Power Plant Impingement Data as Indices of Juvenile Menhaden Abundance

Micah Dean – June 18, 2013

Introduction

With the possible development of a spatially explicit assessment model for Atlantic menhaden, there is a greater need for regional indices of juvenile abundance. In previous assessments, we have relied on a suite of state-specific beach seine surveys to estimate a Juvenile Abundance Index (JAI). However, none of these surveys were designed with menhaden in mind, and there may be substantial mismatch between the survey timing and peak abundance of juvenile menhaden in each study area. Power plant impingement monitoring may provide a meaningful alternative dataset, as these facilities conduct intensive sampling (i.e., multiple times a week) throughout the entire year. Leveraging long-term monitoring data from several plants distributed along the coast may provide a meaningful measure of juvenile menhaden abundance both regionally and for the entire stock.

The entrainment and impingement datasets for Mid-Atlantic (SC to NY) power plants were previously reviewed in 2003 (ASA 2003). The primary purpose of that report was to assess the coast-wide impact of power plants on the Atlantic menhaden stock. The authors focused on the period 1985-2000, but include earlier information as well, if available. The general conclusion of the report was that most power plant datasets are not useful for describing trends in menhaden abundance because they came from one-time studies that ran for 1-3 years (Figure 1). However, out of the 52 power plants that were evaluated in 2003, there are at least 7 that have been collecting data for several decades (Table 1). In addition, I have identified 5 plants in New England that were not previously reviewed, yet have been conducting impingement monitoring since the early 1970s. I have contacted the individual(s) responsible for conducting impingement sampling at these 12 facilities and have requested the following data:

- Number of menhaden impinged per sample period
- Volume of intake water per sample period
- Lengths of menhaden impinged per sample period.
- Description of the cooling water intake structures and the impingement sampling protocol

In all cases, these data were not immediately available, since the focus of these monitoring programs has been to estimate the total annual number of fish impinged on cooling water intake structures (as opposed to a rate of impingement, with an estimate of uncertainty). However, some plants were able to provide the average impingement rate by month or week, while others only had a time series of total annual impingement immediately available. Each person I contacted has promised to assemble a dataset of impingement rates at the highest possible resolution (i.e., by week or month, if not by sample period).

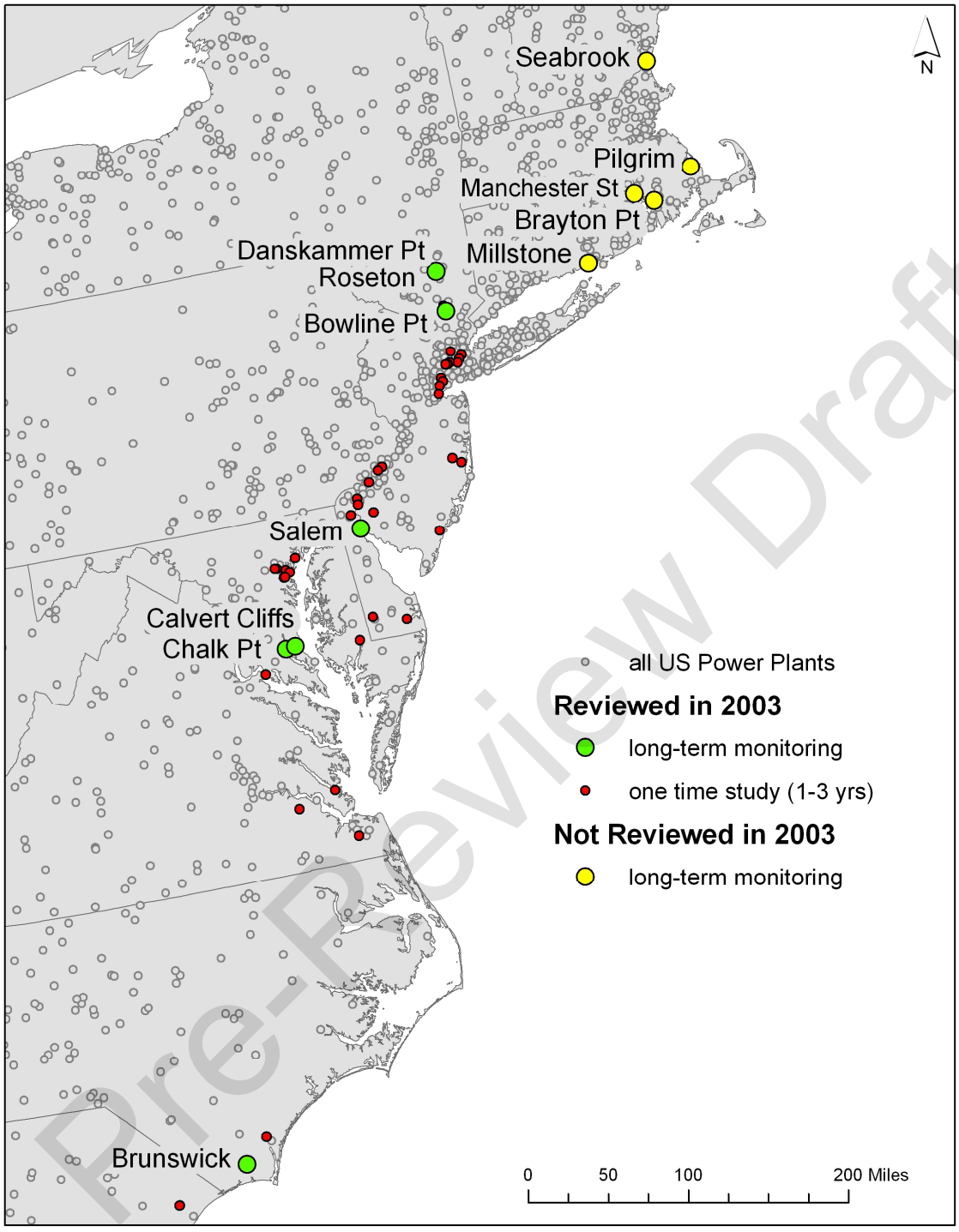

Figure 1. Map of power plants locations that could provide long-term time series of menhaden impingement data.

Table 1. Atlantic Coast power plants with long-term impingement datasets.

Power Plant	Region	Current Status	Impingement Monitoring
Seabrook	Coastal NH	Active	1994-current
Pilgrim	Cape Cod Bay (MA)	Active	1980-current
Brayton Pt	Narragansett Bay (MA)	"closed cycle" in 2012	1974-2011
Manchester St	Narragansett Bay (RI)	Active	1975-current
Millstone	Niantic River (CT)	Active	1972-current (?)
Danskammer Pt	Hudson River (NY)	Decommissioned (2012)	1974-2011
Roseton	Hudson River (NY)	< 5% of capacity since 2008	1973-current
Bowline	Hudson River (NY)	< 5% of capacity since 2008	1975-current
Salem	Delaware Bay/River (NJ)	Active	1978-current
Chalk Pt	Chesapeake Bay (MD)	Active	1984-1999
Calvert Cliffs	Chesapeake Bay (MD)	Active	1975-1998
Brunswick	Cape Fear Estuary (NC)	Active	1973-current

Dataset Descriptions

Impingement sampling is conducted in a similar way at each facility. Intake water passes through a rotating or continuous traveling screen that is “washed” by low and high-pressure hoses. Any fish impinged on these screens fall into a collection sluice that returns them back to the waterbody. This collection sluice can be diverted to a sample container for a set period of time to collect an impingement sample. Fish in each sample are identified to species, measured for total length (taking a subsample of 20-50 fish where necessary) and returned to the waterbody. Each plant has its own sampling frequency, but most collect multiple samples per week, year-round.

The impingement datasets were organized into 2 regions: North (ME to NY) and South (NJ to NC), mimicking the regions used in previous JAI analyses. For each region, I plotted the best (currently) available index of abundance for each plant, as compared to that region’s JAI time series. Additionally, I calculated a Pearson’s correlation coefficient (R) for each pairwise comparison between plants and the regional JAI. Please note that in many cases the “best current index” is simply the total number of menhaden impinged per year and has not been standardized for changes in intake water volume. These will be replaced with more meaningful indices of abundance as the data become available.

Northern Region (ME - NY)

A total of eight coastal power plants with long-term impingement time series were identified between New York and New Hampshire (Table 1). Most of these plants began their monitoring programs in the early 1970s and have conducted the same sampling protocol up to the present day. Three plants (Brayton, Pilgrim, Manchester) have provided either weekly or monthly flow-adjusted menhaden

impingement rates, allowing for some measure of uncertainty in an annual index. The remaining plants (except for Millstone) are in the process of assembling similar datasets. In the interim, the only time series available for these plants are the total number impinged per year.

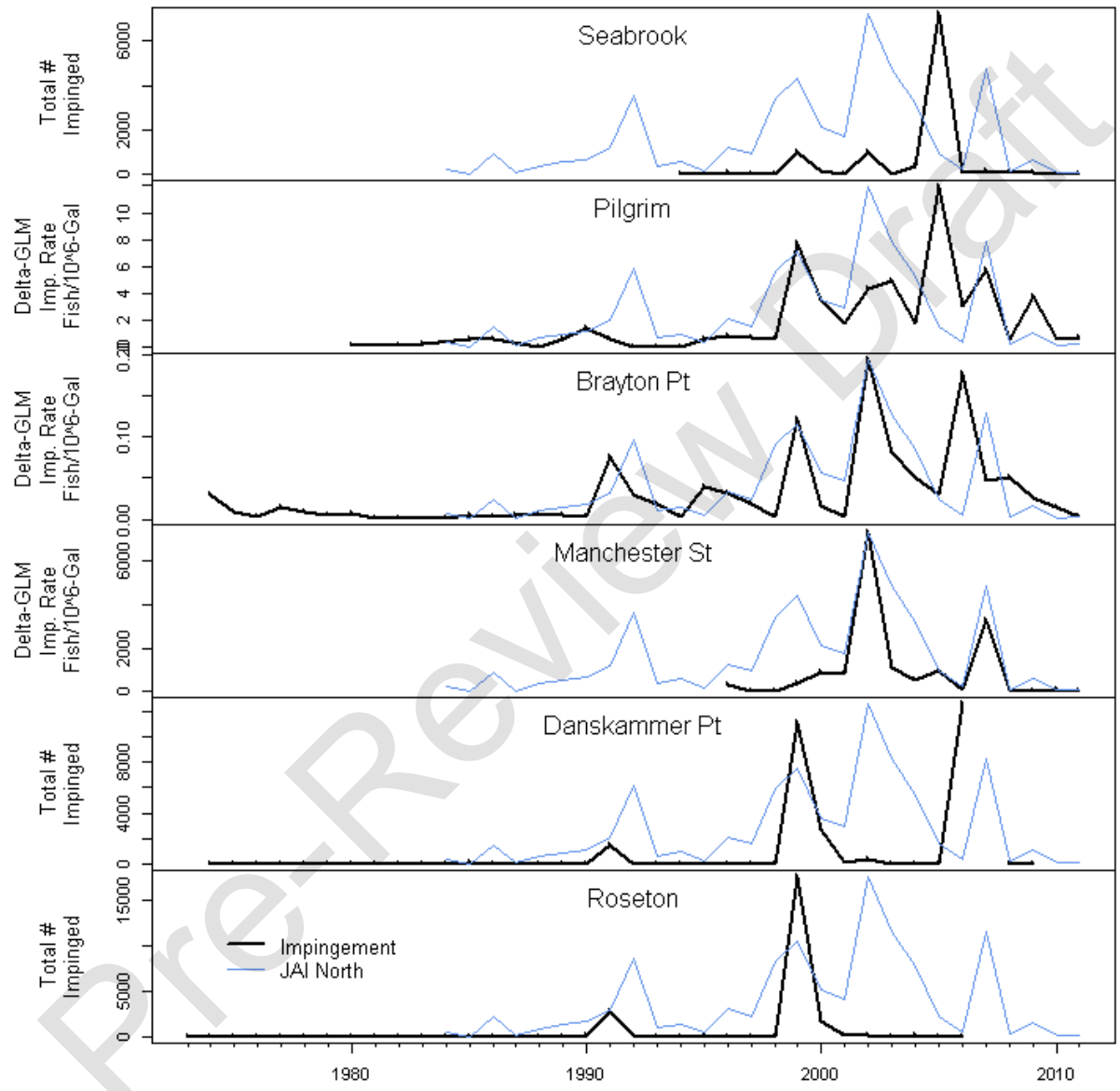

Figure 2. Impingement time series for Nothern power plants, as compared to the regional JAI. Note that Seabrook, Danskammer Pt. and Roseton are simply the total #impinged per year, unadjusted for volume of intake water. I was unable to obtain impingement data for Millstone and Bowline in time for this report.

Table 2. Pearson's correlation coefficient (R) for pair-wise comparisons of impingement time series from Northern plants, as well as the JAI for the same region.

	JAI_NORTH	SEABROOK	PILGRIM	BRAYTON	MANCHESTER	DANSKAMMER	ROSETON
JAI_NORTH	1.00	0.00	0.41	0.56	0.76	0.11	0.31
SEABROOK	0.00	1.00	0.78	0.04	0.11	-0.05	0.02
PILGRIM	0.41	0.78	1.00	0.41	0.27	0.36	0.42
BRAYTON	0.56	0.04	0.41	1.00	0.56	0.65	0.36
MANCHESTER	0.76	0.11	0.27	0.56	1.00	-0.15	-0.12
DANSKAMMER	0.11	-0.05	0.36	0.65	-0.15	1.00	0.65
ROSETON	0.31	0.02	0.42	0.36	-0.12	0.65	1.00

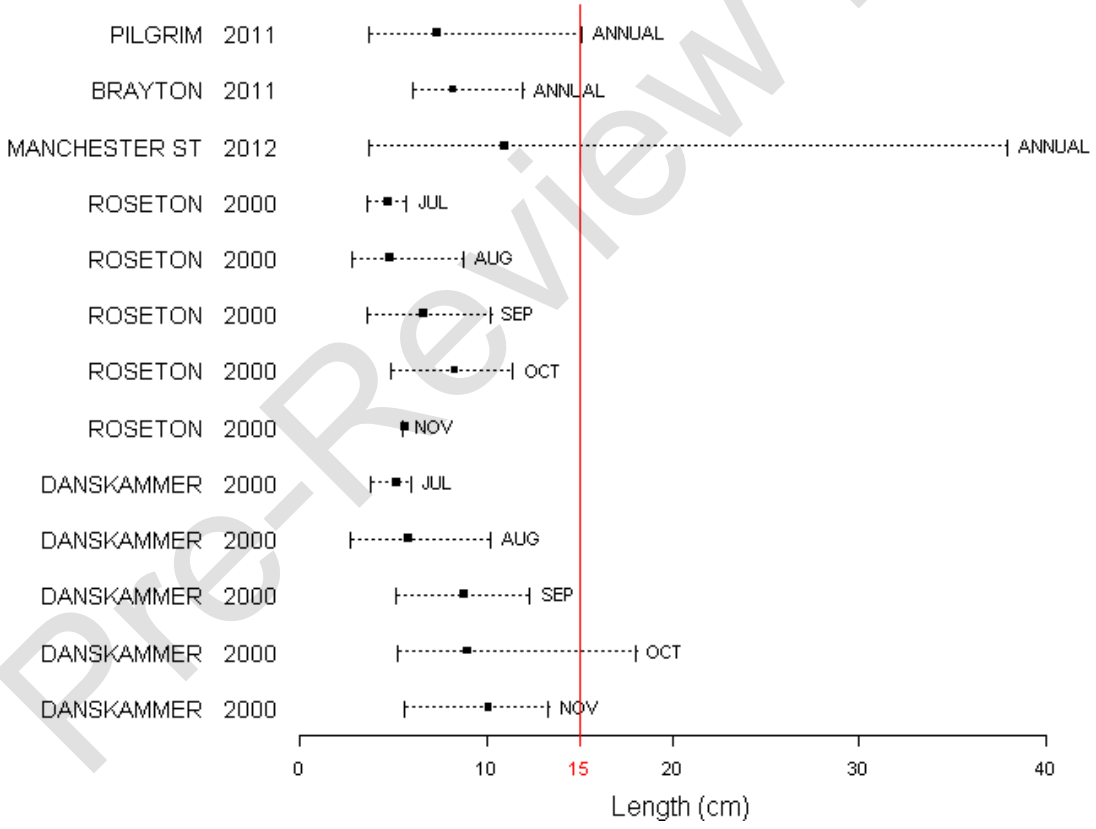

Figure 3. Length summary data for menhaden impinged at Northern power plants. The black square represents the mean length for the group, whereas the "whiskers" represent the minimum and maximum lengths for the group. The red vertical line indicates the length "cutoff" used to define juvenile menhaden in previous JAI analyses (for fish sampled after mid-august).

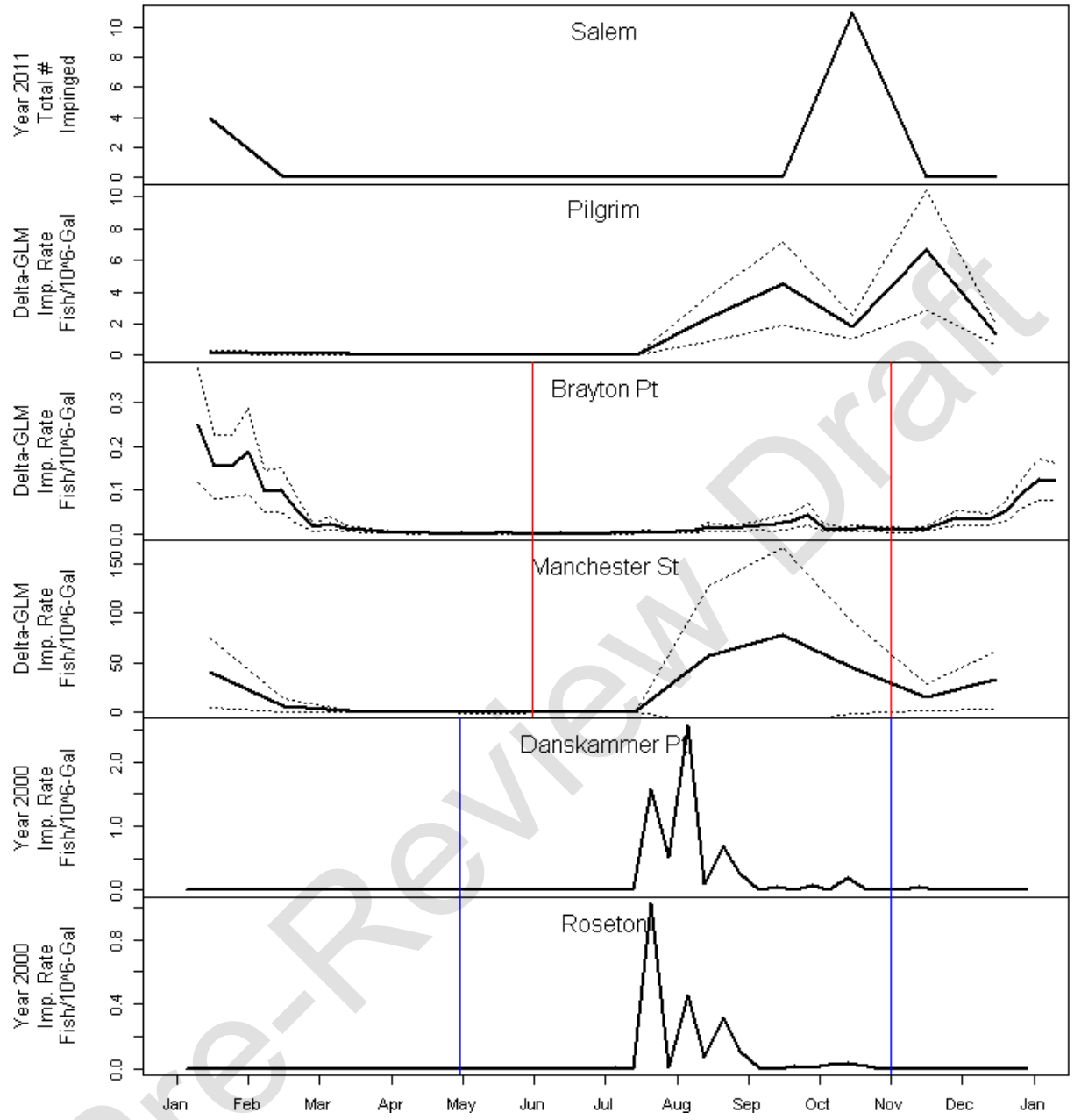

Figure 4. Seasonality of menhaden impingement at Northern power plants. The type of data presented in this figure varies by facility: Salem – monthly total impingement for the year 2011; Pilgrim – delta-lognormal GLM impingement rate (IMPRATE~MONTH); Brayton Pt – delta-lognormal GLM impingement rate (IMPRATE~WEEK); Manchester St – delta-lognormal GLM impingement rate (IMPRATE~MONTH); Danskammer Pt/Roseton – weekly impingement rate for the year 2000. Dashed lines indicate +/- 1 SE for datasets with GLM models. Vertical lines indicate the range of dates for the seine surveys conducted by RIDEM (red) and NYDEC (blue) that go into the JAI.

Seabrook

The Seabrook Nuclear Power Plant is situated on the Seabrook/Hampton harbor in coastal New Hampshire. The cooling water intake for this facility is located ~10 m off the sea floor in ~40 m of water. Impingement samples have been collected from continuous traveling screens (CTS) 1 to 2 times a week since 1994. I have contacted the plant scientist, as well as the environmental contractor responsible for analysis of their biological monitoring data. They supplied me with a recent annual bio-monitoring report, which provides the estimated total menhaden impingement from 1994-2011, as well as monthly impingement for 2011. They are willing to share raw data, including the # menhaden / intake-gallons per sample period.

Contacts: Al Legendre (NextEra Energy); Paul Goehegan (Normandeau)

Pilgrim

The Pilgrim Nuclear Power Plant is located on the western shore of Cape Cod Bay, in Plymouth, Massachusetts. Eight-hour CTS Impingement samples have been collected 3 days a week from 1980 to present. The environmental contractor for this plant has provided monthly impingement rates (fish/hr-sampled) for the full time series. Unfortunately, the raw per-sample data exist only in paper format at this time, but could be made available if we deem necessary. Approximately 60% of the monthly-aggregated samples contained zero menhaden. As such, I used a simple delta-lognormal GLM (IMPINGEMENT_RATE ~ YEAR) to construct an index of abundance.

Contacts: Joe Egan (Entergy Nuclear); Joe Battaglia (Normandeau)

Brayton Point

The Brayton Point Power Station is located on Mount Hope Bay, a portion of eastern Narragansett Bay in Massachusetts. Eight-hour Impingement samples have been collected 3 times per week, year-round since 1972. In 2012, Brayton Point Station was converted to a “closed cycle” plant, meaning its intake water usage has dropped by an order of magnitude, likely ending the 40-year time series. The station’s environmental contractor has provided weekly impingement rates (fish/million-gallons) for the entire time series. Approximately 66% of these weekly-aggregated samples contained zero menhaden. To account for this, I used a simple delta-lognormal GLM (IMPINGEMENT_RATE ~ YEAR) to construct an index. Note that menhaden impingement typically occurs Dec-Feb at this facility.

Contacts: Mike Scherer (Normandeau)

Manchester Street

The Manchester Street Power Station is located on the Providence River, in Providence, RI. Weekly impingement samples have been collected since 1975. RIDEM has provided total annual impingement for the full time series and monthly impingement rates (fish/million-gallons) for 1995-2011. Approximately 40% of these monthly-aggregated samples contained zero-menhaden. As such, I used a delta-lognormal GLM (IMPINGEMENT_RATE ~ YEAR) to construct an index of abundance. Length summary data was immediately available for 2012 only. From these data, it appears some adult menhaden are impinged, in addition to juveniles (Figure 3). Further examination of annual length data is warranted to see how frequently adults are encountered.

Contact: Sam Kaplan (RIDEM)

Millstone

Millstone Nuclear Power Plant is located on the Niantic River, at the eastern end of Long Island Sound. Impingement samples have been collected since 1972, but it is unclear if major gaps exist in their time series. I have been unable to contact someone who is familiar with these data.

Danskammer Point & Roseton

Both Roseton and Danskammer Point Power Stations are located on the Hudson River approximately 106 km upstream from the mouth, in the town of Newburgh, NY. A single 24-hr weekly impingement sample has been collected at each of these plants since the early 1970s. The Danskammer Point plant was damaged by "superstorm" Sandy in 2012 and has since been decommissioned. Roseton power station has been operating at <5% of capacity since 2008, and therefore has minimal intake water flow in recent years. A NYDEC biologist has provided a couple of recent annual reports for these facilities, which have estimates of total annual impingement for the full time-series, as well as flow-adjusted impingement rates for each sample period in the reporting year.

Contact: Chuck Nieder (NYDEC)

Bowline

The Bowline Power Station is located on the Hudson River, approximately 38 km upstream from the mouth, in the town of Haverstraw, NY. Weekly impingement samples have been collected since 1975. However, this plant has been operating <5% capacity since 2006, limiting the utility of the impingement dataset in recent years. No impingement data were immediately available as of this report.

Contact: Chuck Nieder (NYDEC)

Southern Region (NJ – NC)

For the southern 4 plants, I was unable to obtain any new data beyond what was presented in the 2003 review. However, I contacted personnel at each plant who agreed to send updated and higher resolution flow-adjusted impingement data.

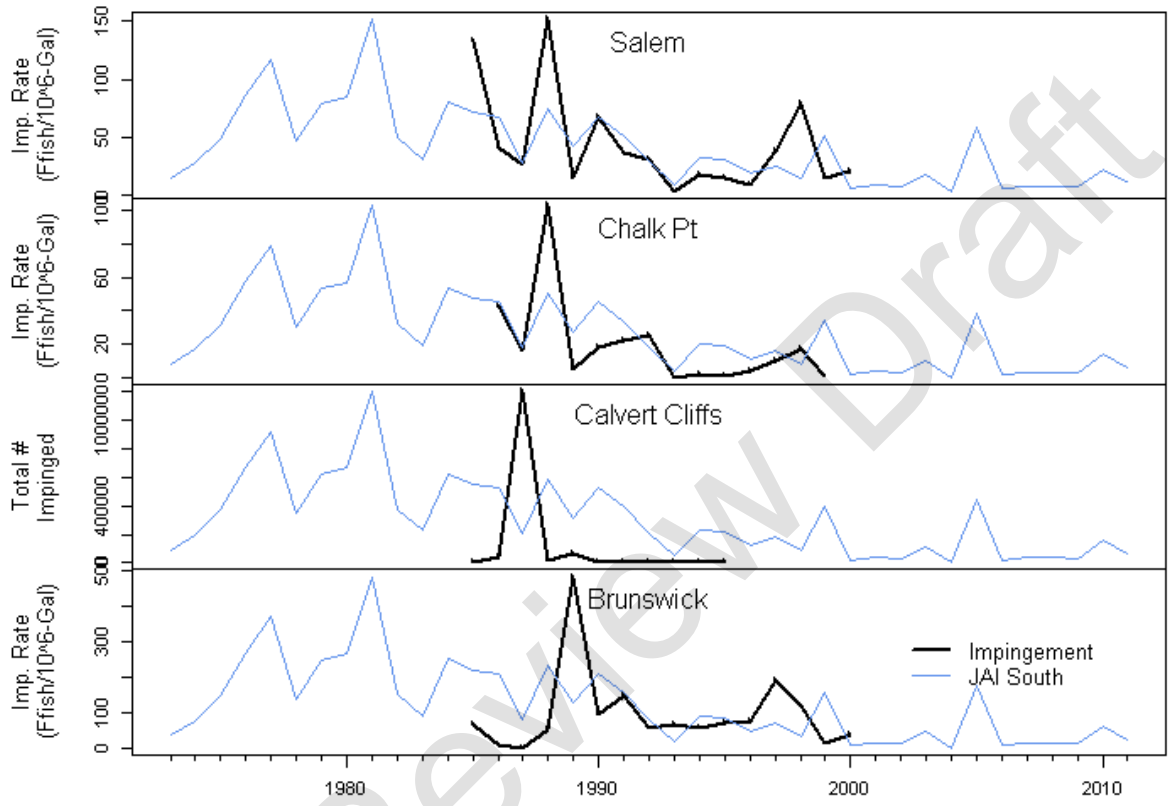

Figure 5. Impingement time series for Southern power plants, as compared to the regional JAI. Note that Calvert Cliffs index is simply the total #impinged per year, unadjusted for volume of intake water.

Table 3. Pearson's correlation coefficient (R) for pair-wise comparisons of impingement time series from Southern plants, as well as the JAI for the same region.

	JAI_SOUTH	SALEM	CHALK PT	CALV CLIFFS	BRUNSWICK
JAI_SOUTH	1.00	0.63	0.64	-0.25	-0.03
SALEM	0.63	1.00	0.89	-0.15	-0.13
CHALK PT	0.64	0.89	1.00	-0.08	-0.20
CALV CLIFFS	-0.25	-0.15	-0.08	1.00	-0.22
BRUNSWICK	-0.03	-0.13	-0.20	-0.22	1.00

Salem

Salem Nuclear Power Plant is located at the northern end of Delaware Bay, in Lower Alloways Creek, NJ. Ten impingement samples per day (1-8 minutes each), three days per week have been made from the continuous traveling screens since 1978. I contacted the manager of the biological monitoring group for this facility and he has agreed to provide a dataset of menhaden impingement rates at the highest possible resolution for the full time series. The salinity at this location can vary dramatically due to the freshwater influence of the Delaware River; according to Mr. Strait, this can have an impact on the assemblage of species impinged. Salinity, water temperature and dissolved oxygen are recorded with each impingement sample and these data can be made available for potential covariates in an index.

Contact: Ken Strait (PSEG)

Chalk Point

Chalk Point power station is located on the Patuxent River, in Aquasco, MD. Weekly impingement samples were collected year-round between 1984 and 1999. I have contacted environmental contractor who formerly managed this program (Jules Loos, now retired), and he has agreed to resurrect the impingement data and provide an impingement time series at either weekly or monthly resolution.

Contact: Jules Loos (Retired)

Calvert Cliffs

Calvert Cliffs Nuclear Power Plant is located on the western shore of Chesapeake Bay, in Lusby, MD. Weekly impingement samples were collected year-round between 1975 and 1999. The biologist who managed the impingement sampling program has agreed to provide a flow-adjusted impingement time series at either weekly or monthly resolution.

Contact: Howard Hixson (Morgan St. University)

Brunswick

The Brunswick Nuclear Power Plant is located in Southport, NC, on the Cape Fear River. Weekly impingement samples were collected between 1973 and 1992, and then monthly samples were collected from 1993 to present. However, an intake water diversion structure was installed in 1983 that dramatically decreased the number of fish impinged. Therefore, I have asked the plant biologist to provide flow-adjusted impingement rate data for the post-diversion period (1983-present).

Contact: Tom Thompson (Duke Energy)

Conclusion

While each power plant represents only a single location, they offer the advantage of an intensive and continuous sampling protocol. Year-round data eliminates the problems associated with a mismatch between seasonal estuary use and the timing of a beach seine survey. However, generalizing the observations made at each facility to the regional scale depends on the availability of useable data at a sufficient number of key locations, and the extent to which they corroborate each other. Due to the crude bits of data I was able to assemble for most of these facilities, it is unclear how useful this approach will be. The largest obstacle to using these data as a measure of juvenile menhaden abundance is actually obtaining the impingement records. Despite many phone calls and emails over the past several weeks, I have received only a small amount of useful data, yet have been given many assurances that additional information will be forthcoming. If we are able to obtain all the data that has been promised to me, I feel this approach could be a useful check against the JAI.