Marine Fisheries

Background

New Jersey's fisheries offer numerous ecological, recreational, and economic benefits. For example, recreational fishing expenditures (jobs, income, and sales) in New Jersey in 2019, the most recent year available, are estimated at $388 million.[1] The ecological value of fisheries species is well documented and includes regulation of food web dynamics, nutrient transport, and complex habitat formation.[2,3] The New Jersey Department of Environmental Protection (DEP) is committed to maintaining healthy fish assemblages and ensuring the sustainability of fish and shellfish populations.

Finfish – striped bass

In order to assess the populations of select marine fish in New Jersey waters, which extend 3 nautical miles from the shore, the DEP has established monitoring programs for striped bass, oysters, and forage fish (i.e., bait fish).[4] New Jersey's Marine Resources Administration has annually surveyed fishes in the Delaware River since 1980 in order to assess fish populations.[5] Surveys of striped bass (*Morone saxatilis*), which is the target fish species of this sampling program, are incorporated into the Atlantic coastal striped bass assessment[6] to estimate recruitment, or the number of fish entering the population. This sampling plan is also mandated as part of the Atlantic States Marine Fisheries Commission's Interstate Fishery Management Plan (FMP) for striped bass.[7]

Shellfish – Delaware Bay oysters

The filter feeding eastern oyster, *Crassostrea virginica*, is a keystone species in the Delaware Bay estuary. A keystone species is defined as one that other species depend upon for their existence. Healthy oyster reefs provide habitat for a vast community of benthic organisms and increase faunal diversity.[8] Due to their high filtration capacity, oysters can even improve local water quality. Since the inception of the oyster industry nearly 300 years ago, New Jersey's natural seed beds have been the major provider for both the seed oyster and the market oyster. Seed oysters are approximately 2 to 20 mm long and can be used for oyster bed enhancement and research. Market oysters are generally harvested when they are at least 65 mm (2.5 inches) long.

Oysters harvested from the Delaware Bay (Jennifer Pyle, NJDEP, 2022)

Forage Fish Index – Delaware River seine survey

The success of a species is contingent upon the survival of their young. The Delaware River provides an important nursery environment for young fish to grow. Monitoring populations of juvenile fish is essential for fishery managers to estimate abundance and evaluate the success of the population. Data collected during the Delaware River Seine Survey provides annual estimates of the population of juvenile fish for many species. This data contributes to the development of fisheries management plans and projections of sustainable harvest levels.

Many species captured during the survey are forage fish, such as Atlantic silverside (*Menidia menidia*) and Atlantic menhaden (*Brevoortia tyrannus*), commonly considered as bait fish. Their schooling behavior, size and abundance make them a significant food source for predator species including striped bass, bluefish, weakfish, and white perch.[9] These predators are important species recreationally, commercially, and economically. Forage species produce abundant offspring, enough to sustain both recreational and commercial fishermen and the natural predators that inhabit the ocean. A lack of forage fish is a signal that the community structure is out-of-balance.

Juvenile striped bass (Jennifer Pyle, NJDEP, 2022)

Status and Trends

Fisheries data collected over multiple time periods are highly variable reflecting changes in fish abundance, survey sampling variability, and measurement error.[10] Autoregressive integrated moving average (ARIMA) models were used to minimize measurement error and help identify qualitative trends in each indicator.[11]

Finfish – striped bass

Striped bass spend much of their adult life in saline waters, however spawning occurs in the fresh- or nearly freshwater portions of the Delaware River, where the survey takes place. Figure 1 displays striped bass data from 1982 to 2019 for young-of-the-year individuals (those that are under one year of age). In the early to mid-1980s, juvenile and adult abundance were low, but as the adult stock recovered, the juvenile index increased.[12] There was a statistically significant increase in the number of striped bass caught per haul from 1982 to 1998 (Kendall Tau = 1.00, $p < 0.05$) followed by a significant decrease from 1999 to 2019 (Kendall Tau = -0.52, $p < 0.05$). During the latter time period, declines in older fish (age 8 and older) were documented starting in approximately 2005.[13] This decline prompted the Atlantic States Marine Fisheries Commission (ASMFC) to implement management measures in order to reduce mortality starting in 2015. As a result, New Jersey imposed stricter size limits for retaining striped bass. While the juvenile index increased after this management change, there was no corresponding increase in the adult population,[14] though several more years of data may be required to understand the impact on the adult population.

The most recent striped bass stock assessment[15] showed that mature female biomass was below sustainable levels, and mortality from fishing was also above sustainable levels. As a result, the ASMFC required states to implement management measures to reduce fishing mortality within one year, and the ASMFC is currently considering options to return biomass levels to sustainable levels.

The seemingly low number of young-of-the-year individuals, or fish born within the current year shown in Figure 1 is remarkably predictive of striped bass abundance.[16] However, the very low number of individuals caught per seine haul is likely in part due to the clustered nature of fisheries populations, and the small footprint of the sampling effort.

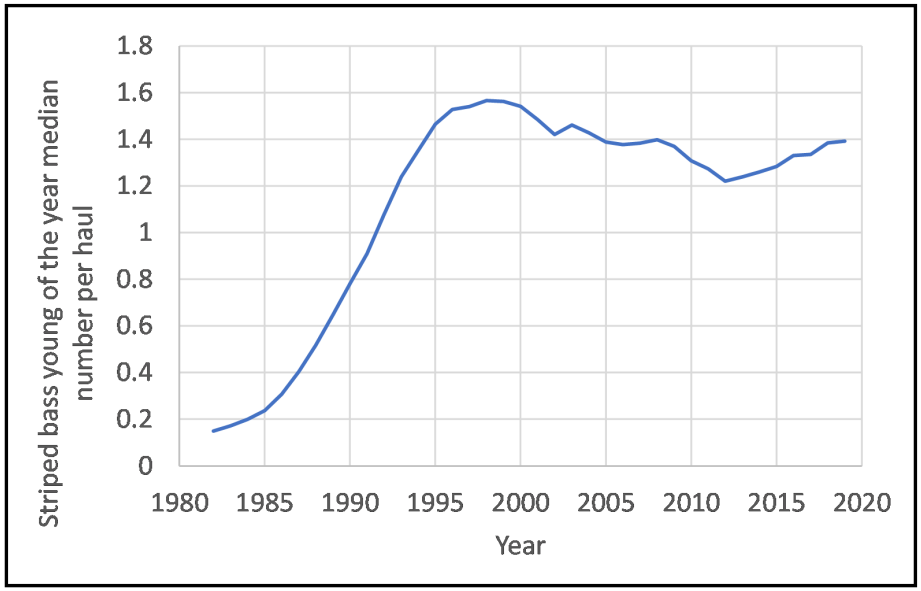

Figure 1: Median of ARIMA model estimated number of young-of-the-year striped bass individuals caught per haul during surveys of the Delaware River.

Shellfish – Delaware Bay oysters

In the oyster fishery, mortality (deaths) and recruitment control the stock size. The majority of oyster mortality comes from disease.[16] In 1957, heavy mortality was discovered in oysters and was caused by a protozoan parasite given the acronym "MSX" (abbreviation for "multinucleated sphere unknown", later classified *Haplosporidium* (formerly *Minchinia nelson*)).[17] By the end of 1959, 90-95% of the oysters on privately leased planted grounds and about half of those on the State managed seed beds had died due to MSX.[18] Oyster populations rebounded slowly and benefitted from a very successful recruitment in 1972 which helped increase the oyster abundance until the early 1980s.[19] The resource seemed to stabilize and harvesting levels were steady until 1984 when a large MSX event killed off essentially all oysters that were susceptible, leaving only MSX -resistant oysters in the population. In 1990, a new oyster disease known as Dermo (*Perkinsus marinus*) arrived in the Delaware Bay and by 1991 it had spread over much of the Bay causing heavy losses of planted and seed oysters.[20] This disease, unlike MSX, was more tolerant of lower salinities and impacted the oyster stock across the Bay, particularly in the lower Bay where higher salinities allowed it to flourish.

By 1995, after 3 years without a planting season, it was determined that the traditional transplant scheme where oysters were harvested from the State managed beds and subsequently planted onto privately leased areas of the Bay was no longer successful.[21] Beginning in 1995, an old strategy was revisited for the first time in 150 years in New Jersey, and harvesters were allowed to forego "transplanting" onto their leased grounds and bring oysters greater than 2.5" harvested from the State's natural seed beds directly to market.[22] This management program of direct harvest from State seed beds continues today.

Oyster populations as evaluated through the ARIMA model show a statistically significant increasing trend beginning in 1995 (Kendall Tau = 0.93, $p < 0.05$). In 2020, the median model predicted abundance of market sized (> 2.5'') oysters across the Delaware Bay, not including those from the very low mortality beds,[23] was 705 million oysters.

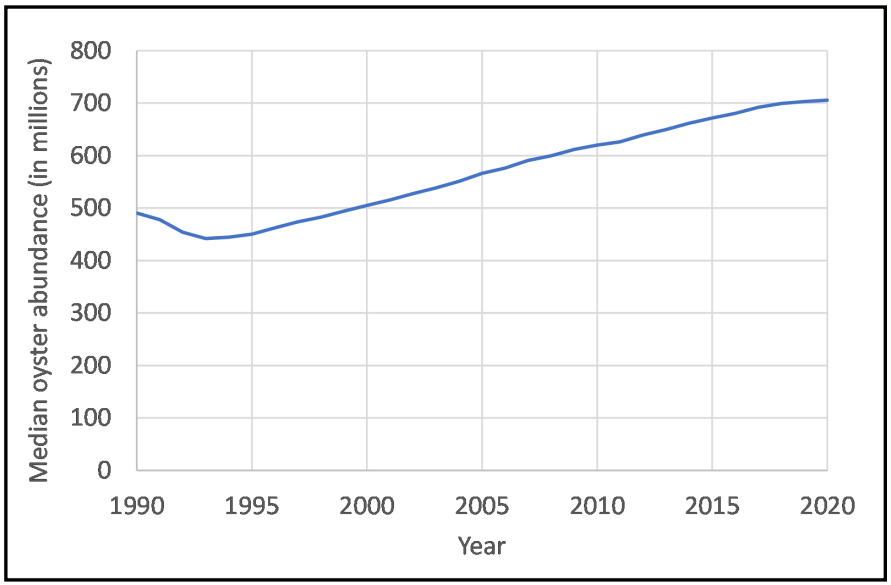

Figure 2: Median ARIMA model estimated abundance of market-sized oysters (>2.5") in the Delaware Bay each year since 1990. Note: data for Very Low Mortality (VLM) beds are not included in this figure due to the low abundance of market sized oysters and available time series for this region.

Forage Fish Index – Delaware River seine survey

Since 1980, forage fish comprise more than 82 percent of the total number of fish collected in the Delaware River seine survey. There was a steep and statistically significant (if accurate) decline in the forage fish index using the ARIMA methodology in the 1980's and the decline has continued since (Figure 3). In the evaluation of the 2019 population, the median fitted abundance was 69 fish per tow, less than half of what was estimated through the 1990s. Forage fish serve as prey for several predators, including striped bass. Increasing striped bass abundance since the 1980s has contributed to the declining abundance of forage fish seen in Figure 3.

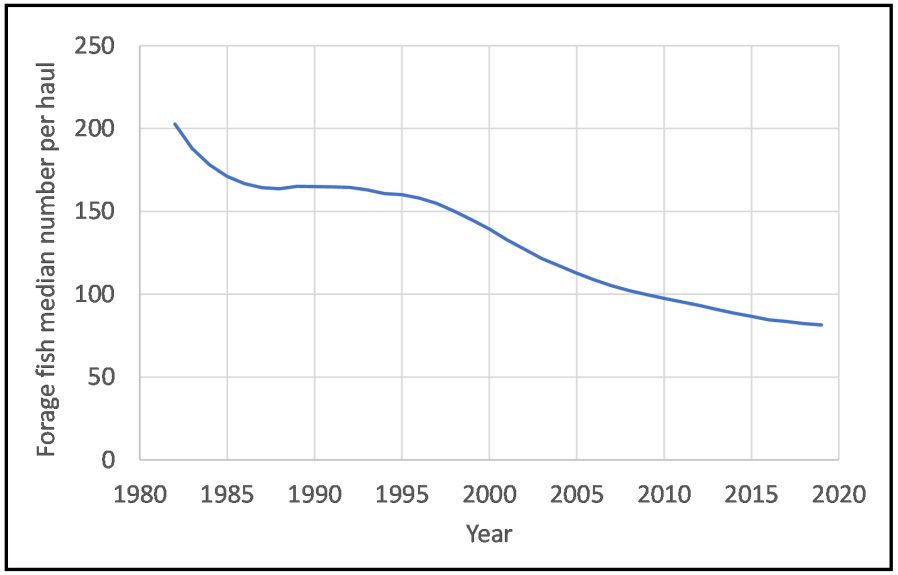

Figure 3: Median ARIMA model estimated number of Delaware River forage fish per haul.

Outlook and Implications

Changes in fish abundance have the potential to cascade throughout the ecosystem with implications for the environment and the economy. For example, a decrease in the forage base has the potential to negatively influence striped bass health through decreased lipid concentrations in muscle tissue.[24] Likewise, changes in predator abundance have the potential to not only influence their prey base, but the structure of entire communities.[25]

Monitoring abundance is crucial to our understanding of population dynamics, and this monitoring also provides glimpses into the status of each of these indicators. There is high confidence that climate change will lead to significant changes in environmental conditions and cause shifts in the spatial and temporal distribution of these species.[27] Some of the impacts of climate change that will affect marine fisheries include warmer water temperatures, increased annual precipitation and more intense precipitation events, and increasingly acidic marine water. It is important that monitoring of the environmental conditions and the abundance and distribution of these species continue in order to understand the impact climate change is having on the ecosystem and to develop strategies to mitigate impacts, where possible.

Finfish – striped bass

The juvenile abundance of striped bass is strongly influenced by environmental factors such as temperature and salinity. However, anthropogenic factors including water quality, pollution, and hydrodynamic alterations[28] play important roles in recruitment which can ultimately influence this migratory species. Climate change is expected to influence precipitation patterns over time, including increased annual precipitation and more intense precipitation events.[29] Heavier rain events leading to an increase in polluted runoff may affect survival for sensitive species such as striped bass.[30]

Shellfish – Delaware Bay oysters

There has been a significant increasing trend in market sized oyster abundance in Delaware Bay since the advent of the direct market fishery in 1995 (Figure 2). Habitat enhancement programs, careful management, and productive partnerships have likely contributed to this trend. Oyster mortality is expected to increase as a result of their inability to survive changes in salinity from more intense precipitation events[31] and weakening shells caused by the increased acidity of marine waters.[32]

Forage Fish Index – Delaware River seine survey

Dissolved oxygen was historically low in the Delaware River due to pollution around Philadelphia. Current water quality testing by DEP shows that the Delaware River is now maintaining a healthy environment for these fish.[33] Since 1980, the dissolved oxygen levels in the river have remained at a healthy level, with values between 6 mg/L and 8 mg/L.

The Delaware River seine survey catches a variety of forage fish that are all important to the ecosystem. For example, forage fish are an integral part of predator-prey dynamics.[34] Continued monitoring will play an essential role in informing management of forage fish.

More Information

The data and information in this chapter have been provided by NJDEP Marine Resources Administration (including the Bureau of Shellfisheries). More information is available at the following web sites:

NJDEP Web Sites (for information on changes in State harvest regulations):
https://www.nj.gov/dep/fgw/shelhome.htm
https://dep.nj.gov/njfw/fishing/marine/

Atlantic State Marine Fisheries Commission (for information on striped bass biology, ecology, and coast wide abundance):
http://www.asmfc.org/species/atlantic-striped-bass

Haskin Shellfish Research Laboratory websites (for information on Delaware Bay oyster stock assessments and oyster biology and ecology):
https://hsrl.rutgers.edu/
https://hsrl.rutgers.edu/SAWreports/index.htm

NOAA Fisheries Service Northeast Fisheries Science Center (for striped bass stock assessment reports):
https://www.fisheries.noaa.gov/new-england-mid-atlantic/population-assessments/fishery-stock-assessments-new-england-and-mid-atlantic

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[23] For much of the Delaware Bay's recorded history oysters were harvested from the State managed oyster seed beds and subsequently planted onto privately leased grounds in the Bay to allow the oysters to grow in order to enhance market quality (e.g., get larger). In 1995, managers worked with industry to allow a system where oysters harvested from the State managed oyster seed beds were brought directly to market, rather than planting the harvested oysters on industry leased grounds.

[24] VLM beds - This region was first formally surveyed in 2007. There is a gradient of natural mortality in the Delaware Bay that is directly related to salinity and Dermo disease in which areas down bay (e.g., closer to the mouth of the bay) experience higher natural mortality rates; lower salinity areas up bay experience lower mortality. The VLM beds experience, on average, the lowest average natural mortality rates (i.e., very low mortality) of all of the oyster seed bed areas. There are very few market sized oysters on the VLM beds relative to all of Delaware Bay and so they are omitted from this discussion and Figure 2.

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