Wildlife Populations: Marine Fisheries

Background

New Jersey's fisheries offer numerous ecological, recreational, and economic benefits. For example, recreational fishing impacts in New Jersey in 2012, the most recent year available, are estimated at $3.7 billion dollars.[i] The ecological value of fisheries species are well documented and include regulation of food web dynamics, nutrient transport, and complex habitat formation.[ii,iii]

Finfish – striped bass

New Jersey's Marine Fisheries Administration has annually surveyed fishes in the Delaware River since 1980. Surveys conducted continuously over such a time period offer a rich view of the natural environment and are indispensable tools with which to assess fish populations.[iv] Surveys of striped bass (*Morone saxatilis*), which is the target species of this sampling program, are incorporated into the coast-wide striped bass assessment[v] to estimate recruitment, or the number of fish entering the population. This sampling plan is also mandated as part of the Interstate Fishery Management Plan (FMP) for striped bass.[vi]

Shellfish – Delaware Bay oysters

The filter feeding eastern oyster, *Crassostrea virginica*, is a keystone species in the Delaware Bay estuary. Healthy oyster reefs provide the basis for a vast community of benthic organisms and increase habitat and faunal diversity. Through their high filtration capacity, oysters can even locally improve 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.

The Department of Environmental Protection manages the oyster resource and works cooperatively with the NJ Shellfisheries Council and Rutgers University's Haskin Shellfish Research Laboratory (HSRL). In 2014, this stock had an estimated dockside value of $4,371,500 and total economic value of $26,226,000[1]. The Delaware Bay oyster fishery is critical to the surrounding bayshore communities, particularly in Cumberland County where unemployment rates have been documented above the state average.[vii] One of the primary oyster management objectives has been focused on maintaining a stable abundance of market sized oysters of at least 2.5 inches. While disease has had a dramatic impact on oyster abundance, habitat enhancement efforts, particularly between 2003 and 2008, have helped maintain abundances. However, federal assistance ended in 2008 and significantly less enhancement work has been completed since then.

Forage Fish Index – Delaware River seine survey

The success of a species is contingent upon the survival of their young. The Delaware River provides a suitable 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 an annual juvenile abundance index 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, 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.[viii] As noted elsewhere in this document, these predators are important species recreationally, commercially and economically. As a major food source for predators, forage fish provide the sustenance necessary for predators to reach reproductive maturity. 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 something is out-of-balance.[ix]

The New Jersey Department of Environmental Protection's Division of Fish and Wildlife developed a forage fish index for the Delaware River which includes the following species: alewife (*Alosa pseudoharengus*), American shad (*Alosa sapidissima*), Atlantic silverside (*Menidia menidia*), Atlantic menhaden (*Brevoortia tyrannus*), banded killifish (*Fundulus diaphanus*), bay anchovy (*Anchoa mitchilli*), blueback herring (*Alosa aestivalis*), Eastern silvery minnow (*Hybognathus regius*), gizzard shad (*Dorosoma cepedianum*), mummichog (*Fundulus heteroclitus*), spot (*Leiostomus xanthurus*) and spottail shiners (*Notropis hudsonius*). The index is calculated as an annual arithmetic mean (average number of fish caught per haul).

Status and Trends

Fisheries times series data are very variable reflecting changes in fish abundance, survey sampling variability, and measurement error.[x] We used autoregressive integrated moving average (ARIMA) models to minimize measurement error and help identify qualitative trends in each indicator[x, xi]. The ARIMA approach derives fitted estimates of abundance over a time series[xii] whose variance is less than the variance of the observed series. We log transformed (base e) the data before use in ARIMA models. Because the interpretation of log transformed data can be challenging (e.g., in log space we can have negative numbers of fish per tow), all results are discussed in terms of their back-transformed values (e.g., on their original scale).[2]

Finfish – striped bass

Striped bass spawning occurs in the fresh- or nearly freshwater portions of the Delaware River. Spawning is triggered by a noticeable increase in water temperature and is enhanced with modest freshwater flows[xiii]. Populations of striped bass measured for this analysis appear to show an increasing trend from 1982 through the mid- to late-1990s using the ARIMA model. This model was used to transform the population data to an index, and several observations can be made with the results. The index in 2015 is 1.25 and is very near the median of the time series (Figure 1). However, the index also depicts a declining striped bass population beginning around the year 2000, discussed below.

A relationship between record low adult striped bass abundances in the early- to mid-1980s[xiv] and low recruitment is apparent from our data. That is, during the period of low adult abundance in the early to mid-1980s our index was low but as the adult stock was rebuilt our juvenile index increased.

Of note in Figure 1, the reader will observe a decline from 2010 through 2013. Preceding the decline are documented declines in older fish (age 8 and older) starting in approximately 2005[xv]. This decline has prompted the ASMFC and member states, including NJ, to implement management measures in order to reduce mortality starting in 2015[xvi]. Different member states implemented different measures to achieve this; in NJ we have changed size limits for retaining striped bass.

The seemingly low number of young-of-the-year individuals shown in the figure is remarkably predictive of striped bass abundance[xvii] and as such have been deemed essential in the modeling of the coast-wide striped bass population. The number of individuals caught per tow is due to the notoriously clustered nature of fisheries populations, combined with the small footprint of our sampling effort. Very often zero or one young-of-the-year striped bass is caught. Very infrequently, as many as 10 or 20 striped bass may be collected at one of the 35 sampling stations. Furthermore, the 100-foot long net that is used in the sampling covers a small area and that area is sampled with less than 100% efficiency.[xviii] Perhaps as many as 50% or more of the fish in the path of the nets manage to escape capture.

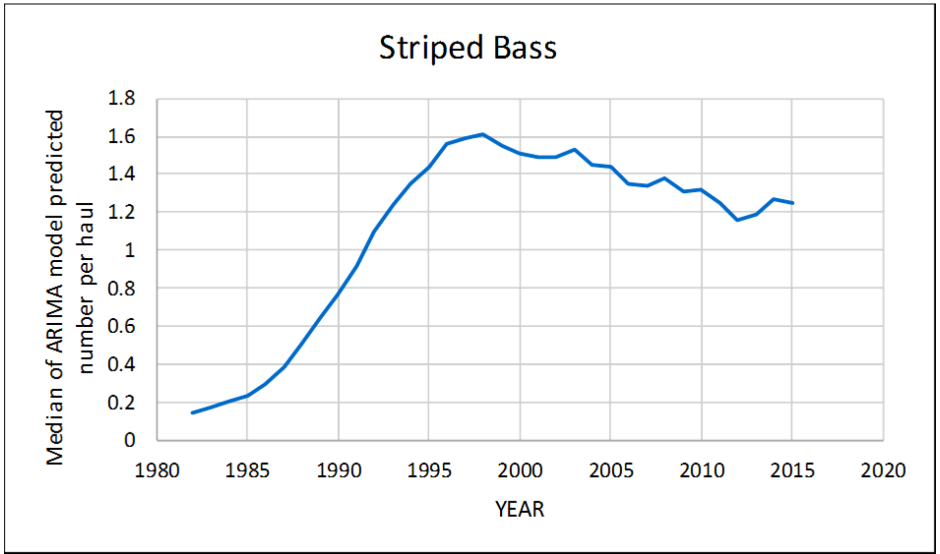

Figure 1: Median of ARIMA model predicted number of young-of-the-year striped bass individuals caught per tow during surveys of the Delaware River.

Shellfish: Delaware Bay oysters

Mortality (deaths) and recruitment (i.e., new oysters) control the stock size. The majority of oyster mortality comes from disease.[xix] In 1957, heavy mortality was discovered in oysters and was caused by a protozoan parasite given the acronym "MSX", standing for "multinucleated sphere unknown" (later classified *Haplosporidium* (formerly *Minchinia*) *nelson*).[xx] 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.[xxi] Today, MSX infections are insignificant due primarily to a very large MSX mortality event that occurred in 1984.[xxii] Oyster populations rebounded slowly and the fishery benefited from a very successful recruitment in 1972, although relative abundance of oysters on the beds began to increase before 1972.[xxiii] Recruitment during this period increased oyster abundance until the early 1980s. The resource seemed to stabilize and harvesting levels were steady. In 1990, a new oyster disease known as Dermo (*Perkinsus marinus*) arrived in the Delaware Bay. By 1991 it had spread over much of the Bay and caused heavy losses of planted and seed oysters.[xxiv] 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 obvious that the traditional transplant scheme where oysters were harvested from the State managed beds and subsequently planted onto privately leased areas of the Bay would no longer work.[xxv] 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.[3]

Oyster populations as evaluated through the ARIMA model, appear to show a continually increasing trend beginning in 1995. The median model predicted abundance of market sized (> 2.5'') oysters across the Delaware Bay, not including those from the very low mortality beds, in 2015 was 601.4 million oysters.[4]

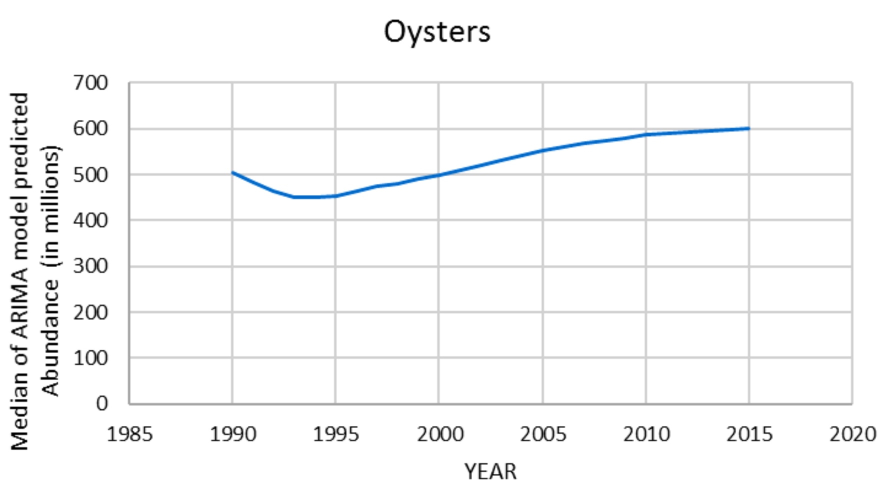

Figure 2: The annual median ARIMA model predicted abundance of market-sized oysters (>2.5") each year since 1990. Note: no data are available for the Very Low Mortality (VLM) beds prior to 2007; given the low abundance of market sized oysters and available time and available time series for this region, VLM oysters are not included in this figure.

Forage Fish Index – Delaware River seine survey

Since 1980, forage fish compromise more than 82 percent of the total number of fish collected. The abundance of forage fish populations within the Delaware River varies annually. Between 1982 and the late 1980s the forage fish index using the ARIMA methodology declined steeply (Figure 3). From the mid-1990s through 2010 the fitted forage fish index declined steeply again. The median fitted

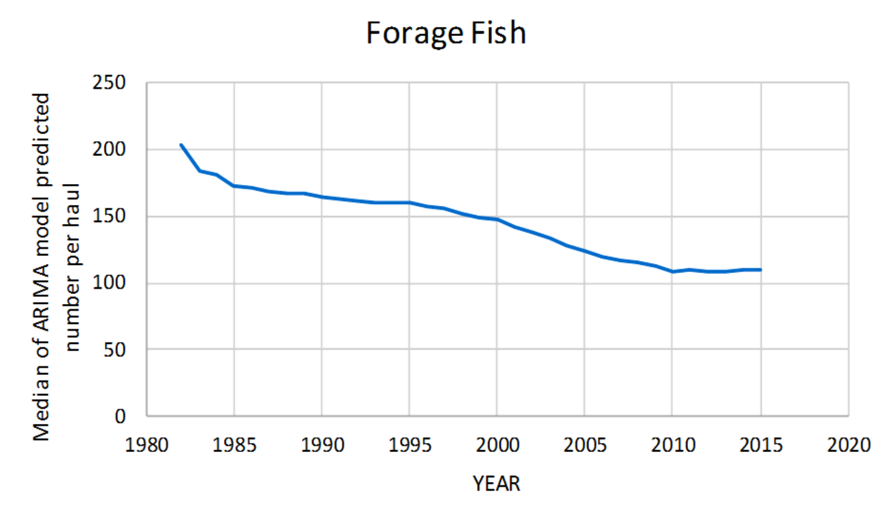

Figure 3: Median ARIMA model predicted number of Delaware River Forage Fish per haul.

abundance has stabilized since 2010. In the evaluation of the 2015 population, the median fitted abundance was 109.82 fish per tow.

During years of severe flooding (2006) and drought (1998, 2002), raw total catches were lower than normal. During a flood year, there is an influx of fresh water causing a drop both in salinity and water temperature. Species that prefer saltier water will move out of the sampling area which will lower the forage fish index. During drought years there is no fresh water influx; salinity and water temperature both rise. As salinity increases, fish retreat into streams and tributaries where salt concentrations are lower.

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 influence striped bass health.[xxvi] Likewise, changes in predator abundance have the potential to not only influence their prey base, but structure entire communities.[xxvii]

Monitoring abundance is crucial to our understanding of population dynamics, and this monitoring also provides glimpses into the status of each of these indicators. It is anticipated that monitoring will continue for each of these indicators.

Finfish – striped bass

Striped bass is managed cooperatively along the east coast by the Atlantic States Marine Fisheries Commission and member states. Factors that drive juvenile abundance (i.e. recruitment) are strongly influenced by environmental factors. However, water quality, pollution, and hydrodynamic alterations[xxviii] play important roles in recruitment and offer New Jersey the opportunity to exert some influence on this migratory species.

Our index of juvenile abundance will continue to be incorporated into the coast wide assessment of striped bass. As our sampling plan continues and proposed management measures are implemented[xxix] we will continue to monitor this indicator for changes in trend.

Shellfish – Delaware Bay oysters

There has been a qualitatively 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 qualitative trend. The Rutgers University Haskin Shellfish Laboratory conducts a stock assessment in the fall of each year. They present their findings to a Stock Assessment Review Committee (comprised of State, Academic, and Federal representatives) that reviews their findings and makes management recommendations to the Delaware Bay Section of the Shellfisheries Council who makes a recommendation to the Commissioner of the DEP. We anticipate continued operation of this management model.

Forage Fish Index – Delaware River seine survey

Pollution around Philadelphia in the mid-1900s caused severe declines in dissolved oxygen.[xxx] This made parts of the lower river uninhabitable for fish during warmer months of the year (typical months of the seine survey). In 1972, the Federal Clean Water Act was enacted and water quality began to improve, allowing a variety of species to move into the previously polluted areas. Current water quality testing by the Bureau of Marine Fisheries shows that the Delaware River is now maintaining a healthy environment for these fish.[xxxi] 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 demonstrates that forage species in the river are an important part of the ecosystem. As the number of forage fish increases, the food available for predator species populations also increases. Predators impact the forage fish index when they begin to compete for food. For example, during a period of decline in the forage fish index (2007-2011), striped bass and white perch numbers were much higher than previous years. As these species numbers increased, the number of forage fish declined. Without a steady food source, predators will look for alternative food. As the forage fish index begins to recover, the number of predator species will rise again. This cycle provides the basis for a forage fish index that varies over time. This is a logical assumption, considering that the seine survey targets juvenile fish, and doesn't catch many larger adult fish, limiting the number of predatory species counted in the survey.

It is unclear whether the decrease in the forage fish index is a natural artifact of the predator-prey relationship or if the decline in the forage fish populations have impacted the striped bass populations. This declining trend in forage fish indicates the essential role that continued monitoring will play in informing management measures to address such issues.

More Information

The data and information in this chapter have been provided by NJDEP Marine Fisheries Administration (including the Bureau of Shellfisheries). More information is available at the following web sites:
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):
http://hsrl.rutgers.edu/
http://hsrl.rutgers.edu/SAWreports/index.htm

NJDEP Web Sites (for information on changes in State harvest regulations):
http://www.nj.gov/dep/fgw/shelhome.htm
http://www.nj.gov/dep/fgw/saltwater.htm

NOAA Fisheries Service Northeast Fisheries Science Center (for striped bass stock assessment reports):
http://www.nefsc.noaa.gov/saw/reports.html

Pyle, J. 2009. Importance of Forage Fish in the Delaware River. Marine Fisheries Digest, May 2009, pp 28-29.

Pyle, J. 2013. Studying the Delaware River. New Jersey Fish and Wildlife Website, May 2013, www.njfishandwildlife.com/artdelstudy13.htm

References

[i]NOAA, Recreational Fisheries Economic Impact Data, Query- 2012 Mid-Atlantic Region, NJ State: https://www.st.nmfs.noaa.gov/apex/f?p=160:32:0::NO:RP:: Accessed online 9/21/2015.
[ii]Holmlund, C. M. and M Hammer. 1999. Ecosystem services generated by fish populations. Ecological Economics 29: 253-268
[iii]Coen, L. D. and R. Grizzle. 2007. The importance of habitat created by molluscan shellfish to managed species along the Atlantic Coast of the United States. Habitat Managament Series # 8 (Atlantic States Marine Fisheries Commission). 108 pp.
[iv] Celestino, M., J. Pyle, L. Barry, and G. Hinks. 2014. NJ Fisheries Surveys: signals from our research. Marine Fisheries Digest, May 2014, pp 6-8.
[v] ASMFC. 2013. Update of the Striped Bass stock assessment using final 2012 data. 74 pp.
[vi] ASMFC (Atlantic States Marine Fisheries Commission). 2003. Fishery Management Report No. 41 of the Atlantic States Marine Fisheries Commission. Amendment 6 to the Interstate Fishery Management Plan for Striped Bass. 63 pp.
[vii]NJDLWD (New Jersey Department of Labor and Workforce Development). 2011. Southern Regional Community Fact Book: Cumberland County Edition. 17 pp. http://lwd.dol.state.nj.us/labor/lpa/pub/factbook/cumfct.pdf
[viii] Buckel, J. A., M. J. Fogarty, and D. O. Conover. 1999. Foraging habits of bluefish, *Pomatomus saltatrix*, on the U.S. east coast continental shelf. Fishery Bulletin 97: 758-775.
[ix]Pers. Comm., R. Allen, NJ Marine Fisheries Administration.
[x]Pennington, M. 1986. Some statistical techniques for estimating abundance indices from trawl surveys. Fishery Bulletin 84(3): 519-525.
[xi]Helser, T. E. and D. B. Hayes. 1995. Providing quantitative management advice from stock abundance indices based on research surveys. Fishery Bulletin 93: 290-298.
[xii]ASMFC. 2009. Horseshoe Crab Stock Assessment for Peer Review.
[xiii]Setzler, E. M., W. R. Boynton, K. V. Wood, H. H. Zion, L. Lubbers, N. K. Mountford, P. Frere, L. Tucker, and J. A. Mihursky. 1980. Synopsis of biological data on striped bass, *Morone saxatilis* (Walbaum). NOAA Technical Report NMFS Circular 433. 69 pp
[xiiv] ASMFC 2013
[xv]ASMFC 2013
[xvi]ASMFC 2014
[xvii]ASMFC 2013
[xviii]Texas Instruments Incorporated (TII). 1979. Efficiency of a 100-ft beach seine for estimating shore zone densities at night of juvenile striped bass, juvenile white perch, and yearling and older (≤ 150 mm) white perch. Texas Instruments Incorporated, Dallas, Texas.
[xix]Powell, E.P., D. Bushek & K. Ashton-Alcox. 2013. Report of the 2013 Stock Assessment Workshop (15th SAW) for the New Jersey Delaware Bay Oyster Beds. Final Annual Report. Rutgers University.
[xx]Ford, S. E. 1997. History and present status of molluscan shellfisheries from Barnegat Bay to Delaware Bay. In: C. L. MacKenzie Jr., V. G. Burrell Jr., A. Rosenfield & W. L. Hobart, editors. The history, present condition, and future of the molluscan fisheries of North and Central America and Europe. Vol. 1. North America: U.S. Department of Commerce, pp. 119-140.
[xxi]Haskin, H. H., L. A. Stauber & J. A. Mackin. 1966 *Minchinia nelsoni* sp. n. (Haplosporida, Haplosporiidae): causative agent of the Delaware Bay oyster epizootic. Science 154:1414-1416., Ford 1997
[xxii]Powell, 2013
[xxiii]Fegley, S. R., S. E. Ford, J. N. Kraeuter & D. R. Jones. 1994. Relative effects of harvest pressure and Disease mortality on the population dynamics of the eastern oyster (*Crassostrea virginica*) in Delaware Bay. NOAA Oyster Disease Res. Prog. Final Rep. Port Norris, NJ. 179 pp.
[xxiv]Ford, 1997
[xxv]Fegley, 2003
[xxvi]Jacobs, J. M., R. M. Harrell, J. Uphoff, H. Townsend, and K. Hartman. 2013. Biological Reference Points for the Nutritional Status of Chesapeake Bay Striped Bass. North American Journal of Fisheries Management: 33(3): 468-481.
[xxvii]Paine, R. T. 1966. Food web complexity and species diversity. The American Naturalist 100(910): 65-75.
[xxviii]Setzler et al. 1980
[xxix] ASMFC 2014
[xxx] ASMFC. 2007. American Shad Stock Assessment Report Volume II. Washington, D.C. p 302.
[xxxi] NJDFW (New Jersey Division of Fish and Wildlife) – Delaware River seine survey data (1980-2013).