An early juvenile (age 0-1) Atlantic Sturgeon abundance estimate and habitat usage within the Delaware River Estuary, USA

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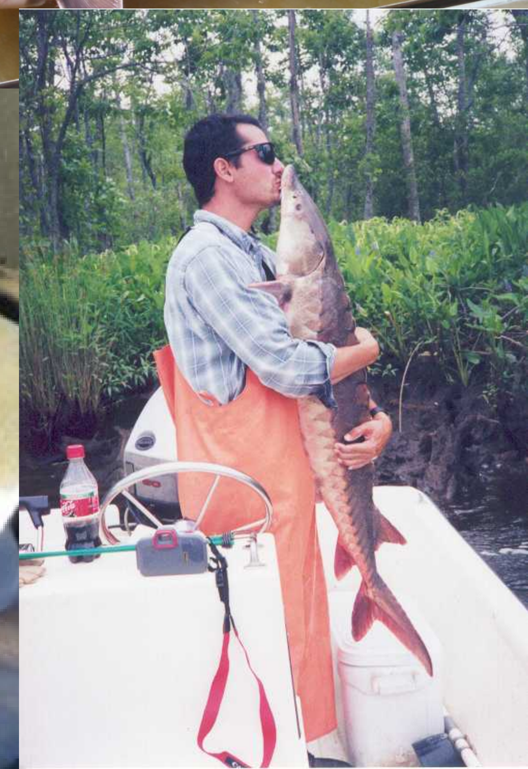
2015 MAC-AFS

Species of Interest

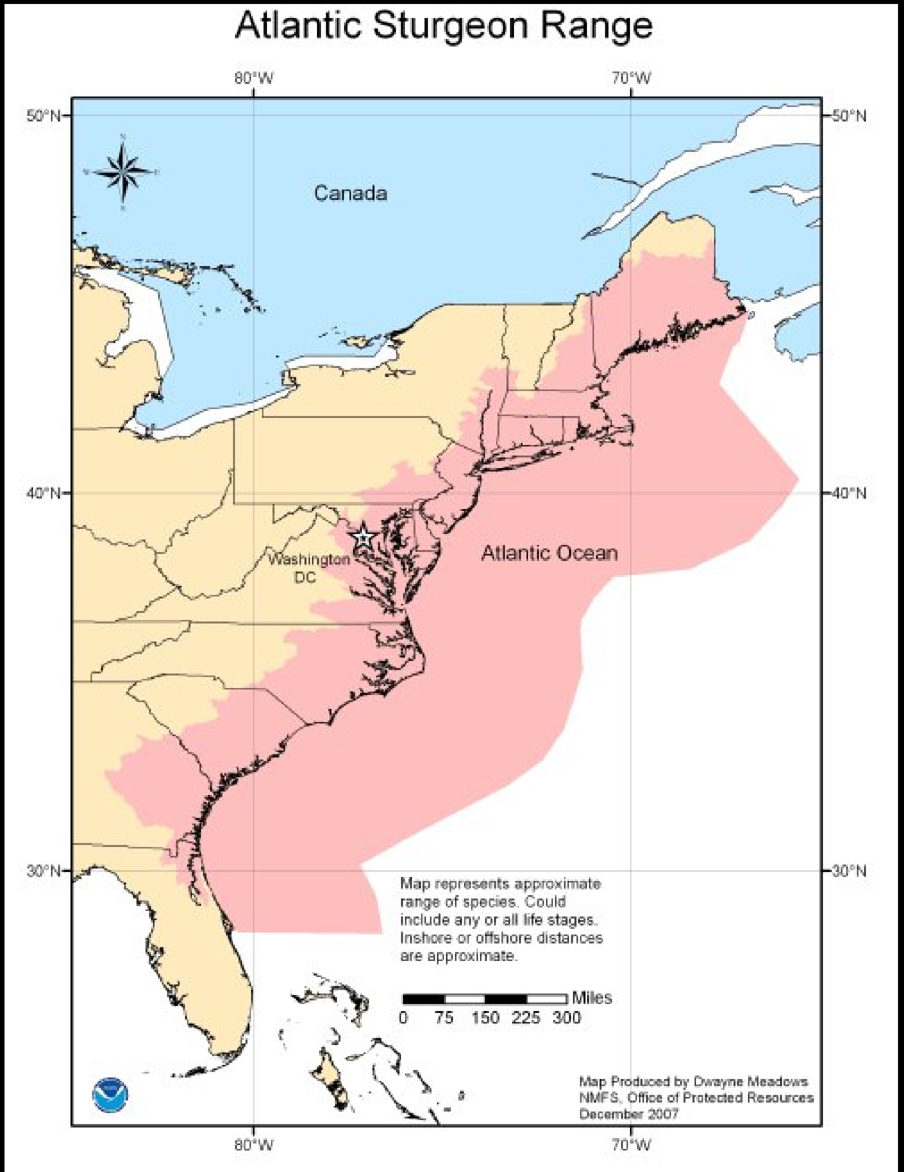


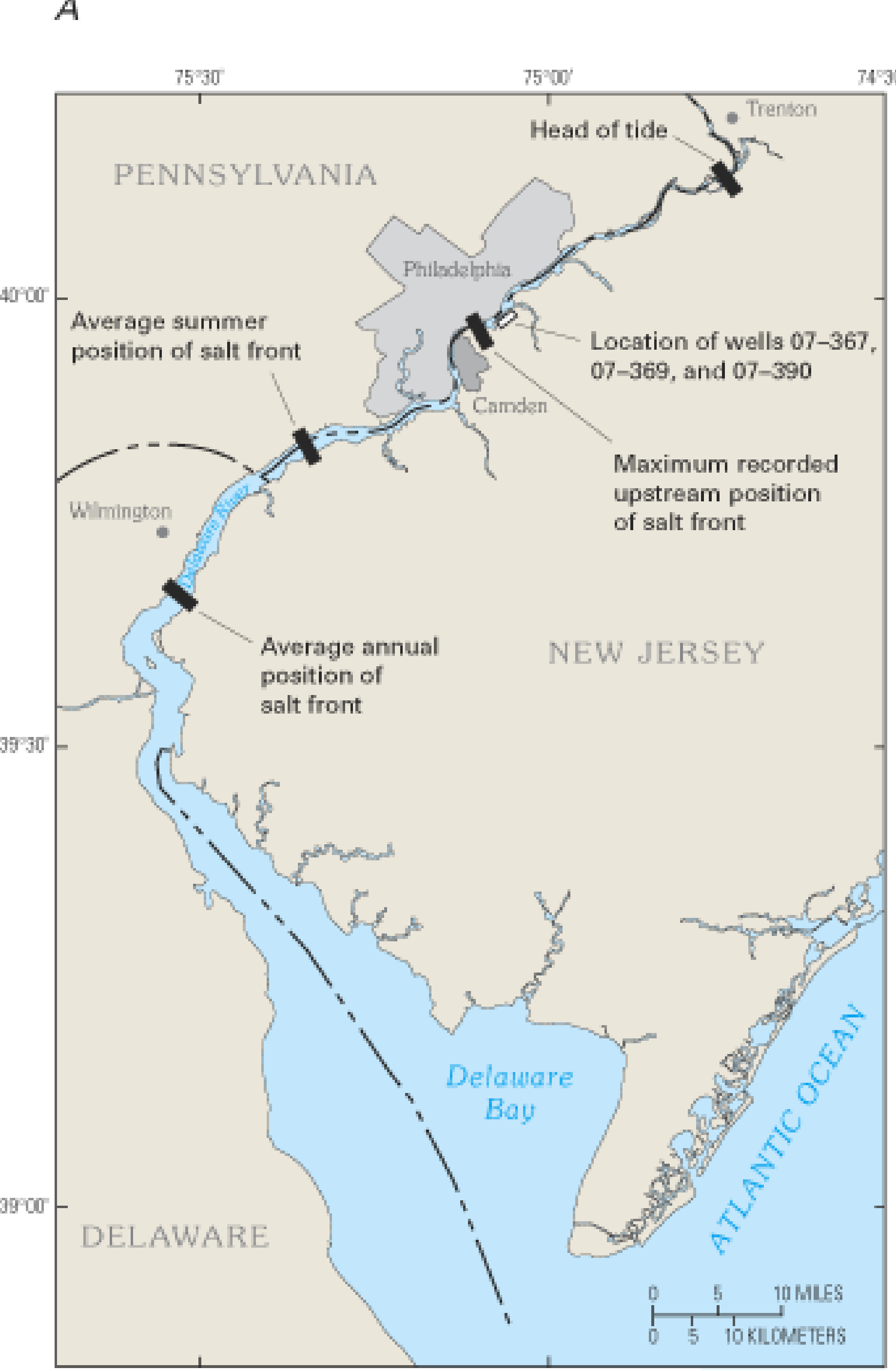
- Biology
- Methods
- Results
- Discussion

Atlantic Sturgeon

Acipenser oxyrinchus oxyrinchus

- Estuary dependent, anadromous species
- Length: 14 ft.
- Weight: up to 800 lbs.
- Lifespan: 60 years
- Fecundity: 400k-8 million eggs per event
- 50% of maximum lifetime egg production: 29 years
- Increase in age at maturation with latitude





Modified from Navoy and Carleton (1995)

Spawning & Post Spawning

- Spawning adults migrate upriver in spring
  - April-May in the mid-Atlantic
  - Individuals skip spawning
- Spawning occurs between the salt front and fall line of large rivers
- Post-spawning: males may remain in the river/lower estuary until fall; females typically exit the rivers within four to six weeks.

Early Development

- Sturgeon eggs are highly adhesive and are deposited on bottom substrate
  - Deposition usually occurs on hard surfaces (e.g., cobble)
- Cold, oxygen rich water is needed for proper larval development
- Once larvae begin migrating downstream they use benthic structure (especially gravel matrices) as refuges
- Juvenile individuals then remain in their natal riverine systems until they reach two years of age (McCord et al. 2007)

USGS

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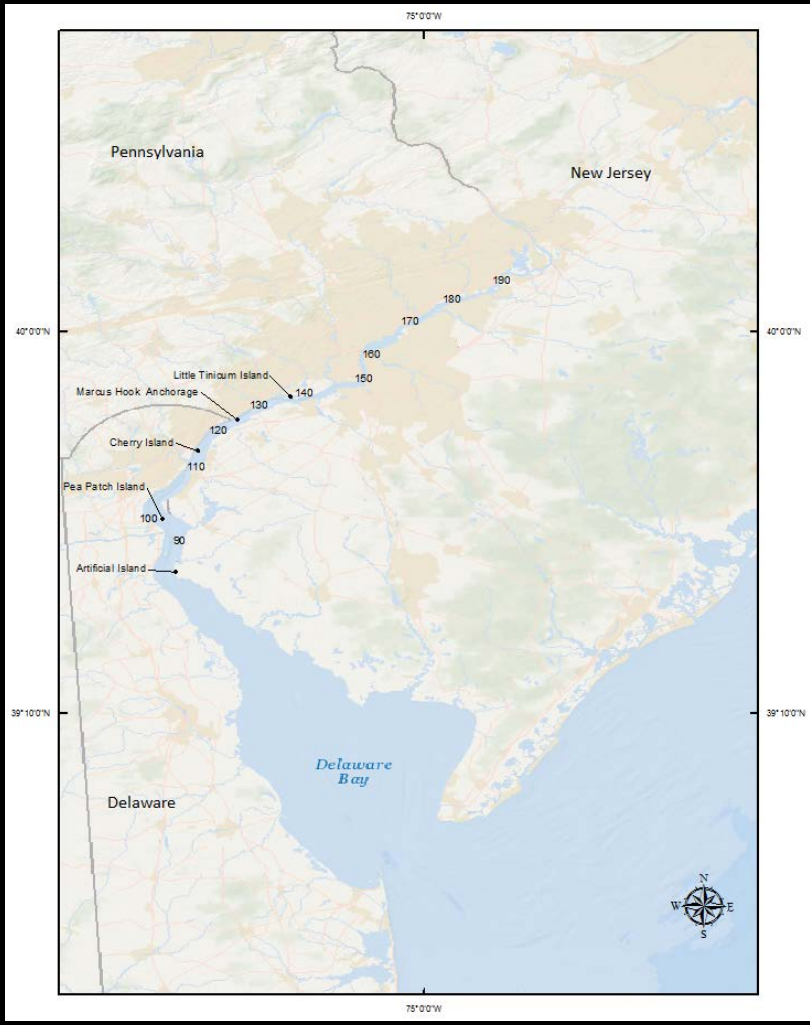
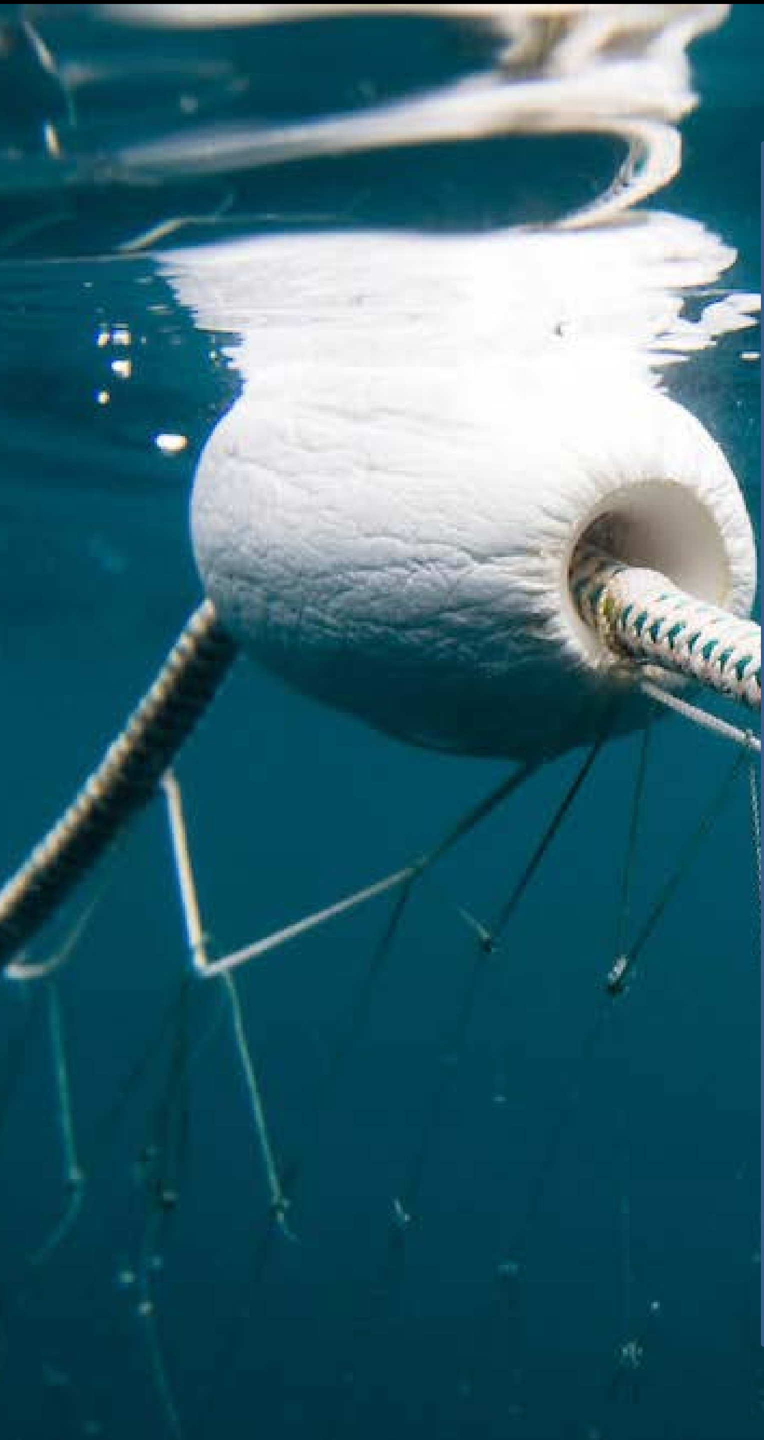
Delaware DFW Monitoring Efforts

- Began identifying juvenile habitat for Atlantic Sturgeon in the Delaware River Estuary in 2009
- Early findings from gill net sampling suggested several key areas were important for juvenile nursery in Delaware River:
  - Little Tinicum Island (rkm 138)
  - Marcus Hook Anchorage (rkm 130)
  - Cherry Island Flats (rkm 110)



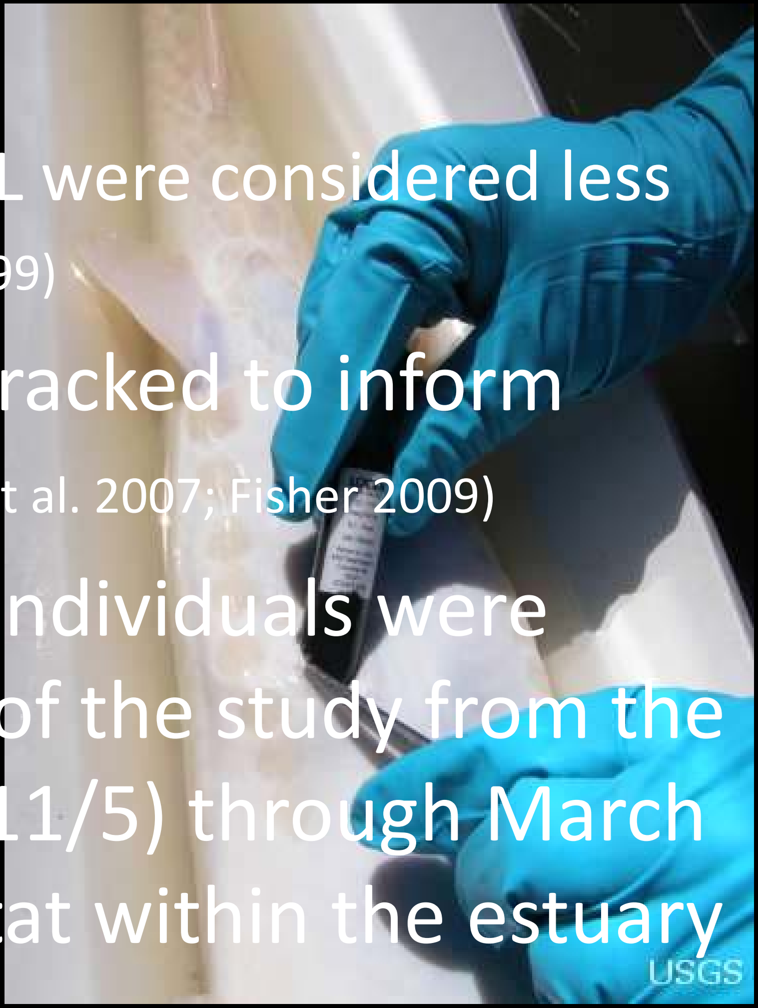
Gill Net Sampling



- Four anchored gill nets simultaneously fished
- 14 sampling events, twice a week for 2 months from November 3 through December 31, 2014
- Anchor nets were set parallel to the current (diagonally when possible) approximately 30 minutes prior to slack tide and pulled at the onset of the next tide
- Nets were 91.5 meters long and 2.4 meters deep; two consisting of 5.1 cm stretch mesh and two with 7.6 cm stretch mesh

Acoustic Tagging

- The first 11 age 0-1 Atlantic Sturgeon caught in 2014 were implanted with acoustic transmitters and released as "sentinel fish"
  - Individuals less than 645 mm TL were considered less than 2 years of age (Shirey et al. 1999)
- "Sentinel fish" were actively tracked to inform where to place gill nets (Kynard et al. 2007; Fisher 2009)
- Additionally, acoustic tagged individuals were monitored during the course of the study from the point of initial release (11/3, 11/5) through March 2015 to identify nursery habitat within the estuary



Size Comparison and Abundance Estimates

- Mean total length by date was analyzed using the Mann-Kendall test (Mann 1945, Kendall 1975, Gilbert 1987) to assess if there was a trend in daily mean length over the course of our study
- Abundance estimates of age-0-1 Atlantic Sturgeon were generated using a Schumacher and Eschmeyer mark-recapture estimator for multiple censuses (Ricker 1975; Kahn et al., 2014)

$$N = \frac{\sum(C_t M_t^2)}{\sum(M_t R_t)}$$

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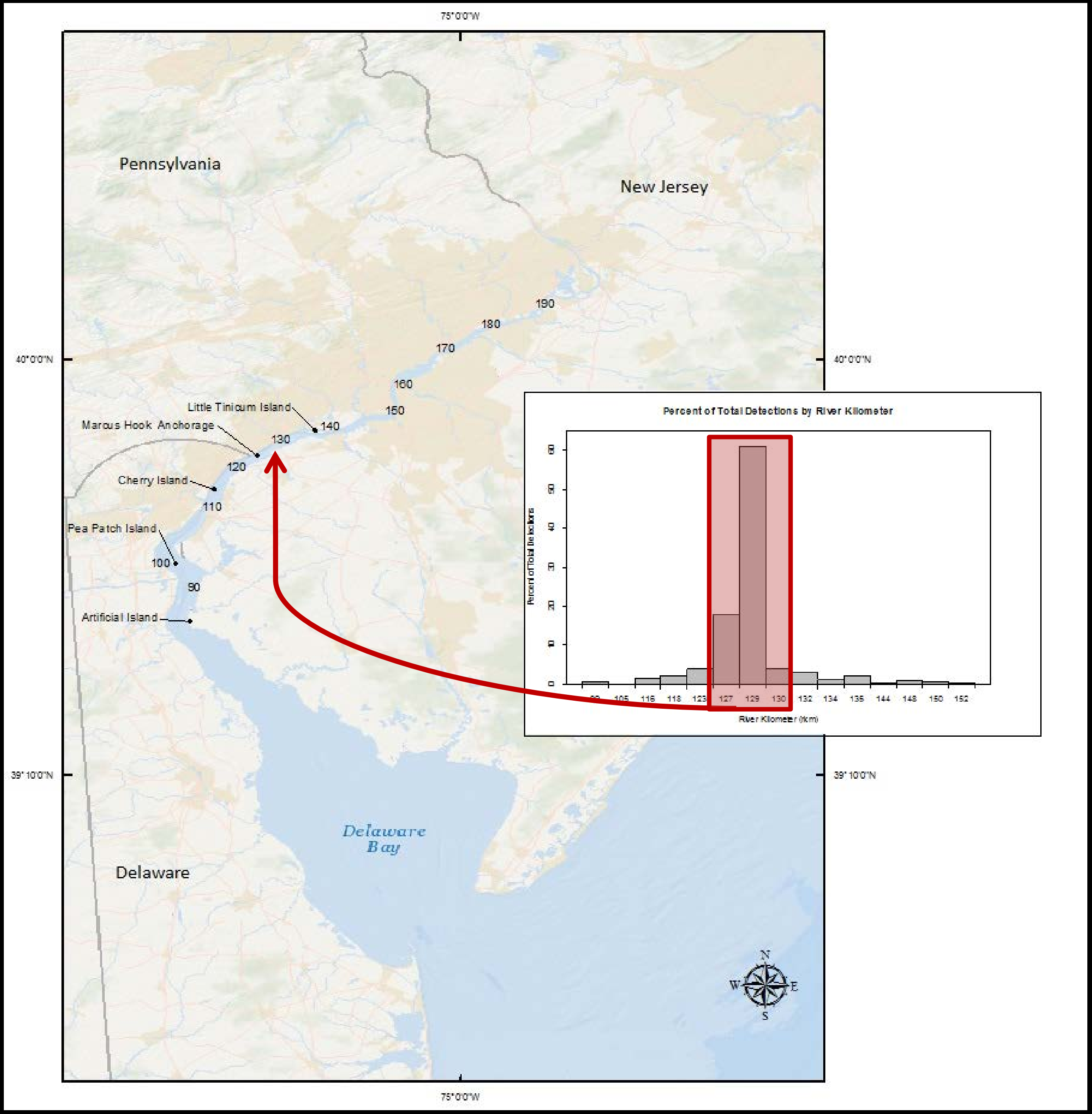
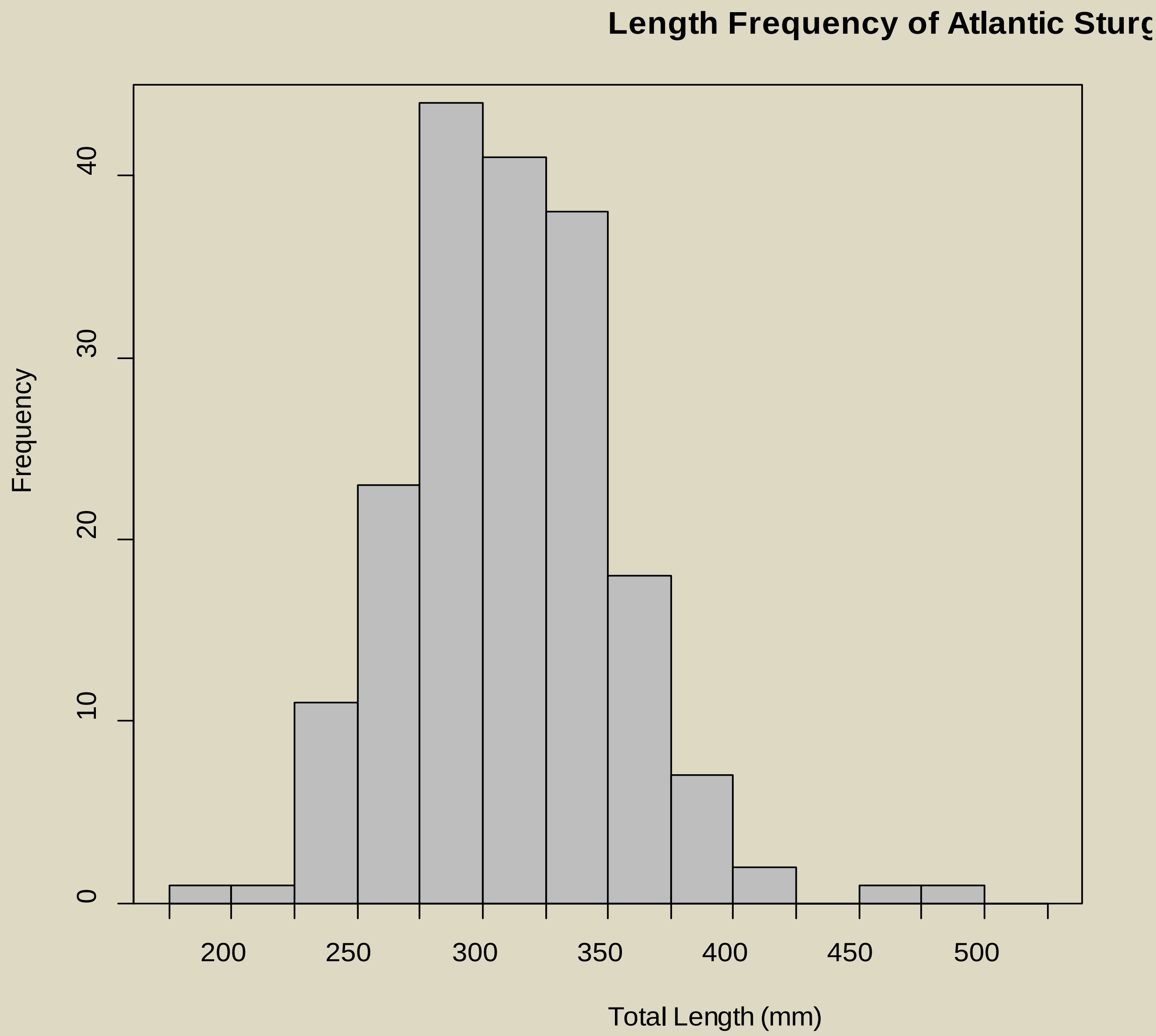
Identifying important juvenile nursery habitats within the Delaware River Estuary

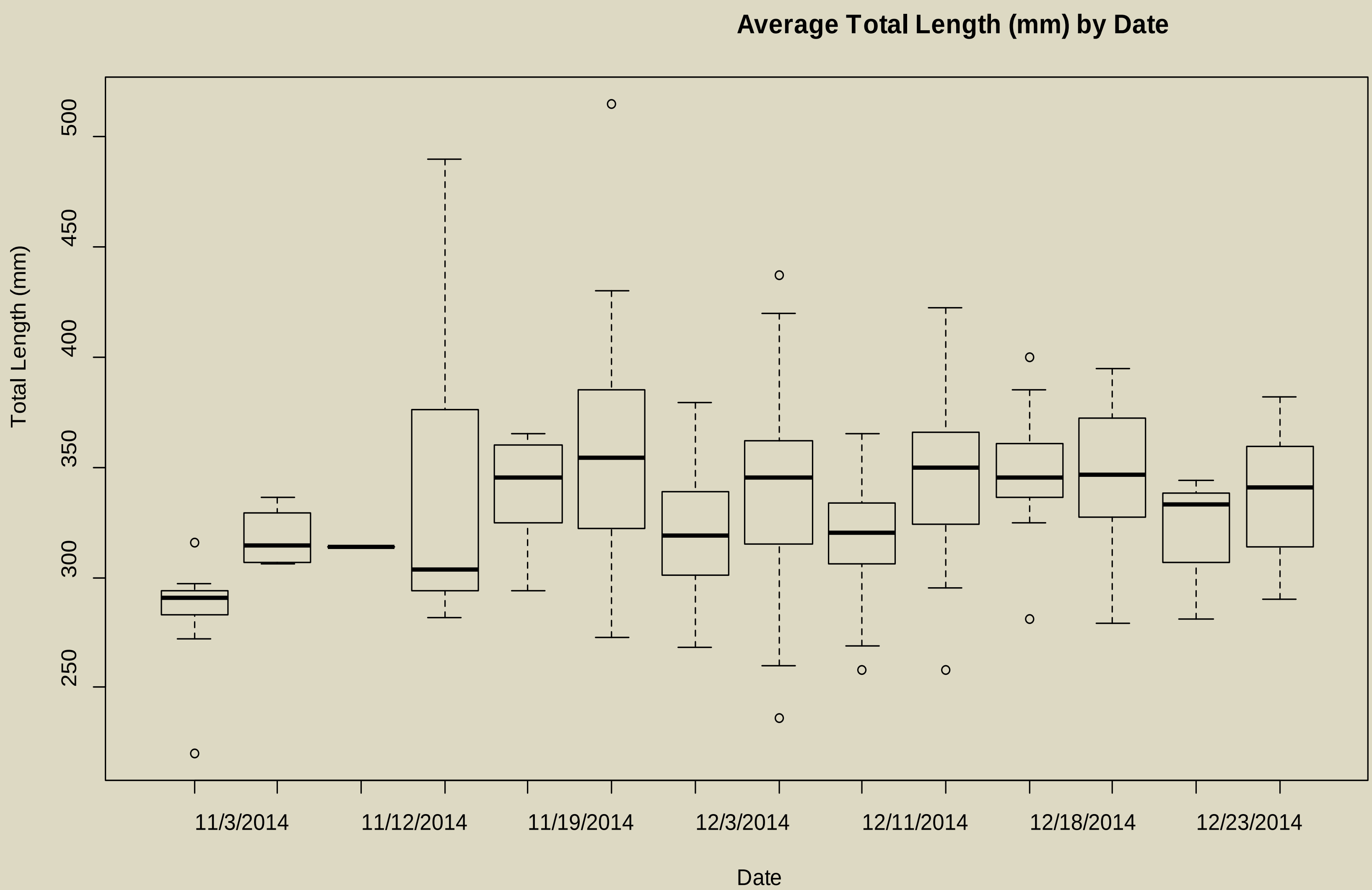


The Marcus Hook area was tremendously important to juvenile river resident Atlantic sturgeon in 2014.



Range: 220.0 – 515.0 mm TL (n=188)

Avg: 336.1 mm TL


Average Total Length (mm) by Date
Total Length (mm)
500
450
400
350
300
250
11/3/2014
11/12/2014
11/19/2014
12/3/2014
12/11/2014
12/18/2014
12/23/2014
Date

Abundance Estimate

Date	Number caught (C_t)	Number recaptured (R_t)	Number marked	Marked fish at large (M_t)
11/3/2014	8	0	8	0
11/5/2014	4	0	4	8
11/12/2014	1	0	1	12
11/13/2014	6	0	6	13
11/19/2014	8	0	8	19
11/25/2014	28	0	28	27
12/3/2014	14	0	14	55
12/4/2014	36	1	36	69
12/11/2014	22	0	21	105
12/12/2014	17	2	15	126
12/18/2014	11	0	11	141
12/19/2014	8	1	7	152
12/23/2014	3	0	3	159
12/31/2014	19	0	19	162
Total	185	4	181	181

Using the Schumacher-Eschmeyer model, the abundance estimate of age 0-1 Atlantic Sturgeon in the Delaware River Estuary was 3,656 individuals (95% confidence interval [CI] = 1,979-23,895 individuals) in 2014

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Study Limitations

- The number of times we could gill net (n = 14) for early juvenile Atlantic Sturgeon was restricted because of limited personnel and adverse weather events

- Also, gaps in the Delaware River receiver array and weak tag signals may have led to underestimated habitat usage

- Our inability to age individuals led us to assume age at length based on previously aged Delaware River specimens and to pool age-0 and age-1 individuals

- While we do acknowledge the logistical constraints of our sampling design, we believe our study adequately characterized the abundance of age 0-1 Atlantic Sturgeon in the Delaware River Estuary

Assumptions using the Schumacher and Eschmeyer mark-recapture model

- 1: Similar to Peterson et al. (2008) and Kahn et al. (2014) we assumed that the population (at age 0-1) was closed
  - Age 0-1 Atlantic Sturgeon are largely considered freshwater residents as emigration from natal estuaries occurs after age 2 (McCord et al. 2007)
  - Further, the habitat utilization based on our acoustic tags supports our application of a closed model

Assumptions using the Schumacher and Eschmeyer mark-recapture model

- 2: All individuals had an equal likelihood of being captured
  - Our passive tracking results, known patterns of juvenile riverine residency and application of the “sentinel fish” technique
- 3: Enough individuals were marked and recaptured to provide a statistically meaningful estimate of abundance using this model
  - Kahn et al. (2014) suggests considering abundance estimates by their 95 % CI range, instead of point estimates to satisfy this model assumption

Main Findings

- We supported evidence of a remnant spawning population in the Delaware River
- Based on our telemetry data, we believe the Marcus Hook area is a critical juvenile habitat, with important nursery functions for age 0-1 individuals occurring down/upriver
- We believe the range of juvenile habitat likely extends beyond the range documented here based on previous studies as far upriver as Trenton, NJ (rkm 212) (Lazzari et al. 1986) and as far downriver as Artificial Island (rkm 80) (Stetzar et al. 2012)

Further Consideration

- The degree of importance for an individual site to natal juvenile residents likely varies by year and ontogenetic stage in response to physical water conditions driven by freshwater discharge and movement of the salt front

- Understanding annual variability in the production of age 0-1 Atlantic Sturgeon is an important step in identifying year class strength and patterns affecting recruitment variability in the Delaware River Estuary

Future Work

- Explore the Huggins closed capture model or some of the Otis type models within Program MARK to improve precision of abundance estimates; higher temporal frequency of habitat
- Examine habitat utilization of adults and potentially early juveniles within the Delaware portion of the Nanticoke River

Questions


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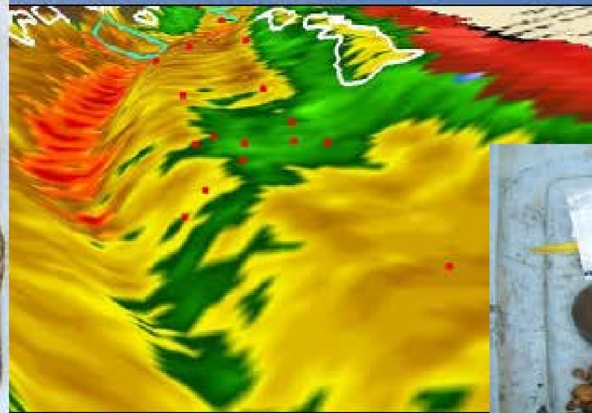


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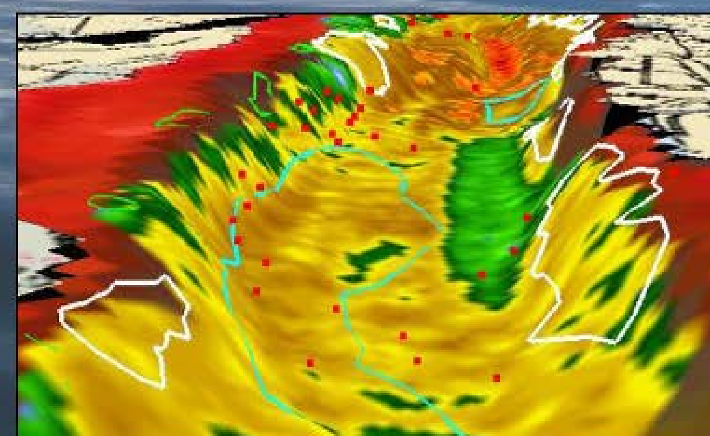
Raccoon Creek
Legend
Sturgeon_relocations
Depositional Zones
Corbicula
Outcrop
WIL082807-5



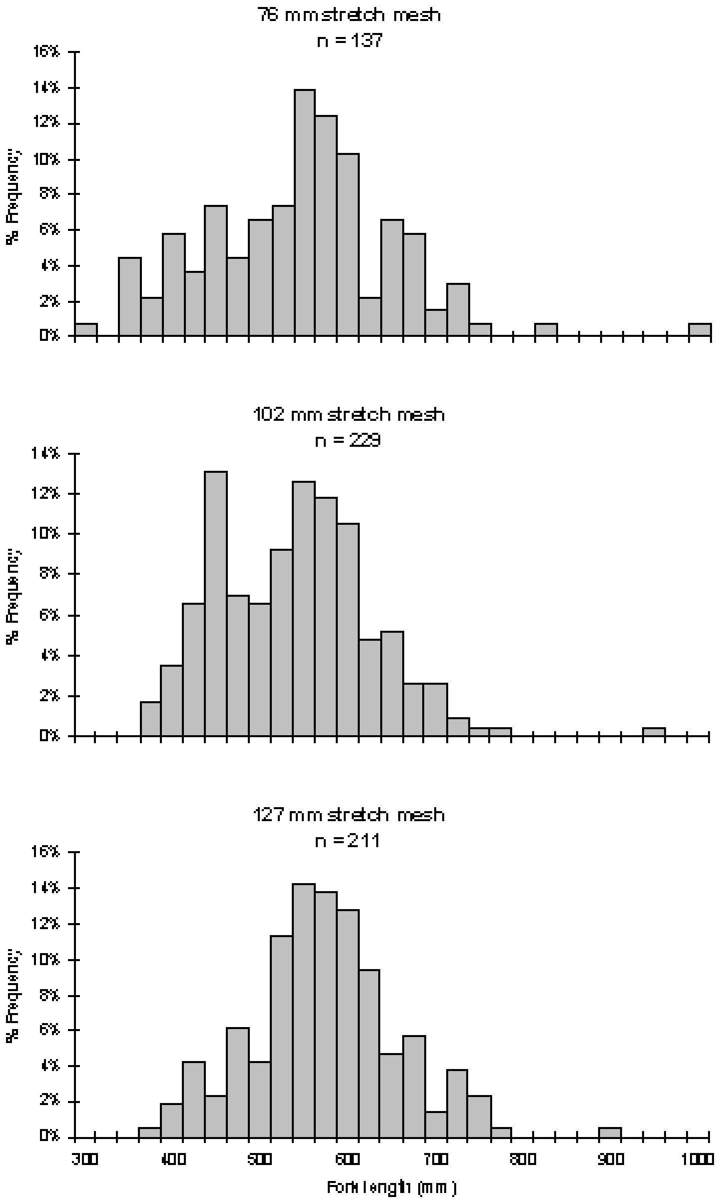
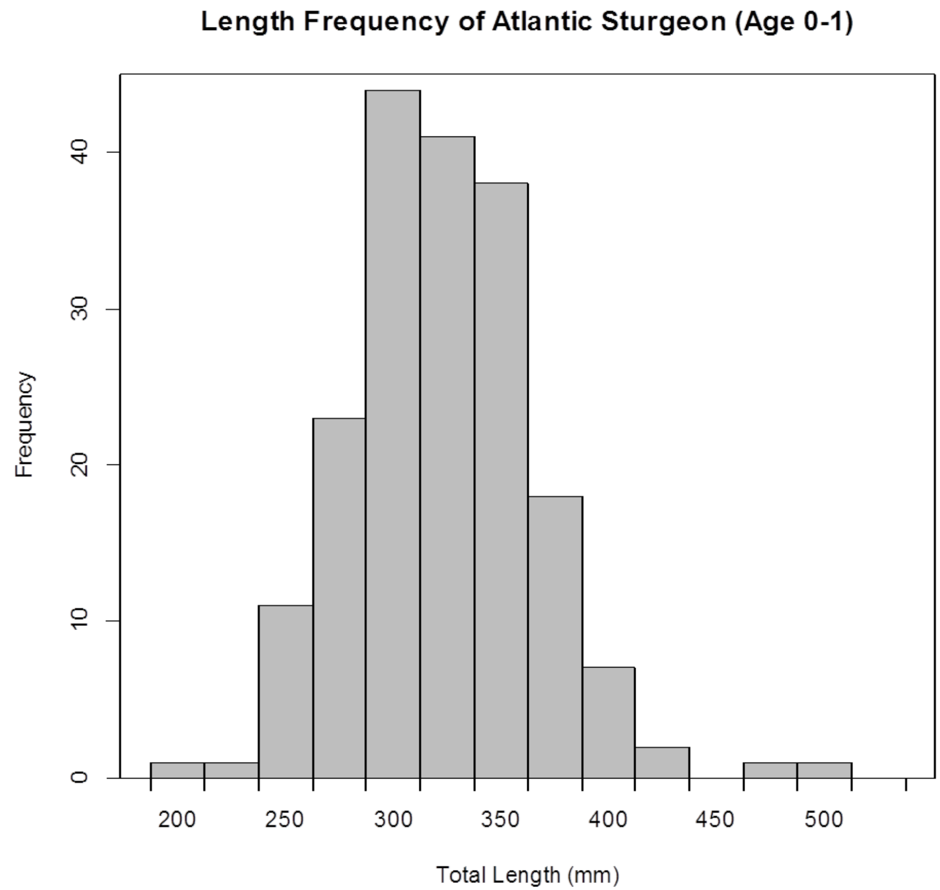
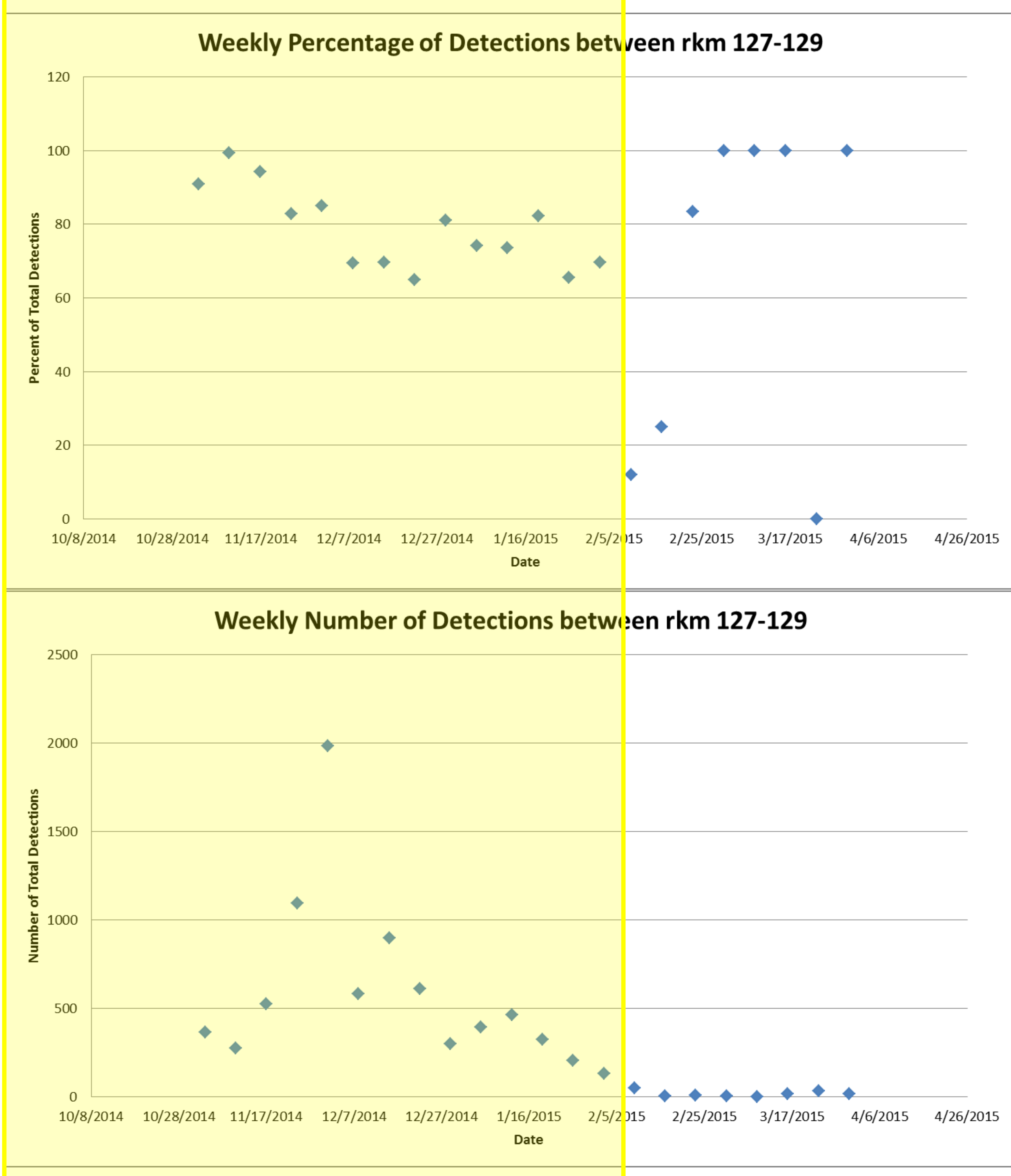
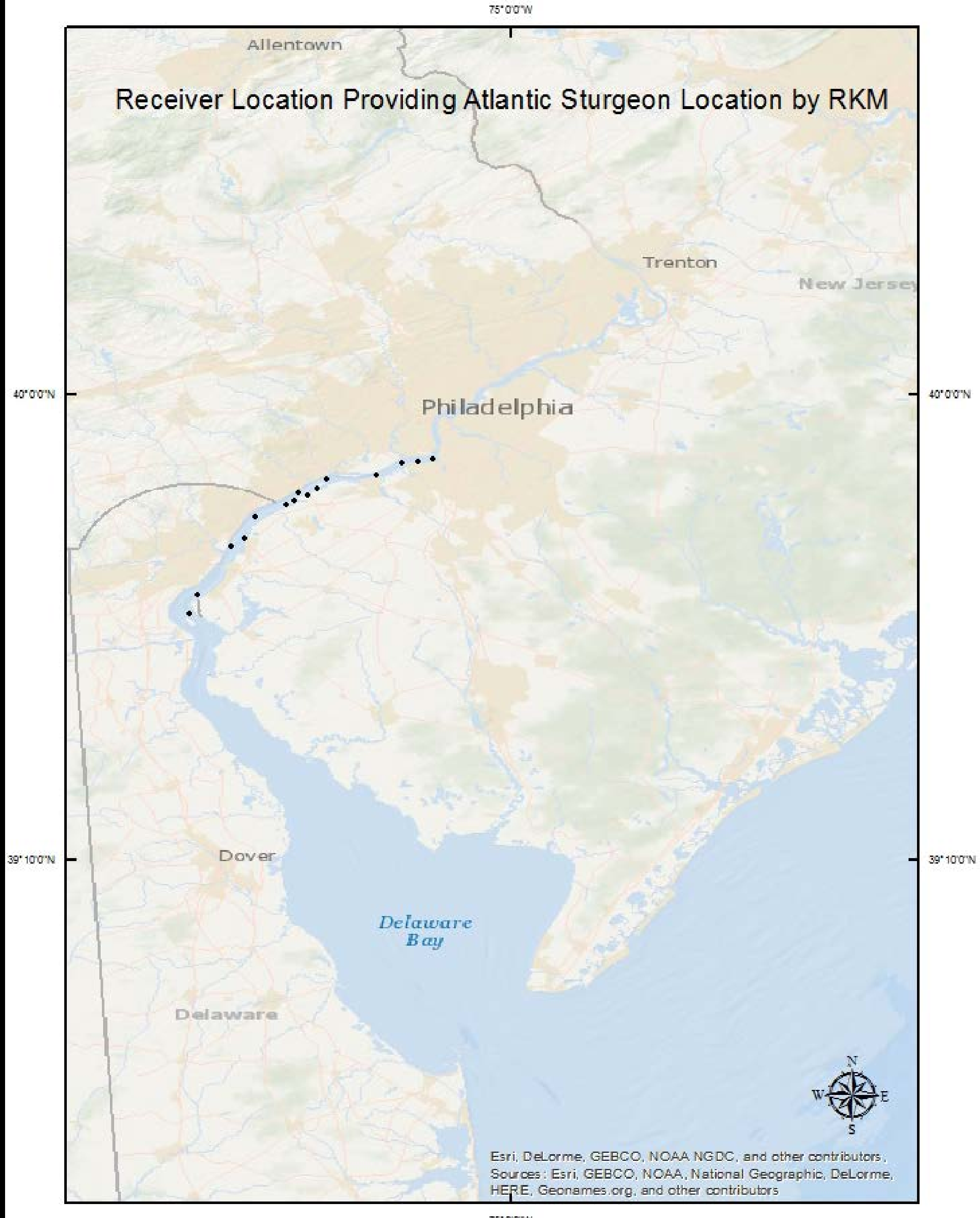


Figure 4: Length frequency histograms of juvenile Atlantic sturgeon caught in the Hudson River (October 2003 – November 2005) for various mesh sizes. A median test showed 127 mm stretch mesh caught significantly larger fish than did the 76 or 102 mm stretch mesh ($p = 0.02$).



- For the weeks with greater than 50 detections, we saw more than 60 % of total detections occurring between rkms. 127-129




Receiver Location Providing Atlantic Sturgeon Location by RKM
75°0'0"W
40°0'0"N
40°0'0"N
39°10'0"N
39°10'0"N
Allentown
Trenton
New Jersey
Philadelphia
Dover
Delaware Bay
Delaware
N
W
E
S
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Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors