Atlantic States Marine Fisheries Commission
Atlantic Menhaden TC and SAS Meeting
Draft Agenda

June 26-27, 2013
1:00 p.m. – 6:00 p.m. (6/26)
8:00 a.m. – 5:00 p.m. (6/27)

The times listed are approximate; the order in which these items will be taken is subject to change; other items may be added as necessary.

WEDNESDAY (1-6pm)

1) Welcome/Review Agenda (**Micah/Amy)**
2) Regional surveys:
   a) NEAMAP, ChesMMAP (**Rob**)
   b) SEAMAP (**Joey**)
   c) NEFSC trawl surveys (**Matt**)
   d) Others?
3) State and federal surveys that catch adult menhaden. **Every TC rep** should prepare a short document containing at least the following info on all agency surveys that collect menhaden (more frequently than rare events).
   a) General description (gear, design, temporal & spatial coverage, targeted species, etc.).
   b) Description of menhaden catch rates (e.g., total numbers caught annually, average CPUE, consistently caught vs. one large tow, etc.)
   c) Metadata description of each data element available (by time period if changed)
   d) Calculate and plot over entire time series the arithmetic and geometric mean catch/effort or other menhaden index appropriate to your study design
   e) If available, plot length and age distributions

THURSDAY (8am-5pm)

4) Continue discussion of state surveys as needed.
5) Icthyoplankton surveys – MARMAP and ECOMON (**Hongsheng Bi/Amy/Genny**)
6) Power plant impingement/entrainment data (**Micah**)
7) Review of past and future/planned treatment of JAI seine surveys (note: will include MA and potentially a few other datasets this time) (**Rob & Micah**)
8) Tagging data discussion – if time allows, continue planning for short-term analysis of tagging data once digitized. Discuss first steps of database development and query building. **Everyone** read Dryfoos et al. 1973 and Nicholson 1978 in preparation.

Massachusetts YOY Winter Flounder Beach Seine Survey

Micah Dean – June 12, 2013

Description

The Massachusetts Division of Marine Fisheries (MDMF) has completed a seine survey annually since 1976 to provide an age-0 winter flounder recruitment index. The survey takes place each year between June 15th and July 4th and covers six Nantucket Sound estuaries on the south side of Cape Cod – Great Pond, Waquoit Bay, Cotuit Bay, Lewis Bay, Bass River, and Stage Harbor (Figure 1). Seining of intertidal and shallow subtidal zones is conducted from two hours before to two hours after high tide. Forty-nine fixed stations, originally chosen for efficient seining (i.e., smooth sediment generally devoid of attached vegetation) and historic availability of age-0 winter flounder, are proportionately allocated by each estuary's littoral perimeter. A 6.4 meter straight beach seine of 4.8 mm nylon mesh equipped with a weighted lead line footrope to minimize escapement is set and hauled perpendicular to shore from an average depth of 0.9 to 1.2 meters. Abundance data is collected by combining three replicate hauls for each station where area swept is meausred using a standardized spreader line while measuring distance from shore. Abundance data provided for individual stations are converted to a standardized catch rate to account for varied haul length. Catch rates are reported as number per square meter.

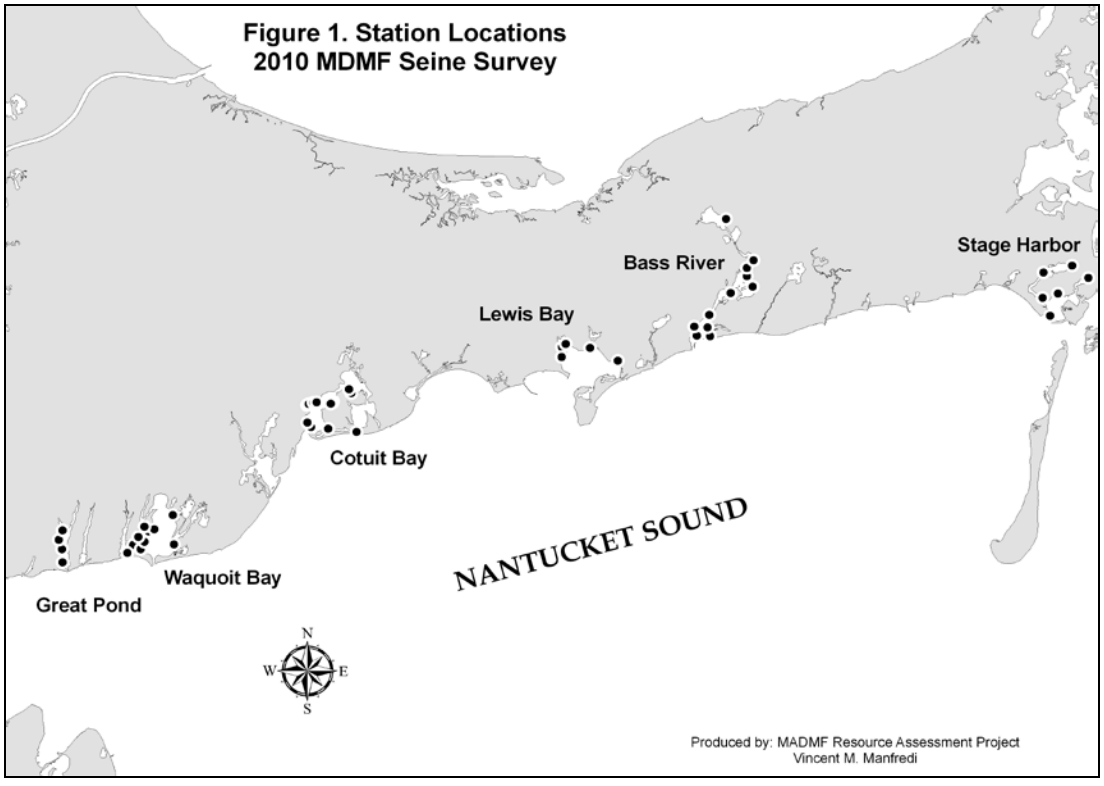


Figure 1. Study area for MDMF seine survey showing individual station locations.

Occurrence of Menhaden

Considering the narrow time frame (~10 days) over which this survey occurs in early summer, it is not ideally suited to provide a meaningful measure of juvenile menhaden abundance. As such, menhaden are infrequently caught, only encountered on 29 (2%) out of the 1521 completed tows. Menhaden were caught in 13 (42%) of the 31 years. Although size data are not collected from this survey, only age-0 menhaden have been caught, with most less than 5 cm.

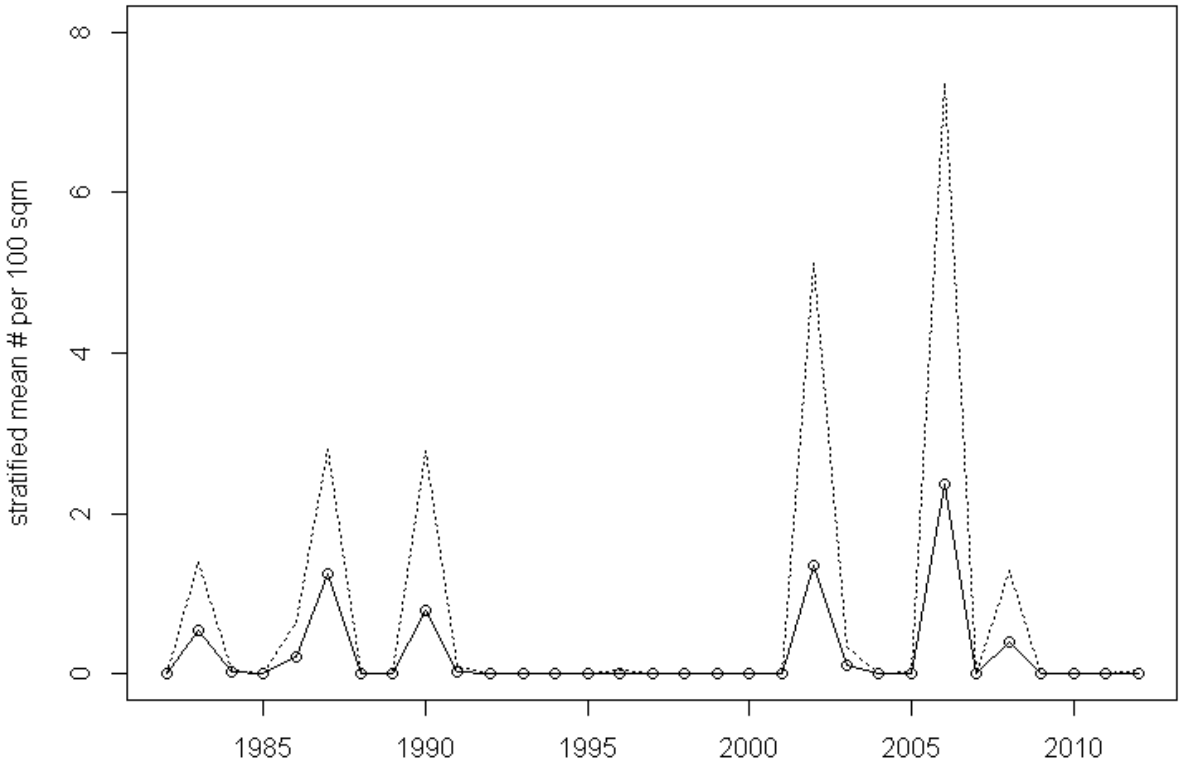


Figure 2. Stratified mean number of menhaden caught per 100 m^2 sampled (stratum = estuary).

Table 1. Total number of survey hauls, number of hauls containing menhaden, and the total number of menhaden caught per year, 1982-2012.

Year	Total Hauls	Hauls w/ menhaden	Menhaden caught
1982	49	0	0
1983	49	7	61
1984	49	1	2
1985	49	0	0
1986	49	2	20
1987	49	7	130
1988	49	0	0
1989	49	0	0
1990	49	2	68
1991	49	1	2
1992	49	0	0
1993	49	0	0
1994	49	0	0
1995	49	0	0
1996	49	1	2
1997	49	0	0
1998	49	0	0
1999	49	0	0
2000	49	0	0
2001	49	0	0
2002	49	1	118
2003	49	2	17
2004	49	0	0
2005	49	1	1
2006	50	2	223
2007	50	0	0
2008	49	1	35
2009	49	0	0
2010	49	0	0
2011	49	0	0
2012	49	1	1
Total	1521	29	680

Massachusetts Bottom Trawl Surveys

Micah Dean – June 12, 2013

Survey Description

Massachusetts has been conducting annual bottom trawl surveys in the spring and fall since 1978. The survey allocates its sampling effort according to a series of 23 strata in Massachusetts state waters, based on five bio-geographic regions and six depth zones. Trawl sites are allocated in proportion to stratum area and randomly chosen in advance within each sampling stratum. However, the survey gear cannot be deployed over very shallow or very rough bottom types and therefore those areas are not sampled. Tows of standard speed and duration are made with a bottom trawl that has had the same design specifications since the survey began. Total weight and length-frequency are collected for all finfish and a subset of invertebrates. Additional information such as age, sex and maturity are collected from a list of priority species.

Occurrence of Menhaden

Since this is a bottom trawl survey at the northern end of the range of menhaden, it is not surprising that very few are encountered. In the spring survey, a total of 19 menhaden have been caught on 15 (0.4%) out of 3,382 tows (Table 1). The fall survey catches somewhat more menhaden, with a total of 2,550 caught on 54 (1.7%) of 3,158 tows. However, almost 90% of these fish were caught on two individual tows in a single year (2007). Furthermore, the majority of menhaden caught by the fall survey are not adults (Figure 1). Considering the rarity of menhaden caught by these surveys, it is unlikely that these data will prove useful in the development of an index of menhaden abundance (Figure 2).

Table 1. Annual number of tows and occurrence of menhaden in the spring and fall Massachusetts bottom trawl surveys.

Spring Survey (May)				Fall Survey (September)			
Year	Number of Tows	Tows with Menhaden	Menhaden Caught	Year	Number of Tows	Tows with Menhaden	Menhaden Caught
1978	95	2	2	1978	91	0	0
1979	100	0	0	1979	98	0	0
1980	98	0	0	1980	97	1	1
1981	97	0	0	1981	95	1	1
1982	95	0	0	1982	93	0	0
1983	94	0	0	1983	85	1	2
1984	99	1	1	1984	92	1	1
1985	93	2	2	1985	88	3	3
1986	94	2	2	1986	90	1	1
1987	97	0	0	1987	88	0	0
1988	91	3	5	1988	75	2	11
1989	94	1	3	1989	68	0	0
1990	95	0	0	1990	87	0	0
1991	98	1	1	1991	86	2	2
1992	92	0	0	1992	77	0	0
1993	88	0	0	1993	81	0	0
1994	87	0	0	1994	97	0	0
1995	97	1	1	1995	95	0	0
1996	101	0	0	1996	95	3	58
1997	98	0	0	1997	90	1	2
1998	89	0	0	1998	86	1	2
1999	96	0	0	1999	91	2	11
2000	97	0	0	2000	93	2	15
2001	98	0	0	2001	96	0	0
2002	100	0	0	2002	89	5	22
2003	96	0	0	2003	93	3	27
2004	99	0	0	2004	84	2	2
2005	94	0	0	2005	92	1	1
2006	100	0	0	2006	96	0	0
2007	101	0	0	2007	101	15	2372
2008	103	0	0	2008	98	0	0
2009	101	0	0	2009	96	0	0
2010	103	0	0	2010	90	2	3
2011	102	0	0	2011	93	1	8
2012	100	2	2	2012	92	4	5
Total	3382	15	19	Total	3158	54	2550

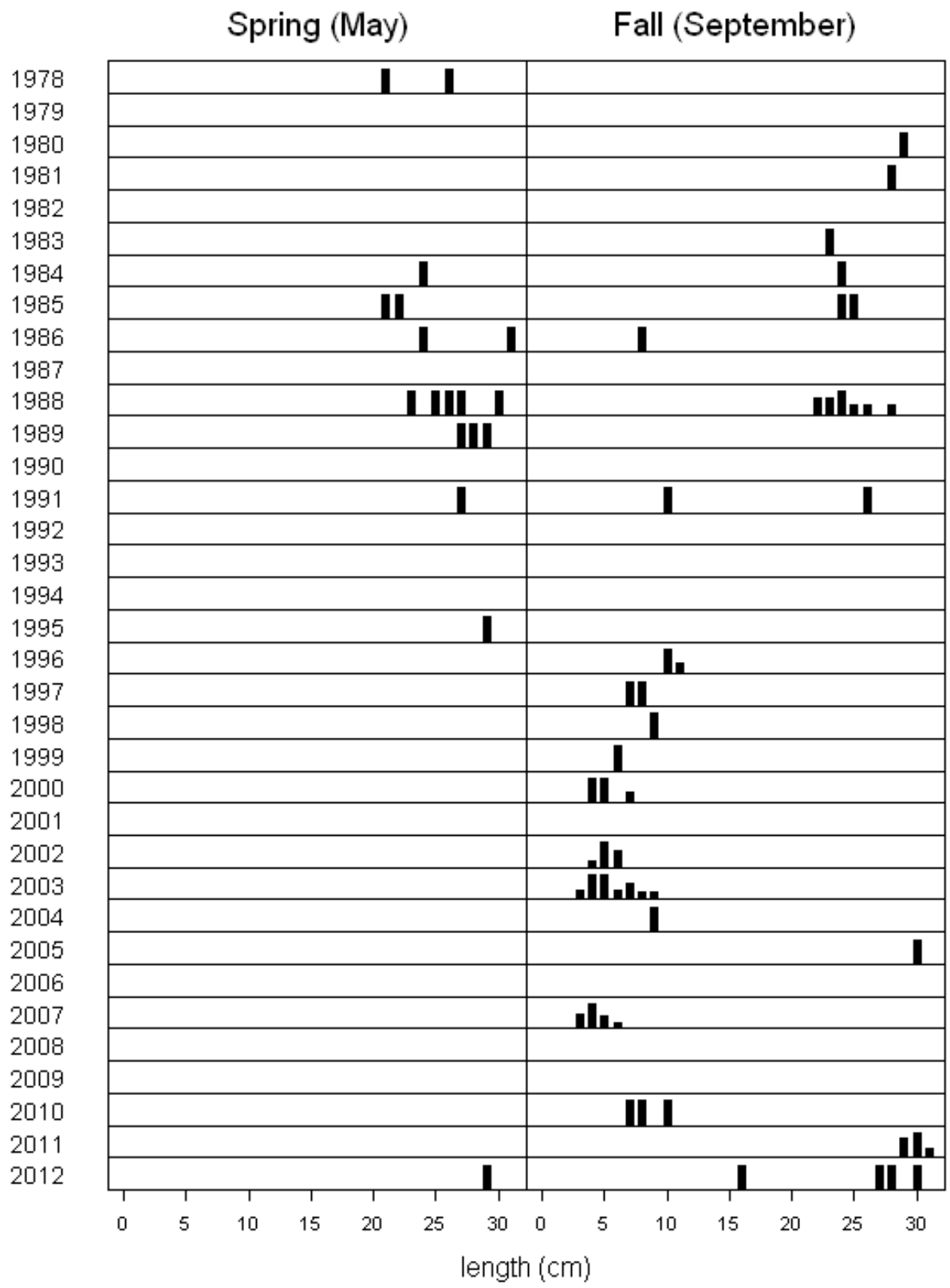


Figure 1. Length frequency data for menhaden caught by Massachusetts bottom trawl surveys in spring and fall.

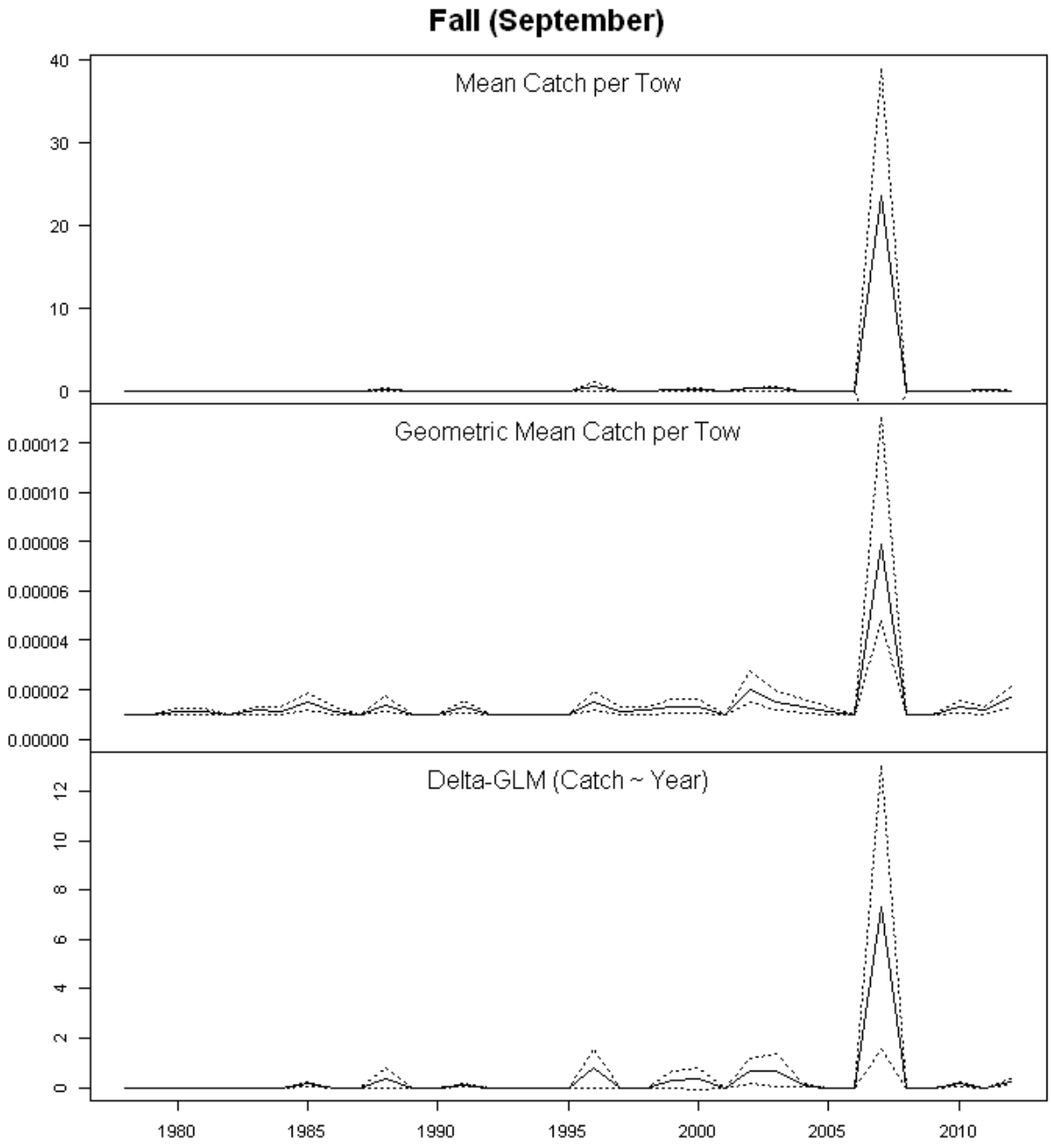


Figure 2. Three potential indices of menhaden abundance from the Massachusetts bottom trawl survey. Dashed lines indicate +/- 1 standard error.

CT, fishery-independent adult menhaden - LIS - 6/10/2013

CONNECTICUT LONG ISLAND SOUND TRAWL SURVEY (LISTS)

The Connecticut DEEP Marine Fisheries Division has conducted a fisheries–independent Trawl Survey in Long Island Sound since 1984. The Long Island Sound Trawl Survey (LISTS) provides fishery independent monitoring of important recreational species, as well as annual total counts and biomass for all finfish taken in the Survey. LISTS also collects data on all living resources seen during the Survey, including total biomass for invertebrates. The Long Island Sound Trawl Survey encompasses an area from New London, Connecticut (longitude 72^{o} 03') to Greenwich, Connecticut (longitude 73^{o} 39'). The sampling area includes Connecticut and New York state waters from 5 to 46 meters in depth and is conducted over mud, sand and transitional (mud/sand) sediment types (see example, Figure 1). Currently, Long Island Sound is surveyed in the spring (April-June) and fall (September-October) periods with 40 sites sampled monthly for a total of 200 sites annually.

The sampling gear employed is a 14 m otter trawl with a 51 mm codend (Table 1). To reduce the bias associated with day-night changes in catchability of some species, sampling is conducted during daylight hours only (Sissenwine and Bowman 1978). LISTS employs a stratified-random sampling design. The sampling area is divided into 1.85 x 3.7 km (1 x 2 nautical miles) sites, with each site assigned to one of 12 strata defined by depth interval (0 - 9.0 m, 9.1 - 18.2 m, 18.3 - 27.3 m or, 27.4+ m) and bottom type (mud, sand, or transitional as defined by Reid et al. 1979). For each monthly sampling cruise, sites are selected randomly from within each stratum. The number of sites sampled in each stratum was determined by dividing the total stratum area by 68 km^2 (20 square nautical miles), with a minimum of two sites sampled per stratum (Table 2). Discrete stratum areas smaller than a sample site are not sampled.

Figure 1. Example of LISTS site map and sites selected and completed for one month, June 2011

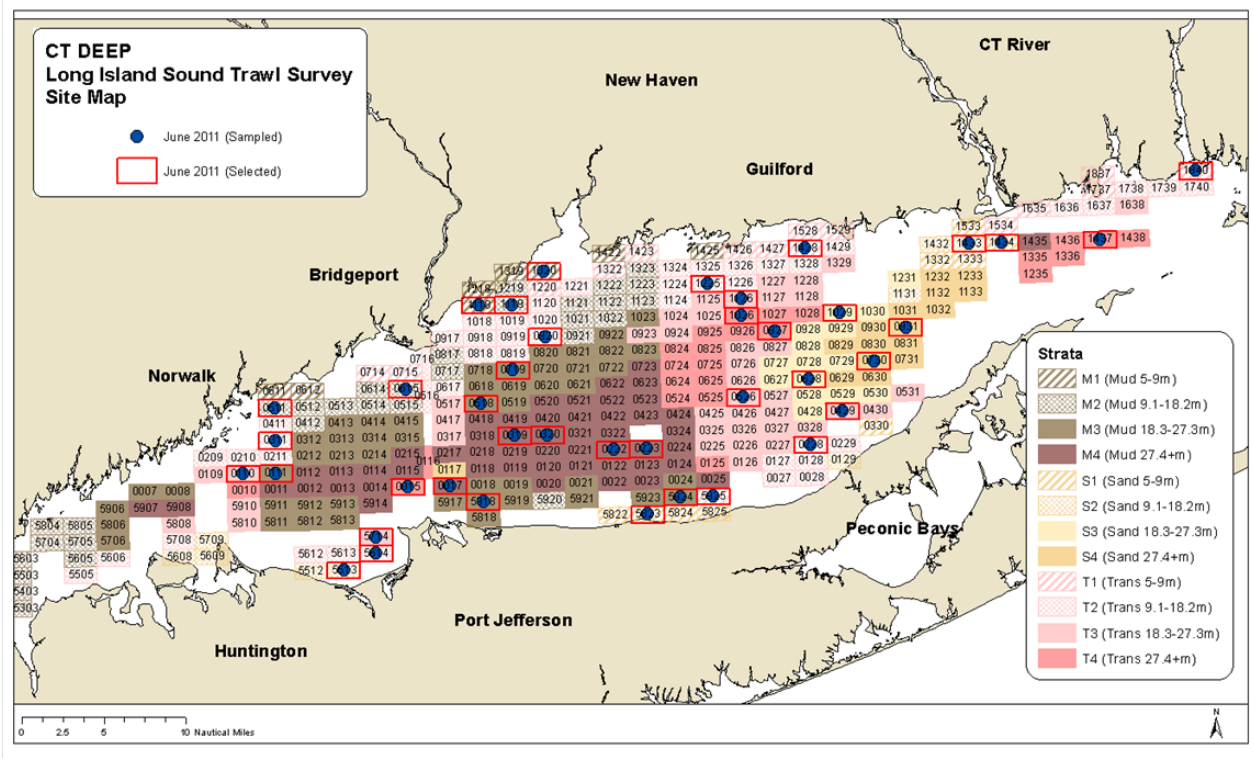


Table 1. LISTS specifications for Wilcox 14m high-rise trawl net and associated gear

Component	Description
Headrope	9.1 m long, 13 mm combination wire rope
Footrope	14.0 m long, 13 mm combination wire rope
Sweep	Combination type, 9.5 mm chain in belly, 7.9 mm chain in wing
Floats	7 floats, plastic, 203 mm diameter
Wings	102 mm mesh, #21 twisted nylon
Belly	102 mm mesh, #21 twisted nylon
Tail Piece	76 mm mesh, #21 twisted nylon
Codend	51 mm mesh, #54 braided nylon
Ground Wires	18.2 m long, 6x7 wire, 9.5 mm diameter
Bridle Wires:	top legs 27.4 m long, 6x7 wire, 6.4 mm diameter
Bottom Legs	27.4 m long, 6x7 wire, 11.1 mm, rubber disc type, 40 mm diameter
Doors	Steel "V" type, 1.2 m long x 0.8 m high, 91 kg
Tow Warp	6x7 wire, 9.5 mm diameter

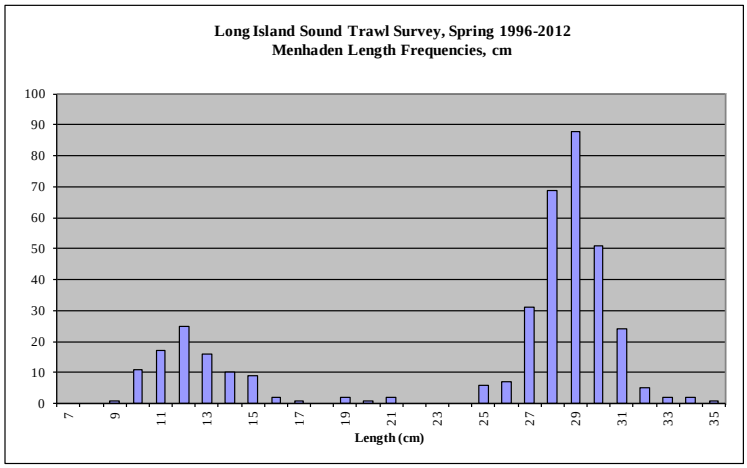
Table 2. The number of sites scheduled for sampling each month within the 12 depth-bottom type strata.

	Depth Interval (m)				
Bottom type	**0 - 9.0**	**9.1 - 18.2**	**18.3 - 27.3**	**27.4+**	**Totals**
Mud	2	3	5	5	15
Sand	2	2	2	2	8
Transitional	3	5	5	4	17
Totals	**7**	**10**	**12**	**11**	**40**

Menhaden catch during the Long Island Sound Trawl Survey average about 400 fish annually, however, two years of higher catches were observed; 1992 (1,115 fish) and 1999 (1,187 fish). LISTS has recorded a catch of 11,242 menhaden from all tows since 1984. Typically the fall survey records higher abundance (28.5% positive tows) with the majority (71%) of the catch being fish less than 20 centimeters long. Only a few menhaden are recorded during spring cruises (7.3% positive tows), however, seventy-five percent of the springtime catch are adults. Menhaden length measurements have been recorded on every tow since 1996 (Figure 2). The average fall geometric mean catch since 1984 has been 0.68 menhaden/tow and the average biomass since 1992 (biomass was first recorded in 1992) has been 0.27 kg/tow (Figure 3). Arithmetic mean catch per tow since 1984 is 3.43 menhaden during the fall and 0.29 menhaden per tow during the spring.

Tables, including raw catch data (zero-filled) and length data, are provided along with total catch, numbers of tows, and indices of abundance in attached file (see: CT_LISTS_MEN.xlsx).
For specific details on methods see:
http://www.ct.gov/deep/lib/deep/fishing/fisheries_management/2011_long_island_sound_trawl_survey.pdf

Figure 2. Long Island Sound Trawl Survey menhaden length frequencies, 1996-2012.



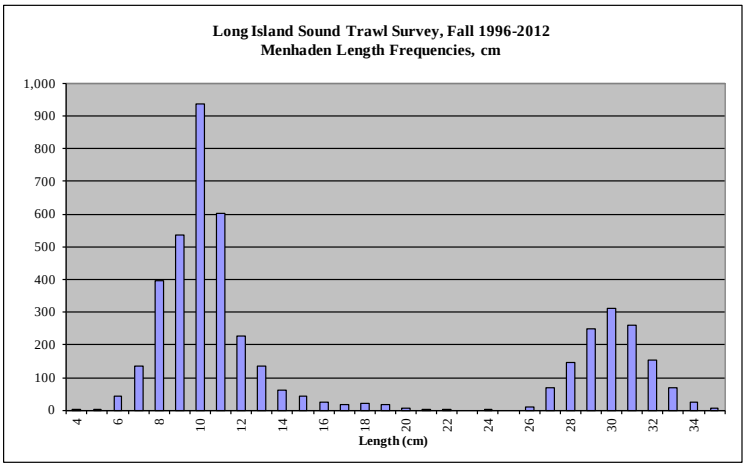
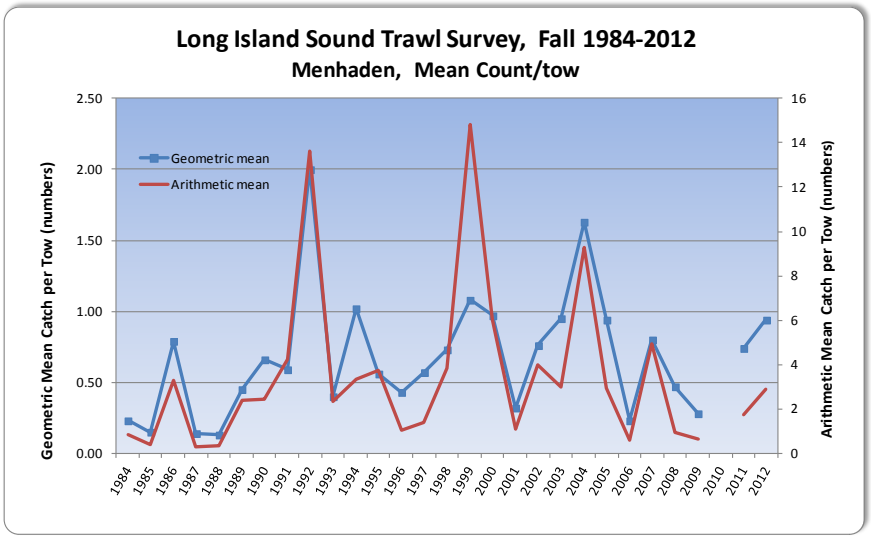


Figure 3. Long Island Sound Trawl Survey menhaden abundance, 1984-2012.



Survey Descriptions for NYSDEC Fishery Independent Surveys
That capture Menhaden Data

NYSDEC Peconic Bay Small Mesh Trawl Survey

Years Sampled: 1987 – 2012

Gear Type: 4.8 m semi-balloon shrimp trawl, the body has 3.8 cm mesh, the codend has 3.2 cm mesh, and the codend liner has 1.3 cm mesh. The footrope is 0.95 cm rope that is 6.4 m long, with legs extended 0.9m and wire rope thimbles spliced at each end, 0.6cm chain hung in loop style on the footrope. The net was towed for 10 minutes at approximately 2.5 knots. The vessel used was a 10.7 m lobster style workboat.

Spatial Coverage: Peconic Bay

Temporal coverage: May through October

Sample Design: Random survey based on a block grid design. The survey area was divided into 77 sampling blocks with each block measuring 1' latitude and 1' longitude.

Sample frequency and number: 16 stations were randomly chosen each week to sample

Information Collected: All finfish species are identified and counted. Environmental information (surface and bottom temperature, salinity, dissolved oxygen, and secchi disc readings) were recorded at each station.

Changes in Sample Design: From 1987 – 1990 the net was set by hand and retrieved using a hydraulic lobster pot hauler. From 1991 to the present the net was set and retrieved using hydraulic trawl winches and an A-frame. Due to vessel problems, the survey was not conducted during the following time periods: 2005 from mid-July through October, 2006 from May through mid-July, 2008 from May through mid-August, and 2010 during May.

NYSDEC Western Long Island Beach Seine Survey

Years Sampled: 1984 – 2012

Gear Type: 200ft x 10ft beach seine with ¼ inch square mesh in the wings, and 3/16 inch square mesh in the bunt. The seine is set by boat in a "U" shape along the beach and pulled in by hand.

Spatial Coverage: Little Neck (LNB) and Manhasset Bay (MAN) on the north shore of Long Island (WLIS), and Jamaica Bay (JAM) on the south shore. Other bays have been sampled on a shorter time frame.

Temporal Coverage: May through October. Pre 2000 sampling was conducted 2 times per month during May – June and once a month July – October. Sampling from 2000 – 2012 was conducted 2 times per month from May – October.

Sample Design: Fixed site survey. Generally 5 – 10 seine sites are sampled in each bay on each sampling trip.

Information Collected: All finfish species are identified and counted. Environmental information (air and water temperature, salinity, dissolved oxygen, tide stage, wind speed and direction, and wave height) has been recorded at each station. Bottom type, vegetation type, and percent cover have been recorded qualitatively since 1988.

NYSDEC Lower Hudson River Beach Seine Survey

Years sampled: 1979 to the present, consistent methodology starting in 1985

Gear type**:** 200 ft x 10 ft beach seine with ¼ inch square mesh in the wings, and 3/16-inch square mesh in the bunt. Bunt is offset. The seine is set by boat in a "U" shape along the beach and pulled in by hand.

Spatial coverage: The lower Hudson River from Dobbs Ferry (River Mile (RM) 18) to Haverstraw (RM 40)

Temporal coverage: Nine bi-weekly trips from Mid-July through early November. Pre-1985 sampling was conducted during six bi-weekly trips from August through early November

Sample design: Fixed site survey.

Sample frequency and number: 25 seine sites were planned to be sampled during each bi-weekly sampling trip. Twenty-five stations were not sampled each bi-weekly trip due to weather or equipment problems.

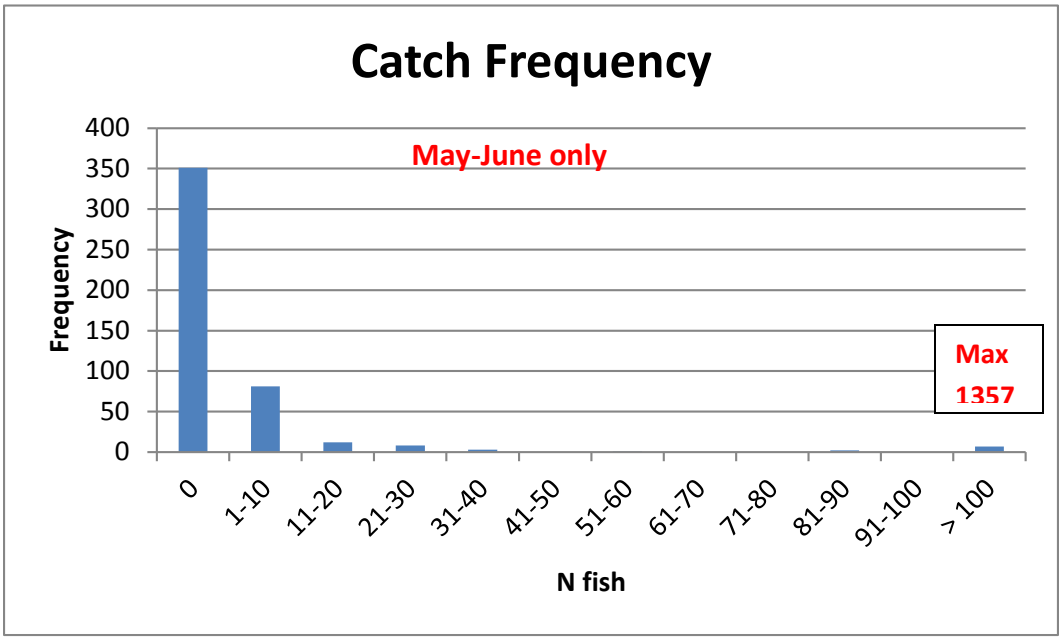
Information collected**:** All finfish species identified and counted, Environmental information (air and water temperature, tide stage, wind speed and direction, and wave height) has been recorded at each station. Salinity has been recorded consistently since 1985, and dissolved oxygen has generally been recorded since 1987, except during 1996, 1997 and the end of 1998 due to equipment problems. Bottom type, vegetation type, and percent cover has been recorded qualitatively since 1988

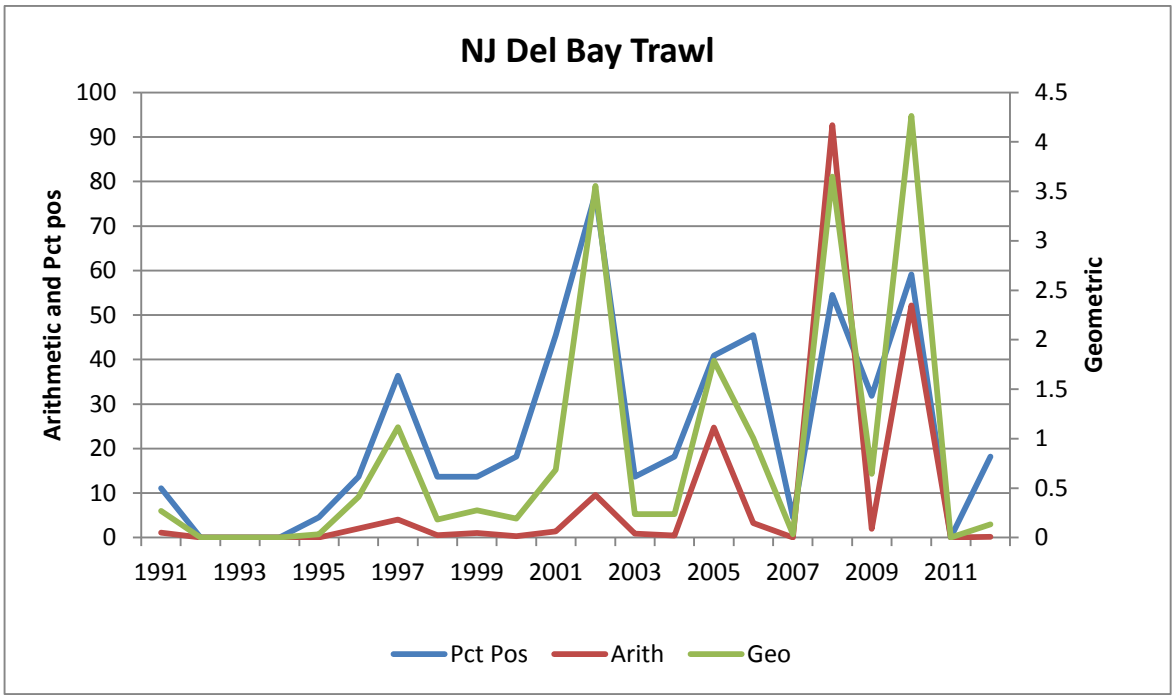
Measure of central tendency and CI: Arithmetic and geometric mean

Changes in sample design: Twenty-five stations were not sampled each bi-weekly trip due to weather or equipment problems, temporal coverage increased from six bi-weekly trips starting in August to nine bi-weekly trips starting in mid-July from 1985 to the present. Starting consistently in 2000 Menhaden age groups were broken out as 0-YOY or 1-OLDER.

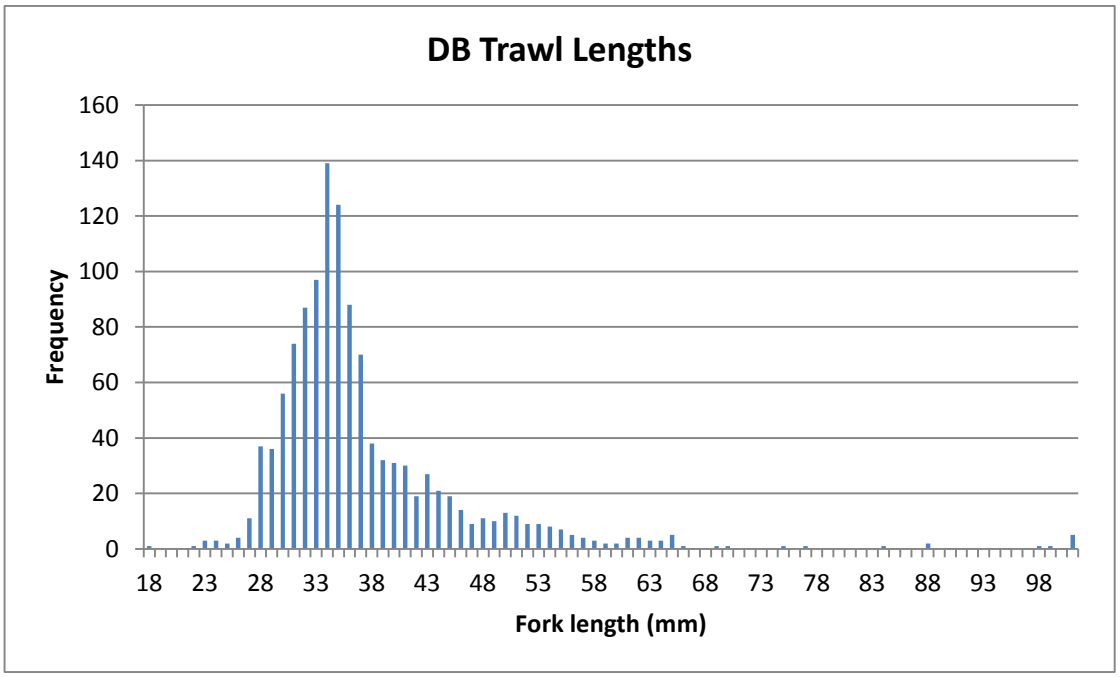
Survey: New Jersey Delaware Bay Trawl
Gear: 16’ otter trawl
Time series: 1991 – present
Frequency: Monthly, April through October
Design: 11 fixed stations
Location: Shoal areas in NJ portion of DE Bay
Variables: Date, station, depth, salinity, temperature, DO, number, lengths
Metadata: To my knowledge, everything has been consistent throughout survey. Sampling was a bit erratic in early years, but May and June seemed stable based on N tows by station.
Synopsis: High frequency of negative tows (~75% overall); few fish over 60 mm (~3% of all fish); Doesn’t appear useful as adult index; never been used as juvenile index but perhaps worth investigating

Month	Tot catch
4	18
5	2446
6	1869
7	138
8	60
9	90
10	368
11	3
Grand Tota	4992

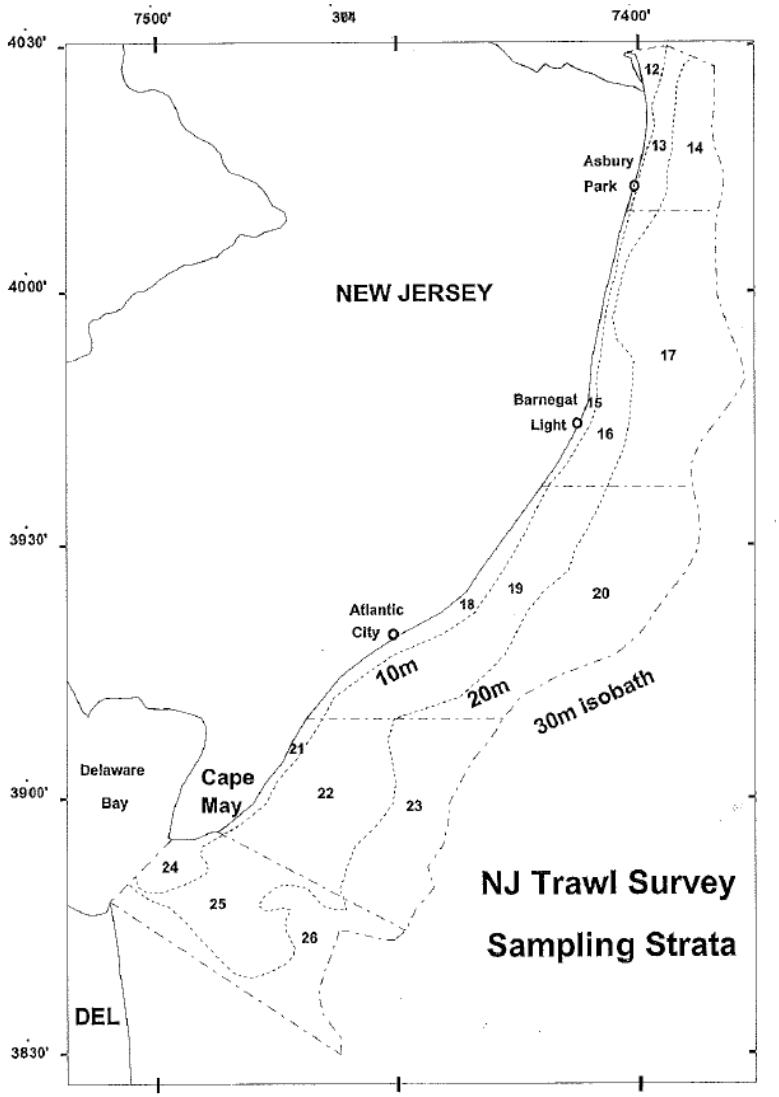




	Pct Pos	Arith	-1 SD	+1 SD	Geo	Lo95	Hi95
1991	11.11	1.11	-2.92	5.14	0.27	-0.39	1.65
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	4.55	0.05	-0.17	0.26	0.03	-0.11	0.20
1996	13.64	2.00	-4.47	8.47	0.41	-0.44	2.56
1997	36.36	4.05	-4.06	12.15	1.12	-0.36	5.96
1998	13.64	0.50	-1.42	2.42	0.18	-0.30	0.99
1999	13.64	1.05	-2.68	4.77	0.28	-0.38	1.61
2000	18.18	0.32	-0.46	1.10	0.19	-0.20	0.78
2001	45.45	1.41	-1.61	4.43	0.69	-0.19	2.51
2002	77.27	9.55	-3.84	22.93	3.56	0.19	16.40
2003	13.64	0.91	-2.72	4.53	0.24	-0.36	1.38
2004	18.18	0.45	-0.73	1.64	0.24	-0.24	1.03
2005	40.91	24.73	-61.69	111.14	1.79	-0.49	14.27
2006	45.45	3.23	-5.41	11.87	1.01	-0.27	4.50
2007	4.55	0.05	-0.17	0.26	0.03	-0.11	0.20
2008	54.55	92.68	-209.53	394.90	3.65	-0.45	38.40
2009	31.82	1.95	-2.83	6.74	0.64	-0.33	3.06
2010	59.09	52.14	-88.11	192.39	4.26	-0.29	38.13
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	18.18	0.18	-0.21	0.58	0.13	-0.14	0.49

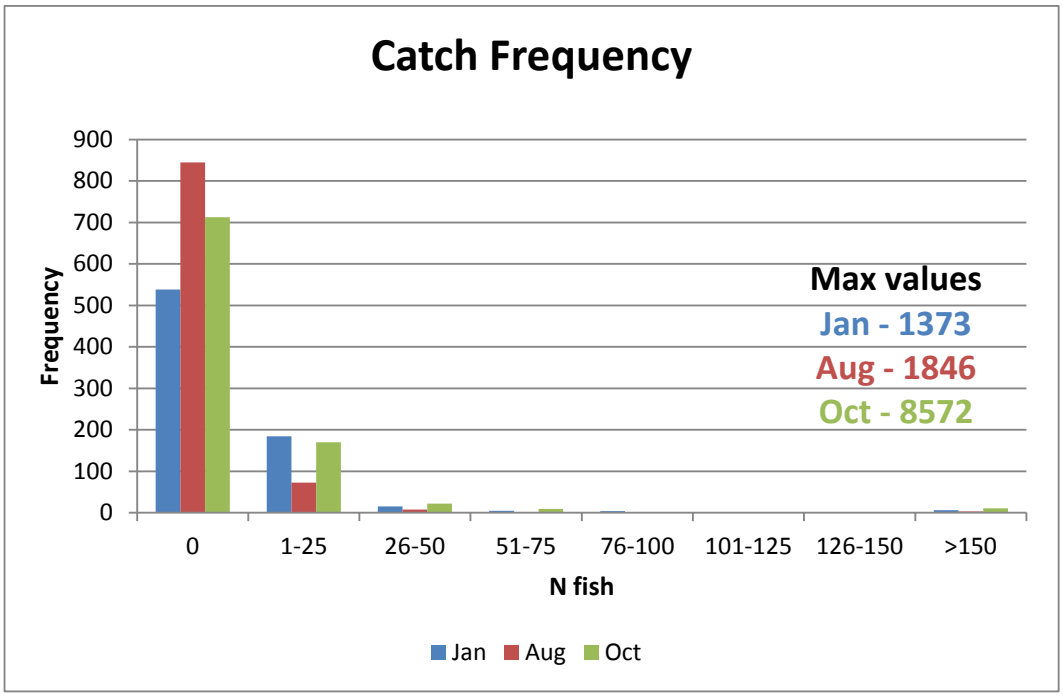

DB Trawl Lengths
Frequency
160
140
120
100
80
60
40
20
0
18
23
28
33
38
43
48
53
58
63
68
73
78
83
88
93
98
Fork length (mm)

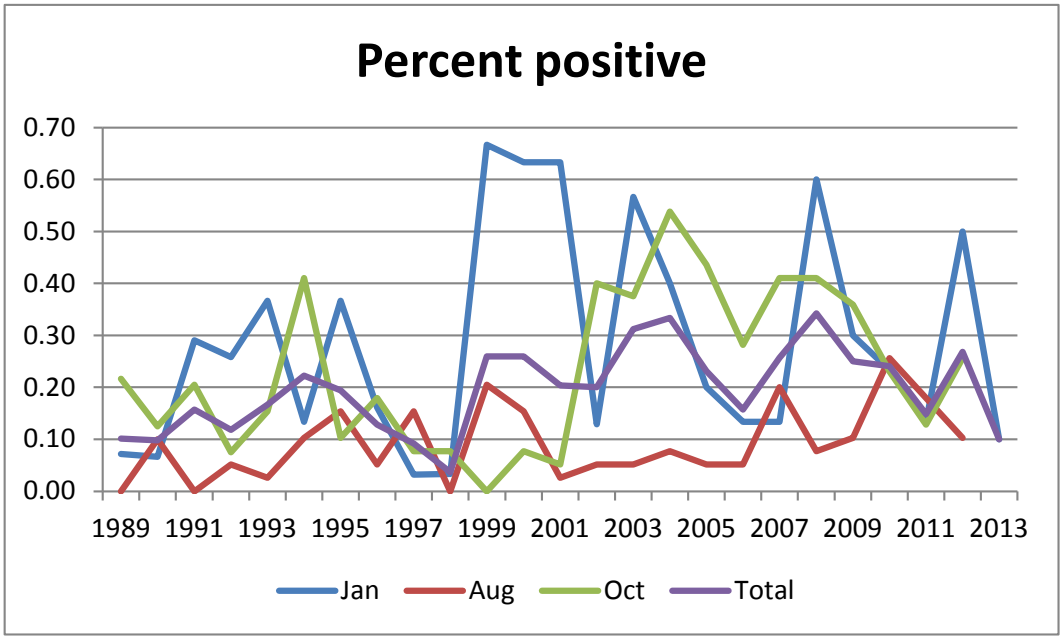
Survey: New Jersey Ocean Trawl
Gear: "three in one" trawl, 30.5m foot rope
Time series: August 1988 – present
Frequency: 5 cruises per year (Jan, Apr, Jun, Aug, Oct)
Design: Stratified random by depth; utilizes NEFSC inshore trawl strata
Location: Cape May to Sandy Hook, shore to 90' isobath
Variables: Date, stratum, station, vessel, tow time, depth, lat/long, temperature, salinity, DO, number, total weight, lengths
Metadata: Changes to survey timing in first few years (consistent since 1991); 5 different vessels over survey history (same vessel since 2002); survey dates shift due to vessel availability and weather
Synopsis: Low percentage of positive tows (<20% overall); few fish >150 mm YOY cut off in fall (<15%); Bottom trawl in "deep" water not effective at catching pelagics; however, there is some evidence that 160+ CPUE lags NJ YOY index by 1 year. Also, Jan fish index appears to lag Oct index, but not convinced they are same fish since LFs (all years combined) don't line up.

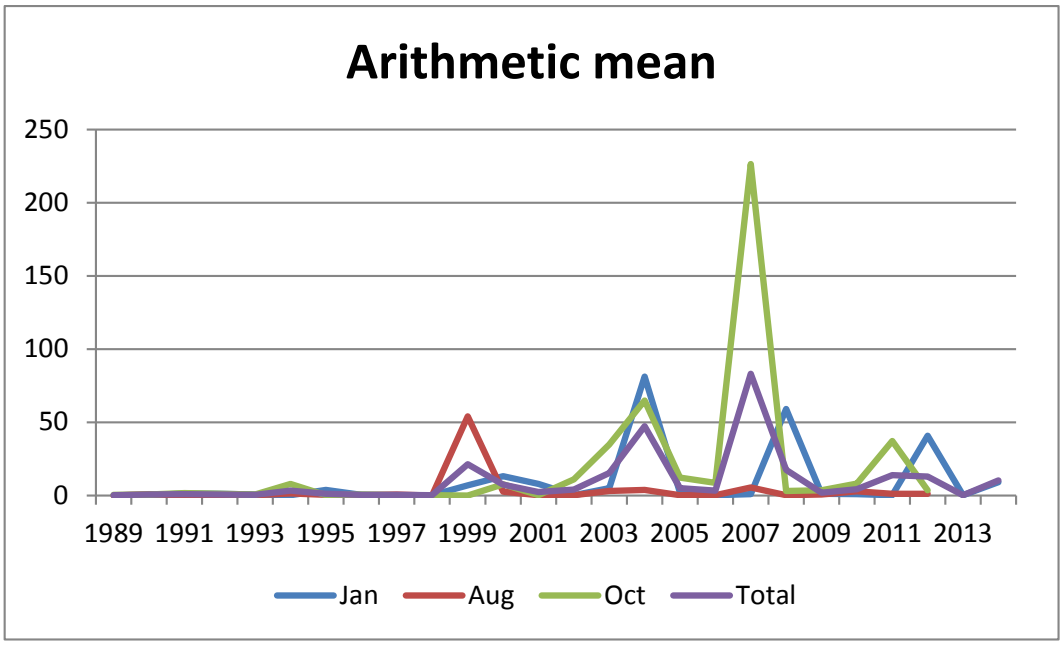


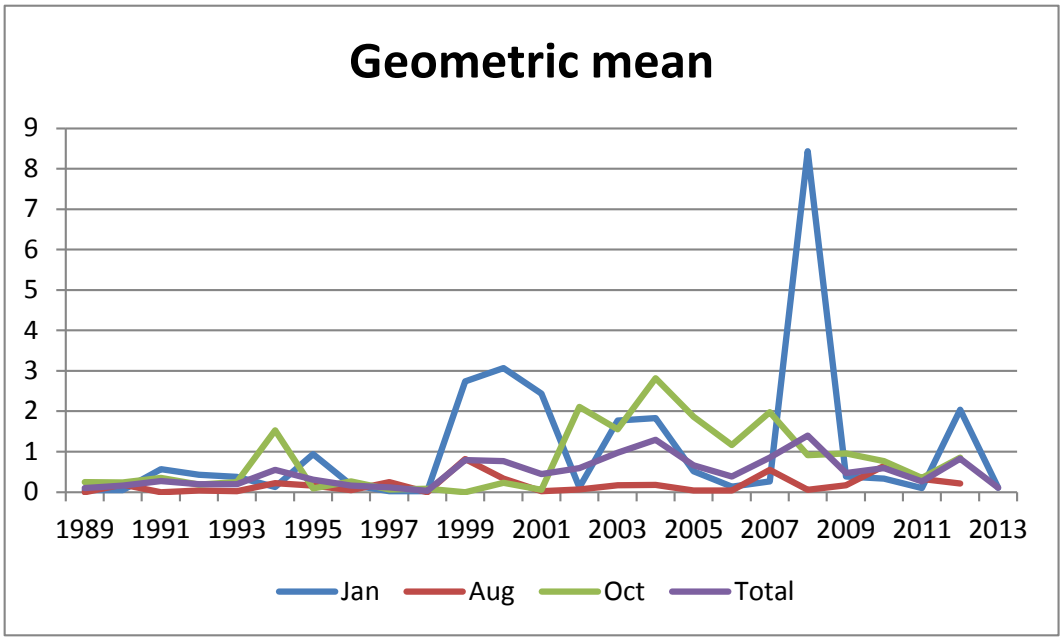
Vessels used
1988 – 1991: F/V Amy Diane
1991 – 1996: F/V Argo Maine
1997: F/V Caitlin
1998 – 2001: F/V Olympia
2002 – present: R/V Seawolf

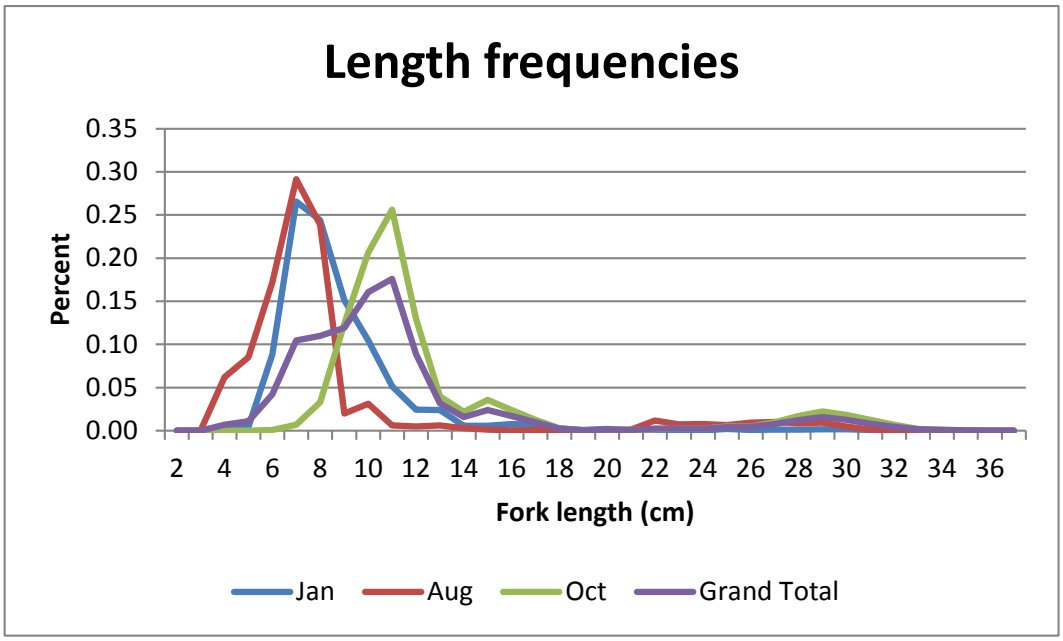
Cruise	N bunker
Jan	6,802
Apr	215
Jun	277
Aug	3,032
Oct	16,941
Dec	164
Grand Tota	27,431

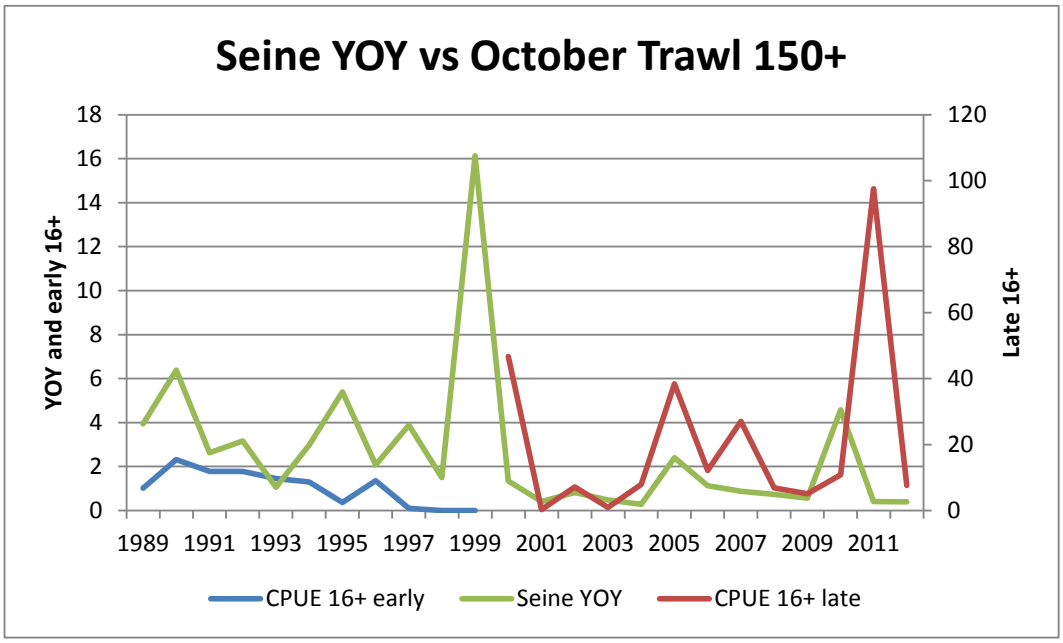

Catch Frequency
900
800
700
600
500
400
300
200
100
0
Frequency
Max values
Jan - 1373
Aug - 1846
Oct - 8572
0
1-25
26-50
51-75
76-100
101-125
126-150
>150
N fish
Jan
Aug
Oct


Percent positive
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
Jan
Aug
Oct
Total


Arithmetic mean
250
200
150
100
50
0
1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013
Jan
Aug
Oct
Total


Geometric mean
9
8
7
6
5
4
3
2
1
0
1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013
Jan
Aug
Oct
Total


Length frequencies
Percent
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36
Fork length (cm)
Jan
Aug
Oct
Grand Total

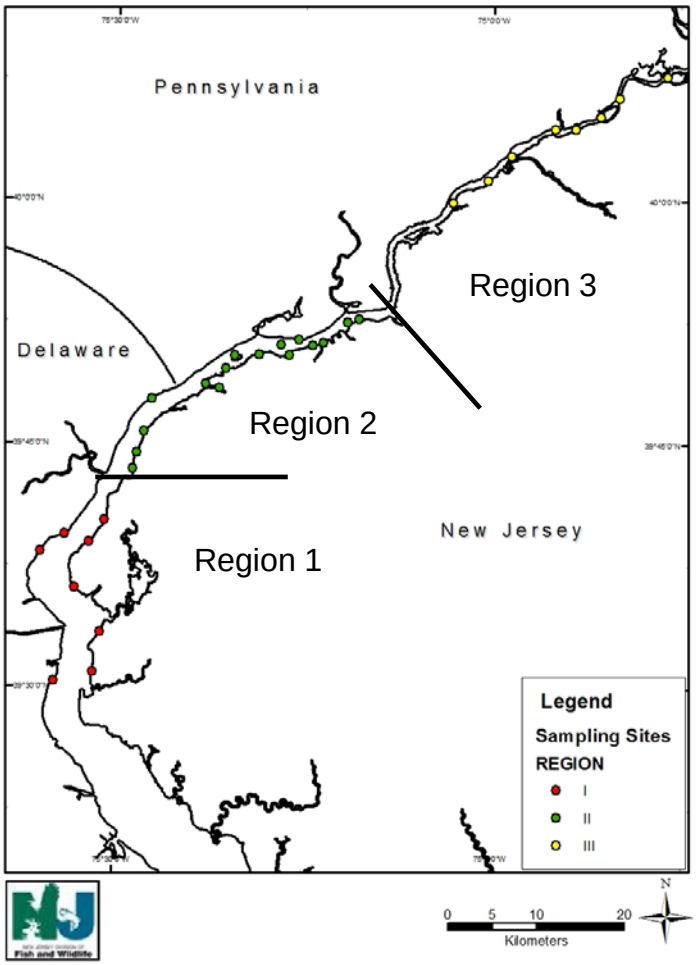

Seine YOY vs October Trawl 150+
YOY and early 16+
18
16
14
12
10
8
6
4
2
0
Late 16+
120
100
80
60
40
20
0
1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011
CPUE 16+ early
Seine YOY
CPUE 16+ late

Survey: New Jersey Juvenile Striped Bass Seine Survey
Gear: 100’ bagged seine, ¼ inch mesh
Time series: 1980-present
Frequency: Twice per month, June to November
Design: Different throughout history, currently 32 fixed stations; three regions based on salinity
Location: Delaware River, RM 53.5 (Salem Nuclear) to 126 (Trenton)
Variables: Year, region, sample round, fixed/random, water temp, salinity, DO, number, lengths
Metadata: Several changes to survey design, including:

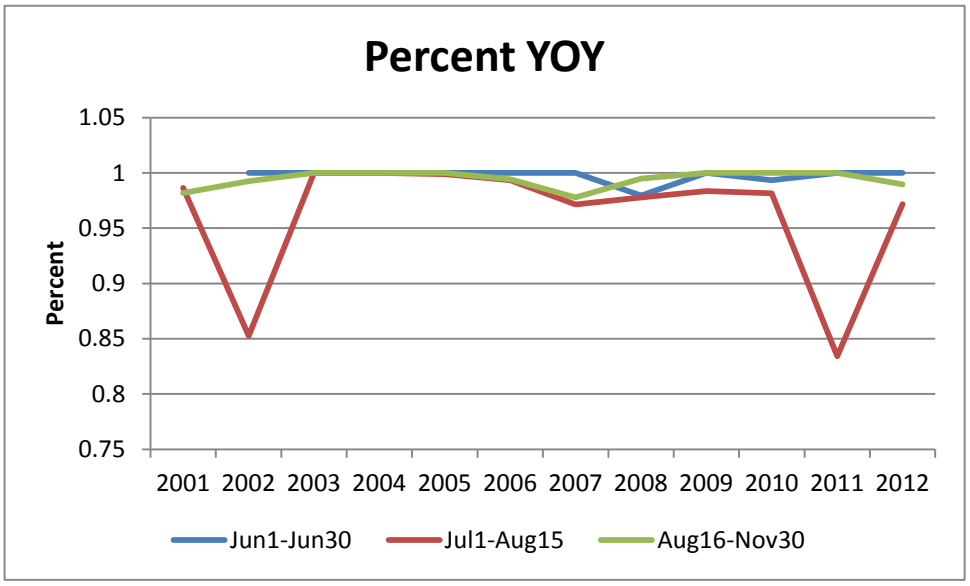
- 1980-1986, “haphazard” sampling
- 1987-1990, replicate tows at 16 fixed stations 2x per month, mid July to mid Nov
- 1991-1997, fixed and random design, single tows, 2x per month, Aug – Oct; 50% of effort in region 2
- 1998 – present, single tows at 32 fixed stations, 2x per month, June to November

Current sites have been relatively consistent since 1998, and many of those have sampling histories back to the 1980s (but not always continuous). Occasionally we “lose” a beach and have to find alternate site. Generally, menhaden catches in upper (fresh water) region are low and drop that region for YOY index. Generally use only first tow at a site during period replicates were performed. Have looked at using all sites vs only “consistent” sites for YOY calculation. Use TC approved YOY length cut-offs to weed out adults. Prior to 2001, only min and max lengths were recorded.

DELAWARE RIVER RECRUITMENT SURVEY SAMPLING AREA

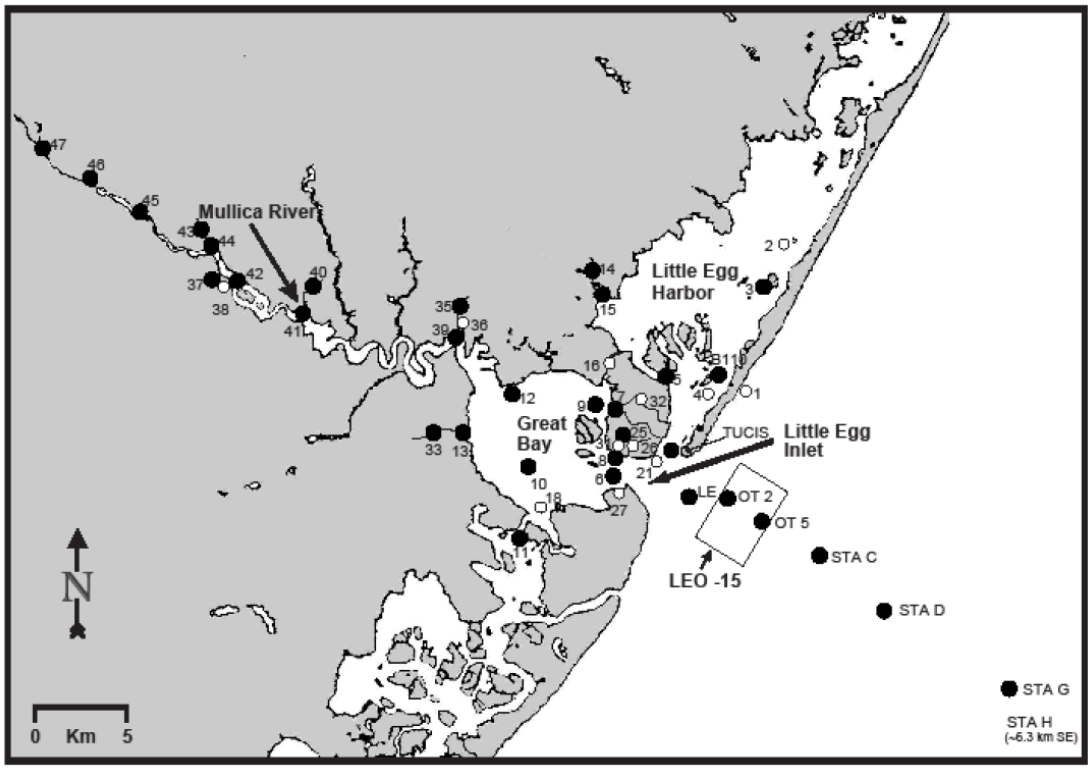


	Menhaden catch			
	Region 1	Region 2	Region 3	
juneB	7,577	6,792	476	14,845
julyA	3,496	14,103	17	17,616
julyB	4,564	3,839	81	8,484
augustA	37,837	13,787	2	51,626
augustB	9,764	13,201		22,965
septembe	8,861	24,997	1	33,859
septembe	13,959	14,475		28,434
octoberA	4,798	3,455		8,253
octoberB	3,822	2,744		6,566
novembe	102	118		220
novembe	1	1		2



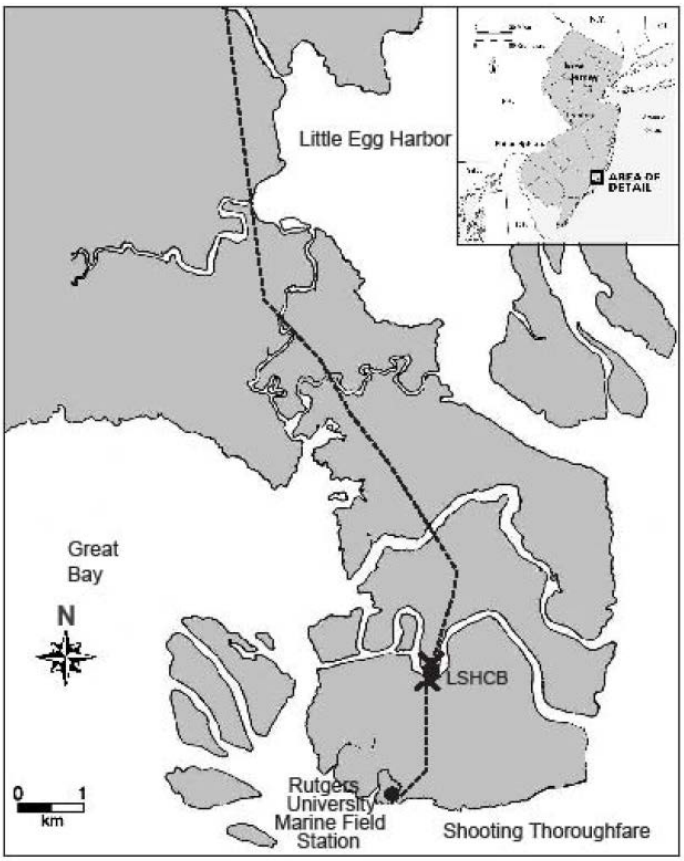
Did not calculate indices since it is almost entirely YOY.

Survey: Rutgers Trawl Survey
Gear: 16 foot trawl, 6 mm codend mesh
Time series: 1988-1990, 1996-present
Frequency: Annually, July and September
Design: 30+ fixed station, 4 replicate 2-minute tows per site per month
Location: primarily Great Bay estuary
Variables: Date, time, number, salinity, temperature, DO
Metadata: New stations added when restarted in 1996



Have not calculated indices yet. Waiting for data request to be fulfilled. Don't expect there to be too many adults.

Survey: Rutgers Ichthyoplankton Survey
Gear: 1-m diameter plankton net, 1mm mesh
Time series: 1989-present
Frequency: Weekly, year round on night time flood tide
Design: 1 fixed station, 3 replicates per night at mid water beginning 1 hour after predicted low tide
Location: Little Sheepshead Creek (Great Bay / Little Egg Harbor, NJ)
Variables: Date, time, flow meter count, number, salinity, temperature, DO
Metadata: A few modifications to survey design in early years, but consistent since 4/2002. Originally, surface and bottom nets deployed simultaneously for 5 replicates per night, and net right as tide turned. Processing of samples is backlogged a few years, so don't have most recent years of data.



No indices calculated yet. Definitely not an adult index, so didn't need it for this meeting. Still waiting for data request to be fulfilled, and will develop YOY index.

MARYLAND JUVENILE STRIPED BASS SURVEY

prepared by Eric Q. Durell

INTRODUCTION

The primary objective of this survey is to document annual year-class success for young-of-the-year (YOY) striped bass (Morone saxatilis) in Chesapeake Bay. Annual indices of relative abundance provide an early indicator of future adult stock recruitment (Schaefer 1972; Goodyear 1985) and document annual variation and long-term trends in abundance and distribution. The juvenile striped bass survey also documents relative abundance of many other fish species in Chesapeake Bay. Over 100 fish species have been collected since 1954.

METHODS

Sample Area and Intensity

Juvenile indices are derived annually from sampling at 22 fixed stations within Maryland's portion of the Chesapeake Bay (Figure 1). They are divided among four of the major spawning and nursery areas: seven each in the Potomac River and Head of Bay areas and four each in the Nanticoke and Choptank rivers. Stations have been sampled continuously since 1954, with changes in some station locations.

Sampling is monthly, with rounds (sampling excursions) occurring during July (Round I), August (Round II), and September (Round III). Replicate seine hauls, a minimum of thirty minutes apart, are taken at each site on each sample round. This produces a total of 132 samples from which Bay-wide means are calculated.

From 1954 to 1961, juvenile surveys included various stations and rounds. Sample sizes ranged from 34 to 46. Indices derived for this period include only stations which are consistent with subsequent years. In 1962, stations were standardized and a second sample round was added for a total of 88 samples. A third sample round, added in 1966, increased sample size to 132.

Auxiliary stations have been sampled on an inconsistent basis and are not included in survey indices. These data enhance geographical coverage in rivers with permanent stations or provide information from other river systems. They are also useful for replacement of permanent stations when necessary. Replicate hauls at auxiliary stations were discontinued in 1992 to conserve time and allow increased geographical coverage of spawning areas. Auxiliary stations were sampled at the Head of Bay (Susquehanna Flats and one downstream station) and the Patuxent River (Table 1, Figure 1).

Sample Protocol

A 30.5-m x 1.24-m bagless beach seine of untreated 6.4-mm bar mesh was set by hand. One end was held on shore while the other was fully stretched perpendicular from the beach and swept with the current. Ideally, the area swept was equivalent to a 729 m^2 quadrant. When depths of 1.6-m or greater were encountered, the offshore end was deployed along this depth contour. An estimate of distance from the beach to this depth was recorded.

Striped bass and selected other species were separated into 0 and 1+ age groupings. Ages were assigned from length-frequencies and verified through scale examination. Age 0 fish were measured from a random sample of up to 30 individuals per site and round. All other finfish were identified to species and counted.

Additional data were collected at each site and sample round. These included: time of first haul, maximum distance from shore, weather, maximum depth, surface water temperature (^{o}C), tide stage, surface salinity (ppt), primary and secondary bottom substrates, and submerged aquatic vegetation within the sample area (ranked by quartiles). Dissolved oxygen (DO), pH, and turbidity (secchi disk) were added in 1997. All data were entered and archived in Statistical Analysis System (SAS) databases (SAS 1990).

Estimators

The most widely used striped bass 'juvenile index' is the arithmetic mean (AM). The AM has been used to predict harvest in New York waters (Schaefer 1972). Goodyear (1985) validated this index as a predictor of harvest in the Chesapeake Bay. The AM is an unbiased estimator of the mean regardless of the underlying frequency distribution (McConnaughey and Conquest 1992). The AM, however, is sensitive to high sample values (Sokol and Rolhf 1981). Additionally, detection of significant differences between annual arithmetic means is often not possible due to high variances (Heimbuch et al. 1983; Wilson and Wiesburg 1991). The geometric mean (GM) has been adopted by the Atlantic States Marine Fisheries Commission (ASMFC) Striped Bass Technical Committee as the preferred index of relative abundance to model stock status. The GM is calculated from the $\log_e(x+1)$ transformation, where x is an individual seine haul catch. One is added to all catches in order to transform zero catches, because the log of 0 does not exist (Ricker 1975). Since the $\log_e$-transformation stabilizes the variance of catches (Richards 1992) the GM estimate is more precise than the AM and is not as sensitive to a single large sample value. It is almost always lower than the AM (Ricker 1975). The GM is presented with 95% confidence intervals (CIs). These are calculated as antilog ($\log_e(x+1)$ mean ± 2 standard errors), and provide a visual depiction of sample variability.

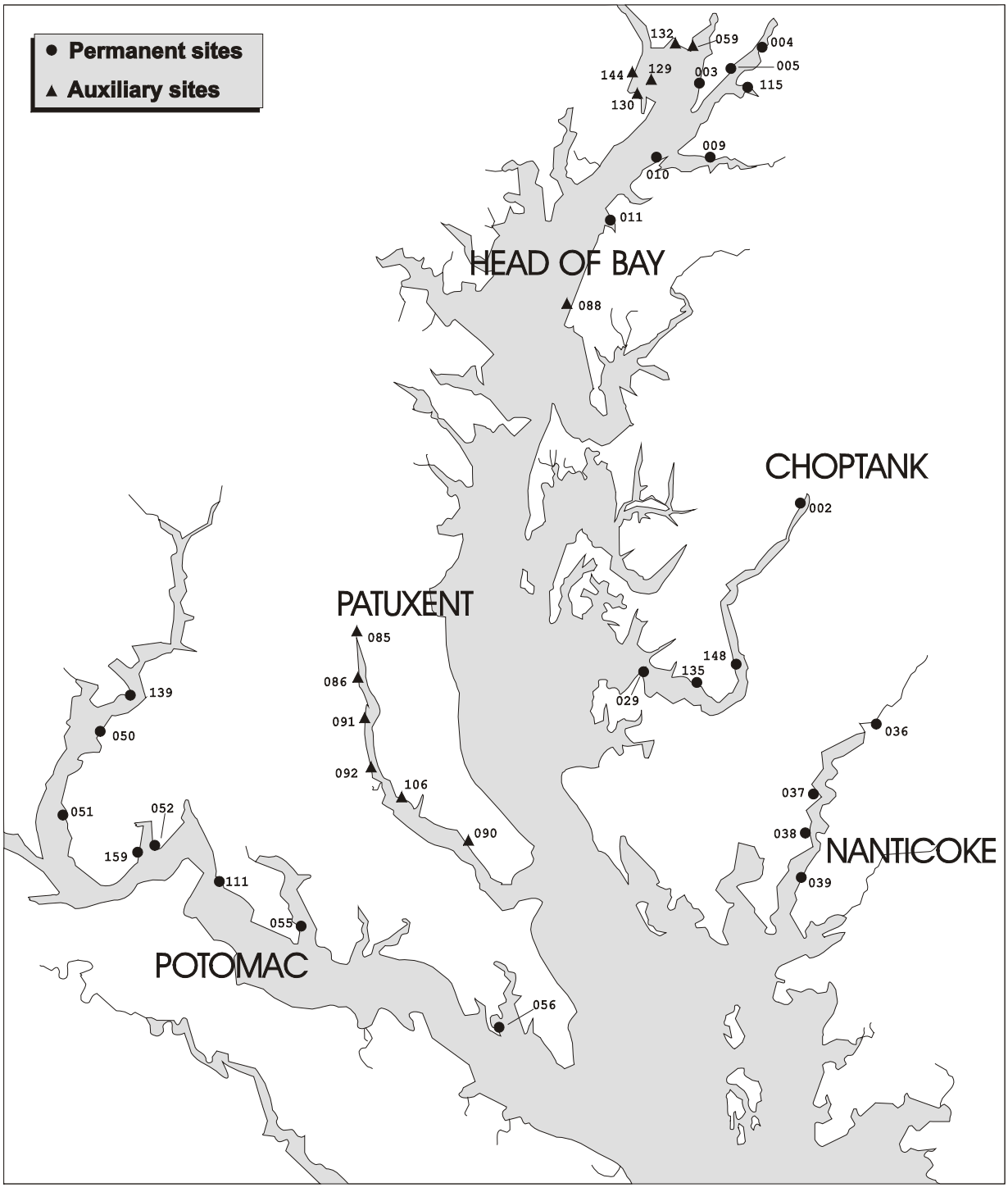
A third estimator, the proportion of positive hauls (PPHL), is the ratio of hauls containing juvenile striped bass to total hauls. Because the PPHL is based on the binomial distribution, it is very robust to bias and sampling error and greatly reduces variances (Green 1979). Its use as supplementary information is appropriate since seine estimates are often neither normally nor log-normally distributed (Richards 1992).

Comparison of these three indices is one method of assessing their accuracy. Similar trends among indices create more certainty that indices reflect actual changes in population abundance. Greatly diverging trends may identify error in one or more of the indices. Differences among annual means were tested with analysis of variance (GLM; SAS 1990) on the $\log_e(x+1)$ transformed data. Terms were considered significant at the $p=0.05$ level.

Atlantic menhaden data

Geometric means for the Head of the Bay, Choptank River, Nanticoke River, Potomac River, Patuxent River and Bay-wide are presented on Figures 2-7.

Figure 1. Maryland Chesapeake Bay juvenile striped bass survey site locations.



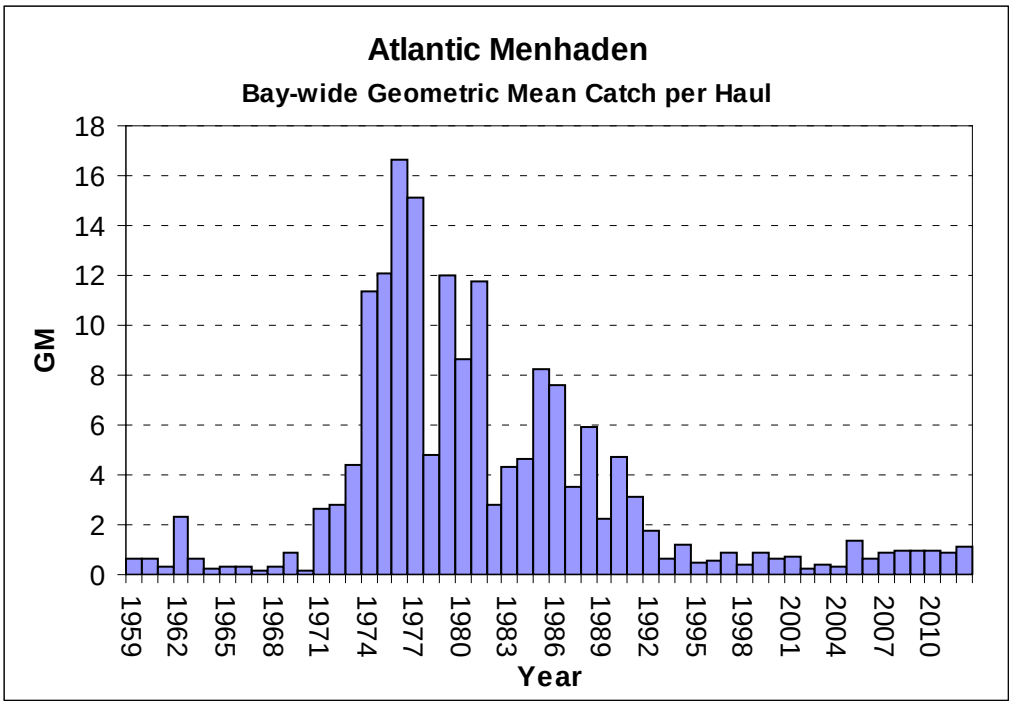


Figure 2. Atlantic menhaden index of relative abundance (geometric mean) for all sampled areas of MD portion of Chesapeake Bay.

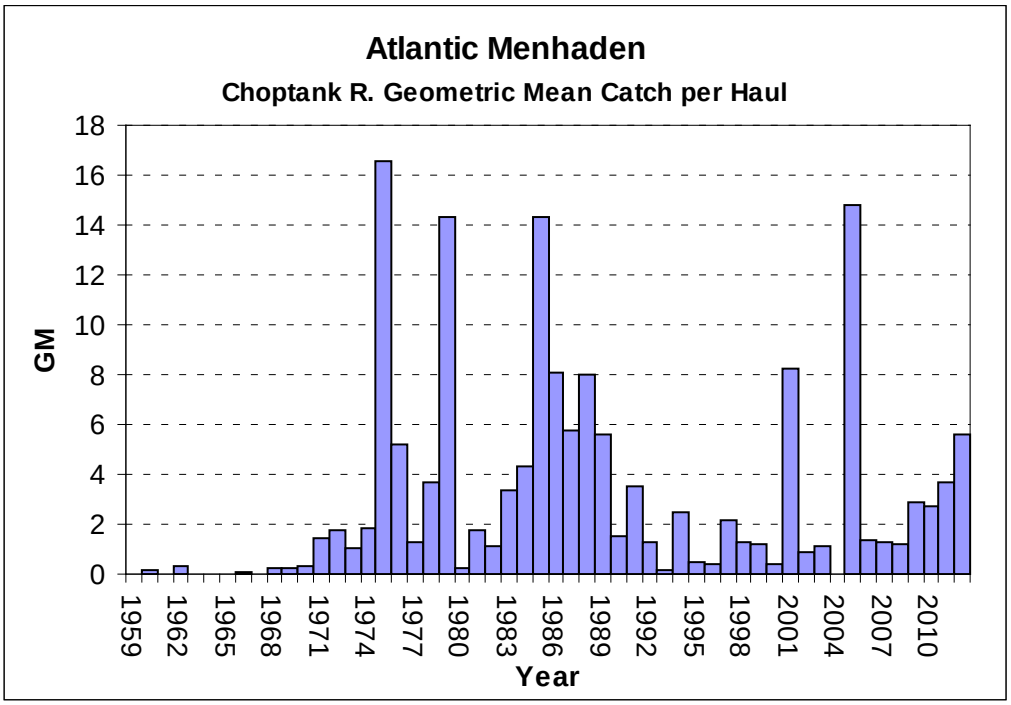


Figure 3. Atlantic menhaden index of relative abundance (geometric mean) for Choptank River.

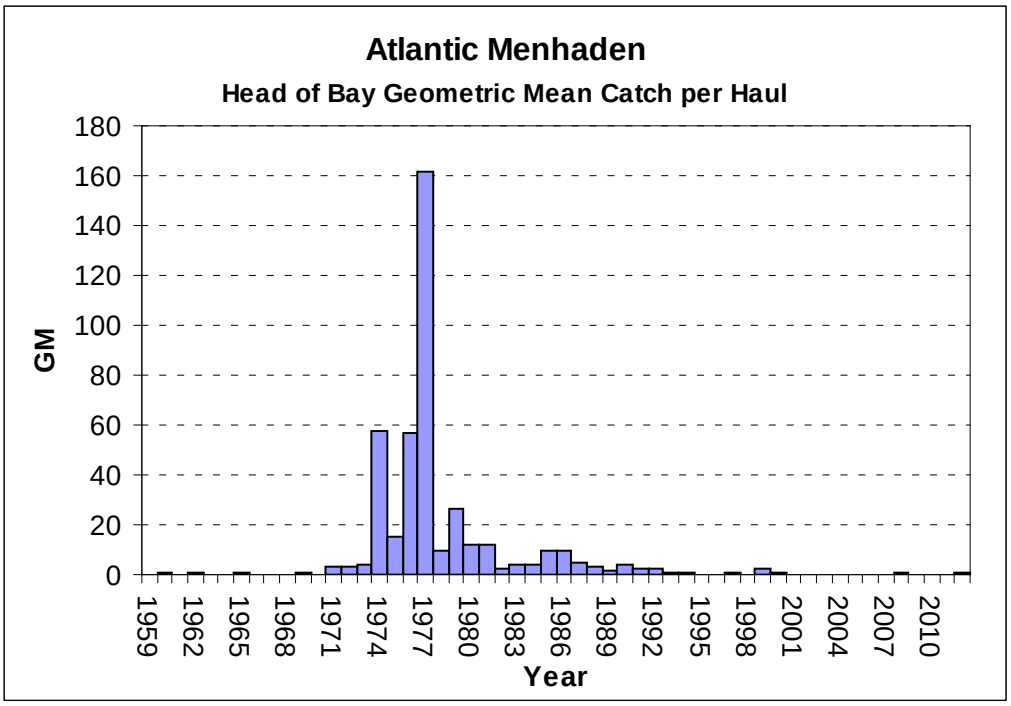


Figure 4. Atlantic menhaden index of relative abundance (geometric mean) for Head of the Bay.

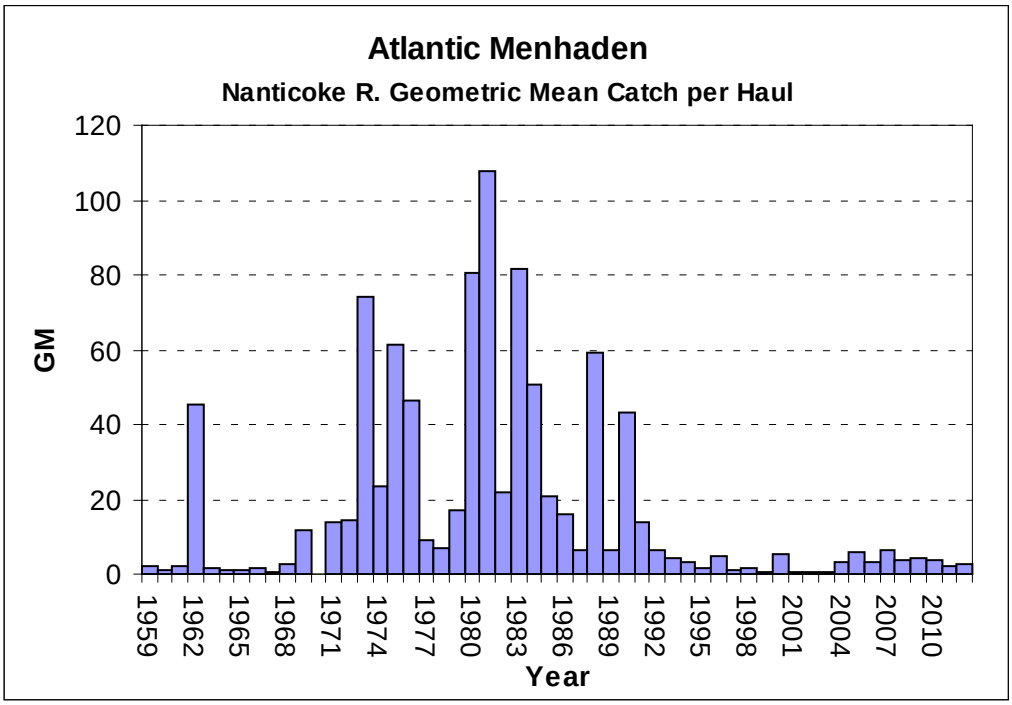


Figure 5. Atlantic menhaden index of relative abundance (geometric mean) for Nanticoke River.

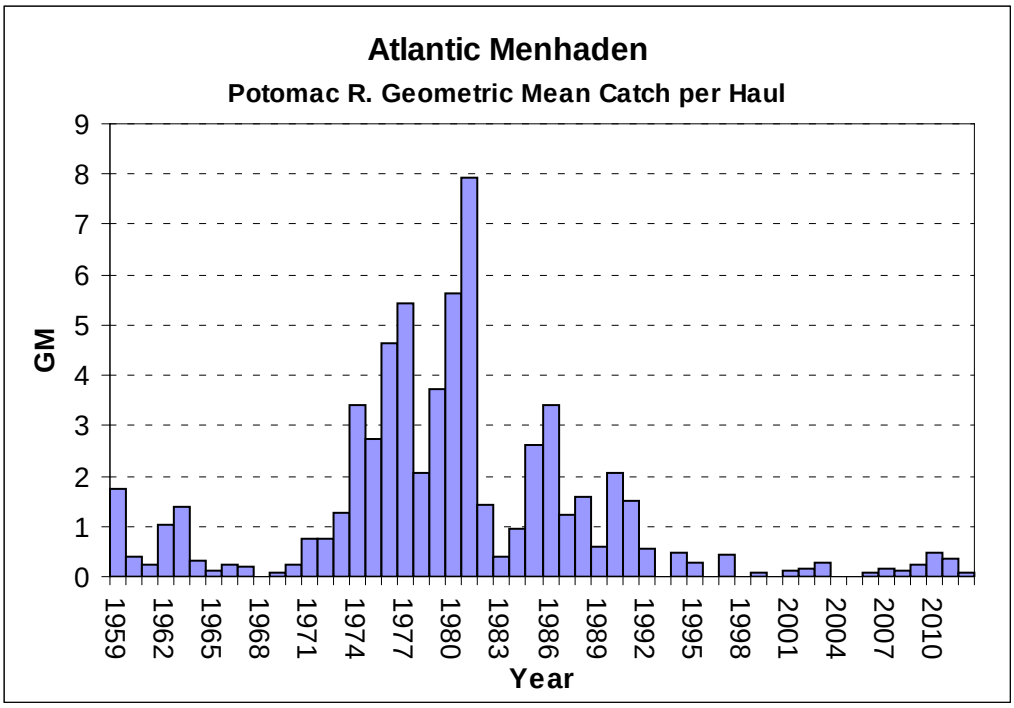


Figure 6. Atlantic menhaden index of relative abundance (geometric mean) Potomac River.

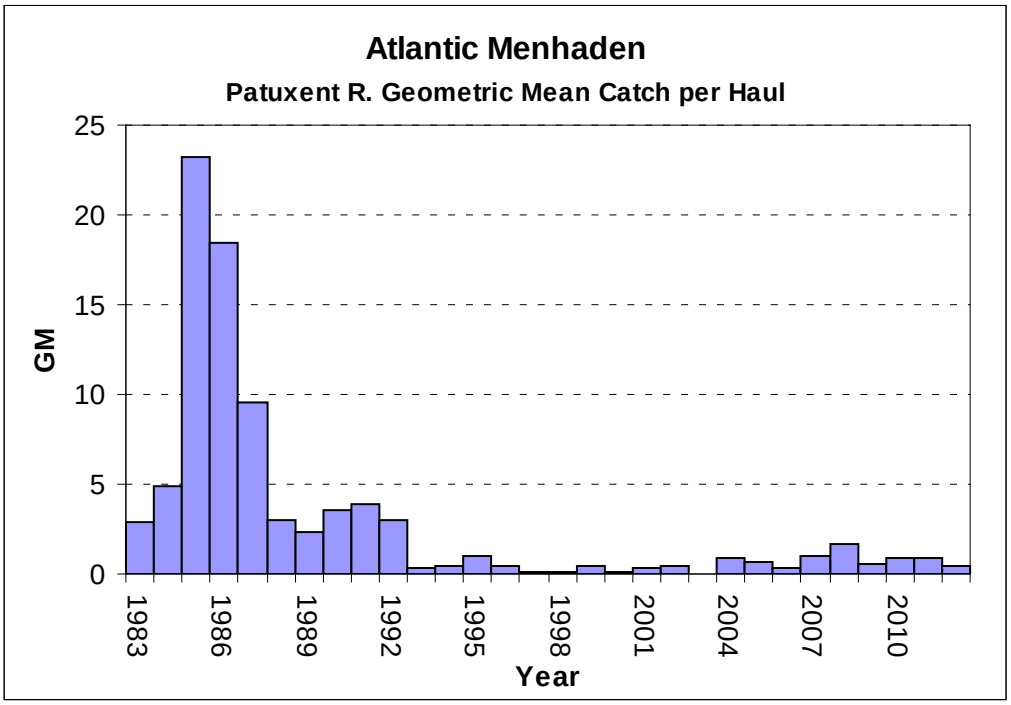


Figure 7. Atlantic menhaden index of relative abundance (geometric mean) Patuxent River.

MARYLAND JUVENILE STRIPED BASS SURVEY
DATA DOCUMENTATION

The Juvenile Striped Bass Survey data set, SEINSTD.SD2, is saved as a SAS data file.

Sample Protocol

A 30.5-m x 1.24-m bagless beach seine of untreated 6.4-mm bar mesh was set by hand. One end was held on shore. The other was fully stretched perpendicular from the beach and swept with the current. When depths of 1.6-m or greater were encountered, the offshore end was deployed along this depth contour. An estimate of distance from the beach to this depth was recorded. Replicate seine hauls, a minimum of thirty minutes apart, are taken at each site on each sample round. Sampling is monthly, with rounds (sampling excursions) occurring during July (Round I), August (Round II), and September (Round III).

Striped bass and selected other species were separated into 0 and 1+ age groupings. Ages were assigned from length-frequencies and verified through scale examination. Age 0 fish were measured from a random sample of up to 30 individuals per site and round. All other finfish were identified to species and counted.

Additional data were collected at each site and sample round. These included: time of first haul, maximum distance from shore, weather, maximum depth, surface water temperature (^{o}C), tide stage, surface salinity (ppt), primary and secondary bottom substrates, and submerged aquatic vegetation within the sample area (ranked by quartiles). DO, pH, conductivity, and turbidity (secchi disk) were added in 1997.

The following is a list of variable names and attributes found in the data set:

VARIABLE #	VARIABLE	COMMENTS, UNITS
41	AGE	Applied to selected species only, years
17	BOTTYPE1	Primary bottom type
18	BOTTYPE2	Secondary bottom type
34	CONDUCT	Conductivity, µS/cm
20	COUNTY	
28	DAY	
24	DEPMAX	Maximum depth net was deployed, feet
10	DISOFFS	Perpendicular distance from shore, meters
37	DO	Dissolved oxygen, mg/L
39	GEAR	BCHS=beach seine
31	GEARLEN	Length of gear, meters
35	HATCH	designates origin of hatchery raised fish
11	HAULNO	First or second seine haul at site

VARIABLE #	VARIABLE	COMMENTS, UNITS
38	JISECCI	secchi disk reading, meters (9.99 when secchi>site)
30	JULDATE	Julian date
32	LATSTRT	latitude; degrees, minutes, decimal seconds
33	LONGSTRT	longitude; degrees, minutes, decimal seconds
23	MESH	stretch mesh size of net, inches
27	MONTH	
21	NOAA	Area code designated by NOAA
36	PH	
1	RIVER	
22	RIVMILE	Distance from mouth of river to site, miles
26	ROUND	Sample round, see protocol
7	SAL	Salinity, ppt
9	SAVPCT	Estimated SAV coverage, by quartiles
2	SITENAME	
29	SITENO	Site number
15	SITETYPE	Indicates permanent or auxiliary site
14	SIZEMAX	Total length of longest specimen of a species, mm
13	SIZEMIN	Total length of smallest specimen of a species, mm
12	SPECCNT	Total number of a species collected
25	SPECNAME	Species name
19	STRMCODE	Code for body of water where site is located
16	SYSTEM	Indicates river or other geographical grouping of sites
40	TEMPWATR	Subsurface water temperature, degrees C
6	TIDE	Tide stage
3	TIMESTRT	Time of first seine haul, military
8	VISIB	Very old, seldom used variable, units unclear
4	WEATHER	
5	WINDSPD	Wind speed, no longer used
42	YEAR	Changed to 4-digit in 2000

Maryland Coastal Bays Trawl and Seine Survey
Results in application to Atlantic menhaden[1]

This survey was developed to characterize fishes and their abundances in Maryland's Coastal Bays, facilitate management decisions, and protect finfish habitats. The Maryland Department of Natural Resources (MDNR) Fisheries Service has conducted the Coastal Bays Fisheries Investigations (CBFI) Trawl and Beach Seine Survey in Maryland's Coastal Bays since 1972, sampling with a standardized protocol since 1989. These gears target finfish although bycatch of crustaceans, molluscs, sponges, and macroalgae are common. Over 130 adult and juvenile species of fishes, 26 molluscs, 20 macroalgae species, and 29 species of arthropods have been collected since 1972. This survey was designed to meet the following three objectives:

1. characterize the stocks and estimate relative abundance of juvenile and adult marine and estuarine species in the Coastal Bays and near-shore Atlantic Ocean;
2. develop annual indices of age and length, specific relative abundance and other needed information necessary to assist in the management of regional and coastal fish stocks; and
3. delineate and monitor areas of high value as spawning, nursery and/or forage locations for finfish in order to protect against habitat loss or degradation.

Study Area

Maryland's Coastal Bays are comprised of Assawoman Bay, Isle of Wight Bay, Sinepuxent Bay, Newport Bay, and Chincoteague Bay. Also included are several important tidal tributaries: St. Martins River, Turville Creek, Herring Creek, and Trappe Creek. Covering approximately 363 km^2 (140 mi^2), these bays and associated tributaries average only 0.9 m (3 feet) in depth and are influenced by a watershed of only 453 km^2 (175 mi^2; MDNR 2005). The bathymetry of the Coastal Bays is characterized by narrow channels, shallow sand bars, and a few deep holes.

Two inlets provide oceanic influences to these bays. Ocean City Inlet is formed at the boundaries of south Fenwick Island and north Assateague Island and is located at the convergence of Isle of Wight Bay and Sinepuxent Bay. Chincoteague Inlet, in Virginia (VA), is approximately 56 km (34 mi) south of the Ocean City Inlet.

The Coastal Bays are separated from the Atlantic Ocean to the east by Fenwick Island (Ocean City) and Assateague Island. Ocean City, Maryland is a heavily developed commercial area and the center of a $2 billion dollar tourism industry catering to approximately 12 million visitors annually (MCBP 2005). Assateague Island is owned by the State of Maryland and the National Park Service (NPS). These entities operate one state (Assateague State Park) and two national parks (Assateague Island National Seashore and Chincoteague National Wildlife Refuge). These properties have campgrounds, small buildings, dunes, beach front with some Off Road Vehicle (ORV) access, and marshes.

The Coastal Bays western shoreline habitat consists of forest, *Spartina* spp. marshes, small islands, residential development, and marinas. Assawoman Bay is bordered by Maryland and Delaware and is characterized by farmland, *Spartina* spp. marshes, a few small islands, and commercial/residential development. Isle of Wight Bay south into Sinepuxent Bay is a heavily

[1] This document is based on "Investigation of Maryland's Coastal Bays and Atlantic Ocean Finfish Stocks. 2012 Final report. Prepared by S. Doctor, C. Jones, C. Kennedy, G. Tyler and A.Wiley. Federal Aid Project N F-50-R-21"

developed commercial/residential area. Two seafood dealers, a public boat launch, and approximately 20 to 50 transient and permanent commercial fishing vessels utilize the commercial harbor located directly west of the Ocean City Inlet. In addition to the commercial harbor, the majority of marinas in Ocean City are located in Isle of Wight Bay. Residential development expansion has begun moving south into Chincoteague Bay. Vast *Spartina* spp. marshes and numerous small islands characterize Chincoteague Bay.

Submerged Aquatic Vegetation (SAV) and macroalgae (seaweeds) are common plants in these bays that provide habitat and foraging sites for fishes and shellfish (Beck *et al.* 2003). Two species of SAV are common in Maryland's Coastal Bays: widgeon grass, *Ruppia maritima*, and eelgrass, *Zostera marina* (MDNR 2005). Common genera of macroalgae include *Chaetomorpha*, *Agardhiella*, *Gracilaria*, and *Ulva*.

Data Collection

A 25 foot C-hawk with a 225 horsepower Evinrude E-tec engine is used for transportation to the sample sites and gear deployment. Latitude and longitude coordinates (waypoints) in decimal degrees, minutes, and fraction of minutes (ddmm.mmm) are used to navigate to sample locations. A GPS is used for navigation, marking sites, and monitoring speed.

Gears

Trawl

Trawl sampling is conducted at 20 fixed sites throughout Maryland's Coastal Bays on a monthly basis from April through October (Figure 1). Samples are usually taken beginning the third week of the month. The boat operator takes into account wind and tide (speed and direction) when determining trawl direction. A standard 4.9 m (16 ft) semi-balloon trawl net is used in areas with a depth of greater than 1.1 m (3.5 ft). Each trawl has a standard 6-minute (0.1 hr) tow at a speed of approximately 2.8 knots. Speed is monitored during tows using the GPS. Waypoints marking the sample start (gear fully deployed) and stop (point of gear retrieval) locations are taken using the GPS to determine the area swept (hectares). Time is tracked using a stopwatch which was started at full gear deployment.

Seine

Seines are used to sample the shallow regions of the Coastal Bays frequented by juvenile fishes. Shore beach seine sampling is conducted at 19 fixed sites beginning in the second weeks of June and September (Figure 1).

A 30.5 m X 1.8 m X 6.4 mm mesh (100 ft X 6 ft X 0.25 in. mesh) bag seine is used at 18 fixed sites in depths less than 1.1 m (3.5 ft.) along the shoreline. However, some sites necessitated varying this routine to fit the available area and depth. GPS coordinates are taken at the start and stop points as well as an estimated percent of net open.

Sample Processing

Fishes and invertebrates are identified, counted, and measured for Total Length (TL) using a wooden millimeter (mm) measuring board with a 90 degree right angle. A meter stick is used for species over 500 mm. At each site, a sub-sample of the first 20 fish (when applicable) of each species sre measured and the remainder counted. On occasion, invertebrate species counts are estimated.

Jellyfishes, ctenophores, bryozoans, sponges, SAV and macroalgae are measured volumetrically (liters, L) using calibrated containers with small holes in the bottom to drain the excess water.

Small quantities (generally ≤ 10 specimens) of invertebrates are occasionally counted. Slightly larger quantities of invertebrates are sometimes visually estimated. Bryozoans and macroalgae are combined for one volume measurement and a biologist estimate the percentage of each species in the sample.

Unknown species are placed in Ziploc bags on ice or kept in a bucket of water and taken to the office for identification. Rare, uncommon, and unrepresented species are fixed and preserved for the voucher collection that was started in 2006.

Data Analysis

Statistical analyses are conducted on species that historically are most abundant in the trawl and beach seine catch data. Additional species are added to the analyses dependant on their recreational importance and biological significance as forage for adult game fish and indicators of water quality. Species rarely encountered and not considered recreationally important, including forage significance, are not included in the analyses.

The Geometric Mean (GM) is calculated to develop species specific annual trawl and beach seine indices of relative abundance (1989-2012). This method was adopted by the Atlantic States Marine Fisheries Commission (ASMFC) Striped Bass Technical Committee as the preferred index of relative abundance to model stock status. The mean is calculated using catch per area covered for trawl and catch per haul for seine. The GM is calculated from the $\log_e(x+1)$ transformation of the catch data and presented with 95% Confidence Intervals (CIs; Ricker 1975). The GM and CIs are calculated as the antilog [$\log_e$-mean$(x+1)$] and antilog [$\log_e$-mean$(x+1) \pm$ standard error * (t value: α=0.05, n-1)], respectively. A geometric grand mean was calculated for the time series (1989-2012) and used as a point estimate for comparison to the annual (2012) estimate of relative abundance.

To investigate species-specific habitat preference for finfish, an analysis of variance was performed on the catch data to determine if sites differed in mean abundance (CPUE) for each species by site for 2012. A subsequent multiple pairwise comparison of means test (Duncan's Multiple Range Test) was performed to determine differences among sites in 2012. The site or group of sites most abundant were classified as primary sites. Secondary sites were second most abundant.

2012 Survey Results: Atlantic Menhaden (*Brevoortia tyrannus*)

Atlantic Menhaden were captured in 7 of 140 trawls (5.0%) and in 14 of 38 beach seines (36.8%) in 2012. A total of 2,186 Atlantic Menhaden were collected in trawl (124 fish) and beach seine (2,062 fish) samples conducted on Maryland's Coastal Bays in 2012. Atlantic Menhaden ranked third out of 71 species in overall finfish abundance. The trawl and beach seine CPUEs were 7.1 fish/hectare and 54.3 fish/haul, respectively.

GM indices of relative abundance were calculated and compared with the 1989-2012 time series grand mean (Figures 2 and 3). The point estimate of the time series grand mean was used as an indicator of central tendency of abundance, against which the 95% CI of the GM indices of relative abundance were compared. The 2012 trawl index was below the standardized grand mean and the seine index was equal to the standardized grand mean (Figures 2 and 3). Since 1989, the trawl index occasionally (ten years) varied from the grand mean and beach seine index has varied nine times from the grand mean.

Duncan's Multiple Range Test indicated that trawl sites T005 and T006 had the highest level of abundance (CPUE) and were classified as a primary sites (Figure 1). There were no secondary trawl sites for Atlantic Menhaden. Beach seine site S010 was determined to be a primary location and seine sites S001, S002, S003, S005, S006, S007, S008, S012, S013, S018, and S019 were classified as secondary sites (Figure 7, Table 10).

The abundance index for trawl was below the grand mean and the index for seines was equal to the grand mean. Atlantic Menhaden were caught more often in near shore locations (beach seine). Therefore, beach seine indices represent a more accurate picture of changes in relative abundance when compared to trawl indices. Significant changes in relative abundance may reflect a combination of environmental conditions (nutrient levels, water temperature, salinity, and dissolved oxygen) and/or overfishing.

The primary trawl sites were in protected areas at the head of Turville Creek (T006) and the St. Martins River (T005). Turville Creek is known to have high nutrient levels and may attract the prey sources of Atlantic Menhaden (Maryland Department of the Environment, 2001). Trawl primary sites are up at the head of creeks and are likely to have high chlorophyll concentrations, a desirable characteristic for a filter feeder (Wazniak *et al.* 2004). The beach seine primary site (S010) for Atlantic Menhaden was located in Grey's creek off Sinepuxent Bay, a muddy protected bay. Primary and secondary seine sites displayed a geographically wide dispersion indicating preference for shallow water habitat with low flow characteristics.

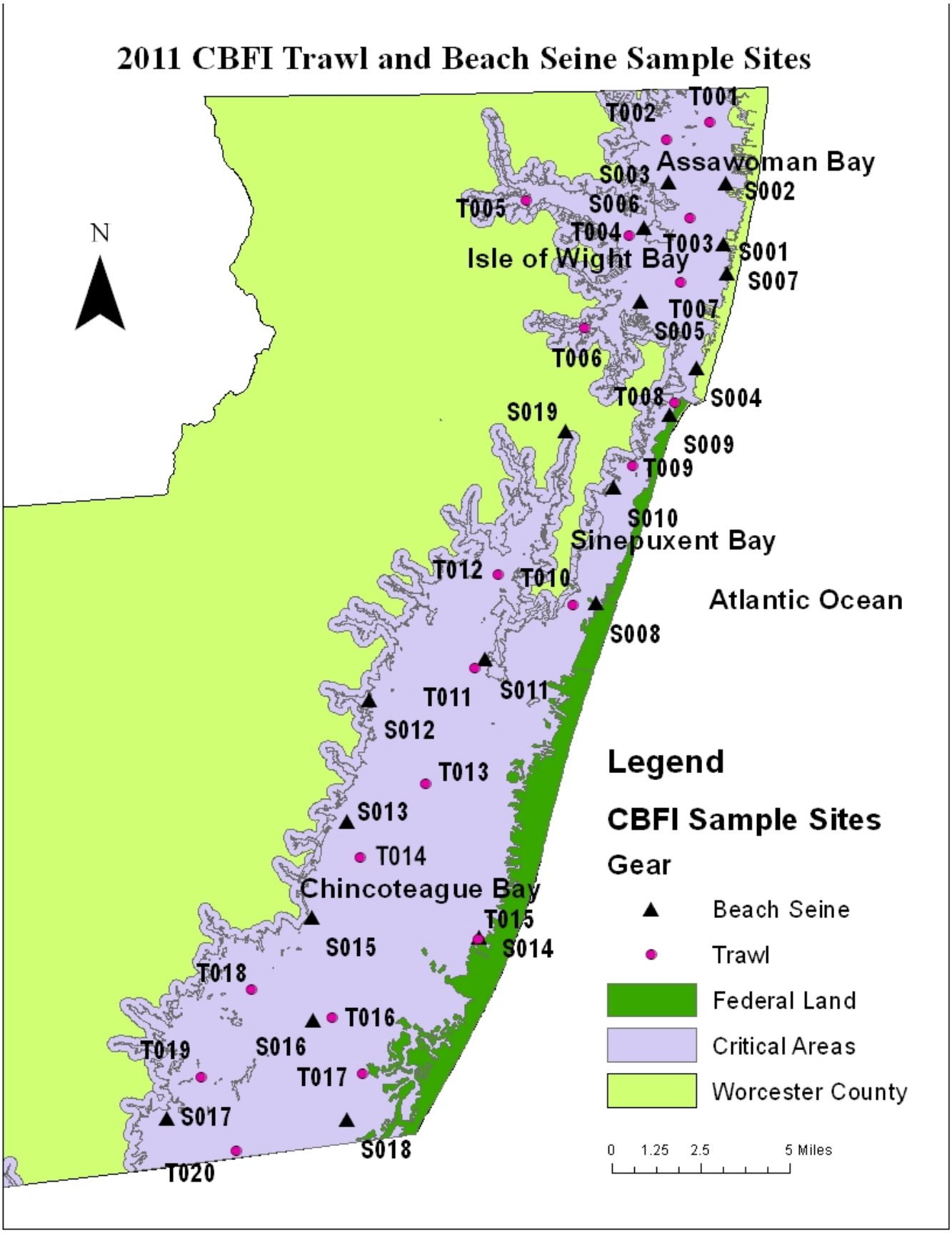


Figure 1. Site locations for the Coastal Bays Fishery Investigations Trawl and Beach Seine Survey

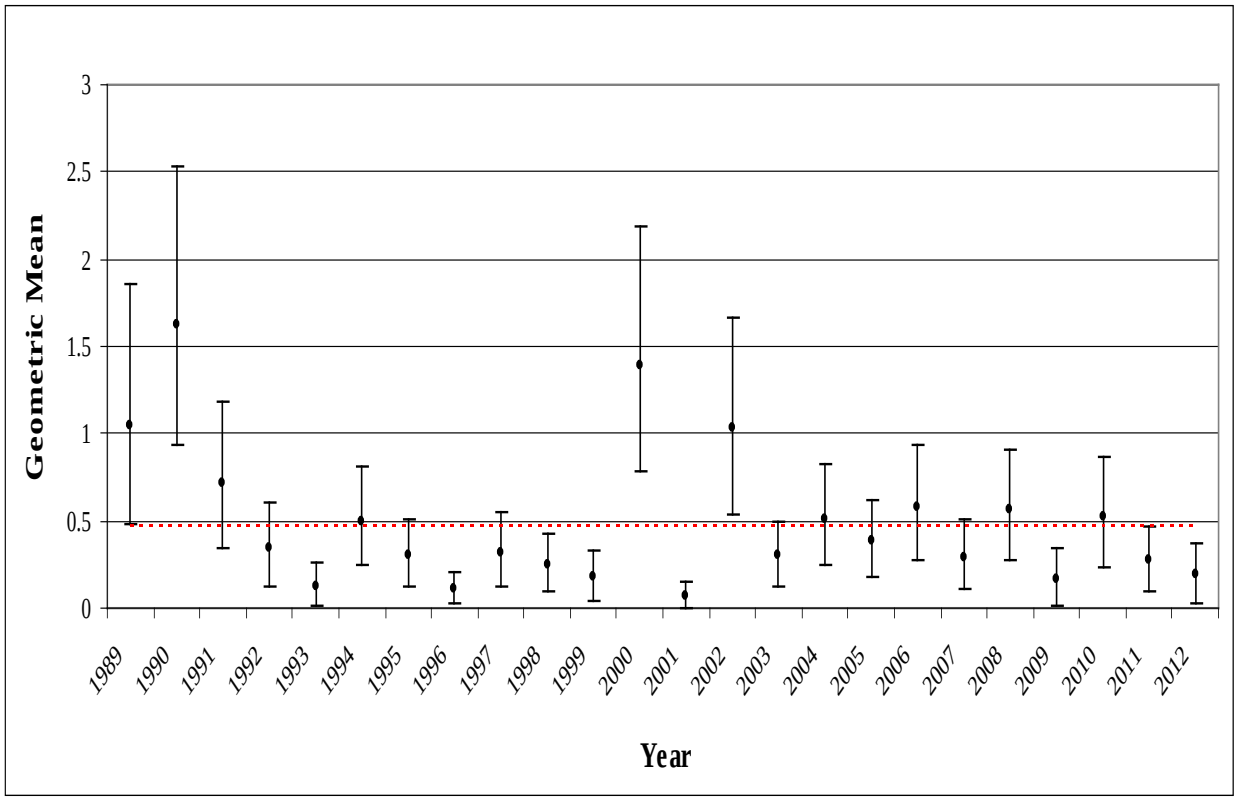


Figure 2. Menhaden trawl index of relative abundance (geometric mean) with 95% confidence intervals. Dotted line represents the 1989 -2012 time series grand mean.

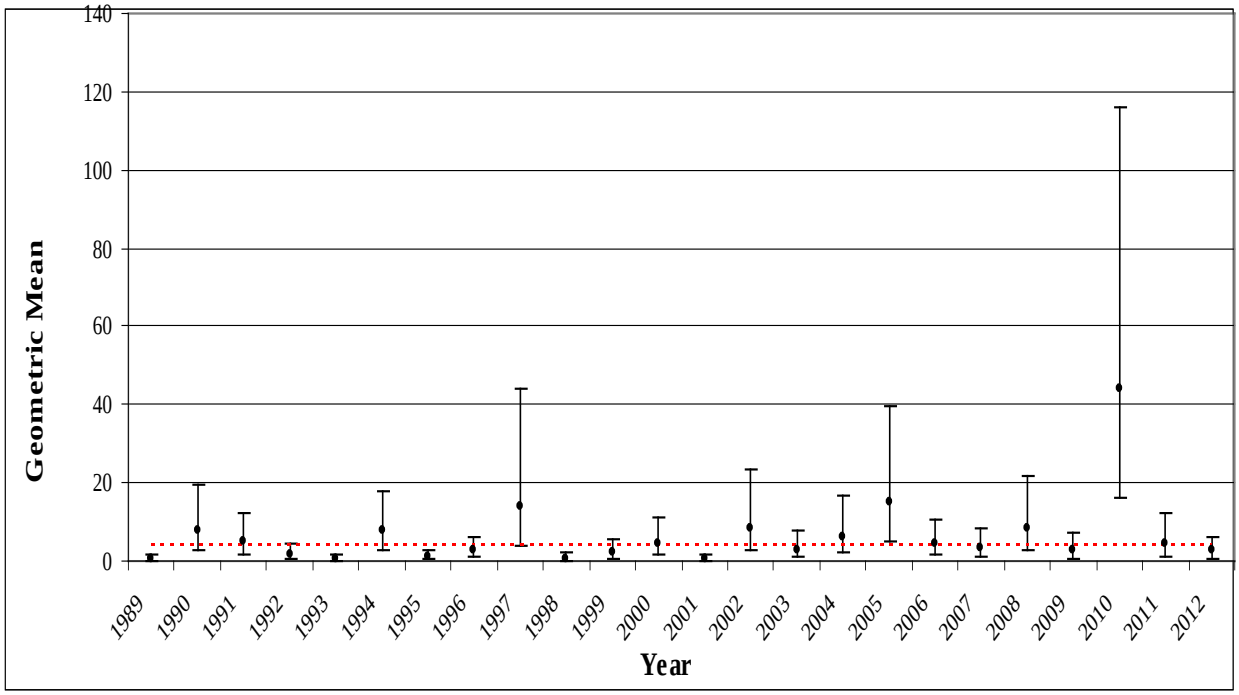


Figure 2. Menhaden seine index of relative abundance (geometric mean) with 95% confidence intervals. Dotted line represents the 1989 -2012 time series grand mean.

Virginia American Shad Monitoring Program

Methods

Since 1998, a staked gillnet American shad monitoring program has been operating in the primary tributaries of lower Chesapeake Bay. In the James, York, and Rappahannock rivers, a single staked gillnet stand is fished on two succeeding days (two approximately 24-h sets) each week between late February and early May. Locations for each staked gillnet were based on those associated with the historic American shad logbook data, and stand locations were selected to approximate the 'average' logbook catch. The exact gear dimensions associated with the logbook data from the James and York Rivers differed slightly from those of the logbook data from the Rappahannock River. Sampling in the James and York rivers is conducted using a 273-m staked gillnet (9.1-m panel length) located at river miles 10 (36° 59.0' N, 76° 28.8' W) and 14 (37° 20.8' N, 76° 37.7' W), respectively (Fig. 1). In the Rappahannock River, a 277-m staked gillnet (14.6-m panel length) is located at river mile 36 (37° 55.9' N, 76° 50.4' W). Nets in the York and James Rivers are constructed of 12.4 cm stretched-mesh monofilament netting while the net used in the Rappahannock River is constructed of 12.7 cm netting.

Adult Atlantic menhaden are routinely captured as bycatch during the monitoring of American shad in all three rivers. Using these bycatch data, an index of relative abundance for Atlantic menhaden was developed using a generalized linear model (GLM). The response variable was total menhaden count and an offset variable defined to be the log of meters of net fished per day was used to account for differential effort across sampling events. Preliminary analyses supported the application of the negative binomial distribution to account for overdispersion. A total of four model parameterizations were examined and AIC statistics strongly favored the full model (Table 1). The index showed a variable pattern across years with relatively low annual estimated coefficients of variation (Fig. 2).

Table 1. Negative binomial GLM parameterizations and associated AIC fit statistics for four models applied to the menhaden bycatch data of the Virginia American shad monitoring program, 1998-2012.

Covariates	**AIC**	**ΔAIC**
Year, Month, River	9989.4	0.0
Year, Month	10001.5	12.1
Year, River	10077.9	88.5
Year	10101.2	111.8

Fig. 1. Locations of staked gill net American shad monitoring sites on the James, York, and Rappahannock rivers, VA, based on historical locations associated with commercial logbook daily catch data.

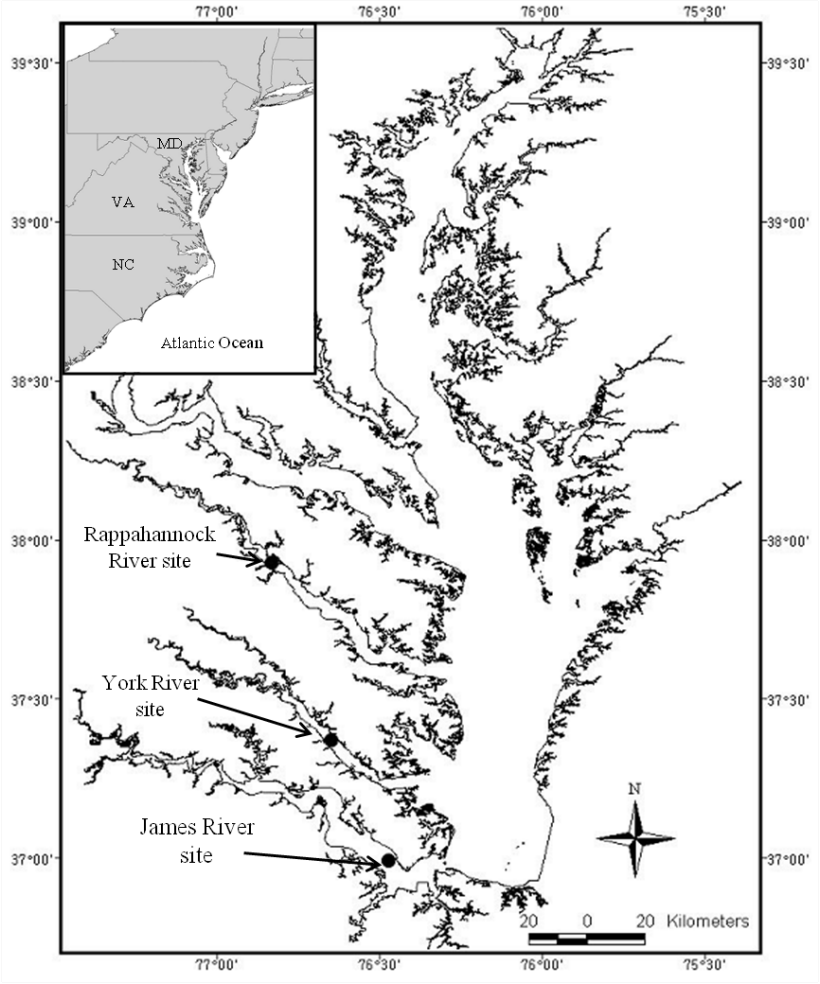
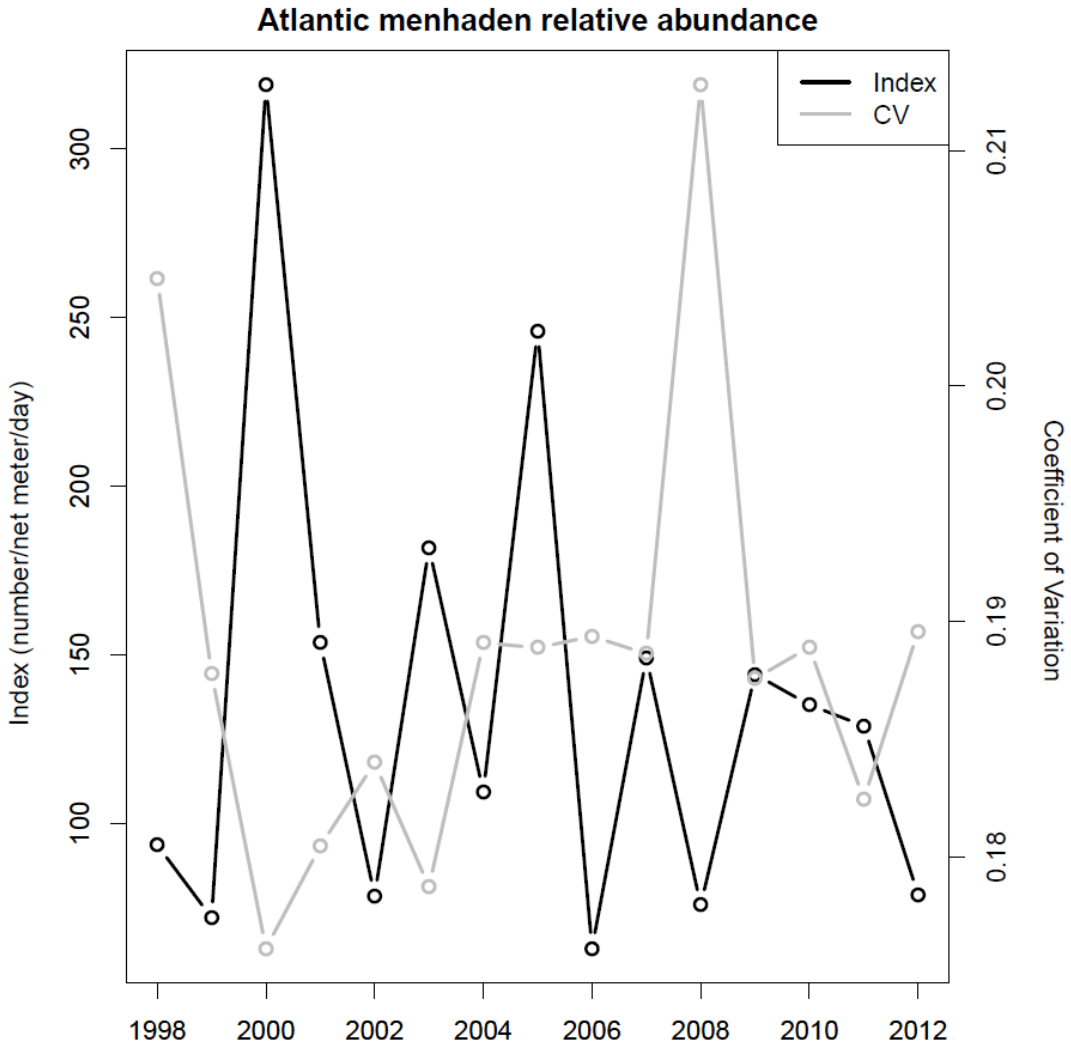


Fig 2. Index of relative abundance and associated estimated coefficients of variation (CV) for Atlantic menhaden captured as bycatch from the Virginia American shad monitoring program, 1998-2012.



Potential Independent Data Sources for Adult Menhaden Abundance
North Carolina

Program 135 – North Carolina Striped Bass Monitoring

Striped Bass Independent Gill Net Survey

The objectives of the striped bass monitoring program is to monitor the status of striped bass in the Albemarle Sound/Roanoke River (A/R) and the Atlantic Migratory stock to assess the effectiveness of management measures and to sustain the depressed populations of striped bass in Central/Southern North Carolina systems by stocking to help the recovery of these stocks. The stratified-random multiple-mesh Independent Gill Net Survey (IGNS) began in October of 1990 to monitor the striped bass resident and overwintering fall/winter population in the Albemarle and Croatan Sounds and the A/R striped bass spring spawning population. The 12 different mesh sizes used allow capture of fish age one and older. Sampling occurs during the fall/winter (November-February) and the spring (March-May) using multiple mesh gill nets. Mesh sizes range 2.5 to 7.0 inch square mesh (ISM) at 0.5 inch intervals, 8.0 and 10 ISM. and consist of four types of gangs- 24 forty yard gill net sections (960 yards fished per sampling day).

1. Large mesh floating (6.5, 5.5, 7.0, 6.0, 8.0, 10.0)
2. Large mesh sinking (6.5, 5.5, 7.0, 6.0, 8.0, 10.0)
3. Small mesh floating (2.5, 3.5, 4.5, 3.0, 4.0, 5.0)
4. Small mesh sinking (2.5, 3.5, 4.5, 3.0, 4.0, 5.0)

There are six sample zones in Albemarle and Croatan sounds divided in one-mile square quadrants with an average of 22 quadrants per zone. (Figures 1-2).

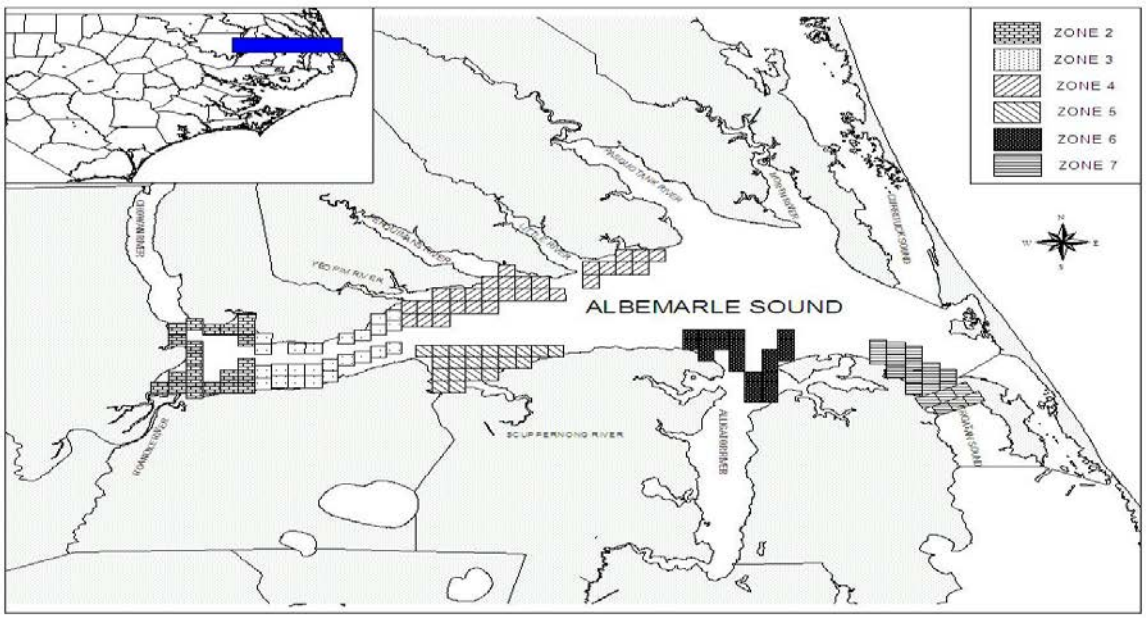


Figure 1. Sample zones for the NCDMF striped bass fall/winter Independent Gill Net Survey, Albemarle and Croatan sounds, NC

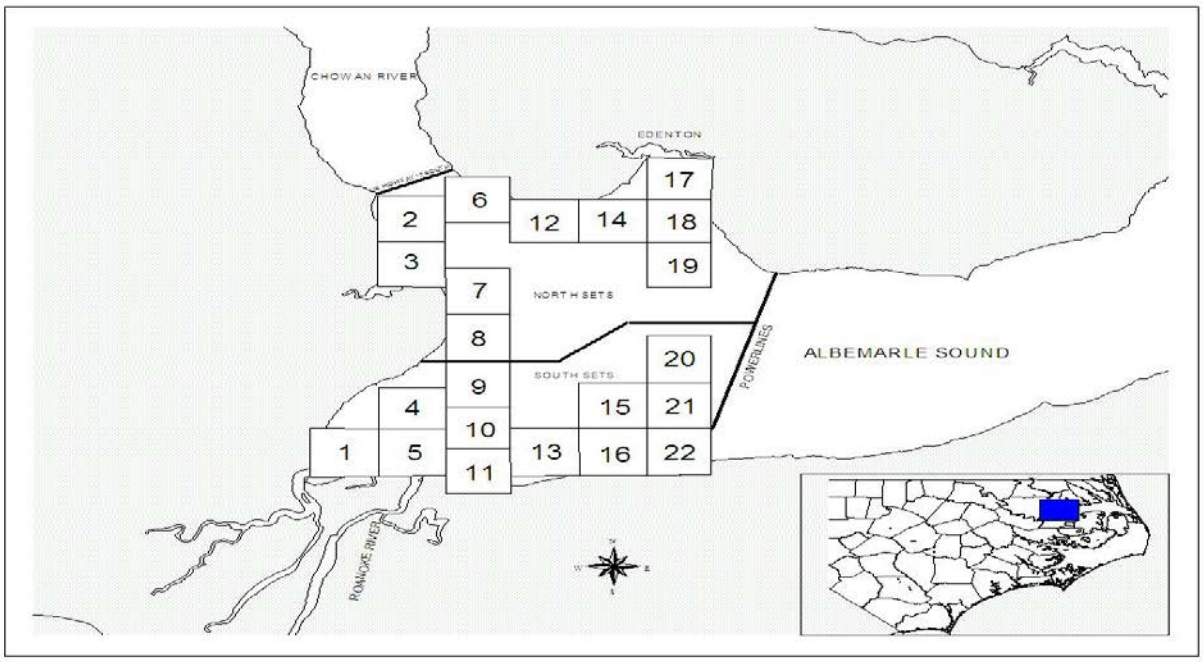


Figure 2 Sample Zone 2 and the north/south quadrants for the NCDMF A/R striped bass spawning stock spring Independent Gill Net Survey, Albemarle Sound, NC.

Each zone is sampled once a month; with a 24 hour soak over 24 fishing days per month and a total of 96 fishing days for the fall/winter season. The spring season concentrates in western Albemarle Sound (zone 2) and is divided into southern and northern areas. Nets are fished daily 7 days a week. Menhaden rank as the number one caught species. Only a range of FL is taken; Min-Max and total number of menhaden are recorded per sample unit. There are 30,592 lengths recorded. 261,934 total recorded number of menhaden (Figure 3). Catch per unit effort for each sampling season are in tables 1 and 2.

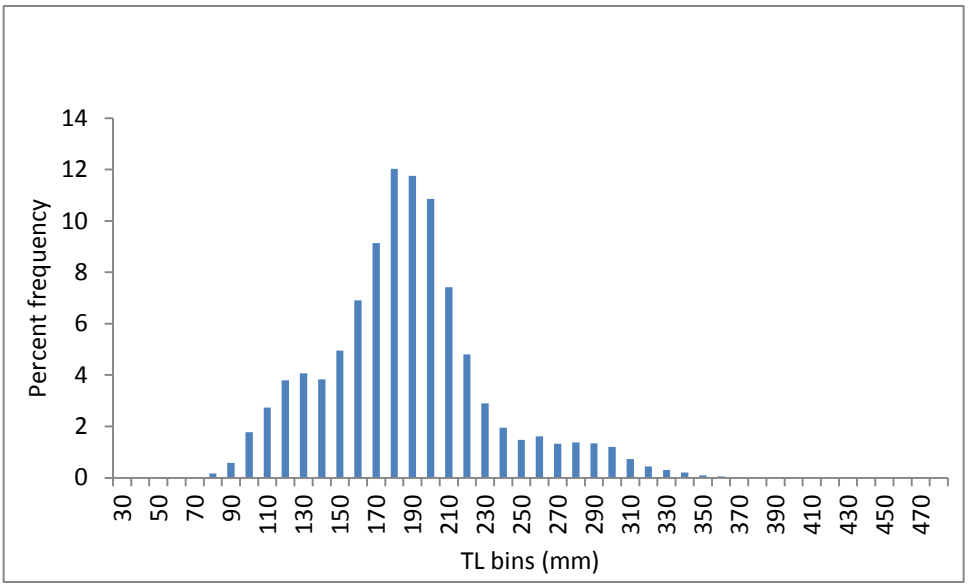


Figure 3 Percent length frequency of menhaden (min-max size) collected from Program 135 n=30,592.

Table 1. CPUE of Menhaden from the spring survey (March-May) in Zone 2

YEAR	EFFORT*	CPUE	SE	CV	N MENHADEN	STDEV
1991	1964	0.503	0.149	1312.36	988	6.602
1992	2330	0.128	0.0214	808.19	298	1.034
1993	2231	0	0	.	0	0
1994	2010	0.001	0.0007	3169.38	2	0.032
1995	1962	0.256	0.0504	873.25	502	2.234
1996	1920	0	0	.	0	0
1997	1968	0.001	0.0005	4436.21	1	0.023
1998	1923	0.001	0.001	4385.2	2	0.046
1999	2044	0.373	0.0847	1026.32	763	3.831
2000	1969	0.005	0.0015	1476.1	9	0.067
2001	1850	0.032	0.0083	1097.01	60	0.356
2002	1872	8.059	0.5363	287.89	15087	23.202
2003	2160	0.01	0.003	1365.74	22	0.139
2004	1835	0.011	0.0046	1740.45	21	0.199
2005	1871	1.43	0.3265	987.93	2675	14.125
2006	1897	5.271	0.42	347.05	9999	18.293
2007	1920	0.221	0.0637	1263.09	424	2.789
2008	1817	20.651	1.2706	262.26	37523	54.16
2009	1534	7.248	0.5918	319.77	11119	23.178
2010	1364	0.07	0.0198	1040.7	96	0.732
2011	1456	7.166	0.4972	264.73	10434	18.971
2012	1008	5.741	0.7157	395.81	5787	22.724

*Effort=one 40 yard net, fished 24 hours

Table 2. CPUE of Menhaden from the fall/winter survey (December-February) in Zones 2-7

SEASON	EFFORT*	CPUE	SE	CV	N MENHADEN	STDEV
1990-1991	1469	4.038	0.5622	533.57	5932	21.546
1991-1992	2483	1.668	0.1337	399.42	4142	6.663
1992-1993	2285	1.323	0.1906	688.55	3024	9.112
1993-1994	2299	1.241	0.0941	363.68	2853	4.513
1994-1995	2297	6.56	0.4093	299.05	15069	19.618
1995-1996	2301	1.111	0.1372	592.42	2556	6.581
1996-1997	2310	0.095	0.0282	1425.29	220	1.357
1997-1998	2251	0.98	0.0936	453.23	2205	4.44
1998-1999	2297	1.004	0.0971	463.58	2306	4.654
1999-2000	2325	0.652	0.1111	821.39	1517	5.359
2000-2001	2281	1.422	0.2389	802.23	3244	11.409
2001-2002	2280	2.998	0.2472	393.76	6835	11.804
2002-2003	2280	5.764	0.4847	401.53	13142	23.144
2003-2004	2112	0.868	0.1813	959.55	1834	8.332
2004-2005	2325	1.066	0.0969	438.04	2479	4.671
2005-2006	2164	5.755	0.4039	326.48	12453	18.788
2006-2007	2199	6.928	0.4465	302.21	15234	20.936
2007-2008	2229	15.249	0.9076	281	33990	42.849
2008-2009	2273	4.168	0.2965	339.12	9475	14.136
2009-2010	2288	2.9	0.1726	284.59	6636	8.254
2010-2011	2274	1.145	0.1126	469.22	2603	5.371
2011-2012	2269	8.097	0.4503	264.92	18373	21.452

*Effort=one 40 yard net, fished 24 hours

Program 915 –Fisheries Independent Assessment (FIA)

Pamlico Sound Independent Gill Net Survey

This project began in March 2001 and provides fishery independent indices of relative abundance by size class, which when applied to the appropriate age-length keys can produce annual catch-at-age (CAA) estimates. These estimates will provide essential data for input into future stock assessments. Fishery independent abundance indices are needed to calibrate or tune parameter estimates and reduce uncertainty in age-based assessment techniques that rely heavily on fishery dependent data (Hilborn and Walters 1992, NRC 1998, Quinn and Deriso 1999). A long-term fishery independent database will allow the North Carolina Division of Marine Fisheries (NCDMF) to assess the status of fish stocks and track cohorts over time without relying solely on recreational and commercial fishery dependent data.

Objectives:

1. To calculate annual indices of abundance in Pamlico Sound for the following target species: Atlantic croaker (*Micropogonias undulatus*), bluefish (*Pomatomus saltatrix*), red drum (*Sciaenops ocellatus*), southern flounder (*Paralichthys lethostigma*), spot (*Leiostomus xanthurus*), weakfish (*Cynoscion regalis*), spotted seatrout (*Cynoscion nebulosus*), and striped bass (*Morone saxatilis*).
2. To supplement samples for age, growth, and reproduction studies in order to determine age structure, sex ratios, and relative cohort size for the target species.
3. To evaluate catch rates and species distribution for identifying and resolving bycatch problems in Pamlico Sound.
4. To characterize habitat use in Pamlico Sound.

Methods

Sampling is based on a stratified-random design by area and water depth, in two regions; Eastern Pamlico Sound, Western Pamlico Sound (Figure 4)

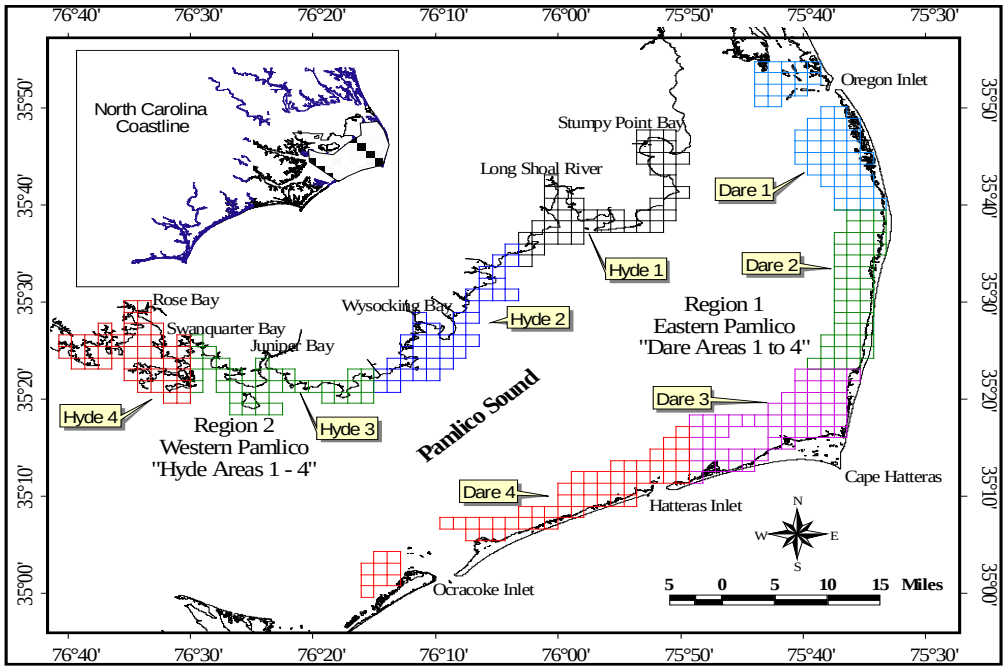


Figure 4. Sample regions and grid system for the Pamlico Sound Independent Gill Net Survey in Dare and Hyde counties.

Water depths are shallow (≤6 feet) and deep (>6 feet) with areas segregated into four similar size areas. Each area is sampled twice a month using stratified-random multiple mesh gill nets from February 15th – December 15. Mesh sizes range 30 yards each (3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5 ISM) 240 yards sink gill net, 12 hour soak. 480 yards fished per sampling day, 32 core samples a month (8 areas x twice a month x 2 samples).

Calculation of Weighted CPUE Estimates by Size Class Distribution

Catch rates of target species are calculated annually and expressed as an overall CPUE along with corresponding length class distributions. The overall CPUE provides a relative index of abundance showing availability of each species to the study. The overall CPUE is defined as the number of a species of fish captured per sample and is further expressed as the number of a species of fish at length per sample, with a sample being one array of nets fished for 12 hours. Due to disproportionate sizes of each stratum and region, the final CPUE estimate is weighted. The total area of each region by stratum is quantified using the one-minute by one-minute grid system and then used to weight the observed catches for calculating the abundance indices. Beginning in 2005, efforts were made to increase efficiency and catch rates in deep water grids. As a result, the previous grid system (2001-2004) was modified so grids with depths not less than 9 feet and grids not located along the 6-foot bathymetric contour were eliminated. As a result the weighting factors from 2005 forward have changed from the prior period (2001-2004). The weighting factors by region and strata beginning in 2005 were:

Region 1: Shallow water - 134.5 square nautical miles
Region 1: Deep water - 54.5 square nautical miles
Region 2: Shallow water - 82.5 square nautical miles
Region 2: Deep water - 70.5 square nautical miles

In order to prevent bias due to unequal sampling across areas and time, only core samples taken each month (n=32) are used in the calculations of the annual weighted CPUE index (Table 3).

Atlantic menhaden are the most abundant species by number. Figure 5 shows length frequencies for menhaden. Data collected include total number and weight captured, per mesh size, and a subset of 5 lengths and subsample weight per mesh size.

Table 3. Weighted arithmetic and geometric mean catch per effort for Atlantic Menhaden in Pamlico Sound

Year	N	MEAN	SE	PSE	Total Number	GEOMEAN
2001	237	36.955	3.62	10	10900	7.19
2002	320	38.195	3.4	9	15099	7.33
2003	320	39.832	3.22	8	14171	10.02
2004	320	42.549	4.64	11	14474	8.38
2005	304	39.556	3.94	10	15774	6.04
2006	320	42.52	3.66	9	16699	9.69
2007	320	22.511	3.45	15	9142	3.47
2008	320	14.091	1.87	13	5681	2.32
2009	320	15.325	1.75	11	6714	2.63
2010	320	29.232	3.76	13	11379	4.31
2011	298	16.188	1.9	12	5808	3.92
2012	307	19.374	2.08	11	7167	4.76

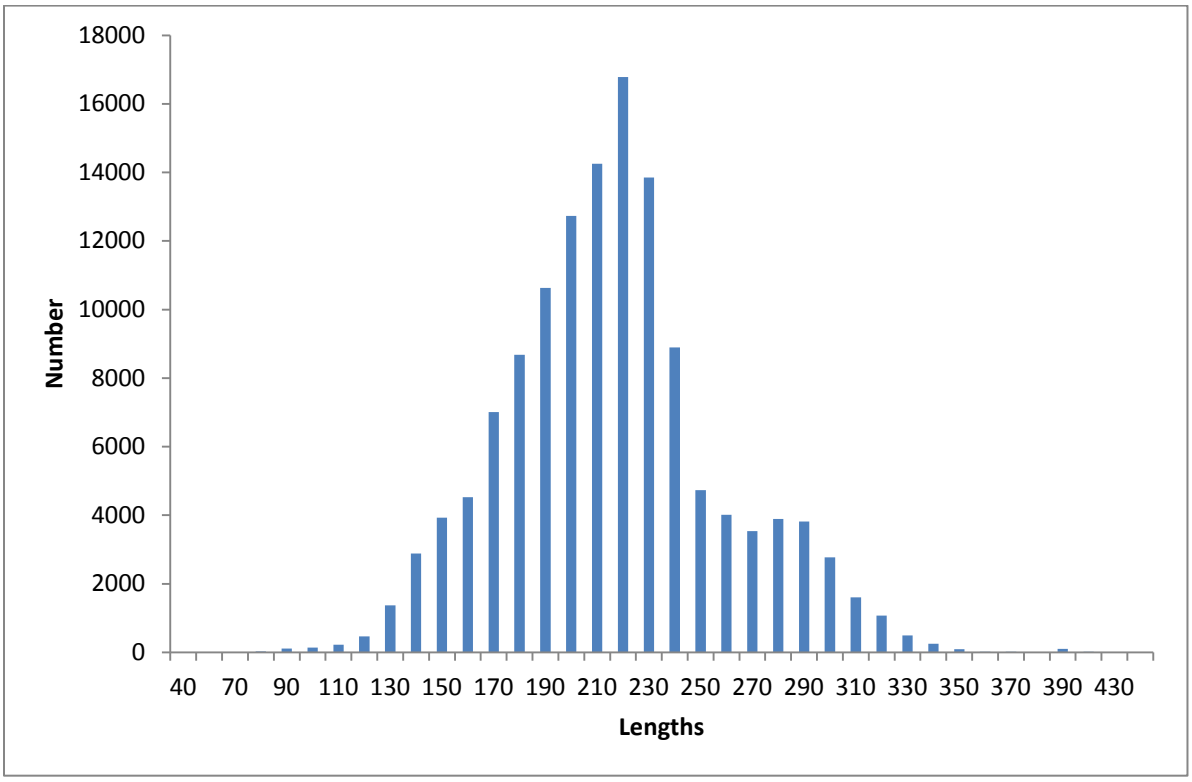


Figure 5. 2001-2012 Length frequency for Atlantic Menhaden in Pamlico Sound (n=133,014)

Pamlico and Neuse Watershed Gill Net Survey and Southern District Gill net Survey

Objectives:

1. To calculate annual indices of abundance in major North Carolina rivers for the following target species: American shad (*Alosa sapidissima*), Atlantic croaker (*Micropogonias undulatus*), bluefish (*Pomatomus saltatrix*), red drum (*Sciaenops ocellatus*), southern flounder (*Paralichthys lethostigma*), southern kingfish (*Menticirrhus americanus)*, Spanish mackerel (*Scomberomorus maculates*), spot (*Leiostomus xanthurus*), spotted seatrout (*Cynoscion nebulosus*), striped bass (*Morone saxatilis*), and weakfish (*Cynoscion regalis*). Catch per unit effort (CPUE) data from fishery independent surveys that standardizes effort will provide an unbiased relative index of abundance to track stock status. Target species may vary by river system.

2. To supplement samples for age, growth, and reproduction studies in order to determine age structure, sex ratios, and relative cohort size for the target species.

3. To evaluate catch rates and species distribution for identifying and resolving management problems in five North Carolina river systems and the Atlantic Ocean.

4. To characterize habitat use in those five river systems.

The Pamlico, Neuse, and Pungo Rivers project began in 2003. The New and Cape Fear rivers project began in May 2008. Sampling methodology is the same as the Pamlico Sound independent gill net survey using a stratified-random design based on areas and water depth. Estuarine waters are divided into two regions: Pamlico (Pamlico, Pungo, Neuse Rivers; Figure 5) and Southern (New and Cape Fear rivers; Figure 6).

Calculation of Weighted CPUE Estimates by Size Class Distribution

Catch rates of target species are calculated annually and expressed as an overall catch per unit effort (CPUE) along with corresponding length class distributions (Table 4 and Table 5; Figure 7 and Figure 8) . The overall CPUE gives an estimate of abundance showing availability of each species to the study, while the length distribution shows the size structure of each species for a given year. The overall CPUE is defined as the number of a species of fish captured per sample and was further expressed as the number of a species of fish at length per sample, with a sample being one array of nets. Due to disproportionate sizes of each strata and region, the final CPUE estimate is weighted. The length frequency distribution for each species is weighted by strata and number caught to determine the contribution of each size class to the final weighted CPUE. The total area of each region by strata is quantified using the one-minute by one-minute grid system and then used to weight the observed catches for calculating the abundance indices. The weighting factors by region and strata are:

Pamlico region:
Pamlico/Pungo River 1: Shallow water - 44 square nautical miles
Pamlico/Pungo River 2: Deep water - 38 square nautical miles
Neuse River 1: Shallow water - 36 square nautical miles
Neuse River 2: Deep water – 31 square nautical miles

Southern region:
New River 1: Shallow water - 12 square nautical miles
New River 2: Deep water - 12 square nautical miles
Cape Fear River: Shallow water - 14 square nautical miles

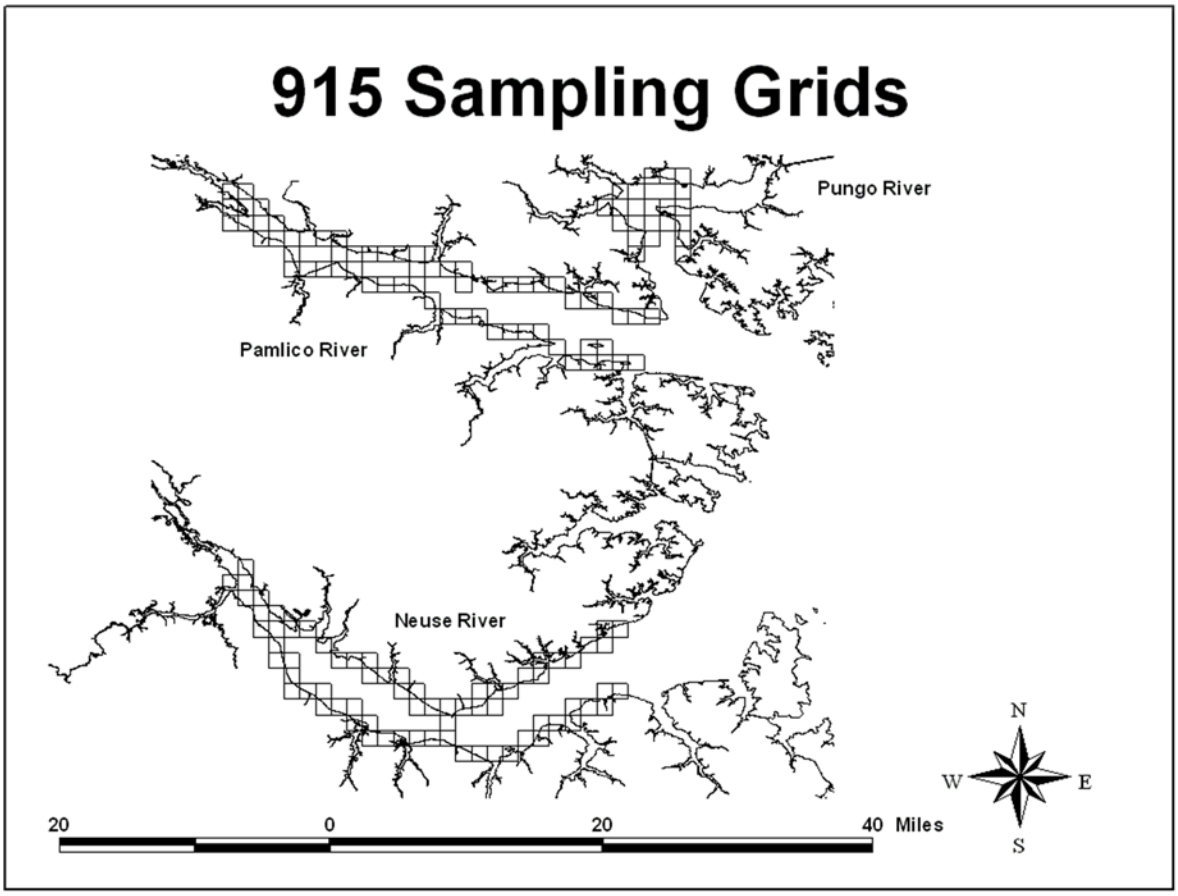


Figure 6. The sample regions and grid system for the Pamlico Region.

Atlantic menhaden are the most abundant species by number. Data collected include total number and weight captured, per mesh size, and a subset of 5 lengths and subsample weight per mesh size, fish condition (alive, dead, spoiled, alive/unmarketable).

Table 4. Weighted Arithmetic and geometric mean catch per effort for Atlantic Menhaden for Pamlico Region.

Year	N	MEAN	SE	PSE	Total Number	GEOMEAN
^ 2003	313	16.47	1.64	10	5,522	3.91
2004	320	20.95	1.66	8	14,440	4.41
* 2005	304	21.09	1.22	6	13,502	6.83
2006	320	41.52	2.47	6	27,452	14.18
2007	320	29.95	1.72	6	20,051	9.94
2008	320	13.6	1.21	9	9,386	4.27
2009	320	18.26	1.27	7	12,410	5.41
2010	320	18.87	1.33	7	13,008	4.74
2011	320	27.74	1.62	6	17,936	10.07
2012	320	38.92	3.39	9	13,139	10.51

^ In 2003 sampling in the Pamlico, Pungo, and Neuse Rivers was reinstated in July 2003 resulting in fewer samples
* In September of 2005 only half of the samples were collected resulting in 16 fewer samples

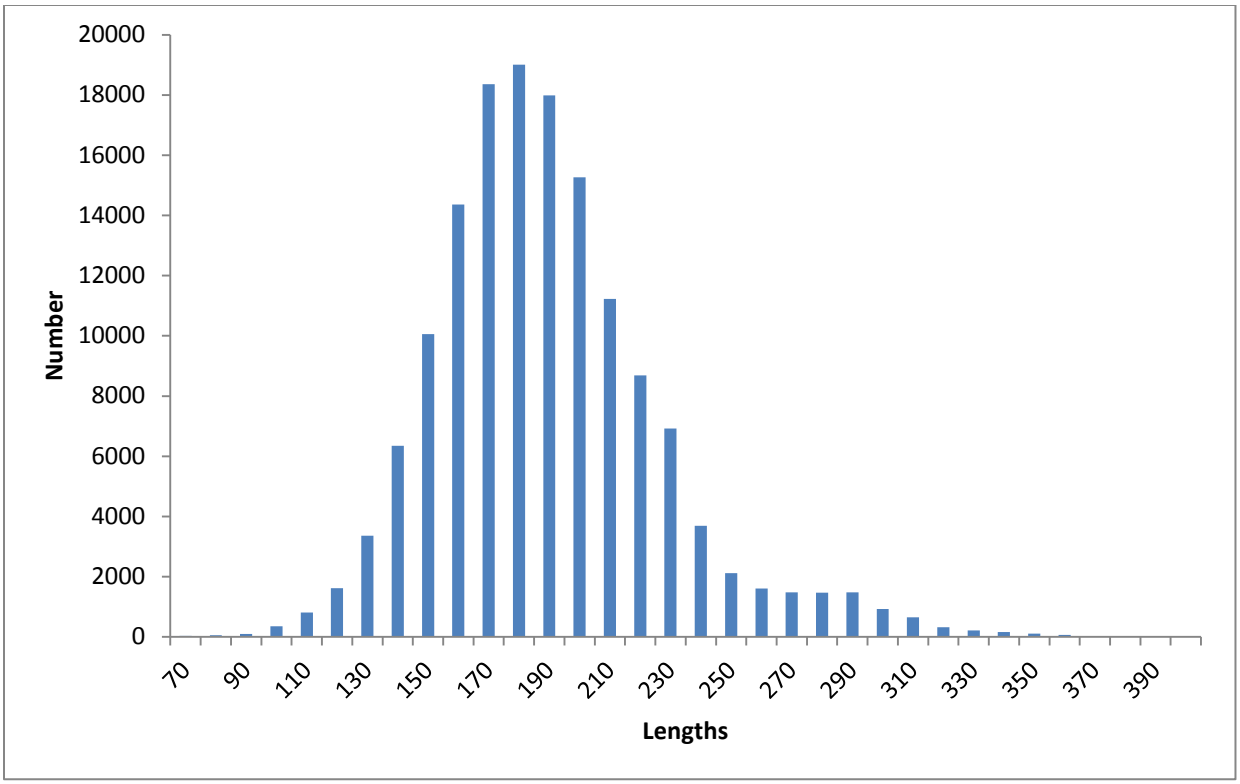


Figure 7. 2003-2012 Length frequency for Atlantic Menhaden in the Pamlico Region (n=148,888)

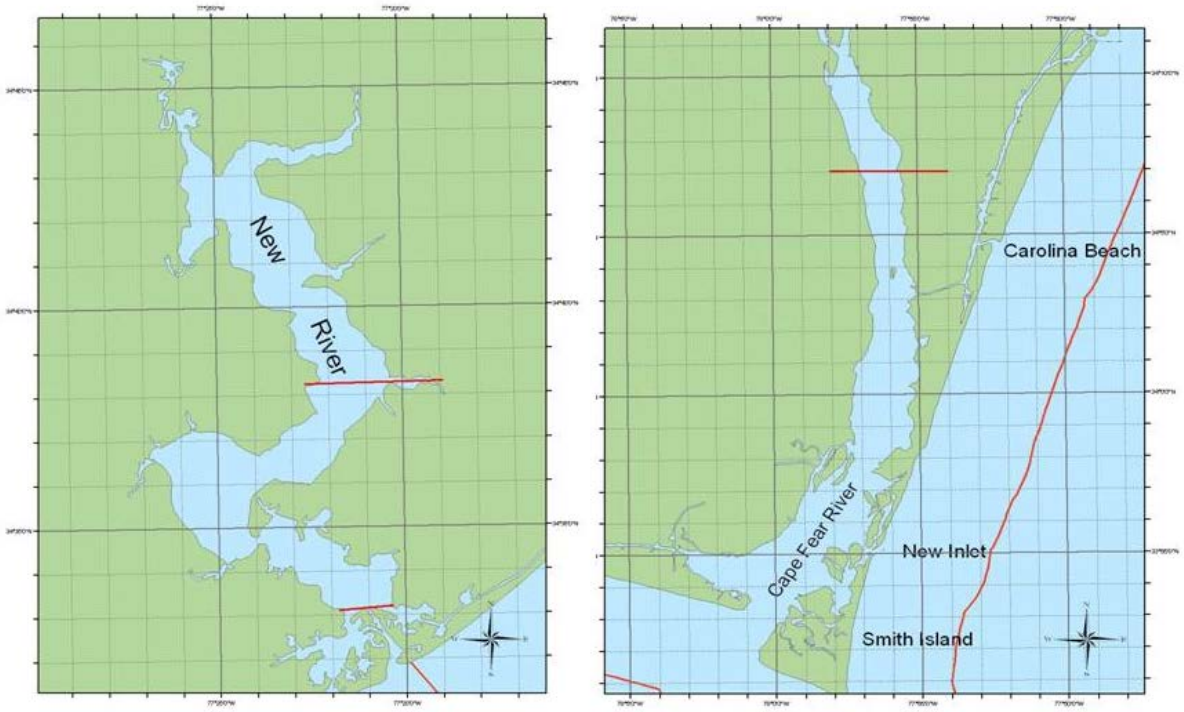


Figure 8. Sample regions and grid system for the Southern region.

Each region is delineated into shallow (≤6 feet) and deep (>6 feet) strata. Areas in Pamlico region are segregated into four similar size areas. Areas in southern region are assigned as upper and lower New river. The Cape fear is considered one area. Each area is randomly sampled twice a month using a stratified-random multiple-mesh gill nets from February 15 – December 15. Mesh sizes range 30 yards

each (3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5 ISM) 240 yards sink gill net, Soak times are 12 hour soak except from April 1 – September 31when soak times are reduced in the Cape Fear and New rivers to 3 hours to reduce interactions with sea turtles. The reduced soak times were fully implemented in 2009.

Table 5. Weighted Arithmetic and geometric mean catch per effort for Atlantic Menhaden in the southern region

Year	N	MEAN	SE	PSE	Total Number	GEOMEAN
2008	84	13.07	2.9	22	1118	1.47
2009	118	15.1	3.41	23	1807	1
2010	120	9.77	1.79	18	1243	0.18
2011	120	15.43	4.5	29	1950	0.59

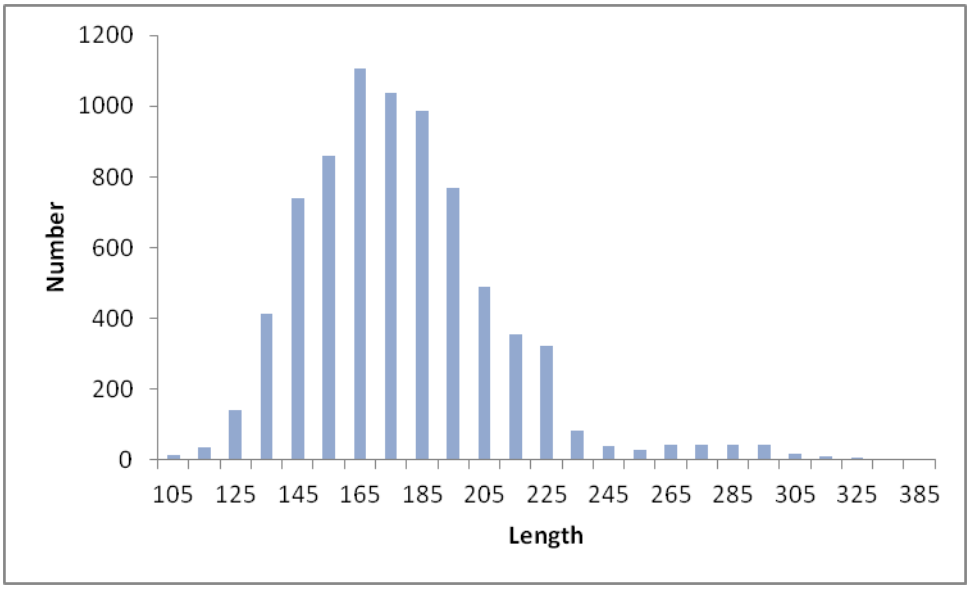


Figure 9. 2008-2011 Length frequency for Atlantic Menhaden in the Pamlico Region (n=7,629)

SCDNR Fishery-Independent Surveys

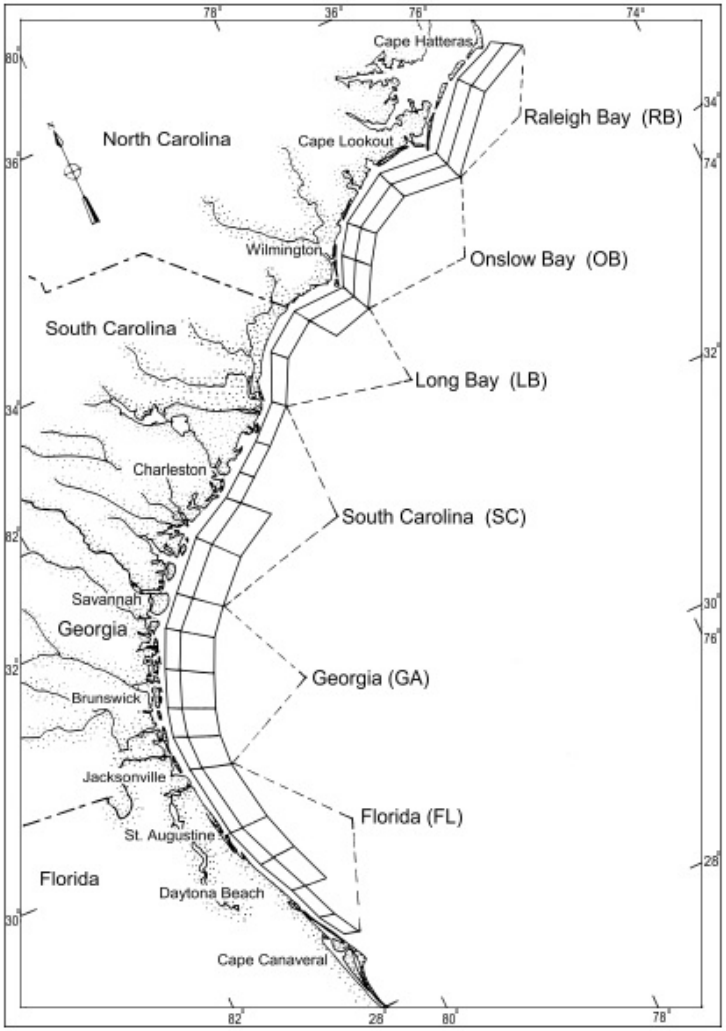
SEAMAP-SA Coastal Survey

Priority Species

Species	Species	Species	Species
Finfish (1989-present)			
Archosargus probatocephalus	*Leiostomus xanthurus*	*Mycteroperca microlepis*	*Pogonias cromis*
Brevoortia smithi	*Leiostomus xanthurus*	*Paralichthys albigutta*	*Pomatomus saltatrix*
Brevoortia tyrannus	*Menticirrhus americanus*	*Paralichthys dentatus*	*Sciaenops ocellata*
Centropristis striata	*Menticirrhus littoralis*	*Paralichthys lethostigma*	*Scomberomorus cavalla*
Chaetodipterus faber	*Menticirrhus saxatilis*	*Peprilus paru*	*Scomberomorus maculatus*
Cynoscion nebulosus	*Micropogonias undulatus*	*Peprilus triacanthus*	
Elasmobranchs (1994-present)			
All Shark Species			
Marine Turtles (1989-present)			
Caretta caretta	*Dermochelys coriacea*	*Chelonia mydas*	*Lepidochelys kempi*
Decapods (1989-present)			
Callinectes sapidus	*Farfantepenaeus duorarum*	*Farfantepenaeus aztecus*	*Litopenaeus setiferus*
Xiphosurans (1995-present)			
Limulus polyphemus			

Methodology

- Seasonal cruises
  - Spring (early April – mid-May)
  - Summer (mid-July – early-August)
  - Fall (October – mid-November)
- Gear
  - Falcon Trawl (20 minute tows during daylight)
    - Body = 1.875 in stretch mesh
    - Cod End = 1.625 in stretch mesh
- 24 shallow water strata
  - Stations randomly selected w/in each stratum
- Data
  - Biological Data: # of individuals, biomass, & individual lengths
  - Hydrographic Data



Spatial/Temporal Coverage

	Florida			Georgia			South Carolina			Long Bay			Onslow Bay			Raleigh Bay		
Year	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
1990	10	10	8	16	16	16	22	22	22	16	16	16	10	10	9	4	4	4
1991	10	10	10	16	16	16	22	22	22	16	16	16	10	10	9	4	4	4
1992	10	10	10	16	16	16	22	22	22	16	16	16	10	10	10	4	4	4
1993	10	10	10	16	16	16	22	22	22	16	16	16	10	10	10	4	4	4
1994	10	10	10	16	16	16	22	22	22	16	16	16	10	10	10	4	4	4
1995	10	10	10	16	16	16	22	22	22	16	16	16	10	10	10	4	4	4
1996	10	10	10	16	16	16	22	22	22	16	16	16	10	10	10	4	4	4
1997	10	10	10	16	16	16	22	22	22	16	16	16	10	10	10	4	4	4
1998	10	10	10	16	16	16	22	22	22	16	16	16	10	10	10	4	4	4
1999	10	10	10	16	16	16	22	22	22	16	16	16	10	10	10	4	4	4
2000	10	10	10	16	16	16	22	22	22	16	16	16	10	10	10	4	4	4
2001	18	18	18	27	27	27	18	18	18	12	12	12	18	18	18	9	9	9
2002	18	18	18	29	29	29	18	18	18	11	11	11	17	17	17	9	9	9
2003	18	18	18	29	29	29	18	18	18	11	11	11	17	17	17	9	9	9
2004	18	18	18	26	26	26	17	17	17	13	13	13	18	18	18	10	10	10
2005	18	18	18	26	26	26	17	17	17	13	13	13	18	18	18	10	10	10
2006	19	19	19	27	27	27	18	18	18	13	13	13	16	16	16	9	9	9
2007	19	19	19	25	25	25	22	22	22	13	13	13	15	15	15	8	8	8
2008	18	18	18	28	28	28	21	21	21	12	12	12	15	15	15	8	8	8
2009	19	19	19	27	27	27	26	26	26	14	14	14	17	17	17	9	9	9
2010	21	21	21	30	30	30	20	20	20	14	14	14	18	18	18	9	9	9
2011	22	22	22	31	31	31	18	18	18	12	12	12	19	19	19	10	10	10
2012	23	23	23	28	28	28	18	18	18	15	15	15	19	19	19	9	9	9
Total	**341**	**341**	**339**	**509**	**509**	**509**	**473**	**473**	**473**	**329**	**329**	**329**	**317**	**317**	**315**	**153**	**153**	**153**

Data

- Biological Data
  - # of individuals
  - Total biomass
  - Individual lengths (nearest cm)
  - Total weight of all individuals
- Hydrographic Data

% Positive Tows by Cruise Season

Stratum	Spring	Summer	Fall	Total
Florida	31.58%	26.10%	20.94%	26.59%
Georgia	18.25%	8.84%	17.68%	15.23%
Long Bay	14.59%	6.38%	6.06%	8.91%
Onslow Bay	30.28%	7.57%	5.88%	13.82%
Raleigh Bay	28.10%	5.88%	9.23%	13.97%
South Carolina	9.09%	2.75%	14.38%	8.75%
Avg. % Positive	**20.21%**	**9.47%**	**12.81%**	**14.40%**

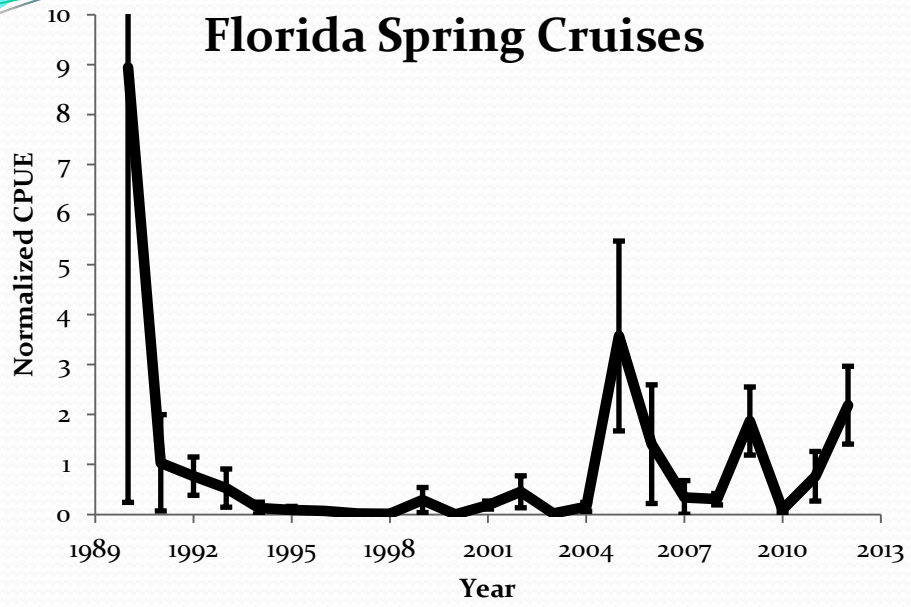
of Menhaden By Area and Cruise

- Highest catches during spring cruises (85.3% of all captured)
  - Especially off GA and FL on average
  - Note two exceptional catches in SC and Long Bay in 2009

	Florida				Georgia				South Carolina				Long Bay				Onslow Bay				Raleigh Bay				All Areas			
Year	Spring	Summer	Fall	Total	Spring	Summer	Fall	Total	Spring	Summer	Fall	Total	Spring	Summer	Fall	Total	Spring	Summer	Fall	Total	Spring	Summer	Fall	Total	Spring	Summer	Fall	Total
1990	1272	110	0	1382	2342	13	184	2539	10	1	2	13	3	0	0	3	2	4	4	10	1	0	1	2	3630	128	191	3949
1991	147	14	27	188	317	1	150	468	72	0	25	97	430	0	0	430	137	0	0	137	0	0	15	15	1103	15	217	1335
1992	109	6	5	120	399	0	13	412	2	0	20	22	474	0	0	474	26	0	0	26	44	0	0	44	1054	6	38	1098
1993	75	19	1	95	22	4	2	28	270	0	27	297	37	32	6	75	12	0	1	13	9	0	0	9	425	55	37	517
1994	18	3	3	24	26	12	134	172	12	1	36	49	60	0	2	62	5	3	5	13	0	0	12	12	121	19	192	332
1995	13	10	12	35	0	0	21	21	3	0	13	16	15	0	0	15	8	1	0	9	5	0	2	7	44	11	48	103
1996	10	3	120	133	55	0	5	60	6	16	37	59	15	14	29	58	22	8	11	41	7	0	2	9	115	41	204	360
1997	3	1	12	16	13	6	2	21	123	23	9	155	7	1	0	8	9	2	0	11	14	0	0	14	169	33	23	225
1998	2	132	4	138	467	0	22	489	0	0	14	14	187	1	11	199	173	0	0	173	35	0	0	35	864	133	51	1048
1999	41	0	2	43	59	0	55	114	0	2	142	144	2	2	14	18	3	0	8	11	27	0	16	43	132	4	237	373
2000	0	0	2	2	210	0	4	214	130	127	1	258	0	0	4	4	0	0	0	0	0	0	0	0	340	127	11	478
2001	48	1	39	88	768	10	51	829	0	0	31	31	11	21	4	36	25	5	7	37	1	1	0	2	853	38	132	1023
2002	116	38	1	155	628	1	0	629	57	8	0	65	8	31	0	39	6	1	4	11	0	0	0	0	815	79	5	899
2003	5	2	2	9	282	5	29	316	45	0	0	45	8	4	0	12	388	11	1	400	13	13	42	68	741	35	74	850
2004	39	11	293	343	23	1	27	51	0	0	5	5	12	0	5	17	11	0	0	11	508	5	5	518	593	17	335	945
2005	914	18	145	1077	2181	24	9	2214	2	0	0	2	53	0	35	88	109	0	0	109	487	0	0	487	3746	42	189	3977
2006	380	30	0	410	3955	223	765	4943	18	6	16	40	30	315	0	345	354	0	1	355	317	0	0	317	5054	574	782	6410
2007	92	0	0	92	173	0	0	173	1	0	0	1	0	1	0	1	17	8	0	25	0	0	0	0	283	9	0	292
2008	78	73	4	155	278	6	26	310	0	0	0	0	0	0	13	13	7	0	1	8	4	2	0	6	367	81	44	492
2009	505	51	0	556	566	46	1	613	2889	0	31	2920	14420	26	1	14447	781	13	0	794	7	7	0	14	19168	143	33	19344
2010	29	108	23	160	163	5	1	169	0	4	39	43	0	0	0	0	68	111	4	183	17	0	8	25	277	228	75	580
2011	239	158	892	1289	346	78	844	1268	0	0	196	196	11	0	12	23	228	41	10	279	161	0	0	161	985	277	1954	3216
2012	715	74	8	797	6	66	16	88	62	0	9	71	0	3	0	3	11	0	16	27	0	0	0	0	794	143	49	986
Total	4850	862	1595	7307	13279	501	2361	16141	3702	188	653	4543	15783	451	136	16370	2402	208	73	2683	1657	28	103	1788	41673	2238	4921	48832

CPUE (Spring Cruises)

	Spring Cruise													
	Florida		Georgia		South Carolina		Long Bay		Onslow Bay		Raleigh Bay		All Areas	
Year	CPUE	Norm CPUE	CPUE	Norm CPUE	CPUE	Norm CPUE	CPUE	Norm CPUE	CPUE	Norm CPUE	CPUE	Norm CPUE	CPUE	Norm CPUE
1990	127.2000	8.9433	146.3750	5.6107	0.4545	0.0581	0.1875	0.0039	0.2000	0.0264	0.2500	0.0231	46.5385	2.3698
1991	14.7000	1.0335	19.8125	0.7594	3.2727	0.4182	26.8750	0.5602	13.7000	1.8080	0.0000	0.0000	14.1410	0.7201
1992	10.9000	0.7664	24.9375	0.9559	0.0909	0.0116	29.6250	0.6175	2.6000	0.3431	11.0000	1.0157	13.5128	0.6881
1993	7.5000	0.5273	1.3750	0.0527	12.2727	1.5681	2.3125	0.0482	1.2000	0.1584	2.2500	0.2078	5.4487	0.2775
1994	1.8000	0.1266	1.6250	0.0623	0.5455	0.0697	3.7500	0.0782	0.5000	0.0660	0.0000	0.0000	1.5513	0.0790
1995	1.3000	0.0914	0.0000	0.0000	0.1364	0.0174	0.9375	0.0195	0.8000	0.1056	1.2500	0.1154	0.5641	0.0287
1996	1.0000	0.0703	3.4375	0.1318	0.2727	0.0348	0.9375	0.0195	2.2000	0.2903	1.7500	0.1616	1.4744	0.0751
1997	0.3000	0.0211	0.8125	0.0311	5.5909	0.7143	0.4375	0.0091	0.9000	0.1188	3.5000	0.3232	2.1667	0.1103
1998	0.2000	0.0141	29.1875	1.1188	0.0000	0.0000	11.6875	0.2436	17.3000	2.2831	8.7500	0.8079	11.0769	0.5640
1999	4.1000	0.2883	3.6875	0.1413	0.0000	0.0000	0.1250	0.0026	0.3000	0.0396	6.7500	0.6233	1.6923	0.0862
2000	0.0000	0.0000	13.1250	0.5031	5.9091	0.7550	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	4.3590	0.2220
2001	2.6667	0.1875	28.4444	1.0903	0.0000	0.0000	0.9167	0.0191	1.3889	0.1833	0.1111	0.0103	8.3627	0.4258
2002	6.4444	0.4531	21.6552	0.8301	3.1667	0.4046	0.7273	0.0152	0.3529	0.0466	0.0000	0.0000	7.9902	0.4069
2003	0.2778	0.0195	9.7241	0.3727	2.5000	0.3194	0.7273	0.0152	22.8235	3.0121	1.4444	0.1334	7.2647	0.3699
2004	2.1667	0.1523	0.8846	0.0339	0.0000	0.0000	0.9231	0.0192	0.6111	0.0807	50.8000	4.6906	5.8137	0.2960
2005	50.7778	3.5701	83.8846	3.2154	0.1176	0.0150	4.0769	0.0850	6.0556	0.7992	48.7000	4.4967	36.7255	1.8701
2006	20.0000	1.4062	146.4815	5.6148	1.0000	0.1278	2.3077	0.0481	22.1250	2.9199	35.2222	3.2523	49.5490	2.5230
2007	4.8421	0.3404	6.9200	0.2653	0.0455	0.0058	0.0000	0.0000	1.1333	0.1496	0.0000	0.0000	2.7745	0.1413
2008	4.3333	0.3047	9.9286	0.3806	0.0000	0.0000	0.0000	0.0000	0.4667	0.0616	0.5000	0.0462	3.5980	0.1832
2009	26.5789	1.8687	20.9630	0.8035	111.1154	14.1971	1030.0000	21.4706	45.9412	6.0630	0.7778	0.0718	171.1429	8.7146
2010	1.3810	0.0971	5.4333	0.2083	0.0000	0.0000	0.0000	0.0000	3.7778	0.4986	1.8889	0.1744	2.4732	0.1259
2011	10.8636	0.7638	11.1613	0.4278	0.0000	0.0000	0.9167	0.0191	12.0000	1.5837	16.1000	1.4866	8.7946	0.4478
2012	31.0870	2.1857	0.2143	0.0082	3.4444	0.4401	0.0000	0.0000	0.5789	0.0764	0.0000	0.0000	7.0893	0.3610
Avg.	**14.2229**	**1.0000**	**26.0884**	**1.0000**	**7.8266**	**1.0000**	**47.9726**	**1.0000**	**7.5773**	**1.0000**	**10.8301**	**1.0000**	**19.6385**	**1.0000**


Florida Spring Cruises
Normalized CPUE
Year
0
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1989
1992
1995
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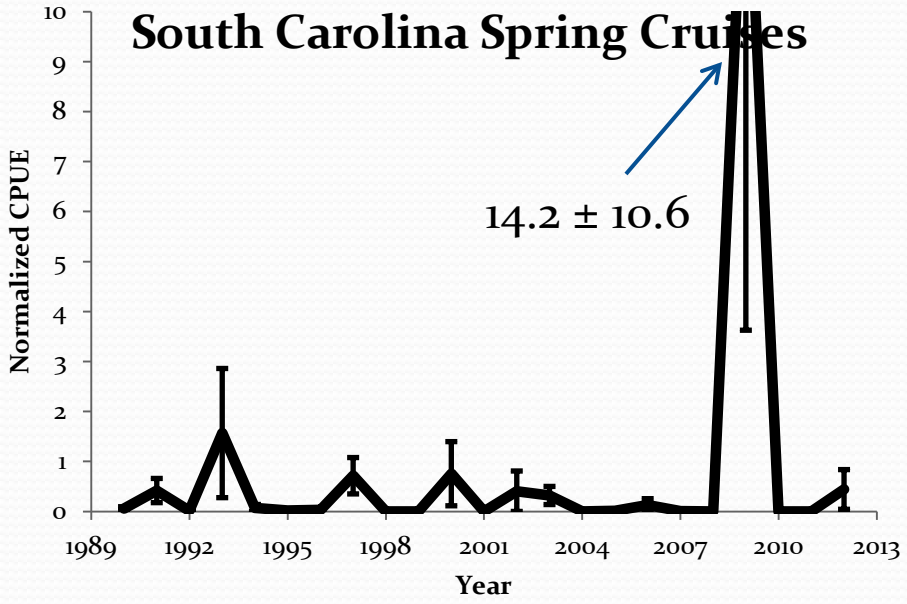
2001
2004
2007
2010
2013


South Carolina Spring Cruises
14.2 ± 10.6
Normalized CPUE
Year
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1989
1992
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2004
2007
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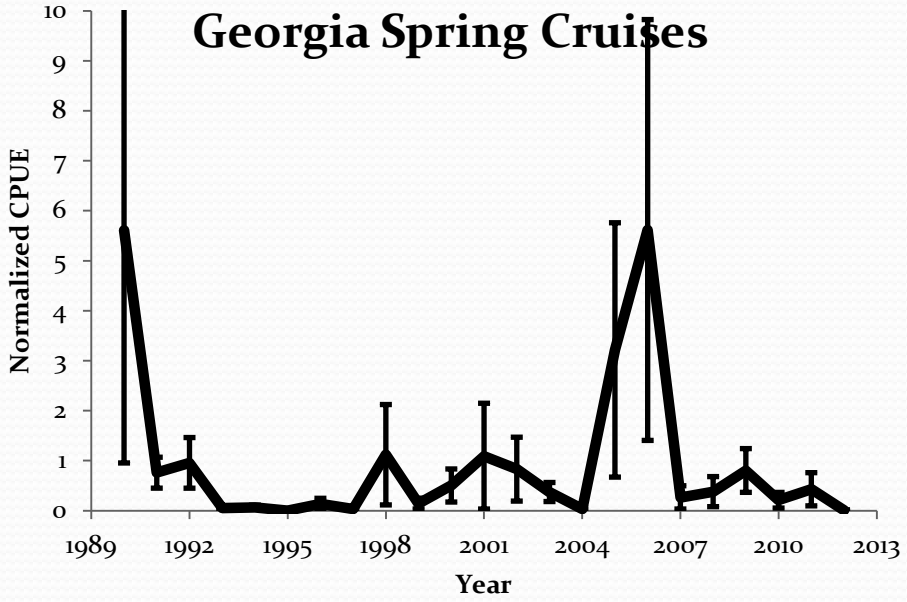
2013


Georgia Spring Cruises
Normalized CPUE
Year
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1989
1992
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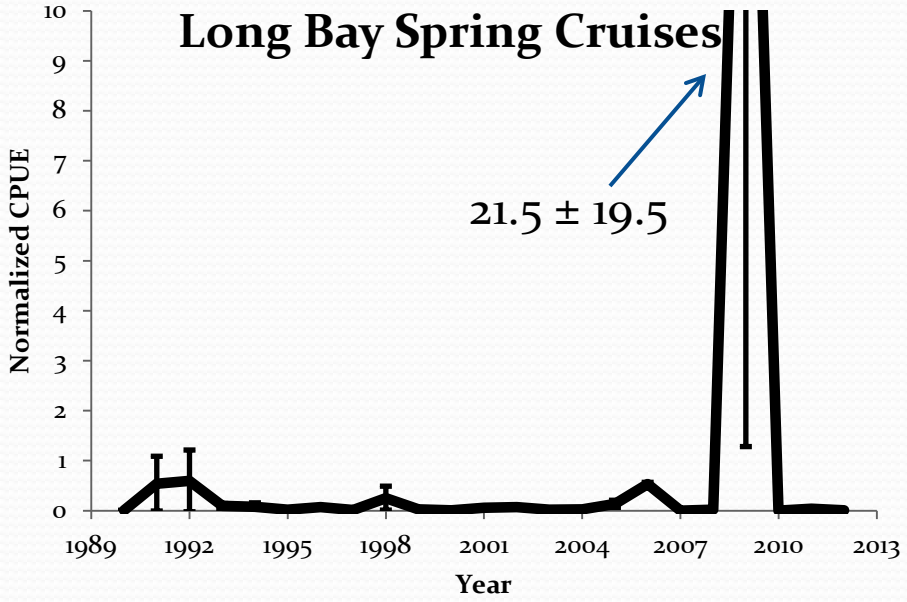
Long Bay Spring Cruises
21.5 ± 19.5
Normalized CPUE
Year
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1
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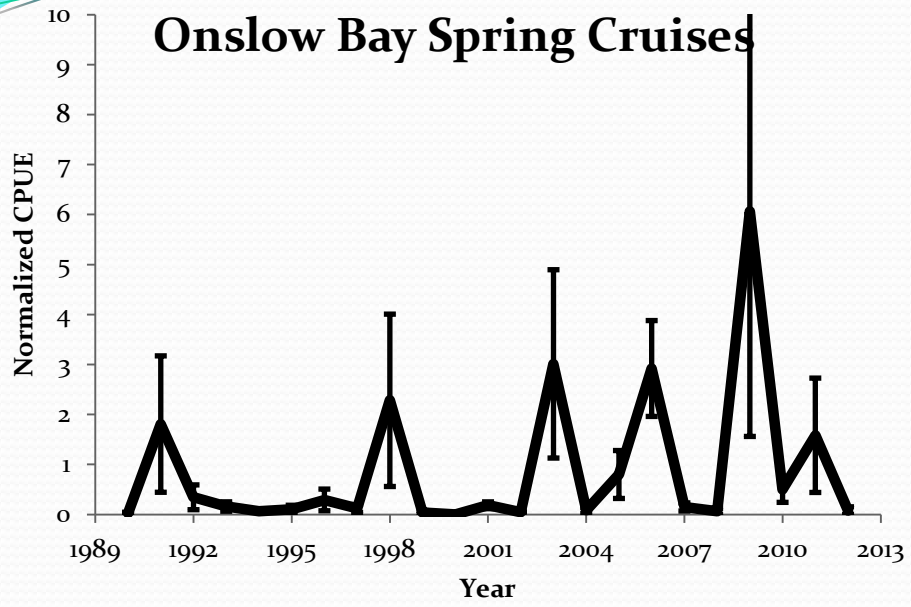
1989
1992
1995
1998
2001
2004
2007
2010
2013


Onslow Bay Spring Cruises
Normalized CPUE
0
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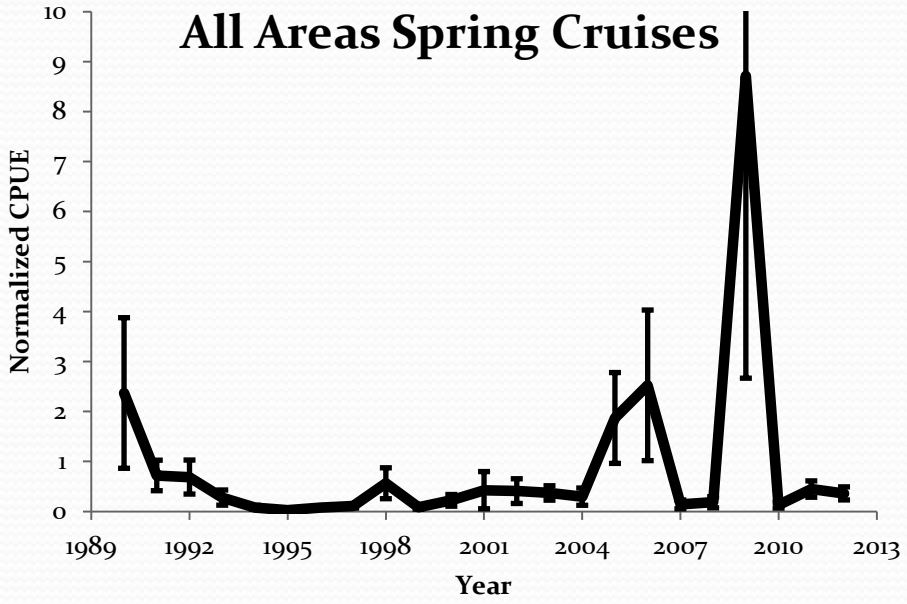
1989
1992
1995
1998
2001
2004
2007
2010
2013
Year


All Areas Spring Cruises
Normalized CPUE
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9
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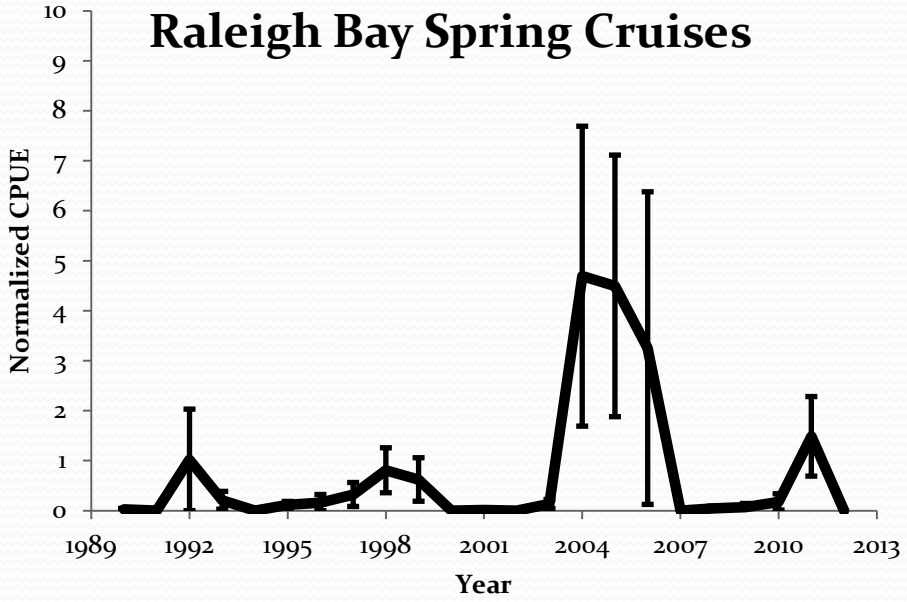
1989
1992
1995
1998
2001
2004
2007
2010
2013
Year


Raleigh Bay Spring Cruises
Normalized CPUE
0
1
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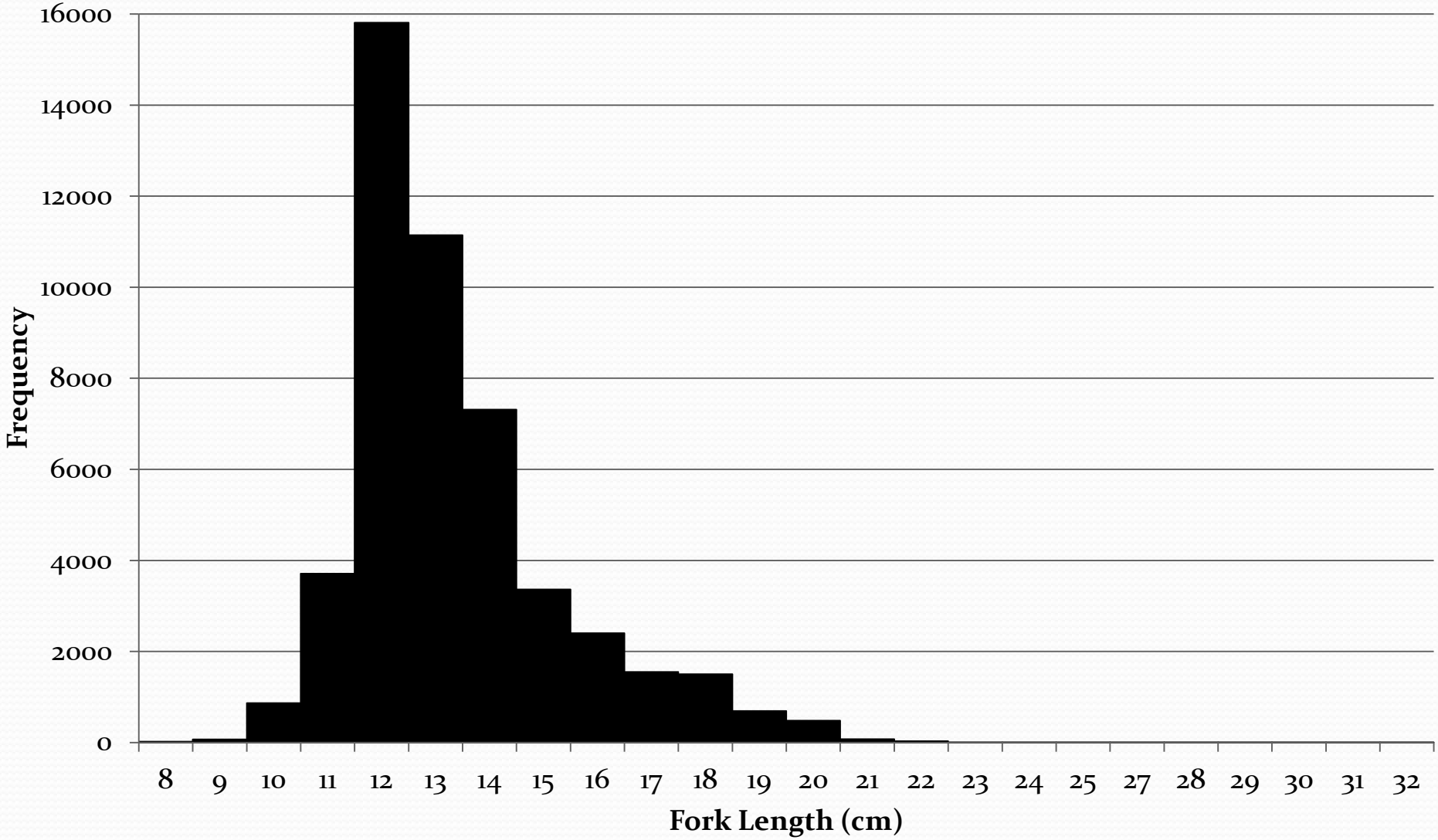
1989
1992
1995
1998
2001
2004
2007
2010
2013
Year

Frequency of Catch (Spring Cruises)

Frequency, by Area							
Catch	**Florida**	**Georgia**	**South Carolina**	**Long Bay**	**Onslow Bay**	**Raleigh Bay**	**All Areas**
0	216	391	424	281	221	110	1643
1-9	70	54	28	31	62	26	271
10-99	44	41	15	11	27	12	150
100-999	10	20	5	5	7	5	52
1000+	1	3	1	1	0	0	6
Total	**341**	**509**	**473**	**329**	**317**	**153**	**2122**

Percent, by Stratum							
Catch	**Florida**	**Georgia**	**South Carolina**	**Long Bay**	**Onslow Bay**	**Raleigh Bay**	**All Areas**
0	63.34%	76.82%	89.64%	85.41%	69.72%	71.90%	77.43%
1-9	20.53%	10.61%	5.92%	9.42%	19.56%	16.99%	12.77%
10-99	12.90%	8.06%	3.17%	3.34%	8.52%	7.84%	7.07%
100-999	2.93%	3.93%	1.06%	1.52%	2.21%	3.27%	2.45%
1000+	0.29%	0.59%	0.21%	0.30%	0.00%	0.00%	0.28%
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

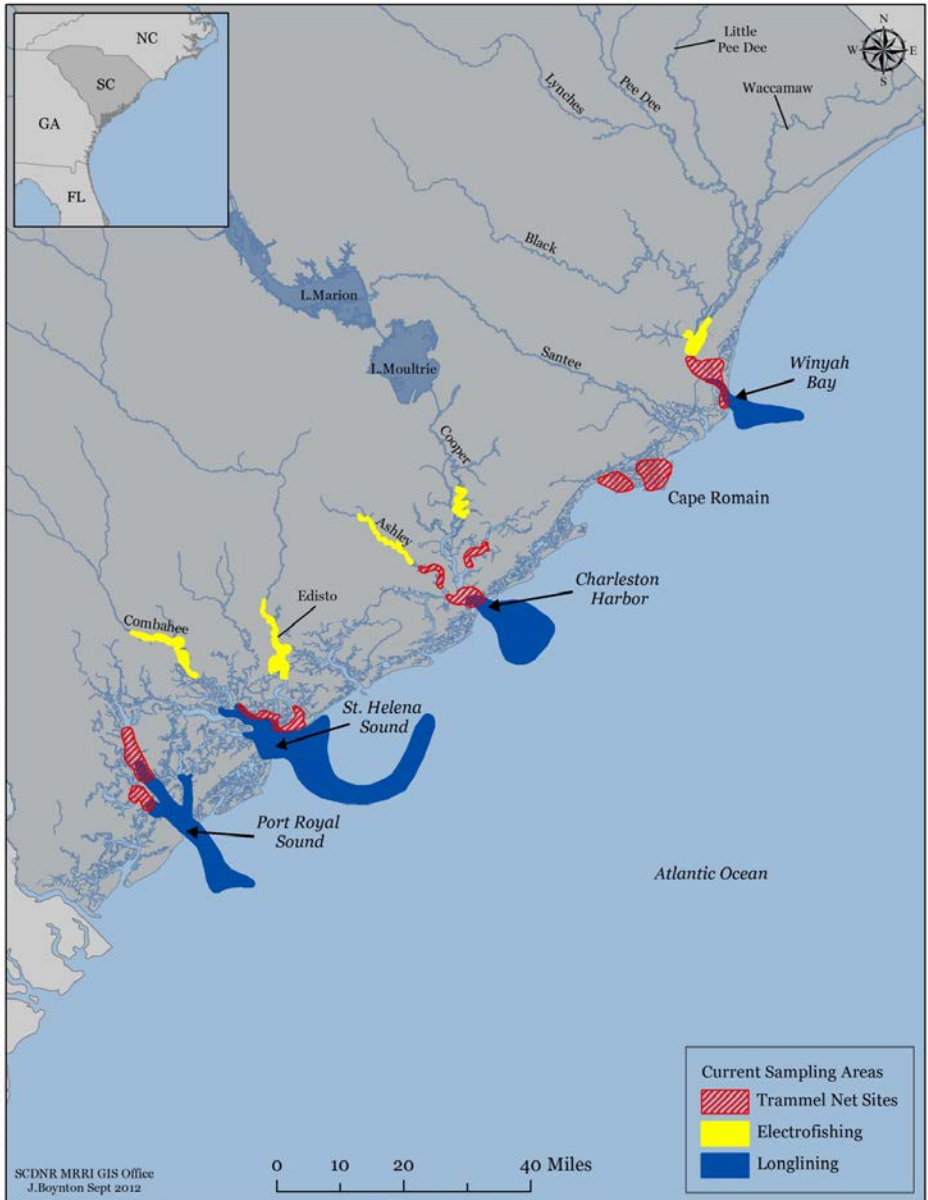
Size Frequency



Electrofishing Survey

Spatial Coverage

- 5 strata in various estuarine systems (salinities < 10 psu)
  - Combahee River
  - Lower Edisto
  - Upper Ashley River
  - Upper Cooper River
  - Winyah Bay System
- 35 to 60 possible sites per stratum
  - Sites for monthly sampling were randomly chosen w/o replacement



Spatial/Temporal Coverage

	Ashley River				Combahee River				Cooper River				Edisto River				Winyah Bay System				Total			
Year	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
2001	12	12	17		3	18	16		9	10	17		12	12	17						36	52	67	
2002	17	18	18	18	17	12	15	17	18	17	18	18	16	16	16	18					68	63	67	71
2003	18	18	18	18	14	16	14	15	16	17	18	17	17	17	10	17			6		65	68	66	67
2004	17	11	18	18	15	17	12	16	18	18	17	18	17	12	18	17	11	16	14	10	78	74	79	79
2005	17	12	18	18	14	15	14	12	18	17	18	13	18	11	12	13	15	16	10	16	82	71	72	72
2006	12	18	18	18	13	14	14	16	18	18	11	17	12	17	16	18	17	16	18	14	72	83	77	83
2007	18	17	9	18	15	15	15	17	17	17	17	16	17	11	15	17	16	11		16	83	71	56	84
2008	18	18	18	17	16	16	16	16	16	18	18	16	17	3	16	15	15	11	18	14	82	66	86	78
2009	16	18	16	17	16	17	17	17	18	18	14	16	15	17	12	16	16	11	14	14	81	81	73	80
2010	15	14	14	8	18	15	16	16	17	16	14	18	17	17	16	17	17	13	10	14	84	75	70	73
2011	9	14	13	15	13	13	13	11	16	15	17	17	15	7	14	12	12	12	12	13	65	61	69	68
2012	14	15	10	14	16	18	14	17	17	9	16	16	16	9	17	17	16	14	11	13	79	65	68	77
Total	**183**	**185**	**187**	**179**	**170**	**186**	**176**	**170**	**198**	**190**	**195**	**182**	**189**	**149**	**179**	**177**	**135**	**120**	**113**	**124**	**875**	**830**	**850**	**832**

Sampling Methodology

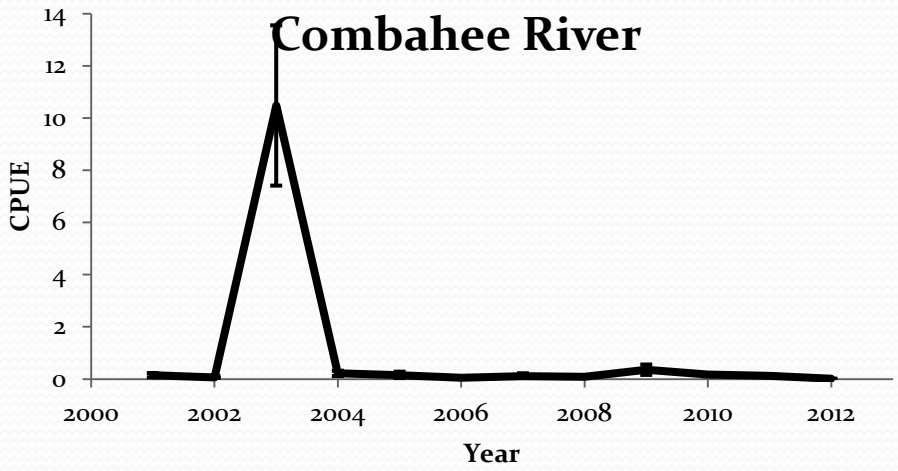
- Sampling gear
  - Electrofishing boat - ~ 3,000 watts of pulsed direct current
- Methodology
  - Near shoreline transect made with tidal current
    - Shock at idle-speed approximately 1.5 to 3 m from the bank
- Targeted species
  - Red drum, spotted seatrout, southern flounder, & striped bass
- Data
  - Biological
    - # of individuals and individual lengths
  - Hydrographic /Sampling Data

% Positive Electrofishing Transects by Month

Year	Combahee River	Edisto River	Ashley River	Cooper River	Winyah Bay System	All Estuaries
January	0.00%	3.17%	3.28%	0.00%	0.00%	1.40%
February	19.30%	37.74%	48.21%	11.29%	17.07%	26.77%
March	50.00%	57.38%	46.77%	17.24%	52.27%	44.40%
April	48.15%	54.39%	47.27%	26.56%	37.50%	42.59%
May	20.00%	50.75%	30.16%	17.65%	16.67%	27.78%
June	14.29%	38.46%	32.31%	24.24%	12.77%	25.42%
July	14.71%	15.87%	26.47%	12.50%	11.90%	16.72%
August	5.56%	9.09%	14.00%	4.41%	4.88%	7.32%
September	1.56%	0.00%	2.99%	10.34%	0.00%	3.23%
October	0.00%	1.54%	0.00%	8.82%	2.94%	2.70%
November	0.00%	1.85%	3.17%	6.67%	0.00%	2.56%
December	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Avg. % Positive	**13.82%**	**23.34%**	**20.84%**	**11.63%**	**13.62%**	**16.77%**

CPUE (February-July Data)

	Ashley River		Combahee River		Cooper River		Edisto River		Winyah Bay System		All Estuaries	
Year	CPUE	Norm CPUE	CPUE	Norm CPUE	CPUE	Norm CPUE	CPUE	Norm CPUE	CPUE	Norm CPUE	CPUE	Norm CPUE
2001	167.6667	3.8108	2.3333	0.1472	10.0769	1.3133	11.6667	0.4024			53.0313	2.5256
2002	2.3714	0.0539	1.0645	0.0671	7.8857	1.0278	6.5455	0.2257			4.5373	0.2161
2003	302.1667	6.8678	166.1724	10.4802	5.9091	0.7701	82.7059	2.8525			141.6970	6.7482
2004	13.1471	0.2988	3.4516	0.2177	8.8889	1.1585	38.7059	1.3349	2.1923	0.5971	13.9565	0.6647
2005	10.9143	0.2481	2.3846	0.1504	51.9333	6.7685	13.1212	0.4525	6.2000	1.6886	17.0195	0.8105
2006	7.0000	0.1591	0.7241	0.0457	4.0571	0.5288	44.4333	1.5325	3.6000	0.9805	11.7792	0.5610
2007	1.0556	0.0240	1.8065	0.1139	2.2121	0.2883	4.3824	0.1511	3.1563	0.8596	2.5120	0.1196
2008	2.0571	0.0468	1.3750	0.0867	2.0000	0.2607	4.4828	0.1546	1.5484	0.4217	2.2500	0.1072
2009	20.0000	0.4546	5.6667	0.3574	1.8286	0.2383	4.4194	0.1524	2.6207	0.7137	6.9814	0.3325
2010	14.4800	0.3291	2.6471	0.1669	0.2647	0.0345	15.4857	0.5341	8.0000	2.1788	7.8679	0.3747
2011	3.0833	0.0701	1.8696	0.1179	1.3438	0.1751	143.9130	4.9635	5.5000	1.4979	28.5873	1.3615
2012	0.3929	0.0089	0.1515	0.0096	1.6364	0.2133	0.7500	0.0259	0.2069	0.0563	0.6452	0.0307
Avg.	**43.9973**		**15.8559**		**7.6728**		**28.9945**		**3.6718**		**20.9977**	


Combahee River
CPUE
Year
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2000
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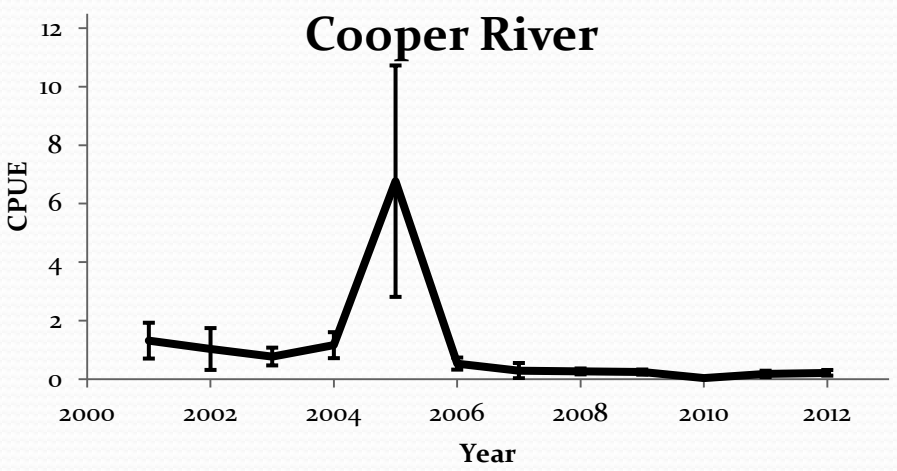
2004
2006
2008
2010
2012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CPUE
Year
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2002
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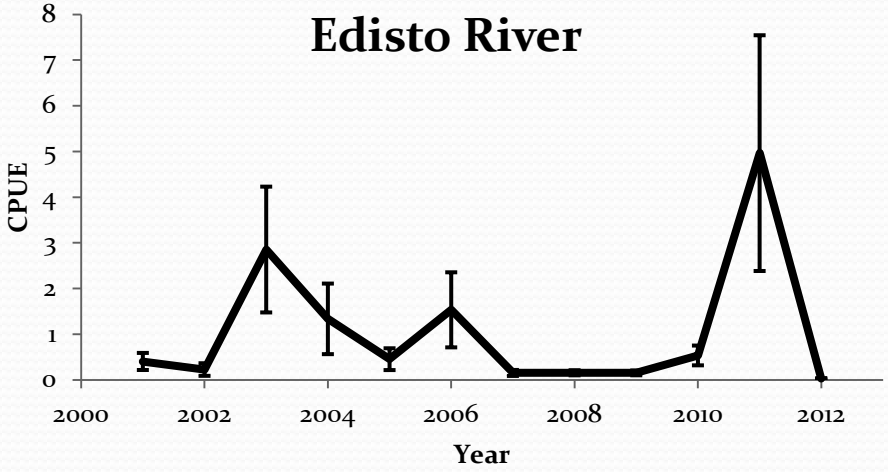
2010
2012


Edisto River
CPUE
Year
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2000
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2004
2006
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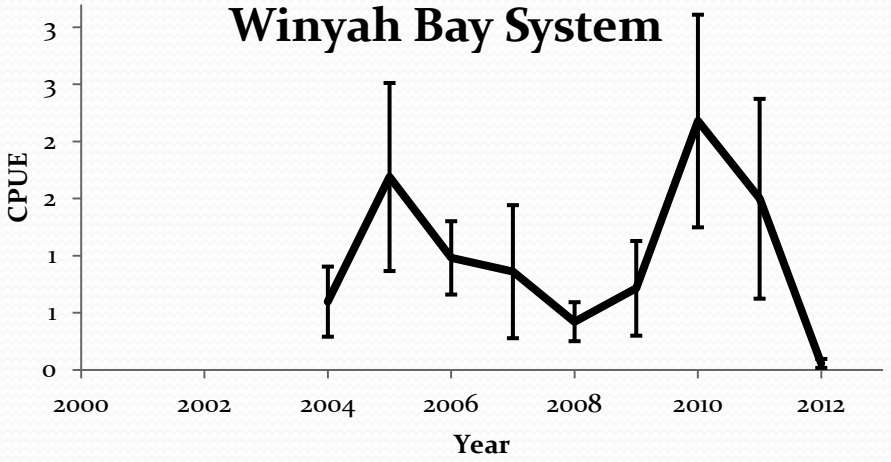
2010
2012


Winyah Bay System
CPUE
Year
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2000
2002
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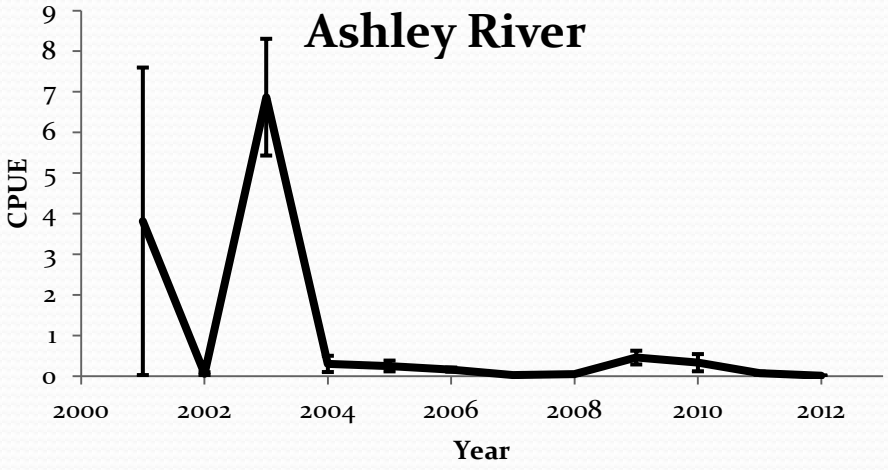
2010
2012


Ashley River
CPUE
Year
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2000
2002
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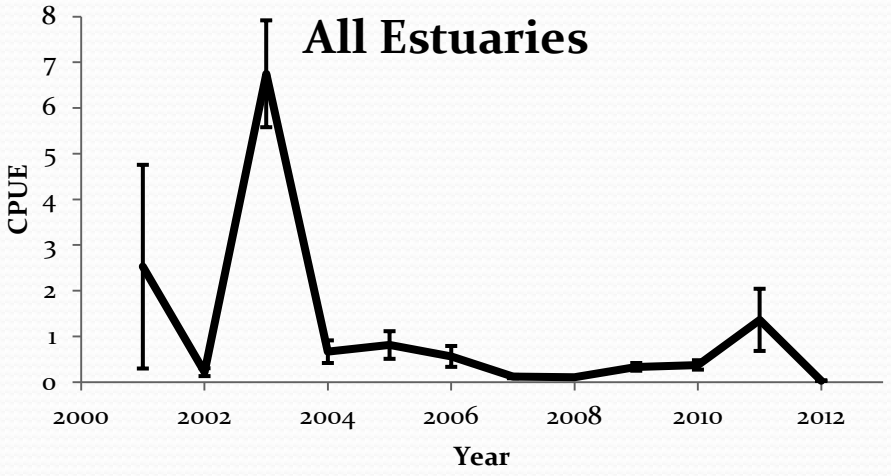
2010
2012


All Estuaries
CPUE
Year
0
1
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4
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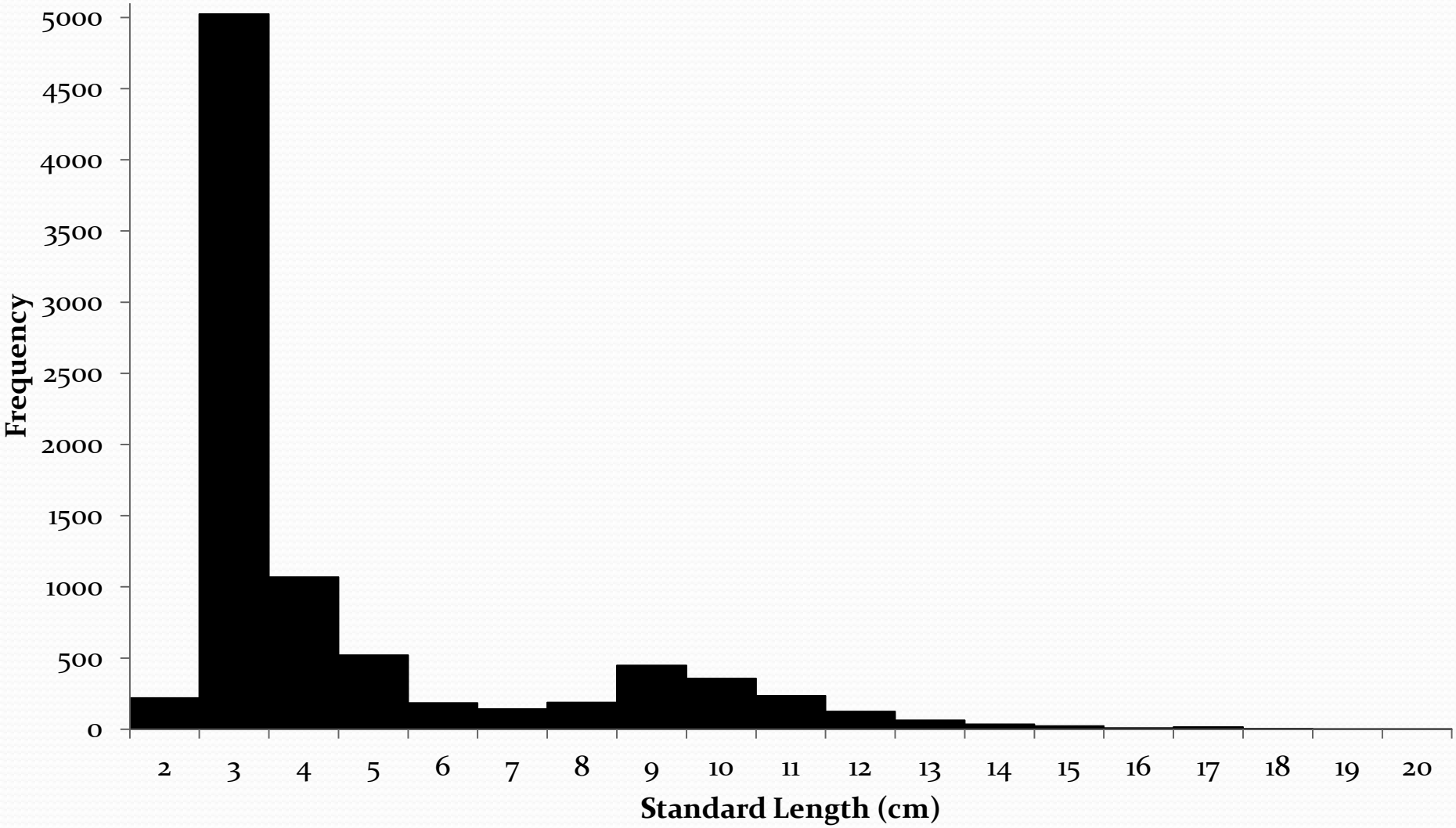
2000
2002
2004
2006
2008
2010
2012

Frequency of Catch

	Frequency, by Stratum					
Catch	**Ashley River**	**Combahee River**	**Cooper River**	**Edisto River**	**Winyah Bay System**	**All Estuaries**
0	194	245	254	143	163	999
1-9	108	66	85	146	71	476
10-99	41	24	40	56	27	188
100-999	23	12	3	18	1	57
1000+	3			3		6
Total	**369**	**347**	**382**	**366**	**262**	**1726**

	Percent, by Stratum					
Catch	**Ashley River**	**Combahee River**	**Cooper River**	**Edisto River**	**Winyah Bay System**	**All Estuaries**
0	52.57%	70.61%	66.49%	39.07%	62.21%	57.88%
1-9	29.27%	19.02%	22.25%	39.89%	27.10%	27.58%
10-99	11.11%	6.92%	10.47%	15.30%	10.31%	10.89%
100-999	6.23%	3.46%	0.79%	4.92%	0.38%	3.30%
1000+	0.81%	0.00%	0.00%	0.82%	0.00%	0.35%
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

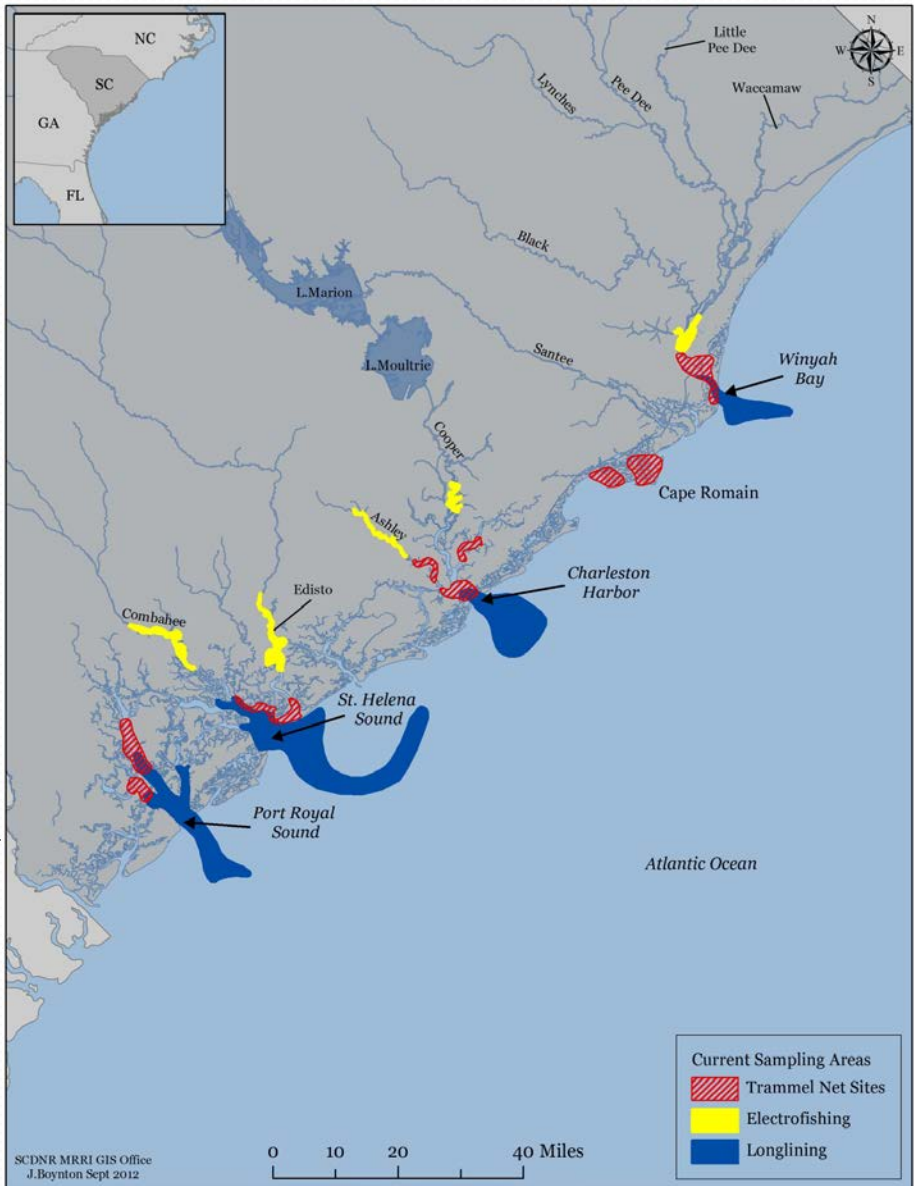
Size Frequency



Trammel Net Survey

Spatial Coverage

- 7 strata in various estuarine systems
  - ACE Basin
  - Ashley River
  - Charleston Harbor
  - Lower Wando River
  - Muddy & Bulls Bays
  - Cape Romain
  - Winyah Bay
- Monthly sampling
  - 10 to 12 sites per stratum sampled
  - Random (w/o replacement) selection from a pool of 22 to 30 sites stratum^{-1}



Spatial/Temporal Coverage

	ACE Basin				Ashley River				Cape Romain				Charleston Harbor			
Year	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
1990							4								8	
1991													23	15	13	20
1992							2	23					12	12	12	12
1993					24	23	24	24					12	12	12	12
1994	21	30	33	16	22	35	34	23					17	20	28	16
1995	32	32	36	35	49	24	29	34					25	30	28	25
1996	35	34	36	22	36	36	33	35					28	29	30	29
1997	36	36	36	24	36	36	36	34		32	36		30	30	30	30
1998	35	31	35	36	34	36	36	36	34	30	37	28	30	30	30	30
1999	34	32	36	36	36	36	36	37	24	36	36	36	30	29	30	31
2000	33	31	36	36	36	36	35	36	35	33	29	36	30	30	29	29
2001	34	32	36	24	37	36	36	36	28	34	36	36	28	29	30	30
2002	34	33	34	36	36	36	36	36	34	30	22	34	30	30	29	30
2003	30	31	24	36	36	36	36	36	33	30	35	35	26	28	29	28
2004	29	34	36	36	34	36	36	35	30	32	35	36	28	30	30	30
2005	35	31	28	34	36	36	36	34	36	24	34	32	27	30	30	28
2006	29	31	20	35	36	35	36	36	35	31	36	34	27	28	29	30
2007	28	34	32	36	36	36	34	36	29	34	22	35	23	29	30	30
2008	30	33	30	36	36	35	35	36	33	23	35	36	30	26	25	29
2009	24	31	34	33	35	34	36	35	32	23	36	34	26	27	30	30
2010	31	36	36	32	36	36	35	36	30	34	36	33	28	30	28	30
2011	35	35	35	35	35	37	34	36	36	34	36	36	28	28	30	30
2012	33	30	32	34	36	35	34	36	36	34	36	34	27	28	29	30
Total	**598**	**617**	**625**	**612**	**702**	**692**	**714**	**687**	**485**	**494**	**537**	**515**	**565**	**580**	**599**	**589**

Spatial/Temporal Coverage

	Lower Wando River				Muddy & Bulls Bay				Winyah Bay				Total			
Year	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
1990			13												25	
1991	44	25	17	45									67	40	30	65
1992	24	23	24	22									36	37	59	34
1993	24	22	24	24									60	57	60	60
1994	24	32	30	24									84	117	125	79
1995	30	25	30	29									136	111	123	123
1996	30	29	30	29									129	128	129	115
1997	30	29	30	29		35	34						132	198	202	117
1998	29	30	30	30	31	23	36	35					193	180	204	195
1999	30	30	29	30	34	35	36	36					188	198	203	206
2000	30	30	30	30	33	34	24	24					197	194	183	191
2001	30	29	30	30	35	36	24	24					192	196	192	180
2002	30	28	30	30	31	33	22	33			7	20	195	197	193	199
2003	30	29	30	29	31	31	32	36	31	32	24	19	217	217	210	219
2004	30	30	30	27	28	34	35	36	29	16	36	35	208	212	238	235
2005	28	30	30	30	31	33	35	32	33	28	35	35	226	212	228	225
2006	30	30	30	30	34	32	23	34	29	32	18	36	220	219	192	235
2007	30	30	30	30	30	28	36	36	33	33	34	33	209	224	218	236
2008	30	28	27	30	35	34	30	33	34	15	21	33	228	194	203	233
2009	30	30	29	30	33	34	23	34	33	24	30	34	213	203	218	230
2010	29	30	30	31	21	29	34	36	19	23	33	20	194	218	232	218
2011	29	29	31	30	34	21	32	24	32	32	30	21	229	216	228	212
2012	20	29	29	30	34	30	36	36	31	30	21	31	217	216	217	231
Total	**641**	**627**	**643**	**649**	**475**	**502**	**492**	**489**	**304**	**272**	**302**	**297**	**3770**	**3784**	**3912**	**3838**

Methodology

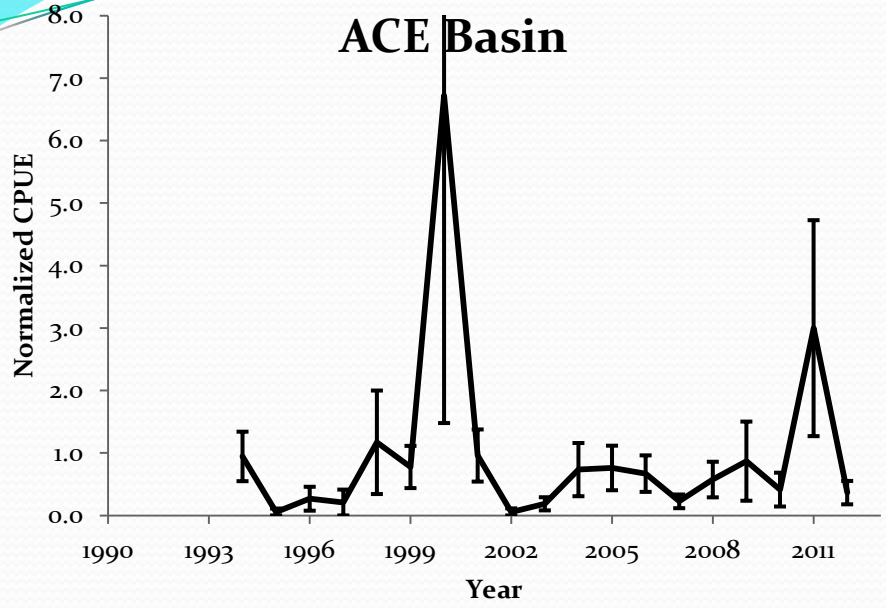
- Trammel net
  - 183 m long x 2.1 m deep
  - Inner panel – 63.5 mm (2.5 in) stretched mesh
  - Outer panel – 355.6 mm (14 in) stretch-mesh
- Set along the shoreline (10 to 20 m from an intertidal marsh flat, <2 m depth) during an ebbing tide
- Targeted species
  - Red drum, spotted seatrout, southern flounder
- Data
  - Biological Data
    - # of individuals and individual lengths
  - Hydrographic/Sampling Data

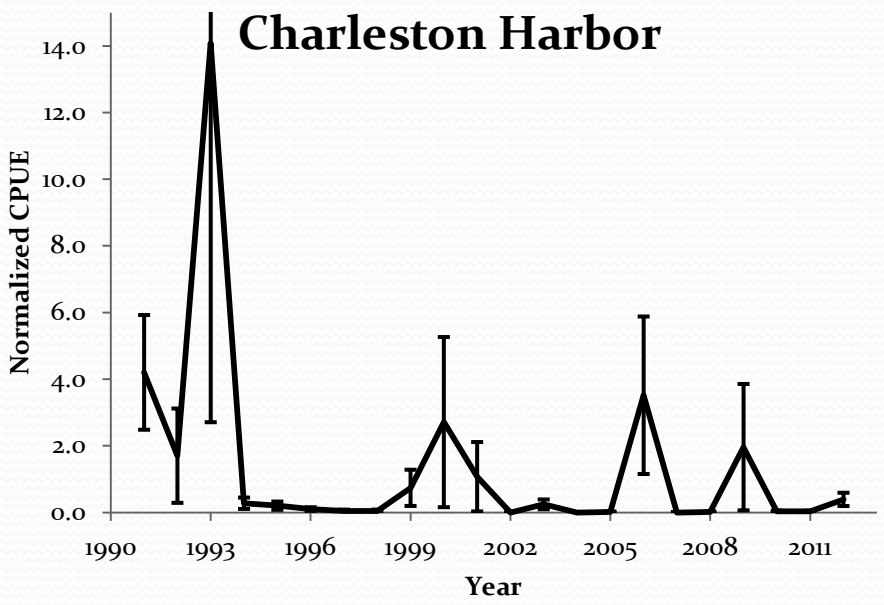
% Positive Trammel Nets by Month

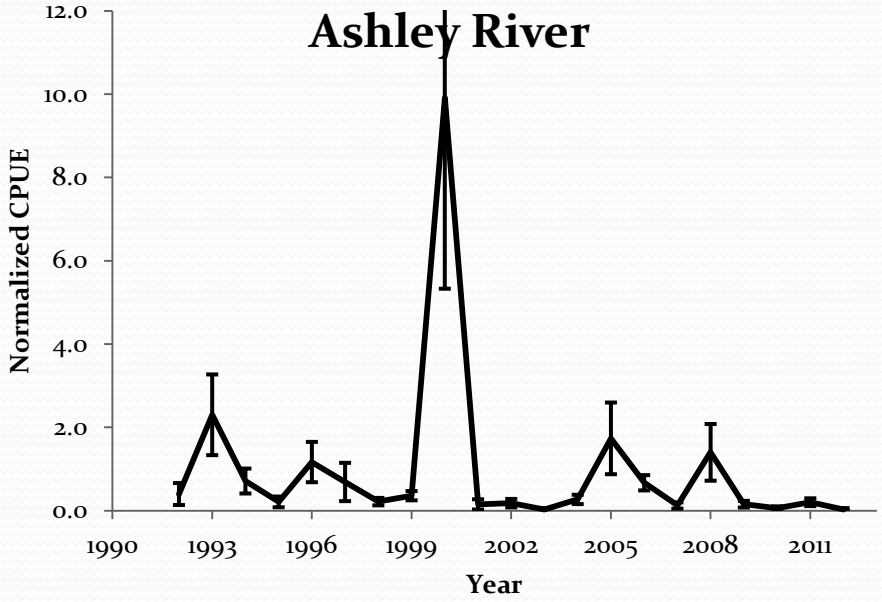
Month	Charleston Harbor	Ashley River	Lower Wando River	ACE Basin	Cape Romain	Muddy & Bulls Bay	Winyah Bay	Total
January	0.5%	2.6%	0.5%	5.5%	3.0%	1.4%	6.1%	2.6%
February	1.0%	3.5%	3.8%	5.0%	2.3%	1.1%	4.0%	3.0%
March	2.0%	3.1%	3.9%	2.6%	5.8%	1.7%	3.1%	3.2%
April	2.6%	0.9%	5.0%	4.4%	5.3%	2.6%	9.9%	3.9%
May	4.8%	3.5%	4.1%	2.5%	7.6%	4.3%	24.5%	5.9%
June	6.6%	5.0%	6.4%	6.6%	13.3%	10.5%	13.3%	8.2%
July	15.4%	14.9%	9.5%	12.8%	21.1%	16.0%	13.4%	14.6%
August	8.4%	17.5%	16.3%	6.3%	19.1%	19.0%	10.0%	14.0%
September	6.2%	11.4%	8.4%	10.6%	19.9%	25.0%	16.0%	13.4%
October	4.6%	10.0%	6.3%	11.3%	14.3%	15.5%	13.5%	10.4%
November	1.5%	2.5%	0.9%	3.2%	10.1%	5.8%	8.9%	4.2%
December	2.0%	0.4%	0.9%	1.5%	5.7%	1.4%	3.8%	2.0%
Total	**4.6%**	**6.3%**	**5.5%**	**6.1%**	**10.6%**	**9.0%**	**10.5%**	**7.1%**

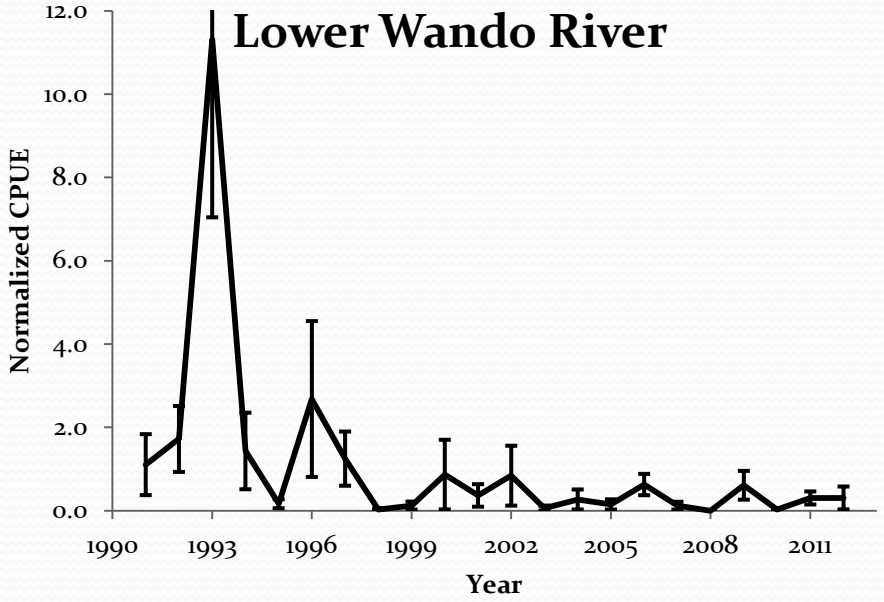
CPUE (June – October Data)

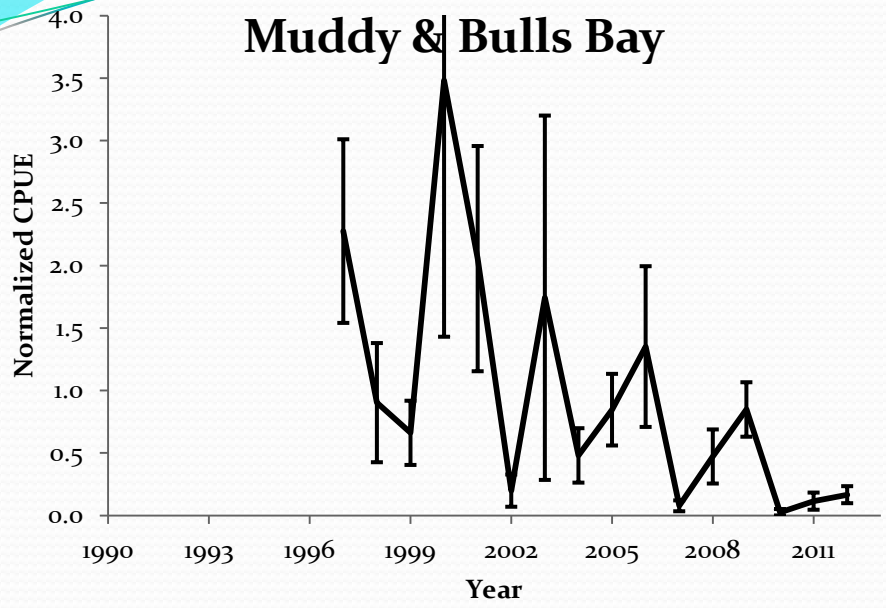
	ACE Basin		Ashley River		Cape Romain		Charleston Harbor		Lower Wando River		Muddy & Bulls Bay		Winyah Bay		All Estuaries	
Year	CPUE	Norm CPUE	CPUE	Norm CPUE	CPUE	Norm CPUE	CPUE	Norm CPUE	CPUE	Norm CPUE	CPUE	Norm CPUE	CPUE	Norm CPUE	CPUE	Norm CPUE
1991							5.9231	4.2032	0.7400	1.1042					2.5132	1.8714
1992			0.2222	0.3988			2.4000	1.7031	1.1538	1.7218					1.3971	1.0403
1993			1.2821	2.3010			19.8500	14.0861	7.5789	11.3095					7.5773	5.6424
1994	0.3043	0.9443	0.3962	0.7111			0.3889	0.2760	0.9600	1.4325					0.5243	0.3904
1995	0.0179	0.0554	0.1167	0.2094			0.2857	0.2028	0.1111	0.1658					0.1286	0.0957
1996	0.0862	0.2675	0.6500	1.1666			0.1429	0.1014	1.7959	2.6799					0.6435	0.4792
1997	0.0667	0.2068	0.3833	0.6880	1.0909	0.3574	0.0600	0.0426	0.8367	1.2486	1.8085	2.2756			0.6581	0.4900
1998	0.3774	1.1708	0.1207	0.2166	0.7692	0.2520	0.0600	0.0426	0.0204	0.0305	0.7174	0.9027			0.3377	0.2514
1999	0.2500	0.7757	0.2000	0.3590	0.8833	0.2894	1.0408	0.7386	0.0816	0.1218	0.5254	0.6611			0.4955	0.3690
2000	2.1667	6.7226	5.5254	9.9170	0.9298	0.3046	3.8200	2.7108	0.5800	0.8655	2.7679	3.4827			2.6718	1.9895
2001	0.3091	0.9590	0.0833	0.1496	1.4545	0.4765	1.5106	1.0720	0.2449	0.3654	1.6333	2.0552			0.8681	0.6464
2002	0.0182	0.0564	0.1000	0.1795	18.1000	5.9291	0.0000	0.0000	0.5625	0.8394	0.1579	0.1987	0.2667	0.0552	2.8503	2.1224
2003	0.0600	0.1862	0.0167	0.0299	0.2500	0.0819	0.3409	0.2419	0.0408	0.0609	1.3846	1.7422	33.4643	6.9302	5.4545	4.0617
2004	0.2364	0.7334	0.1500	0.2692	0.2778	0.0910	0.0000	0.0000	0.1800	0.2686	0.3818	0.4804	4.7632	0.9864	0.6851	0.5101
2005	0.2449	0.7598	0.9667	1.7350	1.2708	0.4163	0.0200	0.0142	0.1000	0.1492	0.6727	0.8465	0.2800	0.0580	0.5193	0.3867
2006	0.2157	0.6692	0.3729	0.6692	18.8000	6.1584	4.9556	3.5166	0.4200	0.6267	1.0741	1.3515	0.7400	0.1532	3.8626	2.8763
2007	0.0727	0.2257	0.0690	0.1238	0.1591	0.0521	0.0000	0.0000	0.0800	0.1194	0.0612	0.0770	0.5455	0.1130	0.1469	0.1094
2008	0.1852	0.5746	0.7797	1.3993	1.4348	0.4700	0.0222	0.0158	0.0000	0.0000	0.3750	0.4718	0.1143	0.0237	0.4353	0.3241
2009	0.2800	0.8688	0.0862	0.1547	3.1556	1.0337	2.7609	1.9592	0.4082	0.6091	0.6739	0.8480	0.2439	0.0505	1.0418	0.7758
2010	0.1333	0.4137	0.0339	0.0608	0.1429	0.0468	0.0435	0.0309	0.0204	0.0305	0.0204	0.0257	0.8571	0.1775	0.1607	0.1196
2011	0.9661	2.9975	0.1129	0.2026	0.2241	0.0734	0.0426	0.0302	0.2041	0.3045	0.0909	0.1144	0.4314	0.0893	0.3108	0.2314
2012	0.1176	0.3650	0.0169	0.0304	0.1379	0.0452	0.5532	0.3926	0.2041	0.3045	0.1321	0.1662	1.8000	0.3728	0.3641	0.2712
Avg.	**0.3223**		**0.5572**		**3.0528**		**1.4092**		**0.6701**		**0.7947**		**4.8288**		**1.3429**	

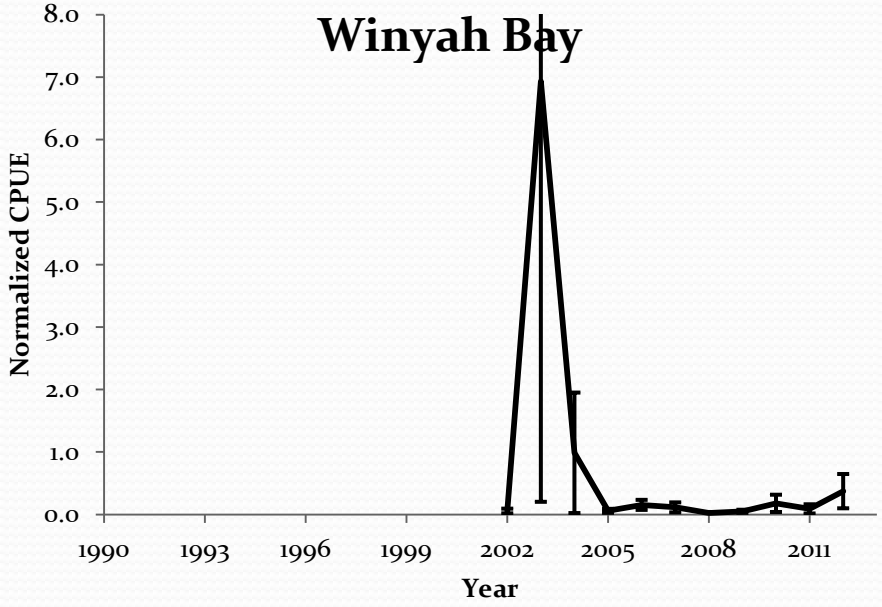

ACE Basin
Normalized CPUE
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1990
1993
1996
1999
2002
2005
2008
2011
Year

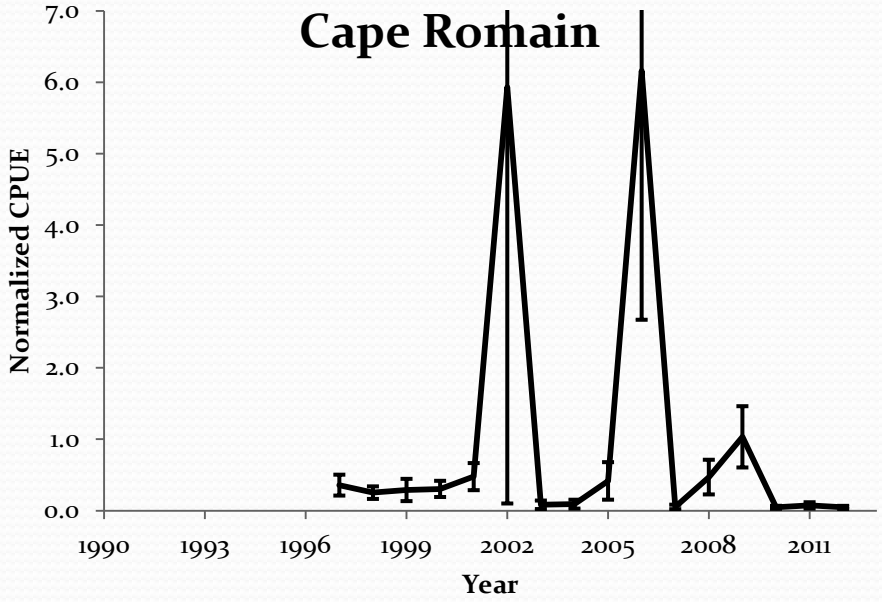

Charleston Harbor
Normalized CPUE
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1990
1993
1996
1999
2002
2005
2008
2011
Year

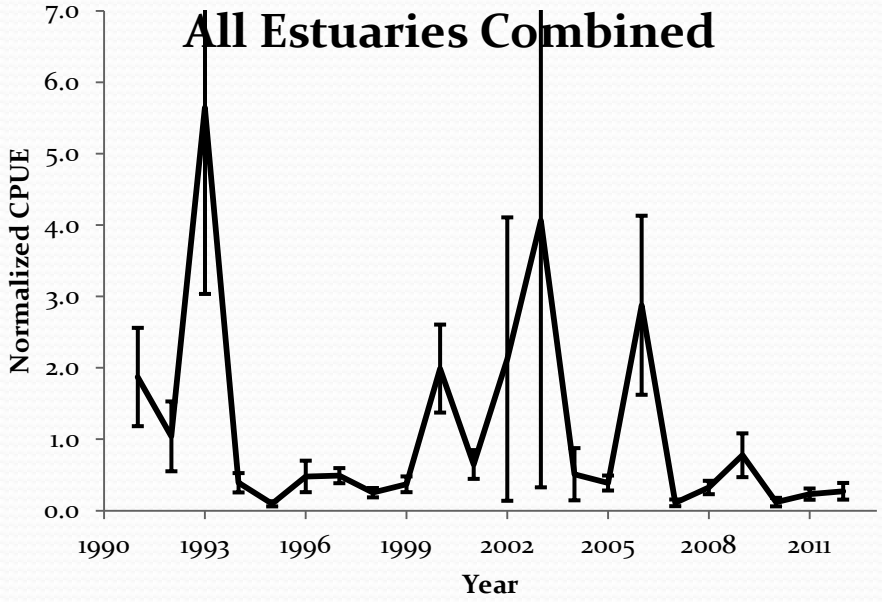

Ashley River
Normalized CPUE
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1990
1993
1996
1999
2002
2005
2008
2011
Year


Lower Wando River
Normalized CPUE
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1990
1993
1996
1999
2002
2005
2008
2011
Year


Muddy & Bulls Bay
Normalized CPUE
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1990
1993
1996
1999
2002
2005
2008
2011
Year


Winyah Bay
Normalized CPUE
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1990
1993
1996
1999
2002
2005
2008
2011
Year


Cape Romain
Normalized CPUE
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1990
1993
1996
1999
2002
2005
2008
2011
Year

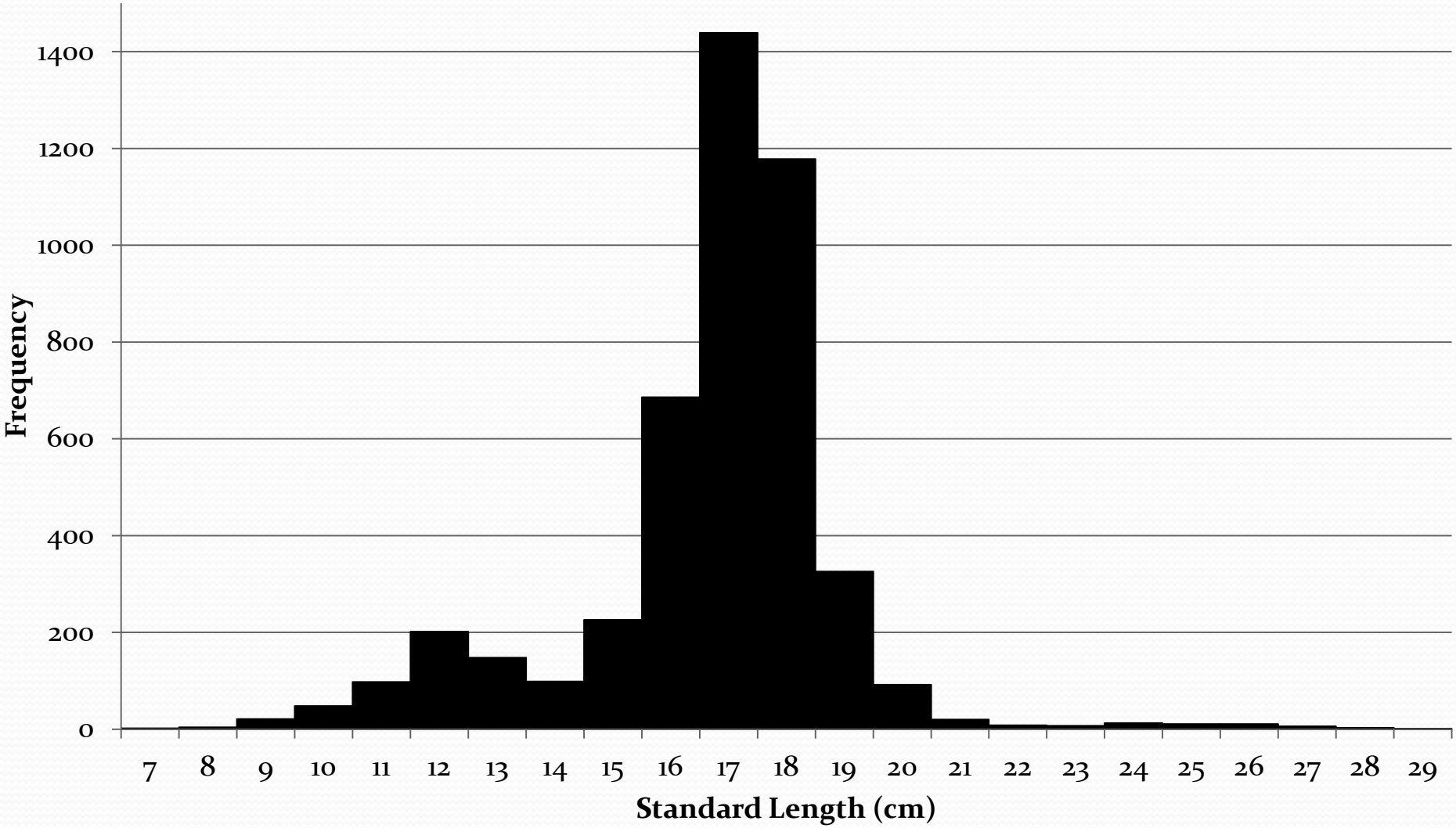

All Estuaries Combined
Normalized CPUE
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1990
1993
1996
1999
2002
2005
2008
2011
Year

Frequency of Catch

Frequency, by Stratum								
Catch	**ACE Basin**	**Ashley River**	**Charleston Harbor**	**Lower Wando River**	**Muddy & Bulls Bay**	**Cape Romain**	**Winyah Bay**	**All Estuaries**
0	929	1035	879	956	692	688	410	5589
1-9	93	122	63	83	131	123	54	669
10-99	5	14	12	16	15	19	7	88
100-999		1	4			4	1	10
1000+							1	1
TOTAL	**1027**	**1172**	**958**	**1055**	**838**	**834**	**473**	**6357**

Percent, by Stratum								
Catch	**ACE Basin**	**Ashley River**	**Charleston Harbor**	**Lower Wando River**	**Muddy & Bulls Bay**	**Cape Romain**	**Winyah Bay**	**All Estuaries**
0	90.46%	88.31%	91.75%	90.62%	82.58%	82.49%	86.68%	87.92%
1-9	9.06%	10.41%	6.58%	7.87%	15.63%	14.75%	11.42%	10.52%
10-99	0.49%	1.19%	1.25%	1.52%	1.79%	2.28%	1.48%	1.38%
100-999	0.00%	0.09%	0.42%	0.00%	0.00%	0.48%	0.21%	0.16%
1000+	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.21%	0.02%
TOTAL	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Size Frequency



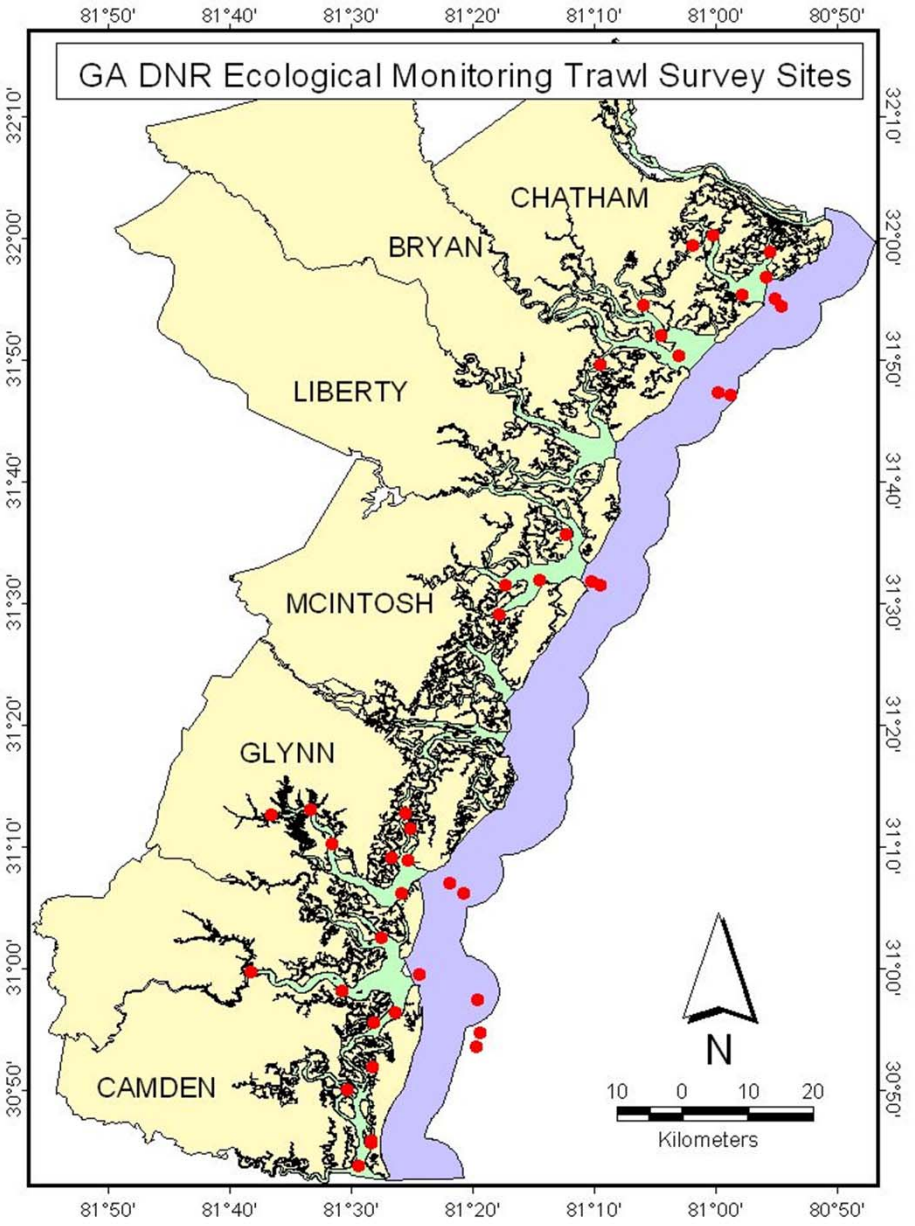
Atlantic Menhaden Data
Collected by GA DNR CRD Ecological Monitoring Trawl Survey
1995-1998, 2003-2012

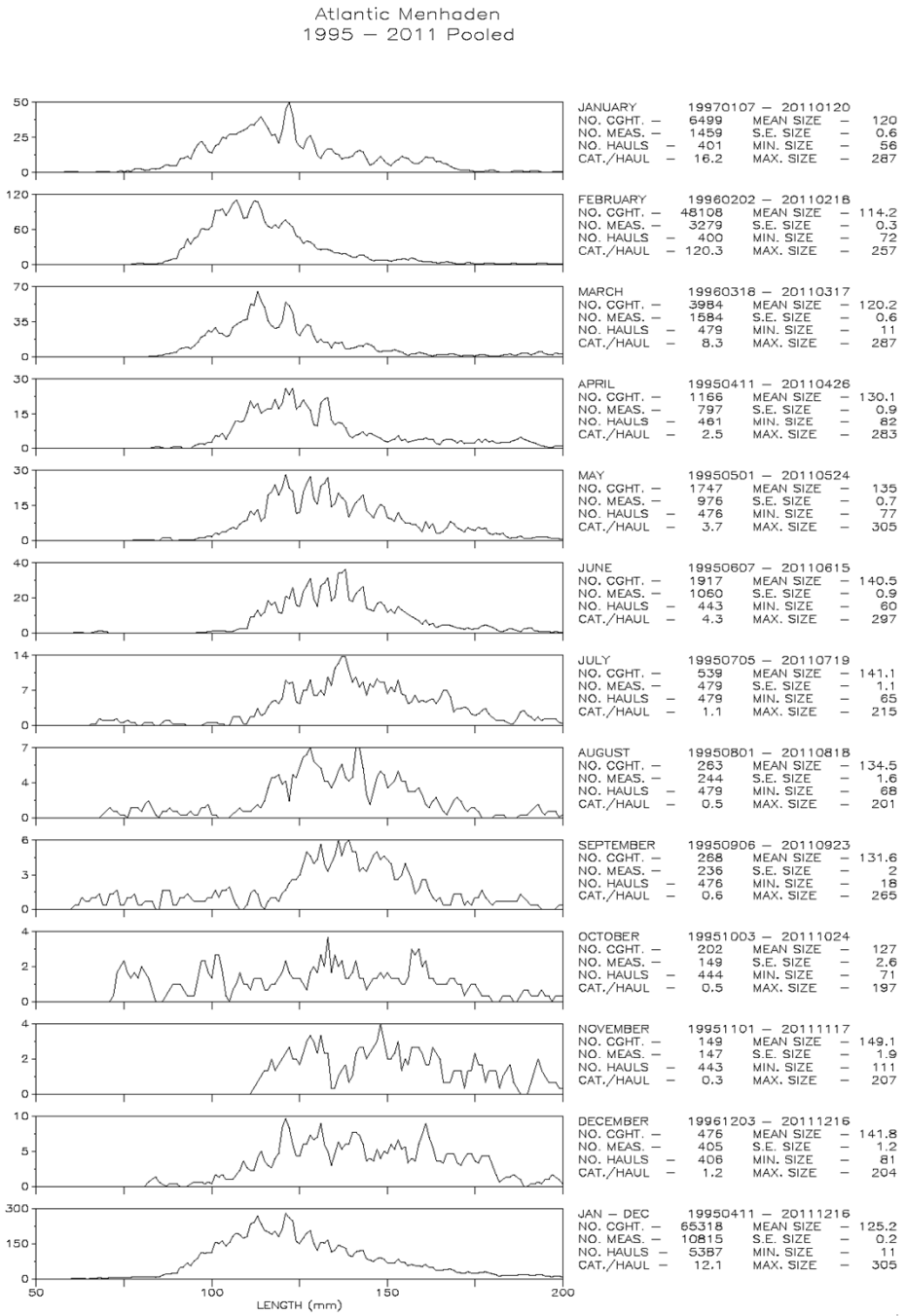
Ecological Monitoring Trawl Survey

- Over 15,000 trawls since 1976.
- 42 monthly stations across 6 sounds (WA, OS, SP, SS, SA, Cu).
- Gear: 40 ft flat trawl net towed for 15 min.
- Monitor abundance, size, and condition of all species.

Purpose:

1) Manage shrimp and crabs
2) Provide estimates of finfish abundance



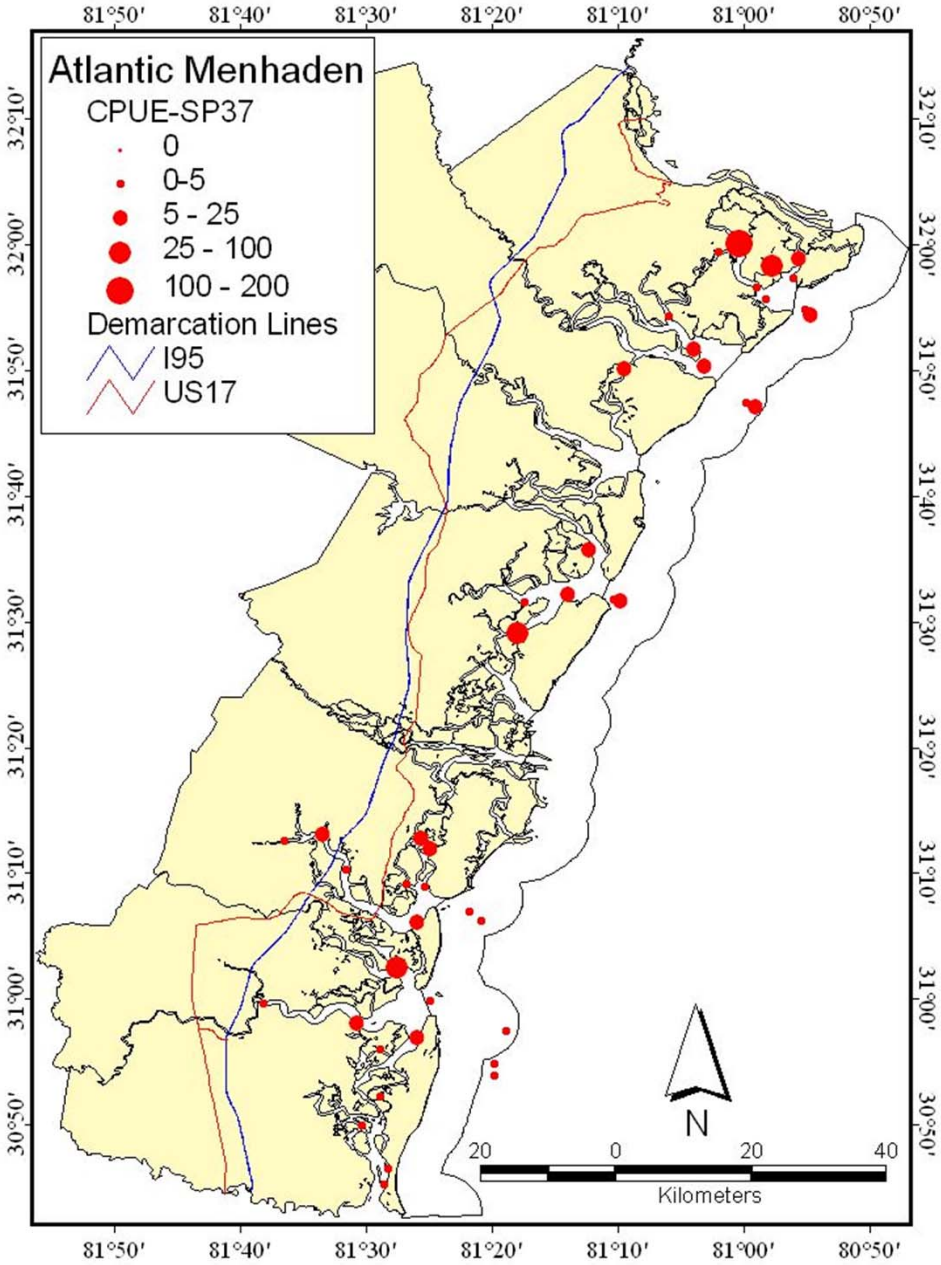


Atlantic Menhaden Length Frequency

Spawning: Nov – Mar Offshore
Larval Development: 1-3 months
Dec-May
Annulli forms: Mar

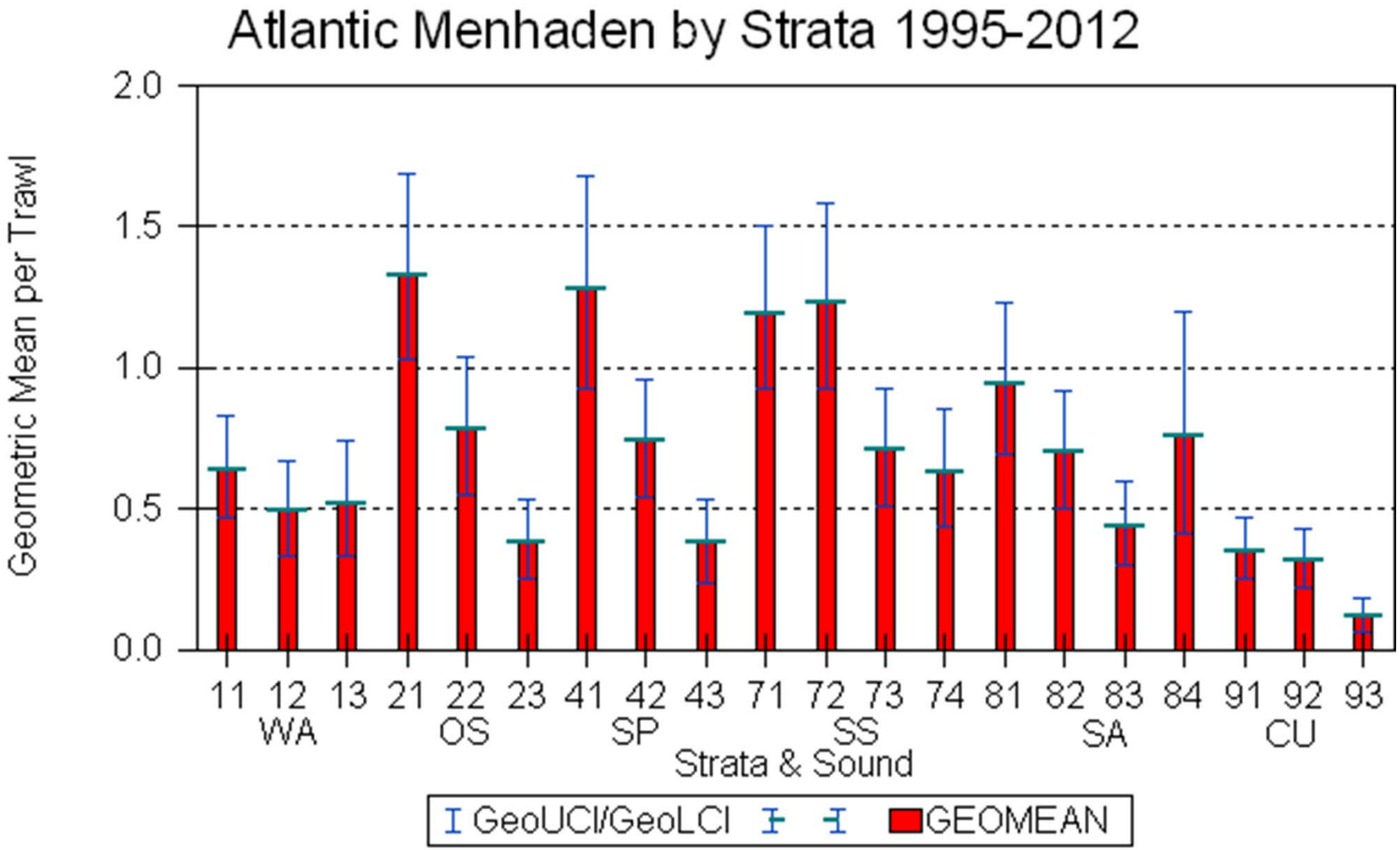
Mature by 3rd year (late Age 2)
180mm FL in SAB, 210mm in MAB

Growth is density dependent



Atlantic Menhaden
By Station

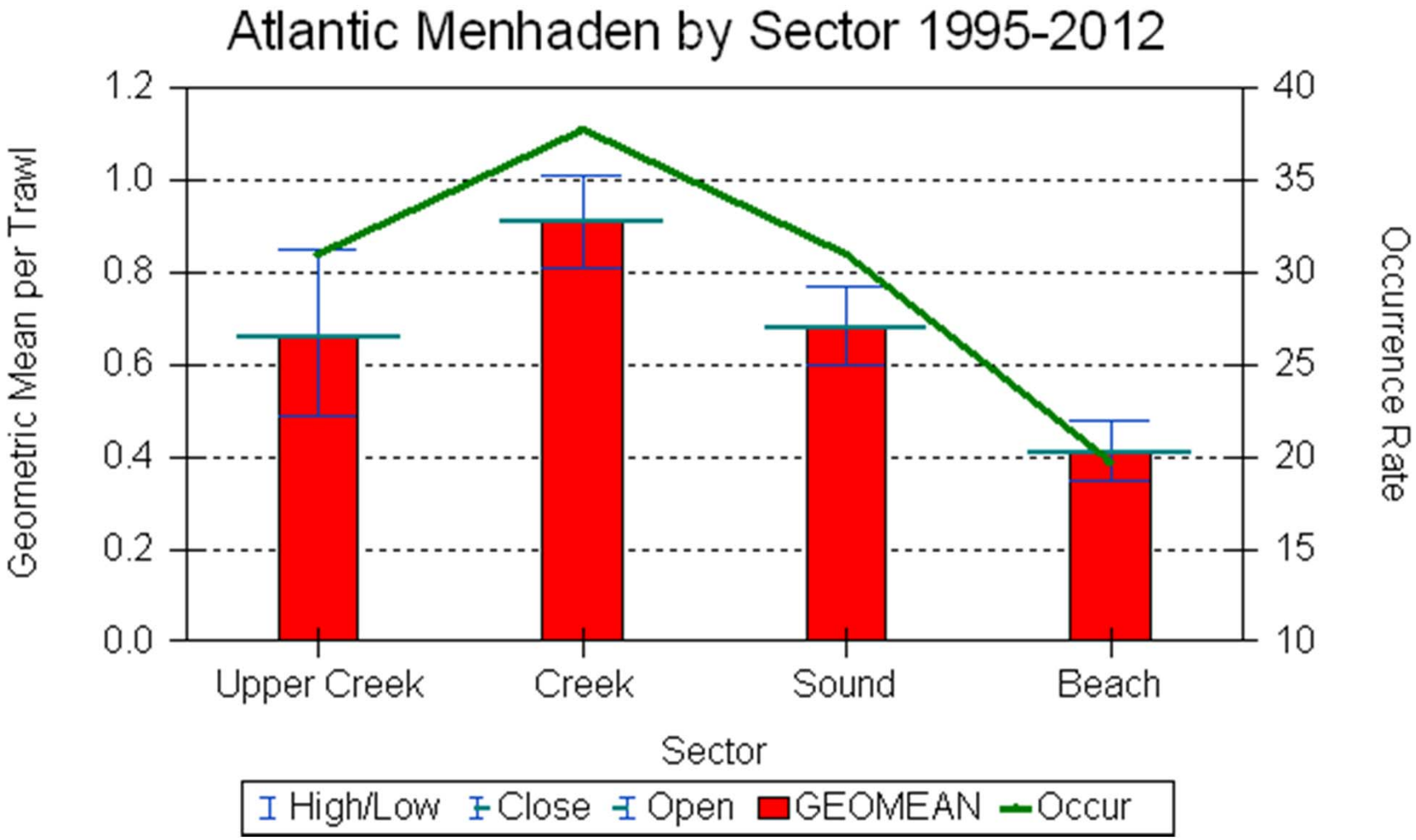
- EMTS 1995-98, 2003-2011
- CPUE = # / standard 15 min trawl

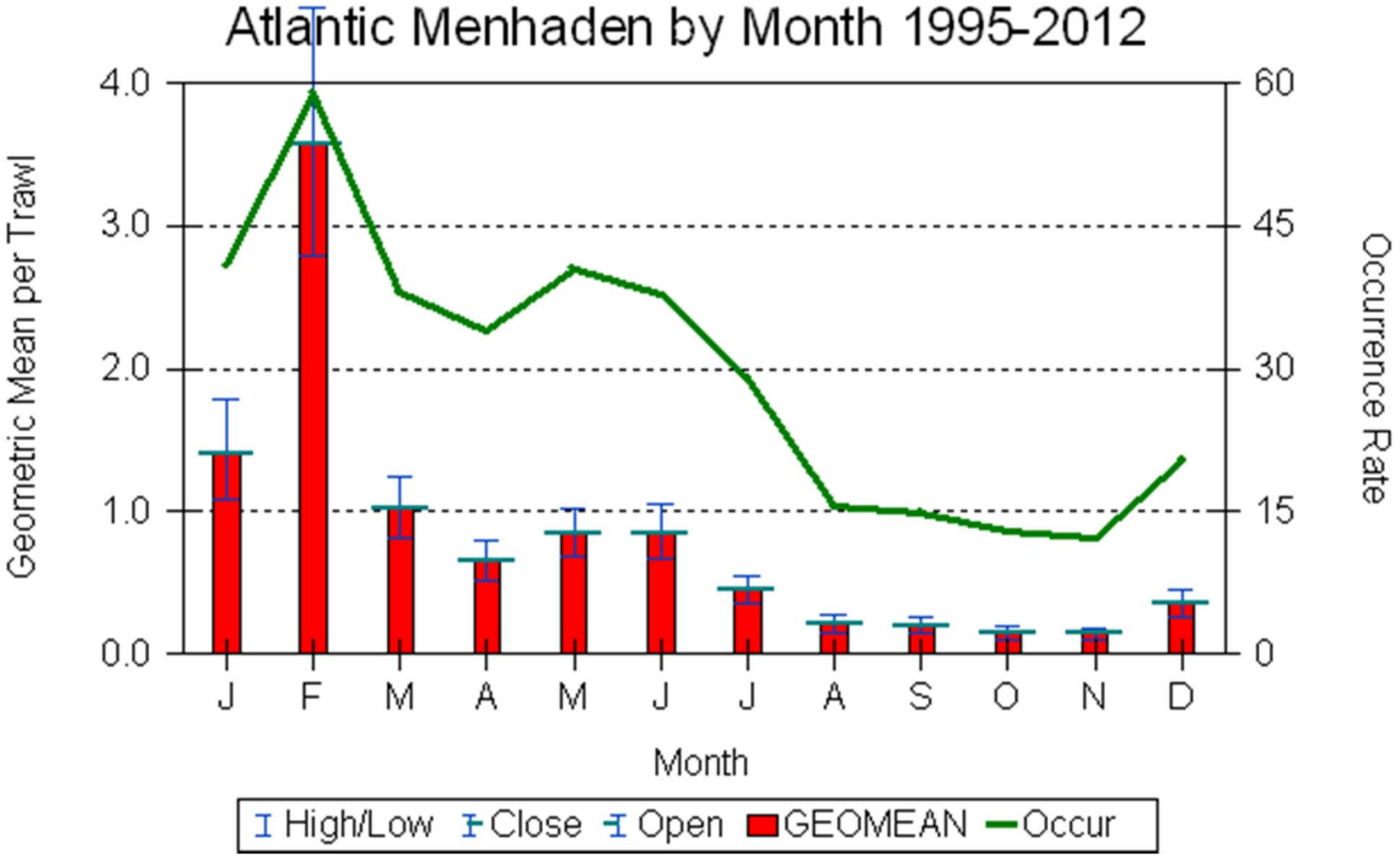


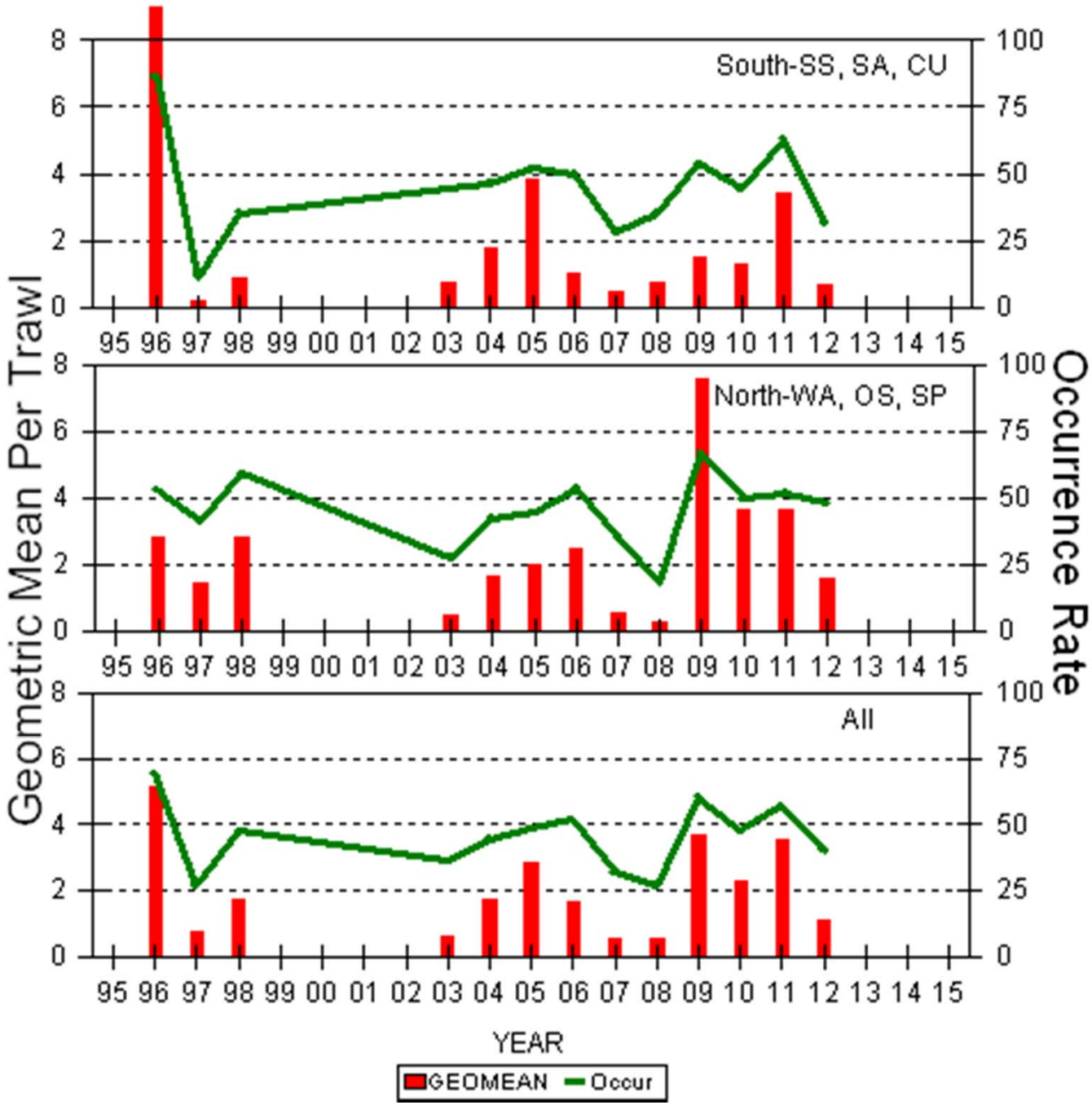
Strata: Character 1 - Sound System, Character 2 - Sector: 1=creek, 2=sound, 3=beach, 4=upriver

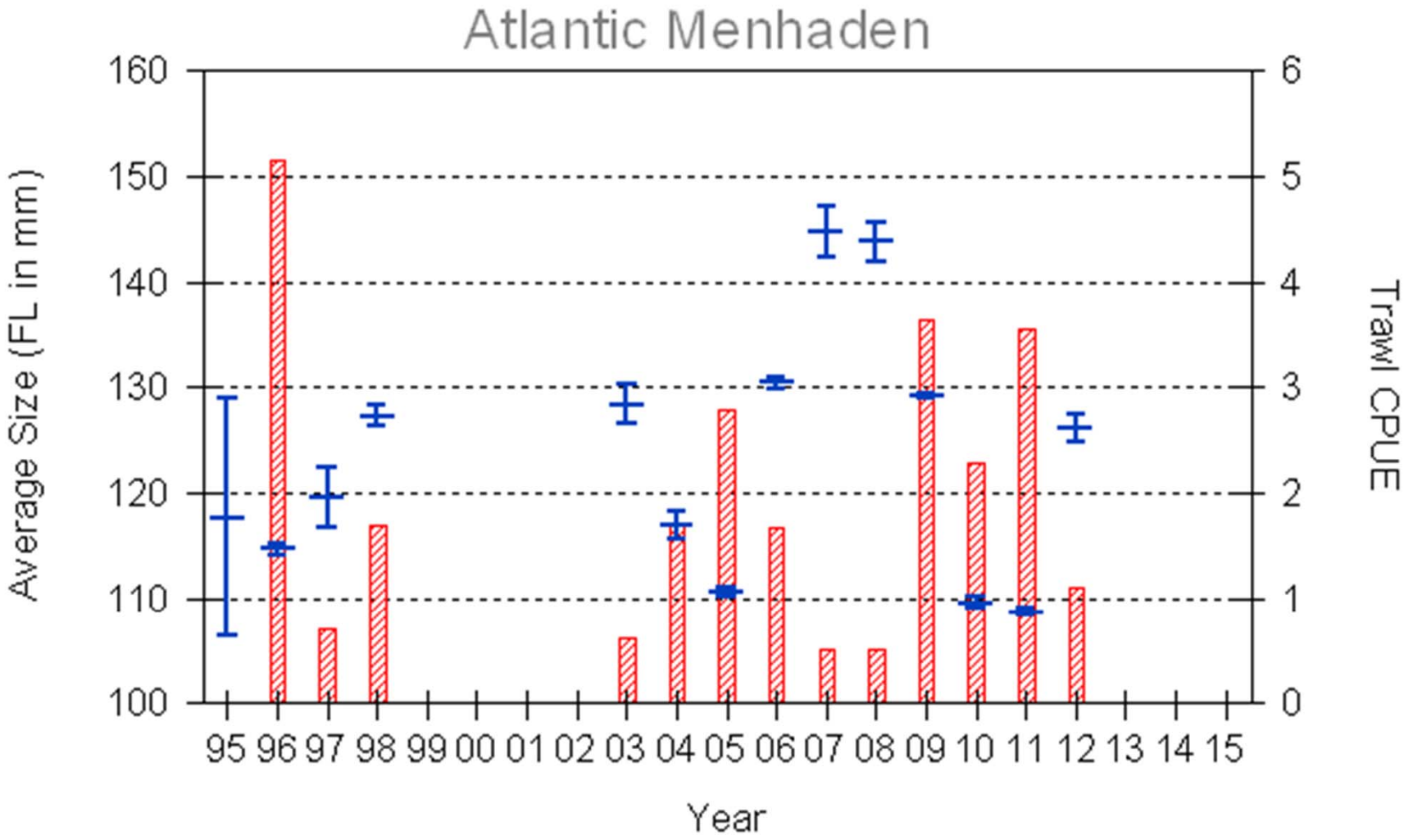
First Character is the Sound: 1=WA, 2=OS, 4=SP, 7=SS, 8=SA, 9=CU

2nd Character is the Strata (sector) 1=creek, 2=sound, 3=beach, 4=upper creek (added 2005)


Atlantic Menhaden by Sector 1995-2012
Geometric Mean per Trawl
Occurrence Rate
1.2
1.0
0.8
0.6
0.4
0.2
0.0
40
35
30
25
20
15
10
Upper Creek
Creek
Sound
Beach
Sector
High/Low
Close
Open
GEOMEAN
Occur


Atlantic Menhaden by Month 1995-2012
Geometric Mean per Trawl
Occurrence Rate
4.0
3.0
2.0
1.0
0.0
60
45
30
15
0
J
F
M
A
M
J
J
A
S
O
N
D
Month
High/Low
Close
Open
GEOMEAN
Occur

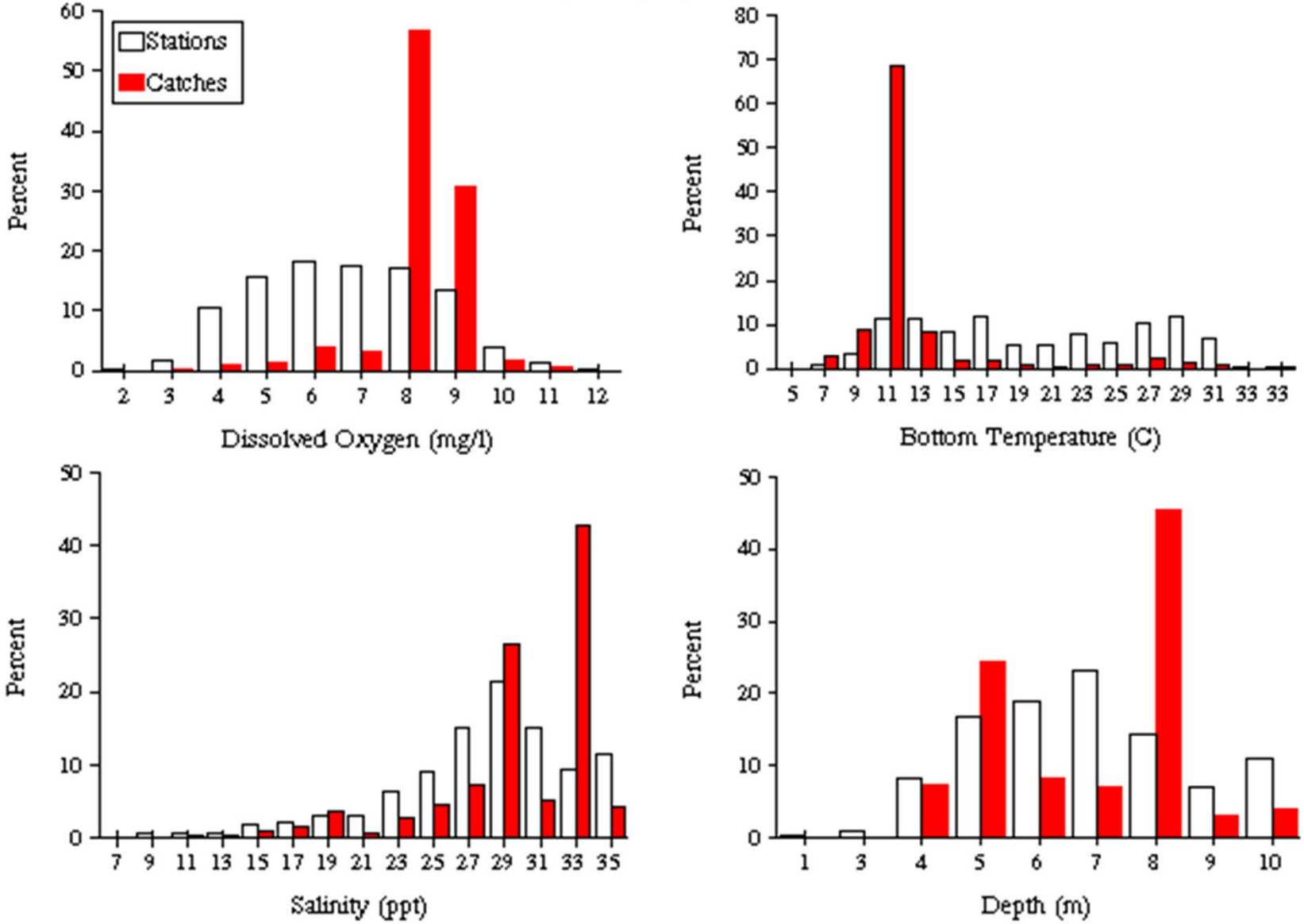

South-SS, SA, CU
North-WA, OS, SP
All
Geometric Mean Per Trawl
Occurrence Rate
YEAR
GEOMEAN
Occur
0
2
4
6
8
0
25
50
75
100
95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15



CPUE = Geometric mean catch per standard 15 minute trawl

Atlantic Menhaden Indices												
Months: Jan-Mar				Areas: Creek, Sound, Beach								
	Geometric Mean				Arithmetic Mean			Catch Info				
Year	Mean	UCI	LCI		Mean	UCI	LCI	MaxCatch	TotCatch	Freq	CatchFreq	Trawls
1995												
1996	5.16	8.67	2.92		64.29	132.29	0.00	2,440	4,629	50	69.44%	72
1997	0.71	1.19	0.33		3.25	5.34	1.16	52	234	19	26.39%	72
1998	1.69	2.53	1.05		12.43	21.34	3.51	434	1,342	51	47.22%	108
1999	No Finfish Sampling Conducted											
2000												
2001												
2002												
2003	0.61	1.06	0.26		1.25	2.01	0.49	9	45	13	36.11%	36
2004	1.70	2.49	1.09		7.78	11.52	4.03	109	840	48	44.44%	108
2005	2.80	4.47	1.64		58.77	115.45	2.08	2,987	6,347	52	48.15%	108
2006	1.68	2.48	1.07		13.07	24.95	1.19	623	1,412	56	51.85%	108
2007	0.52	0.75	0.31		1.57	2.60	0.55	39	170	34	31.48%	108
2008	0.50	0.79	0.27		2.96	5.66	0.27	107	320	29	26.85%	108
2009	3.65	5.92	2.13		307.23	712.36	0.00	20,456	33,181	65	60.19%	108
2010	2.29	3.56	1.38		27.42	44.79	10.04	619	2,961	51	47.22%	108
2011	3.55	5.53	2.18		36.92	63.29	10.56	1,295	3,877	60	57.14%	105
2012	1.10	1.63	0.68		4.70	7.17	2.24	83	494	42	40.00%	105
Overall	**1.76**	**2.01**	**1.53**		**44.54**	**80.26**	**8.82**	**20,456**	**55,852**	**570**	**45.45%**	**1,254**

Atlantic Menhaden Hydrographic Preferences 2006-2011



Menhaden Juvenile Abundance Index Update
November 2011

Fishery-Independent Data – juvenile abundance index

Data collected from seine surveys conducted within several states along the east coast of the U.S. were used to develop indices of relative abundance for juvenile menhaden. The primary objective of these seine surveys is to measure the recruitment strength of species other than menhaden, that is, the underlying sampling protocols were designed to target juvenile striped bass, alosines, or other fishes and species complexes. Although menhaden are a bycatch species in these surveys, the seine catch-per-haul data represent the best available information for the construction of a menhaden juvenile abundance index (JAI).

The calculation of the menhaden JAI was based on data from the following state seine surveys:

- North Carolina alosine seine survey (1972-2010)
- Virginia striped bass seine survey (1967-1973, 1980-2010)
- Maryland striped bass seine survey (1959-2010)
- Connecticut seine survey (1987-2010)
- New Jersey seine survey (1980-2010)
- New York seine survey (1986-2010)
- Rhode Island seine survey (1988-2010)

State seine surveys

The North Carolina Alosine seine survey (Program 100S) has operated continuously from 1972-present in the Albemarle Sound and surrounding estuarine areas. The survey targets juvenile alosine fishes and sampling is conducted monthly from June through October.

The Virginia striped bass seine survey was conducted from 1967-1973 and 1980-present. The survey targets juvenile striped bass following a fixed station design, with most sampling occurring monthly from July through September and occasional collections in October and November. In 1986 the bag seine dimensions were changed from 2 m x 30.5 m x 6.4 mm to the "Maryland" style seine with the dimensions 1.2 m x 30.5 m x 6.4 mm. Rivers sampled in the southern Chesapeake Bay system include the James, Mattaponi, Pamunkey, Rappahannock, and York rivers.

The Maryland striped bass seine survey targets juvenile striped bass and has operated continuously from 1954-present. Survey stations are fixed and sampled in July, August, and September with a beach seine of dimensions 1.2 m x 30.5 m x 6.4 mm. Twenty-two permanent stations within the northern Chesapeake Bay system are sampled with two replicate hauls at each station in four regions: Choptank River, Head of Bay, Nanticoke River, and Potomac River.

The New Jersey striped bass seine survey targets juvenile striped bass and has operated continuously in the Delaware River from 1980-present. The sampling scheme has been modified over the years but the core survey area, sampling locations, and field time frame (June-November) have remained consistent. The current sampling protocol, which was established in 1998, consists of 32 fixed stations sampled twice a month from June through November within three distinct habitats: Area 1 – brackish tidal water; Area 2 – brackish to fresh tidal water; Area 3 – tidal freshwater. A beach seine with dimensions 1.8 m x 30.5 m x 6.4 mm is used for sampling. For the menhaden juvenile index calculation, data from Area 3 were omitted due to the rare occurrences of menhaden in tidal freshwater.

The Connecticut River seine survey targets juvenile alosines in the Connecticut River and has continuously operated from 1987-present. Sampling occurs weekly from July through October with a beach seine of dimensions 2.44 m x 15.2 m x 0.5 cm. Approximately 56 hauls are taken annually from four sites in the lower River located at Deep River, Essex, Glastonbury, and mouth of the Salmon River.

The Rhode Island seine survey targets a variety of fishes in Narragansett Bay and has operated continuously from 1988-present. The survey began with 15 stations in 1988 increasing by one station in each year of 1990, 1993, and 1995, for a total of 18 fixed stations. All 18 fixed stations are sampled in each month from June through October using a beach seine with dimensions 3.05 m x 61 m with mesh size running from 0.635 cm in the wings to 0.476 cm in the bunt.

The New York seine survey targets a variety of fishes in western Long Island Sound and has operated continuously from 1984-present. Sampling occurs with a 61 m beach seine primarily from May through October within three areas: Jamaica Bay, Little Neck Bay, and Manhasset Bay.

Potential biases

Because of the schooling nature of Atlantic menhaden combined with the fact that these seine surveys were originally designed to measure the abundance of other species, it is possible that the menhaden catch data are not truly representative abundance.

Biological Sampling

Length data (in mm) were available for the seine surveys conducted by North Carolina, Virginia, Maryland, and New Jersey; little or no length data are available for the seine surveys conducted by Connecticut, and Rhode Island.

Aging Methods

For state seine surveys (North Carolina, Virginia, Maryland, New Jersey, and New York) with length data, catch-per-haul data were adjusted based on the convention cut-off sizes by month for juvenile menhaden adopted by the Atlantic menhaden Technical Committee in March 2003. Juvenile length cutoffs were defined as: June 1-June 30, 110 mm FL; July 1-August 15, 125 mm FL; and August 16-November 30, 150 mm FL.

Coastwide Index

A coastwide index of juvenile menhaden abundance was developed by combining the state-specific seine data into a single dataset. As noted in the most recent menhaden stock assessment, examination of the raw catch-per-haul data for each state indicated that each data set contained a high proportion of zero catches, or alternatively, a low proportion of hauls where at least one juvenile menhaden was captured (ASMFC 2010). Zero catches can arise for many reasons, and it was reasoned that the use of an active sampling gear combined with the schooling nature of menhaden was the likely cause (Maunder and Punt 2004). Although a variety of strategies can be used to deal with zero catches, in the most recent stock assessment a delta approach was adopted where the probability of obtaining a zero catch and the catch rate, given that the catch is non-zero, were modeled separately (Maunder and Punt 2004). The general form of a delta model is:

$$\Pr(Y = y) = \begin{cases} w & y = 0 \\ (1 - w)\, f(y) & \text{otherwise} \end{cases}$$

Based on analyses described in the most recent assessment report, the probability of obtaining a zero observation was modeled using the binomial distribution and the distribution used to model the non-zero catches was assumed to be lognormal (ASMFC 2010). The delta-lognormal GLM used to develop the coastwide juvenile relative abundance index included *year*, *month*, and *state* as fixed factors. All statistical analyses were conducted using the software package R, version 2.11.0 (R Development Core Team, 2010).

State-Specific Indices

Indices of relative menhaden juvenile abundance were also developed for each state separately. A delta-lognormal GLM that included *year* and *month* as fixed factors was fitted to the state-specific data.

The index trends from the late 1990s through the mid 2000s are generally variable but higher in more northerly states when compared to the more southerly states (Figure 2). The 2009 and 2010 index years are either roughly the same or lower than previous years for all states except Virginia. The Virginia index values for those years are the highest when compared to the previous 15 years.

Results

The trend of the coastwide index is generally low during the 1960s, high from the mid 1970s to mid 1980s, and low to moderate from the mid 1980s to the present (Figure 1). Over the past 20 years, noteworthy strong year-classes occurred in 1999 and 2005.

The state-specific index trends from the late 1990s through the mid 2000s are generally variable but higher in more northerly states when compared to the more southerly states (Figure 2). The 2009 and 2010 index years are either roughly the same or lower than previous years for all states except Virginia.

Correlation analysis indicates strong correlation ($r > 0.65$) between the coastwide index and the four most southern state indices (NC, VA, MD, NJ). In comparison, NY, CT, and RI had Pearson correlation coefficients of 0.35 or less. Although recruitment from all areas is important, the strong influence of the southern state indices on the coastwide index corresponds well with the general understanding that the Chesapeake Bay region is the epicenter of menhaden recruitment (J. Smith, personal communication).

The Virginia index values for 2009 and 2010 are the highest values in nearly two decades for that survey. Strong recruitment in this region in recent years is corroborated by an increase in the percentage of age-1 individuals in the Chesapeake Bay harvest.

Literature Cited

ASMFC. 2010. Atlantic Menhaden Stock Assessment and Review Panel Reports. Stock assessment report 10-02 of the Atlantic States Marine Fisheries Commission. Washington DC. 326p.

Maunder, M.N. and A.E. Punt. 2004. Standardizing catch and effort data: a review of recent approaches. Fisheries Research 70:141-159.

R Development Core Team. 2010. R: A Language and Environment For Statistical Computing. Vienna: R Foundation for Statistical Computing.

Figure 1. Coastwide juvenile abundance index (black line) based on the delta-lognormal GLM with fixed factors *year*, *month*, and *state* fitted to seine catch-per-haul data for 1959-2010 from all states combined. Coefficients of variations (CV; grey line) were calculated from jackknifed derived SEs.

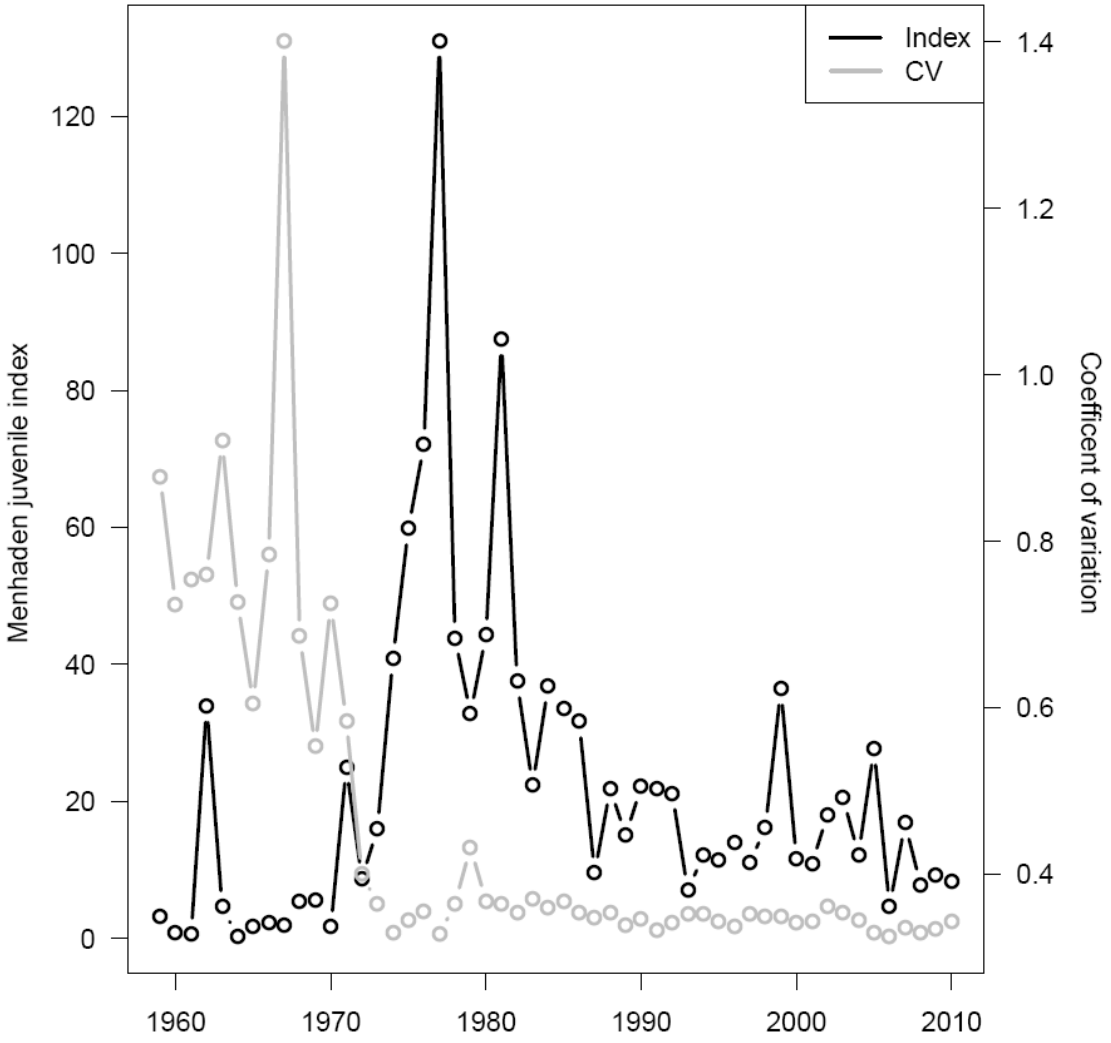


Figure 2. State-specific juvenile abundance indices (black line) based on the delta-lognormal GLM with fixed factors *year* and *month* fitted to seine catch-per-haul data. Coefficients of variations (CV; grey line) were calculated from jackknifed derived SEs.