans do not survive when water temperatures fall below approximately 55°F. Post-larval to adult *Macrobrachium* are grown in fresh water. In the Northeast their culture potential is limited by climate to pond culture in summer and recirculating systems; culture methods are well defined, but economic viability in the region is questionable.

Prawns (*Macrobrachium* spp.) (Photograph from www.ag.auburn.edu/fish)

4. Rainbow smelt (*Osmerus mordax*) — Under investigation as a potential live-bait in Maine and New Hampshire, this fish has mostly been cultured in ponds and tanks. A commercial operation has recently started in Maine, but culture procedures have not been standardized and commercial viability remains to be demonstrated.

5. Muskellunge (*Esox masquinongy*) and other members of the pike family — The West Virginia Department of Natural Resources cultures these fish for enhancement of natural populations. Fingerlings are typically raised on zooplankton in fertilized ponds and then fed minnows or conditioned to accept pelleted food. While culture protocols are fairly well developed, commercial viability remains to be demonstrated.

Muskellunge (*Esox masquinongy*) (Photograph by Kenneth Semmens, West Virginia University Extension Service)

6. Mussels (*Lampsilis* spp., *Villosa* spp., and others) — Limited production is currently used for restoration and enhancement purposes. With many freshwater mussels endangered, threatened, or already extinct, the National Fish Hatchery at White Sulphur Springs in West Virginia has investigated protocols to spawn and culture these mussels. Although potential markets exist for mussels to produce pearls and to be used in toxicity testing, at this time it does not appear prudent to recommend their culture as an option to prospective growers.

7. Turtles and frogs — Occasionally considered as potential aquaculture species, both groups are maintained successfully at zoos and aquariums. Limited production exists globally. Culture methods, regulatory considerations, and commercial viability are problematic.

Baby frogs (Photograph by Joe Buttner)

8. Microalgae — Several species are cultured in tanks under carefully controlled conditions as a food for small animals (e.g., zooplankton, freshwater mussels). A few are grown en masse in tropical/subtropical regions as dietary supplements for the health-food industry, and some interest and potential exists for biofuel products. Attractive from ecological and nutritional perspectives, algae culture requires research to define methods and determine commercial viability.

For More Information

Several relevant fact sheets are available on the culture of different species from the North Central Regional Aquaculture Center (www.ncrac.org) and Southern Regional Aquaculture Center (www.msstate.edu/dept/srac). The fact sheets are accessible and may be downloaded from Center websites. The Aquaculture Network Information Center (http://aquanic.org) provides access to many aquaculture resources.

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Table 1. Freshwater animals and plants cultured in the northeastern United States. Importance in the Northeast (M=major species, S=secondary species, D=demonstration species, E=experimental species) and systems used (P=pond culture, T=tank culture, C=cage culture, R=recirculating systems) are indicated.

Common Name	Scientific Name	Importance	System
Fish			
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*	E	T,P
Paddlefish	*Polyodon spathula*	E	T,P
Muskellunge	*Esox masquinongy*	D	P
Rainbow trout	*Oncorhynchus mykiss*	M	T,R,P,C
Brown trout	*Salmo trutta*	M	T,R,P,C
Brook trout	*Salvelinus fontinalis*	M	T,R,P,C
Tiger trout	*S. fontinalis x S. trutta*	S	T
Atlantic salmon	*Salmo salar*	S	R,T
Rainbow Smelt	*Osmerus mordax*	D/S	P,T
Fathead minnow	*Pimephales promelas*	M	P
Bluntnose minnow	*Pimephales notatus*	S	P
Creek chub	*Semotilus atromaculatus*	S	P
Golden shiner	*Notemigonus crysoleucas*	S	P
Emerald shiner	*Notropis atherinoides*	S	P
Blue catfish	*Ictalurus furcatus*	D	P
Channel catfish	*Ictalurus punctatus*	S	P,C
Brown bullhead	*Ameiurus nebulosus*	S	P
Grass carp (triploid)	*Ctenopharyngodon idella*	D	P
Common carp	*Cyprinus carpio*	D	P,T,R
Koi	*Cyprinus carpio*	S	P,T,R
Comet (goldfish)	*Crassius auratus*	S	P,T,R
White sucker	*Castostomus commersonii*	S	P
Largemouth bass	*Micropterus salmoides*	S	P,T,R
Smallmouth bass	*Micropterus dolomieu*	S	P,T,R
Bluegill sunfish	*Lepomis macrochirus*	S	P,T,R
Hybrid sunfish	*Lepomis macrochrius x L. cyanellus*	S	P,T,R
Pumpkinseed	*Lepomis gibbosus*	S	P,T,R
Black crappie	*Pomoxis nigromaculatus*	S	P,T
White crappie	*Pomoxis annularis*	S	P,T
Yellow perch	*Perca flavescens*	S	P,T,R,C
Walleye	*Sander vitreus*	S	P,T,R
Striped bass	*Morone saxitilis*	S	P,T,C
White bass	*Morone chrysops*	S	P,T,C

Table 1, continued.

Common Name	Scientific Name	Importance	System
Fish, continued			
Hybrid striped bass	*Morone saxatilis x M. chrysops*	M	P,T,R,C
Tilapia	*Oreochromis niloticus* and/or *Sarotherodon* sp.	S	R
Barramundi	*Lates calcarifer*	S	R
Discus and other ornamentals	*Symphysodon* sp.	D	P,T,R
Reptiles			
Diamondback terrapin	*Malaclemys*	E	T
Various turtle species		E	T
Crustaceans			
Crayfish	*Orconectes* spp.	M	P
Red swamp crayfish	*Procambarus clarkia*	S	P
Freshwater prawns	*Macrobrachium rosenbergii*	E	P,R
Mussels			
Mucket	*Actinonaias ligamentina*	E	T,R
Three ridge	*Amblema plicata*	E	T,R
Purple wartyback	*Cylonaias tuberculata*	E	T,R
Northern Riffleshell	*Epioblasma torulosa rangiana*	E	T,R
Plain pocketbook	*Lampsilis cardium*	E	T,R
Wavy-rayed lamp mussel	*Lampsilis fasciola*	E	T,R
Pocketbook	*Lampsilis ovata*	E	T,R
Black sandshell	*Ligumia recta*	E	T,R
Pistolgrip	*Tritogonia verrucosa*	E	T,R
Notched rainbow	*Villosa constricta*	E	T,R
Rainbow	*Villosa iris*	E	T,R
Various Vegetation		S	P,T
Algae			
	Neochloris oleoabundans	E	T
	Bracteacoccus grandis	E	T
	Phaeodactylum tricornutum	E	T
	Oocystis sp.	E	T