

New York Aquaculture Industry: Status, Updates and Opportunities

Report

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Aquaculture Overview

Aquaculture is the cultivation of fish, shellfish, aquatic plants and algae in saltwater or freshwater. Essentially, farming in water. When done properly, aquaculture is an environmentally responsible and sustainable way to source seafood, restore native populations, and can help maintain healthy ecosystems. Aquaculture is not a new industry and has taken place across the world from as early as 1000 BCE in China, where carp were farmed in small ponds for food, to 500 BCE in Rome where oysters were cultivated in Mediterranean lagoons, to modern day where shrimp and catfish are grown in the Mississippi Delta region in ponds (Rabanal 1988). Aquaculture has since grown into a multi-billion-dollar industry. In 2018 worldwide aquaculture produced about 114.5 million tonnes of seafood valued at \$263.6 billion (FAO 2020).

Aquaculture has grown as the result of the expansion of global trade and competitive pricing of farmed products. The leveling of wild fish landings since the mid-1980s has also incentivized increases in the production of farmed seafood (FAO 2020). These factors have also contributed to an increase in seafood consumption worldwide. Wild capture fisheries have been the historical method of providing seafood, but human population growth coupled with wild fish declines has created a gap between supply and demand. According to FAO 2020, the percentage of stocks fished at biologically unsustainable levels increased from 10% in 1974 to 34.2% in 2017. It is estimated that 78.7% of current marine fish landings come from biologically sustainable stocks. In response to wild fisheries that are unable to grow to meet increased demand, aquaculture now supplies more than half of seafood for human consumption globally and is projected to exceed 60% by 2030 (World Bank 2013).

Global aquaculture production more than tripled in live-weight volume from 1997 to 2017 (Naylor et al. 2021). The species groups that contributed to the top 75% of aquaculture production in 2017 included seaweeds, carps, bivalves, tilapia, and catfish, most of which are cultivated overseas (FAO 2020). Asia, especially China, has been the leader in aquaculture production for the past two decades. However, Africa, South America and Europe have all seen significant growth in their aquaculture industries. Norway, Chile, and Egypt are the top producers outside of Asia, with Norway and Chile producing mostly Atlantic salmon (*Salmo salar*) and Egypt producing mostly Nile tilapia (*Oreochromis niloticus*) (Naylor et al. 2021).

United States

Aquaculture production in the United States began with federal and state agencies using cultivated fish to enhance sport fisheries. The United States Commission of Fish and Fisheries was established in 1871 with the goal to propagate fish, including trout and channel catfish for stocking. The oldest fish hatchery in the Western Hemisphere, the Caledonia Fish Hatchery, was started in 1864 by Seth Green in New York to rear brown and rainbow trout for stocking and research, with other states soon following. By 1922 Wisconsin had 12 state hatcheries stocking over 100 million fish each year (FAO 2015). The spawning and cultivation of salmon, which served as the foundation for fish propagation, helped the stock enhancement industry to grow rapidly in the mid to late 1900s. Similar hatcheries were developed in other states and early research at these hatcheries refined the technology to spawn and rear salmonids and channel

catfish, providing the technical foundation for these industries to continue to develop in the late 1900s (FAO 2015).

According to the U.S. Fish and Wildlife Service (USFWS) in 2016, 135 million juvenile fish were released into water bodies in 44 states from 66 national hatcheries. This number does not include state- or privately-owned hatcheries that also stock their local waterways. These stocked fish help maintain healthy ecosystems, provide game for recreational fishermen and restore native populations. Shellfish are also being stocked back into natural waterways to restore depleted or absent historic populations, and to help clean the water and mitigate the effects of eutrophication.

On a global scale, the United States is a minor aquaculture producer. In 2017, the United States ranked 16th in global aquaculture production (FAO 2020). In 2019, the average American ate 19.2 pounds of seafood, an increase of 0.2 pounds from 2018, making the US the world's second largest consumer of seafood behind China (NMFS 2021). However, the US is one of the top importers of fish and seafood, globally. The United States imports between 70-85% of all its seafood, of which 50% is aquaculture products. In 2019 the seafood trade deficit was \$16.9 billion (NMFS 2021). The topmost imported products are shrimp, tuna, salmon, groundfish, freshwater fish, crab, and squid.

According to the USDA Aquaculture Census in 2018 there were a total of 2,932 aquaculture farms in the United States, creating 1.7 million jobs. The US produced 626 million pounds of farmed seafood worth \$1.5 billion in 2017 (NMFS 2021). Marine aquaculture accounted for \$430 million and freshwater aquaculture accounted for \$719 million. The top species in marine aquaculture were oysters (\$186 million), clams (\$129 million), and Atlantic salmon (\$61 million) (NMFS 2021). The top species in freshwater aquaculture were catfish (\$366 million), trout (\$116 million), and tilapia (\$39 million) (USDA 2017).

As a contributor to the overall US economy, aquaculture plays a small role. The value of American aquaculture production (\$1.5 billion) in 2017 was just under 6% of the total \$389 billion value of the American agriculture sector. This is a large increase from 2007 when aquaculture was less than 1% of the total agriculture sector. However, aquaculture represented approximately 21% of the value of the nation's total seafood production in 2016 (NOAA 2018). The importance of aquaculture employment to local economies varies considerably on a regional basis; for example, the aquaculture industry is extremely important in the catfish farming region of the southeastern US (FAO 2020).

In recent years there has been a push to develop a strong and sustainable aquaculture industry in the United States. Industry growth can provide jobs, ecosystem services, and safe and sustainable seafood to meet a growing demand for quality local foods. Growing the domestic aquaculture industry also plays a role in domestic food security by reducing reliance on seafood imports. New York has historically been a leader in aquaculture development in the United States, with some of the first aquaculture of finfish taking place in state waters but has recently been falling behind.

Covid-19

The Covid-19 pandemic highlighted the fragility of the New York's aquaculture industry, but in turn has also shown its resilience. The pandemic has had especially severe impacts on food supply chains, among which perishable food supply chains, like seafood, were the worst hit. The seafood supply chains were disrupted, redirected, or halted by sudden shifts in demand, supply, and limitations on the movement of supplies.

In the US social distancing led to widespread restaurant closures, reduced seafood market foot traffic, and a heavier reliance on home cooking. One factor responsible for much of the economic hardship experienced by the seafood industry is that the public was ill-equipped to purchase and prepare seafood at home, even though 63% of seafood, by weight, was consumed at home prior to the pandemic (Love et al. 2020). By August 2020, both frozen and live seafood exports reached their lowest year-over-year value (White et al. 2018). In addition to lost markets, the aquaculture industry members also faced the challenges of resource availability, production and processing closures, and loss of a workforce.

In direct response to COVID-19, the Coronavirus Aid, Relief, and Economic Security Act (CARES) directed \$300 million to the seafood industry, including aquaculture. Though the administration of the funds has been extremely slow, especially for the aquaculture industry (Gephart et al. 2020; van Senten et al. 2020). While loans (e.g. Paycheck Protection Program) and heterogeneous state-level support were available, aquaculture farmers cited federal support as the most beneficial (van Senten et al. 2020).

In 2020, the federal government also purchased seafood directly, including 20 million pounds of shrimp (<1% total annual harvest) from Gulf of Mexico fishers (Gephart et al., 2020). The Nature Conservancy (TNC) in partnership with The Pew Charitable Trusts (PEW) launched a nationwide project in response to the COVID-19 pandemic and stocked over 5 million excess or oversized oysters, purchased from aquaculture farms, into 20 different restoration sites from Washington to the Mid-Atlantic and New England to support the aquaculture industry and benefit the environment. The National Sea Grant Office also put out a call for COVID-19 rapid response for aquaculture, investing \$2.48 million. Sea Grant Programs from New Hampshire, Connecticut, New Jersey, Delaware, Florida, and Mississippi-Alabama specifically focused on shellfish aquaculture planting "uglies", or over market size oysters, back into natural waterways to support restoration efforts. Other rapid response efforts for aquaculture included support and new initiatives for seaweed aquaculture, education programs for K-12 students, and direct marketing support and assistance for farms pivoting their business during the pandemic.

In New York aquaculture producers were hit hard with the largest market in the state, New York City, closing its restaurants. This closure caused a large pivot for the industry, from selling wholesale to selling direct to the consumer. Some shellfish farmers stated that direct to consumer was a more profitable business model and would continue to use that model moving forward. Others were unable to pivot struggled to sell their oysters, though markets have picked up significantly from 2020. Fish producers in New York also struggled with the closure of NYC and its markets. Farms that were selling for human consumption were able to pivot with sales directly

to the consumer and introduced value added product, like smoked fish, to their repertoire. Many pond stocking producers stated that the pandemic boosted sales. People were home, taking care of their property, spending more time with their families, and wanted fish stocked into their ponds.

Aquaculture in New York

Freshwater Aquaculture Background

Finfish

In 1812, the Philadelphia Academy of Science developed a curriculum in aquaculture for undergraduates at Cornell University. Ichthyologists traveled the US to study and describe the Nation's resources and devise ways to propagate important sport species. By 1831 common carp had been cultured in a pond near Newburgh, New York, though they later escaped into the Hudson River. Lessons in rearing were shared, and by 1832 common carp were being reared as far away as Sonoma, California (Parker 1989).

The New York State Department of Environmental Conservation (NYSDEC) Caledonia Hatchery, established in 1864 by Seth Green, the "Father of Fish Culture," is the oldest hatchery in New York - and the Western Hemisphere. There he studied and taught the biology and methods used to culture brook trout. By 1868 he was selling ~800,000 trout eggs a year to other hatcheries (Parker 1989). In 1869 an imbalance in fish prices at the Fulton Fish Market drove other culturists to expand their hatcheries into other species (e.g. Atlantic salmon, largemouth bass, lake trout, lake white fish) not just for stocking but for human consumption. By 1871 cultured game fish were being used to stock natural waterways to supplement native and non-native populations. That summer 15,000 shad fry were transported from Newburgh, NY to California to be stocked into the Sacramento River (Parker 1989).

Following Caledonia Hatchery's lead, fishery and aquaculture programs began to pop up at universities across the country to promote and support research and industry professionals entering the field. In the 1930s, Cornell University led the nation in the number of graduates from their fishery program. Hatchery programs continued to expand under Federal and state direction. In 1932, the New York Conservation Department, the federal Bureau of Fisheries, and Cornell University established a research and training program at Cortland, New York (Parker 1989). It was around this time that New York began building other hatcheries throughout the state to culture different species of trout.

In 1959, D.C. Haskell of NYSDEC demonstrated that trout grow well under controlled hatchery conditions, leading to standardized rearing protocols (Parker 1989). Commercial hatcheries in New York and the US in the 1960s were mainly used to stock rainbow trout in natural waterways, along with providing baitfish for sport fishing. The rapid expansion of the aquaculture industry and its potential was recognized by the U.S. Fish and Wildlife Service (USFWS) in 1978. This resulted in multiple national laboratories being reorganized as National Fisheries Centers, one of which being the Tunison Fisheries Lab in Cortland, New York (Parker

1989). The Tunison Lab had been established in 1930 specifically to research trout nutrition and feed; it became a United States Geological Survey (USGS) laboratory in the 1970s.

In May of 1983, Governor Mario Cuomo signed the Aquaculture Planning Act which requested a study be done by the Sea Grant Institute of the State University of New York and Cornell University to develop a plan for New York Aquaculture to understand its potential for the state. An outline for recommendations for a plan for New York was published in July of 1985. By 1985 New York had approximately 70 private commercial aquaculture operations. Roughly 30 raised trout and 10-15 raised baitfish and the remaining were part of a cooperative in Delaware County which raised trout to food size for sale in local market. That year 60,000 pounds of trout and 20,000 pounds of baitfish were cultured (NYSG 1985). The New York Aquaculture Association also was created in 1985 in an effort to unite the industry, which was spread out across most of upstate New York and Long Island, and gain traction with legislators to advance the industry. The association was disbanded in 2019 due to lack of organizational structure, activity, and statewide support.

Freshwater finfish aquaculture has since waned with industry members citing trouble acquiring permits, expensive fish health testing, and lack of a clear path forward from state agencies (NYSG 1985, NYSG 2020). Freshwater finfish aquaculture in New York consists mainly of small family owned and operated businesses, and small to medium sized operations selling predominantly to a small regional market.

Ornamental

Ornamental aquaculture refers to the cultivation of aquatic animals, specifically for their beauty or exotic characteristics. Typically, these are colorful reef fish, or goldfish and koi. Many ornamental species are kept in aquariums by home enthusiasts and traded between public and private institutions. There are a few commercial scale ornamental facilities in the US, none of those facilities are in New York.

The ornamental aquaculture industry in New York is small, and compared to other freshwater and marine aquaculture sectors, is almost non-existent and focuses on koi and goldfish. New York has two family-owned farms that raise koi for stocking. In 2018, the USDA reported a revenue of \$108,000 for the ornamental industry in New York, which is nominal compared to \$43.5 million overall for the US ornamental market.

Current Status of Freshwater Aquaculture

Stocking

The stocking of New York's natural waterways with hatchery raised fish is a way to supplement existing wild populations. This is a fishery management tool to help maintain depleted stocks, rebuild populations, and maintain an active recreational fishing industry. Both state and private owned hatcheries culture a variety of fish for restocking (Table 1.)

Table 1. To the best of the author's knowledge these are the finfish species cultivated for stocking in New York state*

Common Name	Scientific Name	Common Name	Scientific Name
Atlantic salmon	<i>Salmo salar</i>	lake herring/cisco	<i>Coregonus artedi</i>
black crappie	<i>Pomoxis nigromaculatus</i>	largemouth bass	<i>Micropterus salmoides</i>
bloater	<i>Coregonus hoyi</i>	muskellunge	<i>Esox masquinongy</i>
bluegill	<i>Lepomis macrochirus</i>	paddlefish	<i>Polyodon spathula</i>
brook trout	<i>Salvelinus fontinalis</i>	pumpkinseed sunfish	<i>Lepomis gibbosus</i>
brown trout	<i>Salmo trutta</i>	rainbow trout	<i>Oncorhynchus mykiss</i>
channel catfish	<i>Ictalurus punctatus</i>	round whitefish	<i>Prosopium cylindraceum</i>
chinook salmon	<i>Oncorhynchus tshawytscha</i>	shiner (minnow)	<i>Notropis hudsonius</i>
Coho salmon	<i>Oncorhynchus kisutch</i>	smallmouth bass	<i>Micropterus dolomieu</i>
fathead minnows	<i>Pimephales promelas</i>	speckled trout	<i>Cynoscion nebulosus</i>
	<i>Oncorhynchus mykiss</i>		
golden rainbow trout	<i>aguabonita</i>	steelhead trout	<i>Oncorhynchus mykiss</i>
golden shiners	<i>Notemigonus crysoleucas</i>	striped bass	<i>Morone saxatilis</i>
			<i>Esox masquinongy X Esox</i>
grass carp	<i>Ctenopharyngodon idella</i>	tiger muskellunge	<i>lucius</i>
			<i>Salmo trutta X Salvelinus</i>
koi (common carp)	<i>Cyprinus rubrofuscus</i>	tiger trout	<i>fontinalis</i>
lake sturgeon	<i>Acipenser fulvescens</i>	walleye	<i>Sander vitreus</i>
lake trout	<i>Salvelinus namaycush</i>	yellow perch	<i>Perca flavescens</i>

*for updates to the list please contact aquaculture@cornell.edu

Each year the New York State Department of Environmental Conservation (NYSDEC) releases approximately 900,000 pounds of fish into more than 1,200 public streams, rivers, lakes, and ponds across the state. The NYSDEC operates 12 hatcheries, each of which specializes in raising one or more species of fish (Figure 1).



Figure 1. Map of New York state fish hatcheries (source:<https://www.dec.ny.gov/outdoor/7742.html>)

The DEC state hatcheries alone stock game fish back into New York’s waterways, but stocking is also done by private aquaculture operations. New York also has about seventeen private producers, who grow a variety of fish species, including multiple species of trout, small and largemouth bass, and even catfish. These producers sell their fish to be stocked into private ponds and game clubs throughout New York, not public waterways, as well as running fee fishing operations. New York relies on aquaculture to support and maintain healthy ecosystems and the recreational fishing industry.

A survey conducted by DEC in 2017 summarized the responses of 11,000 anglers that fished in the calendar year of 2017. Combined direct, indirect, and induced economic impacts of freshwater angling in New York State totaled an estimated \$2.14 billion and supported 10,961 jobs in 2017. Of this total, out-of-state anglers contributed approximately 26%, or \$564 million. Freshwater anglers spent an estimated \$252 million at New York fishing destinations in 2017, and an additional \$204 million was expended at home or while traveling to fishing destinations. Purchases of fishing equipment and fishing-related equipment such as boats, motors, etc., generated an estimated \$1.8 billion in additional expenditures. Recreational fishing brings in significant revenue to the state (NYSDEC 2019).

From the survey it was found that many anglers fished for warmwater gamefish (44%), primarily largemouth and smallmouth bass, and cold-water game fish (28%), including brown trout, rainbow trout, brook trout, steelhead and Chinook salmon. All are species that are cultivated for stocking throughout the state. Anglers fished primarily on inland lakes and ponds (49%), inland streams and rivers (25%), and the Great Lakes and their tributaries (22%) (NYSDEC 2019). Without aquaculture New York’s recreational fishing industry would not be what it is today.

In his 2020 State of the State Address, Governor Andrew Cuomo proposed the Restore Mother Nature initiative, the nation's most aggressive program for significant habitat restoration and flood reduction. One of the goals of the initiative is to make New York the top state for recreational fishing. As part of a proposed \$3 billion Environmental Bond Act, New York would invest in its fish hatcheries to update them and provide state of the art technology to culture and stock New York's most important recreational and game fish. This has been re-introduced by Governor Kathy Hochul as the Green Jobs Clean Air & Water Environmental Bond Act of 2022 with a proposed budget of \$4 billion.

Food

Fish raised for human consumption in New York are exclusively freshwater species at the time of this report. Producers throughout the state culture these to sell as live fish to ethnic fish markets, sell as whole unprocessed fish, or sell as a variety of value-added products such as pre-cut fillets or smoked fillets (Table 2). As of 2021, at the time of writing this report, New York has seven aquaculture facilities producing food fish. There is no formal report that collects data from these facilities to understand how much food fish is being produced in the state, which is a large data gap. Producers were asked to participate in an anonymous survey from NYSG to give a rough estimate of how much food fish was produced in 2020. Only two facilities responded. In 2020, over 405 metric tons of fish were produced for human consumption by these two facilities. Fish are cultured in flow-through systems, recirculating systems, or aquaponics systems. Fish sold for human consumption undergo rigorous permitting requirements to ensure the health and safety of the consumer.

*Table 2. To the best of the authors' knowledge these are the fish cultured for human consumption in New York state**

Common Name	Scientific Name
channel catfish	<i>Ictalurus punctatus</i>
coho salmon	<i>Oncorhynchus kisutch</i>
rainbow trout, steelhead	<i>Oncorhynchus mykiss</i>
largemouth bass	<i>Micropterus salmoides</i>
striped bass	<i>Morone saxatilis</i>
hybrid striped bass	<i>Morone chrysops x Morone saxatilis</i>
tilapia	<i>Oreochromis niloticus</i>

*For updates to the list please contact aquaculture@cornell.edu

Marine Aquaculture

Finfish

Marine finfish aquaculture, typically taking place near-shore or off-shore, remains almost non-existent in New York. In 1997 one aquaculture venture secured federal and state permits authorizing installation of up to four near-shore net pens in state waters off the North Fork of Long Island, around Plum Island. The permits authorized culture of summer flounder in the net pens under a phased approach, within initial stocking threshold of 50,000 fish. Ultimately, about 15-20,000 fish were stocked into two net pens. After a few years with no forward progress, the venture ceased operations in 2000. In 2011, another aquaculture business secured permits to

deploy two net pens at the same location for stocking and culture of striped bass. But, after a vessel strike and the impacts of Hurricane Sandy, the net pens were permanently removed from the water. There have been more recent efforts by some industry members to establish an offshore fish farm in federal waters off the south shore of Long Island, however this has been met with resistance from community and other industry members, and large regulatory hurdles. Despite these challenges, efforts to move the process forward are still being pursued by the company.

Oysters (*Crassostrea virginica*)

Historically, the oyster industry represented one of the most commercially important shellfish resources in New York State dating back to the 1800's. The beginning of oyster culture in New York State involved the movement (transplanting) of natural seed (spat) oysters from "setting" areas to planting areas, which provided optimum growth and fattening for market. The natural seed beds were mainly located in the mouths of rivers in Connecticut and the Hudson River, and areas around Staten Island in New York City. Seed oysters were transplanted to leases, franchises or underwater grants located in Long Island Sound, and Peconic and Gardiner's Bays for grow-out. Matured oysters were moved to areas in Great South Bay, Raritan Bay and Jamaica Bay for fattening prior to market.

New York dominated the oyster industry in the late 1800's through early 1900's. In 1911, a peak production of about 25 million pounds of oyster meat was harvested in the State. The Great South Bay on Long Island was once famous for its production of the Blue Point Oyster. The oyster industry observed a steady decline in production after its peak due mainly to a lack of adequate supply of seed oysters, irregular sets in Connecticut and pollution from urbanization that led to the closure of shellfish lands in Raritan Bay, Jamaica Bay, and areas around New York Harbor. Other factors contributing to the decline in the oyster industry were diseases, predation, changing hydrographic patterns, overfishing, etc. During the period from 1915 through 1921, more than twelve thousand acres of leased shellfish grounds were surrendered back to the State by growers because of a shortage of cheap and reliable seed.

The short supply of oyster seed and the unreliability of spat collectors led to research on the artificial propagation of oysters. The artificial propagation of oyster larvae, which was first reported by Brooks (1879) and later successfully demonstrated by William Wells of the New York State Conservation Commission in 1920 at an experimental hatchery at the Bluepoints Oyster Company, West Sayville, New York, was a significant breakthrough in the oyster industry. The artificial hatchery rearing techniques developed by Wells and Joseph Glancy (New York Conservation Commission) and researchers at the federal government's Milford, Connecticut laboratory led to the establishment of commercial shellfish hatcheries on Long Island in the 1960's.

During the period from 1884 through 1967, approximately 50,000 acres of State-owned underwater lands were allocated to the shellfish industry under franchises or lease agreements. Between 1885 and 1914, a total of 45,081 acres of underwater lands in Peconic and Gardiner's Bays were granted by the County of Suffolk to individuals in perpetuity for the purpose of oyster cultivation. These were called Oyster Grants. Grant holders were required to pay annual taxes on

the grants to avoid reversion to the County and were required to be in continuous use for oyster culture. Currently, there are only 1,694 acres of underwater lands held by franchises in Long Island Sound and all remaining leases have reverted to the State of New York for public use.

Suffolk County has reclaimed most of the oyster grants due to tax arrears and only about 3,400 acres of these oyster grants are currently privately held for oyster cultivation. Various municipalities on Long Island also leased underwater lands for oyster cultivation; the Town of Brookhaven (1829) and the Town of Islip (2011). Frank M. Flower and Sons, Inc. of Bayville, New York represents the last remaining large-scale privately owned shellfish company that operated a hatchery and planted up to 100 million seed oysters and clams annually on leased lands from the Town of Oyster Bay. However, the company ceased hatchery operations in 2020, their lease expires in 2024.

In 2004, the state ceded approximately 100,000 acres of publicly-owned underwater lands in Peconic and Gardiners Bays to Suffolk County specifically for shellfish cultivation. The objective was for the county to establish and implement an aquaculture leasing program for this area. In 2010, Suffolk County started the Suffolk County Aquaculture Lease Program (SCALP) in certified waters of Peconic and Gardiners Bays. The issuance of permits and regulation of shellfish farms falls under the NYSDEC¹. The county grants 5- or 10- acre plots with 60 acres leased each year, for a total of 600 leased acres during the initial 10-year period (2010-2020).

The SCALP was up for a 10-year review in 2020. The review process established that the program needs to work to minimize conflicts between oyster growers and other marine users, introduce better monitoring practices of lease sites, and designate sites specifically for floating or suspended gear. Moving forward, the program will utilize local input for site selection and gear approval. SCALP has proven to be a boon to New York's shellfish industry, with the amount of acreage of underwater land designated for aquaculture practices.

In 2001, oyster landings in New York State were reported to be only 243,375 pounds of meat with a value of \$2.1 million. Between 2012-2014, New York's oyster harvest increased more than three-fold. During this time there was also an increase in wild harvests by baymen. The increase of wild harvested oysters caused a drop in aquaculture oyster harvests for 2014-2015 since wild harvested oysters sold for less than the aquaculture product (LISS 2019). However, since 2017 cultured oysters have accounted for over 50% of the state's harvested oysters. In 2017 aquaculture accounted for exactly 50% of the oyster harvest, but in 2020 cultured oysters accounted for 79% of the state's oyster harvest. This dramatic increase in percentage of cultured oyster landings may be attributed to reductions in wild harvest due to impacts on commercial fisheries due to the Covid-19 pandemic.

¹ §13-0316 (marine hatcheries; off-bottom and on-bottom culture; permits) of New York's Environmental Conservation Law (ECL) and Part 48 (Marine Hatcheries, On-Bottom and Off-Bottom culture Of Marine Plant and Animal Life) in Chapter 1 (Fish and Wildlife), Title 6 (Conservation [A]) of the State's Official Compilation of Codes, Rules and Regulations (NYCRR).

Hard Clams (*Mercenaria mercenaria*)

The hard clam (*Mercenaria mercenaria*), also known as the northern quahog, is native to the North American Atlantic coast. In 2018, 6.8 million pounds of wild caught hard clams were harvested, valued at \$48.3 million, highlighting the importance of this species in the United States (NMFS 2018).

In New York, hard clams represent almost 25% of all seafood products in dockside value (Hudson 2017). Hard clams historically have been found in most bays in New York ranging from Raritan Bay off Staten Island to Napeague Bay near Montauk, as well as in the Long Island Sound. Harvesting of wild stocks was the traditional method used in this fishery, though in the recent decades a shift has been made to farming these bivalves.

The hard clam industry began in the 1930s resulting from the declining abundance of oysters and the loss of oyster grounds. Hard clam landings peaked in 1947 with a record harvest of more than 10 million pounds of meat having a value of over \$6 million. The landings began to decline in the late 1940's through early 1950's. Then began to increase significantly in the 1960's through 1970's due to new sets in Great South Bay reaching a second maximum harvest in 1976 at about nine million pounds of meat.

At one time, New York provided more than 60% of the nation's hard clams and Great South Bay was referred to as the world's richest clam factory. For every year from 1970 through 1994, the dockside value of hard clams landed in New York exceeded that of any other fish or shellfish species landed in the state. In the 1970's, the hard clam fishery in Great South Bay alone accounted for approximately 94% of the hard clams landed in New York State. Between 1976 and 1984 Great South Bay saw an 80% decline in hard clam landings. The fishery has continued to see a decline in hard clam stock, and the fishery in Great South Bay is now almost non-existent. By 2001, hard clam landings dropped to a low of 1.8 million pounds of meat valued at \$13.5 million. The decline in the population of hard clams can be attributed to over-harvesting, recruitment failure, changes in water quality, poaching of seed clams, loss of suitable habitat and pollution (Timmons 2004).

The Bluepoints Company, which held title through a colonial patent to more than 13,000 acres in Great South Bay and operated a marine hatchery and extensive on-bottom hard clam grow-out operation, was forced to go out of business due to the poor water quality and unsuitable growing conditions in Great South Bay. The Nature Conservancy purchased that land and, between the years of 2004 and 2010, more than four million adult clams were relocated there from Connecticut and other parts of Long Island. In 2008, a survey showed a 40-fold increase from the baseline clam population numbers. However, due to a number of recurring harmful algal blooms (HABs) the hard clams have had difficulty surviving. The hard clams will need multiple consecutive years without HABs for the stocks to survive and become self-sustaining (NYSDEC 2013).

Additionally, substantial losses in hard clam production have been reported since the 1990s after a pathogen known as quahog parasite unknown (QPX) wreaked havoc in the aquaculture industry and wild clam populations from Massachusetts to Virginia, with stock mortality

reaching 90-95%. This parasite causes an intense inflammatory response in the clams' tissues and can eventually cause mortality if the parasite proliferates. In 2002, a large die-off of hard clams due to QPX occurred in Raritan Bay (NYSDEC 2013). Starting in 2019, multiple Sea Grant programs, including NYSG, researchers, and industry, collaborated to form the Hard Clam Hub, and have been working together to selectively breed QPX resistant hard clam strains for aquaculture and restoration. As the resistance to QPX is hereditary, breeding only resistant clams will provide growers with more reliable stock.

By 2012, hard clam production increased in New York by more than 70%. This is likely due to increased aquaculture production, the re-opening of shellfish beds after concerted local and state efforts to improve water quality in the Long Island Sound. However, harvest numbers have remained considerably below historic levels with most populations considered low abundance or still in decline (NYSDEC 2013). Hard clams have been extensively cultured throughout the East Coast to bring populations back to fill the void left by declining fisheries. In New York, there are multiple hatcheries, both private and municipal, that culture hard clams for restoration and eventual harvest for consumption.

Bay Scallops (*Argopecten irradians irradians*)

Historically, the bay scallop represented a commercially important shellfish resource in New York State, particularly in Peconic and Gardiner's Bays on the eastern end of Long Island. Bay scallops once supported a profitable commercial fishery in Massachusetts, New York, and North Carolina waters (MacKenzie 2000). However, in the 1930s bay scallop populations and catch crashed alongside eelgrass die-offs in North America and Europe related to "wasting disease", a disease that slowly decays the leaves of the eelgrass, an important habitat for juvenile bay scallops (Fonseca and Uhrin 2009). Some populations were able to slightly recover over time, but in the 1980s additional eelgrass die-offs occurred in the coastal waters of Long Island due to an unusual bloom of the alga, *Aureococcus anophagefferens*, also known as brown tide. This algae bloom devastated bay scallop populations in the Peconic Bay system. The sequential events of eelgrass die offs and brown tide events caused bay scallops in Long Island's waters to come close to extirpation. In 1995, yet another brown tide event decimated bay scallop populations. There have not been any further brown tide events, but scallop populations have remained consistently low.

There have been several efforts to revitalize bay scallop populations, beginning with intense restoration efforts in 2006, by planting scallop seed (bugs) from local and out-of-state hatcheries and establishing spawner sanctuaries in the Peconics (Tettelbach and Smith 2009). Despite these efforts bay scallop populations have yet to recover to their historic levels. However, through restoration efforts larval settlement of bay scallops has increased significantly, and in 2008 the first increase in harvest numbers, which were about 3x higher than pre-restoration numbers, were seen. Harvest numbers continued to increase and in 2010 numbers reached about 13x higher than pre-restoration numbers (Tettelbach et al. 2015). Landings since then have fluctuated but remained relatively stable until 2017 when there was a drastic increase in harvest numbers. In 2017 and 2018 bay scallop landings were reported to exceed 108,000 pounds with a value of \$1.6 million. These numbers can be attributed to intense restoration work and close monitoring of the wild population.

During the summer of 2019 however, there was a catastrophic die-off of adult scallops in the Peconic Bays with estimates of more than 95% mortality; some areas reported 100% mortality. Die-offs continued over the next two years with numbers reaching 99% in 2020 and 90% in 2021. NYSDEC arranged for diagnostic disease testing by the Marine Animal Disease Laboratory (MADL) at Stony Brook University of 32 bay scallops collected from Peconic Bays in November of 2019. A coccidian parasite, a protozoan, was found in the kidneys of both juvenile and adult bay scallops. There was heavy damage to the kidney tissue, enough to cause the mortality of the organism in adult scallops. It is important to note that these parasites are not harmful to humans and do not represent a public health concern (NYSDEC 2020). In November 2019, the Peconic Estuary Partnership, in response to the adult scallop die-off in Peconic Bays, convened a group of scientists, regulators and experts to assess the factors (known and unknown) that may have contributed to the die-off and develop recommendations for future monitoring, research and restoration efforts.

Since 2019 the coccidian parasite has been found in 100% of bay scallops sampled. Lower parasite loads are observed in the animals when water temperatures are lower, but when water temperatures increase the parasite load increases rapidly, especially from May-June. The parasite may be one contributing factor to the recent die offs but, the cause(s) of the die-off is still unknown. It is most likely a combination of disease paired with physiological stress during bay scallop spawning, which is exacerbated by environmental stressors, high water temperatures, and low dissolved oxygen.

Currently, New York's bay scallops are primarily located in the waters of Peconic and Gardiners Bays in eastern Suffolk County and situated within the five east end towns of Riverhead, Southold, Shelter Island, Southampton, and East Hampton. Bay scallop restoration efforts conducted over the past fifteen years by Cornell Cooperative Extension and other partners in Peconic Bays helped to jump-start and rehabilitate the adult scallop population and restore this commercially and recreationally important resource and fishery. There is hope however, adult scallops are spawning, there is successful larval recruitment, and a successful benthic population is being observed. The issue is adults are not surviving post-spawn at the 1-year mark to survive to the time of the fishery opening in November.

Marine hatcheries across Long Island and aquaculture producers will continue to play an important role in any efforts to rehabilitate scallop resources in New York State. Cornell Cooperative Extension of Suffolk County grows and plants scallops and works with local partners to investigate causes and potential mitigation of these scallop mortality events. MADL is also conducting research on bay scallop disease dynamics and selective breeding. NYSDEC provided funding to Stony Brook University (MADL) and CCE to conduct bay scallop population monitoring and disease dynamics research to examine the effect of water quality parameters (temperature, salinity, dissolved oxygen) on scallop health (physiological performance, disease dynamics) and spatial/temporal prevalence of disease in Peconic bay scallop populations. Additionally, CCE received a grant from the North East Regional Aquaculture Center (NERAC) to find 2-year-old wild scallops and spawn them to produce scallops that may be resistant to environmental factors and disease. The project began in 2021 and 50 two-year-old scallops were found and used as broodstock. NYSG has also funded a

project in 2021 with MADL and CCE evaluating survivorship of cultured scallops to temperature and disease in an effort to identify genetic markers and maintain resistant strains for future aquaculture and restoration programs. It is the continued efforts and research that will be essential to the survival of the bay scallop.

Microalgae

Microalgae is an important source of nutrition for aquatic animals. Aquaculture facilities usually culture microalgae either as a direct source of nutrition or additive to aquafeeds. It is commonly used in the culture of mollusks, fish, echinoderms and crustaceans.

In New York, microalgae culture is typically used as a feed for cultivated bivalve molluscan shellfish such as oysters, clams, scallops, and mussels. These organisms are filter feeders and rely on microalgae as a food source. Multiple species of microalgae are grown and mixed to provide a variety of fatty acids and other nutrients to the shellfish. In finfish culture, microalgae is used as a live feed for larval fish, a live feed for the plankton being fed to the fish, and can be added to the water column in the first few days of rearing to create “green-water”.

In 2010, the New York City Department of Environmental Protection (NYCDEP) launched a biofuel pilot project culturing microalgae to be converted into biofuel. The project took place in the Rockaway Wastewater Treatment Plant in Queens, growing algae in wastewater for 10 to 12 days before removing it to be transformed into butanol (Jernigan et al. 2013).

Macroalgae

The history of macroalgae, also referred to as seaweed, is a relatively young industry in New York. Early attempts to culture seaweed in California, Washington State, New York, and the Gulf of Maine in the 1980s and 1990s did not result in commercial production but provided important information for the industry, mostly feasibility. Research had been conducted in New York in the 1980s on various methods of culturing and utilizing seaweed, particularly the brown kelp, *Saccharina latissima* (formerly *Laminaria saccharina*), though other species have been researched in the past.

Researchers in the late 1980s developed and patented a method of growing seaweed using a “water charged atmosphere” growing condition, a seawater misting system to keep algae constantly moist but not saturated. This method was shown to be effective for *Chondrus crispus* and *Gigartina stellata* (currently *Mastocarpus stellatus*), both of which are currently used for food and alternatives to plastic. The trials were conducted directly on land and in multi-tier farm trays, both of which yielded growth of the two species (Moeller et al. 1984).

The Gas Research Institute, the New York State Energy Research & Development Authority, the New York Gas Group, and the New York Sea Grant Institute worked together for a period of five years, spending about \$2 million, to demonstrate the feasibility of cultivating sugar kelp to be used for producing methane natural gas. Its cultivation was successful, and efforts were then focused on increasing crop yield (NYSG 1985). Since then, however, research on this kelp cultivation goal has slowed.

Around 2015 when sugar kelp became a promising candidate in bioremediation studies, research on its cultivation and markets has grown. Sugar kelp is native to New York's coastal waters though the Long Island Sound represents its southernmost limit for the Northeastern Atlantic region. Like shellfish, sugar kelp requires no input for aquaculture growth. Further, sugar kelp is a winter crop and grows between late fall and spring, providing an opportunity for New York farmers to diversify their crops, or environmental organizations to plant bioextraction farms when recreational boating is minimal.

Excess nitrogen in Long Island's water prompted the establishment of the Long Island Nitrogen Action Plan (LINAP) in 2015. Excess nitrogen finds its way into Long Island groundwater and marine waters from outdated septic systems, stormwater run-off, and fertilizer use. Nitrogen is the leading cause of water quality deterioration in the Long Island Sound and its embayments. Poor water quality causes harmful algae blooms, fish kills, and anoxic zones and has severely reduced eelgrass acreage and shellfish populations in New York's marine waters.

One of the methods to address excess nitrogen in marine waters is aquaculture. Aquaculture species, like shellfish and seaweed remove excess nitrogen and other nutrients from the water. *Gracilaria tikvahiae* was found to be a suitable candidate for bioremediation in Long Island Sound, removing nitrogen, carbon, and phosphorus from the environment (Kim et al. 2014). A follow-up study in 2015 looked at sugar kelp as another possible bioextraction species in New York waters. The study indicated that sugar kelp is an effective bioextractant, removing considerable amounts of nitrogen, carbon, and phosphorus (Kim et al. 2015). In 2017, the NOAA Milford Lab found that ribbed mussels (*Geukensia demissa*) were also capable of removing nitrogen from the Bronx River Estuary, an urban waterway (Galimany et al. 2017). Efforts then shifted to growing sugar kelp alongside shellfish to remove excess nutrients from Long Island's waterways.

In 2017 Suffolk County, through the Water Quality Protection and Restoration Program, funded a project by Cornell Cooperative Extension to grow sugar kelp in the Peconic Estuary. To test the feasibility of growing sugar kelp in New York. There was some success with the trials and these experiments marked the first-time sugar kelp was grown in New York State's waters. This proof-of-concept was a milestone for the industry.

Stony Brook University, in 2017, received a three-year grant from the New York Farm Viability Institute Specialty Crop Block Program, run by the United States Department of Agriculture (USDA). The grant was to understand the feasibility of growing sugar kelp in Long Island's shallow water, as it has previously only been grown in waters >20ft deep. The first year of the project, 2018, three farms were seeded with kelp spore spools, one in the Great South Bay, one in Moriches Bay, and one in the Long Island Sound. In 2019 the three farms were seeded again, and in 2020 four farms were seeded, adding the Peconic Estuary as a site. These areas were chosen for a range of water depths and a variety of aquaculture leasing opportunities. The Moriches site was about 2ft at low tide, being the shallowest site in the study. The other sites ranged from 3-20ft in depth. There was success at all grow out sites, with the best being in Moriches Bay, the shallowest, demonstrating that sugar kelp can successfully be grown in shallow waters without kelp blades becoming degraded, torn or damaged. Over the three years

the project has produced over 10,000 lbs. of kelp and removed over 36 pounds of nitrogen from Long Island's waters.

The Long Island Nitrogen Action Plan then launched the Nutrient Bioextraction Initiative (NBI) in 2018. The NBI aims to improve water quality in marine waters by removing excess nitrogen specifically through the cultivation and harvest of shellfish and seaweed. The goals of this program are: 1) create a siting tool for areas that are suitable for nutrient extraction and contribute the most to nitrogen removal, 2) develop a permitting guide for shellfish aquaculture, 3) plan and develop bioextraction projects to understand other seaweed species growth rates, and pathogens in tissues, 4) identify markets and determine the costs of cultivating shellfish and seaweed species for bioextraction, and 5) evaluate the overall economic viability of nutrient bioextraction in New York.

In early 2019, Southampton Marine Station at Stony Brook University began operating a kelp hatchery that has had three successful seasons producing about 45 spools per year used in kelp growth trials in 2019 to 2021 and continues to grow and develop kelp spools for research.

In late 2019, a partnership among the New England Interstate Pollution Control Commission (NEIWPC), Adelphi University, and Seatuck Environmental Association looked at sugar kelp as an extraction method for nitrogen in Long Island. The project had three sites, two were commercial shellfish aquaculture leases in the Town of Islip, and the third was the Angie M Cullin East Marina in the Town of Hempstead. Longlines were seeded in January of 2020. Combined, all sites removed 145.3 lbs. of carbon and 12.0 lbs. of nitrogen demonstrating sugar kelp is a viable source for the bioextraction of carbon and nitrogen from the environment in certified waters (LICF 2020). This project is expected to continue past initial funding with further funding provided by the Long Island Sound Study into 2020 and 2021.

The National Sea Grant office funded the creation of the National Seaweed Hub in 2019 to serve as a science-based, non-advocate resource for domestic seaweed and the seaweed aquaculture industry. The HUB was awarded \$1.1 million to establish needs of the industry nationwide, challenges stakeholders face, and to work to find solutions. The Hub is a partnership between Sea Grant programs from Maine, Alaska, New Hampshire, New York, Oregon, Rhode Island, Woods Hole, and the National Sea Grant Law Center. New York Sea Grant plays an active role in the Hub, working with state stakeholders to advance seaweed aquaculture.

Cornell Cooperative Extension of Suffolk County (CCE) launched a project to evaluate the potential for using sugar kelp harvested from Long Island waters as a fertilizer with local agriculture in May of 2020. The kelp was dried and crushed after harvesting and applied in a field study to tomato and petunia plants. Overall, no difference was found between the kelp fertilizer and the control, and the tomato plants and petunia plants did not show larger fruits or plant size and no reduction in growth in the kelp treated plants (CCE 2020). More research is still needed to establish what specific benefits kelp can offer local agriculture. However, a local New York company is already using kelp as fertilizer and has begun producing fertilizer with wild harvested kelp from New York.

In the summer of 2020 sugar kelp aquaculture had gained significant traction and piqued the interest of Long Island oyster growers. Lazy Point Farms launched a study to develop seaweed aquaculture in New York for its marine environmental benefits, multiple uses, and potential viability as a winter crop for New York's shellfish farmers. In the fall of 2020, 12 growers joined the project deploying kelp spools in waterbodies around Long Island: Montauk, Greenport, Setauket Harbor, Oyster Bay, and several sites in Great South Bay. Lazy Point Farms launched another season in the fall of 2021 with the same growers and several others. A collaboration with Cornell Cooperative Extension has made it possible to conduct hatchery and grow-out experiments that will improve cultivation success. The project has plans for several trial uses for its 2022 harvest.

New York Sea Grant has also funded two projects within the last few years with the Gobler Lab at Stony Brook University. The first project aims to assess the ability of cultivable macroalgae species to inhibit the growth of harmful algal blooms (HABs) species common to New York waters. So far the project has shown promise with the HAB inhibiting effects of the sugar kelp, *Saccharina latissima*, on the okadaic acid producing dinoflagellate, *Dinophysis acuminata* and the saxitoxin producing dinoflagellate, *Alexandrium catenella*. Commercially viable techniques to grow HAB-combative seaweed and shellfish is being looked at, at 10 oyster farms in Long Island. The second project looks at assessing the potential of a new aquaculture species, *Gracilaria tikvahiae*, as a summer seaweed crop to hopefully diversify New York's aquaculture industry. This proposed seaweed will complement the winter sugar kelp crop and potentially can be grown alongside oysters in farms throughout Long Island.

There are several permitting and regulatory issues that currently limit commercial cultivation of seaweed in New York. Seaweed cultivation was not permitted in the Peconic and Gardiners Bays until the recent passage of Senate Bill S6532A, affectionately known as the 'Kelp Bill.'

Although the Governor signed the bill in 2022, cultivation permits await regulatory action by Suffolk County and the NYSDEC. A separate United States Army Corp. of Engineers (USACE) permit (Nationwide Permit 55 – Seaweed Mariculture Activities) is also required to cultivate seaweed on aquaculture leases in New York. The towns of Brookhaven, Islip and Oyster Bay include the cultivation of non-invasive aquatic plants in their leases, which would include sugar kelp. No other townships have active lease or license programs. Seaweed cannot be cultivated in the Long Island Sound and Block Island Sound, waters controlled by the state since only 'shellfish' are referenced in the state's Temporary Marine Area Use Assignment (TMUA), which are state-owned underwater lands.

Current Status of Marine Aquaculture

Finfish

New York currently has no offshore aquaculture in state or federal waters off the coast. There are permit requests in, but progress has been slow.

Shellfish

Today, the New York State Department of Environmental Conservation Marine Division issues permits for aquaculture for both municipal and private hatcheries to culture shellfish for out

planting restoration efforts and for sale to local aquaculture farms, as well as on/off bottom culture permits for aquaculture operations in Long Island’s waters.

Aquaculture has grown in popularity from 2010 to 2020 with the number of private on/off bottom culture permits increasing from 56 to 90 (Table 3). These permits are for private operations using cages or floating gear to culture shellfish to be sold for human consumption. Municipal on/off bottom culture permits are for restoration or research efforts.

Table 3. Licenses and permits issued by NYSEDC from 2010 to 2020.

License/Permit Type	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Marine Hatchery - Municipal	9	9	9	10	9	9	8	9	10	9	10
Marine Hatchery - Private	19	19	19	24	24	29	28	28	29	28	30
On/Off bottom culture - municipal	11	11	11	13	12	12	11	12	13	12	12
On/Off bottom culture - private	56	50	53	56	59	69	69	79	83	80	90

Shellfish have been an important part of New York’s economy, both in aquaculture and in wild harvest. Prior to 2017, wild harvested shellfish and cultured shellfish were reported together (Table 4). Starting in 2017, cultured shellfish have been reported separately. Cultured hard clams and bay scallops are also reported separately but because less than three companies are producing these, the data are confidential. These numbers are included in the total landings (Table 4) but are not specifically shared outside of state totals. In 2017, cultured oysters accounted for 50% of the state’s total oyster harvest but that number has steadily increased to 85% of the state’s total in 2021 (Table 5).

Table 4. New York state shellfish landings (cultured and wild caught combined) from 2010-2021. *This table only includes landings for the three aquacultured species discussed in this aquaculture report: hard clams, oysters, and bay scallops.

Year	Hard clams		Oysters		Bay Scallops	
	Bushels	Value (\$)	Bushels	Value (\$)	Bushels	Value (\$)
2010	121,628	7,774,317	25,574	2,046,527	40,396	585,744
2011	113,140	6,905,304	31,051	2,173,601	28,932	419,509
2012	130,799	9,294,751	44,494	3,114,657	34,011	492,682
2013	176,862	11,772,289	68,773	4,401,569	29,051	421,237
2014	153,793	9,899,812	133,663	9,356,407	100,066	1,450,954
2015	164,021	11,929,333	71,947	5,755,719	65,378	947,980

2016	181,853	12,021,369	48,923	3,913,701	30,470	441,814
2017	152,083	9,671,243	35,165	2,813,224	108,800	1,577,598
2018	137,406	8,090,723	41,690	3,335,179	108,809	1,577,734
2019	156,462	7,844,814	45,853	3,668,234	29,065	639,420
2020	116,087	6,962,466	29,972	2,697,438	4,053	101,335
2021	121,359	7,645,857	43,446	4,779,110	2,146	64,385

Table 5. Cultured oyster harvests and percentage of New York’s total oyster harvest from 2017 to 2021.

Year	Cultured Oysters	State Total Pieces	State Total Harvest (%)
2017	3,538,745	7,033,059	50
2018	4,431,488	8,337,948	53
2019	5,893,420	9,059,645	65
2020	5,194,606	6,491,101	80
2021	7,398,376	8,689,291	85

Shellfish populations throughout Long Island have plummeted due to overharvesting and habitat degradation. New York was once home to some of the most abundant oyster reefs and shellfish beds in the region, but those are almost nonexistent. To help restore New York’s waters and restore habitat, large restoration efforts have been launched both by multiple municipalities and private and public organizations across Long Island. Data on stocking efforts are reported to NYSDEC, however the data were not available at the time of this writing. Below, in addition to the work of the individual townships, are restoration projects that are taking place to help restore shellfish populations.

Municipal hatcheries have played a large role in supplying shellfish seed for restoration efforts. Multiple hatcheries culture hard clams, oysters, and bay scallops to be out planted in their local waterways. These hatcheries have helped develop and support New York’s aquaculture industry (Table 6).

Table 6. Long Island’s municipal hatcheries and their missions*.

Municipal Hatcheries	About
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Town of
East
Hampton

The Aquaculture Department exists for the purpose of enhancing commercially valuable molluscan shellfish stocks in local waters. Shellfish are available for harvest by all properly licensed town residents. The department produces large quantities of seed shellfish - currently hard clams (*Mercenaria mercenaria*), eastern oysters (*Crassostrea virginica*) and bay scallops (*Argopecten irradians*) and disseminates them into local waters including Lake Montauk, Napeague Harbor, Three Mile Harbor, Accabonac Harbor, Northwest Creek and Hog Creek. It operates a shellfish hatchery on Fort Pond Bay, Montauk, a land-based ambient bay water fed nursery on Three Mile Harbor, East Hampton and an on/off-bottom field grow-out system consisting of bags, trays and nets in Napeague Harbor, Amagansett. Some species are also over-wintered in various sites throughout Town.

<http://ehamptonny.gov/149/Aquaculture>

Town of
Brookhaven

The Town of Brookhaven Shellfish Culture Facility currently cultivates 1.5 million 2-3 mm hard clam and 1.5 million 2-3 mm oyster seed annually, the seed being procured from NYSDEC approved hatcheries. The Facility partners with four not-for-profit organizations and provides them with small quantities of seed to allow them to engage in targeted restoration projects. The bulk of the Town production is split between Management Areas and Public Lands to support both shellfish restoration and commercial/public harvest. The Town additionally supports an aquacultural leasing program for both shellfish and seaweed production.

Town of
Hempstead

With a population of over 750,000 residents, The Town of Hempstead is the most populous township in the United States of America. The Town's Department of Conservation and Waterways is responsible for the management of over 10,000 acres of tidal waterways along the south shore of Nassau County in New York State. The estuary known as Hempstead Bay has a long history of wild shellfish harvesting dating back to the pre-colonial era. The tradition of commercial and recreational wild harvest of hard clams continues in Hempstead Bay to this day.

Recognizing the commercial, cultural, and ecological value of the shellfishery in Hempstead Bay, the Town's aquaculture facility is focused on the enhancement of the local wild clam population and the restoration of oyster beds. Most recently, the Town has become involved in culturing sugar kelp spools for regional research and bio-extraction projects.

<https://hempsteadny.gov/674/Shellfish-Restoration-Program>

Town of
Islip

The Town of Islip is dedicated to the responsible development of the aquaculture industry, while expanding the marine-based economy, enhancing shellfish production, and improving the water quality of the Great South Bay.

The Great South Bay Shellfish Cultivation Facility produces shellfish and seaweed for research projects. The hatchery plays a vital role in meeting the needs of the aquaculture community and ensures the continuation of the tradition of farming on the Great South Bay.

<https://islipny.gov/departments/environmental-control/shellfish-facility>

Town of
Oyster Bay

The Town of Oyster Bay Shellfish Hatchery and Aquaculture Program was created with the mission of achieving sustainable shellfish populations and enhancing the health of the waterways along the Town’s north and south shores.

Shellfish aquaculture programs raise juvenile shellfish which are then placed in protected conservation management areas throughout Oyster Bay Harbor, Cold Spring Harbor, and in South Oyster Bay to ensure greatest chances for survival and reproduction, with the goal of re-population and sustainability.

In recent years the Hatchery has engaged in a pilot Kelp Aquaculture program, effectively growing thousands of feet of sugar kelp. The benefits of which include nitrogen bio extraction and carbon sequestration from surrounding waters it was grown in.

<https://oysterbaytown.com/departments/environmental-resources/shellfish-management>

*To update the table, contact aquaculture@cornell.edu

Billion Oyster Project

The Billion Oyster project has a goal of planting a billion oysters back into New York Harbor. New York Harbor used to have a thriving oyster population, but in a short period of time humanity was able to wipe out the native oyster reefs. As of the summer of 2021, the Billion Oyster Project has planted 47 million oysters in an effort to restore these historic reefs that help protect the city from wave damage and serve as habitat for hundreds of aquatic species. In addition to massive restoration efforts, the Billion Oyster Project focuses on engagement and education efforts that involved students and communities in all five boroughs.

Learn more: <https://www.billionoysterproject.org/>

City Island Oyster Reef

The City Island Oyster Reef (CIOR), a non-profit 501(c)(3) community-based organization, was formed in December 2019, to expand existing oyster reef restoration efforts in New York City. The goal is to reestablish oyster populations in the waters surrounding New York City and the Western end of the Long Island Sound. The organization is driven by its volunteers. These “eco-volunteers” collect oyster shells from restaurants and cure them in accordance with NYSDEC

requirements for a year before out plating them in designated restoration sites. They also search beaches and coves for evidence of wild oysters to find the best location for restoration efforts.

Learn more: <https://www.cioysterreef.org/>

Long Island Shellfish Restoration Project

In late 2017 New York state announced a large-scale shellfish restoration initiative involving the establishment of five new shellfish sanctuaries in Suffolk and Nassau counties. These sites will be stocked with up to 168 million juvenile and adult clams and oysters to restore New York's shellfish population. This \$10.4 million project is an effort to improve Long Island's water quality, mitigate harmful algal blooms, enhance shellfish populations, and boost the resilience of coastal communities.

New York State provided \$5.1 million in funding to Cornell Cooperative Extension (CCE) of Suffolk County to construct a state-of-the-art shellfish hatchery to produce seed clams and oysters for this project. CCE is growing approximately 140 million shellfish over the five-year project period. The planted shellfish includes approximately 27 million seed clams, 115 million oyster spat on shell, and approximately 20 million oyster eyed larvae. Four town shellfish hatcheries (Islip, Brookhaven, East Hampton, and Hempstead) also received \$400,000 in grants to make improvements to their existing hatcheries to increase seed production and are providing seed clams and/or spat-on-shell oysters to this restoration effort. Stony Brook University is assisting the involved municipalities with stocking adult clams at the sanctuary sites and conducting monitoring to evaluate the success of the project and help inform future restoration efforts. NYSDEC is purchasing 6.75 million adult clams from certified shellfish dealers for stocking in the sanctuaries. Along with restoration efforts, public and community involvement will play a key role in the success of this project.

Learn more: <https://lishellfishrestorationproject.org/>

Seatuck Half Shells for Habitat

Half Shells for Habitat is a Long Island-wide, oyster shell recovery program designed to collect waste oyster shells from restaurants for later use in oyster restoration projects in local bays. The program, initiated by Seatuck in 2018, collects and processes waste shells according to NYSDEC policies. In this way the shells are air cured and sanitized for at least 6 months at a municipal site before going back into the water. Once returned to the water, shells may provide a vital substrate for larval oysters to attach and grow, helping to rebuild New York's wild oyster reefs. The shells also serve to buffer the effects of coastal acidification. Recycling shells further reduces carbon emissions to the atmosphere because the shells are not burned as waste. The Half Shells for Habitat program has collected over 85,000 lbs. of waste oyster shells with about 16,000 lbs. already returned to the South Shore Bays in several wild oyster reef restoration efforts.

Additional information on H4H can be found on our Seatuck web page <https://seatuck.org/half-shells/> or at Facebook <https://www.facebook.com/HalfShellsForHabitat/> and on Instagram <https://www.instagram.com/halfshellsforhabitat/>

Shinnecock Bay Restoration Program

The Shinnecock Bay Restoration Program (ShiRP) was initiated by the School of Marine and Atmospheric Sciences (SoMAS) and the Institute for Ocean Conservation Science at Stony Brook University in 2012. ShiRP was created as a response to the deteriorating situation in Shinnecock Bay in an effort to improve water quality, increase habitat and create a healthy marine ecosystem. Their projects include creating hard clam sanctuaries by planting adult hard clams in protected areas, creating oyster reefs with spat on shell to be out planted in the bay, re-seeding eelgrass beds to expand the vital habitat in the bay, and evaluating different species of macroalgae to understand which can help mitigate excess nitrogen.

Learn more: <https://shinnecockbay.org/index.html>

Microalgae

New York has a producer cultivating the blue-green microalgae spirulina, a freshwater algae. This algae is being cultured as a dietary supplement for human consumption. The culture of spirulina is not new; however, it is usually grown in a warm tropical environment. In New York the producer has developed an innovative method to culture this microalga year-round entirely indoors.

Macroalgae

As of May 2022, New York has no commercial seaweed farms. All macroalgae projects are research-based at this time. It is anticipated that there will be a transition away from research-based projects for macroalgae as growers apply for commercial permits and enter the various and growing seaweed markets. An issue the seaweed industry faces is that there are currently no markets for New York seaweed. Markets for cultivated seaweed need to be established to support a viable seaweed aquaculture industry. Many entities are exploring market opportunities in New York to ensure its success once permits are approved. Seaweed is marketed in other states for a variety of food products. It is also used in the cosmetic and pharmaceutical industries. Several firms are investigating its use to replace synthetic fibers in packaging and fabrics. NYSG organizes a Seaweed Task Force to address industry needs. Through their input NYSG has published three seaweed regulatory guides to assist producers in processing and marketing (see Resources Section).

Current Production Systems in New York

New York utilizes a wide array of systems, both land-based and in the water, to cultivate its aquaculture products. These systems are highly regulated and overseen by the NYSDEC, the United States Army Corps. of Engineers (USACE), the Environmental Protection Agency (EPA), and the US Coast Guard.

Land-Based Systems

Recirculating Aquaculture Systems (RAS)

Recirculating Aquaculture Systems (RAS) have evolved over the last fifty years through significant research and development. Intensive RAS production requires about 20% of the water that conventional flowthrough or pond culture would use (Helfrich and Libey 1991). These systems are also unique in that aquatic animals can be grown entirely indoors, creating a completely controlled environment so that ideal water temperatures and water quality can be maintained. Environmental control allows for optimal growth rates and predictable harvest times, such that products can reach markets when supplies from elsewhere are low, keeping prices up and avoiding competition with wild fisheries. This eliminates the need to only culture during the warmer months in places like New York where ponds and streams would freeze in the winter. RAS can be freshwater or saltwater, allowing for a wide variety of species to be cultured.

RAS circulates water from fish tanks through mechanical and biological filters, cleansing the water of harmful solutes and solid particles, and then returns clean water to the fish, allowing for most of the water to be recycled. Metabolic waste products from the fish, including solid waste, ammonium and CO₂ are removed or converted into non-toxic forms. RAS can reuse up to 90% or more of the water in the system, significantly reducing the use of new water (Timmons et al. 2018). A completely closed RAS is not possible as water evaporation and non-degradable waste products, i.e., minerals concentrating over time through evaporation, requires that new water periodically be added to maintain water quality (Figure 2).

RAS conserves both water and land required to grow aquatic organisms for aquaculture. These intensive systems utilize a relatively small area of land and require relatively little water per unit of production. For example, using RAS, it is possible to produce over 100,000 pounds of fish in a 5,000 square foot building, while other methods might require acres (43,560 square feet/acre) of land and a large volume of water (Helfrich and Libey 1991). These systems can range from commercial scale, producing hundreds of thousands of pounds of fish, to hobby scale and smaller, producing a few hundred pounds of fish.

New York currently has two commercial scale RAS facilities, there are also several smaller-scale facilities using RAS. Other facilities enhance production by using RAS in the winter months to raise fry before moving them to outdoor ponds in the summer. RAS provides an opportunity for aquaculturists to grow their operations without requiring large amounts of land or water. However, the cost of building and operating systems required to treat recirculated water are high compared to other aquaculture systems. In

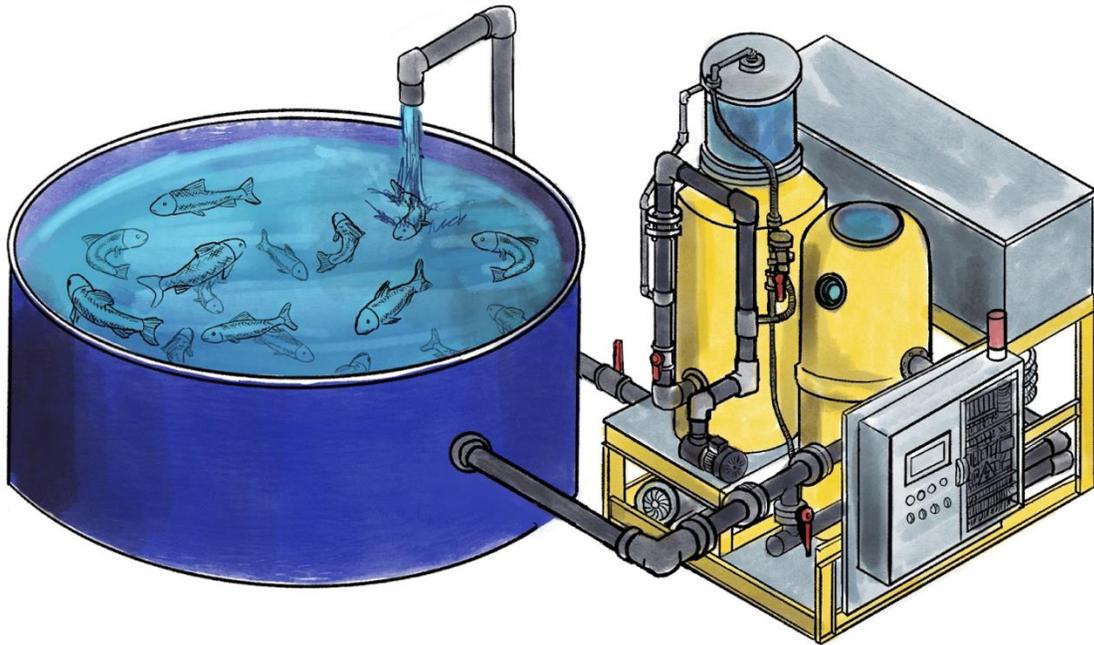


Figure 2. Example drawing of recirculating aquaculture system (RAS)²

Flow-through systems

Flow-through systems continuously introduce water from an outside source and discharge to surface water (rivers, streams, estuaries, lakes, etc.) after it flows through the facility. Raceways, typically long rectangular channels or tanks, with water flowing in one end and out the other, are one of the most common flow-through fish culture systems (Figure 3). Though less common, some flow-through systems utilize circular rearing tanks. Flow-through systems rely on high water volume exchange relative to the tank size to remove waste, push water through the treatment system, and then appropriately discharge the water instead of recirculating it through the system again. The continuous water flow ensures proper oxygen to the fish and flushes out any metabolic wastes.

Water for these systems is usually diverted from streams, springs, or wells and uses gravity to move the water through the facility. Water pumped from wells can be expensive, both in energy to operate the pumps and drilling the wells with sufficient capacity. Surface water sources can be less costly but increase the chances of introducing surface water pathogens and pollutants that may negatively affect fish in the facility. Surface water quality, e.g., temperature, can also fluctuate outside of desirable ranges for optimal growth. Springs are the most advantageous, particularly if a facility can be situated near a spring with significant flow, however, these sites are rare. Water that is used for aquaculture and has been diverted for use in New York is regulated by NYSDEC. Water that is discharged must be treated to remove waste and

² All illustrations done by Georg Pederson for New York Sea Grant - <https://ytorf.com/>

contaminants and is also regulated and monitored by NYSDEC requiring a State Pollutant Discharge Elimination System (SPDES) permit.

Flow-through systems are not just used for finfish aquaculture, but for bivalve culture as well, specifically larval culture. Raceways can be set up to receive a constant flow of new filtered or sterile seawater, with constant aeration. Raceway systems can be used both indoors and outdoors and the long channel systems are more space efficient compared to circular tanks. However, oxygenation and other water parameters tend to be highest at the head of a raceway, producing uneven growth conditions in the raceway channel.

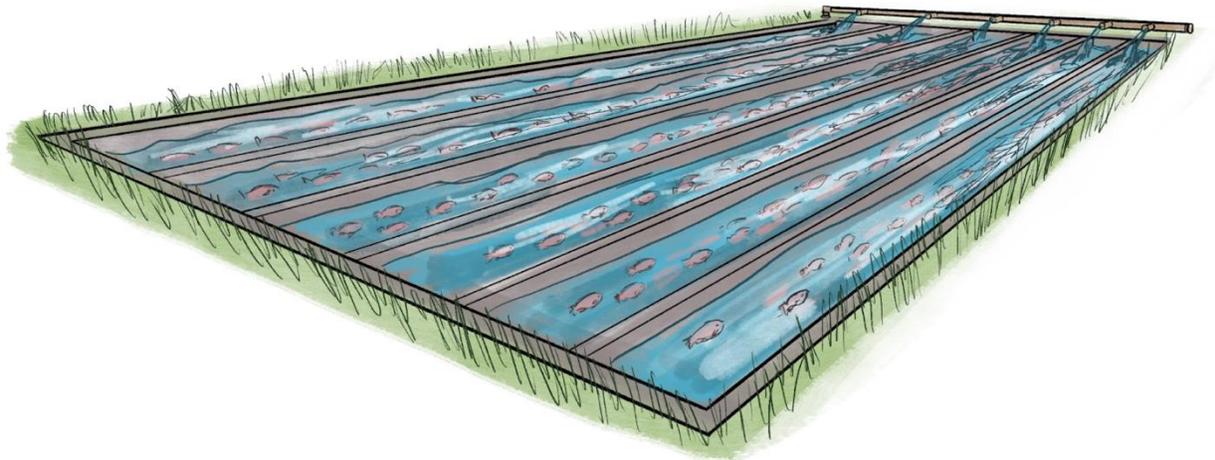


Figure 3. Example drawing of a flow-through raceway system.

Pond aquaculture

Ponds are another popular method of aquaculture production. The climate and topography of the region will determine which type of pond system is appropriate. Watershed pond systems rely on natural precipitation to keep the ponds full. In an area where the main water source is groundwater, like New York, then a levee pond may be more suitable (Whitis 2002). Levee ponds are created in areas where there is inadequate water to fill the ponds from the watershed, and groundwater is needed. For both types of ponds, it is necessary to understand the soil type, site location and the availability of good quality water.

Soil type will influence how well the ponds hold water. To build a pond, soil must contain at least 20% clay. Mud or mud-silt ponds are preferred as they prevent leakage. In New York, outside of Long Island, soil is largely made up of glacial outwash, deltaic sand, and glacial till. This is beneficial for pond producers as it is composed partially of clay, which is impermeable to water. In some cases, New York producers will use natural ponds on their property to grow out their fish. Most pond operations in New York have multiple smaller ponds in a group to ease harvesting and management needs.

Pond aquaculture is a less-intensive culture method compared to tank systems. Typically, an aerator or other aeration device is installed to make sure the pond is well oxygenated, which is especially important in the warmer months when water holds less dissolved oxygen (Figure 4).

Feed is usually dispensed through an automatic feeder in the middle of the pond. It is important to monitor the water quality of the pond to avoid anoxic (low or no oxygen) conditions or dramatic changes in the pH, ammonia or nitrites which could be harmful to the fish.

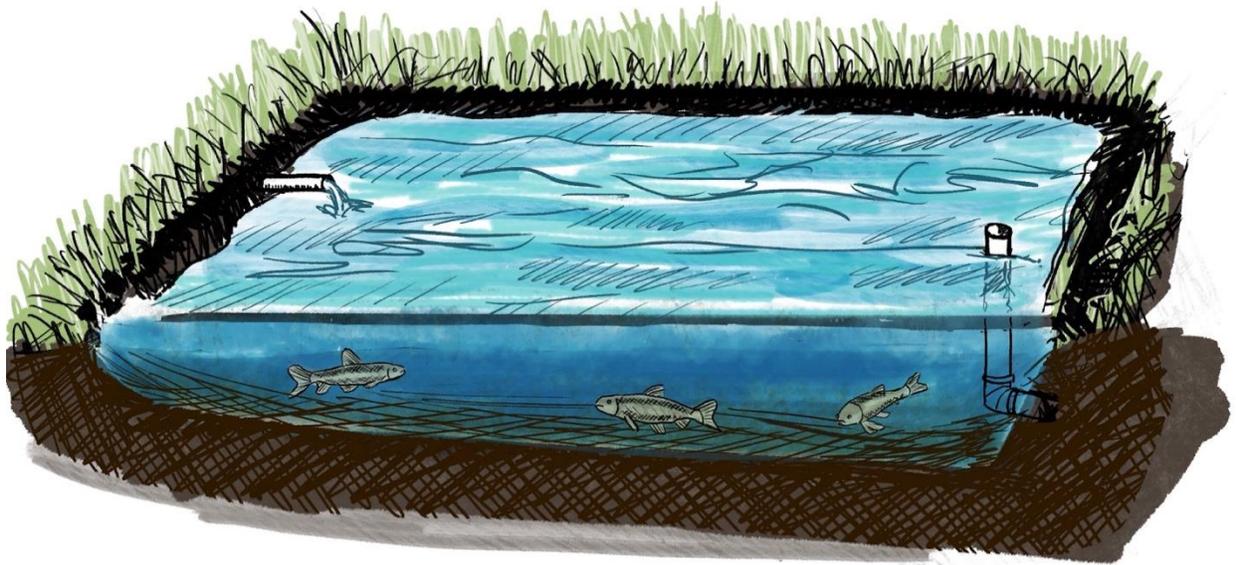


Figure 4. Example drawing of a pond system.

Aquaponics

Aquaponics is the cultivation of plants in water and without soil. This integrated system uses the effluent from a recirculating aquaculture system as a soil-less plant growth medium. In its simplest form, aquaponics circulates wastewater from the tanks housing aquatic animals through the plant beds, where nutrients are absorbed by the plants. The filtered water is then reused in the fish tank (Figure 5). This is a symbiotic relationship where the plants use the fish waste as nutrients, thus “filtering” the water to be reused. This system is similar to RAS and uses significantly less water to grow the plants and sustain aquatic life (Timmons et al. 2018).

Aquaponics can incorporate many of the same water cleaning systems as RAS. Aquaponics systems may be coupled or decoupled, with each version offering advantages and complications related to water use and recirculation. In coupled systems, plants are an integral part of the system in which nitrogen and some minerals are removed before the water is recirculated back to the fish. Decoupled aquaponics uses nutrient-laden wastewater that has been removed from the fish system to grow plants in a separate hydroponic system. In a decoupled scenario, the plant system may be the last stop for water before being released into surface waters or mixed with fresh water before being returned to the fish system.

Aquaponics shows promise as an effective and sustainable food production system, especially in urban areas. Not only can vegetables and other plants be grown in the system, but the fish may also be harvested for consumption. These systems can be used with shrimp, tilapia, trout, hybrid striped bass and other species. Aquaponics also does not require large amounts of space and can

be done entirely indoors for year-round production. There are multiple aquaponics facilities in New York City providing fish and fresh vegetables to their community. This system can also be scaled to a commercial level. Plant production is often the focus of aquaponics systems with fish used as the nutrient source and thus a means of avoiding purchase of costly fertilizers. Fish sold are frequently viewed as a cost offset rather than a main revenue source. New York has a commercial scale coupled aquaponics facility upstate producing hemp and tilapia.

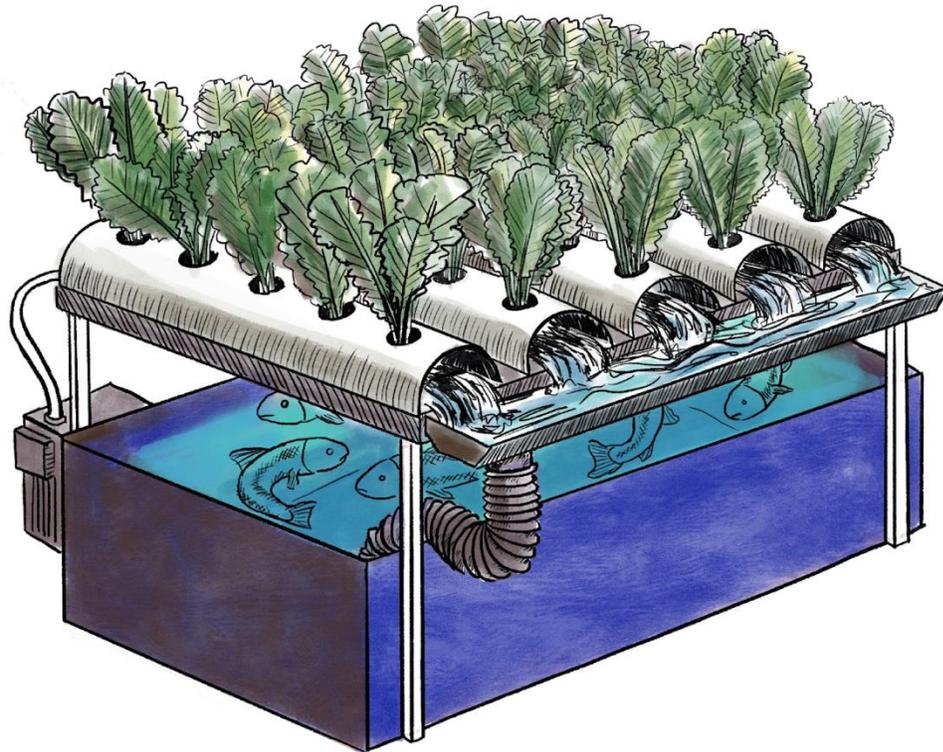


Figure 5. Example drawing of an aquaponics system.

Marine Systems

Net pens

Net pens, or cages, are used in open water areas such as offshore, coastal areas, or large freshwater lakes. “Open ocean” aquaculture refers to net pens that are further offshore, typically sited in deeper water with strong currents. “Nearshore” refers to net pens that are sited in coastal regions, closer to shore, where the currents and conditions are less severe. In both instances the net pens are in constant contact with the environment allowing water to flow freely through the system. States manage coastal waters within 3 nautical miles from land, after which federal jurisdiction takes over up to 200 nautical miles offshore. Siting of offshore aquaculture must take into consideration potential differences in regulations within state and federal management zones.

There are many varying types of net pens, from completely enclosed structures that are submersible, to systems that are open on the surface and enclosed below (figure 6). In most cases

these cages are constructed out of metal or thick polyurethane framework and anchored to the ocean floor by one or multiple points. The type of net pen used is specific for the type of environment and species being grown. For rough open water environments, submersible pens work best as they keep the fish and cages protected from wind and the most severe surface wave action. In calmer environments with more predictable weather, floating net pens are used because of their ease of access and comparatively lower cost than submerged net pens. Both systems require extensive anchoring systems and special tenders to permit crews to work with the fish.

In 2012, a small near-shore system culturing striped bass off the coast of Long Island was effectively destroyed by hurricane Sandy, and never reestablished. As of 2021, New York does not have any off-shore or near-shore aquaculture farms, although permit requests to place net pens offshore in federal waters have been submitted and are still under review.



Figure 6. Example drawing of surface net pens.

On-bottom shellfish culture

On-bottom culture of shellfish refers to the culture method where shellfish are “planted” directly onto the seafloor without any containment (i.e. no cages or bags) (Figure 7). On-bottom culture

is the closest method to the natural growth of wild shellfish. The method, however, can subject the shellfish to increased predation, rough sea conditions, or suffocation in sediment. This method has been used for decades by the Flowers Shellfish Company in Oyster Bay.



Figure 7. Example drawing of on-bottom shellfish culture (i.e. shellfish placed directly on seafloor).

Off-bottom shellfish culture

Off-bottom culture refers to the use of cages, bags, trays, or racks that are deployed on the seafloor, suspended in the water column, or raised off the seafloor (Figure 8). Floating gear, however, is not always considered off-bottom culture and is oftentimes referred to as “surface-culture”. The New York State Department of Environmental Conservation (NYSDEC) refers to both off-bottom culture and surface culture, solely as off-bottom culture.

A Floating Upweller System (FLUPSY) is a system to rear juvenile shellfish. It is typically a floating platform with barrels containing shellfish that uses a motor to pump water up through the barrels. These systems protect juvenile shellfish from predators in open water areas until they are an appropriate size to be transferred to grow-out systems, like cages or bags. The upwelling system pushes algae rich water over the shellfish and out the top of the barrel providing a constant food supply. NYSDEC permits use of FLUPSYs for nursery culture of shellfish seed under a Marine Hatchery Permit.

Bags are, in essence, mesh pockets that contain farmed shellfish as they grow out to market size. These bags provide a safe and enclosed environment for the growing shellfish and facilitate harvesting. They are also used within other types of grow-out systems (e.g., cages and racks).

Cages are large, coated metal structures that hold multiple shellfish bags and prevent them from floating away or touching the bottom and disturbing the benthic environment. Elevated cages provide more exposure to current for filter feeding than benthic placement and provide structural

protection for the shellfish in open water environments. This type of grow-out method requires a sturdy bottom to keep the heavy cages from sinking into the mud and suffocating the oysters.

The rack and bag system consists of a steel rebar structure that multiple shellfish bags are attached to. Rack and bag culture is typically used in locations where water depths allow farmers to access the systems during low tide. They are also used in deeper water to discourage pilferage and are thus raised with heavy-duty hydraulic systems for servicing.

Trays are square mesh cages that are stacked on top of each other. These structures allow the grower to slide mesh shellfish bags in and out of each cage like a “tray”. These are useful to conserve space on a shellfish farm and provide easy access for maintenance and harvesting.

Floating gear used for surface culture remains at the top of the water column, just below the surface. Using this method, shellfish are regularly agitated or tumbled by wave action and never exposed to the air. Gear is flipped regularly to prevent fouling on submerged equipment. Floating cages are a series of shelves with floats on each side that hold up mesh bags filled with shellfish.

Suspended culture systems keep the shellfish in the middle of the water column instead of resting on the bottom or floating at the top. Mesh bags are tied to a rope that is kept stable by poles placed into the seafloor. On the opposite end of where the rope is tied to the bag, is a float. The float brings the bag vertically in the water column, and the rope and poles keep the mesh bag anchored.

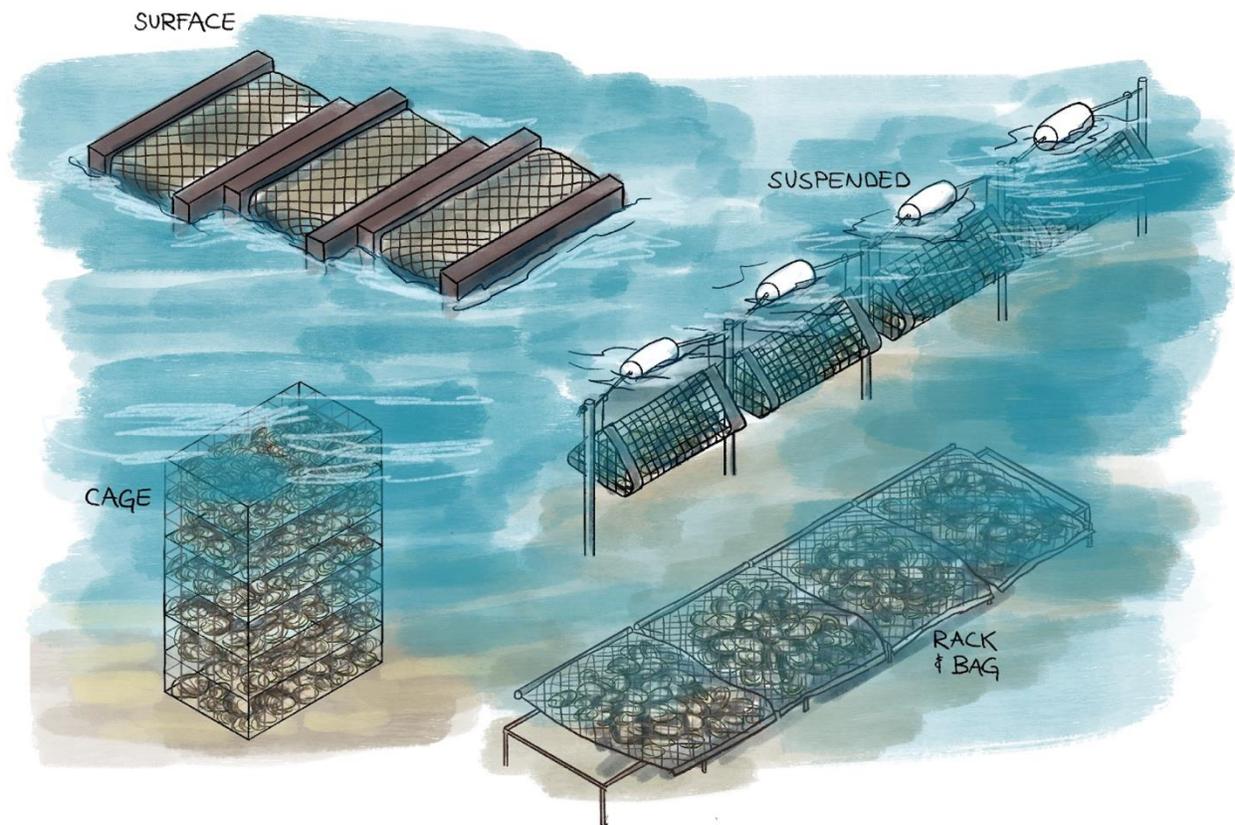


Figure 8. Example drawings of off-bottom shellfish culture (top left: surface culture, top right: suspended culture, bottom left: cage culture, bottom right: rack and bag culture).

Algae

Microalgae

Microalgae is grown for a variety of reasons such as food for other aquatic organisms or human consumption. Microalgae can be cultivated in both marine and freshwater. Microalgae for food or hatchery systems are grown as phototrophic cells or heterotrophic cells. Phototrophic microalgae is typically grown in enclosed cylindrical tanks, which are about 2-3 feet in diameter and 6-8 feet tall (figure 9). This narrow and tall design of the tanks is to facilitate light reaching all the algae cells inside, which is required by the cells for photosynthesis. Light is the limiting factor for production in this design. To maximize lighting, fluorescent or LED light banks surround the tanks, usually on vertical mounts, with additional reflective surfaces to help spread the light. In addition to light, CO₂ and nutrients are added to the tanks to support the growth of the algae. Heterotrophic microalgae production uses only an organic substrate, usually a form of glucose, as a carbon and energy source (Oliver et al. 2020). These systems are usually set up inside in controlled environments to ensure optimal temperature and light. Throughout New York, multiple hatcheries culture multiple species of microalgae in saltwater to use as feed for their shellfish. Additionally, there is a commercial scale algae operation producing spirulina in a freshwater system as a dietary supplement for human consumption.

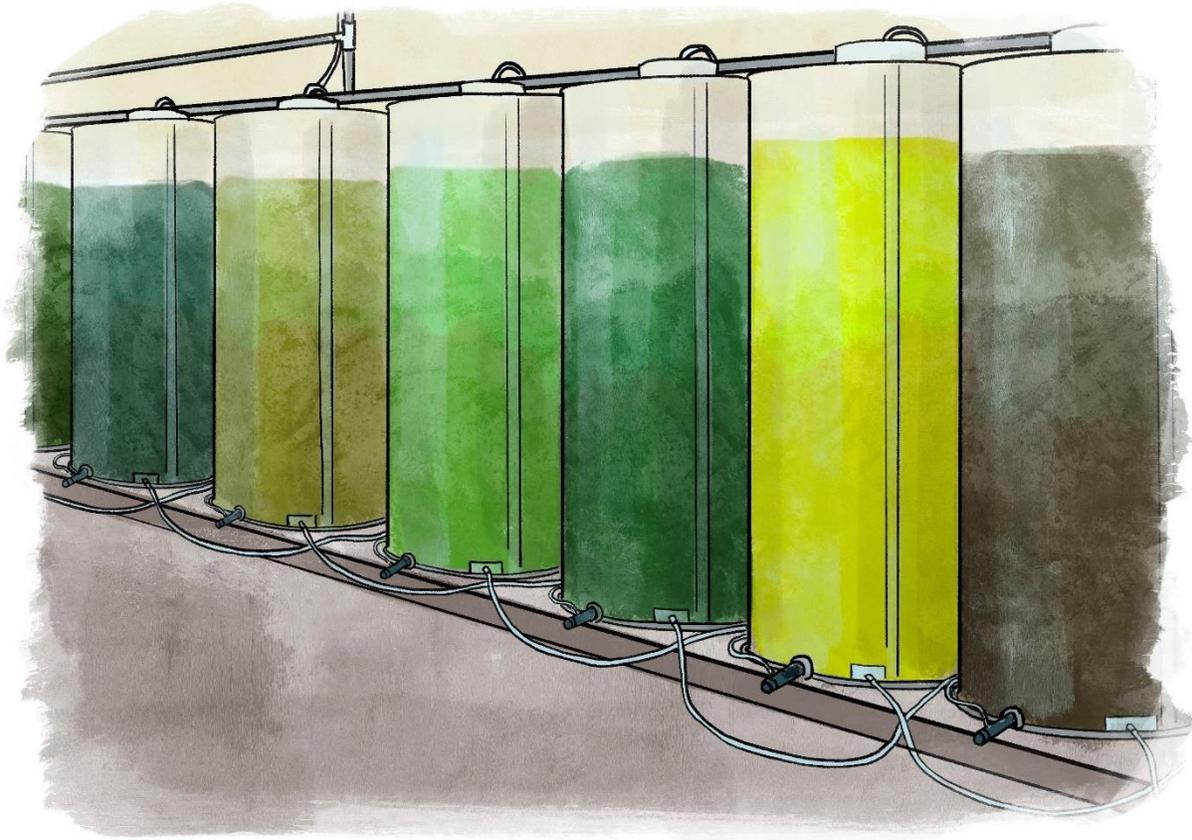


Figure 9. Example drawing of microalgae culture in cylinders.

Macroalgae

Macroalgae exist in both marine and freshwater environments, though most are cultured in marine environments. Macroalgae are divided into three major groups: brown algae, green algae, and red algae. Many cultivated species of brown algae are commonly referred to as kelp. Grow out methods require two mooring points connected by a line with smaller buoys attached throughout to keep the line afloat as the kelp grows (Figure 10). To deploy the kelp at the start of the season, a seed string with kelp sporophytes attached, is wrapped about the grow-out line, and left to grow for about six months until harvest. The lines are typically planted in early winter and harvested in April or May.



Figure 10. Example drawing of sugar kelp lines growing in open water.

Advantages and Disadvantages of Culture Systems in New

System	Advantages	Disadvantages
RAS	<ul style="list-style-type: none"> • Low water volume requirements - recycles and reuses water in system • Location - can essentially be sited anywhere with access to a quality water source • Intensive - culturing more product in a smaller volume and sometimes in a shorter period • Produce year round 	<ul style="list-style-type: none"> • High start-up capital investment • High operating costs • Labor intensive (skilled labor)

System	Advantages	Disadvantages
	<ul style="list-style-type: none"> • Controlled environment - water quality, disease management, etc. • No spread of diseased or escaped fish to local environment • Can produce non-native species • Modular - ability to expand 	
Flow-through	<ul style="list-style-type: none"> • Constant water flow - replaces oxygen, and removes nitrogen waste and CO₂ at low cost/effort • Low concentration of organism waste in effluent • Low operating costs • No escaped fish 	<ul style="list-style-type: none"> • Uses large quantities of water • Location - needs to be sited with a sufficient water source to support production • Limited/no environmental control (i.e., water quality, temperature). • Amendment of water quality not possible • Reduced FCR (Feed Conversion Ratio) as fish will swim more actively with the high flowing current - requiring more feed to meet energy demands • Difficulty expanding or changing original configuration • Water quality unevenly distributed, and thus uneven growth in raceways
Pond	<ul style="list-style-type: none"> • Low-cost startup (if producer already has the land) • Low water use once ponds are filled • Low operating costs • Low maintenance 	<ul style="list-style-type: none"> • Initial land acquisition and siting of ponds can be costly • Seasonal (dependent on outdoor temperatures) • Difficult to monitor organisms • More susceptible to predators • Little control over water quality
Net pen	<ul style="list-style-type: none"> • Free exchange of water and nutrients with the environment • Moderate/high stocking density • Easy harvest • Potential to act as a fish aggregating device 	<ul style="list-style-type: none"> • High start-up costs • High maintenance costs • Potential for disease spread to wild stocks • Potential for escapes • Potential for impacts to the benthic environment

System	Advantages	Disadvantages
		<ul style="list-style-type: none"> • Potential for nutrient loading of the environment due to effluent and waste (causing algae blooms or anoxic zones) • Floating gear/buoys at surface over large area • Potential conflict of water usage
Aquaponics	<ul style="list-style-type: none"> • Little water required; recycles and reuses water in system • Location - is space efficient and can essentially be sited anywhere • High level of nutrient utilization for plants • Diversified crops between plant and fish/shrimp • No spread of diseased or escaped fish • Can produce non-native species • Ability to expand, modular 	<ul style="list-style-type: none"> • High start-up capital investment • Expensive operating costs (labor and electricity) • Scale and efficiency more likely with professional installation/ design • Limited crops - multiple species are compatible, but overall selection is limited • Skilled labor required
On-bottom Shellfish	<ul style="list-style-type: none"> • Relatively low-cost • Low maintenance • Produces robust and hearty shells 	<ul style="list-style-type: none"> • Requires specific bottom substrate (shallow water with hard bottom) • Higher mortality of stock (predation, suffocation in mud, etc.) • Difficulty harvesting • No environmental control (e.g., temperature, dissolved oxygen) (i.e., cages, racks).
Off-bottom	<ul style="list-style-type: none"> • Faster growth compared to on-bottom bags • High survival rates • Better control of fouling (barnacles, algae, mud worms) • Improved shell shape and appearance; higher market value • Product consistency • Easy harvest 	<ul style="list-style-type: none"> • High start-up costs for equipment • Constant monitoring of equipment • Floating gear/buoys at surface • Potential conflict of water usage • Potential greater susceptibility to natural predators

System	Advantages	Disadvantages
Macroalgae	<ul style="list-style-type: none"> • Relatively low cost • Low maintenance • Lower water use conflicts due to seasonality (late fall/early winter to early/mid spring) 	<ul style="list-style-type: none"> • Fresh product typically not available year-round; short, intensive harvest and processing season • Floating buoys at surface (though due to seasonality, this may be less of an issue) • Limited markets (currently)
Microalgae	<ul style="list-style-type: none"> • Low-cost start-up (for some systems) • Low water use requirement • Low maintenance 	<ul style="list-style-type: none"> • Extensive knowledge of algae species being cultured required • Skilled labor required • Expensive operating costs (especially electricity) • Delicate system (water quality, contaminants, temperature, etc.)

Aquaculture Regulations in New York

This section was written with the most current information available in October 2022, but permit requirements are subject to change. To ensure an individual is complying with all regulations and requirements, always check with the managing agency.

Land-based Aquaculture Regulations

The New York State Department of Environmental Conservation (NYSDEC) requires specific permits for the use and discharge of water, and the culture, possession, transport, and stocking of freshwater organisms for the purpose of sale or consumption in the state.

NYSDEC's authority over water discharge and SPDES is established in Environmental Conservation Law §17-0803. NYSDEC, by rule and regulation, require that every applicant for a permit to discharge pollutants into the waters of the state shall file such information and request a permit to perform activities.

NYSDEC's authority over water withdrawal within the state is established in Environmental Conservation Law §15-1501. This law requires all agricultural water withdrawal systems with the capacity to withdraw 100,000 gallons per day or more ("threshold volume") to obtain a Water Withdrawal Permit.

The State requires a fish health certificate for all live fish being placed into water bodies of the State or with the purpose of possessing, selling, offering for sale, bartering, importing, or transporting fish, unless such fish are accompanied by a fish health certification report issued

within the previous 12 months as established by the Fish health certification report law - 6 CRR-NY 188.1.

Environmental Conservation Law §11-1909 grants the Department authority in its discretion to issue any person a hatchery permit, valid during the calendar year of issue, to propagate, raise and sell trout and black bass.

New York Consolidated Laws, NYSDEC, as established by Environmental Conservation Law §11-1911, may issue to the owner or lessee of a farm fish pond a license, effective for a period of five years, entitling the holder to manage such fish ponds to produce fish.

Shellfish and Seaweed Regulations

The New York State Department of Environmental Conservation (NYSDEC) requires a permit for the culture of marine organisms for the purpose of commercial sale or consumption. The Department's authority over aquaculture is established in §13-0316 (marine hatcheries; off-bottom and on-bottom culture; permits) of New York's Environmental Conservation Law (ENV) and Part 48 (Marine Hatcheries, On-Bottom and Off-Bottom culture Of Marine Plant and Animal Life) in Chapter 1 (Fish and Wildlife), Title 6 (Conservation [A]) of the State's Official Compilation of Codes, Rules, and Regulations (NYCRR).

The NYSDEC authority permits aquaculture in designated underwater parcels of land, most leased from the state, county, or town. These include state-owned underwater lands ceded to Suffolk County, municipal-controlled underwater lands in the towns of Islip and Brookhaven, as well as temporary marine area use assignments of state-owned underwater land.

When the New York State legislature ceded control of the state-owned underwater lands in Peconic & Gardiners Bays to Suffolk County for leasing, it was specifically for shellfish cultivation only (§13-0302). However, in 2021 §13-0302 was amended to allow for a pilot sugar kelp research and development program, allowing up to five current shellfish leases to use one acre of their site to participate in coordination with Stony Brook University. Sugar kelp research and development began in December 2020 and will run through 2023. As of 2020, five shellfish producers are participating in the study to learn of sugar kelp's suitability in state waters. Senate Bill S6532A, the 'Kelp Bill', was introduced in 2020 to include commercial seaweed cultivation in Gardiners and Peconic Bays, which are leased out under the SCALP program. The bill was signed by Governor Hochul in 2022 to allow for the cultivation of sugar kelp in Gardiners and Peconic Bays.

Additionally, seaweed cultivation on municipal-controlled underwater lands, in the towns of Islip and Brookhaven, is different from that of the state-owned underwater lands, and those ceded to Suffolk County. Brookhaven has amended their town code aquaculture chapter to include non-invasive marine plants in addition to shellfish (<https://ecode360.com/32377484>). Islip currently includes seaweed cultivation in the Bay Bottom Program leases and is in the process of updating its Town Code to include seaweed.

Both commercial shellfish and seaweed cultivation require aquaculture permits or approvals from NYSDEC, NYS Department of State, the United States Coast Guard (USCG), the United States Army Corp. of Engineers (USACE), and the New York State Department of State (NYS DOS). That permit authorizes the cultivation, harvest and sale of shellfish or seaweed as a mariculture product. The post-harvest management of seaweed products (handling, distribution, processing, storage, food safety, etc.) will be regulated by New York Agriculture and Markets (AGM) or Department of Health (DOH) depending on its end use.

Organism Health in Aquaculture³

Aquatic organism health in aquaculture should be the paramount concern of all producers and allies. Without healthy organisms, there cannot be a sustainable industry. Organism health is a constellation of parameters including the quality of the environment, the wellbeing of the organism, and exposure to infectious and/or toxic agents.

Currently, New York state has one clearly defined and publicly available regulation regarding the health of aquatic organisms in aquaculture and it deals directly with the release of live finfish into state waters; 6 CRR-NY 188.1-188.2. The release of these fish must be accompanied by a Fish Stocking Permit and a Fish Health Certification Report. Such a report must confirm that the fish being released into state waters are free of the following diseases and disease organisms: Viral Hemorrhagic Septicemia (VHS), Spring Viremia of Carp Virus, Furunculosis, Enteric Red Mouth, and Infectious Pancreatic Necrosis (IPN) and that all fish in the family Salmonidae are disease free of whirling disease, infectious hematopoietic necrosis virus (IHN), and *Renibacterium salmoninarum* (bacterial kidney disease). NYSDEC does have a “Policy on the Acceptable Origin of Shell and Shellstock for Introduction in New York Waters”; in this policy it is stated, “Health Certification required prior to issuance of a permit for importation of shellfish into New York. The applicant must submit a Health Certification from an approved Shellfish Pathologist or Veterinarian which provides disease screening for *Haplosporidium nelson* (MSX), *Perkinsus marinus* (Dermo), *Juvenile Oyster Disease* (JOD), *Haplosporidium costale* (SSO), *Quahog Parasite Unknown* (QPX) and other economically and ecologically important pathogens.”

New York has no publicly available resources regarding the management of health status for finfish, crustaceans, or seaweeds used in aquaculture and not intended for release into state waters, i.e., seafood.

New York Fish Health Regulations can be found: <https://www.dec.ny.gov/outdoor/33072.html>

³ This section was written by:
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Out-of-State Requirements Impacting New York’s Aquatic Organism Health in Aquaculture

Although New York does not promulgate specific criteria for the health status of aquatic organisms that are not freshwater finfish being released into the water of New York there are health requirements that must be adhered to. Part 48.3(b)(4)(viii) Chapter I - Fish and Wildlife in New York State Dept. of Environmental Conservation Law requires an importation permit prior to transporting any marine animal or plant into the state for cultivation. Further, this requires a pathology report indicating the organisms are free of pathogens of known significance. This is covered under the broad description of the law and does not specifically list out pathogen testing requirements. Other states and nations do list specific requirements for the importation of live aquatic organisms from New York, or other states for both freshwater and marine species.

It is not within the scope of this publication to expound upon all the individual differences in the state and international requirements, as they are quite varied and fluid in their specificity. Should a New York producer seek to send live organisms out of state, they would need to reach out to an aquatic health specialist in the state or contact the appropriate state department to ensure all requirements are being met.

International shipments of live aquatic organisms have the same variability and fluidity regarding specific health testing requirements, but in this instance a recommendation can be made more concisely. The United States Department of Agriculture (USDA) has purview over aquatic organism health in the United States, and most, if not all nations recognize the USDA as the competent authority in these matters. Additionally, the USDA uses the method of accreditation of veterinarians to extend their reach out to the farm level, and as such when you are considering shipping internationally the best course of action is to contact an accredited aquatic veterinarian, to both act as a liaison with the USDA, and support your health testing and certification of your stock.

New York State Methods of Aquatic Organism Health Management

Though New York has very few aquatic organism health regulations, it is not without options in meeting in-state, interstate, and international commitments to aquatic organism health. When describing the resources that exist in and around the state it is important to consider the two main ways that New York acquires aquatic organism health support. The first way is clinical, on-farm, ongoing health management and second is diagnostics and certification. Below are the four current, as of 2022, options for aquatic health management:

1. Private Veterinarians

In New York private veterinarians can play multiple roles in aquatic organism health from on-farm clinical assessments, disease diagnostics, disease management and if USDA accredited, they could support health certifications for international shipments.

- American Association of Fish Veterinarians: <https://fishvets.org/find-a-fish-vet/>

2. Academic Institutions

The two main academic institutions in New York that have aquatic organism health programs are Cornell University’s College of Veterinary Medicine; Aquatic Animal Health Program, and Stony Brook University School of Marine and Atmospheric Sciences; Marine Animal Disease Laboratory.

- Cornell College of Veterinary Medicine: <https://www.vet.cornell.edu/departments/microbiology-and-immunology/research-areas/aquatic-animal-program/fish-disease-diagnostic-laboratory>
- Stony Brook University Marine Animal Disease Laboratory: <https://you.StonyBrook.edu/madl/>

3. The NYSDEC has two fish health specialists that work mainly out of the Rome, NY Fish Disease Control Center to assist the NYSDEC hatcheries in their health management and compliance with the Great Lakes Fishery Commission list of pathogens. One important aspect of the DEC health program is that it does not work with any private aquaculture and will only support state and municipal projects.

- Rome Fish Disease Control Center: <https://www.dec.ny.gov/outdoor/7742.html>

4. Out-of-State and Regional Resources

There are several resources available to aquaculturists outside of New York. Some of these are private diagnostic labs, other state labs, or university labs.

- Fish and Wildlife Service: <https://www.fws.gov/program/aquatic-animal-health/what-we-do>
- USDA: https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/lab-info-services/CT_Laboratory_Information_Services
 - List of USDA approved out of state facilities to conduct health testing: https://www.aphis.usda.gov/animal_health/lab_info_services/downloads/ApprovedLabs_Aquaculture.pdf

As mentioned, the USDA has purview over aquatic organism health in the United States and provides a National List of Reportable Animal Disease (NLRAD). The World Organization for Animal Health (OIE) has developed a list of aquatic animal diseases to create transparency in global animal diseases. Each organization maintains an active list of manageable diseases and works together to coordinate international, national, and state sale and trade of aquatic species (Table 7).

Table 7. Compares regulated aquatic diseases by New York State, the United States Department of Agriculture’s NLRAD, and the World Organization for Animal Health (OIE). Checkmarks indicate it is included in the health plan and Xs indicate it is not.

Disease	Species	Agent	NYS	USDA	OIE
Viral Hemorrhagic Septicemia (VHS)	Finfish	Rhabdovirus	✓	✓	✓

Disease	Species	Agent	NYS	USDA	OIE
Bacterial Furunculosis	Finfish	Bacteria	✓	X	X
Enteric Red Mouth (ERM)	Finfish	Bacteria	✓	✓	✓
Infectious Pancreatic Necrosis (IPN)	Finfish	Birnavirus	✓	X	X
Spring Viremia of Carp (SVC)	Finfish	Rhabdovirus	✓	✓	✓
Whirling Disease	Finfish	Parasite; <i>Myxobolus cerebralis</i>	✓	✓	✓
Bacterial Kidney Disease (BKD)	Finfish	Bacteria; <i>Renibacterium salmoninarum</i>	✓	X	✓
Infectious Hematopoietic Necrosis (IHN)	Finfish	Rhabdovirus	✓	✓	✓
Infectious Salmon Anemia HPR-deleted	Finfish	Orthomyxovirus	X	✓	✓
Infectious Salmon Anemia HPR-0	Finfish	Orthomyxovirus	X	✓	✓
Epizootic hematopoietic necrosis disease	Finfish	Ranavirus	X	✓	✓
Epizootic ulcerative syndrome	Finfish	Fungus; <i>Aphanomyces invadans</i>	X	✓	✓
Gyrodactylosis	Finfish	Parasite; <i>Gyrodactylus salaris</i>	X	✓	✓
Red sea bream iridoviral disease	Finfish	Iridovirus	X	✓	✓

Disease	Species	Agent	NYS	USDA	OIE
Koi herpes virus	Finfish	Herpesvirus	X	✓	✓
Salmonid alphavirus	Finfish	Alphavirus	X	✓	✓
Tilapia Lake Virus	Finfish	Amnoonvirus	X	✓	✓
<i>Bonamia ostreae</i>	Shellfish	Parasite	X	✓	✓
<i>Bonamia exitiosa</i>	Shellfish	Parasite	X	✓	✓
<i>Marteilia refringens</i>	Shellfish	Parasite	X	✓	✓
<i>Perkinsus marinus</i>	Shellfish	Parasite	X	✓	✓
<i>Perkinsus olseni</i>	Shellfish	Parasite	X	✓	✓
<i>Xenohaliotis californiensis</i>	Shellfish	Parasite	X	✓	✓
abalone herpes virus	Shellfish	Herpesvirus	X	✓	✓
Taura virus	Crustacean	Aparavirus	X	✓	✓
White Spot disease	Crustacean	Whispovirus	X	✓	✓
Necrotizing Hematopancreatitis (NHP)	Crustacean	Bacteria; rickettsial-like	X	✓	✓

Disease	Species	Agent	NYS	USDA	OIE
Yellowhead disease	Crustacean	Yellow head virus	X	✓	✓
Infectious Hypodermal and Hematopoietic necrosis (IHHN)	Crustacean	Parvovirus	X	✓	✓
Crayfish Plague	Crustacean	Fungus; <i>Aphanomyces astaci</i>	X	✓	✓
Infectious myonecrosis (IMN)	Crustacean	Totivirus	X	✓	✓
White Tail disease	Crustacean	Nodavirus (<i>MrNV</i>) and extra small virus (<i>XSV</i>)	X	✓	✓
Acute hepatopancreatic necrosis disease	Crustacean	Bacteria: <i>Vibrio parahaemolyticus</i>	X	✓	✓

Marketing, Processing, and Seafood in New York⁴

New York is home to the Nation’s largest, and oldest, consortium of seafood wholesalers and second largest wholesale seafood market in the world, The Fulton Fish Market. After 180 years of operating out of Manhattan’s downtown financial district, the market moved to a newly built state of the art facility in the Bronx, now re-named The New Fulton Fish Market. With millions of pounds of seafood passing through its doors daily, the market handles nearly 1/3 of the State’s seafood demand. While The Fulton Fish Market represents the largest, there are over 280 seafood wholesalers in New York and 21 processing plants handling wild caught and aquaculture seafood from in and out of the state (Fisheries of the United States 2019).

Marketing/Sales

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There are many avenues of sale for farmed seafood products in New York. Seafood is mostly sold directly to dockside buyers and brokers who handle much of the sales and marketing to other wholesale and retail outlets locally, nationally, and internationally. These buyers tend to aggregate products for large scale commercial sale and rarely brand and associate their products with an individual fisherman or farm. Producers interested in creating a brand and market specifically for their product typically must explore alternative marketing strategies, which bypass the large commercial brokers and buyers and target wholesale and retail markets or consumers directly. These markets can include selling directly to processors, retail outlets, restaurants and foodservice establishments, institutions, and consumers. While this can afford producers more control and the opportunity to build a brand for their products, it requires more time, effort, skills, and resources to succeed. To access these markets producers typically must do more processing and handling of their seafood, which warrants additional regulatory oversight and compliance with Seafood Hazard Analysis Critical Control Point (HACCP) regulation and many other more general food safety regulations that are enforced on the federal and state level. The seafood HACCP regulation requires facilities to develop and implement HACCP plans to introduce preventive controls for potential food safety hazards and ensure seafood is being handled, stored, and distributed safely. In addition to an effective seafood HACCP plan, all food facilities must comply with current good manufacturing practices (GMP's), implement effective Sanitation control procedures (SCP's), and comply with a variety of other prerequisite programs (i.e. food labeling) that vary depending on the facility and products produced.

Processing

Currently the primary form of seafood processing that occurs in New York is the basic cleaning, gutting, and filleting of fish to its most marketable forms (fillets and steaks). New York has a few aquaculture operations that process their own fish. There are also several smokehouses operating in New York, and new and emerging facilities working towards the production and sale of value-added seafood products (fish and seafood cakes, soups, salads etc.). Because of the highly perishable nature of seafood, facilities that help to extend the shelf life of the products and maintain them safely could be an asset to the New York seafood industry. NYSG has published multiple regulatory guides to assist producers in processing and marketing of their seafood products (see Resources Section).

Constraints of the state

The market for seafood throughout the state is highly competitive, bringing in seafood from around the world, with more than 280 wholesale fish markets including the second largest globally. Locally sourced products, while geographically closer to the markets, must compete against the lower cost products coming in from larger commercialized operations across the country and overseas. The many smaller scale operations that make up the New York seafood industry cannot grow, harvest, and process products without significant overhead costs associated with strict harvest and food safety regulations, infrastructure and facilities costs, labor costs, and local transportation constraints. The bottom line is that New York produced seafood costs more. In addition to the higher cost of producing, harvesting, and processing seafood in

New York, many of the locally abundant species are not the most consumed and recognized by American consumers. Of the top ten most consumed seafoods in the U.S., five of them are or have been farmed for consumption in New York. These include shrimp, tilapia, catfish, salmon, and clams (Table 8). All but salmon are produced on small farms or in small scale operations with limited capacity to infiltrate the saturated New York seafood market.

Table 8. Top 10 seafood species consumed in the US. Blue highlighted boxes indicate species currently cultured in NY. Yellow highlighted boxes indicate previously cultured species in NY. Cultured species highlighted are to the best of the author's knowledge. Consumption was calculated by the National Fisheries Institute using NOAA's Fisheries of the United States Report.

Top 10 Seafood Species Consumed in the US	
1	Shrimp
2	Salmon
3	Canned Tuna
4	Alaska Pollock
5	Tilapia
6	Cod
7	Catfish
8	Crab
9	Pangasius
10	Clams

Another major challenge facing New York producers is the lack of infrastructure facilitating the transportation and processing of seafood products safely and in accordance with current food safety regulations. As highly perishable food products, it is important to maintain the cold chain when transporting seafood products to market. Lack of adequate transportation infrastructure makes it difficult for farmers to get their products to many markets throughout the state, even just from Long Island to New York City. This is especially challenging for the small-scale producers who cannot afford to invest in their own cold-chain logistics. These logistical difficulties extend beyond state borders into the region. Producers both in and surrounding New York should be aware of logistical difficulties if including the New York State or New York City markets in their business plan.

Effective marketing necessitates seafood products being accessible to buyers. In many cases, live whole seafoods are not marketable. This was especially apparent during the 2020 COVID-19 pandemic when foodservice establishments shut down and consumers were in search of products to prepare at home. To extend the shelf life of New York seafood and broaden the market for local products, local producers need access to facilities that allow processing of seafoods into marketable forms like fillets and steaks or value-added products like salads, dips, soups, stews, or breaded and battered, etc. Access to refrigerated and frozen storage facilities, processing

facilities, and modern freezing technologies, would afford the industry a more robust and resilient marketing strategy for New York farmed products.

Extension

Extension services in New York help connect citizens, community and government leaders, and industry together, providing resources to support the growth and development of those industries, and help to create a path forward in changing climates. New York currently has two organizations that support complementary aspects of aquaculture extension: New York Sea Grant and Cornell Cooperative Extension of Suffolk County.

New York Sea Grant

Since 1971, New York Sea Grant (NYSG) has represented a statewide network of integrated research, education and extension services promoting coastal community economic vitality, environmental sustainability and citizen awareness and understanding about the State's marine and Great Lakes resources.

NYSG has worked to support the aquaculture industry through the creation of a variety of resources focused on both production and post-production. The annual Seafood Summit, established in 2016, works to bring the seafood industry, including aquaculture members, together to solve problems, make connections and learn. More recently multiple task forces, including the Seaweed Processing and Marketing Task Force and Seafood Processing and Marketing Taskforce, have been established to aid in navigating regulatory requirements for processing and marketing seafood in New York. For over two decades, New York Sea Grant has provided seafood Hazard Analysis and Critical Control Points (HACCP) Training.

In 2020 NYSG hired an Aquaculture Specialist to develop efforts to support the industry. Since then, multiple public events have been held show-casing New York's aquaculture products to consumers in efforts to expand knowledge and understanding about aquaculture in the state. From this hire this report along with an industry wide needs assessment as been published. A Shellfish ECourse, designed to assist interested farmers in understanding the necessary requirements for starting a shellfish farm in the state, was launched in 2021. NYSG also developed multiple curricula for teachers to use in their classrooms focusing on aquaculture and seafood. NYSG is active in multiple Hubs, funded through the National Sea Grant Office, including the: Hard Clam Hub, Seaweed Hub, Striper Hub, and the Great Lakes Aquaculture Collaborative.

NYSG also currently, and over several years, is and has supported several diverse aquaculture research projects which have played a significant role in advancing the aquaculture industry. You can learn more about funded research projects visit: <https://seagrant.sunysb.edu/articles/t/focus-on-research>

To learn more about New York Sea Grant visit: www.nyseagrant.org/aquaculture

Cornell Cooperative Extension of Suffolk County

Cornell Cooperative Extension of Suffolk County puts knowledge to work in pursuit of economic vitality, ecological sustainability, and social well-being. With offices in every county of the state, they bring local experience and research-based solutions together, helping New York state families and communities thrive in our rapidly changing world.

As of 2021, CCE Suffolk County is the only CCE program focused on aquaculture extension, specifically shellfish and seaweed aquaculture. The overall goal of CCE's Aquaculture Program is to help ensure that shellfish populations remain healthy and sustainable so that commercial harvesting and commercial harvesting can continue and remain profitable, preserving this unique and historical way of life that Long Island is known for. CCE is one of the only groups on Long Island that works directly with commercial and non-commercial culturists, giving them the tools and information, they need to master culturing techniques. CCE also conducts applied research with local, state and federal funding to help solve problems and increase production and works with Long Island towns to reseed shellfish areas to keep populations sustainable.

CCE offers the Suffolk Project in Aquaculture Training (SPAT) program. This program was created to help teach volunteers and members about aquaculture and have them actively participate in the culture of oysters. Volunteers and members can participate in monthly workshops and are given shellfish seed and the necessary tools and supplies to grow their own shellfish, either in their own waters or in the SPAT community garden. In exchange for a minimal fee, all permits are secured, and members may keep their oysters for their personal use but are not permitted to sell them. In addition, volunteers also help produce shellfish to seed the bays. SPAT volunteers and members grow shellfish until they reach adult size and release them into local creeks and bays to spawn and promote wild settlement. Volunteers maintain their own hatchery and nursery, giving them ownership over what they are learning. As of 2021, over 1,000 volunteers have taken part in the program, with numbers of participants increasing each year.

To learn more visit: <http://ccesuffolk.org/marine/aquaculture>

Gaps and Recommendations

New York has long recognized the opportunities presented by the aquaculture industry but has been slow to respond to changes or recommendations. In May of 1983 Governor Mario Cuomo signed the Aquaculture Planning Act which requested a study be done by New York Sea Grant and Cornell University to develop a plan for New York Aquaculture and understand its potential for the state.

The 1985 Sea Grant report identified a variety of factors (Table 9), addressed below, but overall stated: *Constraints on orderly development of aquaculture tend to be political and administrative, rather than scientific and technological... Development of aquaculture in general has been constrained by public support.*

In 1988 Michael J. Bragman (then chairman of the Assembly of Agriculture Committee) submitted a special report “Aquaculture in New York State: Technology, Research and Economic Development Prospects” to the New York Speaker of the Assembly, Mel Miller. The Bragman report recommended:

- Regulatory changes,
- Increased extension support and technical information,
- Development of an advocacy group for market structure development,
- Development of cogeneration projects, and
- State financing of aquaculture expansion (access to capital).

New York Sea Grant held conferences in both 1986 and 1999 to address constraints and opportunities for New York Aquaculture. Some progress has been made since the Bragman report; however, the aquaculture industry has remained relatively stagnant in New York.

In January 2021, NYSG conducted a needs assessment to better understand the New York aquaculture industry, its more recent constraints, and opportunities for growth. This assessment was done to establish what specific support is required for the New York aquaculture industry’s success. Despite the diversity of the products produced in New York, similar needs were identified across all types of operations; finfish, shellfish, and seaweed (Table 9).

Table 9. Recommendations from the 1986 Sea Grant report and the 2021 Sea Grant Needs Assessment Key Topics

New York Sea Grant Report 1986 Recommendations
<ul style="list-style-type: none">• Establish a policy in support of aquaculture development in New York State;• Define aquaculture as agriculture under the New York State Agricultural Districts Law;• Define aquaculture as agriculture under Freshwater Wetlands Law;• Amend special state statutes authorizing some Long Island Towns to lease town-owned lands for shellfish cultivation including leasing for finfish and plant aquaculture;• Clarify the allocation of regulatory powers among state and local governments regarding control over local navigable waters;• Provide guidance as to the town zoning authority over state-owned underwater lands leased for aquaculture in New York State of Suffolk County;• Reconcile section 32 of the New York State Navigation Law and section 15-0503 of New York Environmental Conservation Law which addresses permitting of construction of docks and other structures in the waters of New York State to clarify their authority and scope regarding which waters and what structures are covered under each law;• Enact legislation to set tough penalties for theft of aquaculture produce or destruction of aquaculture facilities;• Strengthen the capabilities of existing technology transfer programs such as Sea Grant Extension Program and the Cooperative Extension Service to better serve aquaculture. The capability of these programs to provide for demonstration scale projects should be the objective of this strengthening;

-
- Agencies need to collect and make available information about the aquaculture industry including total business, production, and years in operation;
 - Establish an industry-government advisory panel to advise the state in developing aquaculture;
 - Establish a revolving loan fund for aquaculture start-up capital;
 - NY Ag. and Markets needs to undertake the responsibility as the lead agency for promotion of aquaculture and promote New York as a place for aquaculture development ;
 - NY Ag. and Markets needs to appoint an ombudsman to assist aquaculturists in obtaining permits and provide information about undertaking aquaculture in New York;
 - NY Ag. and Markets needs to take the lead in assisting to petition the federal crop insurance corporation for coverage of their specific crop;
 - NY Ag. and Markets needs to collect and analyze and make available information about aquaculture products in the market;
 - NY Ag. and Markets needs to assist interested aquaculturists to establish producer cooperatives;
 - NY Ag. and Markets needs to assist New York aquaculturists in setting, advertising, and maintaining quality standards.

New York Sea Grant 2021 Needs Assessment Findings

- Streamline regulations and permitting, and less regulatory burden (cost and complexity);
 - Changing state laws to allow for more diverse crop opportunities (i.e., seaweed)
 - Workforce development;
 - Community and local support of aquaculture businesses;
 - Consumer education about aquaculture;
 - Business development assistance (financial, marketing, communication);
 - Develop aquaculture/seafood infrastructure (i.e., logistics, cold storage, feed, processing facilities, etc.);
 - Development of nutrient/carbon credit program;
 - Increase formal aquaculture education, curricula for high schools and degree programs at colleges;
 - Unified aquaculture network;
 - Reinstate the New York Aquaculture Association;
 - Increase capacity for in-state diagnostics of aquatic animal health.
-

The 1985 New York Aquaculture Report had specific recommendations, while the 1988 recommendations and the 2021 Needs Assessment findings were broad. There is, however, a great deal of overlap between all three documents citing regulatory changes and advocacy, community support, increased extension and education support, and financial aid. Overall, the recommendations/findings identify the need for support of the industry from state government agencies and local communities.

Further, New York Sea Grant and Cornell Cooperative Extension of Suffolk County hosted an Aquaculture roundtable in 1998 in Port Jefferson, New York. From these discussions two recommendations were made to support the growth of the industry:

1. “Aquaculture promotion is working in many other states. New York is flat. We don’t do enough in New York State. There is no agency active and supportive of the industry to promote it. New York State needs to promote its aquaculture products.”
2. “Policy – there is no policy in New York saying that it is something important to the state to promote. There needs to be an aquaculture specific policy.”

These two points specifically were discussed in the 1984 report, the 1988 recommendations, and again 23 years later during the needs assessment discussions. Currently, there is no state agency that promotes and supports the industry, giving it the footing and backing it needs to continue to grow. Specifically, the industry would benefit greatly from an agency that will advocate for aquaculture’s rights and promote its products alongside other valued agricultural products.

Regulations

Status and gaps

New York is the only state that touches both the Great Lakes and the Atlantic, giving it incredible opportunities for both marine and freshwater aquaculture. However, much of the state’s aquaculture industry is located on Long Island and focuses on shellfish. As stated previously, New York has a history of land-based freshwater operations, but those have dwindled over the years. Permitting and regulatory requirements are a challenge, especially for fish producers.

NYSDEC is the current permitting agency for aquaculture operations in New York. Beyond permits it has no further responsibility for industry promotion or support of its products. The NYSDEC Division of Marine Resources is responsible for permitting shellfish aquaculture and marine hatcheries. NYSDEC Special Licenses and Fish and Wildlife are responsible for the variety of aquaculture permits needed to culture species of freshwater fish inland. Substantial progress has been made from the 1985 New York Aquaculture Report in terms of the creation of Long Island town and county leases, and clarification of regulatory powers related to leasing underwater lands. The NYSDEC Division of Marine Resources has also recently created a streamlined and easy to understand permitting process by creating a permit that clearly outlines all necessary NYSDEC permits, as well as other agency permits like the U.S. Coast Guard and United States Army Corp. of Engineers (USACE).

However, NYSDEC Special Licenses and Fish and Wildlife do not yet have a cohesive and easily understandable permitting system or guide for freshwater, or land-based aquaculture operations. This is partially due to the uniqueness of each aquaculture facility and each site’s unique siting and permitting needs. Additionally, because inland aquaculture permits cross three NYSDEC departments: Special Licenses, Fish and Wildlife, and Division for Environmental Permits, there is not one department that oversees all aquaculture permitting and siting for land-based freshwater systems. This is where a designated department for aquaculture would benefit the industry and ease the regulatory burden.

Additionally, a recurring concern with fish producers from the NYSG 2021 Needs Assessment is the expense of Fish Health Certificates. Fish Health Certificates are a regulatory requirement to possess, sell, offer for sale, barter, import or transport live fish, or place fish into a New York State body of water. This is an important regulation ensuring that New York's fish and waterways remain healthy and disease free. However, when first implemented the State absorbed the cost for both private and state facilities needing their fish tested to run their businesses and facilities. Currently, each private facility must pay to have their fish tested prior to importing or selling, which requires the producer to send their fish out of state, since New York does not have its own testing facility. The cost of this testing ranges from \$2,000-\$3,000/year which can be a prohibitive cost for small farms. The state hatcheries receive their testing within the state hatchery system, with fees covered by the state.

Recently, there have been efforts to advance the aquaculture industry and change the regulatory framework with the introduction of Senate Bill S4718A and Senate Bills6532A.

- ◇ Senate Bill S4718A is to establish a mollusk shell recycling tax credit in New York. This bill was originally introduced in 2017-2018, then reintroduced in 2021-2022. This would allow for a mollusk shell recycling tax credit program. This bill directs the NYSDEC to promulgate necessary regulations. As of October 2022, this bill is in committee.

The tax credit program would allow no more than \$1,000 or 10 cents multiplied by the number of pounds of bivalves recycled as certified by the NYSDEC. Many farmers across Long Island save and recycle their shells. With most of the New York industry composed of small-scale producers, this shell recycling incentive can have a substantial impact on these businesses and the environment.

- ◇ Senate Bills6532A is to permit kelp cultivation in underwater lands at Gardiner's and Peconic bays. This bill was introduced in 2021- 2022. The modification to Suffolk County leases for underwater lands ceded to it by the state in Gardiner's and Peconic Bays would allow for the permitting of kelp in those lease sites. As of January 2022, this bill has been signed by the Governor.

This affords Suffolk County leaseholders an opportunity to diversify and expand their businesses. Other lease sites in the Town of Brookhaven and the Town of Islip allow for seaweed culture, not just specifically kelp, on their lease sites.

As stated, once a farm is operating and has received their permits, there is no agency to provide designated support and guidance for the aquaculture farm, and promotion of those products. With all other agricultural products, this falls to New York Agriculture and Markets (AGM) and AGM is likely best suited to support statewide aquaculture promotion, though this is not currently part of their operations. Two recommendations from the 1985 New York Aquaculture Report that would assist in supporting the aquaculture industry were:

1. Define aquaculture as agriculture under the New York State Agricultural Districts Law. Current: Agricultural and Markets Law: A fish farm is not used for agricultural production within the meaning of Article 25AA of the Agriculture and Markets

Law. This law was last updated in 2017.

2. Define aquaculture as agriculture under Freshwater Wetlands Law
Current: Does not include aquaculture as agriculture. This law was last updated in 1997.

The gaps in support of the industry from state agencies is not a new issue, but it was further highlighted by the New York Farm Bureau, a non-governmental, volunteer organization with the purpose of solving economic and public policy issues challenging the agricultural industry. The New York Farm Bureau recommended in their 2018 Policies paper that:

- We urge the New York State Department of Agriculture and Markets to establish a division to manage and promote all aspects of aquaculture statewide.
- We recommend that aquaculture waste should be declared an agricultural waste and be under the Department of Agriculture and Markets’ jurisdiction.
- We urge the Department of Agriculture and Markets to hire an aquaculture specialist.
- We support changes to the Farm Plate law that would allow aquaculture to be considered an acceptable agricultural use.

A statewide agriculture plan, which does not currently exist for New York, would be a good step forward to explicitly state the goals and objectives for this sector, including aquaculture. Most counties in New York have Agricultural and Farmland Protection Plans, but of these agricultural plans, less than half the counties include aquaculture or aquaculture products in their definition of agricultural products (Table 10).

Table 10. New York’s counties and if they have an agricultural plan, and if that plan mentions aquaculture as an agricultural product.

County Name	Agriculture Plan	Aquaculture included*	County Name	Agriculture Plan	Aquaculture included*
Albany	Y	N	Niagara	Y	N
Allegany	Y	N	Oneida	Y	Y
Bronx	N	-	Onondaga	Y	N
Broome	Y	N	Ontario	Y	N
Cattaraugus	Y	N	Orange	Y	Y
Cayuga	Y	Y	Orleans	N	-
Chautauqua	Y	N	Oswego	Y	N
Chemung	Y	N	Otsego	Y	Y
Chenango	Y	Y	Putnam	Y	Y
Clinton	Y	Y	Queens	N	-

County Name	Agriculture Plan	Aquaculture included*	County Name	Agriculture Plan	Aquaculture included*
Columbia	Y	N	Rensselaer	Y	N
Cortlandt	Y	Y	Richmond	N	-
Delaware	Y	Y^	Rockland	N	-
Dutchess	Y	Y	St. Lawrence	Y	N/A online
Erie	Y	Y	Saratoga	N	-
Essex	Y	Y	Schenectady	Y	N
Franklin	Y	Y	Schoharie	Y	N
Fulton	Y	N	Schuyler	Y	N
Genesee	Y	N	Seneca	Y	N
Greene	Y	Y	Steuben	Y	Y
Hamilton	N	-	Suffolk	Y	Y
Herkimer	Y	N	Sullivan	Y	Y^
Jefferson	Y	Y	Tioga	Y	Y
Kings	N	-	Tompkins	Y	Y^
Lewis	Y	Y	Ulster	Y	N
Livingston	Y	Y	Warren	Y	N
Madison	Y	N	Washington	Y	N
Monroe	Y	N	Wayne	Y	N
Montgomery	Y	N	Westchester	Y	Y
Nassau	N	-	Wyoming	Y	N
New York	N	-	Yates	Y	Y

*Aquaculture was included in the definition of agriculture, and aquaculture products were listed as acceptable agriculture products, or that the county recognizes aquaculture as a potential new agriculture product. Overall, aquaculture was mentioned *at least once* in the county's agricultural plan.

^Does not explicitly state the word aquaculture but lists fish and aquatic plants as agricultural products.

Recommendations

New York is in a unique position currently; the aquaculture industry is growing world-wide, rapidly, and there has been a focus on developing the state's aquaculture industry since 1984. With the interest of the industry and partners, as well as the "eat local" movement New York has the potential to be a large producer of a variety of aquaculture products and market them to local markets. For aquaculture in New York to reach its full potential and continue to grow alongside its neighboring states it needs a designated state agency to work with and advocate for its members at various levels and stages, this also includes the inclusion of new species to culture, new culture systems, and the inclusion of aquaculture as agriculture in state law.

The state's aquaculture industry requires support from government agencies for diversification of crops and grow-out methods. Currently, Long Island aquaculture is primarily a mono-culture – cultivating mostly oysters. For the industry to grow and expand, new products need to be permitted and researched. Diversification within the aquaculture industry, or even in conjunction with conventional farms, would arguably strengthen the state's food production by providing security to farmers through alternate sources of income and building resilience to future challenges; a lesson learned by many during the Covid-19 pandemic.

New York currently has multiple opportunities to diversify and expand its industry. One current option is seaweed. Though, despite efforts to move seaweed culture forward in New York there still, as of October 2022, is no commercial seaweed production in Long Island. Another opportunity for New York to diversify and expand its aquaculture industry is permitting the expansion of open-ocean and open-lake aquaculture. There were cages in state waters off the North Fork in 1997 and again in 2011, but the business suffered some major losses over some time and eventually removed the cages. More recently, there has been interest from a private company in off-shore marine aquaculture of finfish, although obtaining permits has been slow, with push-back from industry, community members, and regulatory agencies. Other neighboring states have taken steps to look at the possibility of off-shore aquaculture in their marine waters, support off-shore demonstration projects, and some even have active off-shore farms leaving New York behind.

The 1986 Aquaculture Development in New York report recommended that the state promote and support the expansion of offshore aquaculture in its ocean and lakes. Aquaculture operations will eventually expand off-shore, the success of which greatly depends on smart-policies, state support, and public buy-in. NOAA is currently researching off-shore "Aquaculture Opportunity Areas" across the country, areas defined as suitable for off-shore commercial aquaculture operations. Increased federal efforts to enhance offshore aquaculture likely means that this type of aquaculture will grow in the future. New York has an opportunity to work with the industry and other stakeholders to develop policies to create a sustainable offshore aquaculture industry that compliments existing industries and be at the forefront of a growing sector.

Diversification and growth will be a challenge without aquaculture legally defined as an agricultural product. Currently, the industry is left adrift and unsupported with no designated agency to support them or their products. One viable solution would be to develop a formal linkage and partnership between NYSDEC and AGM. This will most likely require both to make substantial changes to their structure, such as devoting personnel to specifically aquaculture. This will be important as the aquaculture-specific agency personnel would have an in-depth

understanding of the goals and needs of the industry. As well as someone to help clearly navigate the process and regulatory framework to establish both marine and freshwater aquaculture businesses. Currently, industry partners must explain processes, systems, and other nuances to government personnel who are unfamiliar with aquaculture and its practices as they navigate the regulatory, processing and marketing landscape. This makes an untenable bureaucratic hurdle for those trying to enter or expand in the state's aquaculture industry.

In July of 2021, the Center for Agricultural Development and Entrepreneurship (CADE), the Dyson School of Cornell University, the Cornell Small Farms Program, and faculty from Columbia University announced the launch of a series of roundtable discussions for food system stakeholders on New York State's agricultural future. This group had a series of round table discussions for interested parties in the summer of 2021 to discuss a long-term vision/ plan for New York State called VISION 2050. The roundtables were set to be the blueprint for creating a long-term vision for New York's agricultural system. New York Sea Grant participated in the conversations, and ensured that New York's seafood, including both aquaculture and wild-caught, were included in the vision discussions. This should not be the only inclusion of seafood in an agricultural plan. The roundtables highlighted New York's need to acknowledge aquaculture as agriculture in its laws and regulations, and ensure it is included and recognized alongside other agricultural products.

AGM began the New York Grown and Certified program in 2016. The program makes it easy for consumers to be able to identify New York produced, safely handled, and environmentally responsible agricultural products. This program is a cooperative effort between producers, processors, wholesalers, retailers, restaurants, and AGM to meet consumer demand for high-quality food and agricultural products. When it was established, New York grown seafood was not included. However, in 2018 AGM expanded its New York Grown and Certified program to include cultured shellfish and fish - of which multiple aquaculture farms across the state now participate. This was a big step for aquaculture producers in the state, and more support from agencies like this is needed. USDA states that "Aquaculture is Agriculture", yet New York has been slow to make the same proclamation.

New York's higher education and workforce

Status and gaps

From the New York State Aquaculture Needs Assessment conducted by NYSG in January of 2021, a key finding that emerged was the lack of a qualified workforce for the industry. Most aquaculture facilities are interested in hiring individuals with previous industry experience, including an understanding of different culture systems, biosecurity, aquatic chemistry, organism biology and other important topic areas. Each facility can be different, but employees that have prior knowledge in aquaculture will be easier to train and can be onboarded faster. As of 2020, there are only two universities in the state which offer degrees or studies specifically in aquaculture, SUNY Cobleskill and SUNY Morrisville, creating a small pool of trained professionals.

SUNY Cobleskill offers two-degree options for those interested in pursuing a career in aquaculture. The first is a two-year Associate Degree in Applied Science, Fisheries and Wildlife

Technology. This degree is for students who are not yet positive of their career path and want to explore both in-field careers and those in laboratories. The other option is a four-year Bachelor of Technology degree in Fisheries and Aquaculture. Graduates of this program will meet the minimum qualifications for NYSDEC Fisheries and Wildlife Technician 1 and 2, Fish Culturist, Aquatic, Marine, Wildlife Biologist, Ecologist, Forest Ranger, Park Ranger, and Environmental Conservation Officer trainee exams. SUNY Cobleskill also has one of the largest and most diverse academic aquaculture facilities in the Northeast, including a 40,000-gallon cold water fish hatchery, quarantine hatchery, tropical fish hatchery, tank farm, and earthen grow out ponds.

SUNY Morrisville offers a two-year associate degree in Applied Science in Aquaculture and Aquatic Science (AAS). The AAS degree provides fundamental training in aquaculture fisheries biology, limnology, and aquaculture sciences. Students can matriculate directly into the Bachelor of Technology degree in Environmental and Natural Resource Management. Graduates of this program also meet the minimum qualifications for NYSDEC Fisheries and Wildlife Technician 1 and 2, Fish Culturist, Aquatic, Marine, Wildlife Biologist, Ecologist, Forest Ranger, Park Ranger, and Environmental Conservation Officer trainee exams. SUNY Morrisville's Aquaculture Center combines the use of both flow through and RAS which a focus on practical training and cultivation of multiple species, central of which is the New York heritage strain of brook trout. Further, the school has a Marine Aquaculture Laboratory focused on tropical corals, and ornamental fish, giving students a wide range of opportunities to gain valuable experience. Additionally, SUNY Morrisville has launched a workforce microcredentials program in aquaculture that focus on building the conceptual knowledge and well as skills-based aquaculture training offered both in person and online formats.

Other universities, specifically Cornell University and Stony Brook University, have multiple faculty and facilities researching various aquaculture topics. However, specific training or education in aquaculture is not available at these institutions. Cornell University offered an online 11-hour course on Recirculating Aquaculture Systems (RAS) created by Dr. Michael Timmons, available for anyone interested in learning more about RAS aquaculture, though this course is not offered for credit.

There are also a limited number of industry collaborations with universities. Much like their terrestrial counterparts, aquaculture farms, specifically land-based farms, provide opportunities for students to get hands-on experience and a chance to research pressing topics. Other areas of collaborations include aquatics nutrition and sustainable feed development, farm technologies, and automation and site planning. These collaborations could open new avenues for funding, research, and employment opportunities for New York. The state has 240 universities and colleges, and aquaculture farms spread throughout providing ample opportunities to collaborate on a wide range of needs.

Most students interested in a career in aquaculture, go out of state to pursue higher education, or they receive an education at one of the above schools and leave the state in pursuit of a career, as career options in aquaculture in New York are limited (NYSG 2021). Currently, aquaculture jobs in New York are primarily in one of the 12 state fish hatcheries run by the NYSDEC. Other employment opportunities in the state are to work for private aquaculture ventures, or town hatcheries on Long Island. However, most farms in the state are small family owned and family

run businesses with limited hiring potential. Town hatcheries are also small, not requiring a large workforce. To be qualified to work at a NYSDEC hatchery for a basic entry level position like Fish Culturist 1, a person must pass a New York State Civil Service exam and meet the following requirements: 60 college semester credit hours including at least 12 credit hours in fisheries, aquaculture or aquatic sciences, aquatic ecology, limnology, or mariculture. Some of these courses will be covered in general biology degrees, or fishery degrees, however those general classes will not specifically prepare students for a test on aquaculture. Additionally, the New York Civil Service test, which must be taken to get on the eligibility list for Fish Culturist, is offered infrequently and in random intervals, making it challenging for prospective employees to plan. In addition, the limited higher education opportunities make meeting the credit hour requirements challenging for New York students. The irregular scheduling of New York State Civil Service Tests limited vocational training opportunities, and small size of existing commercial operations make it challenging to find employment in the New York aquaculture sector. New York is losing valuable knowledge and talent to other states as individuals pursuing aquaculture leave the state to work elsewhere.

The labor challenges are not only due to limited availability of workers with the experience and skills to work on a farm, but the lack of affordable housing near farm operations. When staff cannot secure housing near the jobsite it can be challenging to find and retain a competent workforce. This is especially true for shellfish farmers in Long Island where rental and property prices are extremely high.

Recommendations

Due to their relative complexity, larger aquaculture operations (i.e., land-based, commercial scale recirculating systems) require a more skilled workforce. The pay and experience are more on par with skilled labor jobs than a farm hand job, despite being in the agricultural sector. This setting offers employees opportunities to develop new skills, fine tune their current skills, and make a decent wage. Depending on the position and complexity of the production system, skilled aquaculture workers may need to be knowledgeable in multiple fields including engineering (e.g. plumbing, electrical, fabrication), chemistry and biology. Currently, New York has two commercial-scale facilities, and multiple large state hatcheries, with plenty of room for growth. Looking forward the state has an opportunity to create a skilled aquaculture workforce needed to support domestic farmed seafood production, but needs to simultaneously facilitate the entry into, and expansion of, the industry to retain these workers.

Higher education programs in New York with an aquaculture curriculum could not only attract students coming to the state for their education, but also potentially keep in the state to pursue their career. These universities can build and develop resources for the growing industry, either through research, undergraduate and graduate students needing internships and job experience, or technical expertise. SUNY Cobleskill and SUNY Morrisville are pioneering what aquaculture can look like for universities, students, and industry members in the state. By investing in technical training and education through our extensive university system, New York could develop a strong educated workforce across a variety of disciplines to support the growing aquaculture industry.

New York's K-12 education

Status and gaps

New York currently does not include aquaculture as part of their standard curriculum for students in K-12. New York Agriculture in the Classroom is an agricultural literacy curriculum matrix that is searchable for specific topics on agriculture for students in K-12 for teachers to utilize in their curriculum. These resources are created to fit into the national education standard in science, social studies, and nutrition education and are linked to Common Core Standards. This is a great resource for teachers interested in including agriculture in their classrooms. When the database is searched for the keyword “dairy” twenty-three different lessons pop up for students in K-12. When the database is searched for the keyword “produce” thirty-eight lessons pop up for students in K-12. When the keyword “aquaculture” is searched only two lesson plans come up for students in K-8. Of those one of the lessons covers aquaponics and are for grades K-2 and grades 3-5. The other lesson covers overfishing and aquaculture and are listed for grades 3-5 and 6-8.

The National Future Farmers of America Organization (FFA) was established in 1928 to engage students through agricultural education and promote leadership, personal growth, and career success. Overall, the mission is to prepare future generations for the challenges of feeding a growing population. In 2016 the John Bowne High School FFA team competed at the 91st Annual State FFA convention on May 4-6th. Their aquaculture team took first place. In the 2018-2019 school year the FFA New York chapter had 7,084 students active in the organization, but only three schools participated in the aquaculture sector. On average each year about 4-8 teams compete in the aquaculture team competition. Yet, when looking at other states aquaculture FFA teams are prominent, working with local farms, learning, and participating in Aquaculture Career Development events. New York's students are missing out on these opportunities. It is also important to note that there is no nationwide competition for aquaculture in FFA, only those that are held within each state. Other sectors in FFA can compete on a national level, but aquaculture has yet to be included, this is a gap on a national scale.

The New York Harbor School located on Governor's Island provides a high school education along career education built on New York City's maritime experience. This education instills in students the ethics of environmental stewardship and the skills associated with careers on the water. The school offers a Career and Technical Education (CTE) in aquaculture. Students are taught how to design and maintain recirculating aquaculture systems, as well as production of finfish and algae species. The school also partners with the Billion Oyster Project to culture and replant oysters in New York Harbor. After Junior year students are eligible for SUNY College credits and can take the Seafood HACCP course to prepare for career placement. This program includes not only the biology of aquatic species, but also technology and engineering education required for this industry and provides students with real life experience. Students graduate with technical skills which can be used to go directly into the workforce or pursue higher education in aquaculture.

Additionally, the Board of Cooperative Educational Services (BOCES) offers a CTE program at their Oneida-Herkimer-Madison location, where students are taught aquaculture, aquaponics, and hydroponics with college credit awarded towards Bryant & Stratton College and Paul Smith's

College. These are currently the only two school programs in New York State to offer this type of curriculum and opportunity for students.

Trout in the Classroom (TIC) is a statewide program and allows students K-12 to grow trout from eggs to fingerlings in cold water aquariums throughout the school year. This teaches students about the watersheds in New York and incorporates science and technology through the culture systems. In 2019 TIC in New York was reaching 250 schools and 30,000 students each year. The program in New York was started in 1997 by Joan Stoliar and a small group of fly-fishing anglers and teachers in the Catskills and NYC. The program has since grown nationwide. It is programs like TIC that engage students in STEAM (Science Technology, Engineering, Art and Mathematics) and help them understand different avenues of career paths, like aquaculture.

Recommendations

Aquaculture education for K-12 students is important because there are immense career opportunities in the industry and exposing students to this can broaden their career paths and ideas for the future. Aquaculture crosses many professional paths including, but not limited to, veterinary medicine, science (biology, chemistry, physics, ecology, etc.), technology and engineering. Further, students who are educated in aquaculture will have a strong understanding of the impacts, risks, and benefits of the aquaculture industry as it grows. New York Ag. in the Classroom recently partnered with NYSG in October of 2022 to provide a virtual learning experience for students and teachers across the state. Classes were able to tour an oyster farm in Long Island and speak with the farmer. Teachers were also provided a career development opportunity to tour a Long Island fish market and watch a cooking demonstration. This was the first-time aquaculture was included in this type of programming and over 2,000 students participated across the state. Students and teachers across the state are interested in this industry, learning more about it, and getting involved.

It is recommended that New York invest the time and money to include aquaculture as part of its K-12 curriculum statewide and have more schools offer opportunities like the New York Harbor School. Additionally, the state should encourage teachers and schools to participate in organizations like FFA, giving students opportunities to connect with others, problem solve, and gain valuable experience in a rapidly growing industry.

Extension

Status and gaps

The need for increased extension support was a finding/recommendation in all three reports. Extension professionals can offer guidance and technical expertise to industry members, connect, and make research accessible to the public, and work alongside agency partners for the advancement of that field. Currently, there are two extension programs in place to support the aquaculture industry, New York Sea Grant, and Cornell Cooperative Extension of Suffolk County (CCE). While, New York Sea Grant has multiple staff who currently support the industry in various ways, including technical, regulatory, educational, and post-harvest and seafood safety support, there is only one full-time aquaculture specialist serving the whole state. They have worked to provide resources and programming to the aquaculture and seafood industry for the

last 50 years. See the Resources section for a comprehensive list of NYSG resources developed for the aquaculture industry.

Cornell Cooperative Extension Suffolk County (CCE) has been an important part of shellfish aquaculture extension and education in New York at the Suffolk County Marine Environmental Center. Suffolk County CCE has been an invaluable resource for both the community and the aquaculture industry. Many of New York's commercial oyster farmers participated in the SPAT program to learn about oyster aquaculture prior to starting their farms. Many farmers still rely on CCE Extension Agent's expertise to help them navigate hurdles and answer questions.

The focus on marine aquaculture is not a new issue for New York and in 1986 Cornell University submitted a proposal to AGM to develop educational programs for persons interested in pursuing freshwater aquaculture operations. The objectives of the project were to:

- Integrate and expand documentation of present inland freshwater aquaculture operations within New York.
- Characterize opportunities for expansion of inland aquaculture operations in terms of physical resources, markets, technology needs, and circumstances for success.
- Develop decision-making tools for persons considering entertaining freshwater aquaculture operations including case studies of successful operations.
- Provide training for county-based professional staff of Cooperative Extension and Soil Conservation Service and regional fisheries personnel of the Department of Environmental Conservation based on the findings of this effort to begin to build continuing capability to assist persons interested in future aquaculture development.

It is not clear if the project was funded. However, the points highlighted by the proposal are areas that are still needed by the industry and would benefit it greatly, especially, those interested in getting into land-based aquaculture or expanding their current land-based operations.

Recommendations

The shellfish industry in New York has a strong support network from CCE of Suffolk County. However, there is a large and apparent gap in resources and opportunities for alternative aquaculture operations. Broader outreach, education and extension programs beyond Long Island and shellfish aquaculture are necessary to better support and foster growth in New York's aquaculture industry. For example, there is no facility in the Great Lakes region that matches what CCE Suffolk does for shellfish farmers. A facility designed to help educate, train, and provide resources for farmers and students has the potential to be an invaluable resource for the region. Currently, New York has students, industry partners, and private citizens interested in land-based aquaculture but there is no structured facility for them to receive hands on training or anyone to contact with specific technical expertise. In contrast to the shellfish industry on Long Island for example, the state has no dedicated field extension specialist for finfish or RAS, which are technical areas that will be needed to support the commercial fish farms that are anticipated to become predominant inland.

Extension has always played an important role in the education and support of communities and businesses. Extension targeted towards traditional farmers in New York has been an invaluable

resource, sharing new innovations, science, technology, and providing support in other areas. While CCE and NYSG have worked to support the aquaculture industry, New York is an incredibly large and diverse state making it challenging to provide the support needed to aquaculture farmers statewide, given the current capacity of both programs. An increase in support to increase extension personnel focused on aquaculture would benefit both the industry and communities throughout the state.

Concluding Statements

New York is in a position where proactive and collaborative efforts are required to move the aquaculture industry forward. Over the last 30+ years, multiple reports and surveys of stakeholders, agencies, and industry members across the state have outlined what is needed for aquaculture to be successful. It is clear that New York has the potential to be a leader in aquaculture production, technology, and research, given its freshwater and marine resources, but the state needs commitment to a strong and clear plan to advance it. The inclusion of aquaculture as an agricultural product and development of an aquaculture specific department at the state level could be the first step. These are necessary changes for New York, especially if the state is going to contribute and be a significant part of the ongoing nation-wide growth of aquaculture.

Many of the recommendations highlighted in this report are regulatory changes which would give the aquaculture industry the stable foundation it needs to develop further. In addition to regulatory changes, which will require agency collaboration and initiative, successful advancement of aquaculture in New York also requires commitment and involvement from industry and business partners. It will be necessary for all businesses, farmers, and various stakeholders to come together to create a unified, representative voice in the state. The needs and concerns of each individual farm are collectively the needs and concerns of the industry, but a critical mass advocating for the aquaculture industry will be necessary to gain political traction.

Increased education and outreach via extension programs are also important for successful advancement of aquaculture throughout the state. As of 2022, only two of New York's 240 universities and colleges offer degrees or studies specifically focused on aquaculture, and aquaculture is not included in the standard curriculum for K-12 students. Aquaculture blends many professional paths, so incorporation of aquaculture principles and processes into education both at the K-12 and higher education scales is recommended to allow students to gain valuable knowledge and experience in a rapidly growing industry. Collaborations between aquaculture businesses and universities could open new paths for increased funding, research, and employment opportunities, benefiting both students and employers. Increased outreach via extension programs could also be prioritized to support and foster growth of the aquaculture industry, particularly in areas outside of Long Island.

New York has the capacity to support a thriving aquaculture industry throughout the state on various levels. It will be through the combination of both state and industry efforts, coming together and working towards common goals, that New York can begin to take steps forward to grow and sustain aquaculture in the state.

Additional Resources

Agency Contacts

Agency	Contact Information
United States Army Corp. of Engineers (USACE)	New York District Office US Army Corps of Engineers New York District ATTN: Regulatory Branch, Room 16-400 26 Federal Plaza New York, NY 10278-0090 Email: cenan.publicnotice@usace.army.mil Telephone: 917-790-8511 (Eastern Permit Section - New York City, Nassau, Suffolk) 917-790-8411 (Western Permit Section - Dutchess, Orange, Putnam, Sullivan, Ulster, Westchester, Rockland)
United States Coast Guard	Steve Pothier (GS-11) Waterways Management Specialist Private Aids to Navigation (PATON) First Coast Guard District 408 Atlantic Avenue Boston, MA 02110 Steven.R.Pothier@uscg.mil (617) 223-8347 (617) 823-3947 Cell (617) 223-8291 Fax
New York Department of Agriculture and Markets	Dr. Joy Bennett NY Dept of Agriculture & Markets Division of Animal Industry Albany, NY 12235 Phone: 518-457-3502 Fax:518-485-7773 joy.bennett@agriculture.ny.gov
New York State Department of Environmental Conservation Division of Marine Resources	123 Kings Park Blvd. (Nissequogue River State Park) Kings Park, New York 11754

	631-444-0489
	fw.marine@dec.ny.gov

New York State Department of Environmental Conservation Bureau of Water Resource Management Division of Water	625 Broadway Albany, NY 12233-3508 518-402-8086 DOWinformation@dec.ny.gov
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New York State Department of Environmental Conservation Division of Environmental Permits	4th Floor 625 Broadway Albany, NY 12233-1750 518-402-9167 deppermitting@dec.ny.gov
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New York State Department of Environmental Conservation Bureau of Fisheries	625 Broadway Albany, NY 12233-4753 518-402-8924 fwfish@dec.ny.gov
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New York State Department of Environmental Conservation Fish and Wildlife	625 Broadway Albany, NY 12233-4752 518-402-8985 speciallicenses@dec.ny.gov
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Resources

New York Sea Grant Regulatory Guides

Regulatory Guide to Marketing Farmed Seafood in New York

- <https://seagrant.sunysb.edu/Images/Uploads/PDFs/rapidresponse/Seafood-Guide-Regulatory-Aquaculture.pdf>

Regulatory Guide to Marketing Bivalve Molluscan Shellfish in New York

- <https://seagrant.sunysb.edu/Images/Uploads/PDFs/rapidresponse/Seafood-Guide-Regulatory-MolluscanShellfish.pdf>

Regulatory Guide to Marketing Wild Caught Seafood in New York

- <https://seagrant.sunysb.edu/Images/Uploads/PDFs/rapidresponse/Seafood-Guide-Regulatory-WildHarvest.pdf>

Regulatory Guide to Processing and Marketing Seaweed in New York

- <https://seagrant.sunysb.edu/Images/Uploads/PDFs/rapidresponse/Seafood-Guide-Regulatory-Seaweed.pdf>

New York Sea Grant Supplementary Guides

New York Food Labeling Requirements

- <https://seagrant.sunysb.edu/Images/Uploads/PDFs/rapidresponse/Seafood-Guide1-FoodLabeling.pdf>

Enhancing Seafood Safety and Marketability

- <https://seagrant.sunysb.edu/Images/Uploads/PDFs/rapidresponse/Seafood-Guide2-EnhancingSafetyAndMarketability.pdf>

Seafood HACCP

- <https://seagrant.sunysb.edu/Images/Uploads/PDFs/rapidresponse/Seafood-Guide3-SeafoodHACCP.pdf>

Good Manufacturing Practices (GMPs)

- <https://seagrant.sunysb.edu/Images/Uploads/PDFs/rapidresponse/Seafood-Guide4-GoodManufacturingPractices.pdf>

Sanitation

- <https://seagrant.sunysb.edu/Images/Uploads/PDFs/rapidresponse/Seafood-Guide5-Sanitation.pdf>

Allergens and Cross-Contact

- <https://seagrant.sunysb.edu/Images/Uploads/PDFs/rapidresponse/Seafood-Guide6-AllergensAndCrossContact.pdf>

Marketing Seafood

- <https://seagrant.sunysb.edu/Images/Uploads/PDFs/rapidresponse/Seafood-Guide7-MarketingSeafood.pdf>

Best Practices for Seafood Delivery and Mailing

- <https://seagrant.sunysb.edu/Images/Uploads/PDFs/rapidresponse/Seafood-Guide8-DeliveryAndMailingSeafood.pdf>

Opportunities for Seafood Marketing and Sales on Long Island

- <https://seagrant.sunysb.edu/Images/Uploads/PDFs/rapidresponse/Seafood-OpportunitiesForSeafoodSalesOnLI.pdf>

Seaweed Guide 1

- <https://seagrant.sunysb.edu/Images/Uploads/PDFs/rapidresponse/Seafood-Guide-Seaweed-I.pdf>

Seaweed Guide 2

- <https://seagrant.sunysb.edu/Images/Uploads/PDFs/rapidresponse/Seafood-Guide-Seaweed-II.pdf>

New York Sea Grant Educational Aquaculture Resources

Aquaculture Curriculum

- <https://seagrant.sunysb.edu/seafood/pdfs/curricula/AquacultureCurriculum.pdf>

Lesson Plan: Becoming a Fish-Farmer

- <https://seagrant.sunysb.edu/seafood/pdfs/curricula/LessonPlan-Aquaculturist.pdf>

Seafood Science Curriculum

- <https://seagrant.sunysb.edu/seafood/pdfs/curricula/AquacultureCurriculum.pdf>

Lesson Plan: A Spin on Seafood

- <https://seagrant.sunysb.edu/seafood/pdfs/curricula/LessonPlan-SpinOnSeafood.pdf>

Sea Grant Hubs

Great Lakes Aquaculture Collaborative

- <https://greatlakesseagrant.com/aquaculture/>

Hard Clam Hub

- <https://storymaps.arcgis.com/stories/3425623358164278bbe1ed7f7311a605>

Seaweed Hub

- <https://seaweedhub.org/>

Striper Hub

- <https://cals.ncsu.edu/applied-ecology/news/stripershub-will-address-seafood-deficit/>

Regional Aquaculture Centers

Northeast Regional Aquaculture Center (NRAC)

- <https://www.nrac.org/>

North Central Regional Aquaculture Center (NCRAC)

- <https://www.ncrac.org/>

Southern Regional Aquaculture Center (SRAC)

- <https://srac.msstate.edu/>

Additional Resources

Cornell Aquaculture Program Work Team

- <https://blogs.cornell.edu/aquaculture-pwt/>

East Coast Shellfish Growers Association

- <https://ecsga.org/gardnerbod/>

Long Island Oyster Growers Association

- <https://www.liogany.org/>

National Sea grant Law Center

- <https://nsglc.olemiss.edu/work/ssss/index.html>

National Sea Grant Library

- <https://nsgl.gso.uri.edu/>

National Sea Grant Office Aquaculture Page

- <https://seagrants.noaa.gov/Our-Work/Aquaculture>

National Sea Grant Office Seafood Page

- <https://seagrants.noaa.gov/Our-Work/Aquaculture>

NOAA Aquaculture website

- <https://www.fisheries.noaa.gov/topic/aquaculture>

U.S. Department of Agriculture Aquaculture (USDA) Page

- <https://www.usda.gov/topics/farming/aquaculture>

USDA National Institute of Food and Agriculture Aquaculture Page

- <https://nifa.usda.gov/program/aquaculture>

Aquaculture Education Resources

Aquatic Animal Health Program at Cornell

- <https://www.vet.cornell.edu/departments/microbiology-and-immunology/aquatic-animal-program/aquatic-animal-health-program-courses>

Cornell RAS course

- <https://blogs.cornell.edu/aquaculture/online-course/>

SBU Marine Animal Disease Laboratory

- <https://you.Stony Brook.edu/madl/>

SUNY Cobleskill

- <https://www.cobleskill.edu/academics/schools/agriculture-and-natural-resources/fisheries-wildlife/fisheries-and-aquaculture-bt.aspx>

SUNY Morrisville

- <https://www.morrisville.edu/program/aquaculture-aquatic-science-aas>

SUNY Morrisville Aquaculture Short Courses

- <https://www.morrisville.edu/aq-courses>

Funding/Grant Resources

Grow NY

- <https://www.grow-ny.com/>

Small Business Innovation Research (SBIR)

- <https://www.sbir.gov/>

Sea Grant Funding opportunities

- <https://seagrants.noaa.gov/Funding>

SARE

- <https://www.sare.org/>

New York Farm Viability Institute

- <https://nyfvi.org/>

New York Sea Grant

- <https://seagrants.sunysb.edu/proposals/>

References

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