

JOB 8: ESTUARINE SEINE SURVEY

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Beach seining with 25' bag seine.

JOB 8: ESTUARINE SEINE SURVEY

GOAL

To monitor the abundance and size composition of near-shore young-of-year and forage fish resources, with physical habitat parameters, in order to evaluate the effects of fishing and environmental conditions on the distribution and abundance of marine resources in Long Island Sound.

OBJECTIVES

- 1) *Provide an annual index of recruitment for winter flounder (Age0, 1+), all finfish species taken, and all crab species.*
- 2) *Provide an annual total count for all finfish taken.*
- 3) *Provide an index for shallow subtidal forage species abundance.*

METHODS

Eight sites (Figure 8.1) are sampled during September using an eight-meter (25 ft.) bag seine with 6.4mm (0.25 in.) bar mesh. Area swept is standardized to 4.6 m (15 ft.), width by means of a taut spreader rope and a 30m (98 ft.), measured distance, parallel to, or at a 45° angle to the shoreline, against the current or tide if present. At each site, six seine hauls are taken within two hours before and after low slack tide during daylight hours. All sites have been sampled since 1988 except Milford which was added in 1990.

Finfish, crabs, and other invertebrates taken in each sample are identified to species or lowest practical taxon (full listing given in Appendix 8.1, 8.2) and counted. One exception is inland silverside, which are not separated from Atlantic silverside because they are rare and difficult to identify. Qualitative counts were used for menhaden when abundant ($n > 1000$) to minimize discard mortality. Winter flounder are measured to total length (mm), and classified as young-of-year (YOY) if less than 12 cm and age 1+ if 12cm or larger. The age of flounder near this size was verified in 1990-1992 by examination of the sagittal otolith. Physical data recorded at each seine location included water temperature and salinity at one-meter depth. The geometric (retransformed natural log) mean catch per standard haul is calculated for total finfish catch and individually for the 22 most abundant species, with separate indices for young-of-year (YOY) and winter flounder age 1 and older. Winter flounder YOY catch is also reported for each site. Confidence intervals (95%) for each geometric mean are retransformations of the corresponding log intervals. Frequency of occurrence is given as a percentage of all samples taken each year.

Diversity in the catch, or species richness, was computed for finfish species captured in the Survey over the time series. Species were divided into three groups based on their temperature preferences and seasonal spawning habits as documented in the literature.

Criteria used to assign species into a cold temperate group, warm temperate group, or subtropical group are listed in Job 5.

RESULTS

A total of 48 seine hauls were taken in 2016 at eight sites, yielding a total catch of 13,466 fish of 28 species and 16,072 invertebrates of 17 species. Geometric mean catch of all finfish (159 fish/haul) was above the 29-year time series median of 139 fish/haul (Figure 8.2). Although total catch has varied considerably year to year, the increasing trend is significant ($df=28$, $r^2=0.11$, $p=0.048$). Dominant species contributing to this increase include young-of-year (YOY) black sea bass, tautog, scup (porgy), northern kingfish, striped searobin, and menhaden.

Geometric means were calculated for 22 species commonly captured since the survey began in 1988 (Table 8.1). The most frequently caught species was Atlantic silverside, which occurred in all samples, followed by black sea bass, striped killifish, tautog, snapper bluefish and northern pipefish (Table 8.2). This rank order has changed from previous years, with a notable decrease in winter flounder YOY (Figure 8.3) grubby, and windowpane flounder.

Scup, snapper bluefish, black sea bass and northern kingfish occurrence and abundance showed a marked increase above the 28 year time series average in 2015, with record high abundance for the time series (Tables 8.1 and 8.2). Occurrence of striped searobin and inshore lizardfish also ranked high in the time series. Windowpane flounder remained absent in 2015 after low abundance was observed in 2011 and 2014, and no presence recorded in 2009-10 and 2012-13 (Table 8.1).

Relative Abundance of Juvenile Winter Flounder and Tautog

The 2016 index of YOY winter flounder (0.6 fish/haul) is similar to the 2015 index and continued a modest increase from the record low abundance observed in 2013 (Table 8.3, Figure 8.3). The time series has a significant negative trend ($r^2=0.36$, $p<0.001$, $df=28$), and indicates that a relatively strong year class has not been produced since 1996 (Table 8.1, Figure 8.3). As in previous years, highest abundance was seen at eastern sites (Groton, Waterford, Old Lyme) and Greenwich. Three of the eight sites had no catch (Table 8.3) and the frequency of occurrence of this species has decreased over the time series (Figure 8.3) indicating that juvenile production has contracted in several areas of the Sound. Mean length of YOY winter flounder captured at all sites in 2016 was 59.9mm and shows no trend over the 29-year time series, ranging from 47.3 to 71.1mm.

The 2016 index of YOY tautog (1.1 fish/haul) was near to near the series average of 1.0 tautog /haul, a decline from 2015, the highest abundance in the time series (Table 8.1, Figure 8.4). Overall, the time series has a significant increasing trend ($r^2=0.25$, $p=0.004$, $df=28$). Relatively abundant year classes have been produced in 1998-1999, 2002-2004, 2007-2008, 2012 and 2014-2015. The frequency of occurrence of this species has also

increased over the time series (Figure 8.4) indicating that juvenile production and survival is improving in several areas of the Sound.

Presence of Other Important Recreational Finfish

YOY scup and black seabass are recent additions to the seine survey (Table 8.1, Figures 8.5 and 8.6). Scup occurred in 1999 but the highest relative abundance has been in the last five years of the time series. In 2015 the species was present in record numbers and the 2016 index (1.3 fish/haul) remains above the time series mean (0.8 fish/haul).

YOY black sea bass first appeared in Survey catches in 1991 and every year since 1998, reaching their record highest recorded abundance in 2015 (2.8 fish/haul). The 2016 index (1.9 fish/haul) is the third highest in the time series, behind 2014 and 2015.

YOY bluefish show a pattern similar to black seabass, first appearing in the catch in 1991 and remaining consistent since 1998. Their abundance increased dramatically in 2014 and 2015, returning to average abundance for the time series (0.26 fish/haul) in 2016 (Table 8.4)

Relative Abundance of Forage Species

Seine survey catches are numerically dominated by forage species, defined here as short-lived, highly fecund species that spend the majority of their life cycle inshore where they are common food items for piscivorous fish. An index of forage fish abundance was generated using the catch of four of the most common forage species caught: Atlantic silverside, striped killifish, mummichog, and sheepshead minnow (Figure 8.7). The 2016 index (99 fish/haul) was near the mean (98 fish/haul) for the time series, decreasing from the 2015 index which was the second highest.

Although numerically driven by the abundance of silverside, all four forage fish species increased in abundance and occurrence in 2015 and were at or above their time series mean in 2016. Over the 29 year time series, the forage index has shown considerable variability, common for short-lived forage species, with no significant trend (r^2 0.06, $p=0.12$, Figure 8.7).

Relative Abundance of Invertebrate Species

A total of 16,068 invertebrates comprised of 16 species were captured in 2016 (Table 8.6, Appendix 8.2), similar to 2015. Six crab species were present in the seine hauls, along with three shrimp species, one gastropod and one bivalve. Mud snail, sand shrimp, shore shrimp, green crab, and hermit crab were the most abundant and were observed more than 50% (Table 8.3).

Blue crabs were captured in the Groton, Waterford, Clinton and Milford sites at relatively low abundance in 2016 (n=6 crabs) down from a time series high in 2009 (n=333 crabs). A single Asian shore crab was observed in the Old Lyme site in 2016. The shore shrimp returned to moderate abundance in 2016, after increasing substantially in 2014-2015, while sand shrimp decreased significantly (Table 8.3). Spider crab abundance has also increased nearly ten-fold since 2011 compared to earlier years, with the highest catch observed in 2016.

Finfish Species Richness

Over the 29-year time series, the mean number of cold temperate species captured per seine haul (Figure 8.8, Table 8.7) shows a negative trend ($r^2=0.20$, $p=0.01$). In contrast, the mean number of warm temperate species captured per haul has increased significantly ($r^2=0.61$, $p<0.001$), from about three to more than seven over the time series.

MODIFICATIONS

None.

Table 8.1: Geometric mean catch of finfish species commonly captured in seine samples, 1988-2016. See Appendix 8.1 for complete taxonomic names.

Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
alewife	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
American sand lance	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
American shad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Atlantic menhaden	0.1	0.0	0.0	0.0	0.5	0.0	0.1	0.0	0.0	0.1	0.4	0.4	0.4	0.0	1.0	8.2
Atlantic silverside	68.2	31.6	45.0	88.5	51.2	42.7	37.7	27.0	17.7	23.1	74.3	102.5	99.7	36.1	80.1	113.6
Atlantic tomcod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
black sea bass	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.1	0.0	1.0	0.4	0.2
blueback herring	0.0	0.1	0.0	0.5	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1
bluefish	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.9	0.0	0.1	0.0	0.2
cunner	0.2	0.3	0.0	0.1	0.2	0.0	0.3	0.2	0.3	0.0	0.3	0.5	0.3	0.2	0.3	0.2
fourspine stickleback	0.3	0.4	0.0	0.7	0.1	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0
grubby	0.8	0.1	0.0	0.1	0.5	0.1	0.4	0.3	0.2	0.3	0.2	0.5	0.1	0.2	0.3	0.5
inshore lizardfish	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.4	0.1	0.2	0.2	1.2	0.0	0.0
mummichog	2.8	1.6	1.1	1.9	1.6	3.7	3.3	0.7	1.2	0.5	2.0	0.8	3.2	1.4	3.4	2.9
naked goby	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
northern kingfish	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.2	0.1	0.2
northern pipefish	0.7	0.3	0.4	1.0	0.9	0.9	1.1	0.5	1.0	0.4	2.1	1.0	1.0	1.4	0.5	0.3
northern puffer	0.1	0.3	0.1	0.4	0.1	0.4	0.2	0.5	0.2	0.1	0.1	0.2	0.6	0.2	0.7	0.7
rainbow smelt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
scup	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0	0.6
sheepshead minnow	0.8	1.0	0.1	0.6	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.4	0.2	0.6	0.7
smallmouth flounder	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.3	0.0	0.1	0.0	0.0
striped bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
striped killifish	11.9	7.9	5.9	4.2	3.1	4.9	5.1	3.9	2.0	1.5	7.2	4.5	8.6	7.5	14.5	14.9
striped searobin	0.2	0.2	0.1	0.2	0.1	0.9	0.1	0.0	0.1	0.4	1.9	0.6	0.1	0.4	0.3	0.7
summer flounder	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tautog	0.3	0.1	0.3	0.7	0.4	0.2	0.8	0.7	0.3	0.2	0.9	1.3	0.5	0.6	1.5	1.1
weakfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
windowpane flounder	0.6	0.1	0.2	0.2	0.3	0.3	0.1	0.2	0.7	0.4	0.1	0.1	0.1	0.0	0.0	0.1
winter flounder-age 1+	0.2	0.1	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0
winter flounder YOY	15.4	1.7	2.9	5.2	11.9	5.7	14.2	10.1	19.2	7.5	9.2	8.7	4.3	1.3	3.1	8.1

Table 8.1 *continued*: Geometric mean catch of finfish species commonly captured in seine samples, 1988-2016. See Appendix 8.1 for complete taxonomic names.

Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
alewife	0	0	0	0	0	0	0	0	0	0	0	0	0.0
American sand lance	0	0	0	0	0	0	0.1	0	0	0	0	0	0.0
American shad	0	0	0	0	0	0	0	0	0	0	0	0.1	0.0
Atlantic menhaden	0.4	0.2	0.4	0.6	0.1	0.3	0	0.1	0.03	0.08	1.2	9.9	0.4
Atlantic silverside	85.1	81.3	37.7	74.9	57.5	66.8	96.9	66.5	44.9	34.9	64.8	114.5	73.0
Atlantic tomcod	0	0	0	0	0	0	0	0.1	0	0	0	0	0.0
black sea bass	0.4	0.1	0.5	0.6	0.3	1.1	0.4	3.2	5.2	3.7	10.8	16.3	5.8
blueback herring	0	0	0	0	0	0	0	0	0.01	0.01	0	0.1	0.0
bluefish	0.2	0.1	0.2	0	0	0.3	0	0.2	0.4	0.2	0.8	3.4	0.3
cunner	0.5	0.3	0.1	0.5	0.1	0.2	0.1	0	0.4	0.02	0.5	0.1	0.0
fourspine stickleback	0	0	0	0	0	0	0	0	0	0	0.15	0	0.0
grubby	1.3	0.8	0.3	0.3	0.2	0.5	0.3	0.7	0.2	0.2	0.2	0.2	0.0
inshore lizardfish	0	0	1.9	0.2	0.3	0.2	0.1	0.2	0.2	0.13	1.6	0.4	0.0
mummichog	2.3	1.5	2.5	7.3	2.9	3.8	1.7	3.1	1.6	0.9	5	5.3	2.2
naked goby	0	0	0.1	0	0	0	0	0	0.06	0.05	0.08	0.04	0.0
northern kingfish	0.3	0.1	0	0	0.2	0.3	0.5	0.2	0.5	0.7	1.1	1	0.1
northern pipefish	0.7	0.5	0.6	0.8	0.7	1.9	0.6	1.1	1.4	1.7	2.6	2	0.5
northern puffer	0.7	0.5	0.4	1.2	0.2	0.3	0.4	0.4	0.9	1.1	1.1	1.4	0.2
rainbow smelt	0.2	0	0	0	0	0	0	0	0	0	0	0	0.0
scup	0.2	0.9	0.1	1	0.1	1.9	0.1	0.2	2.1	0.12	2.6	9.5	1.3
sheepshead minnow	0.5	0.2	0.2	3.3	1.2	0.5	0.3	0.5	0.8	0.2	0.6	0.3	0.5
smallmouth flounder	0	0	0	0	0.1	0.2	0.1	0.9	0.4	0.5	0.1	0.2	0.1
striped bass	0	0	0	0	0	0	0	0	0	0	0	0	0.0
striped killifish	12.9	19.4	7.1	21.2	21.7	12.3	15.9	28.7	5.3	3.8	14.5	17.1	10.2
striped searobin	0.5	0.2	0.1	0.3	0.3	0.8	0.2	0.1	0.08	0.17	1.1	0.7	0.0
summer flounder	0	0	0.2	0.1	0.1	0	0.1	0	0.08	0.1	0.04	0.1	0.0
tautog	1.4	0.7	0.4	2.4	1	0.4	0.4	0.3	1.3	0.6	3.5	4.8	1.1
weakfish	0	0	0	0	0	0	0	0	0	0	0.03	0	0.0
windowpane flounder	0.2	0.2	0	0	0.2	0	0	0.1	0	0	0.03	0	0.0
winter flounder 1+	0.1	0.2	0.1	0.1	0.1	0	0	0	0.02	0	0.04	0.03	0.0
winter flounder YOY	11	5.6	0.9	4.7	2	0.8	1	1.1	0.3	0.3	0.5	0.6	0.6

Table 8.2: Frequency of occurrence of finfish species commonly captured in seine samples, 1988-2016. See Appendix 8.1 for complete taxonomic names.

Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
alewife	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.02
American sand lance	0.00	0.00	0.00	0.00	0.02	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
American shad	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Atlantic menhaden	0.06	0.05	0.04	0.04	0.19	0.06	0.10	0.04	0.00	0.06	0.06	0.15	0.10	0.02	0.27	0.58
Atlantic silverside	0.97	0.93	0.96	1.00	1.00	0.96	1.00	0.96	0.94	0.92	0.98	0.94	1.00	0.92	1.00	0.96
Atlantic tomcod	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
black sea bass	0.00	0.00	0.00	0.04	0.00	0.00	0.15	0.04	0.00	0.00	0.06	0.08	0.02	0.25	0.17	0.13
blueback herring	0.00	0.05	0.04	0.13	0.04	0.00	0.06	0.02	0.00	0.00	0.02	0.08	0.02	0.00	0.04	0.06
bluefish	0.00	0.00	0.00	0.10	0.02	0.00	0.02	0.00	0.00	0.02	0.13	0.46	0.04	0.13	0.02	0.10
cunner	0.17	0.19	0.04	0.10	0.15	0.00	0.23	0.15	0.13	0.02	0.21	0.23	0.19	0.15	0.13	0.17
fourspine stickleback	0.17	0.19	0.00	0.23	0.15	0.04	0.02	0.00	0.04	0.00	0.13	0.04	0.02	0.06	0.00	0.00
grubby	0.33	0.07	0.04	0.10	0.31	0.06	0.33	0.25	0.19	0.29	0.17	0.27	0.10	0.17	0.21	0.29
inshore lizardfish	0.06	0.00	0.04	0.00	0.00	0.06	0.10	0.00	0.00	0.29	0.06	0.17	0.19	0.56	0.04	0.00
mummichog	0.47	0.48	0.35	0.40	0.38	0.50	0.42	0.35	0.42	0.15	0.42	0.29	0.44	0.42	0.54	0.44
naked goby	0.00	0.00	0.02	0.06	0.00	0.00	0.00	0.02	0.00	0.00	0.02	0.02	0.00	0.08	0.02	0.02
northern kingfish	0.00	0.00	0.00	0.06	0.08	0.10	0.04	0.15	0.04	0.13	0.10	0.08	0.04	0.13	0.04	0.15
northern pipefish	0.42	0.31	0.37	0.63	0.35	0.50	0.58	0.33	0.44	0.33	0.73	0.48	0.54	0.48	0.19	0.25
northern puffer	0.08	0.24	0.09	0.27	0.08	0.31	0.17	0.40	0.15	0.06	0.10	0.19	0.35	0.17	0.35	0.31
rainbow smelt	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
scup	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.23	0.35	0.25
sheepshead minnow	0.31	0.31	0.09	0.21	0.04	0.02	0.02	0.04	0.00	0.04	0.04	0.06	0.17	0.10	0.15	0.19
smallmouth flounder	0.03	0.00	0.00	0.02	0.00	0.13	0.10	0.06	0.04	0.04	0.00	0.21	0.06	0.13	0.00	0.00
striped bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.06
striped killifish	0.78	0.67	0.65	0.73	0.58	0.65	0.58	0.69	0.54	0.40	0.75	0.67	0.63	0.71	0.85	0.81
striped searobin	0.11	0.12	0.11	0.10	0.08	0.48	0.10	0.02	0.10	0.35	0.60	0.38	0.10	0.29	0.25	0.40
summer flounder	0.00	0.00	0.00	0.00	0.00	0.04	0.10	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00
tautog	0.22	0.05	0.22	0.42	0.31	0.19	0.33	0.33	0.13	0.17	0.38	0.46	0.23	0.40	0.54	0.50
weakfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
windowpane flounder	0.31	0.10	0.13	0.23	0.23	0.19	0.17	0.19	0.35	0.23	0.13	0.13	0.06	0.00	0.02	0.10
winter flounder –age 1+	0.25	0.12	0.00	0.15	0.08	0.23	0.17	0.19	0.10	0.15	0.10	0.06	0.15	0.04	0.02	0.00
winter flounder YOY	0.97	0.71	0.74	0.92	0.98	0.88	0.98	0.94	1.00	0.94	0.92	0.88	0.77	0.58	0.79	0.85

Table 8.2 continued: Frequency of occurrence of finfish species commonly captured in seine samples, 1988-2016. See Appendix 8.1 for complete taxonomic names.

Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
alewife	0	0	0	0	0	0	0	0	0	0	0	0	0
American sand lance	0	0	0	0	0	0	0.04	0	0	0	0	0	0
American shad	0	0	0	0	0	0	0	0	0	0	0	0.04	0
Atlantic menhaden	0.08	0.06	0.13	0.17	0.02	0.15	0.02	0.02	0.04	0.04	0.23	0.54	0.10
Atlantic silverside	1	1	1	1	1	1	1	1	0.98	1	1	1	1.00
Atlantic tomcod	0.02	0.02	0	0	0.02	0	0	0.06	0	0	0	0	0
black sea bass	0.25	0.08	0.23	0.23	0.15	0.27	0.13	0.58	0.75	0.58	0.77	0.9	0.88
blueback herring	0	0	0	0.02	0	0	0.02	0	0.02	0	0	0.02	0
bluefish	0.15	0.04	0.08	0	0.02	0.15	0.02	0.1	0.21	0.08	0.23	0.77	0.21
cunner	0.29	0.21	0.13	0.25	0.1	0.17	0.08	0.04	0.23	0.02	0.31	0.1	0
fourspine stickleback	0.02	0	0.02	0	0	0.02	0	0.04	0	0	0.15	0	0.04
grubby	0.5	0.46	0.27	0.15	0.19	0.27	0.21	0.42	0.23	0.2	0.19	0.15	0.02
inshore lizardfish	0.06	0	0.6	0.13	0.19	0.15	0.13	0.1	0.15	0.13	0.6	0.25	0
mummichog	0.35	0.27	0.48	0.65	0.48	0.5	0.4	0.42	0.35	0.27	0.54	0.65	0.40
naked goby	0.04	0	0.08	0	0.02	0	0	0.02	0.08	0.06	0.08	0.02	0.02
northern kingfish	0.17	0.1	0.02	0.02	0.19	0.17	0.23	0.13	0.29	0.35	0.4	0.38	0.10
northern pipefish	0.48	0.25	0.29	0.42	0.23	0.52	0.4	0.44	0.6	0.6	0.69	0.75	0.31
northern puffer	0.4	0.31	0.29	0.44	0.23	0.23	0.21	0.31	0.42	0.38	0.48	0.31	0.21
rainbow smelt	0.08	0	0	0	0	0	0	0	0	0	0	0	0
scup	0.13	0.29	0.04	0.29	0.02	0.38	0.04	0.06	0.42	0.08	0.48	0.71	0.38
sheepshead minnow	0.15	0.15	0.06	0.4	0.27	0.13	0.1	0.13	0.25	0.07	0.17	0.13	0.13
smallmouth flounder	0	0	0.02	0	0.13	0.15	0.06	0.4	0.17	0.29	0.06	0.15	0.13
striped bass	0	0	0	0	0.02	0	0	0	0	0	0	0	0
striped killifish	0.73	0.96	0.65	0.88	0.94	0.75	0.9	0.98	0.65	0.58	0.88	0.88	0.79
striped searobin	0.38	0.13	0.13	0.27	0.19	0.4	0.17	0.06	0.08	0.15	0.49	0.29	0.02
summer flounder	0	0	0.19	0.06	0.15	0.02	0.04	0	0.08	0.12	0.06	0.13	0.02
tautog	0.54	0.42	0.17	0.54	0.42	0.35	0.31	0.23	0.6	0.33	0.63	0.83	0.67
weakfish	0	0	0	0	0	0	0	0	0	0	0.02	0	0
windowpane flounder	0.21	0.15	0.06	0.04	0.1	0	0.04	0.02	0	0	0.04	0	0
winter flounder 1+	0.17	0.21	0.15	0.08	0.15	0.04	0.04	0.04	0.04	0	0.06	0.04	0.02
winter flounder YOY	0.98	0.94	0.46	0.92	0.71	0.52	0.6	0.63	0.27	0.23	0.33	0.46	0.35

Table 8.3: Mean catch of young-of-year winter flounder at eight sites sampled by seine, 1988-2016.

BPT=Bridgeport, CLT=Clinton, GRT=Groton, GRW=Greenwich, MIL=Milford, OLM=Old Lyme, WTF=Waterford

Year	BPT	CLT	GRT	GRW	MIL	NHH	OLM	WTF	All Sites
1988	*18.72	2.73	11.39	9.63	-	38.66	58.19	29.57	15.4
1989	1.70	1.14	1.53	0.70	-	2.14	2.04	2.99	1.7
1990	3.97	0.19	2.21	0.51	1.62	5.69	16.83	2.64	2.9
1991	1.77	4.10	5.62	1.99	2.46	6.45	15.32	18.25	5.2
1992	3.34	5.53	6.25	9.42	4.29	40.15	47.99	32.52	11.9
1993	1.22	1.40	8.59	4.33	3.62	11.47	13.34	16.66	5.7
1994	4.46	8.11	38.36	4.26	4.62	35.34	61.65	21.03	14.2
1995	1.94	3.19	30.28	7.22	1.77	18.93	34.23	36.58	10.1
1996	7.67	11.81	15.67	*12.61	*6.58	*49.29	91.34	30.53	*19.2
1997	2.87	6.61	23.69	3.43	1.64	3.79	52.01	11.25	7.5
1998	1.24	4.03	17.63	8.12	0.91	22.37	57.19	21.89	9.2
1999	1.04	2.60	25.7	7.95	3.49	0.94	*137.07	36.12	8.7
2000	2.14	0.51	0.76	6.65	0.78	1.74	48.34	*41.56	4.3
2001	0.20	1.12	4.12	1.24	0.59	0	0.91	9.10	1.3
2002	0.91	2.66	3.06	5.08	0.26	1.08	15.55	8.98	3.1
2003	1.88	4.61	*45.78	5.88	0.89	1.70	51.13	32.30	8.1
2004	1.00	*18.36	33.84	11.27	3.36	33.06	11.13	13.04	11.0
2005	1.94	11.14	16.7	7.71	5.14	1.64	4.06	7.30	5.6
2006	0.12	1.38	5.53	0.12	0	0	3.30	1.29	0.9
2007	0.78	5.65	17.90	4.44	0.78	6.42	7.89	7.11	4.7
2008	0.51	2.45	10.84	0.51	0	1.57	2.62	5.94	2.0
2009	0.91	1.62	2.29	0.12	0.51	0.12	0.12	1.75	0.8
2010	0.41	1.11	1.71	1.33	0.12	0.41	1.88	1.57	1.0
2011	0.12	0.98	1.18	2.26	0.78	0.12	4.27	1.45	1.1
2012	0	0.26	0.70	0.76	0	0.12	0.26	0.44	0.3
2013	0	0	1.14	0.26	0	0	0.65	0.57	**0.28
2014	0.12	0.12	1.82	0.26	0.12	0.12	1.35	0.65	0.47
2015	0	0.59	1.96	0.70	0.12	0.12	0.51	2.40	0.64
2016	0.12	0	1.49	0.20	0	0	1.14	6.03	0.63

*record high for a site/year.

**record low for time-series

Table 8.4: Total catch of finfish species commonly captured in seine samples, 1988-2016. See Appendix 8.1 for complete taxonomic names.

Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total	
alewife							1								28	1													0	30	
American sand lance					1		10																13						0	24	
American shad		18	1								151																	42	0	212	
Atlantic menhaden	3	2	2	4	1,074	3	9	2		11	2,003	377	1,236	1	1,284	5,098	1,117	75	117	144	21	54	3	43	2	14	3404	3948	150	20,201	
Atlantic silverside	4750	3316	5,356	6,383	5,468	5,263	6,311	2,352	1,942	3,249	6,345	10,120	8,738	4,417	5,730	13,278	5,122	5,089	3,267	5,087	3,245	4,156	7,063	4,657	4,142	3,958	3832	7549	6459	156,644	
Atlantic tomcod						3					1					1	3				1			8						0	17
black sea bass				10			41	43			27	14	2	687	63	27	110	15	82	109	33	304	86	489	783	1,197	1950	1794	500	8,366	
blueback herring		26																		9			3		1	1			11	0	
bluefish			3	194	10		5	2			3	24	1		13	5	23	8	30		7	53	1	26	54	17	194	289	45	1,007	
cunner	15	27	2	5	19		42	24	63	1	23	142	26	15	110	15	54	35	18	58	8	28	15	2	42	1	73	7	0	870	
fourspine stickleback	33	76		183	11	21	1		3		24	3	1	7			9		2			8		2			13		2	399	
grubby	111	3	2	7	61	6	38	19	21	28	17	55	15	73	33	95	143	76	31	32	16	51	25	55	18	19	18	16	1	1,085	
inshore lizardfish	5		2			4	6			46	6	16	15	103	2		3		169	18	26	22	10	16	23	11	135	38	0	676	
mummichog	1,031	197	171	765	573	1,256	1,943	78	149	190	396	115	1,008	246	811	702	637	543	398	1,203	498	857	299	775	329	199	1098	999	519	17,985	
naked goby			1	4				1			1	1		4	2	2	2		13		2		2	4	4	6	5	1		55	
northern kingfish				3	4	23	2	9	3	10	7	6	5	17	5	21	38	11	1	1	23	42	76	30	54	81	149	113	10	744	
northern pipefish	65	23	33	106	120	82	117	52	241	38	295	141	96	189	87	25	72	92	82	75	156	307	49	248	152	204	413	142	48	3,750	
northern puffer	4	22	13	34	4	37	15	40	25	5	5	13	63	14	79	101	75	93	34	241	19	41	51	28	98	202	97	448	18	1,919	
rainbow smelt						5	2										34													0	41
scup												1		58	172	131	50	154	6	170	14	413	21	30	375	18	485	1573	198	3,869	
sheepshead minnow	174	815	5	345	4	1	2	30		14	19	12	267	59	402	276	205	28	104	1,439	304	203	82	219	238	59	154	60	742	6,262	
smallmouth flounder	1			1		8	14	7	2	5		40	3	12					1		14	21	5	114	63	49	15	13	7	395	
striped bass												1				6						1								0	8
striped killifish	1,511	1,383	748	659	465	773	1,923	520	269	289	1,066	539	1,797	1,494	1,698	3,410	1,548	1,470	1,063	1,994	1,874	1,508	1,300	1,964	720	493	1158	1531	1482	36,649	
striped searobin	22	12	5	94	5	71	5	1	9	40	178	51	7	33	33	62	38	19	6	32	36	82	14	4	7	14	121	84	1	1,086	
summer flounder						2	6		1		1							16	8	8	1	6		6	7	3	11	1		77	
tautog	23	5	23	72	32	16	104	88	42	19	135	174	67	59	153	140	145	64	93	321	131	25	33	27	123	73	467	446	75	3,175	
weakfish																15												4		0	19
windowpane flounder	49	4	22	19	35	30	9	13	71	50	12	10	4		1	5	15	15	3	2	17		2	4			2	0		394	
winter flounder 1+	12	6		7	6	14	13	12	21	282	9	4	7	2	3		9	11	7	6	13	2	2	2	2		3	2	1	458	
winter flounder YOY	900	117	276	410	1,055	483	1,401	916	1,486	874	999	1,497	708	138	302	1,310	914	470	110	365	190	72	71	86	22	24	48	48	74	15,366	

Table 8.5: Total catch of finfish species infrequently captured in seine samples, 1988-2016. See Appendix 8.1 for complete taxonomic names

Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total	
American eel	1	3					1				5													1		2	15				28
Anchovy, spp (YOY)																					15								3051	3066	
Atlantic needlefish																					2								1	3	
banded gunnel											2	3					4	2	3	1	3			1							19
banded rudderfish																							1								1
bay anchovy								4	69		27			1	11		1	12					1				520	24		670	
blue spotted coronet fish												1															2			3	
burrfish, striped				15	2		1			1	9	142	3	8	2	17							10			4				214	
butterfish												1														21				22	
crevalle jack	6							1															1							8	
feather blenny																									36					36	
flying gurnard																					1									1	
gizzard shad																							4							4	
grey snapper				1																										1	
hogchoker							2																		1					3	
lined seahorse							4			1			2								2	7	2	1	2				1	22	
little skate										1					1															2	
northern searobin		2	1				1	1					3	40	24	5	4	13	2	10			1	9		6	35	105		262	
northern sennet																					1									1	
northern star gazer			5																											5	
oyster toadfish	5			1						1	1		1			1	2	1	1	1	2	1				6	2	4	2	32	
pumpkinseed				2													3													5	
rainwater killifish									3	4			2		6	35	53	19	3										4	129	
rock gunnel			1		1	1	1										1													9	
smooth dogfish			1																											1	
spot																											6			6	
striped anchovy																						3								3	
threespine stickleback														11																11	
web burrfish																			1				1							2	
white mullet	1	1	8		3										1					7	7	11		75	68			15	219		
white perch																		3								22				20	
yellow jack																							1							1	

Table 8.6: Total catch of invertebrate species taken in seine samples, 2004-2016. See Appendix 8.2 for complete taxonomic names.

<u>Species</u>	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	<u>Total</u>
bluecrab	1	2	84	31	4	333	35	23	27	18	17	18	6	599
boreal squid				1										1
brown shrimp			11										3	14
channeled whelk							1				3			4
common slipper shell			13											13
flat claw hermit crab	761	532	703	153	244	539	558	441	283	367	562	308	2,878	8329
green crab	234	266	341	147	644	176	308	228	175	253	273	213	256	3514
horseshoe crab													1	1
Japanese shore crab	1		1	1				6	1			1	1	12
Jonah crab						2								2
lady crab	298	119	66	195	92	42	19	24	18	13	41	102	12	1041
mantis shrimp									1					1
mole crab	1	5												6
moon jelly							319						461	780
mud crabs	60	55	74	30	85	67	308	80	80	1100	43	142	9	2133
mud snail	948	2,071	4,478	3,569	3,810	3,128	2,699	2,683	3072	5,787	6,938	11,132	11,687	62002
northern comb jelly						346	36			3,620	1,200		185	5387
northern moon snail													4	4
oyster drill			38											38
rock crab	2						1							3
sand shrimp	278	373	1,027	525	2,625	762	902	1,507	246	1,794	662	207	33	10941
scallop (bay)											3	3	1	7
shore shrimp	990	404	1,149	707	1,390	535	619	762	402	511	1011	4795	478	13753
spider crab	4	5	6	1	3	1	7	33	13	20	14	45	53	205
squid (longfin)												6		6
starfish spp.							1							1

Table 8.7: Cold and warm temperate species captured in the Estuarine Seine Survey.

Cold Temperate Species		Warm Temperate Species	
Common name	Scientific Name	Common name	Scientific Name
alewife	<i>Alosa pseudoharengus</i>	American eel	<i>Anguilla rostrata</i>
American sand lance	<i>Ammodytes americanus</i>	American shad	<i>Alosa sapidissima</i>
Atlantic tomcod	<i>Microgadus tomcod</i>	Atlantic silversides	<i>Menidia menidia</i>
cunner	<i>Tautoglabrus adspersus</i>	bay anchovy	<i>Anchoa mitchilli</i>
grubby	<i>Myoxocephalus aeneus</i>	blueback herring	<i>Alosa aestivalis</i>
little skate	<i>Leucoraja erinacea</i>	black seabass	<i>Centropristis striata</i>
northern pipefish	<i>Syngnathus fuscus</i>	bluefish	<i>Pomatomus saltatrix</i>
rock gunnel	<i>Pholis gunnellus</i>	butterfish	<i>Peprilus triacanthus</i>
rainbow smelt	<i>Osmerus mordax</i>	feather blenny	<i>Hypsoblennius hentz</i>
winter flounder	<i>Pseudopleuronectes americanus</i>	gizzard shad	<i>Dorosoma cepedianum</i>
windowpane flounder	<i>Scophthalmus aquosus</i>	hogchoker	<i>Trinectes maculatus</i>
		lined seahorse	<i>Hippocampus erectus</i>
		menhaden	<i>Brevoortia tyrannus</i>
		naked goby	<i>Gobiosoma boscii</i>
		northern kingfish	<i>Menticirrhus saxatilis</i>
		northern puffer	<i>Sphoeroides maculatus</i>
		northern searobin	<i>Prionotus carolinus</i>
		northern stargazer	<i>Astroscopus guttatus</i>
		oyster toadfish	<i>Opsanus tau</i>
		pumpkinseed	<i>Lepomis gibbosus</i>
		scup	<i>Stenotomus chrysops</i>
		silver perch	<i>Bairdiella chrysoura</i>
		smooth dogfish	<i>Mustelus canis</i>
		smallmouth flounder	<i>Etropus microstomus</i>
		spotted hake	<i>Urophycis regia</i>
		spot	<i>Leiostomus xanthurus</i>
		striped searobin	<i>Prionotus evolans</i>
		striped anchovy	<i>Anchoa hepsetus</i>
		striped bass	<i>Morone saxatilis</i>
		summer flounder	<i>Paralichthys dentatus</i>
		tautog (blackfish)	<i>Tautoga onitis</i>
		white perch	<i>Morone Americana</i>
		weakfish	<i>Cynoscion regalis</i>

Figure 8.1: Sampling locations of the Estuarine Seine Survey.

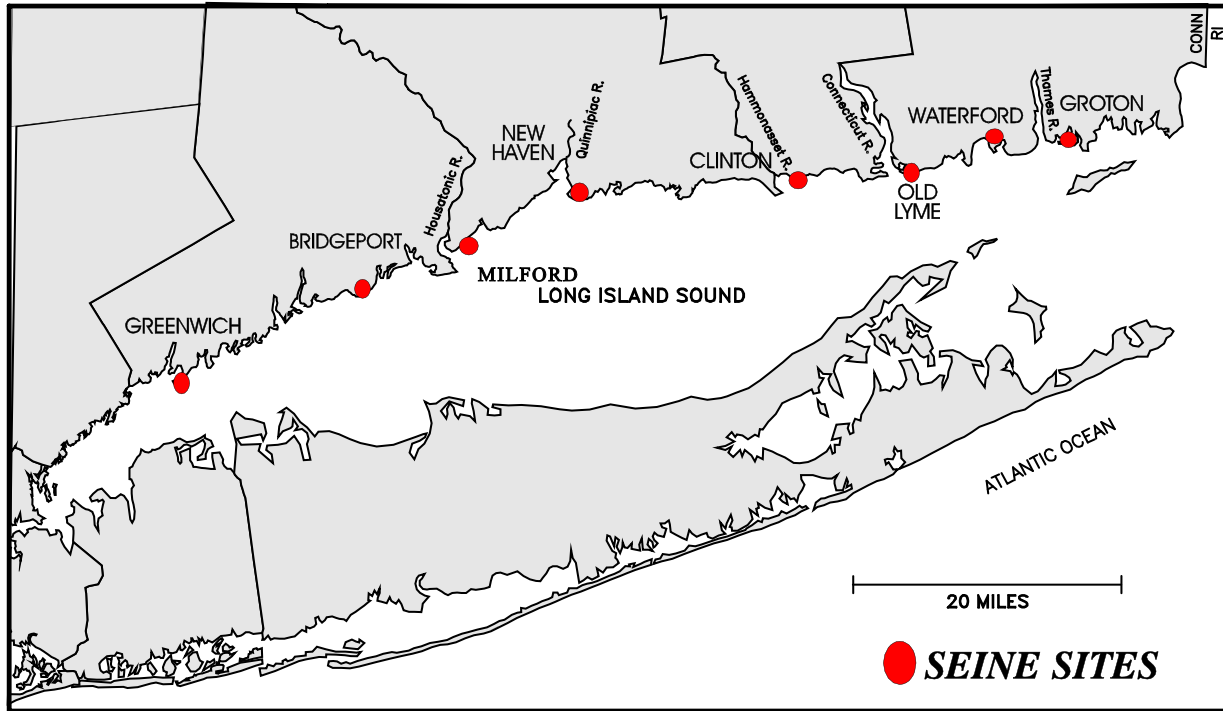
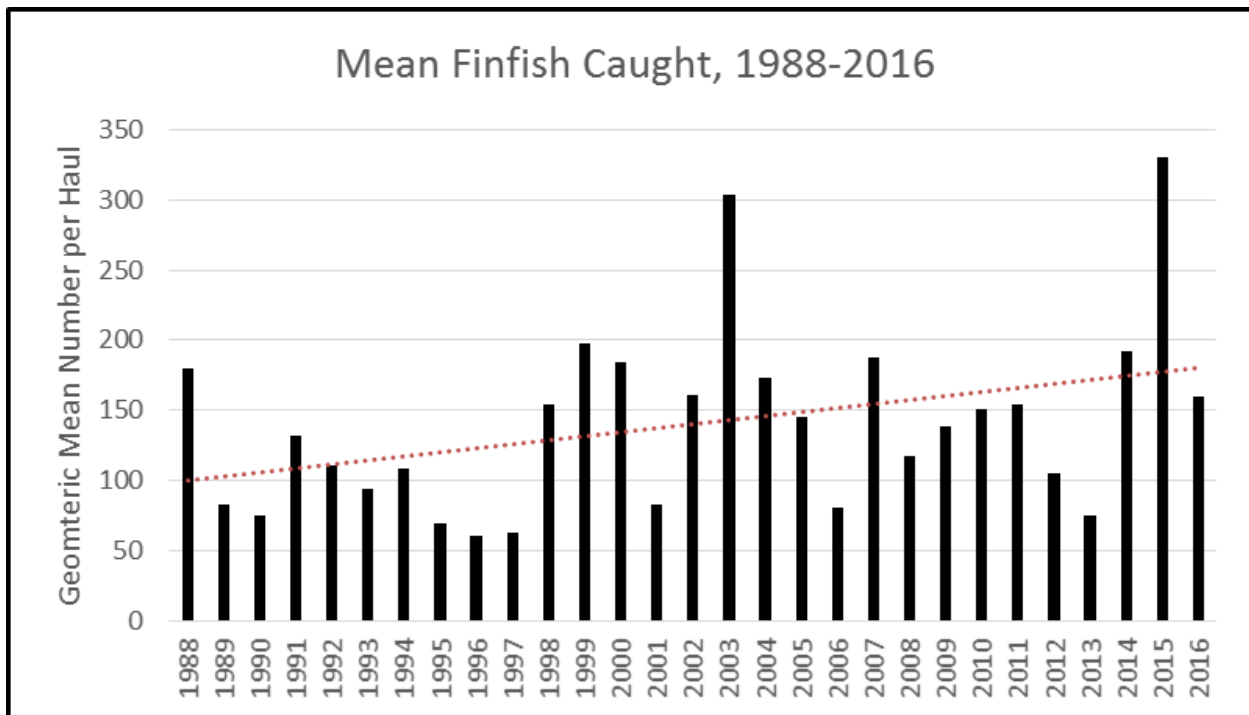


Figure 8.2: Mean catch of all finfish captured in seine samples, 1988-2016. Geometric mean catch (numbers) per haul includes samples at all sites. Note that sampling at the Milford site began in 1990.



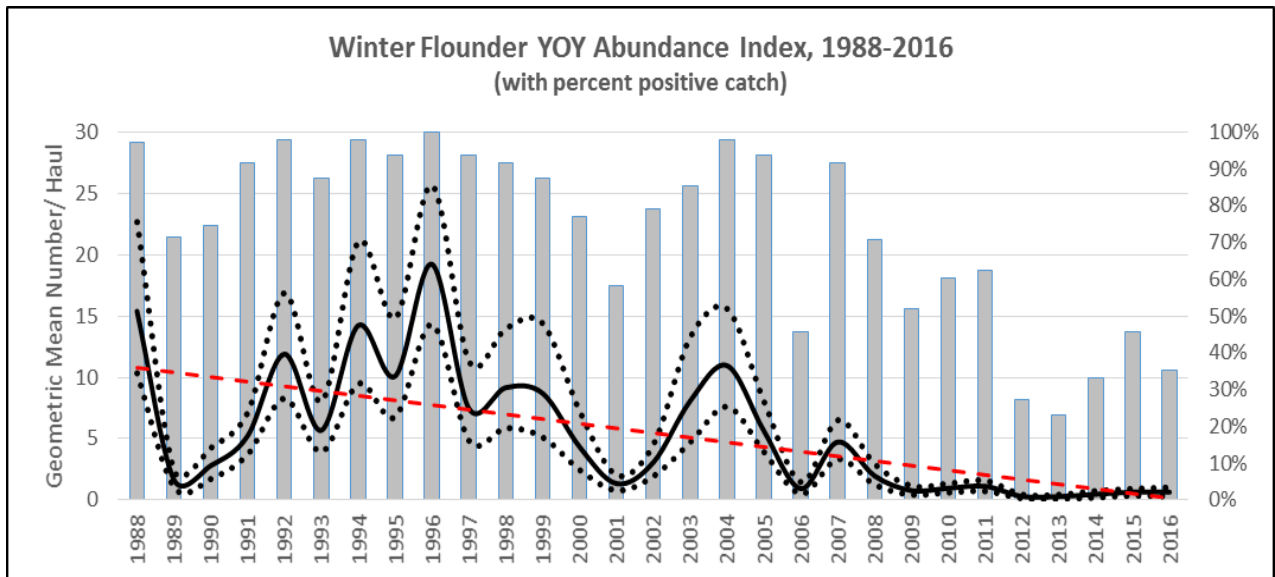


Figure 8.3: Mean catch and occurrence of young-of-year winter flounder, 1988-2016. Confidence intervals (95%) are shown (dotted lines). The negative trend (dashed line) is significant ($r^2 = 0.36$, $p < 0.001$, $df = 28$). Percent of hauls catching winter flounder (shaded bars) has also decreased.

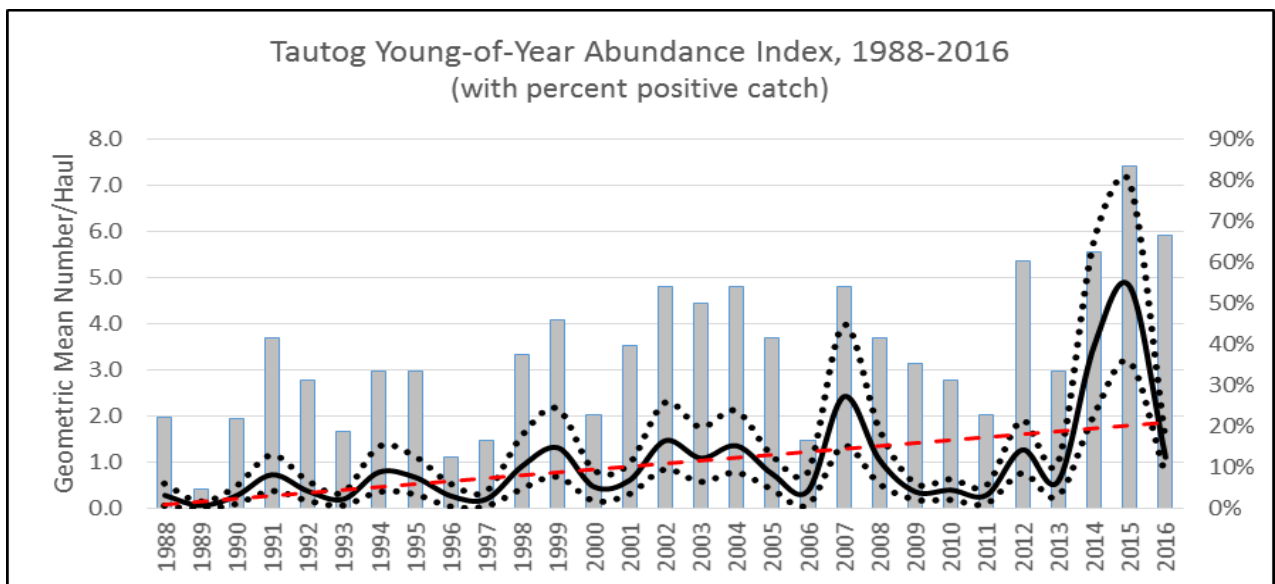


Figure 8.4: Mean catch and occurrence of young-of-year tautog, 1988-2016. Confidence intervals (95%) are shown (dotted lines). The positive trend (dashed line) is significant ($r^2 = 0.25$, $p = 0.003$, $df = 28$). Percent of hauls catching tautog (shaded bars) has also increased.

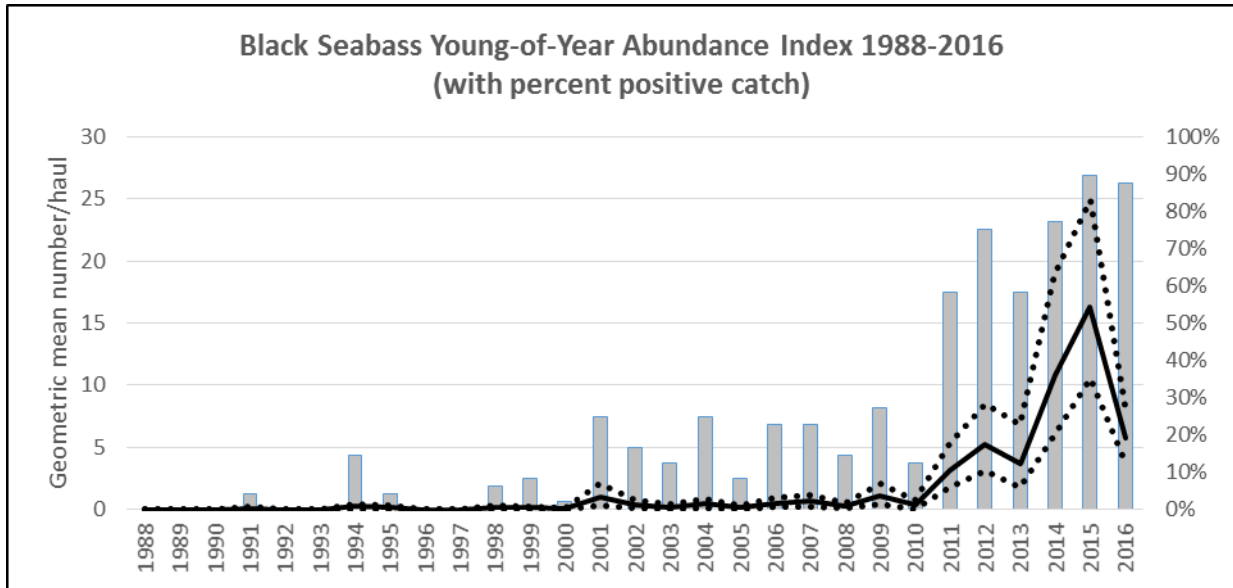


Figure 8.5: Mean catch of black seabass young-of-year, 1988-2016. Annual percent of hauls catching one or more black seabass are also shown.

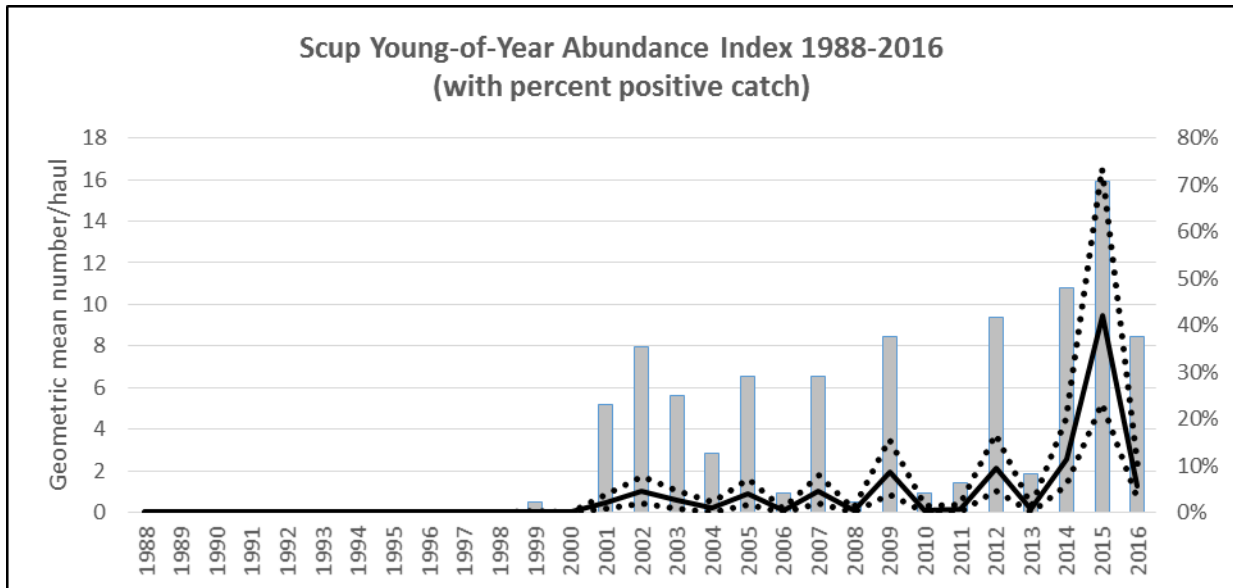
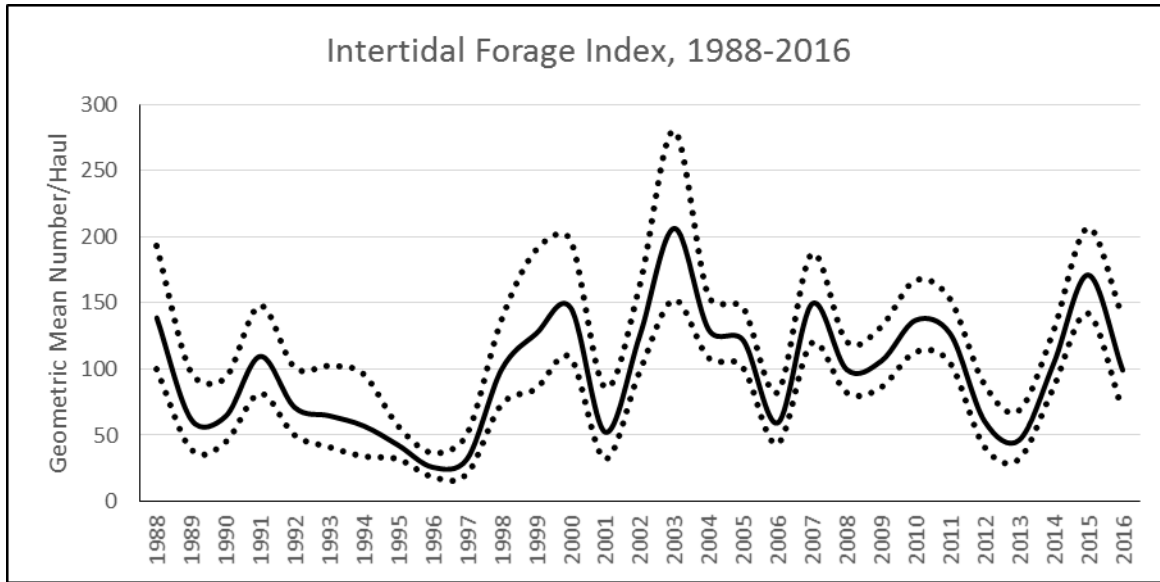


Figure 8.6: Mean catch of scup young-of-year, 1988-2016. Annual percent of hauls catching one or more scup are also shown.



	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean:	139	62	64	110	71	65	57	42	26	32	100	127	146	52	125	206	130	122	59	149	100	106	137	127	60	46	104	171	99

Figure 8.7: Mean catch of forage fish, 1988-2016. Forage species included in the index are Atlantic silversides, mummichog, sheepshead minnow, and striped killifish. Confidence intervals (95%) are shown (dotted lines) and annual geometric mean catch is shown in boxes below. See Appendix 8.1 for complete taxonomic names.

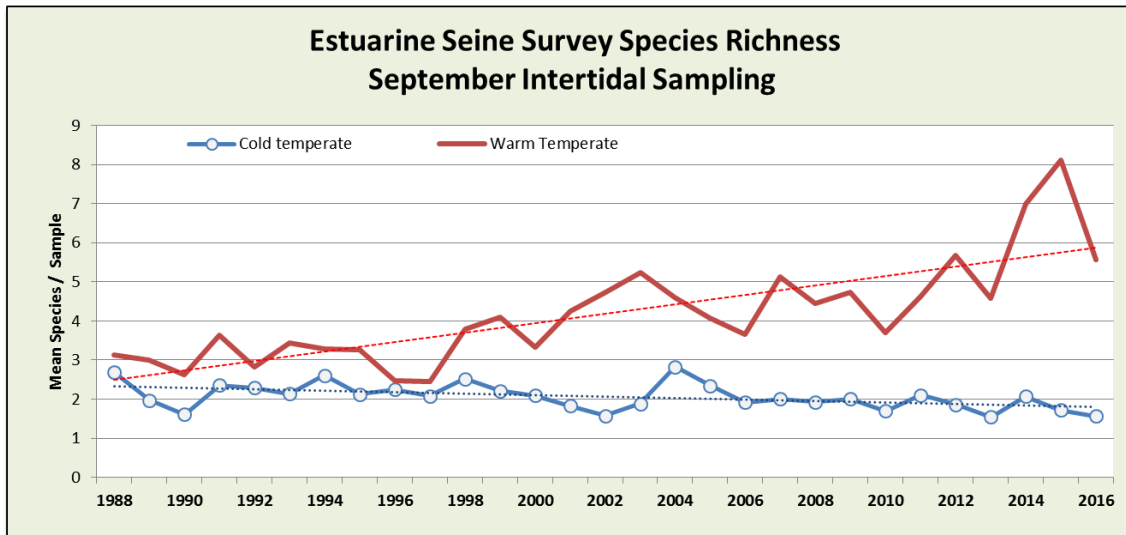


Figure 8.8: Trend in species richness for cold and warm temperate species at eight seine sites, 1988-2016. See Table 8.7 for species listings by group.

Appendix 8.1: Finfish species captured in the Estuarine Seine Survey, 1988-2016.

<u>COMMON NAME</u>	<u>SPECIES CODE</u>	<u>SCIENTIFIC NAME</u>
Alewife	ALW	<i>Alosa pseudoharengus</i>
American eel	EEL	<i>Anguilla rostrata</i>
American shad	ASD	<i>Alosa sapidissima</i>
American sand lance	ASL	<i>Ammodytes americanus</i>
Atlantic needlefish	ANF	<i>Strongylura marina</i>
Atlantic silversides	ASS	<i>Menidia menidia</i>
Atlantic tomcod	TOM	<i>Microgadus tomcod</i>
Banded gunnel	BGN	<i>Pholis fasciata</i>
Banded rudderfish	RUD	<i>Seriola zonata</i>
Bay anchovy	ACH	<i>Anchoa mitchilli</i>
Black-spot stickleback	BSS	<i>Gasterosteus wheatlandi</i>
Black sea bass	BSB	<i>Centropristis striata</i>
Blueback herring	BBH	<i>Alosa aestivalis</i>
Bluefish	BLF	<i>Pomatomus saltatrix</i>
Blue spotted coronetfish	BSC	<i>Fistularia tabacaria</i>
Crevalle jack	CRJ	<i>Caranx hippos</i>
Cunner	CUN	<i>Tautoglabrus adspersus</i>
Feather Blenny	FBL	<i>Hypsoblennius hentzi</i>
Flying Gurnard	FGD	<i>Dactylopterus volitans</i>
Four-spine stickleback	FSS	<i>Apeltes quadracus</i>
Gizzard Shad	GIZ	<i>Dorosoma cepedianum</i>
Gray snapper	GRA	<i>Lutjanus griseus</i>
Grubby	GRB	<i>Myoxocephalus aeneus</i>
Hogchoker	HOG	<i>Trinectes maculatus</i>
Inshore lizardfish	LIZ	<i>Synodens foetens</i>
Little skate	LSK	<i>Raja erinacea</i>
Menhaden	MEN	<i>Brevoortia tyrannus</i>
Mummichog	MUM	<i>Fundulus heteroclitus</i>
Naked goby	NKG	<i>Gobiosoma boscii</i>
Nine-spine stickleback	NSS	<i>Pungitius pungitius</i>
Northern kingfish	NKF	<i>Menticirrhus saxatilis</i>
Northern pipefish	PIP	<i>Syngnathus fuscus</i>
Northern puffer	PUF	<i>Sphaeroides maculatus</i>
Northern searobin	NSR	<i>Prionotus carolinus</i>
Northern stargazer	STR	<i>Astroscopus guttatus</i>
Pumpkinseed	PUM	<i>Lepomis gibbosus</i>
Rainbow smelt	RSM	<i>Osmerus mordax</i>
Rainwater killifish	RWK	<i>Lucania parva</i>
Rock gunnel	RGN	<i>Pholis gunnellus</i>
Northern seahorse	SEH	<i>Hippocampus erectus</i>
Northern sennet	NOS	<i>Sphyræna borealis</i>
Scup	PGY	<i>Stenotomus chrysops</i>
Sheepshead minnow	SHM	<i>Cyprinodon variegatus</i>
Shorthorn Sculpin	SHS	<i>Myoxocephalus scorpius</i>
Skilletfish	SKL	<i>Gobiesox strumosus</i>
Smallmouth flounder	SMF	<i>Etropus microstomus</i>
Smooth dogfish	SMD	<i>Mustelus canis</i>
Spotted hake	SPH	<i>Urophycis regius</i>
Striped anchovy	STA	<i>Anchoa hepsetus</i>
Striped bass	STB	<i>Morone saxatilis</i>
Striped burrfish	SBF	<i>Chilomycterus schoepfi</i>
Striped killifish	SKF	<i>Fundulus majalis</i>
Striped searobin	SSR	<i>Prionotus evolans</i>
Summer flounder	SFL	<i>Paralichthys dentatus</i>
Tautog	BKF	<i>Tautoga onitis</i>
Three-spine stickleback	TSS	<i>Gasterosteus aculeatus</i>

Appendix 8.1 continued:

Toadfish	TDF	<i>Opsanus tau</i>
Weakfish	WKF	<i>Cynoscion regalis</i>
Web Burrfish	WBF	<i>Chilomycterus antillarum</i>
White mullet	WML	<i>Mugil curema</i>
Windowpane flounder	WPF	<i>Scophthalmus aquosus</i>
Winter flounder (YOY)	WFO	<i>Pseudopleuronectes americanus</i>
Winter flounder (AGE 1+)	WFL	<i>Pseudopleuronectes americanus</i>
Yellow jack	YJK	<i>Caranx bartholomaei</i>

Appendix 8.2: Invertebrate species captured in the Estuarine Seine Survey, 1988-2016.

<u>COMMON NAME</u>	<u>SPECIES CODE</u>	<u>SCIENTIFIC NAME</u>
Bay Scallop	SCA	<i>Argopecten irradians</i>
Blue crab	BCR	<i>Callinectes sapidus</i>
Brown Shrimp	BNS	<i>Panaeus aztecus</i>
Chaneled Whelk	CHW	<i>Busycotypus canaliculatus</i>
Northern Comb Jelly	COM	<i>Bolinopsis infundibulum</i>
Green crab	GCR	<i>Carcinus maenas</i>
Hermit crab	HER	<i>Pagurus spp.</i>
Horseshoe crab	HSC	<i>Limulus polyphemus</i>
Japanese crab	JCR	<i>Hemigrapsus sanguineus</i>
Lady crab	LCR	<i>Ovalipes ocellatus</i>
Mantis shrimp	MAN	<i>Squilla empusa</i>
Moon Jelly	MOJ	<i>Aurelia aurita</i>
Mud crab	BMC	<i>Panopeus spp.</i>
Mole crab	MLR	<i>Emerita talpoida</i>
Mud snail	MSN	<i>Nassarius obsoletus</i>
Rock crab	RCR	<i>Cancer irroratus</i>
Sand shrimp	CRG	<i>Crangon septemspinosa</i>
Sea Star	STF	<i>Asterias forbesi</i>
Shore shrimp	PAL	<i>Palaemonetes spp.</i>
Shortfin Squid	ILL	<i>Illex illecebrosus</i>