

Annual Report on the Commercial Monitoring of the Hudson River Blue Crab Fishery



**Prepared by
Gregg Kenney**

**New England Interstate
Water Pollution Control Commission
Lowell, MA**

**In association with
New York State Department of Environmental Conservation
Bureau of Marine Resources
Hudson River Fisheries Unit
New Paltz, NY**

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Foreword

The Hudson River Estuary Action Plan has funded the Blue Crab Project as part of its commitment to conserve fish and crustaceans in the Hudson River Estuary. The goal of the Blue Crab Project is to sustain and enhance the blue crab fishery in the Hudson River Estuary. The Hudson River Estuary Action Plan coordinates this project through the Hudson River Fisheries Unit of the New York State Department of Environmental Conservation (NYSDEC). The NYSDEC has contracted the New England Interstate Water Pollution Control Commission (NEIWPCC) to carry out their objectives. The main objective of the project is onboard monitoring of the Hudson River blue crab fishery to determine catch rates, size, sex, composition, timing and location of catches. Two years of commercial fishery data have now been collected. This report summarizes the commercial monitoring data collected in the 2001 crab fishing season and makes comparisons to data collected in 2000. The Blue Crab Project will also obtain and summarize:

- Published scientific literature pertaining to blue crabs in the Hudson River Estuary.
- Unpublished data on distribution, size and relative abundance from various fisheries sample programs.
- Historical harvest data

Acknowledgements

I would like to thank the fishermen who let me get in their way while they pulled their traps. Andrew Kahnle provided sage advice and pithy comments that improved this report immeasurably. Thanks also to Kathy Hattala and Amanda Cosman for helpful edits and a fine cover photograph. Kris McShane and Mary O'Dell were superior substitute monitors who made thirty-four monitored trips possible.

I would also like to thank Bill Saksen of Mirant, Paul Lindsay of Normandeau Associates, and Ed Radle of the NYSDEC for their assistance in acquiring recent electronic impingement data.

George E. Pataki, Governor
Erin M. Crotty, Commissioner



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Introduction

Blue crabs (*Callinectes sapidus*) are an important species in the Hudson River estuary because they provide commercial and recreational fisheries and play an important ecological role. In the Chesapeake they are important predators, affecting everything from the infaunal community structure to the bioturbation of sediments (Hines et al. 1990). There is currently little published data about blue crabs in the Hudson River Estuary (Wilson and Able, 1992). Prior to the implementation of this project, there was no ongoing collection of biological data for blue crabs and harvest information was limited to catch reports turned in by fishers. This project has begun the collection of important biological information about blue crabs in the estuary.

Objectives

This report summarizes information collected while observing the commercial fishery for blue crabs in the Hudson River Estuary during the summer and fall of 2001. The main objectives of the commercial monitoring effort were to:

- Collect basic biological information about crabs captured in the pots of crab fishers: sex, carapace length, weight and moult frequency.
- Determine the catch per unit of effort (CPUE) for commercial crab fishers in the estuary.
- Collect water quality information in the vicinity of crab pot locations including: temperature, salinity, dissolved oxygen and conductivity.
- Compare biological information of harvested crabs to fishery independent biological data.

Methods

Description of study area

The Hudson River Estuary (Figure 1) extends north approximately 246 km (153 mi) from the Battery at New York City, to the Federal Dam at Troy. Widths of the Estuary range from less than 0.5km (0.3 mi) near the Troy dam to more than 6 km (3.7 mi) in Haverstraw Bay below Peekskill (Kahnle and Stang, 1986). Depths generally range from 10 to 20 m (33 to 66 ft) with a channel maintained for shipping from the Atlantic Ocean to Albany. The location of the salt front varies seasonally with freshwater flow.

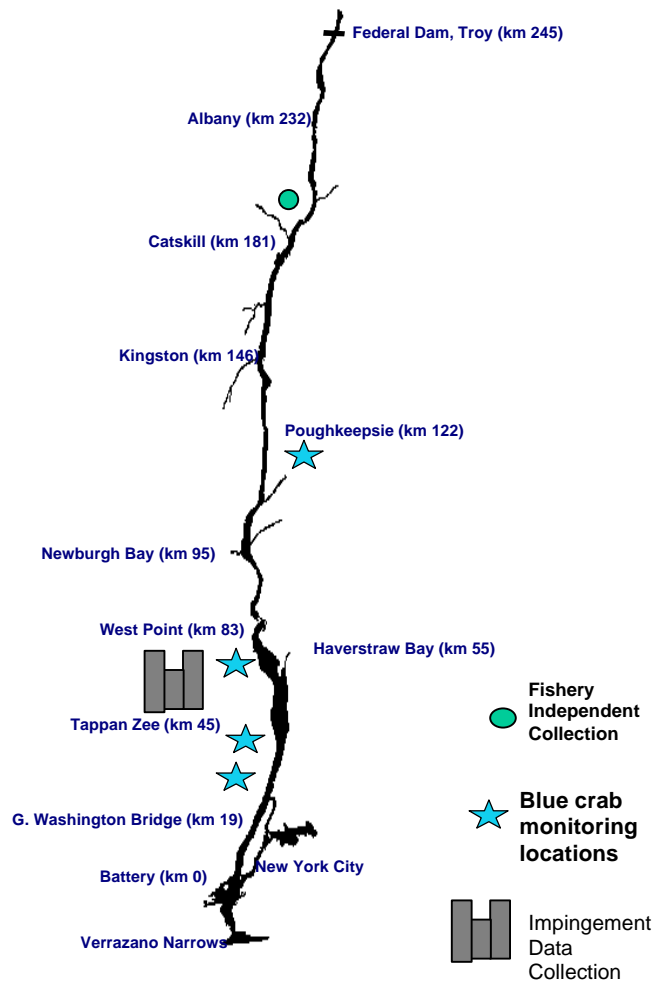


Figure 1. Important Blue Crab Project landmarks in the Hudson River Estuary

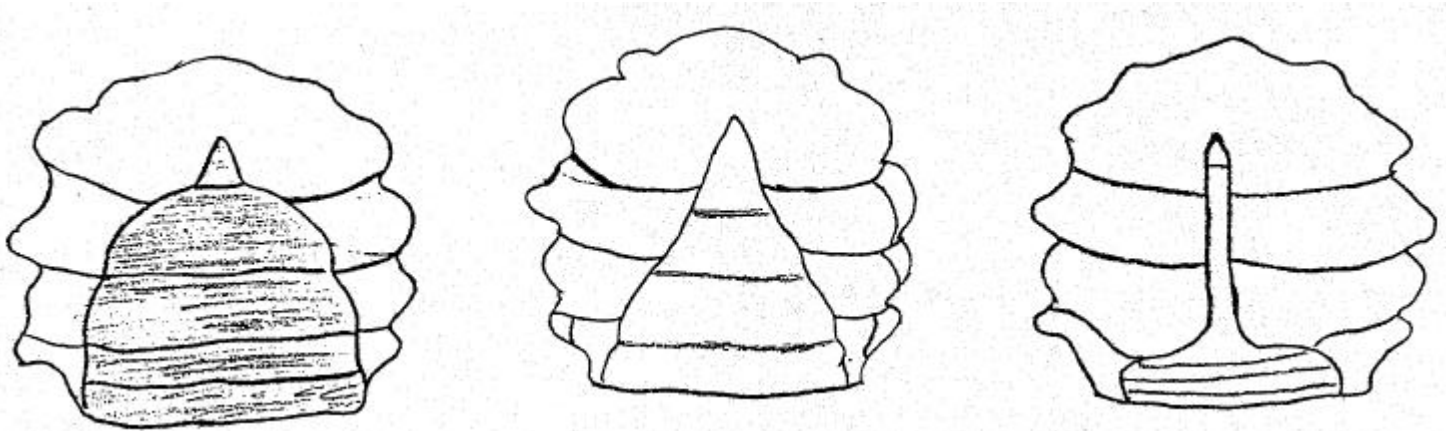
General blue crab biology

Little is known on the life history details of blue crabs in the Hudson River Estuary. Based on work done in the Chesapeake and Delaware Bays, however, we can make some generalizations about the likely life history of blue crabs in the Hudson.

The blue crab is a decapod crustacean that is known anecdotally to inhabit the entire Hudson River Estuary. Wilson and Able (1992) easily collected blue crabs from New York Harbor (RKM 0) to Newburgh (RKM 86) and the New York State Department of Environmental Conservation (2000) has collected blue crabs with a beach seine from Newburgh to Albany (RKM 225). Eggs are released in the lower estuary during the summer months. After hatching, the newborn zoea are carried out to the near shore ocean, where they develop into megalopae. Trawls off the southern Atlantic coast found blue crab megalopae more than forty miles from shore (Nicols and Keney, 1963). After 10-12 molts, about two months, the larval form gradually assumes the shape of a crab. At this point, winds, tide and storms will have transported successful crabs to the relative safety of an estuary (Goodrich et al. 1990, Little and Epifanio 1991). These new 10-20mm recruits typically head toward fresher water in the Chesapeake (Van Engel 1958). In the Hudson, juveniles of similar size begin to appear on impingement screens from generating station intakes in August or September from Haverstraw Bay to Newburgh Bay (Normandeau 1998 and 2000).

As winter approaches blue crabs begin to feed less and cease molting. In the Chesapeake and Delaware they head toward deeper water and may bury themselves into the mud and wait for warmer weather (Cronin 1954 and Van Engel 1958). The severity of winters may affect winter mortality among blue crabs (Kennish et al. 1982). Blue crabs in the Hudson are on the northern fringe of their range (Williams 1974). It is likely that a cold winter on the periphery of the blue crabs' range would be particularly detrimental to winter survival.

Female crabs in the Chesapeake become sexually mature after 18-20 post-larval molts (Van Engel 1958). Data collected by this project found that most Hudson River females make their terminal molt before they attain a width of 125 mm (Figure 9) from point to point across the back (carapace length). It is at this final molt that the female undergoes her once in a lifetime mating event. The female then stores the sperm for future fertilization events, which may occur three to four times annually over the course of her life. The eggs develop beneath her apron and she carries them until she spawns in the lower estuary in areas of high salinity (Van Engel 1958). Salinity of 23 to 28 ppt is ideal for egg hatching (Sandoz and Rogers 1944). Males have no such terminal molt. The shape of their aprons (Figure 2) can distinguish males and females.



MATURE FEMALE

IMMATURE FEMALE

MALE

Figure 2. Shape differences in blue crab aprons

Once mature, the blue crab is a dominant benthic predator. Its powerful claws allow it to lie in wait to ambush small fish that pass by. It also preys upon other crabs, bivalves and dead organisms on the river bottom. Zebra mussels (*Dreissena polymorpha*) are a documented prey item of Hudson River blue crabs (Molloy et al. 1994). The blue crab has strong back appendages it can use as paddles to propel itself through the water. The use of these “paddles” probably inspired the crabs Greek name *Callinectes*, meaning beautiful swimmer.

Hudson River blue crab fishery

The blue crab fishery in the Hudson River Estuary is typically a summer and fall endeavor. Many of the participants were also shad fishers who began crabbing shortly after the shad fishing ended. All of the fishers used crab pots to capture the crabs. These pots are made of 1 ½ inch plastic coated chicken wire mesh that measured eight cubic feet and had holes on four sides for the crabs to enter. The crabs were coaxed into the pot by a container in the center that holds bait. Baits used in the Hudson River included Atlantic menhaden (*Brevoortia tyrannus*), chicken and various fish parts. The crabs enter the pots and are captured by a design that takes advantage of their instincts to rise when they feel trapped.

There are approximately 705 people that hold crab permits in the State of New York. A moratorium on new crab permit holders has been in place since 1999. Of those 705 crab permit holders in the state, twelve are known or suspected to crab in the Hudson River Estuary. Four fishers were monitored while they tended their pots in 2001. One fisherman was added who did not participate in the 2000 season. Another fisher refused permission and several fishers did not actively fish in the 2001 season. It is likely that other fisheries exploit crabs that spend part of their life cycle in the Hudson. The New York harbor is “(New York’s) second most important commercial blue crab fishing area” (Briggs, 1998). New Jersey landings from Raritan Bay were also significant, averaging 55,451 pounds a year between 1991 and 1995 (Stehlik et al. 1998).

There are currently no size or harvest limits on commercial harvest of blue crabs in the Hudson River estuary. However, the fishers generally returned female crabs and crabs less than 127mm (5 inches) in carapace length to the estuary. There is currently no regulation that requires this practice. The only current requirement is the return of egg bearing females to the estuary. Blue crabs offered for sale are often divided into two size categories. “Number ones” include all crabs over 140mm (5.5 inches) and command a premium price. “Number twos” are the smaller crabs that measure less than 140 mm.

Fishery Data Collection

All of the information collected on blue crab catches in the commercial blue crab fishery was obtained through direct observation. Contact was made with these crabbers and permission was asked to monitor their catch. The fishers that consented were observed while they emptied or checked their crab pots. Every effort was made to accompany each participating fisher on a weekly basis. Data on river mile location, location relative to the channel, number of pots checked, time fished (in hours), bait used, water temperature, percent of dissolved oxygen, dissolved oxygen, conductivity, specific conductance, and salinity were collected for each trip.

Water quality data were taken with a YSI model 85 handheld digital meter. The unit was outfitted with new dissolved oxygen membranes monthly throughout the season and was calibrated before each trip. The wire of the unit was marked off at foot intervals and a weight was attached to the end ensuring that the probe was at the desired depth. Data were collected at a variety of depths in the vicinity of each fishers crab pots. Whenever possible, these data were collected at the same location each week.

The total blue crab catch for the trip was recorded in either number of crabs or number of bushels of crabs caught. The number of crabs per bushel changed throughout the course of the season as the average crab size increased (Table 1).

When the number of captured crabs was only available in bushels the most recent conversion was used to estimate the number of crabs captured. Representative samples of the total catch were measured on each trip. The crabs were measured from point to point on the carapace to the nearest millimeter and weighed to the closest gram. It is important to note that the crabs that were counted and measured by the on-board monitor were selected from all crabs caught, including those that were returned to the estuary. Therefore, the size of crabs kept versus those that were released cannot be separated.

Fishery Independent Data Collection

Biological information about crabs in the freshwater portion of the estuary was collected by the use of crab pots. Fifteen pots were constructed matching the specifications above. These pots were set either individually or in small groups in the vicinity of Athens, NY at high tide water depths of three to twelve feet. The pots were emptied and baited weekly. Bait was typically American shad or Atlantic menhaden. Captured crabs were measured from point to point across the carapace to the nearest millimeter and weighed to the closest gram. The number of “coupler” crabs in each pot and the sex and maturity of each crab was also recorded.

Blue crab biological data collected from crabs on the impingement screens of the Bowline and Lovett generating stations was also analyzed. The length-frequency data of all measured male blue crabs collected between 1991-1999 was used to determine average size over the course of a season. All crabs less than 90mm were not analyzed to exclude young of year crabs that would not appear in crab pots.

Statistical Analyses

Change in length through the season was evaluated by a regression of mean length on week of year. Relationships between length and weight are calculated as a curve of weight vs. length. All analyses were conducted with Microsoft Excel 97. Results were considered significant when $p < .05$.

Results and Discussion

Thirty-four trips with commercial blue crab fishers in the Hudson River Estuary were monitored in 2001. Monitored trips occurred from the weeks of 1 July through 14 October. The greatest effort and number of trips monitored occurred during August.

Biological Data

Mean length of immature females did not increase over the season (Figure 3). The slope of a regression of length on week of year was not significant ($p = 0.18$). Mean length of males and mature females increased very slowly during the season (Table 2, Figure 3). Positive slopes for regressions of length on date were significant for both sexes (males, $p = .012$; mature females, $p = .003$).

Patterns of change in length of Hudson River female blue crabs during the growing season were surprising. I did not expect mean length of mature females to increase because length increases should cease after their terminal molt. I have no explanation for these length increases. I also expected immature females to increase in size throughout the growing season until they reach the size of the terminal molt. The data collected, however, suggests that immature females are only briefly susceptible to capture in crab pots. Pots typically only capture crabs greater than approximately 95mm in length and the female terminal molt occurs at approximately 125mm.

Male crabs collected in Athens independent sampling and impingement samples also revealed positive slopes for regression of crab length on week ($p < .0001$ and $p < .0001$) (Figures 4 and 5). The slopes of length change over the growing season were significantly greater for male crabs captured in Athens test pots (.41) and impinged crabs (.93) than the male crabs captured by fishers (.07).

Observed increases in length of male crabs occurred at a slower rate than I expected throughout the growing season. The faster rate of growth exhibited by impinged blue crabs suggests that the length increases were muted by size selectivity of crab pots. Crabs captured by the same gear in an area with very little fishing pressure also exhibited a faster growth rate. This suggests that in areas of high fishing pressure the length increases may be altered by the removal of crabs above the size kept by fishers. It is also possible that differences in habitat between the two areas would affect the size of blue crabs present and the rate at which they grow.

While lengths of mature females and males were very similar, males were heavier than females at a given length (Figure 6). Length weight regressions for both sexes (Figures 7 and 8) were significant (males, $p < .0001$; females, $p < .0001$). Formulas were: Female weight = $0.0081\text{length}^{1.9467}$; Male weight = $0.0005\text{length}^{2.548}$. Newcombe et al. (1949) found very similar relationships in Chesapeake crabs: Male weight = $.00026\text{length}^{2.67}$; female weight = $.00034\text{length}^{2.57}$. This equation would allow the estimation of weight for a crab for which only a length is available.

A length frequency of immature and mature female crabs provided information on size at terminal molt (Figure 9). Most of the mature females had carapace lengths greater than 130mm. No mature females had a carapace length of less than 125mm. Growth increased 32% at the terminal molt for female crabs on the St. Johns River, Florida (Tagatz 1968). This suggests that many blue crabs in the Hudson River Estuary undergo their terminal molt when carapace width is 110-125 mm. Tyler and Cargo (1963) found that pre-terminal molt crab lengths varied more, but were a similar range of 81-130 mm.

Catch Data

Observed fishing activity was distributed around four major areas: Piermont (RKM 41), the Tappan Zee bridge (RKM 43), Stony Point (RKM 64) and Poughkeepsie (RKM 122) (Figure 1). The total number of crabs caught and the number of crabs returned during monitored trips were either recorded directly or estimated from the number of bushels collected (Table 1). The total catch per week observed for all fishers is summarized in Figure 10.

While this gives us a raw number of crabs caught, it does little to estimate catch rates because the number of trips with an on-board monitor varied each week and the amount of effort put in by each fisher varied with each trip. A summary of the number and duration of crab pots fished by each fisher is summarized in Table 3. The average number of pots fished varied from 26.4 to 88.9 pots per fisher.

In order to standardize catch rates a catch per unit of effort was calculated for each trip (Figure 11). This allows comparison of the success of different trips by fishers throughout the estuary. This standardized catch rate is determined by dividing the catch by the effort for each trip. The catch is simply the number of crabs brought on deck. Effort is equal to the product of the number of pots fished and the number of hours the pots were fished. A summary of catch and effort data for the season can be found in Figure 10 and Table 3.

$$\text{Catch per Unit of Effort (CPUE) per trip} = \frac{\text{Total number of crabs caught}}{(\text{Number of pots}) \times (\text{Duration (hrs)})}$$

CPUE was lower in 2001 than 2000 for nearly every week of the season (Figure 12). No one area of the river produced a consistently higher CPUE over the course of the season.

The number of captured males and females was recorded whenever it was possible to collect the information (Figure 13). The fate of the crabs brought on board was also recorded when it could be determined. This allowed the determination of the percentage of catch that became included in the trip's total landing (Figure 14). The proportion of females kept fluctuated wildly, largely because of differences in individual fishers. Some fishers kept highly variable numbers of females depending on the trip and others did not keep females. Therefore, the weekly proportion of kept females fluctuated depending upon which fishers were accompanied in each week. The

proportion of males kept decreased throughout the course of the year. The negative slope of the regression of proportion of kept males on date is significant ($p=.023$). Although this regression is significant the trend may have also been affected by which fishers were accompanied. One fisher only fished in the late summer and fall and kept a relatively small proportion of crabs. The effect of this was to depress the total proportion of kept crabs later in the season.

The number of “coupler” crabs was also recorded, when possible, during the 2001 field season (Figure 15). Mating was documented in the Hudson River from July through September, with a peak in August. Couplers were found at all fishing sites from Piermont to Poughkeepsie. There were no couplers observed in fishery independent pots that were deployed at RKM 187. Interestingly, although there were 52 pairs of couplers found throughout the season, there were never any female crabs found with egg masses attached. This would support the theory that once female crabs mate they head toward more saline water to release their eggs. The highest salt content in the areas monitored in the 2001 season was 10.8 ppt near Piermont (Figure 16), while salinity levels of 23-28ppt are more conducive to egg hatching (Sandoz and Rogers 1944).

Environmental Conditions

Water quality data were taken at all sites throughout the crabbing season. The 2001 season had markedly higher salinity levels in the lower estuary than the 2000 season (Figure 117). The patterns of salinity from the vicinity of the Tappan Zee Bridge are typically indicative of the entire lower estuary. All areas that were at least brackish in 2000 had higher salinity in 2001. The decreased CPUE in 2001 seems to debunk the theory that salinity alone determines the abundance of crabs. While areas of increased salt content may contain more crabs than fresher areas, there are clearly other factors that influence crab abundance.

Temperature patterns were similar between the 2000 and 2001 crabbing seasons. (Figure 18). Crabbing began both years when the water temperature reached approximately 25 °C. Water temperatures remained three to four °C higher than the previous season during July and August of 2001. In both years the final crabber pulled his pots as the water temperature approached 15 °C.

Figures and Tables

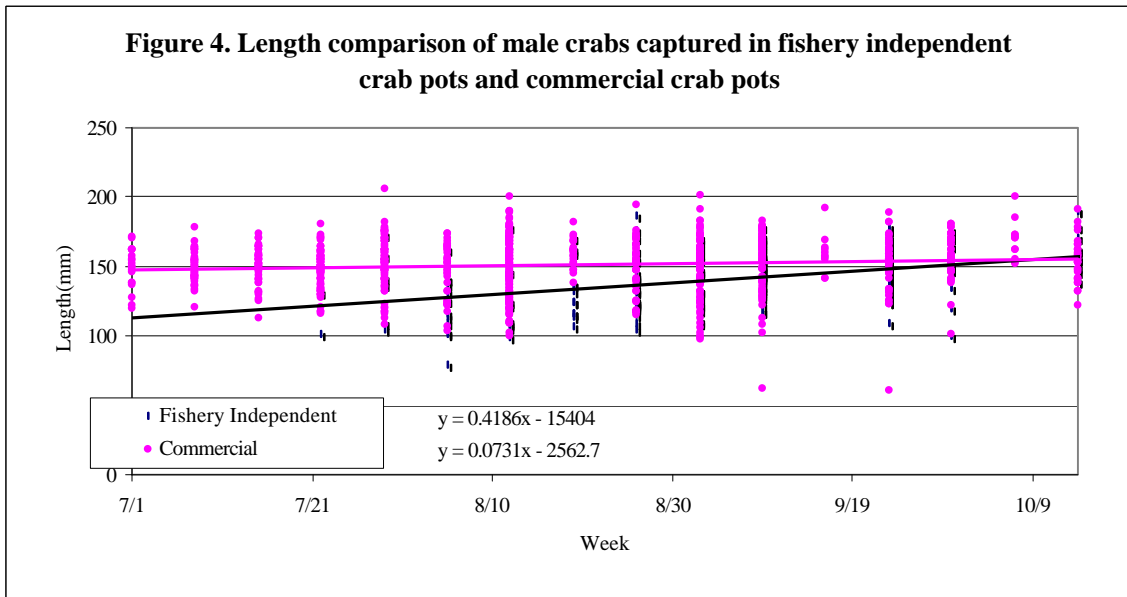
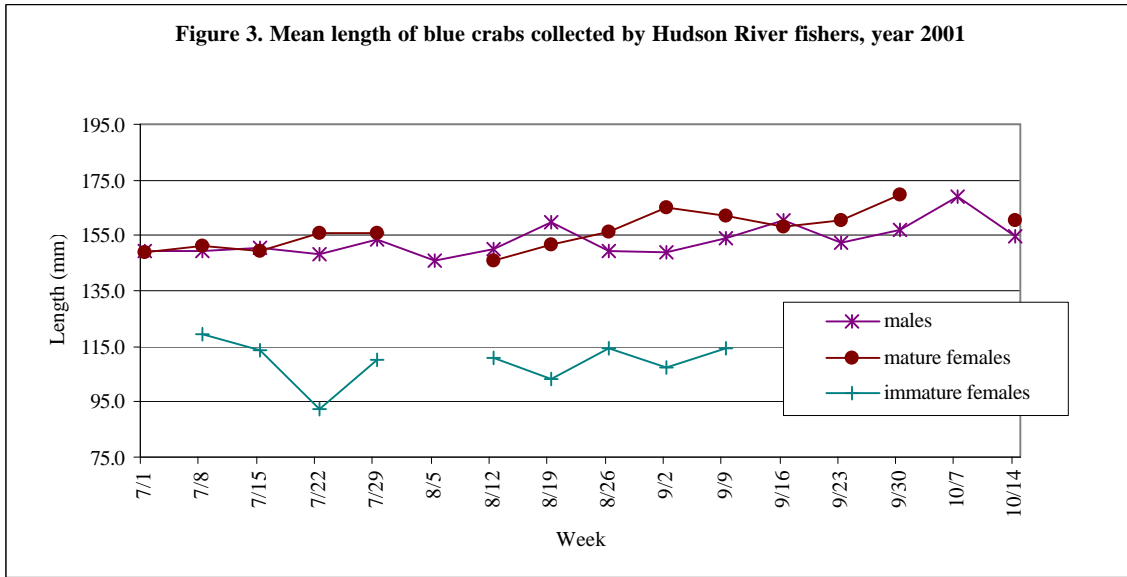


Figure 5. Length comparisons of commercially captured and impinged male blue crabs

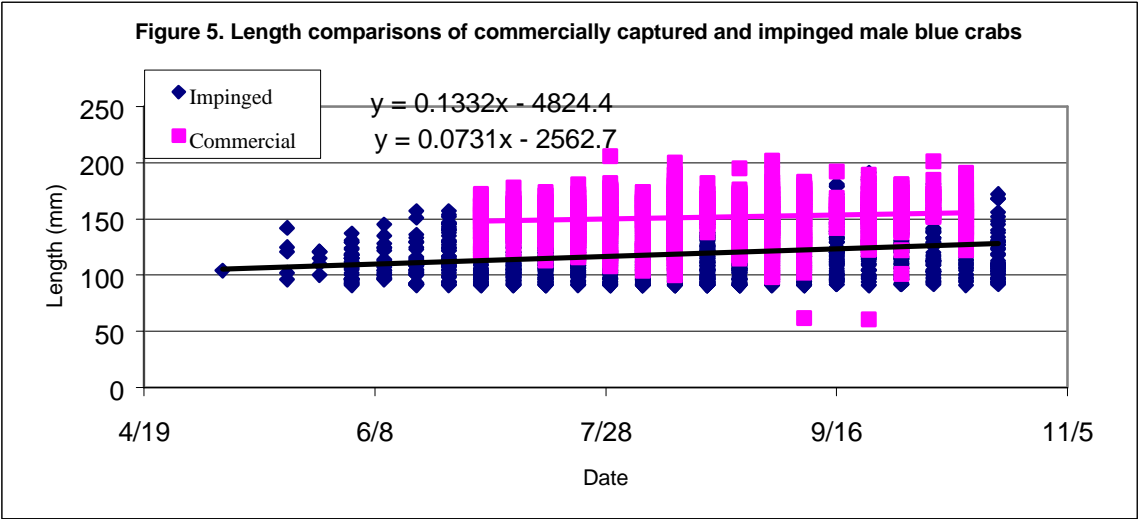


Figure 6. Mean weight of blue crabs collected by Hudson River fishers, 2001

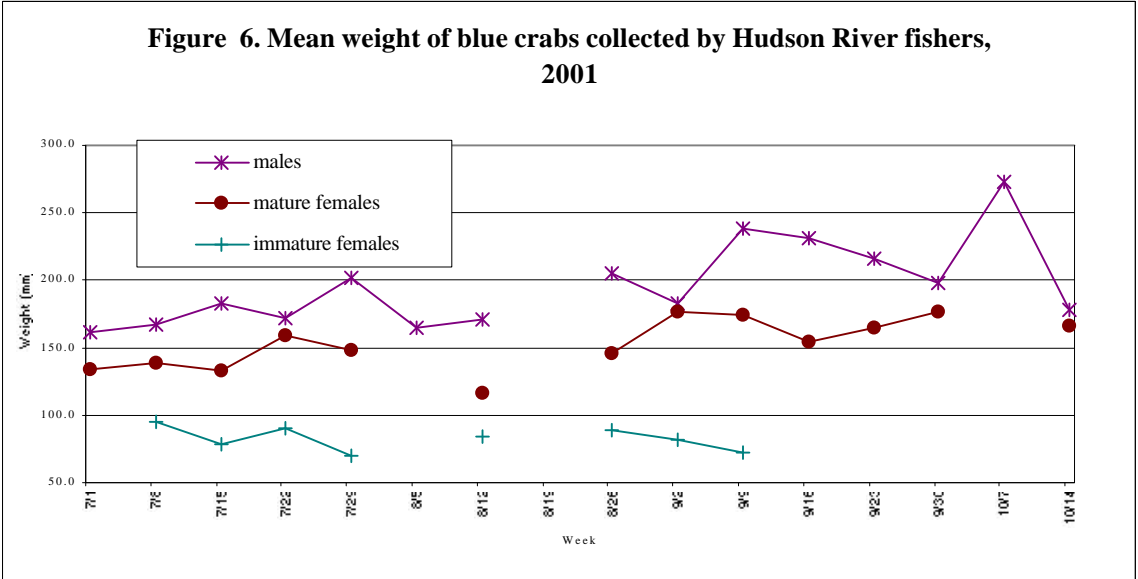


Figure 7. Male blue crabs collected by Hudson River fishers, 2001
n = 633

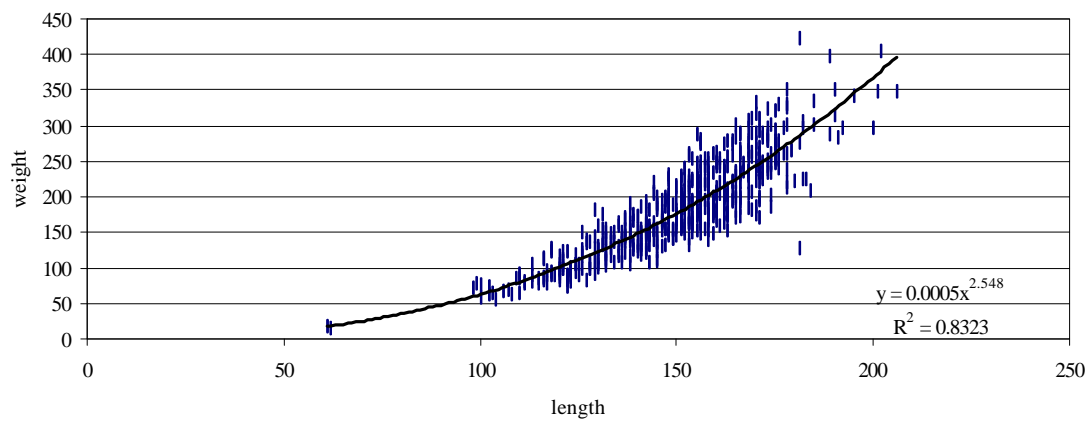


Figure 8. Female crabs collected by Hudson River blue crab fishers, 2001
n = 232

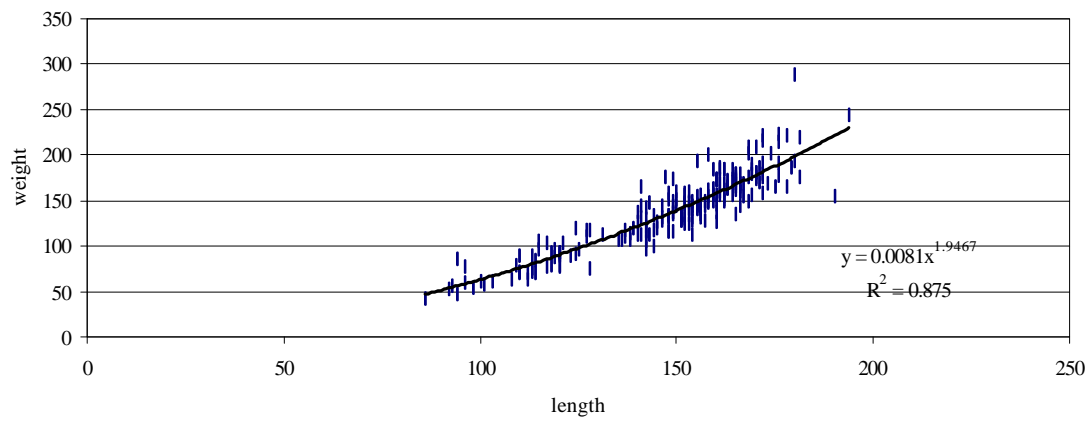


Figure 9. Frequency of crab length classes in immature and mature female crabs collected by commercial fishers in the Hudson River estuary, 2001

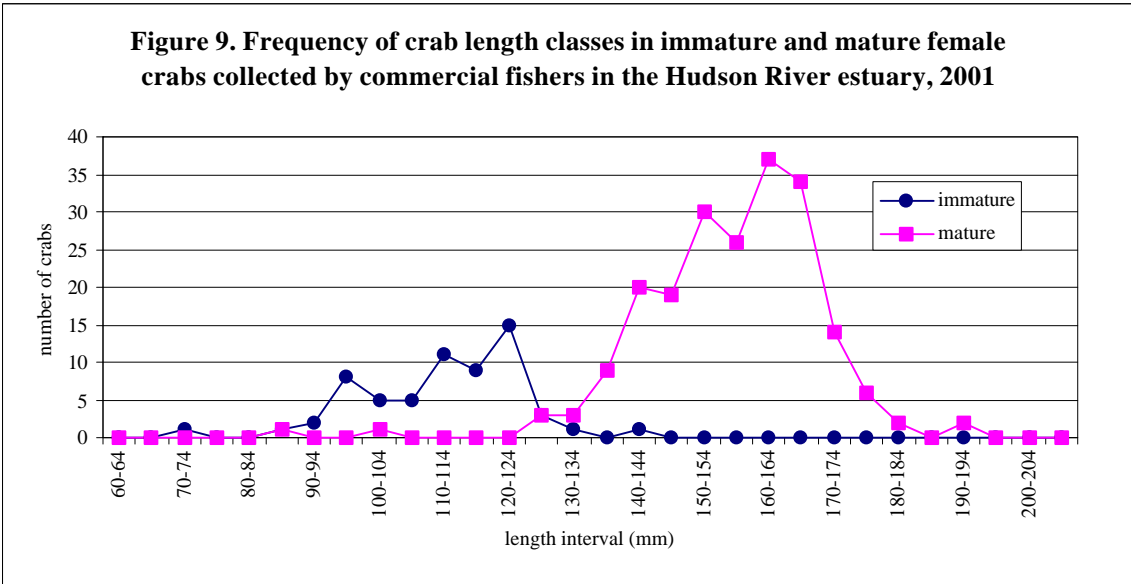
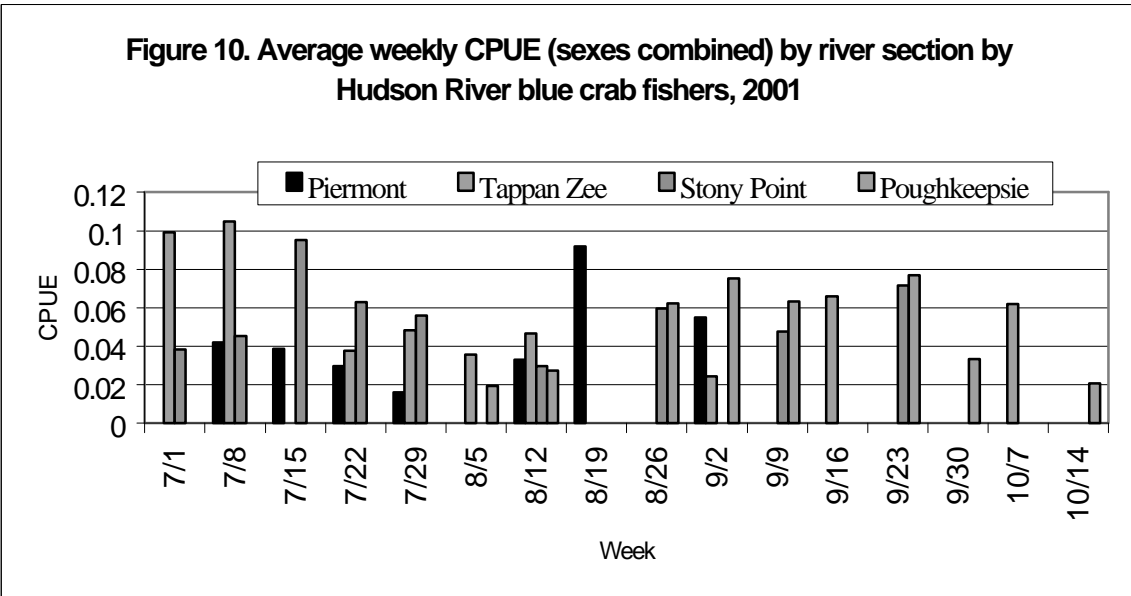
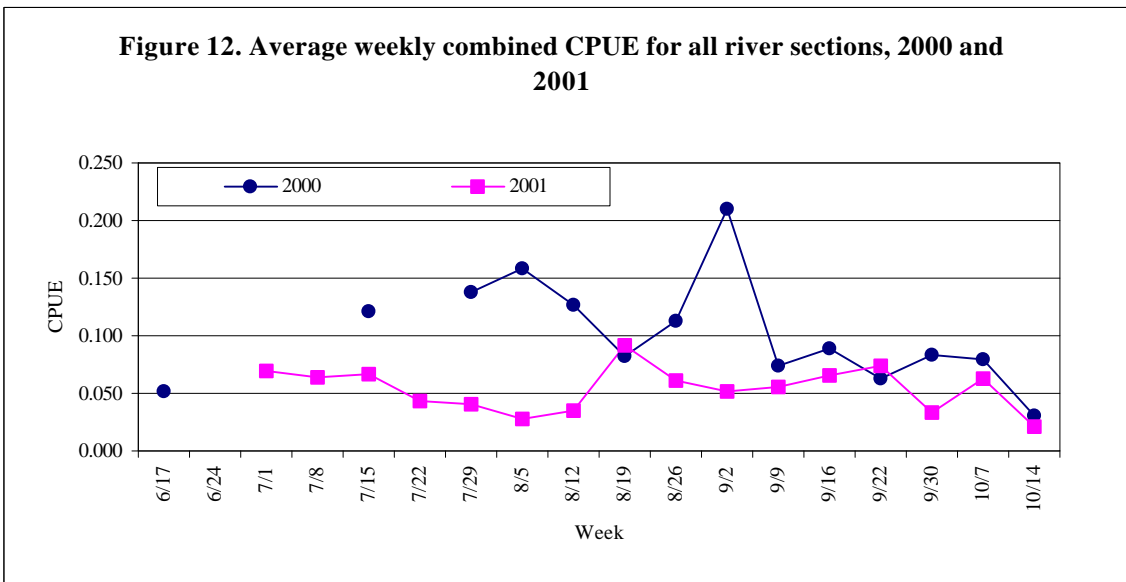
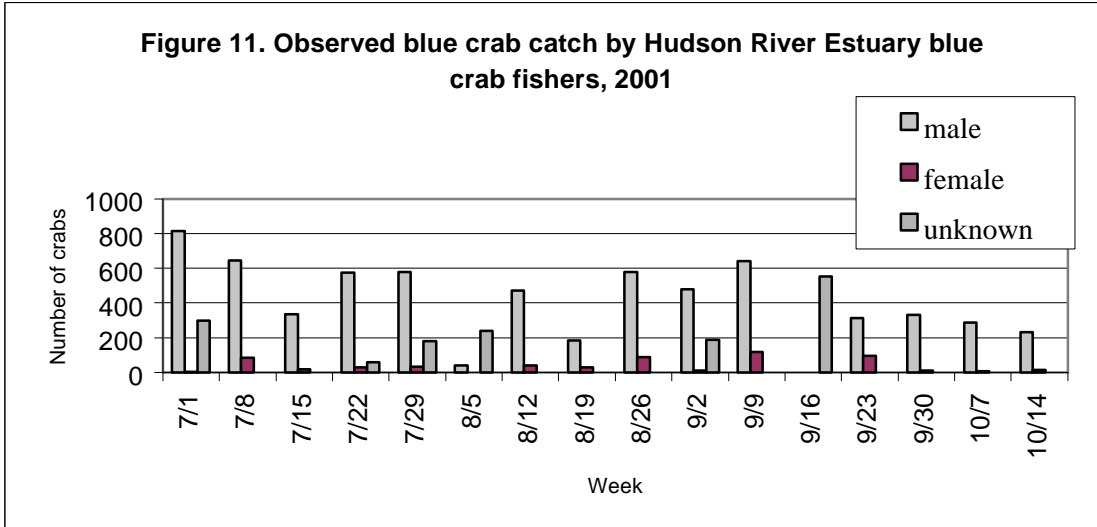


Figure 10. Average weekly CPUE (sexes combined) by river section by Hudson River blue crab fishers, 2001





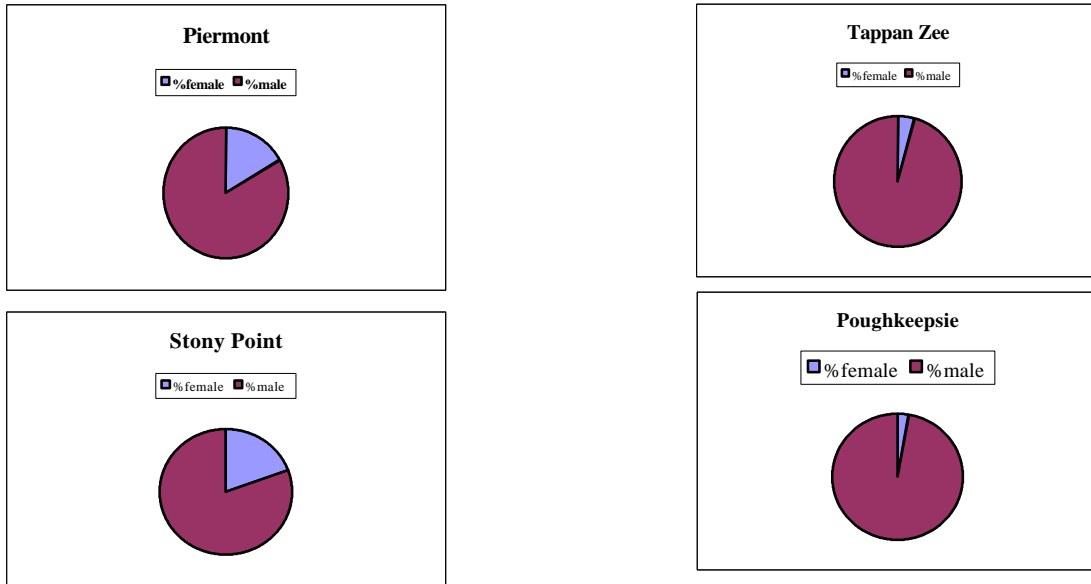


Figure 13. Male and female crabs capture by Hudson River fishers in four locations, 2001

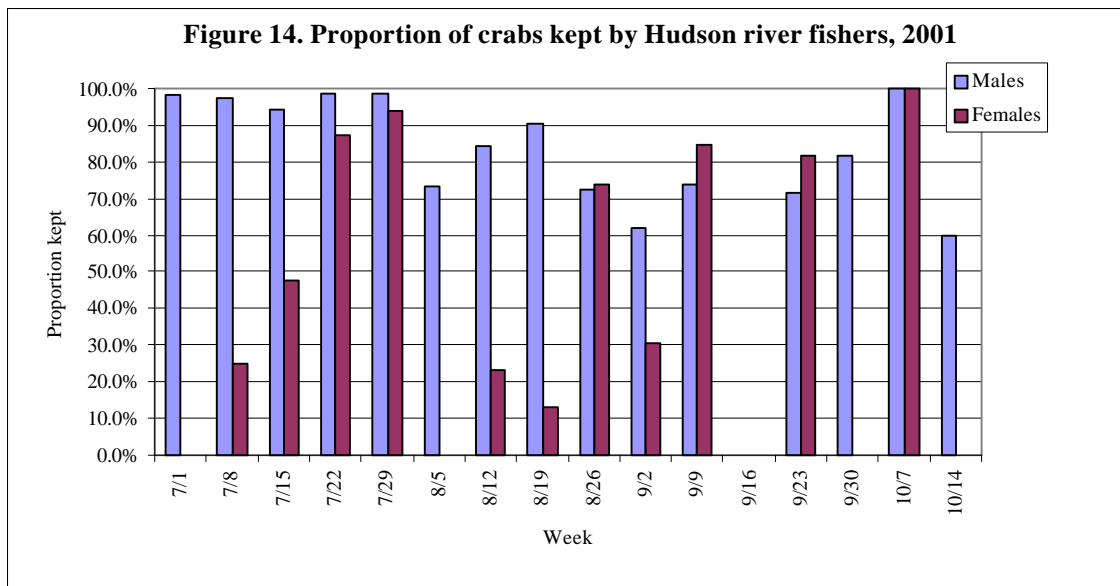


Figure 15. Average number of couplers per unit effort by river section for Hudson River blue crab fishers, 2001

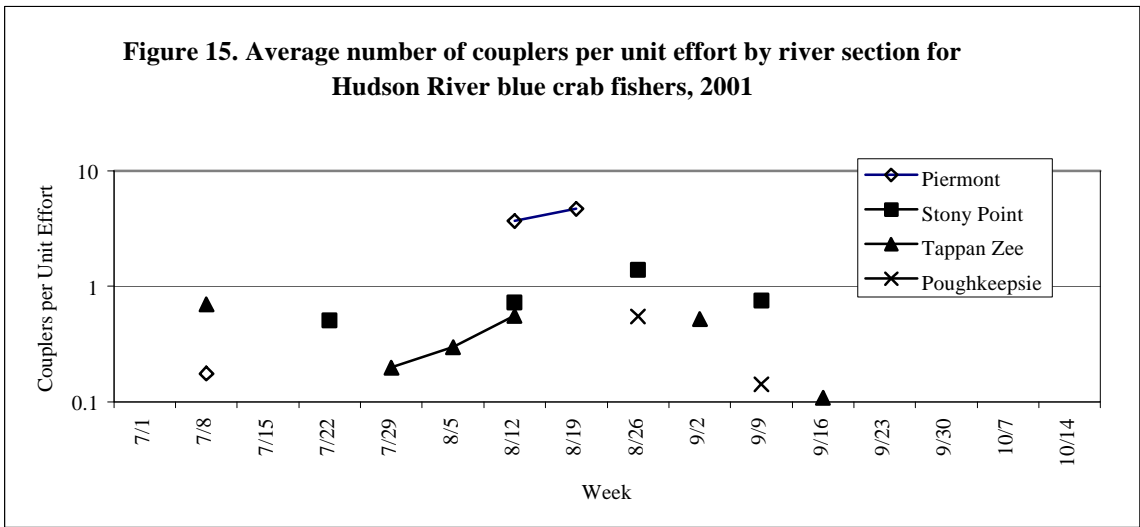
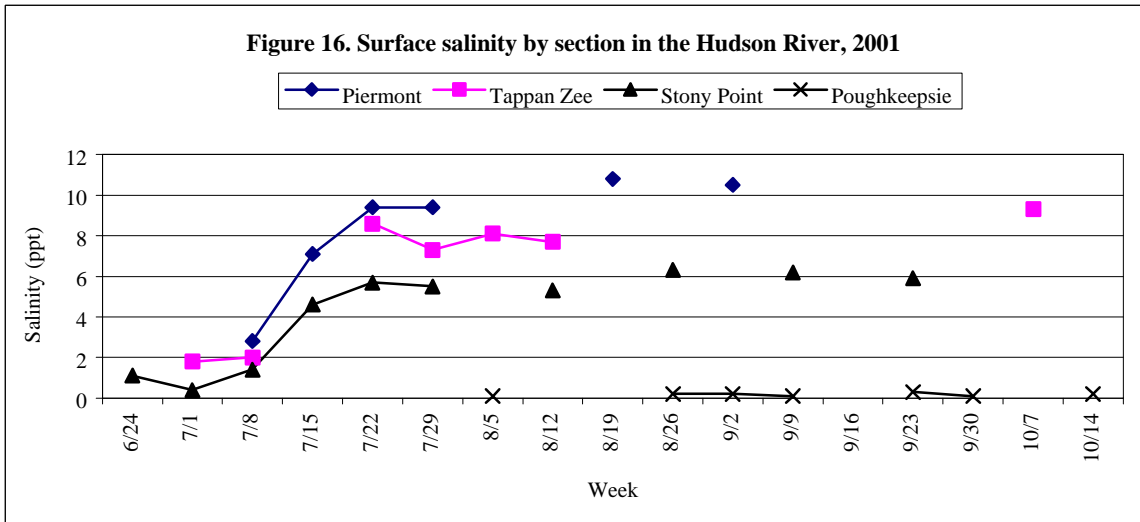


Figure 16. Surface salinity by section in the Hudson River, 2001



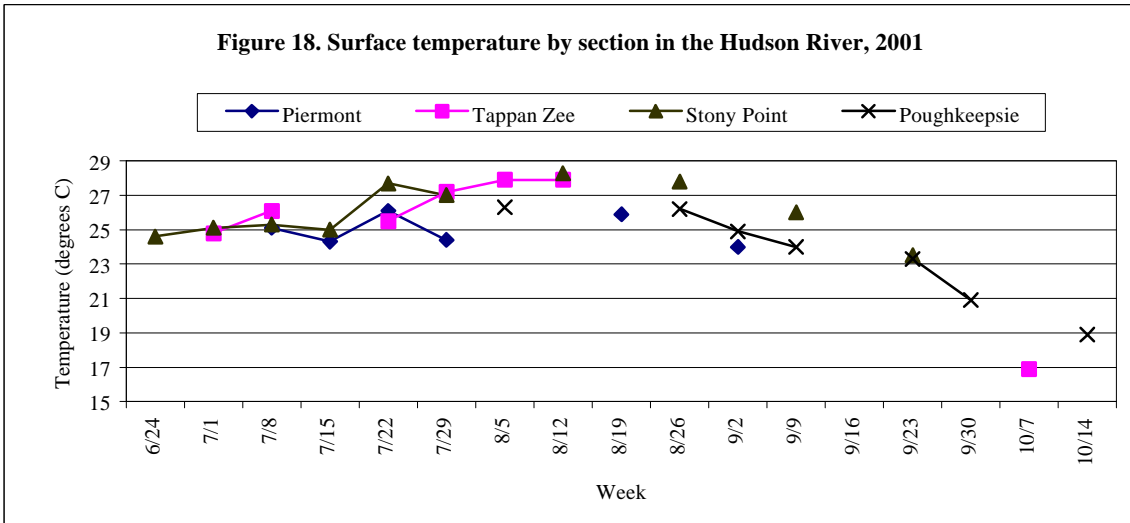
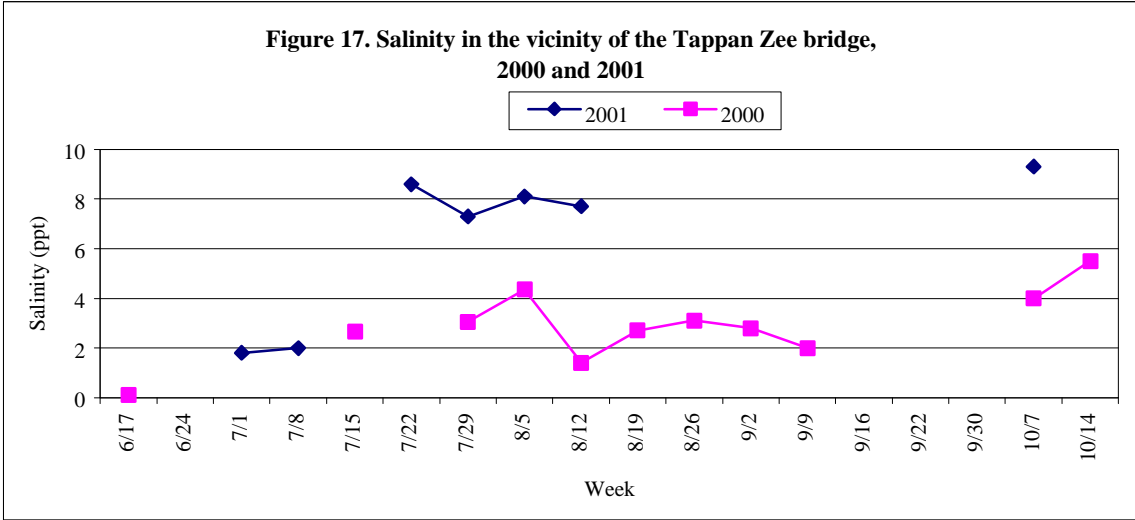


Table 1. Number of crabs per bushel for Hudson River fishers, 2001

Date	crabs/bushel
7/12	102
7/17	99
7/26	82
8/2	80
8/14	76
8/27	92
9/11	85

Table 3. Average number of pots fished (with standard deviation) and average duration (with standard deviation) of soak time, 2001

ID #	Ave # pots	STD	Ave duration (hours)	STD
48	26.4	11.1	93.4	58.6
83	64.1	26.2	57.3	14.4
246	88.9	42.6	138.7	126.3
2337	80.8	18.0	81.3	31.8

Table 2. Length-frequency data for blue crabs measured in 2001, with average lengths and standard deviation.

Carapace width	July		August		September		October	
	male	female	male	female	male	female	male	female
60-64	0	0	0	0	2	0	0	0
65-69	0	0	0	0	0	0	0	0
70-74	0	1	0	0	0	0	0	0
75-79	0	0	0	0	0	0	0	0
80-84	0	0	0	0	0	0	0	0
85-89	0	0	0	2	0	0	0	0
90-94	0	0	0	2	0	2	0	0
95-99	0	0	0	6	2	2	0	0
100-104	0	0	3	6	3	0	1	0
105-109	1	0	2	4	2	2	0	0
110-114	2	6	4	2	3	3	0	0
115-119	6	4	14	4	2	1	0	0
120-124	6	0	23	13	8	2	2	0
125-129	5	1	17	4	12	1	0	0
130-134	17	2	12	0	14	0	2	1
135-139	16	5	17	2	10	1	4	1
140-144	25	17	21	4	17	3	6	2
145-149	27	11	29	3	15	6	9	2
150-154	41	15	30	10	20	10	10	1
155-159	31	9	37	8	31	10	18	1
160-164	24	10	39	14	26	15	7	3
165-169	12	7	36	7	22	18	9	7
170-174	10	2	36	3	18	10	11	2
175-179	4	1	14	2	13	3	4	3
180-184	1	0	7	1	7	3	3	1
185-189	0	0	2	0	1	0	1	0
190-194	0	1	2	0	2	0	1	1
195-199	0	0	1	0	0	0	0	0
200-204	0	0	1	0	1	0	1	0
205-209	0	0	1	0	0	0	0	0
TOTAL	228	92	348	97	231	92	89	25
Average Length	148.8	146.7	151.4	137.0	151.7	154.4	158.0	162.8
Standard Deviation	14.1	17.5	19.6	26.2	21.1	20.8	15.7	14.4

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